HAZARD INFORMATION PROFILES

Supplement to :

UNDRR-ISC Hazard Definition & Classification Review - Technical Report

SENDAI FRAMEWORK
FOR DISASTER RISK REDUCTION 2015-2030

International Science Council
The global voice for science

UNDRR
UN Office for Disaster Risk Reduction

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Data disaggregated by region reflects the coverage of UNDRR's Regional Offices.

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The Sendai Framework for Disaster Risk Reduction 2015–2030 (‘the Sendai Framework’) was one of three landmark agreements adopted by the United Nations in 2015. The other two being the Sustainable Development Goals of Agenda 2030 and the Paris Agreement on Climate Change. The UNDRR/ISC Sendai Hazard Definition and Classification Review Technical Report supports all three by providing a common set of hazard definitions for monitoring and reviewing implementation which calls for “a data revolution, rigorous accountability mechanisms and renewed global partnerships”.

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1. Introduction

This report is a Supplement to the UNDRR-ISC Hazard Definition and Classification Review - Technical report released in July 2020. Aligned with the list of hazards published in the Technical Report, this Supplement comprises of a description of each of the 302 hazard information profiles (HIPs), developed using a consultative process by scientists and experts across the globe.

Responding to increasing calls for 'a data revolution, rigorous accountability mechanisms and renewed global partnerships', the UNDRR-ISC Hazard Definition and Classification Review - Technical report and its Supplement provide an important resource to support the implementation of disaster risk reduction and risk-informed investment, aligned with the Sendai Framework for Disaster Risk Reduction 2015–2030, but also the Sustainable Development Goals of Agenda 2030, the Paris Agreement on Climate Change and the Addis Ababa Action Agenda on Sustainable Financing. It provides a common set of hazard definitions to Governments and stakeholders to inform their strategies and actions on risk reduction and management. Specifically, the report and this supplement could support the development and updating of national and local disaster risk reduction strategies and loss databases, as well as integrating disaster risk reduction into national statistics, legal, accounting and regulatory frameworks and public and private policy, financing and investment decisions.

2. The Project

In May 2019, the UN Office for Disaster Risk Reduction (UNDRR) and the International Science Council (ISC) established a Technical Working Group (TWG) to identify the full scope of hazards relevant to the Sendai Framework for Disaster Risk Reduction as a basis for countries and other actors to review and strengthen their risk reduction policies and operational risk management practices.

The role of the TWG was to develop technical recommendations on the scope and definitions of hazards related to the Sendai Framework. The results of this international collaborative effort were presented in the UNDRR-ISC Hazard Definition and Classification Review - Technical report, released in July 2020. A key recommendation from the Review was the need to engage with the scientific and international community to foster greater alignment and consistency of hazard definitions used worldwide (Recommendations 1, 3 and 6).

Building on these recommendations, this Supplement presents a first comprehensive attempt at compiling available definitions and information on each of the 302 hazards identified in the Technical Report in a concise and structured format.

The development of the profiles involved a wide range of scientific experts from:

- United Nations agencies and scientific networks
- International scientific organisations and other disciplinary unions
- Universities, education and training bodies and research institutes
- Government scientific agencies
- The private sector and the insurance industry

Overall, more than 100 authors were involved in the compilation of the profiles and over 130 reviewers from at least 100 organisations were involved in the peer review process.

3. Hazard Information Profiles

Aligned with the UNDRR-ISC Hazard Definition and Classification Review - Technical report, the HIPs are divided into eight hazard types. Each hazard type is further divided by cluster type and covers a variable number of specific hazards:

- Meteorological and Hydrological hazards with 9 hazards clusters and 60 specific hazards
- Extraterrestrial hazards with 1 hazard cluster and 9 specific hazards
- Geohazards with 3 hazard clusters and 35 specific hazards
- Environmental hazards with 2 hazard clusters and 24 specific hazards
- Chemical hazards with 9 hazard clusters and 25 specific hazards
- Biological hazards with 10 hazard clusters and 88 specific hazards
- Technological hazards with 9 hazard clusters and 53 specific hazards
- Societal hazards with 4 hazard clusters and 8 specific hazards

Note: According to the UN General Assembly Resolution 69/284, the term 'anthropogenic' or 'human-induced' hazards in the Sendai Framework, does not include the occurrence or risk of armed conflicts and other situations of social instability or tension which are subject to international humanitarian law and national legislation (https://www.undrr.org/terminology/hazard). As such, the report authors recognise that hazard terms related to violence and conflict included in this Technical Report are outside the scope of the Sendai Framework. In view of the calls for stronger coherence across the disaster risk reduction, development, climate change and humanitarian agendas, all of which have risk and resilience as underlying concepts, societal hazards were included as part of all-hazard considerations and ensure commonly agreed definitions for any hazard and risk.

Each Hazard Information Profile includes the specific hazard by name, hazard type, hazard cluster and hazard number and the following box outlines content of each HIP:

The Hazard Information Profile Structure

The TWG developed a common template for each hazard information profile comprising four sections:

a) **Name and Reference**

This section includes a reference number (assigned for the purpose of information management for this project), hazard type, cluster type and name of the specific hazard.

b) **Definition**

A definition of the hazard, sourced from an authoritative source (such as the UN agency responsible for providing guidance on the hazard), that reflects scientific consensus on the issues addressed, and that is of broad international relevance. For hazards where no UN level definition exists, definitions were extracted, and when necessary adapted from the most accepted and up-to date academic and scientific sources. The reference(s) for the definition is cited.

c) **Annotations**

This section comprises several sub-sections:

- Possible synonyms or alternative denominations to enable usage of the profiles in relational databases. Equivalents in languages other than English have not been systematically proposed but would be helpful for the uptake and use of the HIPs worldwide.
- Additional description elements which expand on the primary definition of the hazard.
- Where relevant and available, globally used metrics and numeric limits.
- References to key relevant UN conventions or multilateral treaties.
- Examples of drivers, outcomes and risk management practices or processes providing more concrete information on the contexts and possible impacts of the hazard.
- A set of key references from publicly available scientific and institutional sources to support facts and statements made in the HIPs.

d) **Coordination Agency or Organisation**

The TWG drew on their expertise and networks to identify the UN or international organisations that provide technical guidance on the hazard under consideration. The TWG approached these organisations to identify relevant resources and to identify experts to lead or contribute to the development and review of each hazard information profile for the purpose of this project. For many HIPs, this was a clear process but for some HIPs, a coordinating agency or organisation is still to be identified.

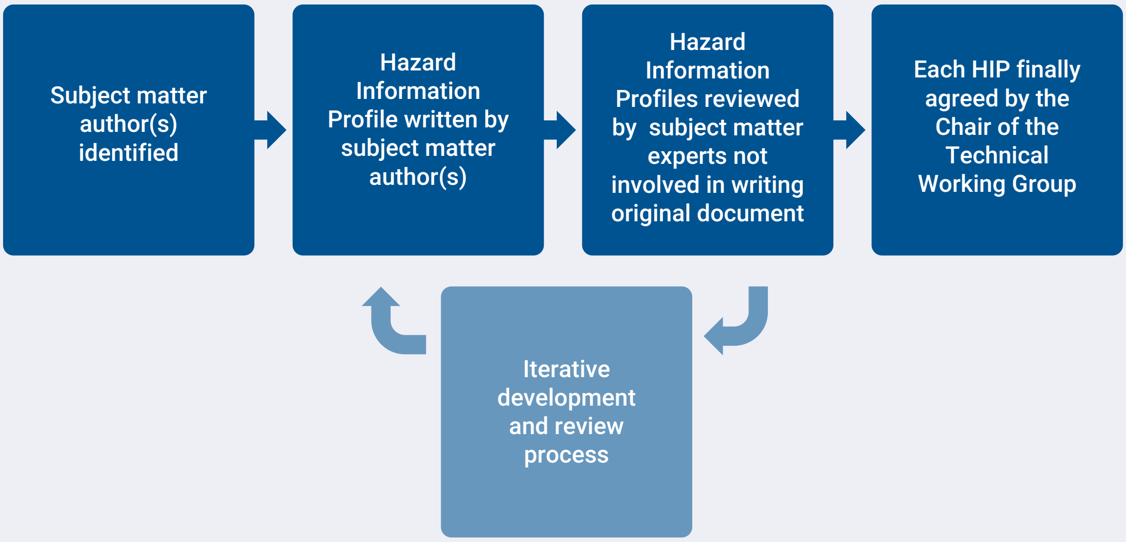
4. The Hazard Information Profile Development Process

The HIP development process was managed by a small project team from the UK Health Security Agency (formerly Public Health England. UK) and Flinders University, Australia, overseen by the TWG Chair, in close consultation with the ISC and UNDRR.

Authors were identified by the TWG and invited to draft HIPs, often in collaboration with other experts. A peer review process by subject matter experts was managed by the Chair of the TWG together with the Chair of the Integrated Research on Disaster Risk (IRDR) and the ISC. The HIPs were finalised by the project team and the TWG Chair. A list of contributing authors and reviewers is included in the annex.

The final output of these efforts is a compilation of existing hazard information across the wider spectrum of hazards identified in the Sendai Framework and the other 2015 UN landmark agreements. It is intended to serve as a baseline for further review and refinement with a view to harmonise hazard information across sectors and organisations and enhance understanding and collaboration between the scientific community and organisations that have the mandate to provide technical guidance on the hazards under consideration.

Figure 1: Iterative Hazard Information Profile Development Process



5. Key Learnings

Development of the HIPs has been a significant undertaking which has led to key learnings as follows.

- **This process was made possible through the close collaboration between a wide range of organisations.** This was an important exercise in what is necessarily an iterative process. It also demonstrates the breadth of expertise needed given the number of hazards identified and the constantly evolving science underpinning hazard characterisation. The authors have used a variety of scientific and other sources to develop robust and usable hazard profiles.
- **Hazards are complex, multidimensional phenomena or processes that require expertise from a range of disciplines to be described accurately**. For example, the definition and characterisation of heatwaves required information from meteorologists, climate scientists, public health scientists, and an understanding of the several definitions used across countries (MH0047).
- **For approximately one third of the HIPs, a UN agreed definition was not identified.** For these, a working definition was drawn from the scientific literature with expert inputs. For example, the definitions for most geohazards come from the scientific literature; the glacial lake outburst flood definition (MH0013) come from a scientific publication that is also routinely quoted by a United Nations organisation; and the definition of airburst (ET0001) came from a Lexicon.
- **During the development process, further changes to the current hazard list were suggested.** For example, following discussion with experts, some hazards have been renamed to reflect more accurately the hazard of concern. For example, the technological hazard 'privacy and data security for citizens-supporting human mental health' was reframed as 'cyberbullying' which took into consideration the significant impacts of cyberbullying on the mental health of people including the young (TL0026). As part of the peer review process it was suggested that some HIPs may need to be split to enable further granularity in any future follow up. For example, the HIP on violence (SO0006) may be split to reflect different types of violence, such as gender-based violence in conflict, domestic violence, etc. Additionally, it was agreed that suggestions for additional hazards can be considered for future iterations in collaboration with organisations and authors engaged in this process.

6. Next Steps

This process has prompted rich conversations within and between organisations and groups regarding the need for standardised hazard information that is supported by the latest scientific evidence. The level of engagement, interest and enthusiasm to contribute and use outputs of this process provides a basis for future collaboration between these organisations and experts. These have been identified in the six recommendations of the Technical Report.

Recommendation 1: Regular review and update

The development and regular review and updating of a standard set of classifications of hazards, and the development of an agreed process of identifying and defining hazards is a critical foundation for risk-based decision-making and action. It is recommended that the hazard list be reviewed by the proposed end-users reflecting the needs of those involved in disaster risk reduction, emergency management, climate change, and increasingly sectoral actors pursuing sustainable development. The latter being consistent with the stipulation of the Sendai Framework that the reduction of disaster risk is an all-of-society and all-of-State institutions engagement. In particular, it will be important to have a more detailed scientific review of the list and hazard information profiles (HIPs) for those hazards that are not currently routinely included in disaster risk management, such as societal hazards.

With this review, it will be important to maintain the development of the HIPs, including the hazard definition and any additional scientific description. This involves developing the ownership of hazard definitions by bodies that have an intergovernmental process for agreeing on wording and definition for standardisation, with continuous engagement from the broader scientific community; and for these coordinating institutions to regularly review and update the list and hazard definitions. Risk by nature is dynamic – hazard definitions and terminologies must adapt to such a reality.

Recommendation 2: Facilitate the development of a multi-hazard information system

Enhancing the classification of hazards and facilitating access to the definition and description of hazards will be important. The next step should be the continuing development of hazard definitions as online resources, encoded following linked-data and open-science best practices. Through a meta-data approach, hazards could be tagged to allow for the list to be searched in multiple ways, thus accommodating diverse user needs. This will involve the development of a simple hazard definition schema to capture all the details of each individual hazard definition, including preferred and alternative names, relationships to other hazards (including parental or causality relationships), and citation of source material. Further alignments to related vocabularies covering the sustainable development goals (SDGs) of Agenda 2030 and some standard scientific vocabularies, as well as incorporating additional language functionality to encompass local hazard terminology, is recommended for future versions

Recommendation 3: Engaging with users and sectors for greater alignment and consistency of hazard definitions

Engagement with a range of users working in disaster risk reduction, emergency management, climate change, and increasingly sectoral actors pursuing sustainable development is needed to further develop hazard definitions. These users are likely to be representatives of Sendai Framework Focal Points and National Platforms for disaster risk reduction, regional economic and social commissions, policymakers, communities and practitioners within and across all sectors. By socialising this report, it will be possible to assess the value of the hazard terminology report and tool by users and sectors. The HIPs could also be used by the United Nations Statistics Division and the National Statistical Offices to ensure interoperability and standardisation of statistically relevant definitions of hazards across the Sendai Framework, Paris Agreement and the SDGs for use at local, national and international levels. This will ensure synchronisation among global and national statistical mechanisms and processes.

Recommendation 4: Use this hazard list to actively engage policymakers and scientists in evidence-based national risk assessment processes, disaster risk reduction and risk-informed sustainable development, and other actions aimed at managing risks of emergencies and disasters

This includes supporting the uptake of the hazard list and HIPs as a tool for countries to investigate the potential sources of risk in their particular context, which requires developing further guidance for end-users. The guidance would elaborate for UN Member States on the efficient application of the hazard list in the implementation and monitoring of and reporting on the Sendai Framework and disaster risk-related SDGs, mainstreaming disaster risk reduction and resilience building with and across all sectors as agreed in Sendai Framework Global Target E. Relevant activities may include strengthening the science-policy interface for policy development, open-science research investments, setting evidence-based legislation and regulations, undertaking national and local risk and capacity assessments, plan-making, conducting exercise simulations, service delivery, infrastructure development, community mobilisation, education, monitoring and evaluation and other forms of capacity development.

Recommendation 5: Conduct further work to operationalise parameters for exposure, vulnerability and capacity, building on the UNGA definitions

This is a much needed complementary exercise to the hazard definition process, which is the subject of this report. Exposure and vulnerability, and capacity, together with hazard, are the fundamental ingredients of risk, yet there is no agreed set of parameters for vulnerabilities or exposures. Much work has been done in defining and standardising parameters for exposure in the context of natural or geophysical hazards, and in defining indicators of vulnerability for disaster risk reduction, but no consensus exists in the definition or application of exposure or vulnerability for use in risk assessment across the list of hazards within the broad scope of this report. This is an undertaking that could be charged to the recently established Working Group on Vulnerability and Exposure of the Global Risk Assessment Framework (GRAF).

Recommendation 6: Address cascading and complex hazards and risks

There is an urgent need to investigate further the direct and indirect linkages and effects of natural, biological, technological and other human-induced hazards to identify better and understand cascading and complex hazards and risks in a systematic way. The shift towards a broader view and a more context-dependent definition of hazards requires a systematic approach to risk that considers hazard, vulnerability, exposure and capacity together and better understands their complex interactions. The hazard list and associated HIPs may assist the activities of the GRAF, informing efforts to develop an enhanced understanding of the systemic nature of risk, including the management of systemic risks.

Hazard Information Profiles

METEOROLOGICAL AND HYDROLOGICAL

MH0001 / **METEOROLOGICAL AND HYDROLOGICAL / Convective-Related**

Downburst

Definition

A downburst is a violent and damaging downdraught reaching the ground surface, associated with a severe thunderstorm (WMO, 1992).

Reference

WMO, 1992. International Meteorological Vocabulary. WMO-No. 182, 2nd edition. World Meteorological Organization (WMO). https://library.wmo.int/doc_num.php?explnum_id=4712 Accessed 13 October 2020.

Annotations

Synonyms

Microburst, Macroburst, Wind Sear.

Additional scientific description

Downbursts are powerful winds that descend from a thunderstorm and spread out quickly once they hit the ground. These winds can easily cause damage similar to that of an EF0 (65–85 mph winds) or even EF1 (86–110 mph winds) tornado, and are sometimes misinterpreted as tornadoes. However, downbursts are a completely separate phenomenon (NOAA, 2019). The key differences between a downburst and a tornado are expressed by two words – IN and OUT (NOAA, 2019):

- *IN* - all wind flows INTO a tornado. Debris is often lying at angles due to the curving of the inflow winds.
- *OUT* - all wind flows OUT from a downburst. Debris is often lying in straight lines (hence the term ‘straight line winds’) parallel to the outward wind flow.

Downbursts are also far more frequent than tornadoes – in fact, for every one tornado there are approximately ten downburst damage reports. Tornadoes average about 800 per year in the United States, in contrast to an average of 100,000 thunder-storms (NOAA, 2019).

Metrics and numeric limits

Comparison of a microburst and the larger macroburst (NOAA, 2019):

Microburst	Macroburst
Damaging winds extending up to 2.5 miles (4 km)	Damaging winds extending more than 2.5 miles (4 km)
Lasts 5 to 15 minutes	Lasts 5 to 30 minutes
Can cause damaging winds up to 168 mph (270 kph)	Damaging winds, causing widespread, tornado-like damage, up to 134 mph (216 kph)

Key relevant UN convention / multilateral treaty

Not applicable.

Examples of drivers, outcomes and risk management

Downbursts are a particular hazard to aircraft at low level, especially on take-off or landing. An aircraft approaching a downburst will first encounter a strong headwind, which will lead to an increase in indicated airspeed. When trying to fly a set airspeed on approach, a pilot might therefore be tempted to reduce power. This would be very dangerous because, as the aircraft passes thorough the downburst, the wind becomes a tailwind and the indicated airspeed and lift drop. The significant downward force of air in the downburst may be enough to force the aircraft into the ground or at least cause it to lose a significant amount of height. The subsequent loss of performance, as the aircraft encounters tailwinds, may cause further loss of height and be enough to cause the aircraft to stall (SKYbrary, no date).

Many lives have been saved because of the reduction, if not elimination, of potential airline crashes caused by dangerous wind shear conditions on take-off and landing. These saved lives are the result of training pilots on the dangers of microbursts and the installation of Doppler radars at major airports across the United States to warn pilots when microbursts are present (Wilson and Wakimoto, 2001).

References

NOAA, 2019. How do downbursts form? National Oceanic and Atmospheric Administration (NOAA) National Weather Service. www.weather.gov/lmk/downburst Accessed 19 November 2019.

SKYbrary, no date. Microburst. www.skybrary.aero/index.php/Microburst Accessed 19 November 2019.

Wilson J.W. and R.M. Wakimoto, 2001. The discovery of the downburst: T. T. Fujita's contribution. Bulletin of the American Meteorological Society, 82:49-62. https://journals.ametsoc.org/doi/pdf/10.1175/1520-0477%282001%29082%3C0049%3ATDOTDT%3E2.3.CO%3B2.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0002 / **METEOROLOGICAL AND HYDROLOGICAL / Convective-Related**

Lightning (Electrical Storm)

Definition

Lightning is the luminous manifestation accompanying a sudden electrical discharge which takes place from or inside a cloud or, less often, from high structures on the ground or from mountains (WMO, 2017).

Reference

WMO, 2017. International Cloud Atlas: Lightening. World Meteorological Organization (WMO). https://cloudatlas.wmo.int/lightning.html Accessed 26 November 2019.

Annotations

Synonyms

Bolt, Thunderbolt, Bolt-from-the-blue, Firebolt, Thunderstroke, Thunderball.

Additional scientific description

Lightning is a transient, high-current electric discharge with pathlengths measured in kilometres. The most common source of lightning is the electric charge separated in ordinary thunderstorm clouds. Well over half of all lightning discharges occur within the thunderstorm cloud and are called intracloud discharges (AMS, 2012).

Lightning is a large electrical discharge caused by a thundercloud. It can occur within a cloud as intracloud lightning, between clouds as intercloud lightning, or between the cloud and the earth as cloud-to-ground lightning. A lightning discharge consists of pulses of electric current carried by electrons. The current is driven by a high voltage between the cloud's charge centres or between them and the earth. During the development of a thundercloud, negative charge is accumulated in the hail-forming region at the central part of the cloud, and positive charge in the top region which consists of ice crystals (Finnish Meteorological Institute, 2019).

Lightning strikes are classified into different types according to their own characteristics. The two most common types are cloud-to-ground lightning and cloud-to-cloud lightning (WMO, 2017).

- *Cloud-to-ground lightning* is lightning discharge between a cumulonimbus cloud and the ground. Of all types of lightning, cloud-to-ground lightning poses the greatest threat to people and facilities on the ground (WMO, 2017). The usual cloud-to-ground lightning has been studied more extensively than other lightning forms because of its practical interest (i.e., as a cause of injury and death, disturbances in power and communication systems, and ignition of forest fires) and because lightning channels below cloud level are more easily photographed and studied with optical instruments (AMS, 2012). Cloud-to-ground lightning can occur as either positively or negatively charged bolts. Positively charged bolts are considerably more rare, more powerful (e.g., by an order of magnitude or more) and often can strike miles beyond the parent anvil of the thunderstorm (e.g., these positive strikes are referred to as a 'bolt out of the blue') (NOAA, 2019).
- *Cloud-to-cloud lightning* and cloud-to-air discharges are less common than intracloud or cloud-to-ground lightning. All discharges other than cloud-to-ground are often lumped together and called cloud discharges (AMS, 2012; WMO, 2017). Cloud-to-cloud lightning is the discharge between areas of cloud without the discharge channel reaching the ground. For most of the time, it occurs between oppositely charged portions of the same cloud but sometimes it takes place between two separate clouds. Since the discharge channel of cloud-to-cloud lightning may be obscured by the cloud, it may or may not be visible to an observer on the ground. It may therefore be surprising to learn that cloud-to-cloud lightning is, in fact, the most frequently occurring type of lightning. It occurs around ten times more often than cloud-to-ground lightning. Cloud-to-cloud lightning does not pose a threat to life and property on the ground. However, this type of lightning takes place in the sky and sometimes passes through the clear air between clouds, it is therefore of great practical interest to those concerned with the safety of aircraft (WMO, 2017).

Ball lightening includes a fireball which sometimes appears after a lightning flash. Its diameter is usually between 10 and 20 cm and rarely attains 1 m. The fireball moves slowly through the air or along the ground, it may be distorted in passing through narrow places and usually vanishes suddenly with a violent explosion (WMO, 1992).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Not available.

Examples of drivers, outcomes and risk management

Lightning strikes the earth more than 8 million times per day. The risk of being struck is low but the consequences of lightning strike injuries are serious. During 2003–2012, lightning caused an average of 35 deaths per year in the United States (CDC, no date). The Centres for Disease Control and Prevention also provides helpful fact sheets on lightning safety tips, first aid recommendations, lightning strike victim data, information for workers, information for outdoor recreation, information for organised sporting events, information for water activities, and information for pet owners (CDC, 2020).

As an example of a National Alerting Parameters, the China Meteorological Administration (2012) has three alerting thresholds and related preventative measures, Including:

- Yellow: "In 6 hours, there will be thunder & lightning and likely to cause disasters."
- Orange: "In 2 hours, the thunder & lightning is either occurring or will occur with a high likelihood, and it's quite possible to cause disasters or accidents."
- Red: "In 2 hours, the thunder & lightning is either occurring or will occur with a highest likelihood; it's extreme possible to cause disasters or accidents."

References

AMS, 2012. Lightning. American Meteorological Society (AMS), Glossary of Meteorology. http://glossary.ametsoc.org/wiki/Lightning Accessed 25 November 2019.

CDC, no date. Lightning. Centres for Disease Control and Prevention (CDC). www.cdc.gov/disasters/lightning/index.html Accessed 8 October 2020.

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WMO, 2017. Lightening: Cloud Discharge. World Meteorological Organization (WMO). https://cloudatlas.wmo.int/en/lightning-cloud-discharges.html Accessed 23 March 2021.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0003 / **METEOROLOGICAL AND HYDROLOGICAL / Convective-Related**

Thunderstorm

Definition

A thunderstorm is defined as one or more sudden electrical discharges, manifested by a flash of light (lightning) and a sharp or rumbling sound (thunder) (WMO, no date).

Reference

WMO, no date. International Cloud Atlas. World Meteorological Organization (WMO). cloudatlas.wmo.int/thunderstorm.html Accessed 5 December 2019.

Annotations

Synonyms

None identified.

Additional scientific description

Thunderstorms are associated with cumulonimbus clouds (WMO, 2017) and are most often accompanied by precipitation that, when it reaches the ground, is in the form of a shower of rain, snow, snow pellets, small hail or hail. Thunderstorms can cause tornadoes, strong winds, and flash flooding (Habitat for Humanity, 2021).

Metrics and numeric limits

Example types of thunderstorms (NOAA, no date a,b; Australian Government, no date):

Single-cell	Single-cell thunderstorms are small, brief, weak storms that grow and die within an hour or so. They are typically driven by heating on a summer afternoon. Single-cell storms may produce brief heavy rain and lightning.
Multi-cell	A multi-cell storm is a thunderstorm in which new updrafts form along the leading edge of rain-cooled air (the gust front). Individual cells usually last 30 to 60 minutes, while the system as a whole may last for many hours. Multicell storms may produce hail, strong winds, brief tornadoes, and/or flooding.
Squall line	A squall line is a group of storms arranged in a line, often accompanied by 'squalls' of high wind and heavy rain. Squall lines tend to pass quickly and are less prone to produce tornadoes than are supercells. They can be hundreds of miles long but are typically only 10 or 20 miles wide.
Supercell	A supercell is a long-lived (greater than 1 hour) and highly organised storm feeding off an updraft (a rising current of air) that is tilted and rotating. This rotating updraft – as large as 16 kilometres (10 miles) in diameter and up to ~15,000 meters (50,000 feet) tall – can be present as much as 20 to 60 minutes before a tornado forms. Scientists call this rotation a mesocyclone when it is detected by Doppler radar. The tornado is a very small extension of this larger rotation. Most large and violent tornadoes come from supercells.
Mesoscale convective system	A mesoscale convective system (MCS) is a collection of thunderstorms that act as a system. An MCS can spread across large areas and last more than 12 hours. On radar one of these might appear as a solid line, a broken line, or a cluster of cells.
Mesoscale convective complex	A mesoscale convective complex (MCC) – a particular type of MCS – is a large, circular, long-lived cluster of showers and thunderstorms identified by satellite. It often emerges out of other storm types during the late-night and early-morning hours.

Mesoscale convective vortex	A mesoscale convective vortex (MCV) is a low-pressure centre within an MCS that pulls winds into a circling pattern, or vortex. With a core only 30 to 60 miles wide and 1 to 3 miles deep, an MCV is often overlooked in standard weather analyses. But an MCV can take on a life of its own, persisting for up to 12 hours after its parent MCS has dissipated. This orphaned MCV will sometimes then become the seed of the next thunderstorm outbreak. An MCV that moves into tropical waters, such as the Gulf of Mexico, can serve as the nucleus for a tropical storm or hurricane.
Derecho	A derecho (pronounced similar to 'deh-REY-cho' in English) is a widespread, long-lived wind storm that is associated with a band of rapidly moving showers or thunderstorms. Although a derecho can produce destruction similar to that of tornadoes, the damage typically is directed in one direction along a relatively straight swath. As a result, the term 'straight-line wind damage' sometimes is used to describe derecho damage. By definition, if the wind damage swath extends more than 400 kilometres (~250 miles) and includes wind gusts of at least 93 km/h (58 mph) or more along most of its length, then the event may be classified as a derecho.
Virga	Thunderstorms can be considered dry if they do not produce any rain at the surface. However, for the fire weather community, a 'dry thunderstorm' may be used to describe a storm producing very little rainfall, such that it is not effective in checking fire spread after lightning ignition. The second scenario is more common, although there are rare instances when thunderstorms produce no sensible rainfall. In the purest sense, 'dry' thunderstorms produce rain just below the cloud base but due to a very dry atmosphere below the cloud base, the rain evaporates at some point between the cloud base and the ground. Meteorologically speaking, this is called a virga.

Key relevant UN convention / multilateral treaty

Not applicable.

Examples of drivers, outcomes and risk management

As an example of National Alerting Parameters, the United States Weather Service defines a thunderstorm as a severe thunderstorm when it produces hail one inch (2.54 cm) or larger in diameter and/or winds equal or exceed 58 mph (93 kmh) (NOAA, no date c).

References

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NOAA, no date a. Severe weather 101: Thunderstorm types. National Oceanic and Atmospheric Administration (NOAA), The National Severe Storms Laboratory. www.nssl.noaa.gov/education/svrwx101/thunderstorms/types Accessed 5 December 2019.

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WMO, 2017. Cumulonimbus (Cb) (Weilbach 1880). World Meteorological Organization (WMO). https://cloudatlas.wmo.int/en/clouds-genera-cumulonimbus.html Accessed 23 March 2021.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0004 / **METEOROLOGICAL AND HYDROLOGICAL / Flood**

Coastal Flood

Definition

Coastal flooding is most frequently the result of storm surges and high winds coinciding with high tides. The surge itself is the result of the raising of sea levels due to low atmospheric pressure. In particular configurations, such as major estuaries or confined sea areas, the piling up of water is amplified by a combination of the shallowing of the seabed and retarding of return flow (WMO, 2011).

Reference

WMO, 2011. Manual on Flood Forecasting and Warning. WMO-No. 1072. World Meteorological Organization (WMO). www.wmo.int/pages/prog/hwrp/publications/flood_forecasting_warning/WMO%201072_en.pdf Accessed 18 November 2019.

Annotations

Synonyms

Storm Surge, Coastal inundation.

Additional scientific description

Major deltas such as the Mississippi and Ganges are prone to coastal flooding when affected by hurricanes (cyclones). Another sensitive area is the southern North Sea in western Europe, as a result of particular tracks of winter depressions. If the surge takes place near the mouth of a river issuing into the sea, the river flow will be obstructed due to the surge, resulting in severe flooding over and near the coastal areas. Tsunamis resulting from sub-seabed earthquakes are a very specific cause of occasionally severe coastal flooding (WMO, 2011).

Coastal flooding is largely a natural event, however human influence on the coastal environment can exacerbate coastal flooding (Dawson et al., 2009). Extraction of water from groundwater reservoirs in the coastal zone can enhance subsidence of the land increasing the risk of flooding (Nicholls, 2002).

Seawater can flood the land via several paths:

- *Direct flooding*: the sea height exceeds the elevation of the land, often where waves have not built up a natural barrier such as a dune system.
- *Overtopping of a barrier*: the barrier may be natural or human engineered and overtopping occurs due to swell conditions during storm or high tides often on open stretches of the coast. The height of the waves exceeds the height of the barrier and water flows over the top of the barrier to flood the land behind it. Overtopping can result in high velocity flows that can erode significant amounts of the land surface which can undermine defence structures (Gallien et al., 2011).
- *Breaching of a barrier*: the barrier may be natural (sand dune) or human engineered (sea wall), and breaching occurs on open coasts exposed to large waves. Breaching is where the barrier is broken down or destroyed by waves allowing the seawater to extend inland and flood the areas.

Metrics and numeric limits

The extent and magnitude of coastal flooding is a function of the elevation inland flood waters penetrate, which is controlled by the topography of the coastal land exposed to flooding; storm surge conditions; and the broader bathymetry of the coastal area (Bell et al., 2017).

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

The governance structure of coastal zones may be strengthened in different ways (WMO, 2013):

- Promoting better co-operation between different levels and sectors of government, taking into account trends of decentralisation and the need for (national) coordination.
- Facilitating cooperation between government and the private sector, taking into account trends of privatisation but also the need to safeguard the public interest.
- Better involvement between stakeholders and citizens in development and management issues, to promote societal acceptance of development projects as well the long-term sustainability of development projects (arrangements and incentives for maintenance).
- Creating arrangements for dealing with uncertainties and sharing of risks (insurance).

Flooding constitutes a particular challenge in low-lying areas as deltas and coastal plains and land subsidence caused by sediment deficits or ground water extraction can further exacerbate the problem.

Coastal flooding can result in considerable economic losses and casualties. Moreover, coastal flooding can result in a wide range of environmental impacts on different spatial and temporal scales. Flooding can destroy coastal habitats such as coastal wetlands and estuaries and can erode dune systems (Hunt and Watkiss, 2011).

There are many ways in which humans are trying to prevent the flooding of coastal environments. Technical measures for flood control include dike or seawall or levee construction (hard engineering structures) (Short and Masselink, 1999), maintenance of natural dune systems, protection of coastal ecosystems (natural defence) (Alongi, 2008) and different flood proofing and accommodation activities. Engineered protection structures along the coast such as sea walls, if not well planned, can alter the natural processes of the beach, often leading to erosion on adjacent stretches of the coast which also increases the risk of flooding (Pope, 1997).

Non-structural mechanisms also exist to mitigate coastal flooding: building regulations; coastal hazard zoning; urban development planning; spreading risk through insurance; and enhancing public awareness (Snoussi et al., 2008; Dawson et al., 2011).

Generally, even moderate flooding hazards should be taken very seriously due to the potentially disastrous consequences, and flood protection is a key aspect in coastal disaster risk reduction.

The effects of flooding on health are extensive and significant, ranging from mortality and injuries resulting from trauma and drowning to infectious diseases and mental health issues (acute and long-term). While some of these outcomes are relatively easy to track, ascertaining the human impact of floods is still weak. For example, it has been reported that two-thirds of deaths associated with flooding are from drowning, with the other third from physical trauma, heart attacks, electrocution, carbon monoxide poisoning and fire. Often, only immediate traumatic deaths from flooding are recorded (WHO, 2013).

Morbidity associated with floods is usually due to injuries, infections, chemical hazards and mental health effects (acute as well as delayed) (WHO, 2013). Hypothermia may also be a problem, particularly in children, if trapped in floodwaters for lengthy periods (WHO, no date). There may also be an increased risk of respiratory tract infections due to exposure (loss of shelter, exposure to flood waters and rain). Power cuts related to floods may disrupt water treatment and supply plants thereby increasing risk of water-borne diseases as well as the proper functioning of health facilities, including cold chain (WHO, no date).

Floods can potentially increase the transmission of the following communicable diseases: water-borne diseases (such as typhoid fever, cholera, leptospirosis and hepatitis A) and vector-borne diseases (such as malaria, dengue and dengue haemorrhagic fever, yellow fever, and West Nile Fever) (WHO, no date).

The longer-term health effects associated with a flood are less easily identified. They include effects due to displacement, destruction of homes, delayed recovery and water shortages (WHO, 2013).

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WHO, 2013. Floods in the WHO European Region: Health effects and their prevention. World Health Organization (WHO), Regional Office for Europe. https://apps.who.int/iris/handle/10665/108625 Accessed 2 October 2020.

WMO, 2011. Manual on flood forecasting and warning, WMO-No. 1072. World Meteorological Organization (WMO). www.wmo.int/pages/prog/hwrp/publications/flood_forecasting_warning/WMO%201072_en.pdf Accessed 18 November 2019.

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Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0005 / **METEOROLOGICAL AND HYDROLOGICAL / Flood**

Estuarine (Coastal) Flood

Definition

Estuarine flooding is flooding over and near coastal areas caused by storm surges and high winds coincident with high tides, thereby obstructing the seaward river flow. Estuarine flooding can be caused by tsunamis in specific cases (WMO, 2011).

Reference

WMO, 2011. Manual on flood forecasting and warning. WMO-No. 1072. World Meteorological Organization (WMO). www.wmo.int/pages/prog/hwrp/publications/flood_forecasting_warning/WMO%201072_en.pdf Accessed 17 April 2020.

Annotations

Synonyms

Flood, Flooding, Coastal flooding.

Additional scientific description

Estuaries are inlet areas of the coastline where the coastal tide meets a concentrated seaward flow of fresh water in a river. The interaction between the seaward flow of river water and landward flow of saline water during high tides may cause a build-up of water or inland-moving tidal bore. Frequently, the funnel shape characteristic of many estuaries causes an increase in high water levels in the upper, narrowing reaches of the associated river. These types of flood are mostly experienced in deltaic areas of rivers along the coasts, for example the mouths of the Ganges. They are more frequent and less severe in terms of inundated depth and area than flooding caused by storm surges (WMO, 2011).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Storm surges and high winds coinciding with high tides are the most frequent cause of estuarine/coastal flooding. The surge itself is the result of the raising of sea levels due to low atmospheric pressure. In particular configurations, such as major estuaries or confined sea areas, the piling up of water is amplified by a combination of the shallowing of the seabed and retarding of return flow. Major deltas such as the Mississippi and Ganges are prone to this type of flooding when affected by hurricanes (cyclones). Another sensitive area is the southern North Sea in western Europe, owing to particular tracks of winter depressions. If the surge takes place near the mouth of a river issuing into the sea, the river flow will be obstructed due to the surge, resulting in severe flooding over and near the coastal areas. Tsunamis resulting from sub-seabed earthquakes are a very specific cause of occasionally severe coastal flooding (WMO, 2011).

Floods are one of the most common hazards. The effects of flooding on health are extensive and significant, ranging from mortality and injuries resulting from trauma and drowning to infectious diseases and mental health issues (acute and long-term). While some of these outcomes are relatively easy to track, ascertaining the human impact of floods is still weak. For example, it has been reported that two-thirds of deaths associated with flooding are from drowning, with the other third from physical trauma, heart attacks, electrocution, carbon monoxide poisoning and fire. Often, only immediate traumatic deaths from flooding are recorded (WHO, 2013).

Morbidity associated with floods is usually due to injuries, infections, chemical hazards and mental health effects (acute as well as delayed) (WHO, 2013). Hypothermia may also be a problem, particularly in children, if trapped in floodwaters for lengthy periods (WHO, no date). There may also be an increased risk of respiratory tract infections due to exposure (loss of shelter, exposure to flood waters and rain). Power cuts related to floods may disrupt water treatment and supply plants thereby increasing the risk of water-borne diseases, as well as the proper functioning of health facilities, including cold chain (WHO, no date). Floods can potentially increase the transmission of the following communicable diseases: water-borne diseases (such as typhoid fever, cholera, leptospirosis and hepatitis A) and vector-borne diseases (such as malaria, dengue and dengue haemorrhagic fever, yellow fever, and West Nile Fever) (WHO, no date).

The longer-term health effects associated with a flood are less easily identified. They include effects due to displacement, destruction of homes, delayed recovery and water shortages (WHO, 2013).

References

WHO, no date. Flooding and communicable diseases fact sheet. World Health Organization (WHO). www.who.int/hac/techguidance/ems/flood_cds/en Accessed 4 October 2020.

WHO, 2013. Floods in the WHO European Region: Health effects and their prevention. World Health Organization (WHO), Regional Office for Europe. https://apps.who.int/iris/handle/10665/108625 Accessed 2 October 2020.

WMO, 2011. Manual on flood forecasting and warning, WMO-No. 1072. World Meteorological Organization (WMO). www.wmo.int/pages/prog/hwrp/publications/flood_forecasting_warning/WMO%201072_en.pdf Accessed 17 April 2020.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0006 / **METEOROLOGICAL AND HYDROLOGICAL / Flood**

Flash Flood

Definition

A flash flood is a flood of short duration with a relatively high peak discharge in which the time interval between the observable causative event and the flood is less than four to six hours (WMO, 2006).

Reference

WMO, 2006. Technical Regulations. Volume III: Hydrology, WMO-No. 49. World Meteorological Organization (WMO). www.wmo.int/pages/prog/hwrp/publications/technical_regulations/49_III_E_supplement1.pdf Accessed 20 November 2019.

Annotations

Synonyms

Storm-driven flood, Freshet, Huayco.

Additional scientific description

A flash flood is generally characterised by raging torrents after heavy rains, a dam or levee failure or a sudden release of water in a previously stopped passage (i.e., by debris or ice) that rips through riverbeds, urban streets, or mountain canyons sweeping away everything in its path. Steep terrain tends to concentrate runoff into streams very quickly and is often a contributory factor. Changes in soil properties (e.g., burn areas from wildfires), hydrophobic or impervious soils, removal of surface vegetation, and excess runoff from warm rainfall on significant snowpack can also be important contributors (NOAA, no date a; AMS, 2017).

Metrics and numeric limits

A flash flood is a flood that begins within 6 hours, and often within 3 hours, of a heavy rainfall (NOAA, no date b).

Flash floods are highly localised in space: they are restricted to basins of a few hundred square kilometres or less. They are also restricted in time: response times not exceeding a few hours or even less. This means very little time for warning (NOAA, no date b).

Flash flood hazard measurement and modelling requires a complex approach as more environmental factors must be considered and regularly monitored: topographic parameters (average slope, slope range and valley density for the catchment), soil and surface parameters (surface runoff, infiltration and interception: soil depth, physical soil type, the ratio of barren/vegetation-covered surfaces), and hydrological parameters (precipitation, consecutive rainy days, etc.) (Liu and Smedt, 2005).

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Drivers of flash flood: The intensity of the rainfall, the location and distribution of the rainfall, the land use and topography, vegetation types and growth/density, soil type, and soil water-content all determine how quickly flash flooding may occur, and influence where it may occur (NOAA, no date b).

Outcomes and impacts of flash flood: Flash floods account for approximately 85% of flooding cases and have the highest mortality rate (defined as the number of deaths per number of people affected) among different classes of flooding (e.g., riverine, coastal). With more than 5000 lives lost to flash flooding each year, flash floods are among the world’s deadliest natural hazards and have significant social, economic and environmental impacts (WMO, 2019).

Control and monitoring measures of flash flood: Flash floods are a major natural hazard throughout the world. Flash floods are the number one killer among all weather-related hazards. A vast majority of deaths from flash floods, as high as 90% in tropical countries, are due to drowning from victims being caught by rapidly rising waters (Smith, 1992).

Predicting flash floods requires accurate detection and estimation of rainfall events, which are typically intense and very localised. Operational prediction methods include flash flood monitoring and prediction algorithms (FFMPA) used in Europe and the United States. FFMPA alerts forecasters when flash flooding is imminent based on radar-estimated rainfall amounts compared to hydrologic model-based rainfall thresholds. Advances in forecasting convective rainstorms help to improve the performance of FFMPA by providing a longer lead time of impending flash floods (Hong et al., 2013).

Reducing societal exposure to flash floods is key to any mitigation measure. The combination of non-structural measures and small-scale structural measures could be more effective in managing flash flood risk. There are many non-structural measures that can reduce the impact of floods such as land-use planning, building construction codes, soil management, acquisition policies, insurance and risk transfer, awareness raising, public information, emergency system, and recovery plans. Structural activities including property protection such as relocation and reinforcement, and structural engineering projects such as levees, diversions, and channel improvements are some of the actions that mitigate the societal impacts of flash floods (Colombo et al., 2002).

Flash floods differ from river floods in various ways. Notably they manifest and dissipate in less time and occur in more condensed spatial areas. These factors make their forecasting a unique challenge compared to traditional flood forecasting approaches. In this regard, the World Meteorological Organization has launched the Flash Flood Guidance System (FFGS) with global coverage. A system such as the FFGS is an important tool for providing operational forecasters and disaster management agencies with real-time informational guidance products pertaining to the threat of small-scale flash flooding. The FFGS provides remotely sensed precipitation estimates (e.g., radar and satellite-based rainfall estimates) and allows product adjustments based on forecaster experience with local conditions, incorporation of other information (e.g., Numerical Weather Prediction output) and any last minute local observations (e.g., non-traditional rain gauge data) (WMO, 2019).

Health impacts from floods including flash floods: The effects of flooding on health are extensive and significant, ranging from mortality and injuries resulting from trauma and drowning to infectious diseases and mental health issues (acute and long-term). While some of these outcomes are relatively easy to track, ascertaining the human impact of floods is still weak. For example, it has been reported that two-thirds of deaths associated with flooding are from drowning, with the other third from physical trauma, heart attacks, electrocution, carbon monoxide poisoning and fire. Often, only immediate traumatic deaths from flooding are recorded (WHO, 2013).

Morbidity associated with floods is usually due to injuries, infections, chemical hazards and mental health effects (acute as well as delayed) (WHO, 2013). Hypothermia may also be a problem, particularly in children, if trapped in floodwaters for lengthy periods (WHO, no date). There may also be an increased risk of respiratory tract infections due to exposure (loss of shelter, exposure to flood waters and rain). Power cuts related to floods may disrupt water treatment and supply plants thereby increasing the risk of water-borne diseases as well as the proper functioning of health facilities, including cold chain (WHO, no date).

Floods can potentially increase the transmission of the following communicable diseases: water-borne diseases (such as typhoid fever, cholera, leptospirosis and hepatitis A) and vector-borne diseases (such as malaria, dengue and dengue haemorrhagic fever, yellow fever, and West Nile Fever) (WHO, no date).

The longer-term health effects associated with a flood are less easily identified. They include effects due to displacement, destruction of homes, delayed recovery and water shortages (WHO, 2013).

References

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WMO, 2019. Flash Flood Guidance System (FFGS). World Meteorological Organization (WMO). www.wmo.int/pages/prog/hwrp/flood/ffgs/index_en.php Accessed 18 November 2020.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0007 / **METEOROLOGICAL AND HYDROLOGICAL / Flood**

Fluvial (Riverine) Flood

Definition

A fluvial flood is a rise, usually brief, in the water level of a stream or water body to a peak from which the water level recedes at a slower rate (WMO, 2012).

Reference

WMO, 2012. Definition number 543. International Glossary of Hydrology. WMO-No. 385. World Meteorological Organization (WMO). www.wmo.int/pages/prog/hwrp/publications/international_glossary/385_IGH_2012.pdf Accessed 16 April 2020.

Annotations

Synonyms

Flood, Flooding.

Additional scientific description

Fluvial flooding occurs over a wide range of river and catchment systems. Floods in river valleys occur mostly on flood plains or wash lands as a result of flow exceeding the capacity of the stream channels and spilling over the natural banks or artificial embankments (Fernandez, 2015).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Drivers of fluvial flood: Fluvial (riverine) flooding primarily results from an extended precipitation event that occurs at, or upstream from, the affected area. It can also occur when traditional flood-control structures, such as levees and dikes, are overtopped (NOAA, no date).

Outcomes and impacts of fluvial flood: Flooding of areas used for socio-economic activities produces a variety of negative impacts. The magnitude of adverse impacts depends on the vulnerability of the activities and population and the frequency, intensity and extent of flooding. Some of these factors include loss of lives and property, loss of livelihoods, decreased purchasing power and production power, mass migration, psychosocial effects, hindering of economic growth and development, and political implications (APFM, no date).

Control and monitoring measures of fluvial flood: Floods are important components of the natural hydrological regime. They are a major source of water; they flush pollutants and sediment from river networks. It is also natural for rivers to overtop their banks with greater or lesser frequency and occupy their flood plains. As a result, floods can cause property damage and bring death and injury to many communities. While there is no evidence as yet that the frequency or magnitude of flooding has increased world-wide, flood-prone areas are becoming increasingly densely populated and thus more vulnerable. Consequently, a series of major flood disasters has occurred in recent years, with death and destruction being caused by such events on every continent (GWP, 2013).

There is a need for an approach to flood management that improves the functioning of the river basin as a whole, recognising that floods have beneficial impacts and can never be fully controlled. Such an approach seeks to maximize the net benefits from the use of floodplains and to minimise loss of life, subordinating flood loss reduction to the overall goal of maximising the efficient use of the floodplain (APFM, 2020).

Integrated Flood Management (IFM) is a process that promotes an integrated, rather than fragmented, approach to flood management. It integrates land and water resources development in a river basin, within the context of Integrated Resources Management, with a view to maximising the efficient use of floodplains and to minimising loss of life and property. IFM, like Integrated Water Resources Management, should encourage the participation of users, planners and policymakers at all levels. The approach should be open, transparent, inclusive and communicative; should require the decentralisation of decision-making; and should include public consultation and the involvement of stakeholders in planning and implementation. IFM calls for a paradigm shift from the traditional fragmented approach and encourages the efficient use of the resources of the river basin, employing strategies to maintain or augment the productivity of floodplains, while at the same time providing protective measures against losses due to flooding (APFM, no date).

Health impacts of floods including fluvial (riverine) floods: Floods are one of the most common hazards. The effects of flooding on health are extensive and significant, ranging from mortality and injuries resulting from trauma and drowning, to infectious diseases and mental health problems (acute and long-term). While some of these outcomes are relatively easy to track, ascertaining the human impact of floods is still weak. For example, it has been reported that two-thirds of deaths associated with flooding are from drowning, with the other third from physical trauma, heart attacks, electrocution, carbon monoxide poisoning and fire. Often, only immediate traumatic deaths from flooding are recorded (WHO, 2013).

Morbidity associated with floods is usually due to injuries, infections, chemical hazards and mental health effects (acute as well as delayed) (WHO, 2013). Hypothermia may also be a problem, particularly in children, if trapped in floodwaters for lengthy periods (WHO, no date). There may also be an increased risk of respiratory tract infections due to exposure (loss of shelter, exposure to flood waters and rain). Power cuts related to floods may disrupt water treatment and supply plants thereby increasing the risk of water-borne diseases, as well as affecting proper functioning of health facilities, including cold chain (WHO, no date). Floods can potentially increase the transmission of the following communicable diseases: water-borne diseases (such as typhoid fever, cholera, leptospirosis and hepatitis A) and vector-borne diseases (such as malaria, dengue and dengue haemorrhagic fever, yellow fever, and West Nile Fever) (WHO, no date).

The longer-term health effects associated with a flood are less easily identified. They include effects due to displacement, destruction of homes, delayed recovery and water shortages (WHO, 2013).

References

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WHO, 2013. Floods in the WHO European Region: Health effects and their prevention. World Health Organization (WHO), Regional Office for Europe. https://apps.who.int/iris/handle/10665/108625 Accessed 2 October 2020.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0008 / **METEOROLOGICAL AND HYDROLOGICAL / Flood**

Groundwater Flood

Definition

A groundwater flood is the emergence of groundwater at the ground surface away from perennial river channels or the rising of groundwater into man-made ground, under conditions where the 'normal' ranges of groundwater level and groundwater flow are exceeded (BGS, 2010).

Reference

BGS, 2010. Groundwater flooding research overview. British Geological Survey (BGS). www.bgs.ac.uk/research/groundwater/flooding/groundwater_flooding.html Accessed 18 November 2019.

Annotations

Synonyms

Flood.

Additional scientific description

Groundwater flooding is a different type of hazard than river or surface water flooding in that the onset is not an immediate process where water suddenly encroaches areas not normally inundated. In contrast, the water levels within permeable strata will gradually rise over time giving rise to the formation of springs and ephemeral streams, areas of ponding, surcharging of wells and boreholes, and water ingress in basements, tunnels, or other below ground structures. Water levels can remain high for many weeks or even months, depending on the nature of the underlying strata and meteorological and hydrological conditions (WMO, no date).

Groundwater flooding occurs when the natural underground drainage system cannot drain rainfall away quickly enough, causing the water table to rise above the ground surface. It can pose a significant flood hazard for many rural communities and its increased frequency in recent years highlights the need for further research (Geological Survey Ireland, 2021).

Both perched groundwater and periodic springs can be causes of floods:

- *Perched groundwater*: a groundwater body, generally of moderate dimensions, supported by a relatively impermeable stratum and which is located between a water table and the ground surface (WMO, 2012).
- *Periodic spring*: a spring flowing irregularly in relation to the hydrological regime of groundwater or in connection with karstic conditions is generally known as a periodic or seasonal spring (WMO, 2012).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

European Union Floods Directive (2007/60/EC): The Directive on the assessment and management of flood risks entered into force on 26 November 2007. It requires member states to assess if all water courses and coastlines are at risk from flooding, to map the flood extent and assets and humans at risk in these areas, and to take adequate and coordinated measures to reduce this flood risk. The Directive also reinforces the rights of the public to access this information and to have a say in the planning process (European Commission, 2007).

Examples of drivers, outcomes and risk management

Floods are one of the most common hazards. The effects of flooding on health are extensive and significant, ranging from mortality and injuries resulting from trauma and drowning to infectious diseases and mental health problems (acute and long-term). While some of these outcomes are relatively easy to track, ascertaining the human impact of floods is still weak. For example, it has been reported that two-thirds of deaths associated with flooding are from drowning, with the other third from physical trauma, heart attacks, electrocution, carbon monoxide poisoning and fire. Often, only immediate traumatic deaths from flooding are recorded (WHO, 2013).

Morbidity associated with floods is usually due to injuries, infections, chemical hazards and mental health effects (acute as well as delayed) (WHO, 2013). Hypothermia may also be a problem, particularly in children, if trapped in floodwaters for lengthy periods (WHO, no date). There may also be an increased risk of respiratory tract infections due to exposure (loss of shelter, exposure to flood waters and rain). Power cuts related to floods may disrupt water treatment and supply plants thereby increasing the risk of water-borne diseases, as well as affecting proper functioning of health facilities, including cold chain (WHO, no date). Floods can potentially increase the transmission of the following communicable diseases: water-borne diseases (such as typhoid fever, cholera, leptospirosis and hepatitis A) and vector-borne diseases (such as malaria, dengue and dengue haemorrhagic fever, yellow fever, and West Nile Fever) (WHO, no date).

The longer-term health effects associated with a flood are less easily identified. They include effects due to displacement, destruction of homes, delayed recovery and water shortages (WHO, 2013).

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Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0009 / **METEOROLOGICAL AND HYDROLOGICAL / Flood**

Ice-Jam Flood Including Debris

Definition

An ice jam flood including debris is defined as an accumulation of shuga including ice cakes, below ice cover. It is broken ice in a river which causes a narrowing of the river channel, a rise in water level and local floods (WMO, 2012).

Shuga is defined as accumulation of spongy white ice lumps, a few centimetres across, formed from grease ice or slush, and sometimes from anchor ice rising to the surface (WMO, 2012).

Reference

WMO, 2012. Definition number 1352. International Glossary of Hydrology. WMO-No. 385. World Meteorological Organization (WMO). www.wmo.int/pages/prog/hwrp/publications/international_glossary/385_IGH_2012.pdf Accessed 17 April 2020.

Annotations

Synonyms

Flood, Flooding.

Additional scientific description

An ice jam flood is caused by an accumulation of ice in a river, stream or other flooding source that reduces the cross-sectional area available to carry the flow and forces an increase in water-surface elevation (WMO, 2012).

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

Not applicable.

Examples of drivers, outcomes and risk management

In rivers/streams that experience seasonal ice formation and melt, if the melting is more rapid upstream than downstream, ice floes can accumulate in rivers, forming constrictions and damming flows, causing river levels to rise upstream of the ice jam. A sudden release of the 'ice jam' can cause a flood wave similar to that caused by a dam break, to move downstream. Both meltwater and heavy rainfall in steep areas can cause landslips and debris flows. As the debris picked up by rivers moves downstream, major constrictions can build up. When these build-ups collapse or are breached, severe flooding can result. These phenomena are difficult to predict (WMO, 2011; FEMA, 2018).

Floods are one of the most common hazards. The effects of flooding on health are extensive and significant, ranging from mortality and injuries resulting from trauma and drowning, to infectious diseases and mental health problems (acute and long-term). While some of these outcomes are relatively easy to track, ascertaining the human impact of floods is still weak. For example, it has been reported that two-thirds of deaths associated with flooding are from drowning, with the other third from physical trauma, heart attacks, electrocution, carbon monoxide poisoning and fire. Often, only immediate traumatic deaths from flooding are recorded (WHO, 2013).

Morbidity associated with floods is usually due to injuries, infections, chemical hazards and mental health effects (acute as well as delayed) (WHO, 2013). Hypothermia may also be a problem, particularly in children, if trapped in floodwaters for lengthy periods (WHO, no date). There may also be an increased risk of respiratory tract infections due to exposure (loss of shelter, exposure to flood waters and rain). Power cuts related to floods may disrupt water treatment and supply plants thereby increasing the risk of water-borne diseases as well as affecting proper functioning of health facilities, including cold chain (WHO, no date). Floods can potentially increase the transmission of the following communicable diseases: water-borne diseases (such as typhoid fever, cholera, leptospirosis and hepatitis A) and vector-borne diseases (such as malaria, dengue and dengue haemorrhagic fever, yellow fever, and West Nile Fever) (WHO, no date).

The longer-term health effects associated with a flood are less easily identified. They include effects due to displacement, destruction of homes, delayed recovery and water shortages (WHO, 2013).

References

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WHO, no date. Flooding and communicable diseases fact sheet. World Health Organization (WHO). www.who.int/hac/techguidance/ems/flood_cds/en Accessed 4 October 2020.

WHO, 2013. Floods in the WHO European Region: Health effects and their prevention. World Health Organization (WHO), Regional Office for Europe. https://apps.who.int/iris/handle/10665/108625 Accessed 2 October 2020.

WMO, 2011. Manual on flood forecasting and warning, WMO No. 1072. World Meteorological Organization (WMO). www.wmo.int/pages/prog/hwrp/publications/flood_forecasting_warning/WMO%201072_en.pdf Accessed 25 November 2019.

WMO, 2012. Definition number 1352. International Glossary of Hydrology. WMO-No. 385. World Meteorological Organization (WMO). www.wmo.int/pages/prog/hwrp/publications/international_glossary/385_IGH_2012.pdf Accessed 17 April 2020.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0010 / **METEOROLOGICAL AND HYDROLOGICAL / Flood**

Ponding (Drainage) Flood

Definition

A ponding flood is a flood which results from rainwater ponding at or near the point where it falls because it is falling faster than the drainage system (natural or man-made) can carry it away (WMO, 2006).

Reference

WMO, 2006. Technical Regulations Volume III: Hydrology. WMO-No. 49. Page IX. World Meteorological Organization (WMO). https://library.wmo.int/doc_num.php?explnum_id=4564

Annotations

Synonyms

Drainage flood, Surface retention.

Additional scientific description

A ponding flood is that part of the precipitation which remains on the ground surface, without running off or infiltrating, until it evaporates or transpires (Flood Site, 2008).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Floods are one of the most common hazards. The effects of flooding on health are extensive and significant, ranging from mortality and injuries resulting from trauma and drowning to infectious diseases and mental health problems (acute and long-term). While some of these outcomes are relatively easy to track, ascertaining the human impact of floods is still weak. For example, it has been reported that two-thirds of deaths associated with flooding are from drowning, with the other third from physical trauma, heart attacks, electrocution, carbon monoxide poisoning and fire. Often, only immediate traumatic deaths from flooding are recorded (WHO, 2013).

Morbidity associated with floods is usually due to injuries, infections, chemical hazards and mental health effects (acute as well as delayed) (WHO, 2013). Hypothermia may also be a problem, particularly in children, if trapped in floodwaters for lengthy periods (WHO, no date). There may also be an increased risk of respiratory tract infections due to exposure (loss of shelter, exposure to flood waters and rain). Power cuts related to floods may disrupt water treatment and supply plants thereby increasing the risk of water-borne diseases as well as affecting proper functioning of health facilities, including cold chain (WHO, no date). Floods can potentially increase the transmission of the following communicable diseases: water-borne diseases (such as typhoid fever, cholera, leptospirosis and hepatitis A) and vector-borne diseases (such as malaria, dengue and dengue haemorrhagic fever, yellow fever, and West Nile Fever) (WHO, no date).

The longer-term health effects associated with a flood are less easily identified. They include effects due to displacement, destruction of homes, delayed recovery and water shortages (WHO, 2013).

References

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Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0011 / **METEOROLOGICAL AND HYDROLOGICAL / Flood**

Snowmelt Flood

Definition

A snowmelt flood is a significant flood rise in a river caused by the melting of snowpack accumulated during the winter (WMO, 2012).

Reference

WMO, 2012. Definition number 1352. International Glossary of Hydrology. WMO-No. 385. World Meteorological Organization (WMO). www.wmo.int/pages/prog/hwrp/publications/international_glossary/385_IGH_2012.pdf Accessed 26 November 2019.

Annotations

Synonyms

Flood, Flooding, Melt-induced flooding, Snowmelt-runoff floods.

Additional scientific description

In upland and high-latitude areas where extensive snow accumulates over winter, the spring thaw produces meltwater runoff. If temperature rises are rapid, the rate of melting may produce floods, which can extend to lower parts of the river systems. The severity of meltwater floods will increase if the thaw is accompanied by heavy rainfall and can be further exacerbated if the subsoil remains frozen. Although a seasonal occurrence where major snowfields exist in headwaters, which may produce beneficial flooding in downstream areas, severe effects can occur on smaller scales, especially in areas subject to changes between cold and warmer rainy winter weather (USGS, no date; WMO, no date).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Drivers: High soil moisture conditions prior to snowmelt, frozen ground, heavy snow cover, widespread heavy rain during the melt period, and rapid snowmelt (unseasonably warm temperatures, high humidity, rainfall, etc.) (NOAA, no date).

Outcomes and impacts: The effect of snowmelt on potential flooding, mainly during the spring, causes concern for many people around the world. Besides flooding, rapid snowmelt can trigger landslides and debris flows. In combination with specific weather conditions, such as excessive rainfall on melting snow for example, it may even be a major cause of floods (USGS, no date).

Control and monitoring measures: The Flash Flood Guidance System (FFGS) of the World Meteorological Organization takes into account estimated precipitation from several sources, such as satellites, radar as available, and gauges as available to be input into a snow model (SNOW -17) which estimates snow water equivalent (SWE) and melt that are input into the Sacramento-soil moisture accounting model (SAC-SMA) to estimate upper soil moisture (soil water deficit). SNOW-17 uses air temperature as an index to determine energy exchange across the snow-air interface. In addition to temperature, the only other input variable needed to run the model is precipitation. Air temperature is also used to estimate snowmelt. SWE is referred to as the depth of water produced if a snow cover is completely melted on a horizontal surface. The SWE product generated by FFGS is a direct output of the SNOW-17 accumulation and ablation model. Melt is the estimate of ablation due to melt processes and is the direct output of the SNOW-17 model (WMO, 1999).

Health impacts from floods: Floods are one of the most common hazards. The effects of flooding on health are extensive and significant, ranging from mortality and injuries resulting from trauma and drowning, to infectious diseases and mental health problems (acute and long-term). While some of these outcomes are relatively easy to track, ascertaining the human impact of floods is still weak. For example, it has been reported that two-thirds of deaths associated with flooding are from drowning, with the other third from physical trauma, heart attacks, electrocution, carbon monoxide poisoning and fire. Often, only immediate traumatic deaths from flooding are recorded (WHO, 2013).

Morbidity associated with floods is usually due to injuries, infections, chemical hazards and mental health effects (acute as well as delayed) (WHO, 2013). Hypothermia may also be a problem, particularly in children, if trapped in floodwaters for lengthy periods (WHO, no date). There may also be an increased risk of respiratory tract infections due to exposure (loss of shelter, exposure to flood waters and rain). Power cuts related to floods may disrupt water treatment and supply plants thereby increasing the risk of water-borne diseases as well as affecting proper functioning of health facilities, including cold chain (WHO, no date). Floods can potentially increase the transmission of communicable diseases (WHO, no date).

The longer-term health effects associated with a flood are less easily identified. They include effects due to displacement, destruction of homes, delayed recovery and water shortages (WHO, 2013).

References

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Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0012 / **METEOROLOGICAL AND HYDROLOGICAL / Flood**

Surface Water Flooding

Definition

Surface water flooding is that part of the rain which remains on the ground surface during rain and either runs off or infiltrates after the rain ends, not including depression storage (WMO, 2012).

Reference

WMO, 2012. Definition number 1465. International Glossary of Hydrology. WMO-No. 385. World Meteorological Organization (WMO). www.wmo.int/pages/prog/hwrp/publications/international_glossary/385_IGH_2012.pdf Accessed 17 April 2020.

Annotations

Synonyms

Surface detention, Depression storage, Surface retention.

Additional scientific description

Surface water flooding is caused when the volume of rainwater falling does not drain away through the existing drainage systems or soak into the ground but lies on or flows over the ground instead. This type of flooding is usually short-lived and associated with heavy downpours of rain, thunderstorms etc. (NFU, 2019). The UK Government provides a real time flood information service which is easily accessible (UK Government, no date).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Floods tend to be caused by a number of natural events such as rain from slow moving or stationary low-pressure areas, thunderstorms, and tropical cyclones. The amount and duration of the rainfall, soil type and saturation, geography and whether it is an urban area can affect the magnitude and impacts of the flooding. Flooding can occur at the place of a heavy rain event or far downstream away from the causal rain event. Flooding can also be caused by other factors such as storm surge, tsunamis, ice jam, glacial lake outburst, as well as being human influenced such as dam burst, improper land use planning, etc. (Geoscience Australia, no date).

Floods are one of the most common hazards. The effects of flooding on health are extensive and significant, ranging from mortality and injuries resulting from trauma and drowning to infectious diseases and mental health problems (acute and long-term). While some of these outcomes are relatively easy to track, ascertaining the human impact of floods is still weak. For example, it has been reported that two-thirds of deaths associated with flooding are from drowning, with the other third from physical trauma, heart attacks, electrocution, carbon monoxide poisoning and fire. Often, only immediate traumatic deaths from flooding are recorded (WHO, 2013).

Morbidity associated with floods is usually due to injuries, infections, chemical hazards and mental health effects (acute as well as delayed) (WHO, 2013). Hypothermia may also be a problem, particularly in children, if trapped in floodwaters for lengthy periods (WHO, no date). There may also be an increased risk of respiratory tract infections due to exposure (loss of shelter, exposure to flood waters and rain). Power cuts related to floods may disrupt water treatment and supply plants thereby increasing the risk of water-borne diseases as well as affecting proper functioning of health facilities, including cold chain (WHO, no date). Floods can potentially increase the transmission of the following communicable diseases: water-borne diseases (such as typhoid fever, cholera, leptospirosis and hepatitis A) and vector-borne diseases (such as malaria, dengue and dengue haemorrhagic fever, yellow fever, and West Nile Fever) (WHO, no date).

The longer-term health effects associated with a flood are less easily identified. They include effects due to displacement, destruction of homes, delayed recovery and water shortages (WHO, 2013).

References

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UK Government, no date. Flood information service. https://flood-warning-information.service.gov.uk/warnings Accessed 2 October 2020.

WHO, no date. Flooding and communicable diseases fact sheet. World Health Organization (WHO). www.who.int/hac/techguidance/ems/flood_cds/en Accessed 4 October 2020.

WHO, 2013. Floods in the WHO European Region: Health effects and their prevention. World Health Organization (WHO), Regional Office for Europe. https://apps.who.int/iris/handle/10665/108625 Accessed 2 October 2020.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0013 / **METEOROLOGICAL AND HYDROLOGICAL / Flood**

Glacial Lake Outburst Flood

Definition

A 'glacial lake outburst flood' is a phrase used to describe a sudden release of a significant amount of water retained in a glacial lake, irrespective of the cause (Emmer, 2017).

References

Emmer, A., 2017. Glacier Retreat and Glacial Lake Outburst Floods (GLOFs). https://oxfordre.com/naturalhazardscience/view/10.1093/acrefore/9780199389407.001.0001/acrefore-9780199389407-e-275?print=pdf#page=1 Accessed 7 October 2020.

Annotations

Synonyms

GLOF.

Additional scientific description

The term glacial lake outburst flood (GLOF) is used here to refer to the catastrophic release of a water reservoir that has formed either at the side, in front, within, beneath or on the surface of a glacier. Dam structures that impound the water reservoir may be composed primarily of glacial ice, morainic debris, or bedrock (GAPHAZ, 2017).

GLOFs are characterised by extreme peak discharges, often several times in excess of the maximum discharges of hydrometeorological induced floods, with an exceptional erosion/transport potential. They can therefore turn into flow-type movements, such as GLOF-induced debris flow (Emmer, 2017; UN-SPIDER, no date).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Drivers: Key overarching determinants of GLOF susceptibility and the resulting event magnitude are the size of the glacier lake, the outburst mechanism (and related hydrograph), and the characteristics of the downstream torrent (determined by channel inclination and debris availability). Ice-dammed lakes can develop at the margin of an advancing (or surging) glacier, when side-valleys or depressions at the side of the glacier become truncated and blocked. Many such lakes formed in high mountain regions during the Last Glacial Maximum and more recently during and following the Little Ice Age. Over time, as the glaciers retreat, the support of the ice dam is removed and the lake may drain catastrophically or remain trapped behind lateral moraines of the former glacier (GAPHAZ, 2017; UN-SPIDER, no date).

Susceptibility and control measures: Various schemes have been proposed for assessing the susceptibility of glacial lakes to an outburst flood, mostly drawing on remotely sensed information to characterise semi-quantitatively the cryospheric environment, lake and dam area, and other geotechnical and geomorphic characteristics of the upstream catchment area of the lake. The potential for unstable rock and/or ice to impact into a lake can be determined using worst-case runout distances. Assessment approaches have mostly been developed and tailored towards regional implementation, especially for moraine dammed lakes, for which McKillop and Clague (2007) gave a comprehensive overview of many of the relevant susceptibility factors that may condition or trigger an outburst event (GAPHAZ, 2017).

Health impacts: The effects of flooding on health are extensive and significant, ranging from mortality and injuries resulting from trauma and drowning, to infectious diseases and mental health problems (acute and long-term). While some of these outcomes are relatively easy to track, ascertaining the human impact of floods is still weak. For example, it has been reported that two-thirds of deaths associated with flooding are from drowning, with the other third from physical trauma, heart attacks, electrocution, carbon monoxide poisoning and fire. Often, only immediate traumatic deaths from flooding are recorded (WHO, 2013).

Morbidity associated with floods is usually due to injuries, infections, chemical hazards and mental health effects (acute as well as delayed) (WHO, 2013). Hypothermia may also be a problem, particularly in children, if trapped in floodwaters for lengthy periods (WHO, no date). There may also be an increased risk of respiratory tract infections due to exposure (loss of shelter, exposure to flood waters and rain). Power cuts related to floods may disrupt water treatment and supply plants thereby increasing the risk of water-borne diseases as well as affecting proper functioning of health facilities, including cold chain (WHO, no date). Floods can potentially increase the transmission of the following communicable diseases: water-borne diseases (such as typhoid fever, cholera, leptospirosis and hepatitis A) and vector-borne diseases (such as malaria, dengue and dengue haemorrhagic fever, yellow fever, and West Nile Fever) (WHO, no date).

The longer-term health effects associated with a flood are less easily identified. They include effects due to displacement, destruction of homes, delayed recovery and water shortages (WHO, 2013).

References

Emmer, A., 2017. Glacier Retreat and Glacial Lake Outburst Floods (GLOFs). https://oxfordre.com/naturalhazardscience/view/10.1093/acrefore/9780199389407.001.0001/acrefore-9780199389407-e-275?print=pdf#page=1 Accessed 7 October 2020.

GAPHAZ, 2017. Assessment of Glacier and Permafrost Hazards in Mountain Regions: Technical Guidance Document. Standing Group on Glacier and Permafrost Hazards in Mountains (GAPHAZ). www.gaphaz.org/files/Assessment_Glacier_Permafrost_Hazards_Mountain_Regions.pdf Accessed 20 November 2019.

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WHO, 2013. Floods in the WHO European Region: Health effects and their prevention. World Health Organization (WHO), Regional Office for Europe. https://apps.who.int/iris/handle/10665/108625 Accessed 2 October 2020.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0014 / **METEOROLOGICAL AND HYDROLOGICAL / Lithometeors**

Black Carbon (Brown Clouds)

Definition

Black carbon refers to the absorbing components of soot, often defined using elemental carbon and some condensed organics. Black carbon is an important part of the combustion product commonly referred to as soot. Black carbon in indoor environments is largely due to cooking with biofuels such as wood, dung and crop residue. Outdoors, it is due to fossil fuel combustion (diesel and coal), open biomass burning (associated with deforestation and crop residue burning), and cooking with biofuels (Ramanathan and Carmichael, 2008).

Reference

Ramanathan, V. and G. Carmichael, 2008. Global and regional climate changes due to black carbon. Nature Geoscience, 1:221-227.

Annotations

Synonyms

Soot, Brown clouds.

Additional scientific description

Black carbon is the sooty black material emitted from gas and diesel engines, coal-fired power plants, and other sources that burn fossil fuel. It comprises a significant proportion of atmospheric particulate matter or PM, which is an air pollutant (US EPA, 2019).

Elevated black carbon concentrations in areas with high solar radiation are a major contributor to the so-called 'brown clouds' covering large regions, for instance in Asia. Brown clouds have led to dimming of the Earth's surface, warming of the atmosphere and perturbation of the hydrological cycle, possibly affecting the monsoon (WMO, 2009).

Black carbon is the product of incomplete combustion of fuels and can be analysed by means of different methodologies. When its light-absorbing properties are measured, soot is referred to as black carbon. When its concentration is measured by thermal-optical techniques, soot is known as elemental carbon (Popovicheva et al., 2010).

Despite intensive efforts in recent decades, no widely accepted standard measurement method exists for determining black carbon or light-absorbing carbon. Real-time black carbon measurements can be performed using optical methods, which measure the absorption of light through a filter collecting airborne particles (Ahmed et al., 2010).

Metrics and numeric limits

Not identified

Key relevant UN convention / multilateral treaty

UNECE Convention on Long-range Transboundary Air Pollution (CLRTAP): Since 1979 the Convention on Long-range Transboundary Air Pollution has addressed some of the major environmental problems of the United Nations Economic Commission for Europe (UNECE) region through scientific collaboration and policy negotiation (UNECE, 1979). The Convention has been extended by eight protocols that identify specific measures to be taken by Parties to cut their emissions of air pollutants. The Convention, which now has 51 Parties identifies the Executive Secretary of UNECE as its secretariat.

Partnership for Clean Indoor Air (PCIA): The Partnership for Clean Indoor Air is bringing together governments, industry and non-governmental organisations to increase the use of affordable, reliable, clean, efficient, and safe home cooking and heating practices (United Nations, no date). More than 147 Partner organisations are contributing resources and expertise to improve health, livelihoods and quality of life by reducing exposure to air pollution, primarily among women and children, from household energy use. The PCIA is focusing on four priority areas: addressing social/cultural barriers to adopting improved technology; supporting the development of local business models and markets for improved cooking and heating techniques; improving the design and performance of improved fuels and technology; and demonstrating reduced exposure to indoor air contaminants.

Global Alliance for Clean Cook stoves (GACC): The Clean Cooking Alliance works with a global network of partners to build an inclusive industry that makes clean cooking accessible to the three billion people who live each day without it (CCA, 2015). Established in 2010, the Alliance is driving consumer demand, mobilising investment to build a pipeline of scalable businesses, and fostering an enabling environment that allows the sector to thrive. Clean cooking transforms lives by improving health, protecting the climate and environment, empowering women, and helping consumers save time and money.

Examples of drivers, outcomes and risk management

Drivers: Black carbon is formed by the incomplete combustion of fossil fuels, biomass and biofuels. Sources include: mobile sources, particularly dieseldriven road vehicles, nonroad mobile machinery and ships; residential heating in combustion facilities, particularly burning of biomass such as fossil fuel coal and wood; and open biomass burning, forest fires and agricultural waste burning (EEA, 2013).

Black carbon is a major contributor to the fine particulate (PM2.5) burden in the air. It is small enough to be easily inhaled into the lungs and has been associated with adverse health effects. The Near-Road Exposures to Urban Air Pollutants Study (NEXUS), evaluated that peat-burning wildfires release enormous amounts of particulate matter, including black carbon, which has been linked to increased risk of heart failure and respiratory hospital visits (US EPA, 2019).

Air quality monitoring networks: the status of black carbon monitoring in Europe has been reported by the European Environment Agency (EEA, 2013).

Control measures: recommended measures include requiring regular vehicle emissions tests, retirement, or retrofitting; banning or regulating slash-andburn clearing of forests and burning of agricultural waste; requiring shore-basedelectrification/power of ships, regulating idling at terminals, and mandating fuel standards for ships seeking to dock; banning or regulating the sale of certain fuels and/or requiring the use of cleaner fuels; requiring permits to operate industrial, power generating, and oil refining facilities, and periodic permit renewal and/or modification of equipment; and requiring filtering technology and high temperaturecombustion for existing power generation plants (EEA, 2013).

References

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Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0015 / **METEOROLOGICAL AND HYDROLOGICAL / Lithometeors**

Dust storm or Sandstorm

Definition

A dust storm is an ensemble of particles of dust or sand energetically lifted to great heights by a strong and turbulent wind (WMO, 2017).

Reference

WMO, 2017. Dust Storm or Sandstorm. International Cloud Atlas, World Meteorological Organization (WMO). https://cloudatlas.wmo.int/dust-storm-or-sandstorm.html Accessed 19 November 2019.

Annotations

Synonyms

Not available.

Additional scientific description

Dust storms or sandstorms generally occur in areas where the ground is covered with loose dust or sand. Sometimes, after having travelled great distances, they may be observed over areas where no dust or sand covers the ground. The forward portion of a dust storm or sandstorm may have the appearance of a wide and high wall that advances fairly rapidly. Walls of dust or sand often accompany a cumulonimbus that may be hidden by the dust or sand particles. They may also occur without any clouds along the forward edge of an advancing cold air mass (WMO, 2017).

Metrics and numeric limits

Emissions of sand and dust particles in the air typically have a wind threshold value ranging from about 4 m/s in desert areas to close to 10 m/s in semi-arid regions. As a first approximation, and being fully aware that visibility in sandstorms and dust storms may be influenced by the optical characteristics of the aerosols (chemical composition, particle size spectra) and lighting conditions (solar azimuth, background luminance, presence of medium or high cloud), the following thresholds, which are familiar to human observers and automated systems alike, are recommended (ICAO, 2009):

VIS <3000 m visibility and gusts of >=20 kt	'light' sandstorm or dust storm
VIS <1500 m visibility and gusts of >=30 kt	'moderate' sandstorm or dust storm
VIS <500 m and gusts of >= 40 kt	'heavy' sandstorm or dust storm

Key relevant UN convention/multilateral treaty

The UN Sand and Dust Storm (SDS) Coalition includes the World Meteorological Organization, United Nations Convention to Combat Desertification, United Nations Development Programme, United Nations Environment Programme, Food and Agriculture Organization, World Health Organization, World Bank, etc. and was launched at the United Nations Convention to Combat Desertification (UNCCD) Conference of the Parties on 6 September 2019 (United Nations, 2019).

Examples of drivers, outcomes and risk management

Sand and dust storms are a meteorological hazard, which is related to the process of wind erosion of surface soil and the mineral dust aerosol emission to the atmosphere. They are frequent in northern Africa, the Middle East and Europe, the Arabian Peninsula, Central Asia, northern India, north-western China, southern Mongolia and adjacent Asian countries. In desert regions of Australia and the USA they can seriously threaten human health, agriculture, aviation, ground transportation, the solar energy industry, air quality, infrastructure and industry, as well as aquatic and terrestrial ecological systems. Dust aerosol can carry irritating spores, bacteria, viruses and persistent organic pollutants. Sand and dust storms also transport nutrients to the oceans and affect marine biomass production, which in turn influences greenhouse gas emissions in the marine environment (WMO, 2019).

The World Meteorological Organization Sand and Dust Storm Warning Advisory and Assessment System (SDS-WAS) enhances the ability of countries to deliver timely, quality sand and dust storm forecasts, observations, information and knowledge to users through an international partnership of research and operational communities. It operates through the Global SDS-WAS Steering Committee and three regional nodes: for (i) Northern Africa, Middle East and Europe, (ii) Asia, and (iii) the Americas (Baklanov, 2018).

In terms of health impacts from dust storms and sandstorms, the UNCCD recognizes that sand and dust storms cause numerous human health problems in different regions around the world, especially in arid and semi-arid regions, and that there is a need to reinforce protective strategies to reduce the negative impacts of sand and dust storms on human health (United Nations, 2019).

Examples of national guidance on the health impacts from dust storms and sandstorms include (i) a fact sheet provided by the Australian Government on the health impacts of dust storms where exposure can produce common symptoms that include Itchy or burning eyes; throat irritation; skin irritation; coughing or sneezing; and/or respiratory or breathing difficulties, including asthma attacks (Australian Capital Territory, 2018) and (ii) a guidance sheet on acute exposure and threats to respiratory health prepared by the American Thoracic Society (2018).

References

American Thoracic Society, 2018. Sand and Dust Storms: Acute Exposure and Threats to Respiratory Health. Patient Education: Rapid Response Series www.thoracic.org/patients/patient-resources/resources/sand-and-dust-storms.pdf Accessed 12 October 2020.

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United Nations, 2019. Combating sand and dust storms, 2019. Resolution adopted by the General Assembly on 19 December 2019. A/RES/74/226. https://undocs.org/en/A/RES/74/226 Accessed 12 October 2020.

WMO, 2017. Dust Storm or Sandstorm. International Cloud Atlas, World Meteorological Organization (WMO). https://cloudatlas.wmo.int/dust-storm-or-sandstorm.html Accessed 19 November 2019.

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Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0016 / **METEOROLOGICAL AND HYDROLOGICAL / Lithometeors**

Fog

Definition

Fog is a suspension of very small, usually microscopic water droplets in the air, reducing visibility at the Earth's surface (WMO, 2017).

Reference

WMO, 2017. Fog. International Cloud Atlas: World Meteorological Organization (WMO). https://cloudatlas.wmo.int/fog.html Accessed 20 November 2019.

Annotations

Synonyms

Not identified.

Additional scientific description

Under light wind, stable and humid conditions, if the air near the ground cools sufficiently, water vapour in the air may condense into tiny water droplets. These droplets reduce the visibility near ground level. This phenomenon is called fog (Hong Kong Observatory, 2019).

Fog differs from cloud only in that its base is at the Earth's surface while the cloud base is above the Earth's surface. When composed of ice crystals, it is termed ice fog (WMO, 2017). Visibility reduction in fog depends on the concentration of cloud condensation nuclei and the resulting distribution of droplet sizes. According to American Meteorological Society (AMS) weather observing practice, fog that hides less than 0.6 of the sky is called ground fog. If fog is so shallow that it is not an obstruction to vision at a height of 6 feet above the surface, it is called simply shallow fog (AMS, 2012).

Fog is easily distinguished from haze by its higher relative humidity (near 100%, having physiologically appreciable dampness) and grey colour. Haze does not contain activated droplets larger than the critical size according to Köhler theory (AMS, 2012).

Mist may be considered an intermediate between fog and haze; its particles are smaller (a few microns maximum), it has lower relative humidity than fog, and does not obstruct visibility to the same extent (AMS, 2012).

There is no distinct line, however, between any of these categories. Near industrial areas, fog is often mixed with smoke, and this combination has been known as smog. However, fog droplets are usually absent in photochemical smog, which only contains inactivated haze droplets (AMS, 2012).

In aviation weather observations fog is encoded F, and ground fog GF (AMS, 2012).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

Not applicable.

Examples of drivers, outcomes and risk management

Fogs of all type originate when the temperature and dew point of the air become identical (or nearly so). This may occur through cooling of the air to a little beyond its dew point (producing advection fog, radiation fog or upslope fog), or by adding moisture and thereby elevating the dew point (producing steam fog or frontal fog). Fog seldom forms when the dew point spread is greater than 4°F (AMS, 2012).

Fog is defined as ‘obscurity in the surface layers of the atmosphere, which is caused by a suspension of water droplets’. By international agreement (particularly for aviation purposes) fog is the name given to resulting visibility of less than 1 km (0.6 mile), however in forecasts for the public this generally refers to visibility of less than 180 m (0.1 mile) (UK Met Office, 2019).

In terms of national alerting parameters, examples include alerting parameters for issuing a fog advisory in Canada (Government of Canada, 2019) and alerting parameters for a heavy fog warning in China (China Meteorological Administration, 2012).

References

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UK Met Office, 2019. What is the difference between mist, fog and haze? www.metoffice.gov.uk/weather/learn-about/weather/types-of-weather/fog/difference-mist-and-fog Accessed 20 November 2019.

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Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0017 / **METEOROLOGICAL AND HYDROLOGICAL / Lithometeors**

Haze

Definition

Haze is a suspension in the air of extremely small, dry particles invisible to the naked eye and sufficiently numerous to give the air an opalescent appearance (WMO, 2017).

Reference

WMO, 2017. Haze. International Cloud Atlas, World Meteorological Organization (WMO). https://cloudatlas.wmo.int/haze.html Accessed 13 October 2020.

Annotations

Synonyms

Not available.

Additional scientific description

As light is scattered by haze particles, distant bright objects or lights seen through the haze appear yellowish or reddish, while dark objects appear bluish. Haze particles may have a colour of their own that also contributes to this effect (WMO, 2017).
In addition, haze has been described as particles suspended in air, reducing visibility by scattering light; often a mixture of aerosols and photochemical smog (AMS, 2012).
Some specific types of haze include:

- *Dust haze*: A suspension in the air of dust or small sand particles, raised from the ground prior to the time of observation by a dust storm or sandstorm. The dust storm or sandstorm may have occurred either at or near the observation site or far from it (WMO, 2017).
- *Sand haze*: Haze caused by the suspension in the atmosphere of small sand or dust particles, raised from the ground prior to the time of observation by a sandstorm or dust storm (WMO, 1992).

Many aerosols increase in size with increasing relative humidity due to deliquescence, drastically decreasing visibility. On Köhler curve plots of saturation relative humidity versus aerosol particle radius, equilibrium haze particles are to the left of the peak, while growing cloud droplets are to the right (AMS, 2012).

Many haze formations are caused by the presence of an abundance of condensation nuclei which may grow in size, due to a variety of causes, and become mist, fog, or cloud. Distinction is sometimes drawn between dry haze and damp haze, largely on the basis of differences in optical effects produced by the smaller particles (dry haze) and larger particles (damp haze), which develop from slow condensation upon the hygroscopichaze particles (AMS, 2012).

Dry haze particles, with diameters of the order of 0.1 micron, are small enough to scatter shorter wavelengths of light preferentially (although not according to the inverse fourth-power law of Rayleigh scattering). Such haze particles produce a bluish colour when the haze is viewed against a dark background, for dispersion allows only the slightly bluish scattered light to reach the eye. The same type of haze, when viewed against a light background, appears as a yellowish veil, for here the principal effect is the removal of the bluer components from the light originating in the distant light-coloured background (AMS, 2012).

Haze may be distinguished by this same effect from mist, which yields only a grey obscuration, since the particle sizes are too large to yield appreciable differential scattering of various wavelengths (AMS, 2012).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

Not applicable.

Examples of drivers, outcomes and risk management

In meteorology, haze is caused by suspended dry solid particles in the air such as dust or salt. Haze is an atmospheric phenomenon in meteorological observation and the particles of which it is formed are termed lithometeors. It can obscure vision and directly influence horizontal visibility (AMS, 2012).

In terms of national alerting parameters, one example is the alerting parameters for sandstorm warning in China (China Meteorological Administration, 2012).

References

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China Meteorological Administration, 2012. Weather Warnings: Gale. www.cma.gov.cn/en/WeatherWarnings/WarningSignals/201203/t20120320_166873.html Accessed 22 November 2019.

WMO, 1992. International Meteorological Vocabulary. WMO-No. 182. World Meteorological Organization (WMO). https://library.wmo.int/doc_num.php?explnum_id=4712 Accessed 27 November 2019.

WMO, 2017. Haze. International Cloud Atlas, World Meteorological Organization (WMO). https://cloudatlas.wmo.int/haze.html Accessed 13 October 2020.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0018 / **METEOROLOGICAL AND HYDROLOGICAL / Lithometeors**

Polluted Air

Definition

Polluted air is air containing dust, smoke, micro-organisms or gases different from those from which it would normally be composed (WMO, 1992).

Alternative definition: Polluted air is air which contains gases and particles emitted to the atmosphere by a variety of human activities and natural sources, or formed in the atmosphere, that at critical levels have harmful effects on human health, animals, plants and ecosystems, or reduce visibility and corrode materials, buildings and cultural heritage sites (UNEP, no date).

Reference

WMO, 1992. International Meteorological Vocabulary. WMO-No. 182. World Meteorological Organization (WMO). https://library.wmo.int/doc_num.php?explnum_id=4712 Accessed 26 November 2019.

UNEP, no date. Frequently Asked Questions on Air Pollution. International Day for Clean Air for blue skies, United Nations Environment Programme (UNEP). www.cleanairblueskies.org/did-you-know/frequently-asked-questions-air-pollution Accessed 11 November 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

Air pollution is caused by gases and particles emitted to the atmosphere by a variety of human activities, such as the inefficient combustion of fuels, agriculture, and farming. There are also natural sources contributing to air pollution, including particles of soil dust and salt in sea spray (UNEP, no date).

Air pollutants can be emitted directly from a source (i.e., primary pollutants) or can form from chemical reactions in the atmosphere (i.e., secondary pollutants). When concentrations of these substances reach critical levels in the air, they harm humans, animals, plants and ecosystems, and reduce visibility and corrode materials, buildings and cultural heritage sites (UNEP, no date).

The main atmospheric pollutants affecting human health are particulate matter, ground-level ozone (O3) and nitrogen dioxide (NO2) (US EPA, 2020a,b,c). The fine particles that damage human health are known as PM2.5 (particles with a diameter of less than 2.5 micrometres), which can penetrate deep into the lungs and pass into the bloodstream, affecting different organs and bodily functions. These particles can either be emitted directly or formed in the atmosphere from several different emitted pollutants (e.g., ammonia [NH3] and volatile organic compounds [VOCs]) (Air Pollution Information System, 2016; US EPA, 2020d; UNEP, no date).

Ground-level ozone is an important secondary pollutant. It is a potent lung irritant and stunts growth in plants. It also oxidises surfaces with which it comes into contact, degrading the materials from which they are made. Ozone is also a powerful greenhouse gas. Tropospheric ozone is different to ozone in the upper atmosphere (stratosphere), which protects us from ultraviolet light from the sun (UNEP, no date).

Nitrogen oxides (NOx) are a group of air pollutants, comprising nitrogen dioxide (NO2) and nitrogen monoxide (NO). Nitrogen dioxide is the most harmful of these compounds and is generated from human-driven activities. It impacts human health, reduces atmospheric visibility, and can play a significant role in climate change, at high concentrations. It is also a critical precursor to the formation of ground-level ozone (UNEP, no date).

Particulate matter (both the aerosol that is directly emitted to the atmosphere and the secondary aerosol that is formed in the atmosphere) has a wide range of negative impacts, which depend on the chemical composition of the particles (UNEP, no date). Black carbon, which is a carbon particle produced as a result of partial combustion of hydrocarbons that contributes to air pollution, has strong negative impacts on health and contributes to climate warming (No More Planet, 2021). Aerosol has negative impacts on biodiversity in terrestrial ecosystems (especially sulphur- and nitrogen-containing aerosol), and in high concentrations impacts visibility and has a soiling effects on surfaces (UNEP, no date).

Metrics and numeric limits

While all individuals experience different levels of health impacts from air pollution, across large city or country populations, there is no evidence of a completely safe level of air pollution, especially in the case of particulate matter. However, to help guide countries to achieve cleaner air for health, the World Health Organization (WHO) has set normative guideline values for all major air pollutants, above which, negative impacts on population health are likely (WHO, 2005). For example, the WHO estimates that reducing annual average fine particulate matter (PM2.5) concentrations from levels of 35 µg/m3 (an interim air quality guideline commonly used in many developing country cities), to the WHO guideline level of 10 µg/m3, could reduce air pollution related deaths by around 15%. This does not mean that there are no health effects below those guidelines, but that they represent health-based targets useful for tracking the burden of disease from air pollution, informing national level targets and standards, and monitoring the effectiveness of air quality management efforts designed to improve health (WHO, 2005).

There are currently no set International standards for the other impacts of air pollution.

The impact of air pollution on climate is defined through the global warming potential, such as used in the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2014).

Key relevant UN convention/multilateral treaty

United Nations Economic Commission for Europe (UNECE) Convention on Long-range Transboundary Air Pollution (UNECE, no date).

Climate and Clean Air Coalition (Climate and Clean Air Coalition, no date).

Examples of drivers, outcomes and risk management

The key message is that air pollution is now the greatest environmental threat to health and ecosystems, but it is preventable. The World Meteorological Organization (WMO) reports that there are solutions and technology for mitigating air pollution. Improving air quality requires all stakeholders on board, from individuals to private companies to governments. Air pollution contributes to heart disease, stroke, lung cancer and other respiratory diseases. It is estimated to be responsible for 7 million premature deaths per year, predominantly in low- and middle-income countries. Air pollution also threatens the economy, food security and the environment (WMO, 2020).

The WMO works toward enhanced availability and quality of observations of several important air pollutants such as black carbon, tropospheric ozone, and atmospheric dust through the Global Atmosphere Watch programme (WMO, 2021a) to support evidence-based policy on the environment (WMO, 2021b). Members are working on the development of forecasting systems that will help reduce acute air pollution episodes (WMO, 2020).

The WMO also leads global research and strengthens scientific knowledge on connections between air quality and climate and is developing the science-based tools to support policy-making on air pollution and climate change mitigation (WMO, 2020).

The WMO Global Atmosphere Watch initiated the Global Air Quality Forecasting and Information System (GAFIS) initiative, which builds a platform for providers and users of air quality forecast and information systems (WMO, 2021c). It will enable access to, and use of, air quality prediction and analysis products at various temporal and spatial scales by a multiplicity of communities and stakeholders interested in air quality (WMO, 2020).

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UNEP, no date. Frequently Asked Questions on Air Pollution. International Day for Clean Air for blue skies, United Nations Environment Programme (UNEP). www.cleanairblueskies.org/did-you-know/frequently-asked-questions-air-pollution Accessed on 11 November 2020.

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US EPA, 2020b. Ground-Level Ozone Pollution. United States Environmental Protection Agency (US EPA). www.epa.gov/ground-level-ozone-pollution Accessed 23 March 2021.

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WMO, 2021a. Global Atmosphere Watch Programme. World Meteorological Organization (WMO). https://public.wmo.int/en/programmes/global-atmosphere-watch-programme. Accessed 23 March 2021.

WMO, 2021b. Environment. World Meteorological Organization (WMO). https://public.wmo.int/en/our-mandate/focus-areas/environment. Accessed 23 March 2021.

WMO, 2021c. Global Air Quality Forecasting and Information System (GAFIS). World Meteorological Organization (WMO). https://community.wmo.int/activity-areas/gaw/science-for-services/gafis. Accessed 23 March 2021.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0019 / **METEOROLOGICAL AND HYDROLOGICAL / Lithometeors**

Sand haze

Definition

Sand haze is haze caused by the suspension in the atmosphere of small sand or dust particles, raised from the ground prior to the time of observation by a sandstorm or dust storm (WMO, 1992).

Reference

WMO, 1992. International Meteorological Vocabulary, WMO-No. 182. World Meteorological Organization (WMO). https://library.wmo.int/doc_num.php?explnum_id=4712 Accessed 13 October 2020.

Annotations

Synonyms

Dust haze.

Additional scientific description

Sand haze is reduced visibility in the atmospheric boundary layer which is caused by suspended particles of soil, mixed into the air during strong winds. It is particularly prevalent in desert regions where there is little moisture and few plants to hold the sand grains to the surface (AMS, 2012).

After a sandstorm the larger sand grains fall out of the air quickly, leaving a sand haze of medium-sized particles (1–100 µm diameter, including silt and fine sand) and small particles (< 1 µm diameter, including clay particles) (AMS, 2012).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Not available.

Examples of drivers, outcomes and risk management

Sand haze can be considered as one of many causes of air pollution. Air pollution is a major environmental risk to health. By reducing air pollution levels, countries can reduce the burden of disease from stroke, heart disease, lung cancer, and both chronic and acute respiratory diseases, including asthma. The lower the levels of air pollution, the better the cardiovascular and respiratory health of the population, both long- and short-term. The World Health Organization has published an assessment of health effects of air pollution and thresholds for health-harmful pollution levels (WHO, 2018).

Sand haze contains particulate matter, which is a common proxy for air pollution. The major components of atmospheric particulates are sulphates, nitrates, ammonia, sodium chloride, black carbon, mineral dust and water. It consists of a complex mixture of solid and liquid particles of organic and inorganic substances suspended in the air. While particles with a diameter of 10 microns or less (≤ PM10) can penetrate and lodge deep inside the lungs, the even more health-damaging particles are those with a diameter of 2.5 microns or less (≤ PM2.5). The latter can penetrate the lung barrier and enter the blood system. Chronic exposure to particles contributes to the risk of developing cardiovascular and respiratory diseases, as well as lung cancer (WHO, 2018).

Small particulate pollution has health impacts even at very low concentrations – and no threshold has been identified below which no damage to health is observed. Therefore, the WHO 2005 guideline limits aim to achieve the lowest concentrations of particulate matter possible (WHO, 2018).

References

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Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0020 / **METEOROLOGICAL AND HYDROLOGICAL / Lithometeors**

Smoke

Definition

Smoke is a suspension in the air of small particles produced by combustion (WMO, 2017).

Reference

WMO, 2017. Smoke. International Cloud Atlas, World Meteorological Organization (WMO). https://cloudatlas.wmo.int/smoke.html Accessed 13 October 2020.

Annotations

Synonyms

Not relevant

Additional scientific description

This lithometeor may be present either near the Earth's surface or in the free atmosphere. Viewed through smoke, the Sun appears very red at sunrise and sunset, and shows an orange tinge when high in the sky. Smoke from relatively near cities may be brown, dark grey or black. Smoke in extensive layers originating from fairly near forest fires, scatters the sunlight and gives the sky a greenish-yellow hue. Evenly distributed smoke from very distant sources generally has a light greyish or bluish hue. When smoke is present in large quantities, it may be distinguished by its smell (WMO, 2017).

When the lithometeor 'smoke' is present in the free atmosphere, it is typically distinguished from clouds of smoke (clouds from fires or resulting from industry) by its diffuse appearance and by the absence of any discernible outlines (WMO, 2017).

Air quality is also compromised by natural contaminants such as aeroallergens (pollen, moulds), smoke from wildfires, airborne sand and dust as well as by personal behaviour such as tobacco smoke exposure or indoor burning of solid fuels. When inhaled, these contaminants penetrate deeply into the respiratory system and may initiate a range of damaging biological reactions in the human body (WMO, 2014). As a result, air pollution is now one of the world's greatest environmental health risks.

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Not available.

Examples of drivers, outcomes and risk management

The World Meteorological Organization (WMO) has responded to urgent requests for assistance from Members in several impacted regions by initiating a Vegetation Fire and Smoke Pollution Warning and Advisory System (VFSP-WAS) (WMO, 2019). This provides guidance for addressing both fire and smoke hazards and proposes to support the potential foundation of regional centres to address air quality and the impact of smoke.

The Southeast Pacific, one of the regions most affected by vegetation fires and smoke pollution, has established the first Regional Vegetation Fire and Smoke Pollution Warning and Advisory Centre, operated by the Meteorological Service of Singapore. During the wildfire season, the centre provides up-to-date and timely information for people to protect themselves (WMO, 2019).

The Southeast Pacific Centre serves as a prototype for other centres to be established around the world. The WMO encourages all Members impacted by wildfires and related health problems to participate in this activity and provide the relevant data and support for VFSP-WAS (WMO, 2019).

Smoke is one of the many causes of air pollution. Air pollution is a major environmental risk to health. By reducing air pollution levels, countries can reduce the burden of disease from stroke, heart disease, lung cancer, and both chronic and acute respiratory diseases, including asthma. The lower the levels of air pollution, the better the cardiovascular and respiratory health of the population, both long- and short-term. The World Health Organization has published an assessment of health effects of air pollution and thresholds for health-harmful pollution levels (WHO, 2018).

Smoke contains particulate matter, which is a common proxy for air pollution. The major components of atmospheric particulates are sulphates, nitrates, ammonia, sodium chloride, black carbon, mineral dust and water. It consists of a complex mixture of solid and liquid particles of organic and inorganic substances suspended in the air. While particles with a diameter of 10 microns or less (≤ PM10) can penetrate and lodge deep inside the lungs, the even more health-damaging particles are those with a diameter of 2.5 microns or less (≤ PM2.5). The latter can penetrate the lung barrier and enter the blood system. Chronic exposure to particles contributes to the risk of developing cardiovascular and respiratory diseases, as well as lung cancer (WHO, 2018).

Small particulate pollution has health impacts even at very low concentrations – and no threshold has been identified below which no damage to health is observed. Therefore, the WHO 2005 guideline limits aim to achieve the lowest concentrations of particulate matter possible (WHO, 2018).

References

WHO, 2018. Ambient (outdoor) air pollution. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health Accessed 13 October 2020.

WMO, 2014. Air Quality and Human Health: A Priority for Joint Action. World Meteorological Organization (WMO). https://public.wmo.int/en/resources/bulletin/air-quality-and-human-health-priority-joint-action Accessed 13 October 2020.

WMO, 2017. Smoke. International Cloud Atlas, World Meteorological Organization (WMO). https://cloudatlas.wmo.int/smoke.html Accessed on 26 November 2019.

WMO, 2019. Wildfires and Smoke Pollution – Warning and Advisory. https://public.wmo.int/en/resources/meteoworld/wildfires-and-smoke-pollution-%E2%80%93-warnings-and-advisory Accessed 10 December 2019.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0021 / **METEOROLOGICAL and HYDROLOGICAL / Marine**

Ocean Acidification

Definition

Ocean acidification refers to a reduction in the pH of the ocean over an extended period, which is caused primarily by uptake of carbon dioxide from the atmosphere and can also be caused by other chemical additions or subtractions from the ocean (IPCC, 2011).

Reference

IPCC, 2011. IPCC Workshop on Impacts of Ocean Acidification on Marine Biology and Ecosystems. Intergovernmental Panel on Climate Change (IPCC). https://archive.ipcc.ch/pdf/supporting-material/IPCC_IAOMBE_WorkshopReport_Japan.pdf Accessed 1 October 2020.

Annotations

Synonyms

Not available.

Additional scientific description

The ocean absorbs around 30% of carbon dioxide (CO2) released to the atmosphere as a result of human activities. As CO2 dissolves in seawater, it alters the carbonate chemistry of the seawater, resulting in a fall in pH and accompanying declines in dissolved carbonate ion concentration and an increase in the partial pressure of CO2 (pCO2) as well as an increase in the concentration of dissolved bicarbonate ions. The decrease in the concentration of dissolved carbonate ions lowers the saturation state of biogenic forms of calcium carbonate minerals, including calcite and aragonite (IPCC, 2019; UNESCO, no date).

Metrics and numeric limits

The seawater carbon system has four measurable variables and at least two of these are needed in order to 'constrain' the carbon system relative to ocean acidification: pH, pCO2, total alkalinity (TA), and total dissolved inorganic carbon (DIC). Temperature and salinity data are also required.

The units of these parameters are pH on total scale; pCO2 [μatm]; DIC [μmol/kg]; and TA [μmol/kg] (IOC, 2018; IPCC, 2019).

Key relevant UN convention / multilateral treaty

United Nations 2030 Agenda on Sustainable Development (UNGA, 2015).

Examples of drivers, outcomes and risk management

Ocean acidification occurs when the CO2 absorbed by the ocean reacts with seawater, resulting in a shift in the dissolved carbonate chemistry, including increased acidity levels in the marine environment (i.e., decreased seawater pH). The observed changes have been shown to cause a range of responses at the organism level that can affect biodiversity and ecosystem structure. Direct consequences for marine life can propagate through the food web and affect ocean-related services and uses, including food security in terms of fisheries and aquaculture, livelihoods, coastal protection, tourism, and cultural heritage.

For example, decreases in dissolved carbonate ion concentrations have been shown to impact the growth and larval survival of key marine calcifying organisms, including oysters, mussels and corals. The impact on corals is likely to result in weaker reefs making them prone to storm damage and altering the structural complexity that supports biologically diverse reef ecosystems. Effects on growth, reproduction, and predatory avoidance have also been observed for many other marine organisms from changes in pH and/or pCO2. Food production from marine calcifiers in both wild and aquaculture fisheries is expected to be adversely impacted by ocean acidification, with some aquaculture facilities already implementing monitoring and adaptation strategies.

It may be possible to lessen the impacts of ocean acidification on ocean services through mitigation and adaptation strategies informed by appropriate monitoring and improved understanding of natural and human-induced variability, as well as the rate of change, combined with studies of biological impacts. Further investigation is also required as ocean acidification may act as a stress multiplier when combined with other changes in the marine environment, including changes in temperature and oxygen concentrations.

References

IOC, 2018. Update on IOC custodianship role in relation to SDG 14 indicators. Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization. www.ioc-unesco.org/index.php?option=com_oe&task=viewDocumentRecord&docID=21938 Accessed 20 December 2019.

IPCC, 2019. IPCC Special Report on the Ocean and Cryosphere in a Changing Climate. www.ipcc.ch/site/assets/uploads/sites/3/2019/12/SROCC_FullReport_FINAL.pdf Accessed 20 December 2019.

UNESCO, no date. Ocean Acidification. United Nations Educational, Scientific and Cultural Organization (UNESCO). en.unesco.org/ocean-acidification Accessed 20 December 2019.

UNGA, 2015. Transforming Our World: The 2030 Agenda for Sustainable Development. United Nations General Assembly (UNGA). https://sustainabledevelopment.un.org/post2015/transformingourworld Accessed 1 October 2020.

Coordinating agency or organisation

United Nations Educational, Scientific and Cultural Organization (UNESCO) and the Intergovernmental Oceanographic Commission (IOC).

MH0022 / **METEOROLOGICAL AND HYDROLOGICAL / Marine**

Rogue Wave

Definition

Rogue waves are extreme waves with overall or crest heights that are abnormally high relative to the background significant wave height (WMO, 2018).

Reference

WMO, 2018. Guide to Wave Analysis and Forecasting, WMO No. 702. World Meteorological Organization (WMO). https://library.wmo.int/index.php?lvl=notice_display&id=7700#.XzPLuigzaUk Accessed 12 August 2019.

Annotation

Synonym

Freak wave, Extreme storm wave.

Additional scientific description

Rogue waves, called 'extreme storm waves' by scientists, are those waves which are greater than twice the size of surrounding waves. They are very unpredictable, and often come unexpectedly from directions other than those of the prevailing wind and waves. Since these waves are uncommon, measurements and analysis of this phenomenon are extremely rare (NOAA, 2019).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Exactly how and when rogue waves form is still under investigation, but there are several known causes.

- *Constructive interference:* Extreme waves often form because swells, while traveling across the ocean, do so at different speeds and directions. As these swells pass through one another, their crests, troughs, and lengths sometimes coincide and reinforce each other. This process can form unusually large, towering waves that quickly disappear. If the swells are travelling in the same direction, these mountainous waves may last for several minutes before subsiding (NOAA, 2019).
- *Focusing of wave energy:* When waves formed by a storm develop in a water current against the normal wave direction, an interaction can take place which results in a shortening of the wave frequency. This can cause the waves to dynamically join together, forming very big 'rogue' waves. Currents where these are sometimes seen include the Gulf Stream and the Agulhas Current. Extreme waves developed in this fashion tend to be longer-lived than those formed by constructive interference (NOAA, 2019).

A good knowledge of the extreme wave environment and related wave/structure interactions is required for the design of safe and economic offshore structures and ships (Clauss, 2002).

References

Clauss, G.F., 2002. Dramas of the sea: episodic waves and their impact on offshore structures. Applied Ocean Research, 24:147-161.

NOAA, 2019. What is a rogue wave? National Ocean Service, National Oceanic and Atmospheric Administration (NOAA). https://oceanservice.noaa.gov/facts/roguewaves.html Accessed 26 November 2019.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0023 / **METEOROLOGICAL AND HYDROLOGICAL / Marine**

Sea Water Intrusion

Definition

Seawater intrusion is the process by which saltwater infiltrates a coastal aquifer, leading to contamination of fresh groundwater (NRC, 2011).

Reference

NRC, 2011. Saltwater Intrusion and Climate Change: A primer for local and provincial decision-makers. Natural Resources Canada (NRC). www.gov.pe.ca/photos/original/cle_WA1.pdf Accessed 13 October 2020.

Annotations

Synonyms

Saltwater intrusion, Saltwater encroachment.

Additional scientific description

With rising sea levels, saline water intrusion into coastal aquifers, surface waters and soils is expected to become more frequent and advance further inland. Salinisation of groundwater, surface water and soil resources also increases with land-based drought events, and decreasing river discharge in combination with water extraction and sea-level rise (Oppenheimer et al., 2019).

Seawater intrusion is also known as saltwater intrusion, and defined as ‘a process by which saltwater invades freshwater in service water or groundwater bodies’ (WMO, 2012).

Metrics and numeric limits

Surface water salinity is described by units of electrical conductivity (EC). Groundwater salinity is described by units of parts per million (ppm). Scientific reports use decisiemens per metre (dS/m) as the main unit of measure (USGS, 2019).

The concentration is the amount (by weight) of salt in seawater, as expressed in parts per million (ppm) (USGS, 2019). Salinity is the measure of the concentration of dissolved (soluble) salts in water from all sources.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Saltwater intrusion refers to the process by which sea water infiltrates coastal groundwater systems, thus mixing with the local freshwater supply. Groundwater is stored in the pores and fractures of rock beneath the surface, and the rock formations containing groundwater are referred to as aquifers (Prince Edward Island Department of Environment, Labour and Justice, 2011).

Aquifers are naturally replenished (or recharged) by way of precipitation (rain, snowmelt) that seeps into the ground and eventually reaches the water table. Because saltwater is denser than freshwater, this saline groundwater may ‘intrude’ beneath fresh groundwater, creating a saltwater ‘wedge’ at the coastline. In addition to the local hydraulic and density gradients, the nature of this saltwater–freshwater interaction is controlled by many factors, including the characteristics of the aquifer (such as permeability and thickness) and the characteristics of any layers of rock underlying or overlying the aquifer (confining layers) (NRC, 2011; Government of Australia, 2015; Chun et al., 2018).

Further natural and anthropogenic drivers of seawater intrusion are discussed by White and Kaplan (2017).

The table provides a summary of strategies, approaches, and tools to mitigate the impacts of saltwater intrusion (Montanari, 2017; White and Kaplan, 2017).

Strategy	Approach	Tools
Modified water withdrawals	Optimise amounts, locations, and timing	Modelling and scenario analysis
	Water conservation	Irrigation efficiency improvement
		Rainwater harvesting
		Use reduction
Modified water deliveries	Optimise amounts, locations, and timing	Modelling and scenario analysis
	Enhance fresh groundwater recharge	Infiltration ponds/basins
		Land-use conversions
		Artificial recharge
Engineered structures	Direct freshwater	Diversions
	Impede saltwater	Saltwater barriers and other structures

As part of the Regional Adaptation Collaborative (RAC) of Natural Resources Canada, case studies have been developed in each of the Atlantic Canadian provinces in order to better understand saltwater intrusion, as well as the challenges and needs it presents. Case studies are being conducted to investigate existing conditions and the potential impacts of climate change on groundwater resources (NRC, 2011).

References

Chun, J.A., C. Lim, D. Kim and J.S. Kim, 2018. Assessing impacts of climate change and sea-level rise on seawater intrusion in a coastal aquifer. Water, 10:357. doi.org/10.3390/w10040357

Government of South Australia, 2015. Measuring salinity. https://landscape.sa.gov.au/mr/publications/measuring-salinity Accessed 13 October 2020.

Montanari, A., 2017. Lecture: Seawater intrusion. www.albertomontanari.it/?q=node/152 Accessed 5 December 2019.

NRC, 2011. Saltwater Intrusion and Climate Change: A primer for local and provincial decision-makers. Natural Resources Canada (NRC). www.gov.pe.ca/photos/original/cle_WA1.pdf Accessed 5 December 2019.

Oppenheimer, M., B.C. Glavovic , J. Hinkel, R. van de Wal, A.K. Magnan, A. Abd-Elgawad, R. Cai, M. Cifuentes-Jara, R.M. DeConto, T. Ghosh, J. Hay, F. Isla, B. Marzeion, B. Meyssignac and Z. Sebesvari, 2019. Sea level rise and implications for low-lying islands, coasts and communities. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate. www.ipcc.ch/srocc/chapter/chapter-4-sea-level-rise-and-implications-for-low-lying-islands-coasts-and-communities Accessed 13 October 2020.

Prince Edward Island Department of Environment, Labour and Justice, 2011. Saltwater Intrusion and Climate Change. www.gov.pe.ca/photos/original/cle_WA1.pdf Accessed 14 April 2021.

USGS, 2019. Saline Water and Salinity. United States Geological Survey (USGS). www.usgs.gov/special-topic/water-science-school/science/saline-water-and-salinity?qt-science_center_objects=0#qt-science_center_objects Accessed 13 October 2020.

White, E. and D. Kaplan, 2017. Restore or retreat? Saltwater intrusion and water management in coastal wetlands. Ecosystem Health and Sustainability, 3:e01258. doi.org/10.1002/ehs2.1258

WMO, 2012. Entry 1268. International Glossary of Hydrology, WMO-No. 385. World Meteorological Organization (WMO). www.wmo.int/pages/prog/hwrp/publications/international_glossary/385_IGH_2012.pdf

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0024 / **METEOROLOGICAL AND HYDROLOGICAL / Marine**

Sea Ice (Ice Bergs)

Definition

Sea ice is any form of ice found at sea (WMO, 2015).

Reference

WMO, 2015. Manual on the Global Observing System: Volume 1 – Global aspects: Annex V to the WMO Technical Regulations: WMO No. 544. World Meteorological Organization (WMO). Accessed 5 December 2019.

Annotations

Synonyms

Ice floes, Pack ice.

Additional scientific description

The presence of sea ice in polar and subpolar oceans is a defining environmental factor that interacts with weather and climate and impacts on the ecology and human activities in these regions. Sea ice is also a significant natural hazard, both through direct interaction with assets and infrastructure and through the indirect impacts of variability and rapid changes in its distribution, in particular in Arctic and subarctic regions.

There are three types of sea-ice hazard: broad, long-term hazards and risks associated with a rapid reduction in (summer) ice volume and extent; near-term hazards resulting from changes in sea-ice extent and dynamics such as increased coastal erosion and threats to coastal infrastructure; and immediate risks and the potential for disasters derived from the combination of sea-ice hazards and human activities such as shipping or offshore resource development (Eicken and Mahoney, 2015).

Owing to a wide range of possible causes, preventing disasters and mitigating hazards requires approaches that address a multitude of factors. Hazard and risk maps are one option to help in the long-term planning and coordination of emergency response assets. Such maps do not appear to be available at the regional scale in the Arctic, although national ice forecasting services may generate local maps that indicate ice severity as a hazard indicator. For example, the Chinese Marine Environmental Forecasting Center's Ice Severity Zones (Zhang et al., 2013) or the Barnett Ice Severity Index used in the United States (Eicken et al., 2009; Eicken and Mahoney, 2015).

Ice crystals form at the surface of the ocean mixed layer. Under sustained heat loss these ice crystals aggregate and can form a solid layer and up to several metres thick. During this process the solid ice expels salt (brine rejection), which increases the salinity of the underlying water and can initiate convective mixing in the ocean. In a few places where this cold, salty water is dense enough, it can sink via overflowing plumes along the bottom topography to reach the ocean abyss. This newly formed dense water generally flows slowly at depth towards the equator.

A thick sea-ice layer restricts wind and wave action near coastlines, lessening coastal erosion and protecting ice shelves. Sea ice also creates an insulating cap across the ocean surface, which reduces evaporation and heat loss to the atmosphere. As a result, the weather over ice-covered areas tends to be colder and drier than it would be without ice (Scott and Hansem, 2016).

Metrics and numeric limits

Not available.

Key relevant UN convention/multilateral treaty

International Code for Ships Operating in Polar Waters (Polar Code) (IMO, 2017).

Examples of drivers, outcomes and risk management

Sea Ice Trackers and Analysis: The Norwegian Meteorological Institute gives access to the latest products and information about sea ice via its website. It provides satellite imagery, operational ice charts, automatic sea ice analysis, and sea ice trackers, etc (Norwegian Meteorological Institute, no date).

References

Eicken, H. and A.R. Mahoney, 2015. Sea ice: hazards, risks, and implications for disasters. In: Schroder, J.F., J.T. Ellis and D.J. Sherman (eds.), Coastal and Marine Hazards, Risks, and Disaster. pp. 381-401. Elsevier. www.sciencedirect.com/science/article/pii/B9780123964830000133

Eicken, H., A.L. Lovecraft and M. Druckenmiller, 2009. Sea-ice system services: A framework to help identify and meet information needs relevant for Arctic observing networks. Arctic, 62:119-136.

IMO, 2017. International Code for Ships Operating in Polar Waters (Polar Code). International Maritime Organization (IMO). https://www.imo.org/en/OurWork/Safety/Pages/polar-code.aspx Accessed 8 October 2020.

Norwegian Meteorological Institute, no date. Sea ice climate indicators. cryo.met.no/en/sea-ice-climate-indicator Accessed 5 December 2019.

Scott, M. and K. Hansem, 2016. Sea ice. NASA Earth Observatory. earthobservatory.nasa.gov/features/SeaIce Accessed 5 December 2019.

Zhang, X.L., Z.H. Zhang, Z.J. Xu, G. Li, Q. Sun and X.J. Hou, 2013. Sea ice disasters and their impacts since 2000 in Laizhou Bay of Bohai Sea, China. Natural Hazards, 65:27-40.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0025 / **METEOROLOGICAL AND HYDROLOGICAL / Marine**

Ice Flow

Definition

Ice flow is the motion of ice driven by gravitational forces, ice stress or, for sea ice, wind, water currents and tide (AMS, 2012).

References

AMS, 2012. Ice flow. Glossary of Meteorology. American Meteorological Society (AMS). http://glossary.ametsoc.org/wiki/Ice_flow Accessed 31 October 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

Ice flow in a marine setting includes ice as glaciers which terminate in the ocean in the form of floating ice tongues or ice shelves, sea ice, and river and lake ice.

Floating ice is defined as any form of ice found floating on water. The principal types of floating ice are lake ice, river ice, and sea ice which form by the freezing of water at the surface. Sea ice can occur in the form of fast ice or drift/pack ice (AMS, 2012a). Floating ice can also be found where glacier ice, which flows under gravitational forces or ice stress, terminates in the ocean. This can create floating ice in the form of floating ice tongues, which are narrow extensions of a glacier (AMS, 2012b) or floating ice shelves, thick ice formation with a fairly level surface, formed along a polar coast and in shallow bays, and inlets where it is attached to the shore (AMS, 2012c).

Ice flow of marine origin is a hazard for navigation in the form of floating ice in motion and the use of ice surfaces as transport routes. This includes, icebergs which calve from marine terminating glaciers, ice jams, ice floes and ice edge.

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Not identified.

References

AMS, 2012a. Ice flow. Glossary of Meteorology. American Meteorological Society (AMS). http://glossary.ametsoc.org/wiki/Ice_flow

AMS, 2012b. Ice tongue. Glossary of Meteorology. American Meteorological Society (AMS). https://glossary.ametsoc.org/wiki/Ice_tongue

AMS, 2012c. Ice shelf. Glossary of Meteorology. American Meteorological Society (AMS). https://glossary.ametsoc.org/wiki/Ice_shelf

Coordinating agency or organisation

Not identified.

MH0026 / **METEOROLOGICAL AND HYDROLOGICAL / Marine**

Seiche

Definition

Seiches are sea-level oscillations at the resonant frequency of enclosed bodies of water (WMO, 2011).

Reference

WMO, 2011. Guide to Storm Surge Forecasting, WMO No. 1076. World Meteorological Organization (WMO). https://library.wmo.int/doc_num.php?explnum_id=7747 Accessed 13 October 2020.

Annotations

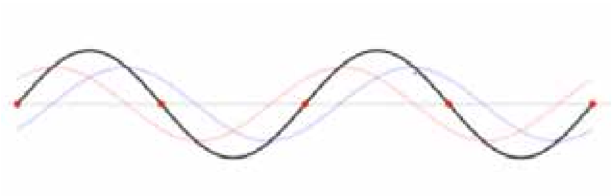
Synonyms

None found.

Additional scientific description

Similar in motion to a seesaw, a seiche is a standing wave in which the largest vertical oscillations are at each end of a body of water with very small oscillation at the 'node', or centre point, of the wave. Standing waves can form in any enclosed or semi-enclosed body of water, from a massive lake to a small coffee cup (NOAA, 2018).

The graphic shows a standing wave (black) depicted as the sum of two propagating waves travelling in opposite directions (blue and red) (NOAA, 2018).



Metrics and numeric limits

Not applicable.

Key relevant UN convention/multilateral treaty

Not applicable.

Examples of drivers, outcomes and risk management

Seiches are typically caused when strong winds and rapid changes in atmospheric pressure push water from one end of a body of water to the other. When the wind stops, the water rebounds to the other side of the enclosed area. The water then continues to oscillate back and forth for hours or even days. Earthquakes, tsunamis, or severe storm fronts may cause seiches along ocean shelves and ocean harbours (NOAA, 2018).

Lake Erie is known for seiches, especially when strong winds blow from southwest to northeast. These have caused a number of notable events: in 1844, a 22-foot seiche breached a 14-foot-high sea wall killing 78 people and damming the ice to the extent that Niagara Falls temporarily stopped flowing; and as recently as 2008, strong winds created waves 12 to 16 feet high, leading to flooding near Buffalo, New York (NOAA, 2018).

Another example is Lake Pontchartrain, Louisiana, which is known to routinely form small seiches after the passage of after-noon squall lines during summer (NOAA, 2018).

References

NOAA, 2018. What is a seiche? National Ocean Service, National Oceanic and Atmospheric Administration (NOAA). https://oceanservice.noaa.gov/facts/seiche.html Accessed 26 November 2019.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0027 / **METEOROLOGICAL AND HYDROLOGICAL / Marine**

Storm Surge

Definition

A storm surge reflects the difference between the actual water level under the influence of a meteorological disturbance (storm tide) and the level which would have occurred in the absence of the meteorological disturbance (i.e., astronomical tide) (WMO, 2008, 2011, 2017).

References

WMO, 2008. Technical Regulations, Volume III: Hydrology, WMO No. 49. World Meteorological Organization (WMO). www.wmo.int/pages/prog/hwrp/publications/technical_regulations/49_III_E_supplement1.pdf Accessed 26 November 2019.

WMO, 2011. Guide to Storm Surge Forecasting, WMO No. 1076. World Meteorological Organization (WMO). https://library.wmo.int/doc_num.php?explnum_id=7747 Accessed 12 August 2020.

WMO, 2017. Regional Association IV – Hurricane Operational Plan for North America, Central America and the Caribbean, WMO-No. 1163. World Meteorological Organization (WMO). https://library.wmo.int/doc_num.php?explnum_id=3781 Accessed on 26 November 2019.

Annotations

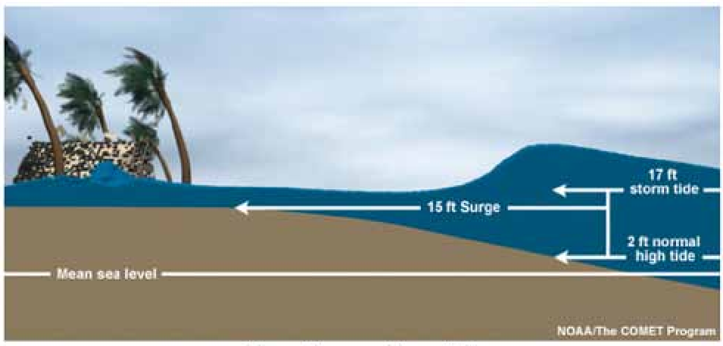
Synonyms

Not identified.

Additional scientific description

A storm surge is the rise in seawater level caused solely by a storm. It is the abnormal rise in seawater level during a storm, measured as the height of the water above the normal predicted astronomical tide. The surge is caused primarily by a storm's winds pushing water onshore. The amplitude of the storm surge at any given location depends on the orientation of the coast-line with the storm track, the intensity, size, and speed of the storm, and the local bathymetry (NOAA, 2019a). This is illustrated in the graphic below (NOAA, 2019a).

A storm tide is the water level that results from the combination of the storm surge and the normal (astronomical) tide. A 3-metre (9.8 feet) storm surge on top of a high tide that is 2 metres (6.6 feet) above the mean sea level will produce a storm tide that is 5 metres (16.4 feet) above mean sea level. Storm surge should not be confused with storm tide. This rise in water level can cause extreme flooding in coastal areas, resulting from storm tides reaching up to 6 meters (20 feet) or more in some cases (NOAA, 2019b).



Storm Surge vs. Storm Tide

Metrics and numeric limits

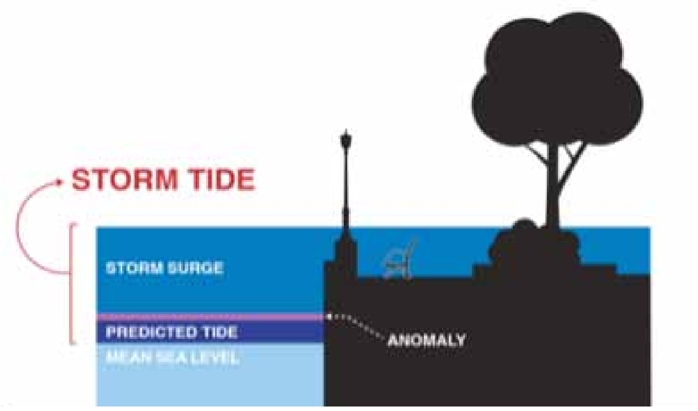
Not available.

Key relevant UN convention / multilateral treaty

Not available.

Examples of drivers, outcomes and risk management

On top of a storm tide are pounding waves generated by the powerful winds. The area of seawater flooding may extend along the coast for over 100 km, with water pushing several kilometres inland if the land is low lying. The combined effects of the storm tide and surface waves can destroy buildings, wash away roads and run ships aground (Australian Government, 2020).



Examples of National Alerting Parameters include storm surge warning issued in Canada (Government of Canada, 2019) and an Advisory for storm surge watch/warning issued by the World Meteorological Organization (WMO, 2017).

References

Australian Government, 2020. Storm Surge. Bureau of Meteorology. www.bom.gov.au/cyclone/tropical-cyclone-knowledge-centre/understanding/storm-surge Accessed 13 October 2020.

Government of Canada, 2019. Storm Surge: Criteria for Public Weather Alerts. www.canada.ca/en/environment-climate-change/services/types-weather-forecasts-use/public/criteria-alerts.html#stormSurge Accessed 26 November 2019.

NOAA, 2019a. What is storm surge? National Ocean Service, National Oceanic and Atmospheric Administration (NOAA). https://oceanservice.noaa.gov/facts/stormsurge-stormtide.html Accessed 26 November 2019.

NOAA, 2019b. Storm Surge Overview. National Hurricane Center and Central Pacific Hurricane Center, National Oceanic and Atmospheric Administration (NOAA). www.nhc.noaa.gov/surge

WMO, 2017. Regional Association IV – Hurricane Operational Plan for North America, Central America and the Caribbean, WMO-No. 1163. World Meteorological Organization (WMO). https://library.wmo.int/doc_num.php?explnum_id=3781 Accessed 26 November 2019.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0028 / **METEOROLOGICAL AND HYDROLOGICAL / Marine**

Storm Tides

Definition

A storm tides is the actual sea level as influenced by a weather disturbance. The storm tide consists of the normal astronomical tide plus the storm surge (WMO, 2017).

References

WMO, 2017. Regional Association IV – Hurricane Operational Plan for North America, Central America and the Caribbean, WMO-No. 1163. World Meteorological Organization (WMO). https://library.wmo.int/doc_num.php?explnum_id=3781 Accessed on 26 November 2019.

Annotations

Synonyms

Not identified.

Additional scientific description

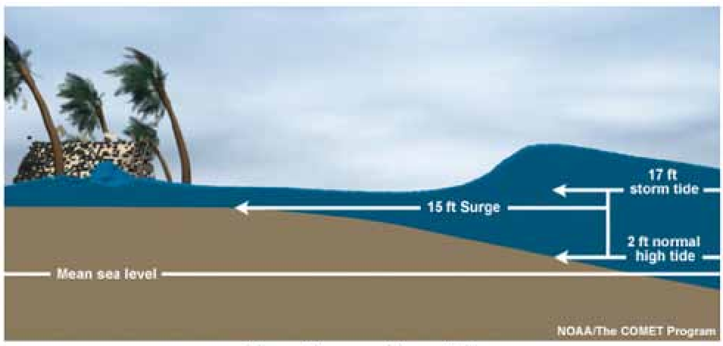
A storm tide is the water level that results from the combination of the normal (astronomical) tide and a storm surge (an abnormal rise of water generated by a storm, over and above the predicted astronomical tide) (NOAA, no date).

A 3-metre storm surge on top of a normal high tide that is 2 metres above mean sea level will produce a storm tide that is 5 metres above mean sea level (NOAA, no date).

Storm surge should not be confused with storm tide (NOAA, no date).

This rise in water level associated with a storm tide can cause extreme flooding in coastal areas particularly when a storm surge coincides with a normal high tide, resulting in storm tides of up to 20 feet or more in some cases (NOAA, 2019a).

The components responsible for a storm tide are illustrated in the graphic below (NOAA, 2019b).



Storm Surge vs. Storm Tide

Metrics and numeric limits

Not available.

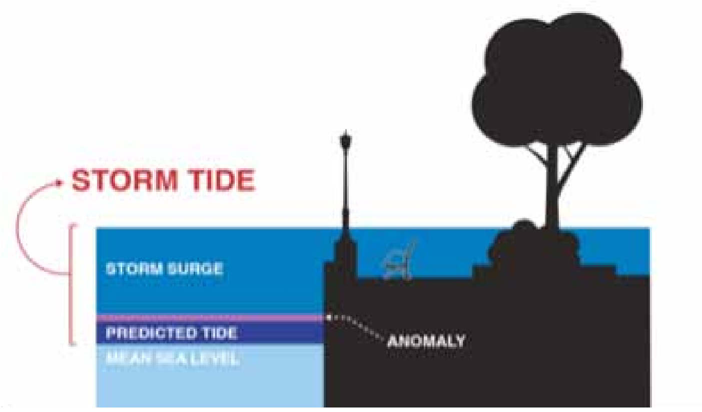
Key relevant UN convention / multilateral treaty

Not available.

Examples of drivers, outcomes and risk management

The worst impacts associated with storm tides occur when a storm surge arrives on top of a high tide. Under this scenario, the storm tide can reach inland areas that might otherwise have been unaffected. Added to this are pounding waves generated by the powerful winds. The area of sea water flooding may extend along the coast for 100 kilometres or more, with water pushing several kilometres inland if the land is low lying. The combined effects of the storm tide and waves can destroy buildings, wash away roads and run ships aground (Australian Government, 2020).

The example below illustrates water level differences for storm surge, storm tide, and a normal (predicted) high tide in relation to mean sea level. Storm tide is the total observed seawater level during a storm, which is the combination of storm surge (the rise in seawater level caused solely by a storm) and normal high tide (NOAA, 2019b).



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Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0029 / **METEOROLOGICAL and HYDROLOGICAL / Marine**

Tsunami

Definition

Tsunami is the Japanese term meaning wave ('nami') in a harbour ('tsu'). It is a series of travelling waves of extremely long length and period, usually generated by disturbances associated with earthquakes occurring below or near the ocean floor (IOC, 2019).

Reference

IOC, 2019. Tsunami Glossary, 2019. Intergovernmental Oceanographic Commission (IOC), Technical Series, 85. Fourth Edition. IOC/2008/TS/85 rev.4. https://unesdoc.unesco.org/ark:/48223/pf0000188226?posInSet=1&queryId=aeb846ae-edfb-4d66-a03a-385a5d5897f0

Annotations

Synonyms

Not found.

Additional scientific description

A tsunami may also be referred to as a 'seismic sea wave' and, incorrectly, a 'tidal wave'. Volcanic eruptions, submarine landslides, and coastal rock falls can also generate tsunamis, as can a large meteorite impacting the ocean. These waves may reach enormous dimensions and travel across entire ocean basins with little loss of energy. They proceed as ordinary gravity waves with a typical period of between 10 and 60 minutes. Tsunamis steepen and increase in height on approaching shallow water, inundating low-lying areas, and where local submarine topography causes the waves to steepen, they may break and cause great damage. Tsunamis have no connection with tides; the popular name, tidal wave, is entirely misleading (IOC, 2019).

The Intergovernmental Oceanographic Commission (IOC) uses the following terms to assess the scale and impact of a tsunami (IOC, 2019):

- Travel time: Time required for the first tsunami wave to propagate from its source to a given point on a coastline.
- Arrival time: Time of the first maximum of the tsunami waves.
- Inundation or Inundation-distance: The horizontal distance inland that a tsunami penetrates, generally measured perpendicularly to the shoreline.
- Inundation (maximum): Maximum horizontal penetration of the tsunami from the shoreline. A maximum inundation is measured for each different coast or harbour affected by the tsunami.
- Inundation area: Area flooded with water by the tsunami.
- Inundation height: Elevation reached by seawater measured relative to a stated datum such as mean sea level or the sea level at the time of tsunami arrival, at a specified inundation distance. Inundation height is the sum of the flow depth and the local topographic height. Sometimes referred to as tsunami height.
- Inundation line: Inland limit of wetting measured horizontally from the mean sea level line. The line between living and dead vegetation is sometimes used as a reference. In tsunami science, the landward limit of tsunami run-up.
- Leading wave: First arriving wave of a tsunami. In some cases, the leading wave produces an initial depression or drop in sea level, and in other cases, an elevation or rise in sea level. When a drop in sea level occurs, sea level recession is observed.
- Mean height: Average height of a tsunami measured from the trough to the crest after removing the tidal variation.
- Run-up
  - Difference between the elevation of maximum tsunami penetration (inundation line) and the sea level at the time of the tsunami. In practical terms, run up is only measured where there is clear evidence of the inundation limit on the shore.

  - Elevation reached by seawater measured relative to some stated datum such as mean sea level, mean low water, sea level at the time of the tsunami event, etc., and measured ideally at a point that is a local maximum of the horizontal inundation. Where the elevation is not measured at the maximum of horizontal inundation, this is often referred to as the inundation height.
- Tsunami amplitude: Usually measured on a sea level record, it is (1) the absolute value of the difference between a particular peak or trough of the tsunami and the undisturbed sea level at the time, (2) half the difference between an adjacent peak and trough, corrected for the change of tide between that peak and trough. It is intended to represent the true amplitude of the tsunami wave at some point in the ocean. However, it is often an amplitude modified in some way by the tide gauge response.
- Tsunami period: Amount of time that a tsunami wave takes to complete a cycle, or one wavelength. Tsunami periods typically range from 5 to 60 minutes. Tsunami period is often measured as the difference between the arrival time of the highest peak and the next one measured on a water level record.
- Tsunami wavelength: The horizontal distance between similar points on two successive waves measured perpendicular to the crest. The wavelength and the tsunami period give information on the tsunami source. For tsunamis generated by earthquakes, the typical wavelength ranges from 20 to 300 km. For tsunamis generated by landslides, the wavelength is much shorter, ranging from hundreds of metres to tens of kilometres.

For more terms see IOC (2019).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Not available.

Examples of drivers, outcomes and risk management

Tsunamis are created by an underwater disturbance such as an earthquake, landslide, volcanic eruption, and meteorite or generated by meteorological or atmospheric disturbances.

Primary hazards/damage. Damage and destruction from tsunamis is the direct result of three factors: inundation, wave impact on structures, and erosion. Deaths occur by drowning and physical impact or other trauma when people are caught in the turbulent, debris-laden tsunami waves. Strong tsunami-induced currents have led to the erosion of foundations and the collapse of bridges and seawalls. Floatation and drag forces have moved houses and overturned railroad cars (IOC, 2019:6).

Tsunami associated wave forces have demolished frame buildings and other structures. Considerable damage is also caused by floating debris, including boats, cars, and trees that become dangerous projectiles that may crash into buildings, piers, and other vehicles. Ships and port facilities have been damaged by surge action caused by even weak tsunamis. Fires resulting from oil spills or combustion from damaged ships in port, or from ruptured coastal oil storage and refinery facilities, can cause damage greater than that inflicted directly by the tsunami (IOC, 2019:6).

Secondary hazards/damage can result from sewage and chemical pollution following the destruction. Damage of intake, discharge, and storage facilities can also present dangers. Of increasing concern is the potential effect of tsunami drawdown, when receding waters uncover cooling water intakes associated with nuclear power plants (IOC, 2019:7).

Risk management for tsunamis includes guidelines on tsunami risk assessment/management. Examples include IOC (2015) and UNDRR (2017).

Regional Coordination and Centres: The IOC is coordinating the implementation of a global tsunami warning system, building upon its experiences in the Pacific to establish regional warning systems for the Indian Ocean (IOTWMS); Caribbean Sea (ICG-CARIBE-EWS); and the North-eastern Atlantic, the Mediterranean and connected seas (ICG-NEAMTWS). The regional systems coordinate international tsunami warning and mitigation activities, including the issuance of timely and understandable tsunami bulletins to IOC Member States.

The Intergovernmental Coordination Group for Tsunamis addresses tsunami risk globally through the following groups:

ICG-PTWS Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System, formerly ICG/ITSU, was renamed by Resolution EC-XXXIX.8 of the IOC Executive Council in 2006 as proposed by the International Coordination Group for the Tsunami Warning System in the Pacific at its 20th Session in 2005 (Recommendation ITSU-XX.1). There are presently 46 Member States in the ICG-PTWS. ICG/ITSU, the International Coordination Group for the Tsunami Warning System in the Pacific was established by Resolution IV-6 of the 4th Session of the IOC Assembly in 1965. The Pacific Tsunami Warning Center (PTWC) serves as the Tsunami Service Provider (TSP) for the Pacific Ocean. Other TSPs for specific regions of the Pacific Ocean are the North West Pacific Tsunami Advisory Center (NWPTAC) and the South China Sea Tsunami Advisory Center (SCSTAC). The ICG-PTWS presently comprises over 40 Member States and oversees warning system operations and facilitates coordination and cooperation in all international tsunami mitigation activities.

ICG-IOTWMS The Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG-IOTWMS) was formed in response to the tragic tsunami on December 26th 2004, in which over 230,000 lives were lost around the Indian Ocean region. The ICG-IOTWMS comprises 28 Member States. There are three TSPs in the Indian Ocean, hosted by the governments of Australia, Indian and Indonesia.

ICG-NEAMTWS The Intergovernmental Coordination Group for the Tsunami Early Warning and Mitigation System in the North-eastern Atlantic, the Mediterranean and connected seas (ICG-NEAMTWS) was formed in response to the tragic tsunami on 26 December 2004, in which over 230,000 lives were lost around the Indian Ocean region (Indian Ocean Tsunami Information Centre, no date). The ICG-NEAMTWS consists of Member States bordering the North-eastern Atlantic and those bordering and within the Mediterranean and connected seas. There are currently five accredited Tsunami Service Providers (France, Greece, Italy, Portugal, Turkey) in the NEAM region providing tsunami services and alerts to subscribing Member States.

ICG-CARIBE-EWS The Intergovernmental Coordination Group for the Tsunami and Other Coastal Hazards Warning System for the Caribbean and Adjacent Regions (ICG-CARIBE-EWS) was established in 2005 and currently comprises 32 Member States and 16 Territories in the Caribbean.

Tsunami Service Providers (TSPs) are centres that monitor seismic and sea level activity and issue timely tsunami threat information within an ICG framework to National Tsunami Warning Centres (NTWCs) / Tsunami Warning Focal Points (TWFPs) and other TSPs operating within an ocean basin. The NTWCs / TWFPs may use these products to develop and issue tsunami warnings for their countries. TSPs may also issue public messages for an ocean basin and act as NTWCs providing tsunami warnings for their own countries. Currently there are nine operational TSPs.

National Tsunami Warning Centres (NTWCs) are a centre officially designated by the government to monitor and issue tsunami warnings and other related statements within their country according to established national Standard Operating Procedures.

World Tsunami Awareness Day, 5 November every year: The United Nations, through UN Resolution 70/203 adopted on 22 December 2015, has designated 5 November as World Tsunami Awareness Day (UNDRR, 2020). The day aligns with the International Day for Disaster Reduction (13 October) and the seven targets of the Sendai Framework for Disaster Risk Reduction 2015–2030 (ITIC, 2020). The IOC is a key international partner of the UNDRR on World Tsunami Awareness Day.

Tsunami Ready is a voluntary community recognition programme that promotes tsunami hazard preparedness as an active collaboration among federal, state/territorial and local emergency management agencies, community leaders and the public. The main goal of the programme is to improve public safety before, during and after tsunami emergencies. It aims to do this by establishing guidelines for a standard level of capability to mitigate, prepare for and respond to tsunamis, and working with communities to help them meet the guidelines and ultimately become recognised as 'tsunami ready' by the National Weather Service. It was first implemented in the United States .To date, there are 26 IOC-UNESCO Tsunami Ready recognised communities in 18 countries and territories, excluding those implemented in the United States.

Community engagement with evacuation zones and the 'blue lines' project In New Zealand, the Wellington Region Emergency Management Office has developed the Blue Line Project in collaboration with communities in Wellington's southern coastal suburbs. In this project, the local community helps to plan evacuation routes and safe locations based on indicative evacuation zone mapping, and blue lines are painted on the road surface at the maximum estimated tsunami inundation extent. Accompanying evacuation signage is installed. Community members are engaged early in the project, publicising the work and helping to develop blue line locations, evacuation zone maps and information boards. The communities participating in the Blue Line Project can be considered to have a higher degree of public education regarding tsunami evacuation than other communities (Fraser et al., 2016). Other communities around the world have used similar community engagement strategies.

References

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UNDRR, 2017. Words into Action Guidelines: National Disaster Risk Assessment Tsunami hazard and risk assessment. www.preventionweb.net/files/52828_02tsunamihazardandriskassessment.pdf Accessed 14 October 2020.

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UNESCO and IOC, 2019. Tsunami Glossary. http://itic.ioc-unesco.org/images/stories/about_tsunamis/tsunami_glossary/tsunami_glossary_en_v19.pdf Accessed 21 April 2021.

Coordinating agency or organisation

United Nations Educational, Scientific and Cultural Organization (UNESCO) and the Intergovernmental Oceanographic Commission (IOC-UNESCO).

MH0030 / **METEOROLOGICAL AND HYDROLOGICAL / Pressure-Related**

Depression or Cyclone (Low Pressure Area)

Definition

A depression or cyclone is a region of the atmosphere in which the pressures are lower than those of the surrounding region at the same level (WMO, 1992).

Reference

WMO, 1992. International Meteorological Vocabulary, WMO-No. 182. 2nd Edition. World Meteorological Organization (WMO). https://library.wmo.int/doc_num.php?explnum_id=4712 Accessed 13 October 2020.

Annotations

Synonyms

Low

Additional scientific description

A depression or cyclone is represented on a synoptic chart by a system of isobars at a specified altitude level (or a system of contours at a specified pressure level) which enclose relatively low values of pressure (or altitude) (WMO, 1992).

Metrics and numeric limits

A depression or area of low pressure generally refers to a low pressure area with winds below storm strength of 89 km/h (WHO, 2015).

Key relevant UN convention / multilateral treaty

Not applicable.

Examples of drivers, outcomes and risk management

Depending on the size of a depression or cyclone, the impact can extend over a very wide area, with strong winds and heavy rain. However, the greatest damage to life and property is not from the wind, but from secondary events such as storm surges, flooding, landslides and tornadoes (WHO, no date).

Factors associated with vulnerability include settlements located in low-lying coastal areas (direct impact); poor building design, or construction; insufficient lead time for warning and evacuation; noncompliance with evacuation procedures where recommended; and inadequate shelter (WHO, no date).

The main impacts include direct impacts and indirect impacts.

Direct impacts: Injuries, trauma, and asphyxiation due to entrapment are observed and result from building collapse and wind-strewn debris. Electrocution or drowning happen while securing property such as television antennas or boats (WHO, no date).

Indirect Impacts: Risk for water-borne disease and vector-transmitted disease can be exacerbated: human exposure to disease vectors can be increased due to changes in the physical environment. The impact on health infrastructures and all lifeline systems can be significant and may result in food shortages and interruption of basic public health services (water, etc) (WHO, no date). Short- and long-term mental health effects have been observed (WHO, no date).

References

WMO, 1992. International Meteorological Vocabulary, WMO-No. 182. 2nd Edition. World Meteorological Organization (WMO). https://library.wmo.int/doc_num.php?explnum_id=4712 Accessed 13 October 2020.

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Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0031 / **METEOROLOGICAL AND HYDROLOGICAL / Pressure-Related**

Extra-tropical Cyclone

Definition

An extra-tropical cyclone is a low-pressure system which develops in latitudes outside the tropics (WMO, 1992).

Reference

WMO, 1992. International Meteorological Vocabulary, WMO-No. 182. 2nd Edition. World Meteorological Organization (WMO). https://library.wmo.int/doc_num.php?explnum_id=4712 Accessed 13 October 2020.

Annotations

Synonyms

Mid-latitude storm, Baroclinic storm.

Additional scientific description

An extra-tropical cyclone is a storm system that primarily gets its energy from the horizontal temperature contrasts that exist in the atmosphere. Extra-tropical cyclones (also known as mid-latitude or baroclinic storms) are low pressure systems with associated cold fronts, warm fronts, and occluded fronts. In contrast, tropical cyclones typically have little to no temperature differences across the storm at the Earth's surface and their winds are derived from the release of energy due to cloud/rain formation from the warm moist air of the tropics (NASA, 2020).

Notes for clarification: Differences between an extra-tropical cyclone and a tropical cyclone:

- An extra-tropical cyclone is a low-pressure system that primarily gets its energy from the temperature difference in the horizontal direction across the cyclone (known as temperature gradient in meteorology). Structurally, tropical cyclones have their strongest winds near the Earth's surface, while extra-tropical cyclones have their strongest winds near the tropopause – about 8 miles (12 km) up. These differences are due to the tropical cyclone being 'warm-core' in the troposphere (below the tropopause) and the extra-tropical cyclone being 'warm-core' in the stratosphere (above the tropopause) and 'cold-core' in the troposphere. 'Warm-core' refers to being relatively warmer than the environment at the same pressure surface ('pressure surfaces' are simply another way to measure height or altitude).
- A tropical cyclone will often transform into an extra-tropical cyclone as it recurves poleward and to the east. Occasionally, an extra-tropical cyclone will lose its frontal features, develop convection near the centre of the storm and transform into a full-fledged tropical cyclone. Such a process is most common in the North Atlantic and Northwest Pacific basins. The transformation of a tropical cyclone into an extra-tropical cyclone (and vice versa) is currently one of the most challenging forecasting problems (NOAA, 2004; Hong Kong Observatory, 2019).

Extra-tropical cyclones are large rotating weather systems that occur in the extra-tropics (generally more than 30° latitude away from the equator). They consist of an approximately circular region of low surface pressure, of a radius of 100–2000 km, accompanied by cold and warm fronts. They typically develop in regions of strong horizontal temperature gradients, which are commonly denoted on a weather chart as a cold or quasi-stationary front. In turn, such fronts often connect to a pre-existing decaying extra-tropical cyclone, which itself is situated some way downstream (typically to the north-east) (CCPO, no date).

Contents

At the same time, high up in the atmosphere (around 10 km altitude) a jet stream is typically found relatively close by. In fact, the intensity of an extra-tropical cyclone is closely related to the strength of this jet stream. The strongest extra-tropical cyclones occur in the winter months when the jet stream is at its strongest. Periods when the jet stream is unusually strong can lead to two or more strong cyclones occurring within days of each other. The total lifecycle of an extra-tropical cyclone from birth (genesis) through to development and on to decay (lysis) can occasionally be more than 10 days, although somewhere in the range of 2 to 5 days is more typical (Frame et al., 2017).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Not available.

Examples of drivers, outcomes and risk management

The major hazards associated with extra-tropical cyclones are high winds and precipitation (rain and snow). Precipitation occurs primarily along fronts and, on average, is not particularly intense relative to that delivered by tropical cyclones and convective storms (Frame et al., 2017).

References

CCPO, no date. Horizontal Structure of Atmosphere. Chapter 2. Center for Coastal Physical Oceanography (CCPO). www.ccpo.odu.edu/SEES/ozone/class/Chap_2/2_4.htm Accessed 15 April 2021.

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Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0032 / **METEOROLOGICAL AND HYDROLOGICAL / Pressure-Related**

Sub-Tropical Cyclone

Definition

A sub-tropical cyclone is a non-frontal low-pressure system that has characteristics of both tropical and extratropical cyclones. Like tropical cyclones, they are non-frontal, synoptic-scale cyclones that originate over tropical or subtropical waters and have a closed surface wind circulation about a welldefined centre (WMO, 2017).

References

WMO, 2017. Regional Association IV - Hurricane Operational Plan for North America, Central America and the Caribbean. Tropical Cyclone Programme, Report No. TCP-30, World Meteorological Organization (WMO). https://library.wmo.int/doc_num.php?explnum_id=3781 Accessed 14 October 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

A sub-tropical cyclone is a low-pressure system, developing over tropical or subtropical waters which initially contains few tropical characteristics. With time the subtropical cyclone can become a tropical cyclone (WMO, 2018).

Sub-tropical cyclones have organised moderate to deep convection, but lack a central dense overcast. Unlike tropical cyclones, subtropical cyclones derive a significant proportion of their energy from baroclinic sources and are generally cold-core in the upper troposphere, often being associated with an upper-level low or trough. In comparison to tropical cyclones, these systems generally have a radius of maximum winds occurring relatively far from the centre (usually greater than 60 nautical miles), and generally have a less symmetric wind field and distribution of convection (WMO, 2017; NOAA, no date).

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

Not applicable.

Examples of drivers, outcomes and risk management

Impacts from sub-tropical cyclones are from storm surges and significant rainfall which cause flooding. Strong wind gusts can also cause impacts.

Human health can be severely affected by wind-related hazards such as subtropical cyclones and other windstorms. Direct effects occur during the impact phase of a storm, causing death and injury due to the force of the wind. Becoming airborne, being struck by flying debris or falling trees and road traffic accidents are the main dangers. Indirect effects, occurring during the pre- and post-impact phases of the storm, include falls, lacerations and puncture wounds, and occur when preparing for, or cleaning up after a storm. Power outages are a key issue and can lead to electrocution, fires and burns and carbon monoxide poisoning from gasoline powered electrical generators. Worsening of chronic illnesses due to lack of access to medical care or medication is also an issue. Other health impacts include infections and insect bites (Goldman et al., 2014).

The effects of flooding on health are extensive and significant, ranging from mortality and injuries resulting from trauma and drowning, to infectious diseases and mental health problems (acute and long-term). While some of these outcomes are relatively easy to track, ascertaining the human impact of floods is still weak. For example, it has been reported that two-thirds of deaths associated with flooding are from drowning, with the other third from physical trauma, heart attacks, electrocution, carbon monoxide poisoning and fire. Often, only immediate traumatic deaths from flooding are recorded (WHO, 2013).

Morbidity associated with floods is usually due to injuries, infections, chemical hazards and mental health effects (acute as well as delayed) (WHO, 2013). Hypothermia may also be a problem, particularly in children, if trapped in floodwaters for lengthy periods (WHO, no date). There may also be an increased risk of respiratory tract infections due to exposure (loss of shelter, exposure to flood waters and rain). Power cuts related to floods may disrupt water treatment and supply plants thereby increasing the risk of water-borne diseases and may also affect the proper functioning of health facilities, including cold chain (WHO, no date). Floods can potentially increase the transmission of the following communicable diseases: water-borne diseases (such as typhoid fever, cholera, leptospirosis and hepatitis A) and vector-borne diseases (such as malaria, dengue and dengue haemorrhagic fever, yellow fever, and West Nile Fever) (WHO, no date).

The longer-term health effects associated with a flood are less easily identified. They include effects due to displacement, destruction of homes, delayed recovery and water shortages (WHO, 2013).

References

Goldman, A., B. Eggen, B. Golding and V. Murray, 2014. The health impacts of windstorms: a systematic literature review. Public Health, 128:3-28.

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Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0033 / **METEOROLOGICAL AND HYDROLOGICAL / Precipitation-Related**

Acid Rain

Definition

Acid rain is rain which in the course of its history has combined with chemical elements or pollutants in the atmosphere and reaches the Earth's surface as a weak acid solution (WMO/UNESCO, 2012).

Reference

WMO/UNESCO, 2012. International Glossary of Hydrology. World Meteorological Organization (WMO) / United Nations Educational, Scientific and Cultural Organization (UNESCO). www.wmo.int/pages/prog/hwrp/publications/international_glossary/385_IGH_2012.pdf Accessed 15 November 2019.

Annotations

Synonyms

Not available.

Additional scientific description

Acids form when certain atmospheric gases (primarily carbon dioxide, sulphur dioxide, and nitrogen oxides) come into contact with water in the atmosphere or on the ground and are chemically converted to acidic substances. Oxidants play a major role in several of these acid-forming processes. Carbon dioxide dissolved in rain is converted to a weak acid (carbonic acid). Other gases, primarily oxides of sulphur and nitrogen, are converted to strong acids (sulphuric and nitric acids). Rain is naturally slightly acidic owing to carbon dioxide, natural emissions of sulphur and nitrogen oxides, and to certain organic acids, however, emissions from human activities can make it much more acidic. Occasional pH readings of well below 2.4 (the acidity of vinegar) have been reported in industrialised areas (NASA, 2014).

The principal natural phenomena that contribute acid-producing gases to the atmosphere are emissions from volcanoes and from biological processes that occur on land, in wetlands, and in the oceans. The effects of acidic deposits have been detected in glacial ice thousands of years old in remote parts of the globe (Pawar, no date).

The main human sources are industrial and power-generating plants, and transportation vehicles. Since the industrial revolution, emissions of sulphur and nitrogen oxides to the atmosphere have increased. Industrial and energy-generating facilities that burn fossil fuels, primarily coal, are the principal sources of increased sulphur oxide emissions (NASA, 2019).

Metrics and numeric limits

Acidity and alkalinity are measured using a pH scale for which 7.0 is neutral. The lower the pH of a substance (below 7.0), the more acidic it is. The higher the pH of a substance (above 7.0), the more alkaline it is. Normal rain has a pH of about 5.6; while the pH of acid rain is typically between 4.2 and 4.4 (US EPA, 2019).

Key relevant UN convention / multilateral treaty

The Convention on Long-range Transboundary Air Pollution ('LRTAP Convention') (UNECE, 1979) serves as an umbrella convention for the international regime on the regulation of transboundary acidification in the member states of the United Nations Economic Commission for Europe (UNECE). The USA and Canada are members of the UNECE as are all European countries. Since 1979, the LRTAP Convention has addressed some of the major environmental problems of the UNECE region through scientific collaboration and policy negotiation. The Convention has been extended by eight protocols that identify specific measures to be taken by Parties to cut their emissions of air pollutants. The Convention, which now has 51 Parties identifies the Executive Secretary of the UNECE as its secretariat.

The 1986 U.S.-Canada Air Quality Agreement is a bilateral agreement aimed at addressing the transboundary air pollution that leads to acid rain (Government of Canada, 2021). The Ozone Annex was added to the Canada-United States Air Quality Agreement (December 2000) to address the transboundary air pollution leading to high air quality levels of ground-level ozone, a major component of smog (Government of Canada, 2021). The long-term goal of the Ozone Annex is the attainment of the ozone air quality standards in both countries. Where there are transboundary flows of the pollution that creates ozone, the Ozone Annex commits both countries to reduce their emissions of nitrogen oxides and volatile organic compounds, the precursor pollutants to ground-level ozone.

Examples of drivers, outcomes and risk management

Acid rain results when sulphur dioxide (SO2) and nitrogen oxides (NOX) are emitted into the atmosphere and transported by wind and air currents, and the SO2 and NOX carried in the air react with water, oxygen and other chemicals to form sulphuric and nitric acids. These then mix with water and other materials before falling to the ground in rain. While a small proportion of the SO2 and NOX that cause acid rain is from natural sources such as volcanoes, most is from the burning of fossil fuels. The major source of SO2 and NOX in the atmosphere is burning of fossil fuels to generate electricity. Two-thirds of SO2 and a quarter of the NOX in the atmosphere are from electric power generation. Winds can transport SO2 and NOX over long distances and across national borders making acid rain an international problem, for everyone and not just those living near the emission sources (US EPA, 2019).

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Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0034 / **METEOROLOGICAL AND HYDROLOGICAL / Precipitation-Related**

Blizzard

Definition

A blizzard is a severe snow storm characterised by poor visibility, usually occurring at high-latitude and in mountainous regions (WMO, 1992).

Reference

WMO, 1992. International Meteorological Vocabulary, No. 182. World Meteorological Organization (WMO). https://library.wmo.int/doc_num.php?explnum_id=4712 Accessed 18 November 2019.

Annotations

Synonyms

In Russia 'purga' or 'metel', Snow storm.

Additional scientific description

The term blizzard is generally used in North America and Great Britain. There are differing thresholds for defining and issuing warnings for blizzards.

Metrics and numeric limits

Thresholds for defining and issuing warnings for blizzards vary by country.

In the USA, a blizzard warning is issued for winter storms with sustained or frequent winds of 35 mph (56 km/hr) or higher with considerable falling and/or blowing snow that frequently reduces visibility to 1/4 of a mile (0.4 km) or less. These conditions are expected to prevail for a minimum of 3 hours (Eye on the Sky, no date).

In the UK, a blizzard is defined as moderate or heavy falling snow (either continuous or in the form of frequent showers) with winds speeds of 30 mph (48 km/hr) or more and a reasonably extensive snow cover reducing visibility to 200 metres (0.13 miles) or less (UK Met Office, 2019).

In Canada, alerting parameters for issuing a blizzard warning include when winds of 40 km/hr or more are expected to cause widespread reductions in visibility to 400 metres (0.25 miles) or less, due to blowing snow, or blowing snow in combination with falling snow, for at least 4 hours. North of the tree line the thresholds are the same as the national thresholds except when conditions are expected to last for at least 6 hours (Government of Canada, no date).

Key relevant UN convention / multilateral treaty

Not applicable.

Examples of drivers, outcomes and risk management

A blizzard is severe winter weather characterised by strong winds, and heavy or blowing snow that causes low to zero visibility. In whiteout conditions associated with blizzards people have become lost even when going only short distances (Environment and Climate Change Canada, no date).

Winter storms create a higher risk of car accidents, hypothermia, frostbite, carbon monoxide poisoning, and heart attacks from overexertion, etc. To avoid these risks, the warnings and preventative instructions from local and national authorities should be followed.

References

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UK Met Office, 2019. Blizzards and Snow Drifts. www.metoffice.gov.uk/weather/learn-about/weather/types-of-weather/snow/blizzard Accessed 18 November 2019.

Coordinating agency or organisation

World Meteorological Organization (WMO)

MH0035 / **METEOROLOGICAL AND HYDROLOGICAL / Precipitation-Related**

Drought

Definition

A drought is a period of abnormally dry weather characterised by a prolonged deficiency of precipitation below a certain threshold over a large area and a period longer than a month (WMO, 2020).

Reference

WMO, 2020. Guidelines on the Definition and Monitoring of Extreme Weather and Climate Events. World Meteorological Organization (WMO). Final version forthcoming. www.wmo.int/pages/prog/wcp/ccl/documents/GUIDELINESONTHEDEFINTIONANDMONITORINGOFEXTREMEWEATHERANDCLIMATEEVENTS_09032018.pdf Accessed 18 November 2019.

Annotations

Synonyms

Not identified.

Additional scientific description

Drought is described as conditions that are significantly drier than normal or otherwise limiting moisture availability to a potentially damaging extent (WMO and GWP, 2016) or as conditions where there had been a prolonged absence or marked deficiency of precipitation (WMO/UNESCO, 2012).

Whereas drought may be defined simply as the absence of water, it is a complex phenomenon which is monitored over a number of time scales and often defined according to need. It is a slow-onset phenomenon that gradually intensifies and can impact many sectors of the economy and the environment (Drought Observatory, no date).

Droughts can be characterised in terms of their severity, location, duration and timing. Droughts can arise from a range of hydrometeorological processes that supress precipitation and/or limit surface water or groundwater availability. There are various drought indicators and indices that provide options for identifying the severity, location, duration onset and cessation of such conditions. It is important to note that the impacts of drought can be as varied as the causes of drought. Droughts can adversely affect agriculture and food security, hydropower generation and industry, human and animal health, livelihood security, and personal security and access to education. Such impacts depend on the socio-economic contexts in which droughts occur, in terms of who or what is exposed to the droughts and the specific vulnerabilities of the exposed entities (WMO and GWP, 2016).

The drought community has defined several different types of drought that have can general or specific sector impacts (NOAA, no date b):

- *Meteorological drought*: Occurs when dry weather patterns dominate an area. It is defined usually on the basis of the degree of dryness and the duration of the dry period.
- *Hydrological drought*: Occurs when low water supply becomes evident and is associated with the effects of periods of precipitation shortfalls on surface or subsurface water supply.
- *Agricultural drought*: Occurs when agricultural production becomes affected. It focuses on precipitation shortages, differences between actual evapotranspiration, soil water deficits, reduced groundwater and so on.
- *Socioeconomic drought*: Relates the supply and demand of some economic goods with elements of meteorological, hydrological, and agricultural drought. It also occurs when the demand for an economic good exceeds supply as a result of a weather-related shortfall in water supply.

Metrics and numeric limits

Specific indices have been created to assess drought. For example, the Palmer Drought Index and Standardized Precipitation Index (SPI), and advanced complex models (such as the National Land Data Assimilation System [NLDAS] or the Combined Drought Indicator in Europe) (European Drought Observatory, 2019) which calculate soil moisture and other hydrological variables. There are also indices used for water supply forecasting (such as the Surface Water Supply Index [SWSI]), and indices which reflect impacts on vegetation (such as the Vegetation Health Index [VHI] and Vegetation Drought Response Index [VegDRI]) (NOAA, no date c).

Indicators are variables or parameters used to describe drought conditions and these include precipitation, temperature, streamflow, groundwater and reservoir levels, soil moisture and snowpack. Indices are typically computed numerical representations of drought severity, assessed using climatic or hydrometeorological inputs. They aim to measure the qualitative state of droughts on the landscape for a given time period. Indices can simplify complex relationships and provide useful communication tools for diverse audiences and users, including the public. Indices are used to provide quantitative assessment of the severity, location, timing and duration of drought events. Severity refers to the departure from normal of an index. A threshold for severity may be set to determine when a drought has begun, when it ends, and the geographic area affected. Location refers to the geographic area experiencing drought conditions. The timing and duration are determined by the approximate dates of onset and cessation (WMO and GWP, 2016).

The World Meteorological Organization (WMO)'s Handbook of Drought Indicators and Indices provides a compendium of the most commonly used drought indicators/indices that are being applied across drought-prone regions. The indexes are grouped under: meteorology (23 indices); soil moisture (4 indices); hydrology (8 indices); remote-sensing (10 indices); and composite or modelled (5 indices). Each index is elaborated in detail with its origin, characteristics, input parameters, application, strengths, weaknesses, resources, and references (WMO and GWP, 2016). The Handbook includes many commonly used drought indicators/indices such as several versions of the Palmer Drought Indices and the Keetch-Byram Drought Index.

The Standardized Precipitation Index (SPI) is an index that considers only precipitation and it is easy to use. A period of record of at least 30 years of data is recommended, and a shorter period should only be used with caution. The SPI can be very useful when the amount of data for calculations is limited. It is can be easier to communicate in some situations than other more complex indices as it is only based on rainfall received and a comparison with historical rainfall amounts. The SPI is an index based on the probability of receiving a given amount of precipitation, and the probabilities are standardised such that an index of zero indicates the median precipitation amount (half of the historical precipitation amounts are below the median, and half are above the median). The index is negative for drought, and positive for wet conditions. The SPI can be computed from one month to 24 months, to capture both short-term and long-term conditions (WMO, 2012; NOAA, no date c). In June 2011, the Sixteenth World Meteorological Congress adopted a resolution that recommended that the SPI be used by all National Meteorological and Hydrological Services (NMHSs) around the world to characterise meteorological droughts, in addition to other drought indices that were in use in their service (WMO, 2011).

Key relevant UN convention / multilateral treaty

The United Nations Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, particularly In Africa (UNCCD, 1994). Established in 1994, the United Nations Convention to Combat Desertification (UNCCD) is the sole legally binding international agreement linking the environment and development to sustainable land management. The Convention addresses specifically the arid, semi-arid and dry sub-humid areas, known as the drylands, where some of the most vulnerable ecosystems and peoples can be found (UNCCD, 2017).

This is the most comprehensive global commitment to achieve Land Degradation Neutrality (LDN) in order to restore the productivity of vast expanses of degraded land, improve the livelihoods of more than 1.3 billion people, and reduce the impacts of drought on vulnerable populations.

The United Nations Watercourses Convention (United Nations, 1997), which entered into force on 17 August 2014.

Examples of drivers, outcomes and risk management

There has been much work on drought management. The Integrated Drought Management Programme (IDMP), co-sponsored by the WMO and the Global Partnership Water (GWP), have developed a three pillar approach to Integrated Drought Management. These pillars include: drought monitoring and early warning; drought vulnerability and impact assessment; and drought mitigation, preparedness and response. IDMP has over 35 partner organisations, including the Food and Agriculture Organization of the United Nations (FAO) and the United Nations Convention to Combat Desertification (UNCCD). IDMP developed the National Drought Management Policy Guidelines, which include a 10-step process to assist countries in developing national drought plans and polices (WMO and GWP, 2014).

Drought can have a serious impact on health, agriculture, economies, energy and the environment. An estimated 55 million people globally are affected by droughts every year, and they are the most serious hazard to livestock and crops in nearly every part of the world. Drought threatens people's livelihoods, increases the risk of disease and death, and drives mass migration. Water scarcity impacts 40% of the world's population, and as many as 700 million people are at-risk of being displaced as a result of drought by 2030 (WHO, no date a).

The probability of drought-related health impacts varies widely and largely depends upon drought severity, baseline population vulnerability, existing health and sanitation infrastructure, and available resources with which to mitigate impacts as they occur (Stanke et al., 2013). When drought causes water and food shortages there can be many impacts on the health of the affected population, which may increase the risk of disease and death. Drought may have acute and chronic health effects, including: malnutrition due to the decreased availability of food, including micronutrient deficiency (such as iron-deficiency anaemia); increased risk of infectious diseases (such as cholera, diarrhoea, and pneumonia), due to acute malnutrition, lack of water and sanitation, and displacement; psycho-social stress and mental health disorders; and disruption of local health services due to a lack of water supplies, loss of buying power, migration and/or health workers being forced to leave local areas. Severe drought can also affect air quality by making wildfires and dust storms more likely, increasing health risk in people already impacted by lung diseases, like asthma or chronic obstructive pulmonary disease (COPD), or with heart disease (WHO, no date a).

As the health cluster lead for global emergencies, the World Health Organization (WHO) works with partners to respond to drought-related disasters. This includes: ensuring appropriate food supplementation; health services, like immunisation, child and maternal health, and mental health; assembling mobile health teams and outreach; epidemic surveillance, early warning and response; and calling for emergency funding to support health action (WHO, no date a).

The WHO provides a useful Technical Hazard Sheet on drought (no date b).

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Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0036 / **METEOROLOGICAL AND HYDROLOGICAL / Precipitation-Related**

Hail

Definition

Hail is precipitation in the form of particles of ice (hailstones). These can be either transparent, or partly or completely opaque. They are usually spheroidal, conical or irregular in form, and generally 5–50 mm in diameter. The particles may fall from a cloud either separately or agglomerated in irregular lumps (WMO, 2017).

Reference

WMO, 2017. International Cloud Atlas: Hail. World Meteorological Organization (WMO). https://cloudatlas.wmo.int/hail.html Accessed 22 November 2019.

Annotations

Synonyms

Hailstone, Hailstorm.

Additional scientific description

Falls of hail always occur as showers. They are generally observed during heavy thunderstorms (WMO, 2017).

Hailstones usually form around a nucleus, that may not be at their geometric centre. The nucleus may be anywhere between a few millimetres and a centimetre in diameter. The nucleus is spheroidal or conical and is composed of ice that is usually opaque, but sometimes transparent (WMO, 2017).

Hailstones can occur with a great variety of forms and dimensions, even within a single fall. An 'onion skin' formation, for example, consists of a nucleus surrounded by alternating layers of opaque and transparent ice. There are usually not more than five layers, except in very large hailstones, which have been found to have 20 or more layers. Some other hailstones do not have any layers and consist of transparent or opaque ice only. They typically have a density of between 0.85 g/cm3 and 0.92 g/cm3 but may have a lower density if they have large cavities filled with air. Some hailstones are partly composed of spongy ice, which is a mixture of ice, water and air. In exceptional circumstances, large hailstones can stick together to form irregular lumps of giant hail (WMO, 2017).

Hailstones form when a nucleus collects cloud droplets or drops of rain. There is no general agreement on the nature of this nucleus; the tendency is, however, to admit that it is usually a particle of small hail that has formed around a snow pellet (WMO, 2017).

Metrics and numeric limits

Hail size is often estimated by comparing it to a known object. Details on scales are available from NOAA (2019).

Key relevant UN convention / multilateral treaty

Not available.

Examples of drivers, outcomes and risk management

Most hailstorms are made up of a mix of different sizes, and only the very largest hail stones pose serious risk to people caught in the open.

The destructive effects of hailstorms upon plant and animal life, buildings and property, and aircraft in flight render them a prime object of weather modification studies (AMS, 2012).

Examples of National Alerting Parameters for hail include those issued in China (China Meteorological Administration, 2012) and the United States, where a hail warning is issued when hail is forecast to be one inch or more in diameter (NOAA, 2020).

References

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Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0037 / **METEOROLOGICAL AND HYDROLOGICAL / Precipitation-Related**

Ice Storm

Definition

An ice storm involves the intense formation of ice on objects by the freezing, on impact, of rain or drizzle (WMO, 1992).

Reference

WMO, 1992. International Meteorological Vocabulary. World Meteorological Organization (WMO). https://library.wmo.int/doc_num.php?explnum_id=4712 Accessed 25 November 2019.

Annotations

Synonyms

Silver storm.

Additional scientific description

An ice storm (also called a 'silver storm') is a storm characterised by a fall of freezing precipitation. The attendant formation of glaze on terrestrial objects creates many hazards (AMS, 2012).

Ice storms result from the accumulation of freezing rain, which is rain that becomes supercooled and freezes upon impact with cold surfaces. Freezing rain is most commonly found in a narrow band on the cold side of a warm front, where surface temperatures are at or just below freezing (NWS, no date).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Heavy accumulations of ice can bring down trees and topple utility poles and communication towers. Ice can disrupt communications and power for days while utility companies repair extensive damage. Even small accumulations of ice can be extremely dangerous to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces (AMS, 2012).

The impact of ice storms can be very significant. This is illustrated by the impact of the 1998 ice storm in Canada and the United States.

Late on 4 January 1998 freezing rain began to fall on eastern Ontario, southwestern Quebec, and southern New Brunswick and Nova Scotia, Canada. This continued for six days, ending on 10 January. These areas were pelted with 80 mm or more of freezing rain and the event doubled the amount of precipitation experienced in any prior ice storm. The result was a catastrophe that produced the largest estimated insured loss (CAD 1.44 billion) in the history of Canada (Lecomte et al., 1998).

The storm slashed across northern New York and parts of Vermont, New Hampshire and Maine in the United States, leaving a vast trail of damage and destruction (approximately USD 200 million in insured losses). Nevertheless, the damage in the United States paled in contrast to that sustained in Canada (Lecomte et al., 1998).

The combined Canadian and United States insured loss stands in excess of USD 1.2 billion or CAD 1.75 billion, as of 1 October 1998 (Lecomte et al., 1998).

In Canada, 28 deaths were attributed to the storm; in the United States, 17 people lost their lives (Lecomte et al., 1998).

According to Emergency Preparedness Canada, electrical outages in the affected areas of Canada deprived 4.7 million people or 16% of the Canadian population of power. In the United States, 546,000 people were without electricity. Thus, in both countries over 5 million people were without power (heat, light and in many instances, water) in the cold of mid-winter, which intensified the human suffering (Lecomte et al., 1998).

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NWS, no date. National Weather Service (NWS) Training Site. www.weather.gov/source/zhu/ZHU_Training_Page/winter_stuff/winter_wx/winter_wx.html Accessed 13 December 2019.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0038 / **METEOROLOGICAL AND HYDROLOGICAL / Precipitation-Related**

Snow

Definition

Snow is the precipitation of ice crystals, isolated or agglomerated, falling from a cloud (WMO, 2017).

Reference

WMO, 2017. International Cloud Atlas Manual on the Observation of Clouds and Other Meteors: Snow. World Meteorological Organization (WMO). https://cloudatlas.wmo.int/snow.html Accessed 13 October 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

The form, size and concentration of ice crystals differ considerably according to the temperature and supersaturation at which they develop. A fall of snow usually includes various types of snow crystals and almost all types of crystal may be observed during a single fall of snow. Small droplets of frozen water are often attached to snow crystals. If present in great numbers, these can obscure the crystalline structure of the snow. At temperatures above about -5°C, the crystals generally clump to form snowflakes (WMO, 2017).

The National Oceanic and Atmospheric Administration (NOAA) National Severe Storms Laboratory reports the occurrence of various type of snow hazard (NOAA, 2019):

- *Snow flurries:* Light snow falling for short durations. No accumulation or light dusting is all that is expected.
- *Snow showers:* Snow falling at varying intensities for brief periods. Some accumulation is possible.
- *Snow squalls:* Brief, intense snow showers accompanied by strong, gusty winds. Accumulation may be significant. In North America, snow squalls are best known in the Great Lakes Region of Canada.
- *Blowing snow*: Wind-driven snow that reduces visibility and causes significant drifting. Blowing snow may be snow that is falling and/or loose snow on the ground picked up by the wind.
- *Blizzards*: Winds over 35 mph with snow and blowing snow, reducing visibility to 1/4 mile or less for at least 3 hours.

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Not available.

Examples of drivers, outcomes and risk management

The UK Natural Hazards Partnership has developed a short science informed guide on snow and ice that addresses transport, critical infrastructure, environmental contamination and health (UK NHP, 2013).

Road transport: The main effect of snow and ice on roads is to reduce adhesion of the surface, resulting in loss of control and collisions. On hills, loss of traction may result in vehicles being unable to progress uphill. Blockage of the road leads to disruption according to the traffic density. Road operators attempt to maintain adhesion of the surface by application of salt and grit, both prior to and during ice and snow formation. However, heavy snow at temperatures well below 0°C requires very frequent treatment which can be impossible to deliver to congested roads (UK NHP, 2013).

Rail transport: Trains are affected by loss of adhesion, and this is treated at vulnerable locations by application of sand. However, the main impacts of snow and ice on rail transport are freezing of points and loss of electrical connection between electric trains and power supply from catenaries or especially from the third rail (UK NHP, 2013).

Airports and aircraft: The lift surfaces (mainly the wings) of aircraft must be ice free for safe take-off, so any aircraft that has accumulated ice or snow while on the ground must be de-iced before take-off. This is a time-consuming procedure which can result in delays. Large civil aircraft do not generally accumulate much ice during flight and heaters keep the critical areas free. However, other aircraft flying at low levels are vulnerable to icing and must follow defined procedures to maintain safe flight. The biggest delays at airports are usually caused by snow that impedes progress along taxiways and aprons. Compared with runways, these cover a vast area and are difficult to maintain in a clear state (UK NHP, 2013).

Energy supply and telecommunications: Snow and ice accumulate on transmission cables, trees, masts and pylons, especially when the temperature is close to freezing. The additional weight can lead to sagging of cables and collapse of trees and masts. Collapse of pylons is exceptional in the UK, but has occurred in other countries in these conditions. Ice on electricity cables can affect transmission. The most frequent impacts are from falling trees that pull-down local transmission cables with them (UK NHP, 2013).

Water Supply: Low temperatures can lead to freezing and bursting of water supply pipes in the ground or in buildings, leading to loss of supply, freezing of the escaped water on surrounding roads or other surfaces, and water damage to buildings and their contents, including potential impacts of electrical short-circuits through the water, including electrical fires (UK NHP, 2013).

Environmental impact: The main effects of snow and ice on the environment are: the polluting potential from treatments used to prevent and remove ice from roads, vehicles and buildings; the polluting potential from accumulations of slurry and milk on farms due to road disruption; disposal of salt, grit and oil contaminated snow into rivers; and release of polluting materials as a result of freezing pipes etc. at industrial processes (UK NHP, 2013).

Health and health services: Health impacts of snow and ice may be divided into two categories. Cold temperatures usually coexist with snow and ice and have separate and more significant health effects.

- *Health:* The direct impacts are mainly broken bones and lacerations resulting from falls on ice covered pavements and roads. The indirect impacts are injuries resulting from accidents incurred from the impact of snow and ice on travel leading to road traffic accidents, etc. Loss of mains water supplies due to frozen pipes which burst can also be a health risk, particularly for vulnerable individuals (such as those dependent on renal dialysis). Loss of power supplies during and after a snowstorm also impacts on health, including obtaining health care supplies and continuing medical treatment for chronic illness in the community such as dialysis. Injuries/infections sustained while clearing snow after a snowstorm (UK NHP, 2013).
- *Health services*: Impacts on health services include increases in hospital admissions for acute injury and trauma from slips and falls and other ice- and snow-related incidents and acute presentation of chronic illnesses due to loss of essential services such as power, water and transport. This occurs on the background of increased demand for health services in winter, due to circulating infections such as influenza and the impact of cold temperatures on health (UK NHP, 2013).

The snowfall alert by Canada is an example of a national alerting parameter (Government of Canada, 2019).

References

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Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0039 / **METEOROLOGICAL AND HYDROLOGICAL / Precipitation-Related**

Snow Storm

Definition

A snow storm is a meteorological disturbance giving rise to a heavy fall of snow, often accompanied by strong winds (WMO, 1992).

Reference

WMO, 1992. International Meteorological Vocabulary, WMO-No. 182. World Meteorological Organization (WMO). https://library.wmo.int/doc_num.php?explnum_id=4712 Accessed 13 October 2020.

Annotations

Synonyms

Winter storm, Blizzard.

Additional scientific description

The National Severe Storms Laboratory report that three basic ingredients are necessary to make a winter storm (NOAA, no date):

- *Cold air:* Below freezing temperatures in the clouds and near the ground are necessary to make snow and/or ice.
- *Lift:* Something to raise the moist air to form clouds and cause precipitation. An example of lift is warm air colliding with cold air and being forced to rise over the cold dome. The boundary between the warm and cold air masses is called a front. Another example of lift is air flowing up a mountainside.
- *Moisture:* To form clouds and precipitation. Air blowing across a body of water, such as a large lake or the ocean, is an excellent source of moisture.

Metrics and numeric limits

Not applicable

Key relevant UN convention / multilateral treaty

Not applicable.

Examples of drivers, outcomes and risk management

Winter storms create a higher risk of car accidents, hypothermia, frostbite, carbon monoxide poisoning, and heart attacks from overexertion. Winter storms and blizzards can bring extreme cold, freezing rain, snow, ice, and high winds. A winter storm can last a few hours or several days; knock out heat, power, and communication services; and place older adults, young children, and sick individuals at greater risk (US Government, 2020).

The UK Natural Hazards Partnership has developed a short science informed guide on snow and ice that addresses transport, critical infrastructure, environmental contamination and health (UK NHP, 2013).

Road transport: The main effect of snow and ice on roads is to reduce adhesion of the surface, resulting in loss of control and collisions. On hills, loss of traction may result in vehicles being unable to progress uphill. Blockage of the road leads to disruption according to the traffic density. Road operators attempt to maintain adhesion of the surface by application of salt and grit, both prior to and during ice and snow formation. However, heavy snow at temperatures well below 0°C requires very frequent treatment which can be impossible to deliver to congested roads (UK NHP, 2013).

Rail transport: Trains are also affected by loss of adhesion, and this is treated at vulnerable locations by application of sand. However, the main impacts of snow and ice on rail transport are freezing of points and loss of electrical connection between electric trains and power supply from catenaries or especially from the third rail (UK NHP, 2013).

Airports and aircraft: The lift surfaces (mainly the wings) of aircraft must be ice free for safe take-off, so any aircraft that has accumulated ice or snow while on the ground must be de-iced before take-off. This is a time-consuming procedure which can result in delays. Large civil aircraft do not generally accumulate much ice during flight and heaters keep the critical areas free. However, other aircraft flying at low levels are vulnerable to icing and must follow defined procedures to maintain safe flight. The biggest delays at airports are usually caused by snow that impedes progress along taxiways and aprons. Compared with runways, these cover a vast area and are difficult to maintain in a clear state (UK NHP, 2013).

Energy supply and telecommunications: Snow and ice accumulate on transmission cables, trees, masts and pylons, especially when the temperature is close to freezing. The additional weight can lead to sagging of cables and collapse of trees and masts. Collapse of pylons is exceptional in the UK but has occurred in other countries in these conditions. Ice on electricity cables can affect transmission. The most frequent impacts are from falling trees that pull-down local transmission cables with them (UK NHP, 2013).

Water supply: Low temperatures can lead to freezing and bursting of water supply pipes in the ground or in buildings, leading to loss of supply, freezing of the escaped water on surrounding roads or other surfaces, and water damage to buildings and their contents, including potential impacts of electrical short-circuits through the water, including electrical fires (UK NHP, 2013).

Environmental impact: The main effects of snow and ice on the environment are: the polluting potential from treatments used to prevent and remove ice from roads, vehicles and buildings; the polluting potential from accumulations of slurry and milk on farms due to road disruption; disposal of salt, grit and oil contaminated snow into rivers; and release of polluting materials as a result of freezing pipes etc. at industrial processes (UK NHP, 2013).

Health and health services: Health impacts of snow and ice may be divided into two categories. Cold temperatures usually coexist with snow and ice and have separate and more significant health effects.

- *Health:* The direct impacts are mainly broken bones and lacerations resulting from falls on ice covered pavements and roads. The indirect impacts are injuries resulting from accidents incurred from the impact of snow and ice on travel leading to road traffic accidents, etc. Loss of mains water supplies due to frozen pipes which burst can also be a health risk, particularly for vulnerable individuals (such as those dependent on renal dialysis). Loss of power supplies during and after a snowstorm also impacts on health, including obtaining health care supplies and continuing medical treatment for chronic illness in the community such as dialysis. Injuries/infections sustained while clearing snow after a snowstorm (UK NHP, 2013).
- *Health services*: Impacts on health services include increases in hospital admissions for acute injury and trauma from slips and falls and other ice- and snow-related incidents and acute presentation of chronic illnesses due to loss of essential services such as power, water and transport. This occurs on the background of increased demand for health services in winter, due to circulating infections such as influenza and the impact of cold temperatures on health (UK NHP, 2013).

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US Government, 2020. Ready. Winter Weather. www.ready.gov/winter-weather#:~:text=Winter%20storms%20create%20a%20higher,%2C%20ice%2C%20and%20high%20winds Accessed 14 October 2020.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0040 / **METEOROLOGICAL AND HYDROLOGICAL / Temperature-Related**

Cold Wave

Definition

A cold wave is a period of marked and unusual cold weather characterised by a sharp and significant drop in air temperatures near the surface (maximum, minimum and daily average) over a large area and persisting below certain thresholds for at least two consecutive days during the cold season (WMO, 2020).

Reference

WMO, 2020. Guidelines on the Definition and Monitoring of Extreme Weather and Climate Events. World Meteorological Organization (WMO). www.wmo.int/pages/prog/wcp/ccl/documentsGUIDELINESONTHEDEFINTIONANDMONITORINGOFEXTREMEWEATHERANDCLIMATEEVENTS_09032018.pdf Accessed 18 November 2019.

Annotations

Synonyms

Not available.

Additional scientific description

In the United States, the US National Weather Service defines a cold wave as a rapid fall in temperature within 24 hours to temperatures requiring substantially increased protection to agriculture, industry, commerce, and social activities. The criterion for a cold wave is thus twofold: the rate of temperature fall, and the minimum to which it falls. The latter depends on region and time of year (AMS, 2019).

In China, a cold wave is defined as disastrous weather in winter. Cold air coming down from high latitudes strengthens quickly under special weather conditions when entering middle and low latitude areas, which will bring a sharp temperature decrease, gales and snowfall and rainfall. When southward cold air reaches a certain standard, it will become a cold wave (China Meteorological Administration, 2012). A cold wave should not be confused with a 'cold spell', which instead refers to persistently below-average temperature conditions occurring during the warm season, which can also have severe impacts on society, in particular for human health and agriculture (WMO, 2020).

Metrics and numeric limits

The World Meteorological Organization guidelines on the definition and monitoring of extreme weather and climate events advise the following (WMO, 2020):

- *Index:* Daily values of Tmax, Tmin, and/or average temperature. Another index could be computed using temperature change in the 24 hours prior to the onset of the event.
- *Threshold:* Determined based on historical values of the index.
- *Temporal:* Station-level information on starting date, ending date, and duration of the event. Persistence of conditions for a cold wave are two days.
- *Spatial:* Calculate the area affected, by providing the percentage of stations where the threshold was surpassed; locate the coordinates of the impacted stations and the center with the highest/lowest values of the indices; and optional, but recommended if resources are available, to use a geographical information system (GIS) to calculate the area affected by the event, the magnitude, and severity.

Key relevant UN convention / multilateral treaty

Not available.

Examples of drivers, outcomes and risk management

National Alerting parameters for Cold Wave Warning are available in China (China Meteorological Administration, 2012).

Human health impacts from cold waves include mortality from ischaemic heart disease and cerebrovascular disease both of which increase in cold weather. An increase in respiratory disease is generally attributed to cross-infection from indoor crowding, and the adverse effects of cold on the immune system's resistance to respiratory infection, as well as to the fact that low temperatures assist survival of bacteria in droplets (Eurowinter Group, 1997).

Living in a cold house can affect health at any age, not just in old age, for a variety of reasons. Although the extra deaths in elderly people are caused mainly by cardiovascular and respiratory disease, far greater numbers have minor ailments that lead to a huge burden of disease, costs to the health system, and misery. Compared with those who live in a warmer house, respiratory problems are roughly doubled in children, arthritis and rheumatism increase, and mental health can be impaired at any age. Adolescents who live in a cold house have a five-fold increased risk of multiple mental health problems (Dear and McMichael, 2011).

As an example, the Cold Weather Plan for England first launched in 2011 helps prevent the major avoidable effects on health during periods of cold weather in England (UK Government, 2020).

References

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Dear, K.B.G. and M.J. McMichael, 2011. The health impacts of cold homes and fuel poverty. British Medical Journal, 342. https://doi.org/10.1136/bmj.d2807

Eurowinter Group, 1997. Cold exposure and winter mortality from ischaemic heart disease, cerebrovascular disease, respiratory disease, and all causes in warm and cold regions of Europe. Lancet, 349:1341-1346.

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Zhang, X., L. Alexander, G.C. Hegerl, P. Jones, A.K. Tank, T.C. Peterson, B. Trewin and F.W. Zwiers, 2011. Indices for monitoring changes in extremes based on daily temperature and precipitation data. WIREs Climate Change, 2:851-870.

Coordinating agency or organisation

World Meteorological Organization (WMO) and World Health Organization (WHO).

MH0041 / **METEOROLOGICAL AND HYDROLOGICAL / Temperature-Related**

Dzud

Definition

A dzud (a Mongolian term that describes ‘severe winter conditions’’, sometimes spelled zud) is a cold-season disaster in which anomalous climatic (i.e., heavy snow and severe cold) and/or land-surface (snow/ ice cover and lack of pasture) conditions lead to reduced accessibility and/or availability of forage/pastures, and ultimately to high livestock mortality during winter–spring. Severe dzuds (high mortality) result from a combination of growing-season drought and severe weather (Natsagdorj and Dulamsuren, 2001; Nandintsetseg et al., 2017, 2018a,b).

References

Natsagdorj, L. and J. Dulamsuren, 2001. Some aspects of assessment of the dzud phenomena. Pap Meteorol Hydrol 23:3-18 [in Mongolian].

Nandintsetseg, B., M. Shinoda and B. Erdenetsetseg, 2017. Contributions of multiple climate hazards and overgrazing to the 2009/2010 winter disaster in Mongolia. Natural Hazards, 92:109-126.

Nandintsetseg, B., M. Shinoda, Ch. Du and E. Munkhjargal, 2018a. Cold-season disasters on the Eurasian steppes: Climate-driven or man-made. Scientific Reports, 8:14769.

Nandintsetseg, B., M. Shinoda and B. Erdenetsetseg, 2018b. Developing an early warning system of Dzud (cold-season disaster) in Mongolia. doi: 10.13140/RG.2.2.33661.72161

Annotations

Synonyms

Winter storm, Blizzard, Cold surge.

Additional scientific description

There is a conventional classification of dzud types based on direct factors contributing to conditions that prevent animals from grazing for consecutive days, finally resulting in their starvation. These include (Fernandez-Gimenez et al., 2011):

- *White dzud* defined as conditions during which grasses that grow during the summer and decay during the subsequent cold season are covered by deep snow, preventing grazing. The snow depth during these conditions substantially exceeds plant height. This is the most common and disastrous dzud type.
- *Iron (or glass) dzud* happens when grasses are covered with impenetrable ice that is produced through melted and refrozen snow (most likely occurring during spring and autumn).
- *Black dzud* refers to freezing temperatures and lack of snow in winter (essential for livestock and human water) and limited forage/pasture due to preceding summer drought.
- *Storm and cold dzuds* both tend to result from strong winds and blizzard, and cold surge conditions. These weather patterns reduce the intake of pasture by livestock, which is determined by the availability of phytomass (i.e., not covered by snow and ice) and grazing time.
- *Hoof dzud* is primarily associated with lack of pasture, often caused by overgrazing. This may occur when an excessive number of animals are concentrated in relatively good but limited pasturelands.

A combined (or multiple) dzud occurs when two or more of the above types of dzud occur together.

Note: human-induced vulnerability, including inadequate pasture management, lack of herder experience, poverty, and insufficient winter preparedness can increase the risks of dzud impacts.

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

A dzud is a compound hazard occurring in a cold dry climate, and encompassing drought, heavy snowfall, extreme cold, and windstorms. It can last all year round and can cause mass livestock mortality and dramatic socioeconomic impacts – including unemployment, poverty, and mass migration from rural to urban areas, giving rise to heavy pressure on infrastructure and social and ecosystem services (Murray et al., 2012). Dzuds occurred in Mongolia in 1944–1945, 1954–1955, 1956–1957, 1967–1968, 1976–1977, 1986–1987, 1993–1994, and 1996–1997. The dzud of 1944–1945 was a record for the 20th century with mortality of one-third of Mongolia's total livestock, with the 2009–2010 dzud causing similarly high animal mortality (Murray et al., 2012).

References

Fernandez-Gimenez, M., B. Batjav and B. Baival, 2011. Understanding Resilience in Mongolian Pastoral Social-ecological Systems. www.bing.com/search?q=There+is+a+conventional+classification+of+dzud+types+based+on+in+terms+of+direct+factors+contributing+to+conditions+that+prevent+animals+from+grazing+for+consecutive+days%2C+finally+resulting+in+their+starvation.+T%2C+these+include%3A&cvid=9e16de569cdc42ea95afd55c783565fd&FORM=ANAB01&PC=U531 Accessed 16 April 2021.

Murray, V., G. McBean, M. Bhatt, S. Borsch, T.S. Cheong, W.F. Erian, S. Llosa, F. Nadim, M. Nunez, R. Oyun, and A.G. Suarez, 2012. Case studies. In: Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, pp. 487-542. www.ipcc.ch/site/assets/uploads/2018/03/SREX-Chap9_FINAL-1.pdf Accessed 8 October 2020.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0042 / **METEOROLOGICAL AND HYDROLOGICAL / Temperature-Related**

Freeze

Definition

A freeze is an air temperature equal to or less than the freezing point of water (D °C) (adapted from WMO, 1992).

Reference

WMO, 1992. International Meteorological Vocabulary. World Meteorological Organization (WMO). https://library.wmo.int/doc_num.php?explnum_id=4712 Accessed 18 November 2019.

Annotations

Synonyms

Frost, Freeze event, Killing frost.

Additional scientific description

Technically, the word 'frost' refers to the formation of ice crystals on surfaces, either by freezing of dew or a phase change from vapour to ice; however, the word is widely used by the public to describe a meteorological event when crops and other plants experience freezing injury (FAO, 2005).

Growers often use the terms 'frost' and 'freeze' interchangeably, with the vague definition being 'an air temperature less than or equal to 0°C'. A 'frost' is the occurrence of an air temperature of 0°C or lower, measured at a height of between 1.25 and 2.0 m above soil level, inside an appropriate weather shelter. Water within plants may or may not freeze during a frost event, depending on several avoidance factors (e.g., supercooling and concentration of ice nucleating bacteria). A 'freeze' occurs when extracellular water within the plant freezes (i.e., changes from liquid to ice) (FAO, 2005).

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

The economic losses due to a widespread freeze event can be enormous. Direct crop losses can exceed a billion dollars. According to the United States National Climatic Data Center, five of the billion-dollar weather disasters over the past 30 years have been caused by agricultural freezes (Brotak, 2014).

A number of different methods are available for preventing freeze damage to crops. It is important for growers to be aware of these so that they can evaluate which procedures are feasible and economical for combating freeze damage. The methods are described in terms of active and passive techniques. Active methods are those which are used when the danger of a freeze event is present and include such techniques as adding heat and covering crops. Passive methods are those used well in advance of the freeze event and include scheduling of planting and harvesting within the safe freeze-free period, and appropriate crop and field selection, among others (Canadian Ministry of Agriculture, Food and Rural Affairs, 1985).

References

Brotak, E., 2014. The big freeze: frost's costly impact on agriculture. Weatherise, 67:30-35.

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FAO, 2005. Frost Protection: fundamentals, practice and economics. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/3/a-y7223e.pdf Accessed 2 November 20202.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0043 / **METEOROLOGICAL AND HYDROLOGICAL / Temperature-Related**

Frost (Hoar Frost)

Definition

A hoar frost is a deposit of ice produced by the deposition of water vapour from the surrounding air and is generally crystalline in appearance (WMO, 2017).

Reference

WMO, 2017. International Cloud Atlas: Hoar Frost. World Meteorological Organization (WMO). https://cloudatlas.wmo.int/hoar-frost.html Accessed 1 November 2020.

Annotations

Synonyms

Rime, Advection hoar frost, Radiation frost.

Additional scientific description

There are two types of hoar frost: hoar frost (proper) and advection hoar frost.

Hoar frost: A deposit of ice that generally assumes the form of scales, needles, features or fans and which forms on objects the surface of which is sufficiently cooled, generally by nocturnal radiation, to bring about the deposition of the water vapour contained in the ambient air. Hoar frost proper is ordinarily deposited on objects at or near the ground, mainly on their horizontal surfaces. Hoar frost is observed especially during the cold part of the year when the air is calm and the sky is clear (WMO, 2017).

Advection hoar frost: A deposit of ice that generally assumes crystalline form and which forms on objects, the surface of which is sufficiently cold to bring about deposition of the water vapour contained in the air coming into contact with this surface, usually through a process of advection. Advection hoar frost is deposited mainly on vertical exposed surfaces. It is observed when relatively warm damp air suddenly invades a region where the temperature of the exposed surfaces is below 0°C and below the frost-point of the advected air (WMO, 2017).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

The Australian Government provides guidance on the impact of frost damage (Australian Government, 2014). Clear, calm and dry nights following cold days are the precursor conditions for a hoar frost. These conditions are most often met during winter and spring when high pressures follow a cold front, bringing cold air from the Southern Ocean into settled cloudless weather. When the loss of heat from the earth during the night decreases the temperature at ground level to zero, a frost occurs. Wind and cloud reduce the likelihood of frost by decreasing the loss of heat to the atmosphere. The extent of frost damage is determined by how quickly the temperature takes to get to zero, the length of time temperatures stay below zero, and how far below zero the temperature falls (Australian Government, 2014).

In Australia, frost damage occurs to legume pods and seeds, canola pods, flowers and seeds and cereal grains, flowers, or whole heads if the stem freezes around the flag leaf or in the boot. Flowering wheat, triticale, podding canola and field peas are some of the most sensitive crops to frost. Barley and oats are the most tolerant (Australian Government, 2014).

References

Australian Government, 2014. Frost Damage tin crops – where to from here? Grains Research and Development Corporation. https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2014/03/frost-damage-in-crops-where-to-from-here Accessed 1 November 2020.

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Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0044 / **METEOROLOGICAL AND HYDROLOGICAL / Temperature-Related**

Freezing Rain (Supercooled Rain)

Definition

Freezing rain is rain where the temperature of the water droplets is below 0°C. Drops of supercooled rain may freeze on impact with the ground, in-flight aircraft or other objects (WMO, 2017).

Reference

WMO, 2017. International Cloud Atlas Manual on the Observation of Clouds and Other Meteors. WMO-No. 407. World Meteorological Organization (WMO). https://cloudatlas.wmo.int/en/supercooled-rain.html Accessed 25 November 2019.

Annotations

Synonyms

Freezing drizzle.

Additional scientific description

Freezing rain or freezing drizzle is precipitation that first falls in liquid form but then descends through a layer of cold air. If this layer is thick enough and the air temperature is below freezing, the precipitation freezes on contact with the ground (or an object that is below freezing temperature), forming a coating of ice on its surface. Driving, and even walking can be dangerous in such conditions. Ice-coated utility lines or poles can be brought down due to the excess weight of the ice (Environment and Climate Change Canada, 2019).

Freezing rain can sometimes land on surfaces exposed to the air (such as tree limbs) in air temperatures slightly above freezing in strong winds. Local evaporational cooling may result in freezing. Freezing rain frequently occurs, therefore, as a transient condition between the occurrence of rain and ice pellets (sleet). When encountered by an aircraft in flight, freezing rain can cause a dangerous accretion of clear icing (AMS, 2012).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Freezing rain is a rare type of liquid precipitation that strikes a cold surface and freezes almost instantly. The weight of the ice can sometimes be enough to bring down trees and power lines, and the glaze of ice on the ground ('black ice') effectively turns roads and pathways into an ice rink. The freezing rain can also be extremely hazardous for aircraft (UK Met Office, no date).

Freezing rain tends to occur in those parts of the world, for example the USA, where weather systems can produce freezing rain. These are associated with ice storms, and if enough glaze collects on trees or power lines, the weight of the ice can cause them to break and result in large-scale disruption (UK Met Office, no date).

The impact of freezing rain leading to ice storms can be significant. This is illustrated by the impact of the 1998 ice storm in Canada and the United States.

Late on 4 January 1998 freezing rain began to fall on eastern Ontario, southwestern Quebec, and southern New Brunswick and Nova Scotia, Canada. This continued for six days, ending on 10 January. These areas were pelted with 80 mm or more of freezing rain and the event doubled the amount of precipitation experienced in any prior ice storm. The result was a catastrophe that produced the largest estimated insured loss (CAD 1.44 billion) in the history of Canada (Lecomte et al., 1998).

The storm slashed across northern New York and parts of Vermont, New Hampshire and Maine in the United States, leaving a vast trail of damage and destruction (approximately USD 200 million in insured losses). Nevertheless, the damage in the United States paled in contrast to that sustained in Canada (Lecomte et al., 1998).

The combined Canadian and United States insured loss stands in excess of USD 1.2 billion or CAD 1.75 billion, as of 1 October 1998 (Lecomte et al., 1998).

In Canada, 28 deaths were attributed to the storm; in the United States, 17 people lost their lives (Lecomte et al., 1998).

According to Emergency Preparedness Canada, electrical outages in the affected areas of Canada deprived 4.7 million people or 16% of the Canadian population of power. In the United States, 546,000 people were without electricity. Thus, in both countries over 5 million people were without power (heat, light and in many instances, water) in the cold of mid-winter, which intensified the human suffering (Lecomte et al., 1998).

In terms of national alerting thresholds, Canada issues a freezing rain warning when freezing rain is expected to pose a hazard to transportation or property, or when freezing rain is expected for at least two hours (in some provinces four hours) (Environment Canada, no date). A winter weather watch is issued in the USA when any accretion of freezing rain or freezing drizzle on road surfaces is observed. A winter storm warning is issued when a half inch (1.3 cm) or greater accretion of freezing rain is expected (NOAA, no date).

References

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Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0045 / **METEOROLOGICAL AND HYDROLOGICAL / Temperature-Related**

Glaze

Definition

Glaze is a smooth compact deposit of ice, generally transparent, formed by the freezing of super-cooled drizzle droplets or raindrops on objects with a surface temperature below or slightly above 0°C (WMO, 2017).

Reference

WMO, 2017. International Cloud Atlas: Glaze. World Meteorological Organization (WMO). https://cloudatlas.wmo.int/glaze.html Accessed 20 November 2019.

Annotations

Synonyms

Not available.

Additional scientific description

The deposit of ice formed by the freezing of fog or cloud droplets not supercooled at the time of impact with objects at temperatures well below 0°C, is known as glaze. Glaze on the ground must not be confused with ground ice which, on a road surface, is known as 'black ice' (WMO, 2017).

Glaze covers all parts of surfaces exposed to precipitation. It is generally fairly homogeneous and morphologically resembles clear ice. At or near the ground, glaze forms when drizzle droplets or raindrops become supercooled as they fall through a layer of air at a sub-frost point temperature. In the free atmosphere, glaze is observed when aircraft are exposed to supercooled precipitation. Glaze forms by the slow freezing of supercooled liquid water and so penetrates the air gaps between the particles of ice before freezing (WMO, 2017).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Not available.

Examples of drivers, outcomes and risk management

Glaze is denser, harder, and more transparent than either rime or hoarfrost. Its density may be as high as 0.8 or 0.9 g/cm3. Factors that favour glaze formation are large drop size, rapid accretion, slight supercooling, and slow dissipation of heat of fusion. The opposite effects favour rime formation. The accretion of glaze on terrestrial objects constitutes an ice storm; as a type of aircraft icing it is called clear ice. Glaze, as well as rime, may form on ice particles in the atmosphere. Ordinary hail is composed entirely (or nearly so) of glaze; the alternating clear and opaque layers of some hailstones represent glaze and rime, deposited under varying conditions around the growing hailstone (AMS, 2012).

References

AMS, 2012. Glossary of Meteorology: Glaze. American Meteorological Society (AMS). http://glossary.ametsoc.org/wiki/Glaze Accessed 20 November 2019.

WMO, 2017. International Cloud Atlas: Glaze. World Meteorological Organization (WMO). https://cloudatlas.wmo.int/glaze.html Accessed 13 October 2020.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0046 / **METEOROLOGICAL AND HYDROLOGICAL / Temperature-Related**

Ground Frost

Definitions

Ground frost is a covering of ice, in one of its many forms, produced by the sublimation of the water vapour on objects colder than 0°C (WMO, 1992).

Ground frost occurs when the temperature of the upper layer of the soil is less than 0°C (WMO, 1992).

Reference

WMO, 1992. International Meteorological Vocabulary. WMO-No. 182. World Meteorological Organization (WMO). https://library.wmo.int/doc_num.php?explnum_id=4712 Accessed 13 October 2020.

Annotations

Synonym

Frost.

Additional scientific description

A ground frost refers to the formation of ice on the ground, objects or trees, whose surfaces have a temperature below the freezing point of water. During situations when the ground cools faster than the air, a ground frost can occur without an air frost. A grass frost, an un-official type of ground frost, can occur when other surfaces – such as concrete or road surfaces – do not experience a frost, due to their better ability to retain warmth. It is possible for a grass frost to occur in late spring or even early summer when the risk of more widespread frosts has disappeared (UK Met Office, 2019).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Not available.

Examples of drivers, outcomes and risk management

The Food and Agriculture Organization of the United Nations (FAO) has published a summary of frost protection methods. Rather than cold temperature, frost damage to crops results mainly from extracellular (i.e., not inside the cells) ice formation inside plant tissue, which draws out water and dehydrates the cells causing injury to the cells. Following cold periods, plants tend to harden against freeze injury, and lose this hardening after a warm spell. A combination of these and other factors determine the temperature at which ice forms inside the plant tissue and when damage occurs (FAO, no date).

The FAO recommends risk management methods which include passive and active protection methods:

- Passive protection includes methods that are implemented before a frost night to help avoid the need for active protection. The main passive methods are site selection; managing cold air drainage; plant selection; canopy trees; plant nutritional management; proper pruning; plant covers; avoiding soil cultivation; irrigation; removing cover crops; soil covers; trunk painting and wraps bacteria control; and planting date for annual crops. Passive methods are usually less costly than active methods and often the benefits are sufficient to eliminate the need for active protection (FAO, no date).

- Active protection methods include heaters; wind machines; helicopters; sprinklers; surface irrigation; foam insulation; and combinations of methods. All methods and combinations of methods are undertaken during a frost night to mitigate the effects of sub-zero temperatures. The cost of each method varies depending on local availability and costs. In some cases, a frost protection method has multiple uses (e.g., sprinklers can also be used for irrigation) and the benefits from other uses need to be subtracted from the total cost to evaluate fairly the benefits in terms of frost protection (FAO, no date).

Examples of national alerting parameters include those for a Frost Advisory by Canada (Government of Canada, 2019) and a Frost Warning by China (China Meteorological Administration, 2012).

References

China Meteorological Administration, 2012. Weather Warnings: Frost. www.cma.gov.cn/en/WeatherWarnings/WarningSignals/201203/t20120320_166759.html Accessed 19 November 2019.

FAO, no date. Recommended Methods Of Frost Protection. Chapter 2. Food And Agriculture Organization of The United Nations (FAO). www.fao.org/3/y7223e/y7223e08.htm Accessed 13 October 2020.

Government of Canada, 2019. Alerting Parameters Environment Canada uses for Issuing a Frost Advisory. www.canada.ca/en/environment-climate-change/services/types-weather-forecasts-use/public/criteria-alerts.html#frost Accessed 19 November 2019.

UK Met Office, 2019. What is frost? www.metoffice.gov.uk/weather/learn-about/weather/types-of-weather/frost-and-ice/frost Accessed 21 November 2019.

Coordinating agency or organisation

World Meteorological Organization.

MH0047 / **METEOROLOGICAL and HYDROLOGICAL / Temperature-related**

Heatwave

Definition

A heatwave is a marked warming of the air, or the invasion of very warm air, over a large area; it usually lasts from a few days to a few weeks (WMO, 1992).

Alternative definition: A heatwave is a marked unusual period of hot weather over a region persisting for at least two consecutive days during the hot period of the year based on local climatological conditions, with thermal conditions recorded above given thresholds (WMO, 2020).

References

WMO, 1992. International Meteorological Vocabulary. WMO-No. 182. World Meteorological Organization (WMO) https://library.wmo.int/doc_num.php?explnum_id=4712 Accessed 22 November 2019.

WMO, 2020. Event Types of Hazards and Extreme Events (Draft). World Meteorological Organization (WMO). www.wmo.int/pages/prog/wcp/wcdmp/meeting/documents/Catalogue_Hazards_Extreme_Events_WMO_091117.pdf Accessed 9 November 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

The World Meteorological Organization (WMO) uses a definition that has practical utility in addressing human health impacts. It defines heatwaves as, “periods of unusually hot and dry or hot and humid weather that have a subtle onset and cessation, a duration of at least two to three days and a discernible impact on human activities” (WMO and WHO, 2015).

However, this definition is not sufficient to guide National Meteorological and Hydrological Services in developing practical methods and tools for a heatwave monitoring system that would allow comparisons across regional or international borders. Common characteristics of heatwaves such as magnitude, duration, extent, severity, and timing of the event during the heat season, are often used to compare heatwave events (Global Heat Health Information Network, 2020).

Heatwaves differ from warm spells. Similar to heatwaves, warm spells are defined as a persistent period of abnormally warm weather in a location. A warm spell can similarly be defined in terms of the 90th or 95th percentile of daily maximum temperature (Tmax). A warm spell occurs at any time of the year, whereas heatwaves can only occur in the warm season (WMO, 2020).

Metrics and numeric limits

It is not possible to adopt universal numeric limits to characterise heatwaves, because heatwave conditions are locally defined and can vary significantly at sub-national scales, due to influences of geography and topography, built environment, and atmospheric and other conditions. International technical efforts instead focus on the adoption of consistent approaches for allowing countries to define and monitor heatwaves on an operational basis, based on their local conditions, applications requirements, and other descriptive characteristics.

National warning systems use a range of diverse indices of multiple combined variables and locally defined thresholds to describe excessive or dangerous heat conditions. Examples of national parameters used to define heat warnings include those for Canada (Environment and Climate Change Canada, 2019), China (China Meteorological Administration, 2012), Switzerland (MeteoSwiss, 2019), United States (NOAA, 2019), Republic of Korea (KMA, 2019), and India (Government of India, 2020).

Many heatwave definitions use bio-meteorological or holistic indices to better characterise heat risk, including:

- *Bio-meteorological Indices*: heat index, humidex, apparent temperature, excess heat index, human energy-budget based indices (e.g., standard effective temperature, perceived temperature, physiological equivalent temperature, universal thermal climate index) (Zare et al., 2018).
- *Holistic approach:* wet-bulb globe temperature, health-related assessment of the thermal environment, Heat Stress Index, Excess Heat Index-acclimatization, Excess heat factor (Zare et al., 2018).

The WMO guidelines on the definition and monitoring of extreme weather and climate events (WMO, 2021) seek to provide guidance on defining, characterising, monitoring and reporting information on extreme weather and climate events on an operational basis. It is expected that adherence to these guidelines by the meteorological community will provide a basis for attributing extreme weather and climate events and for verifying forecasting and prediction services (WMO, 2020).

Key relevant UN convention / multilateral treaty

United Nations Framework Convention on Climate Change (UNFCCC) (UN General Assembly, 1994).

Sendai Framework for Disaster Risk Reduction (UNDRR, 2015).

United Nations Framework Convention to Combat Desertification (UNCCD, 1994).

Examples of drivers, outcomes and risk management

Drivers: Persistent, abnormally high temperatures can be caused by a variety of climate and weather phenomena, but the principal driver of a heatwave is a strong and slow-moving high pressure system that remains in place over an area for a period of time. In some cases, these systems are held in place by an atmospheric blocking pattern, such as an omega block, which is a pair of low pressure zones that surround a high pressure zone and serve to lock it in place for an extended period. Climate change is monitored through observed increases in heatwave frequency, intensity, and magnitude. Other drivers of heatwaves include longer-term climate patterns such as the El Niño Southern Oscillation (ENSO), weather extremes such as tropical storms, and climatic extremes such as droughts, which rob the soil of moisture and can increase the intensity of heat events (Global Heat Health Information Network, 2020).

Heatwave outcomes: Heatwaves, warm spells and high temperatures have significant impacts on human and animal health, worker productivity, agricultural production, ecosystems and economies. The built environment and critical infrastructure that supports society, such as buildings, water, transportation and energy systems are also adversely affected by heatwaves (Boyle et al., 2010).

Risk management: Heatwaves interact with and amplify the impacts, magnitude, and severity of other hazards such as wildfire, drought, cyclones, urban heat islands, and hazardous air quality. A multi-hazard risk management approach is therefore recommended for heatwaves, including early warning systems and planning. In urban areas, consideration of night-time temperatures and urban heat island effects is important for determining appropriate thresholds for heatwave advisories. Essential components of health impact-orientated warning systems and early action for heatwaves, include assessments of heatwaves and health impacts, definitions and methodologies, communication of warnings, intervention strategies, and longer-term planning perspectives for managing heatwave events (WMO and WHO, 2015).

References

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Zare, S., N. Hasheminejad, H. Shirvan, R. Hemmatjo, K. Sarebanzade and S. Ahmadi, 2018. Comparing Universal Thermal Climate Index (UTCI) with selected thermal indices/environmental parameters during 12 months of the year. Weather and Climate Extremes, 19:49-57.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0048 / **METEOROLOGICAL AND HYDROLOGICAL / Temperature-Related**

Icing (Including Ice)

Definition

Icing refers to any deposit or coating of ice on an object caused by the impact of liquid hydrometeors, usually supercooled (WMO, 1992).

Reference

WMO, 1992. International Meteorological Vocabulary. WMO-No. 182. World Meteorological Organization (WMO). https://library.wmo.int/doc_num.php?explnum_id=4712 Accessed on 25 November 2019.

Annotations

Synonyms

Not identified.

Additional scientific description

Icing, in general, is any deposit or coating of ice on an object, caused by the impingement and freezing of liquid (usually supercooled) hydrometeors; to be distinguished from hoar frost in that the latter results from the deposition of water vapour (NOAA, 2019).

An ice deposit may form on different parts of an aircraft when flying in supercooled clouds or precipitation. The intensity and characteristics of the icing vary, but depend primarily on the degree of supercooling, the droplet diameters and concentration, and the characteristics of the airflow around the aircraft. The main types of icing are soft rime, hard rime, clear ice, and glaze (WMO, 2017, 2020a,b,c,d).

Necessary conditions for icing include air temperatures at or below 0°C and supercooled liquid water droplets or wet snow-flakes.

However, If an aircraft has been in below freezing temperatures and then in above freezing temperatures, the aircraft's surface temperature can remain below freezing for some time. Thus, icing still may be possible in ambient temperatures above freezing (NOAA, 2019).

NOTE: Supercooled liquid water droplets are predominantly found at temperatures ranging from 0°C to -20°C. Although rare, small amounts of supercooled water droplets can be found at temperatures as low as -40°C. The smaller and purer the droplets, the lower their freezing points.

NOTE: When a supercooled droplet strikes an object such as the surface of an aircraft, the impact destroys the internal stability of the droplet and raises its freezing temperature. This is known as aerodynamic heating – the temperature rise resulting from adiabatic compression and friction as the aircraft penetrates the air (NOAA, 2019).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Factors which affect the icing threat for aeroplanes include: particle size; particle concentration; shape of aircraft surfaces; aircraft speed; environmental temperature; and aircraft surface temperature (must be 0°C or less) (NOAA, 2019). This table illustrates icing effects on primary forces and the resulting effect on aircraft (NOAA, 2019).

Primary force	Icing effect on force	Resulting effect on aircraft
Lift	Decreased	Excessive loss of lift will cause aircraft to lose altitude
Weight	Increased	Excessive weight will cause aircraft to lose altitude
Thrust	Decreased	Excessive loss of thrust will cause aircraft to lose airspeed and lift
Drag	Decreased	Excessive drag will cause aircraft to lose airspeed and lift

Heavy accumulations of ice can bring down trees and topple utility poles and communication towers. Ice can disrupt communications and power for days while utility companies repair extensive damage. Even small accumulations of ice can be extremely dangerous to motorists and pedestrians. Bridges and overpasses are particularly dangerous because they freeze before other surfaces (AMS, 2012).

An example of a National Alerting Parameter for icing is that by China for road icing (China Meteorological Administration, 2012).

References

AMS, 2012. Glossary of Meteorology: Ice storm. American Meteorological Society (AMS). http://glossary.ametsoc.org/wiki/Ice_storm Accessed 25 November 2019.

China Meteorological Administration, 2012. Weather Warnings: Road Icing. www.cma.gov.cn/en/WeatherWarnings/Warning-Signals/201203/t20120320_166766.html Accessed 25 November 2019.

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WMO, 2017. International Cloud Atlas: Icing. World Meteorological Organization (WMO). https://cloudatlas.wmo.int/en/icing.html Accessed 13 October 2020.

WMO, 2020a. Soft Rime. World Meteorological Organization (WMO). https://cloudatlas.wmo.int/en/soft-rime.html Accessed 16 April 2021.

WMO, 2020b. Hard Rime. World Meteorological Organization (WMO). https://cloudatlas.wmo.int/en/hard-rime.html Accessed 16 April 2021.

WMO, 2020c. Clear Ice. World Meteorological Organization (WMO). https://cloudatlas.wmo.int/en/clear-ice.html Accessed 16 April 2021.

WMO, 2020d. Glaze. World Meteorological Organization (WMO). https://cloudatlas.wmo.int/en/glaze.html Accessed 16 April 2021.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0049 / **METEOROLOGICAL AND HYDROLOGICAL / Temperature-Related**

Thaw

Definition

Thaw is the melting of snow or ice at the Earth's surface due to a temperature rise above 0°C (WMO, 1992).

Reference

WMO, 1992. International Meteorological Vocabulary. WMO-No. 182. World Meteorological Organization (WMO). https://library.wmo.int/doc_num.php?explnum_id=4712 Accessed 13 October 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

Additional definitions of thaw include:

To melt a substance, ice for example, by warming it to a temperature greater than the melting point of the substance, or to have frozen contents melted (AMS, 2012).

To free something from the binding action of ice by warming it to a temperature above the melting point of ice (AMS, 2012).

A warm spell when ice and snow melt, for example, 'January thaw' (AMS, 2012).

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

Not applicable.

Examples of drivers, outcomes and risk management

A spring thaw is when warmer temperatures and resulting snow melt can produce large amounts of runoff in a short period of time, as each cubic foot of compacted snow contains gallons of water. During early spring, frozen land prevents melting snow or rainfall from seeping into the ground. The water then runs off the surface and flows into lakes, streams, and rivers, causing excess water to spill over their banks. The addition of seasonal storms can result in severe spring flooding (US FEMA, no date).

The effects of flooding on health are extensive and significant, ranging from mortality and injuries resulting from trauma and drowning to infectious diseases and mental health problems (acute and long-term). While some of these outcomes are relatively easy to track, ascertaining the human impact of floods is still weak. For example, it has been reported that two-thirds of deaths associated with flooding are from drowning, with the other third from physical trauma, heart attacks, electrocution, carbon monoxide poisoning and fire. Often, only immediate traumatic deaths from flooding are recorded (WHO, 2013).

Morbidity associated with floods is usually due to injuries, infections, chemical hazards and mental health effects (acute as well as delayed) (WHO, 2013). Hypothermia may also be a problem, particularly in children, if trapped in floodwaters for lengthy periods (WHO, no date). There may also be an increased risk of respiratory tract infections due to exposure (loss of shelter, exposure to flood waters and rain). Power cuts related to floods may disrupt water treatment and supply plants thereby increasing the risk of water-borne diseases but may also affect proper functioning of health facilities, including cold chain (WHO, no date). Floods can potentially increase the transmission of the following communicable diseases: water-borne diseases (such as typhoid fever, cholera, leptospirosis and hepatitis A) and vector-borne diseases (such as malaria, dengue and dengue haemorrhagic fever, yellow fever, and West Nile Fever) (WHO no date).

The longer-term health effects associated with a flood are less easily identified. They include effects due to displacement, destruction of homes, delayed recovery and water shortages (WHO, 2013).

References

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WHO, 2013. Floods in the WHO European Region: Health effects and their prevention. Regional Office for Europe, World Health Organization (WHO). https://apps.who.int/iris/handle/10665/108625 Accessed 2 October 2020.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0050 / **METEOROLOGICAL AND HYDROLOGICAL / Terrestrial**

Avalanche

Definition

An avalanche is a mass of snow and ice falling suddenly down a mountain slope and often taking with it earth, rocks and rubble of every description (WMO, 1992).

Reference

WMO, 1992. International Meteorological Vocabulary. WMO-No. 182. World Meteorological Organization (WMO). https://library.wmo.int/doc_num.php?explnum_id=4712 Accessed 4 December 2019.

Annotations

Synonyms

Not identified.

Additional scientific description

An avalanche is a rapid flow of snow down a hill or mountainside (NSIDC, 2021). Although avalanches can occur on any slope given the right conditions, certain times of the year and certain locations are more dangerous than others. Winter, particularly from December to April in the Northern Hemisphere, is when most avalanches tend to happen (NSIDC, no date).

There are different types of avalanche (SLF, no date a):

- *Loose snow avalanches* start from a single point and form when snow is not well bonded. A loose snow avalanche consisting of dry powder generally requires a slope angle of 40°. In very steep terrain, as individual snow particles become loose, roll downwards and bump into more particles, they form an inverted-V-shaped avalanche. Because loose snow avalanches usually carry less snow and travel more slowly than slab avalanches, they are also less dangerous.
- *Slab avalanches* can only form when the snowpack comprises multiple layers of snow. Slab avalanches are characterised by the simultaneous release of a cohesive snow layer (slab). Steeper than around 30°, slab avalanches are usually bigger than a typical skier avalanche (which is on average 50 m wide, 150–200 m long and 50 cm thick) and reach speeds of 50–100 km/h.
- *Gliding avalanches*, like slab avalanches, have a distinct, broad fracture line, but differ from other types of avalanches in as much as the entire snowpack is released. The slope must be sufficiently steep, but gliding can occur at a slope angle of just 15°. Gliding avalanches can occur only on a smooth substrata, typically consisting of flattened grass or slabs of rock.
- *Powder avalanches* arise mostly from slab avalanches. A powder cloud forms in the presence of a large altitude difference when a sufficient quantity of snow becomes suspended in the air. Powder avalanches can reach speeds of 300 km/h and cause tremendous damage.
- *Wet-snow avalanches* are usually triggered naturally, most often by a big rise in temperature. Meltwater or occasionally rainwater penetrating the snowpack weakens the bonds between the snow crystals, thereby destabilising layers in which the water accumulates. Both loose snow avalanches and slab avalanches can consist of wet snow.

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Avalanche danger is enhanced in some circumstances, commonly in windy conditions on fresh snow slopes; when there is rapid, significant, warming of the snow to above 0°; and on steeper, shadier slopes (White risk, no date).

Avalanche protection and control measures include early warning which is key. The European Avalanche Warning Services (EAWS) brings together 29 avalanche warning services from 16 countries (EAWS, 2020).

By way of controlled explosions, artificial avalanche triggering aims temporarily to safeguard possible starting zones, avalanche paths and deposition zones, and to prevent large avalanches and lengthy closures (SLF, no date b).

Defensive structures prevent the formation of avalanches. In other circumstances, when an avalanche is released, it can be diverted or intercepted by a dam. Other means of protection against avalanches include physical structures for buildings and snow sheds. In order to stop an avalanche completely, depending on its speed, a dam may need to be more than 20 m high. Many dams have a dual function: they protect against avalanches in winter, and against flooding and debris flows once the snow has melted. Snow sheds are known as avalanche galleries or tunnels, and are the classic structures for protecting transportation routes. Among the typical measures for protecting buildings are wall reinforcement, the erection of a solid structure (Spaltkeil), which is rather like a log splitting wedge, to break the avalanche, and a building design (Ebenhöch) in which the roof seamlessly merges with the terrain or an embankment (SLF, no date c).

References

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Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0051 / **METEOROLOGICAL AND HYDROLOGICAL / Terrestrial**

Mud Flow

Definition

A mud flow is a flow of water so heavily charged with sediment and debris that the flowing mass is thick and viscous (WMO and UNESCO, 2012).

Reference

WMO and UNESCO, 2012. International Glossary of Hydrology. WMO-No.385. World Meteorological Organization (WMO) and United Nations Educational, Scientific and Cultural Organization (UNESCO). www.wmo.int/pages/prog/hwrp/publications/international_glossary/385_IGH_2012.pdf Accessed 13 October 2020.

Annotations

Synonyms

Hyperconcentrated flow, Land slide, Debris flow.

Additional scientific description

A flow is a spatially continuous movement in which the surfaces of shear are short-lived, closely spaced, and usually not preserved. The component velocities in the displacing mass of a flow resemble those in a viscous liquid. Often, there is a gradation of change from slides to flows, depending on the water content, mobility, and evolution of the movement. Debris flows and mudflows usually occur in small, steep stream channels and are commonly mistaken for floods (Highland and Bobrowsky, 2008).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Possibly one of the most significant mudflow events in recent times was reported from Indonesia.

On 29 May 2006, hot mud and gas began gushing from a rice field near a gas exploration well in East Java. More than a decade later, the Lusi mud flow continues on the Indonesian island (NASA, 2019).

Over the years, flows of boiling mud from the Lusi Mud Flow have displaced more than 40,000 people, destroyed 15 villages, and caused nearly USD 3 billion in damage (NASA, 2019).

The Lusi eruption has become one of the most dramatic and damaging eruptions of its type. Some villages have been buried by layers of mud 40 metres (130 feet) thick. The mud, which has a consistency similar to porridge, pours constantly from Lusi's main vent. Every thirty minutes or so, surges in the flow send plumes of water vapour, carbon dioxide, and methane shooting tens of meters into the air (NASA, 2019).

In the early years of the eruption, mud oozed over homes, factories, highways, and farmland. Now it spreads within a network of earthen levees, retention ponds, and distribution channels that form a rectangular grid around the main eruptive vents. Channels direct the mud into holding ponds to the north and south. Large volumes of mud get flushed into the Porong River, which flows east toward the Bali Sea (NASA, 2019).

References

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NASA, 2019. A Muddy Mess in Indonesia. National Aeronautics and Space Administration (NASA). https://earthobservatory.nasa.gov/images/145198/a-muddy-mess-in-indonesia Accessed 13 October 2020.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0052 / **METEOROLOGICAL AND HYDROLOGICAL / Terrestrial**

Rock slide

Definition

A rock slide is a movement of a mass of soil or rock on an individualized failure surface (Dennis and Didier, 2019).

Reference

Dennis, F. and H. Didier, 2019. Rock slides and rock falls, a fatality? Encyclopaedia of the Environment (2019). www.encyclopedie-environnement.org/en/soil/rocky-landslides-and-landslides-a-fatality Accessed 20 October 2020.

Annotations

Synonyms

Translational slide, Rotational slide, Rock fall.

Additional scientific description

Different types of slide can be distinguished according to the shape of the failure surface. These can be identified as translational landslides and rotational slides:

- *Translational landslides* generally occur on one or two planes (referred to as 'wedges') of pre-existing discontinuity(s) in the rock mass. A well-known example in France is the Claps de Luc-en-Diois where, in 1442, thick limestone beds slipped on a stratification plane following the erosion of the foot of the slope by the Drôme river. The volume of the slip exceeds 1 hm3. But the largest rock slide in the Alps in the last two millennia was the one that affected the marl slope north of Mont Granier in November 1248. Nearly 500 hm3 of marl rock slid eastward on the stratification joints, destroying several villages and killing more than 1000 people (Dennis and Didier, 2019).
- *Rotational slides* occur on an axisymmetric surface; they are sometimes called circular slides because on a vertical section, the failure surface is an arc of a circle. They can occur in continuous massifs (often in soils) or without discontinuity planes allowing translational sliding. An example is given by the slide from La Clapière to Saint-Etienne-de-Tinée in France, with a volume of about 50 hm3 (Dennis and Didier, 2019).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

High precipitation, natural erosion, temperature variations or extreme stresses such as earthquakes can trigger rock slides and rock falls (NGI, no date).

Six of the 26 catastrophic landslides of the 20th Century listed by the United States Geological Survey (USGS, no date) were associated with rock slides, including the Usoy rock slide, USSR (1911); Khait rock slide, USSR (1949, 12,000 to 20000 deaths); and the Bairaman rock slide debris avalanche, Papua New Guinea (1986, village destroyed). These three rock slides were triggered by earthquakes. In 1974 in Peru, the Mayunmarca rock slide debris avalanche, which resulted in the loss of 450 lives was associated with high rainfall.

In terms of natural hazards, the Encyclopaedia of the Environment reported two categories of protection: active protections to remove the hazard itself and passive protections, which do not seek to oppose natural phenomena only to limit their harmful consequences for developments (buildings, communication routes) (Dennis and Didier, 2019).

- *Active protections* are diverse and include (i) general methods, such as surface or deep drainage, and slope vegetation that limits erosion due to runoff (gully excavation) and infiltration that alters mechanical properties (friction, cohesion of rock joints); (ii) supports, such as retaining walls, rock bolts or anchored mesh covered with sprayed concrete; (iii) wire mesh (draped or pinned), i.e., metal structures designed to contain the massif and prevent the spread of falling rocks and blocks; and (iv) scaling/mining, which are radical solutions that comprise removing unstable elements, although these solutions are not always as definitive as expected (the continuous alteration and the blast vibrations are often harmful to the stability of the surrounding massifs) (Dennis and Didier, 2019).
- *Passive protections* are also diverse: (i) barriers and dikes are gabions or concrete blocks placed at the foot of unstable slopes; their purpose is to stop the propagation of rock elements before reaching the stakes; their location, which requires sufficient space and their dimensioning, takes into account the properties of the materials that constitute them, but first of all numerical simulations that are made to model the propagation of blocks (trajectory circulations); (ii) the diverters are also embankments; installed on the slope, they divert the flow of the elements towards a space without stakes; (iii) protection galleries, similar to avalanche tunnels, are likely to protect communication routes when crossing corridors; (iv) rigid fences are placed on steep slopes as close as possible to the starting areas; their installation is often difficult to achieve; and (v) deformable wire-mesh can be placed lower on the slopes until they are close to the issues at stake; the most well-known case is the use of 'submarine' type nets (used during the Second World War to prevent the penetration of ports by submarine vehicles) stretched between rigid poles and maintained by fusible carabiners; this device is thus calculated to resist an impact energy previously determined in the study of randomness and its propagation (Dennis and Didier, 2019).

The appropriate responses to reduce the risks associated with rock instabilities are effective but often require a large budget. It is not viable to consider eliminating risk wherever it exists. The best protection is always based first on geological reconnaissance, followed by preventative actions such as drainage or regular purging of unstable elements and on monitoring based on measurements when movements are detected. Such monitoring often triggers an alert with a road closure or evacuation of an inhabited area (Dennis and Didier, 2019).

References

Dennis, F. and H. Didier, 2019. Rock slides and rock falls, a fatality? Encyclopaedia of the Environment (2019). www.encyclopedie-environnement.org/en/soil/rocky-landslides-and-landslides-a-fatality Accessed 20 October 2020.

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USGS, no date. Catastrophic Landslides of the 20th Century – Worldwide. United States Geological Survey (USGS). www.usgs.gov/natural-hazards/landslide-hazards/science/catastrophic-landslides-20th-century-worldwide?qt-science_center_objects=0#qt-science_center_objects Accessed 19 October 2020.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0053 / **METEOROLOGICAL AND HYDROLOGICAL / Wind-Related**

Derecho

Definition

Derechos are fast-moving bands of thunderstorms with destructive winds. The winds can be as strong as those found in hurricanes or even tornadoes. Unlike hurricanes and tornadoes, these winds follow straight lines (NOAA, 2019).

Reference

NOAA, 2019. What is a Derecho? National Oceanic and Atmospheric Administration (NOAA). https://scijinks.gov/derechos Accessed 26 November 2019.

Annotations

Synonyms

Not applicable.

Additional scientific description

A derecho (pronounced similar to 'deh-REY-cho') is a widespread, long-lived wind storm that is associated with a band of rapidly moving showers or thunderstorms. Although a derecho can produce destruction similar to the strength of tornadoes, the damage is typically directed in one direction along a relatively straight swath. As a result, the term 'straight-line wind damage' is sometimes used to describe derecho damage. By definition, if the wind damage swath extends more than 240 miles (about 400 km) and includes wind gusts of at least 58 mph (93 km/h) or greater along most of its length, then the event may be classified as a derecho (NOAA, 2019).

A derecho is a widespread convectively induced straight-line windstorm. Specifically, the term is defined as any family of particularly damaging downburst clusters produced by a mesoscale convective system (AMS, 2012a). Such systems have sustained bow echoes with book-end vortices and/or rear-inflow jets and can generate considerable damage from straight-line winds. Damage must be incurred either continuously or intermittently over a swath of at least 650 km (~400 miles) and a width of approximately 100 km (~60 miles) or more. The term derecho derives from a Spanish word that can be interpreted as 'straight ahead' or 'direct' and was chosen to distinguish between wind damage caused by tornadoes (AMS, 2012b), which have rotating flow, from straight-line winds.

The National Oceanic and Atmospheric Administration Storm Prediction Center reports that the types of Derecho include: serial derechos, progressive derechos, hybrid derechos and low-point derechos (NOAA, 2018).

Metrics and numeric limits

The winds associated with derechos are not constant and may vary considerably along the derecho path, sometimes being below severe limits (57 mph [92 kmh] or less) and sometimes being very strong (from 75 mph [121 kph] to over 100 mph [161 kph]). This is because the swaths of stronger winds within the general path of a derecho are produced by what are called downbursts, and downbursts often occur in irregularly arranged clusters, along with embedded microbursts and burst swaths. Derechos might be said to be made up of families of downburst clusters that extend, by definition, continuously or nearly continuously for at least 250 miles (about 400 km) (NOAA, 2018).

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Derechos are formed as follows. When the wet air in a thunderstorm meets the drier air surrounding it, the water in the air evaporates. When water evaporates, it cools the air around it. Since the cool air is denser, it rapidly sinks to the ground and creates strong winds. The downburst can suck more dry air into the storm, making even stronger downbursts or clusters of downbursts. Derechos occur when the right conditions for downbursts occur over a wide area (NOAA, 2019). See also NOAA (2018) for more detailed information about derechos.

Because derechos are most common in the warm season, those involved in outdoor activities are especially at risk. Campers or hikers in forested areas are vulnerable to being injured or killed by falling trees, and those at sea risk injury or drowning from storm winds and high waves that can overturn boats. Another reason those outdoors are especially vulnerable to derechos is the rapid movement of the parent convective system. Typically, derecho-producing storm systems move at speeds of 50 mph or more, and a few have been recorded at 70 mph. For someone caught outside, such rapid movement means that darkening skies and other visual cues that serve to identify the impending danger (e.g., gust front shelf clouds) appear at very short notice (NOAA, 2018).

References

AMS, 2012a. Glossary of Meteorology: Mesoscale Convective System. American Meteorological Society (AMS). https://glossary.ametsoc.org/wiki/Mesoscale_convective_system Accessed 25 March 2021.

AMS, 2012b. Glossary of Meteorology: Tornado. American Meteorological Society (AMS). https://glossary.ametsoc.org/wiki/Tornado Accessed 25 March 2021.

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Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0054 / **METEOROLOGICAL AND HYDROLOGICAL / Wind-Related**

Gale (Strong Gale)

Definition

A gale is wind with a speed of between 34 and 40 knots (62–74 km/h, 32–38 mph). Also known as Beaufort scale wind force 8 (WMO, 1992).

Reference

WMO, 1992. International Meteorological Vocabulary. WMO-No. 182. World Meteorological Organization (WMO). https://library.wmo.int/doc_num.php?explnum_id=4712 Accessed on 20 November 2019.

Annotations

Synonyms

Not found.

Additional scientific description

The numerical limits of a gale are defined by the Beaufort Scale which is an empirical measure that relates wind speed to observed conditions at sea or on land (Royal Meteorological Society, 2018). Its full name is the Beaufort wind force scale.

Metrics and numeric limits

A gale is wind with a speed of between 34 and 40 knots (62–74 km/h, 32–38 mph). Also known as Beaufort scale wind force 8 (WMO, 1992).

Key relevant UN convention / multilateral treaty

Not applicable.

Examples of drivers, outcomes and risk management

Human health can be severely affected by windstorms. Direct effects occur during the impact phase of a storm, causing death and injury due to the force of the wind. Becoming airborne, being struck by flying debris or falling trees and road traffic accidents are the main dangers. Indirect effects, occurring during the pre- and post-impact phases of the storm, include falls, lacerations and puncture wounds, and occur when preparing for, or cleaning up after a storm. Power outages are a key issue and can lead to electrocution, fires and burns and carbon monoxide poisoning from gasoline powered electrical generators. In addition, worsening of chronic illnesses due to lack of access to medical care or medication can occur. Other health impacts include infections and insect bites (Goldman et al., 2014).

Many countries have National Alerting Parameters for Gale, including the Philippines (PAGASA, no date), China (China Meteorological Administration, 2012), the Republic of Korea (Korea Meteorological Administration, 2019) and the United States (NOAA, 2019).

References

China Meteorological Administration, 2012. Gale. www.cma.gov.cn/en/WeatherWarnings/WarningSignals/201203/t20120320_166873.html Accessed 20 November 2019.

Goldman, A., B. Eggen, B. Golding and V. Murray, 2014. The health impacts of windstorms: a systematic literature review. Public Health, 128:3-28.

Korea Meteorological Administration, 2019. Criteria for advisory/warning information. https://web.kma.go.kr/eng/weather/forecast/standard_warning_info.jsp Accessed 20 November 2019.

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PAGASA, no date. Gale Warning. http://bagong.pagasa.dost.gov.ph/marine Accessed on 20 November 2019.

Royal Meteorological Society, 2018. The Beaufort Scale: How is wind speed measured? www.rmets.org/resource/beaufort-scale Accessed 20 November 2019.

WMO, 1992. International Meteorological Vocabulary. WMO-No. 182. World Meteorological Organization (WMO). https://library.wmo.int/doc_num.php?explnum_id=4712 Accessed on 20 November 2019.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0055 / **METEOROLOGICAL AND HYDROLOGICAL / Wind-Related**

Squall

Definition

A squall is an atmospheric phenomenon characterised by a very large variation of wind speed: it begins suddenly, has a duration of the order of minutes and decreases suddenly in speed. It is often accompanied by a shower or thunderstorm (WMO, 2018).

Reference

WMO, 2018. Manual on Codes, International Codes, Volume I.2. WMO-No. 306. World Meteorological Organization (WMO). www.wmo.int/pages/prog/www/WMOCodes/WMO306_vI2/Publications/2015editionUP2018/WMO306_vI2_en_ONLINE.pdf Accessed 13 October 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

The National Oceanic and Atmospheric Administration (NOAA) National Weather Service describes a squall as follows (NOAA, 2019):

- A strong wind characterised by a sudden onset in which the wind speed increases to at least 16 knots and is sustained at 22 knots or more for at least one minute.
- In nautical use, a severe local storm considered as a whole, that is, winds and cloud mass and (if any) precipitation, thunder and lightning.

The American Meteorological Society describes a squall as follows (AMS, 2012):

- A strong wind characterised by a sudden onset, a duration of the order of minutes, and then a sudden decrease in speed. In U.S. observational practice, a squall is reported only if a wind speed of 16 knots or more is sustained for at least two minutes (thereby distinguishing it from a gust).
- In nautical use, a severe local storm considered as a whole, that is, winds and cloud mass and (if any) precipitation, thunder and lightning.

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Not available.

Examples of drivers, outcomes and risk management

Squalls are sudden changes in wind conditions. In general, a squall may not be very strong and may only last for a short time. However, owing to their unpredictability and sudden arrival, squalls pose a threat to marine operations that require a fairly calm sea state (Lu et al., 2018).

Human health can be severely affected by wind-related hazards such as squalls and windstorms. Direct effects occur during the impact phase of a storm, causing death and injury due to the force of the wind. Becoming airborne, being struck by flying debris or falling trees and road traffic accidents are the main dangers. Indirect effects, occurring during the pre- and post-impact phases of the storm, include falls, lacerations and puncture wounds, and occur when preparing for, or cleaning up after a storm. Power outages are a key issue and can lead to electrocution, fires and burns and carbon monoxide poisoning from gasoline powered electrical generators. In addition, worsening of chronic illnesses due to lack of access to medical care or medication can occur. Other health impacts include infections and insect bites (Goldman et al., 2014).

References

AMS, 2012. Glossary of Meteorology: Squall. American Meteorological Society (AMS). http://glossary.ametsoc.org/wiki/Squall Accessed 26 November 2019.

Goldman, A., B. Eggen, B. Golding and V. Murray, 2014. The health impacts of windstorms: a systematic literature review. Public Health, 128:3-28.

Lu, Y., M. Ozaki and R. Wada, 2018. Squalls in sea off coast of Japan and their effects on marine operations based on weather observatory data at remote islands. Journal of Marine Science and Technology, 23:104-121.

NOAA, 2019. National Weather Service Glossary: Squall. National Oceanic and Atmospheric Administration (NOAA). https://forecast.weather.gov/glossary.php?word=SQUALL Accessed 13 October 2020.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0056 / **METEOROLOGICAL AND HYDROLOGICAL / Wind-Related**

Subtropical Storm

Definition

A subtropical storm is a subtropical cyclone in which the maximum sustained surface wind speed (using the U.S. 1-minute average) is 34 kt (39 mph or 63 km/hr) or more (NOAA, 2019).

Reference

NOAA, 2019. Glossary of NHC Terms. National Hurricane Center (NHC) and Central Pacific Hurricane Center, National Oceanic and Atmospheric Administration (NOAA). www.nhc.noaa.gov/aboutgloss.shtml Accessed on 14 October 2020.

Annotation

Synonyms

Not available.

Additional scientific description

Subtropical cyclone: A non-frontal low-pressure system that has characteristics of both tropical and extratropical cyclones. Like tropical cyclones, they are non-frontal, synoptic-scale cyclones that originate over tropical or subtropical waters and have a closed surface wind circulation about a well-defined centre. In addition, they have organised moderate to deep convection, but lack a central dense overcast. Unlike tropical cyclones, subtropical cyclones derive a significant proportion of their energy from baroclinic sources and are generally cold-core in the upper troposphere, often being associated with an upper-level low or trough. In comparison to tropical cyclones, these systems generally have a radius of maximum winds occurring relatively far from the centre (usually above 60 nmi), and generally have a less symmetric wind field and distribution of convection (NOAA, 2019).

Subtropical depression: A subtropical cyclone in which the maximum sustained surface wind speed (using the U.S. 1-minute average) is 33 kt (38 mph or 62 km/hr) or less (NOAA, 2019).

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

Not applicable.

Examples of drivers, outcomes and risk management

Impacts from sub-tropical storms include storm surges and significant rainfall events which cause flooding. Strong wind gusts and tornadoes may also occur.

Human health can be severely affected by wind-related hazards such as subtropical storms and other windstorms. Direct effects occur during the impact phase of a storm, causing death and injury due to the force of the wind. Becoming airborne, being struck by flying debris or falling trees and road traffic accidents are the main dangers. Indirect effects, occurring during the pre- and post-impact phases of the storm, include falls, lacerations and puncture wounds, and occur when preparing for, or cleaning up after a storm. Power outages are a key issue and can lead to electrocution, fires and burns and carbon monoxide poisoning from gasoline-powered electrical generators. Worsening of chronic illnesses due to lack of access to medical care or medication can also occur. Other health impacts include infections and insect bites (Goldman et al., 2014).

The effects of flooding on health are extensive and significant, ranging from mortality and injuries resulting from trauma and drowning to infectious diseases and mental health problems (acute and long-term). While some of these outcomes are relatively easy to track, ascertaining the human impact of floods is still weak. For example, it has been reported that two-thirds of deaths associated with flooding are from drowning, with the other third are from physical trauma, heart attacks, electrocution, carbon monoxide poisoning and fire. Often, only immediate traumatic deaths from flooding are recorded (WHO, 2013).

Morbidity associated with floods is usually due to injuries, infections, chemical hazards and mental health effects (acute as well as delayed) (WHO, 2013). Hypothermia may also be a problem, particularly in children, if trapped in floodwaters for lengthy periods (WHO, no date). There may also be an increased risk of respiratory tract infections due to exposure (loss of shelter, exposure to flood waters and rain). Power cuts related to floods may disrupt water treatment and supply plants thereby increasing the risk of water-borne diseases but may also affect proper functioning of health facilities, including cold chain (WHO, no date). Floods can potentially increase the transmission of the following communicable diseases: water-borne diseases (such as typhoid fever, cholera, leptospirosis and hepatitis A) and vector-borne diseases (such as malaria, dengue and dengue haemorrhagic fever, yellow fever, and West Nile Fever) (WHO, no date).

The longer-term health effects associated with a flood are less easily identified. They include effects due to displacement, destruction of homes, delayed recovery and water shortages (WHO, 2013).

References

Goldman, A., B. Eggen, B. Golding and V. Murray, 2014. The health impacts of windstorms: a systematic literature review. Public Health, 128:3-28.

NOAA, 2019. Glossary of NHC Terms. National Hurricane Center (NHC) and Central Pacific Hurricane Center, National Oceanic and Atmospheric Administration (NOAA). www.nhc.noaa.gov/aboutgloss.shtml Accessed on 14 October 2020.

WHO, no date. Flooding and communicable diseases fact sheet. World Health Organization (WHO). www.who.int/hac/techguidance/ems/flood_cds/en Accessed 4 October 2020.

WHO, 2013. Floods in the WHO European Region: Health effects and their prevention. Regional Office for Europe, World Health Organization (WHO). https://apps.who.int/iris/handle/10665/108625 Accessed 2 October 2020.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0057 / **METEOROLOGICAL AND HYDROLOGICAL / Wind-Related**

Tropical Cyclone (Cyclonic Wind, Rain [Storm] Surge)

Definition

A tropical cyclone is a cyclone of tropical origin of small diameter (some hundreds of kilometres) with a minimum surface pressure in some cases of less than 900 hPa, very violent winds and torrential rain; sometimes accompanied by thunderstorms. It usually contains a central region, known as the 'eye' of the storm, with a diameter of the order of some tens of kilometres, and with light winds and a more or less lightly clouded sky (WMO, 2017).

Alternative definition: A tropical cyclone is a warm-core, non-frontal synoptic-scale cyclone, originating over tropical or subtropical waters, with organised deep convection and closed surface wind circulation about a well-defined centre (WMO, 2017).

References

WMO, 2017. Manual on Codes, International Codes, Volume I.2, WMO-No. 306. World Meteorological Organization (WMO). https://library.wmo.int/doc_num.php?explnum_id=5831 Accessed 25 November 2019.

Annotations

Synonyms

Typhoon, Hurricane, Cyclone, Severe tropical cyclone.

Note: Typhoon, hurricane, cyclone, and tropical cyclone are different terms for the same weather phenomenon in different geographical regions (WMO, no date):

- In the western North Atlantic, central and eastern North Pacific, Caribbean Sea and Gulf of Mexico, such a weather phenomenon is called a 'hurricane'.
- In the western North Pacific, it is called a 'typhoon'.
- In the Bay of Bengal and Arabian Sea, it is called a 'cyclone'.
- In the western South Pacific and southeast India Ocean, it is called a 'severe tropical cyclone'.
- In the southwest India Ocean, it is called a 'tropical cyclone'.

Additional scientific description

Depending on the maximum sustained wind speed, tropical cyclones are designated as follows (WMO, no date):

- A tropical depression when the maximum sustained wind speed is less than 63 km/h.
- A tropical storm when the maximum sustained wind speed is more than 63 km/h*. It is then also given a name.
- Depending on the ocean basin, either a hurricane, typhoon, severe tropical cyclone, severe cyclonic storm or tropical cyclone when the maximum sustained wind speed is more than 119 km/h*.

*The designation thresholds for storm and hurricane are based on the Beaufort Scale.

Tropical cyclones can be hundreds of kilometres wide and can bring destructive high winds, torrential rain, storm surges and occasionally tornadoes (WMO, no date).

The typhoon season in the western North Pacific region typically runs from May to November. The Americas/Caribbean hurricane season runs from 1 June to 30 November, peaking in August and September. The cyclone season in the South Pacific and Australia normally runs from November to April. In the Bay of Bengal and Arabian Sea, tropical cyclones usually occur from April to June, and September to November. The East Coast of Africa normally experiences tropical cyclones from November to April (WMO, no date).

Metrics and numeric limits

Strength thresholds for tropical cyclone intensity vary according to the geographical regions indicated above. For the hurricane, the Saffir-Simpson Hurricane Wind Scale is used, where hurricane strength varies from Category 1 to 5: Category 1 (maximum sustained wind speeds of 119–153 km/h), Category 2 (maximum sustained wind speeds of 154–177 km/h), Category 3 (maximum sustained wind speeds of 178–209 km/h), Category 4 (maximum sustained wind speeds of 210–249 km/h) and Category 5 (maximum sustained wind speeds exceeding 249 km/h) (NOAA, no date).

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Meteorologists around the world use modern technology such as satellites, weather radars and computers etc. to track tropical cyclones as they develop. Tropical cyclones are often difficult to predict, because they can suddenly weaken or change their course. However, meteorologists use state-of-art technologies and develop modern techniques such as numerical weather prediction models to predict how a tropical cyclone evolves, including its movement and change of intensity, when and where one will hit land and at what speed. Official warnings are then issued by the National Meteorological Services of the countries concerned (WMO, no date). The impact of a tropical cyclone and the expected damage depend not just on wind speed, but also on factors such as the moving speed, duration of strong wind, storm surge and accumulated rainfall during and after landfall, sudden change of moving direction and intensity, and the structure (e.g., size and intensity) of the tropical cyclone, as well as human response to tropical cyclone disasters (NOAA, no date).

The World Meteorological Organization (WMO) framework allows the timely and widespread dissemination of information about tropical cyclones. As a result of international cooperation and coordination, tropical cyclones are increasingly being monitored from their early stages of formation. The activities are coordinated at the global and regional level by the WMO through its World Weather Watch and Tropical Cyclone Programmes. The Regional Specialised Meteorological Centres with the activity specialisation in tropical cyclones, and Tropical Cyclone Warning Centres, all designated by the WMO, are functioning within its Tropical Cyclone Programme. Their role is to detect, monitor, track and forecast all tropical cyclones in their respective regions. The Centres provide, in real-time, advisory information and guidance to the National Meteorological Services (WMO, no date).

The health impacts of tropical cyclones depend on the number of people living in low-lying coastal areas in the storm's direct path, the built environment including building design, and whether there is sufficient time for warning and evacuation (WHO, 2020).

Tropical cyclones, may directly and indirectly affect health in many ways, for example by: increasing cases of drowning and other physical trauma; increasing risks of water- and vector-borne infectious diseases; increasing mental health effects associated with emergency situations; disrupting health systems, facilities and services, leaving communities without access to health care when it is needed most; and damaging basic infrastructure, such as food and water supplies and safe shelter (WHO, 2020).

When tropical cyclones cause floods and sea surges, the risk of drowning and water- or vector-borne diseases increases. In addition, flood waters may contain sewage and chemicals, hide sharp objects made of metal or glass and electrical lines, or host dangerous snakes or reptiles, which can result in diseases, injuries, electrocution and bites. The greatest damage to life and property is not from the wind itself, but from secondary events such as storm surges, flooding, landslides and tornadoes (WHO, 2020).

The World Health Organization (WHO) works with Member States to build resilient and proactive health systems that can anticipate the needs and challenges during emergencies so that they are more likely to reduce risks and respond effectively when needed. During disasters, such as tropical cyclones, the WHO helps to restore primary care services so that facilities can deliver essential services, including immunisation, basic treatment for common illnesses, acute malnutrition and maternal care while ensuring the ongoing supply of medications for people living with HIV, tuberculosis or diabetes. As the health cluster lead for global emergencies, the WHO also works with partners to ensure appropriate food supplementation; to assemble mobile health teams and outreach; to conduct epidemic surveillance, early warning and response; and to call for emergency funding to support health action (WHO, 2020).

References

NOAA, no date. Saffir-Simpson Hurricane Wind Scale. National Oceanic and Atmospheric Administration (NOAA). https://www.nhc.noaa.gov/aboutsshws.php Accessed 16 April 2021.

WHO, 2020. Tropical cyclones. World Health Organization (WHO). www.who.int/health-topics/tropical-cyclones#tab=tab_3 Accessed 7 October 2020.

WMO, no date. Tropical Cyclone. World Meteorological Organization (WMO). https://public.wmo.int/en/our-mandate/focus-areas/natural-hazards-and-disaster-risk-reduction/tropical-cyclones Accessed 16 April 2021.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0058 / **METEOROLOGICAL AND HYDROLOGICAL / Wind-Related**

Tropical Storm

Definition

A tropical storm is a rapid rotating storm originating over tropical oceans. It has a low pressure centre and clouds spiralling towards the eyewall surrounding the 'eye'. Its diameter is typically around 200 to 500 km, but can reach 1000 km. The related hazards are very violent winds, torrential rain, high waves, storm surges and in some cases tornadoes, causing direct effects such as flash floods, flooding, coastal inundation, and indirect effects such as landslides and mudslides. The winds blow anti-clockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere (WMO, 2020).

The intensity of tropical storms is based on the wind speed. A tropical storm is a tropical cyclone with the maximum sustained winds of 34 knots (17.5 m/s, 63 km/h) to 47 knots (24.2 m/s, 87 km/h) near the centre. When reaching this intensity, they are named in the interests of public safety (WMO, 2021).

References

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WMO, 2021. Tropical Cyclones. World Meteorological Organization (WM). https://public.wmo.int/en/our-mandate/focus-areas/natural-hazards-and-disaster-risk-reduction/tropical-cyclones

Annotations

Synonyms

Tropical cyclone is a generic term. However, once this weather phenomenon has reached a specific intensity (wind speed exceeding 117 km/h), depending on the region, it can be designated as a hurricane, typhoon, tropical cyclone, cyclonic storm (WMO, 2021).

Additional scientific description

A tropical cyclone originates over tropical oceans from where it draws the energy to develop. In addition to sufficient energy from the ocean, a favourable environment is associated with enough moisture in the atmosphere, low to moderate windshear (difference between winds at low and upper atmospheric levels), and enough Coriolis force (a force associated with the rotation).

They can develop in the North Atlantic, Indian Ocean and Pacific Ocean. Depending on the basin, the terminology for this weather phenomenon differs: hurricane in the North Atlantic, typhoon in the western North Pacific, and tropical cyclone in the Indian Ocean and South Pacific Ocean.

Metrics and numeric limits

Depending on the maximum sustained wind speed, tropical cyclones are designated as follows:

- *Tropical depression*: when the maximum sustained wind speed is less than 63 km/h k or 34 knots
- *Tropical storm*: when the maximum sustained wind speed is more than 63 km/h or 34 knots. It is then also given a name.
- *Hurricane, typhoon, tropical cyclone, cyclonic storm*: when the maximum sustained wind speed exceeds 117 km/h or 63 knots.

Key relevant UN convention / multilateral treaty

Not applicable.

Examples of drivers, outcomes and risk management

References

WHO, 2020. Tropical cyclones. World Health Organization (WHO). www.who.int/health-topics/tropical-cyclones#tab=tab_3 Accessed 7 October 2020.

WMO, 2021. Storm Surge. World Meteorological Organization (WMO). https://public.wmo.int/en/our-mandate/focus-areas/natural-hazards-and-disaster-risk-reduction/storm-surge

https://public.wmo.int/en/our-mandate/focus-areas/natural-hazards-and-disaster-risk-reduction/tropical-cyclones

The Operational Plans of the five WMO Tropical Cyclone Programme regional bodies, and their associated glossaries are available here: https://community.wmo.int/tropical-cyclone-operational-plans

World Meteorological Organization (WMO) Regional Association I - Tropical Cyclone Operational Plan for the South-West Indian Ocean, Tropical Cyclone Programme, report No. TCP-12, WMO-NO 1178

Typhoon Committee Operational Manual, Tropical Cyclone Programme, report No. TCP-23, WMO/TD No.196.

Panel on Tropical cyclones Operational Plan for the Bay of Bengal and the Arabian Sea, report No. TCP-21, WMO/TD-No. 84

(WMO Regional Association IV – Hurricane Operational Plan for North America, Central America and the Caribbean. Tropical Cyclone Programme. WMO-No. 1163.

WMO Regional Association V - Tropical Cyclone Operational Plan for the South Pacific and South-East Indian Ocean, Tropical Cyclone Programme, report No. TCP-24, WMO-NO 1181.

Rappaport, E. (2014). Fatalities in the United States from Atlantic Tropical Cyclones: New Data and Interpretation. Accessible at: https://www.deepdyve.com/lp/american-meteorological-society/fatalities-in-the-united-states-from-atlantic-tropical-cyclones-new-0lJut2urZS. Accessed 13 May 2021.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0059 / **METEOROLOGICAL AND HYDROLOGICAL / Wind-Related**

Tornado

Definition

A tornado is a rotating column of air, extending from the base of a cumuliform cloud, and often visible as a condensation funnel in contact with the ground, and/or attendant circulating dust or debris cloud at the ground (WMO, 2017).

Reference

WMO, 2017. International Cloud Atlas: Tornado. World Meteorological Organization (WMO). https://cloudatlas.wmo.int/tornado.html Accessed 25 November 2019.

Annotations

Synonyms

Twister, Land spout, Cold air funnel, Waterspout, Funnel, Whirlwind.

Additional scientific description

A large tornado in which the condensation funnel is at least as wide horizontally at the ground as it is in height from the ground to the cloud base may be referred to as a wedge tornado. During the dissipation stage of a tornado, the condensation funnel will shrink and narrow in width, becoming rope-like (a rope funnel), and may also become contorted. Some tornadoes may contain secondary vortices within the main circulation (suction vortices or subvortices) (WMO, 2017a).

Metrics and numeric limits

Tornadoes can be classified into the following distinct formation groups (WMO, 2017b): Type I (in association with supercells; WMO, no date), Type II (in association with quasi-linear convective systems), and Type III (localised convective and shear vortices – these comprise landspouts, waterspouts and cold-air funnels).

Definitions for the Type III tornados are as follows (WMO, 2017b):

- *Landspout*: A tornado that does not arise from organised storm-scale rotation and is therefore not associated with a wall cloud (murus) or a mesocyclone.
- *Waterspout:* A tornado occurring over water. It is normally a relatively small, weak rotating column of air over open water below a Cumulonimbus or Cumulus congestus cloud.
- *Cold-air funnel:* A funnel cloud or (rarely) a small, relatively weak tornado that can develop from a small shower or thunderstorm when the air aloft is unusually cold.

The strength of a tornado can be estimated from the degree of damage caused using the Enhanced Fujita scale (Wind Science and Engineering Center, 2004; National Weather Service, no date).

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Owing to the unpredictable nature of tornados, protecting the public is focused on education and outreach which provide information on the tornado as a threat, how to identify a tornado and practical measures on how individuals can protect themselves, and how to find and watch warning systems that alert the public (CDC, 2020).

Since the advent of Doppler Radar, lead times for tornado warnings have increased from when a tornado first touches the ground to upwards of 14 to 20 minutes or more beforehand (WMO, 2017b; National Geographic, 2019).

References

CDC, 2020. Staying Safe in a Tornado. Centers for Disease Control and Prevention (CDC). www.cdc.gov/nceh/features/tornadosafety/index.html Accessed 25 March 2021.

National Geographic, 2019. What we know – and what we don't – about the science of tornadoes. www.nationalgeographic.com/news/2019/5/140430-tornadoes-meteorology-atmospheric-science-disasters Accessed 2 November 2021.

National Weather Service, no date. The Enhanced Fujita Scale (EF Scale). www.weather.gov/oun/efscale Accessed 25 March 2021.

Wind Science and Engineering Center, 2004. A Recommendation for an Enhanced Fujita Scale (EF Scale). www.spc.noaa.gov/faq/tornado/ef-ttu.pdf Accessed 25 March 2021.

WMO, no date. Glossary: Supercell. World Meteorological Organization (WMO). https://cloudatlas.wmo.int/en/glossary.html#S Accessed 25 March 2021.

WMO, 2017a. International Cloud Atlas Manual on the Observation of Clouds and Other Meteors. WMO-No. 407. World Meteorological Organization (WMO). https://library.wmo.int/index.php?lvl=notice_display&id=5357ICA-New-classifications.html#.YEJrt5vLfIE Accessed 25 November 2019.

WMO, 2017b. Guidelines for Nowcasting Techniques. WMO-No. 1198. World Meteorological Organization (WMO). https://library.wmo.int/doc_num.php?explnum_id=3795 Accessed 2 November 2020.

Coordinating agency or organisation

World Meteorological Organization (WMO).

MH0060 / **METEOROLOGICAL AND HYDROLOGICAL / Wind-Related**

Wind

Definition

Wind is air motion relative to the Earth's surface. Unless otherwise specified, only the horizontal component is considered (WMO, 1992).

Reference

WMO, 1992. International Meteorological Vocabulary. WMO-No. 182. World Meteorological Organization (WMO). https://library.wmo.int/doc_num.php?explnum_id=4712 Accessed 25 November 2019.

Annotations

Synonyms

Not identified.

Additional scientific description

Wind velocity is an important consideration in relation to, for example, airborne pollution and the landing of aircraft (WMO, 2018). Surface wind is considered mainly as a two-dimensional vector quantity specified by two numbers representing direction and speed (WMO, 2018).

The extent to which wind is characterised by rapid fluctuations is referred to as gustiness, and single fluctuations are called gusts (WMO, 2018).

Metrics and numeric limits

An internationally recognised scale for measuring wind is the Beaufort Scale, which is an empirical measure that relates wind speed to observed conditions at sea or on land. Its full name is the Beaufort wind force scale (Royal Meteorological Society, 2018).

The Beaufort wind force scale has 13 levels including: calm, light air, light breeze, gentle breeze, moderate breeze, fresh breeze, strong breeze, near gale, gale, strong gale, storm, violent storm, and hurricane. Of note, the quoted wind speed is that measured at 10 m above ground, not at the surface (which, at 2 m, may be only 50–70% of these values (Royal Meteorological Society, 2018).

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Wind is a main or contributing component to a number of hazards such as derecho, tropical cyclone, blizzard, sub-tropical cyclone, subtropical storm, tornado, and tropical storm. Wind is also associated with the dispersal of dust storms, volcanic ash and coastal floods (WMO, 2019).

Human health can be severely affected by windstorms (Goldman et al., 2014). Effects include direct effects, which occur during the impact phase of a storm, causing death and injury due to the force of the wind. Becoming airborne, being struck by flying debris or falling trees and road traffic accidents are the main dangers. Indirect effects, occurring during the pre- and post-impact phases of the storm, include falls, lacerations and puncture wounds, and occur when preparing for, or cleaning up after a storm. Power outages are a key issue and can lead to electrocution, fires and burns, and carbon monoxide poisoning from gasoline powered electrical generators. Worsening of chronic illnesses due to lack of access to medical care or medication can also occur. Other health impacts include infections and insect bites.

References

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Royal Meteorological Society, 2018. The Beaufort Scale. www.rmets.org/resource/beaufort-scale Accessed 9 November 2020.

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WMO, 2019. Event Types of Hazards and Extreme Events. World Meteorological Association (WMO). www.wmo.int/pages/prog/wcp/wcdmp/meeting/documents/Catalogue_Hazards_Extreme_Events_WMO_091117.pdf Accessed 9 November 2020.

Coordinating agency or organisation

World Meteorological Organization (WMO).

EXTRATERRESTRIAL

ET0001 / **EXTRATERRESTRIAL / Extraterrestrial**

Airburst

Definition

An airburst is defined as an explosion in the air, especially of a nuclear bomb or large meteorite (Lexico Dictionary, no date).

Reference

Lexico Dictionary, no date. Airburst. www.lexico.com/en/definition/airburst Accessed 17 December 2019.

Annotations

Synonyms

Air-blast, Fireballs, Bolides, Superbolides.

Additional scientific description

Meteoroids are objects in space that range in size from dust grains to small asteroids. Think of them as ‘space rocks’: when meteoroids enter Earth’s atmosphere (or that of another planet, like Mars) at high speed and burn up, the fireballs or ‘shooting stars’ are called meteors. When a meteoroid survives a trip through the atmosphere and hits the ground, it is called a meteorite (NASA, no date).

Research has revealed why meteors explode before impacting the Earth. During model simulations of meteors entering Earth’s atmosphere, air that was pushed into the meteoroid was allowed to percolate inside, which lowered the strength of the meteoroid significantly. In essence, air was able to reach the insides of the meteoroid and cause it to explode from inside out (Tabetah and Melosh, 2017; Williams, 2017).

The hazardous effects are estimated using both semi-analytical models, realised now as simple calculators, and numerical simulations of airbursts of large meteoroids and asteroids. The numerical simulations are based on the equations of hydrodynamics and radiation transfer. Dangerous consequences include shock waves with high wind speeds, fluxes of thermal radiation capable of igniting fires and causing skin burns, seismic effects of airbursts, and ionosphere disturbances. The dangerous effects of a shock wave and thermal radiation on people are considered in the context of the Chelyabinsk meteorite of 2013 and the Tunguska airburst of 1908 (Ryabova et al., 2019).

On 15 February 2013, a meteor exploded in the sky over Chelyabinsk, southern Russia. Although no people or buildings were hit by the resulting meteorite, the shockwave from the exploding object injured about 1500 people and caused damage to 7200 buildings in the region. The fireball was caught on video, mainly by dash cameras throughout the region, and posted on the internet by news organisations and individuals. Although the Chelyabinsk meteorite probably weighed about 12,000 to 13,000 tonnes and measured 17 to 20 metres in diameter before exploding, scientists were quick to point out that it was very small compared to other objects that could potentially hit the Earth. The explosion released energy estimated at about 500 kilotons of TNT (about 20 to 30 times more energy than the Hiroshima atomic bomb). The event brought to the world’s attention the very real hazards associated with the impact of objects from outer space (Nelson, 2018).

In the early morning of 30 June 1908, a powerful explosion over the basin of the Podkamennaya Tunguska River (Central Siberia), devastated 2150 ± 50 km2 of Siberian taiga. Eighty million trees were thought to have been flattened, and a great number of trees and bushes were burnt in a large part of the explosion area. Eyewitnesses described the flight of a “fire ball, bright as the sun”. Seismic and pressure waves were recorded in many observatories across the world. Bright nights were seen over much of Eurasia. These different phenomena, initially considered non-correlated, were subsequently linked together as different aspects of the ‘Tunguska event’.

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

Not applicable.

Examples of drivers, outcomes and risk management

The International Asteroid Warning Network (IAWN) was established in 2013 as a result of the UN-endorsed recommendations for an international response to a potential near-Earth object (NEO) impact threat, to create an international group of organisations involved in detecting, tracking, and characterising NEOs. IAWN is tasked with developing a strategy using well-defined communication plans and protocols to assist governments in analysing asteroid impact consequences and in planning mitigation responses. Currently, IAWN includes members from Europe, Asia, South America and North America (IAWN, 2020).

IAWN has proposed the following definition: An asteroid, meteoroid, or a comet as it passes near Earth, enters the Earth's atmosphere, and/or strikes the Earth, or provokes changes in inter-planetary conditions that affect the Earth's magnetosphere, ionosphere, and thermosphere.

Criteria and thresholds related to this definition are as follows: the probability that an NEO will impact Earth (either 1% warning and 10% for terrestrial preparedness planning); the probable size, or at least its luminosity in the night sky (greater than 10 meters or at least absolute magnitude 28); and how far in the future the NEO will impact Earth (20 years).

The European Space Agency's (ESA) Space Situational Awareness (SSA) programme partners with many countries, organisations and individuals. In particular, it has strong links with the United Nations Committee on the Peaceful Uses of Outer Space (UNCOPUOS), which facilitates the Space Mission Planning Advisory Group (SMPAG) and IAWN. SMPAG and IAWN were both established in response to the need for an international response to the threat of NEO impacts. SMPAG coordinates the technological know-how of agencies, including ESA, recommending specific responses to asteroid threats, including basic research and development, impact mitigation measures and deflection missions. Depending on the capabilities and specific technologies available to each agency, options are made to ensure the best use is made of skills of each organisation. ESA's primary projects are the SSA programme – especially the dedicated NEO segment, mapping of threat scenarios to mission types, as well as AIM – ESA's Asteroid Impact Mission (ESA, 2018).

IAWN and SMPAG have agreed on the following criteria and thresholds for impact-response actions:

1. IAWN shall warn of predicted impacts exceeding a probability of 1% for all objects characterised to be greater than 10 metres in size, or roughly equivalent to absolute magnitude of 28 if only brightness data can be collected.

   Rationale: Impact probabilities greater than 1% are rare. Most objects greater than 10 meters in size will have effects (air blast and pieces) that could reach the Earth's surface. IAWN is compelled to warn populations if bodies will have effects that reach the ground. Setting threshold at 1% is a compromise between not being overly alarmist and not warning too late for necessary action to be initiated. It is a probability figure that individuals and governments can comprehend. An alert such as this demonstrates that IAWN is functioning. Further, it ensures the flow of communications from IAWN to the public and the United Nations.
2. Terrestrial preparedness planning is recommended to begin when warned of a possible impact: predicted to be within 20 years; when probability of impact is assessed to be greater than 10%; and when the object is characterised to be greater than 20 meters in size, or roughly equivalent to absolute magnitude of 27 if only brightness data can be collected.

   Rationale: Terrestrial preparedness and increased potential for impact will also involve determination of a 'risk corridor' from objects with 10% impact probabilities and impacts in less than 20 years. This provides populations and population centres on the Earth with the information to begin preparations for emergency preparedness if needed. The surprising effects of the Chelyabinsk event in 2013 from an object ~18 meters in size, in turn led to the establishment of a lower limit (20 meters) in these threshold criteria.
3. SMPAG should start mission option(s) planning when warned of a possible impact: predicted to be within 50 years; when probability is assessed to be greater than 1%; and when the object is characterised to be greater than 50 meters in size, or roughly equivalent to absolute magnitude of 26 if only brightness data can be collected.

   Rationale: Several decades warning, if available, enables sufficient lead time to mount characterisation missions. If a 1% probability on a 100-meter object is assessed, SMPAG will be informed immediately following verification of the precise orbit. Part of such a characterisation mission would likely deploy a transponder with the object.

References

ESA, 2018. Space Mission Planning Advisory Group (SMPAG). European Space Agency (ESA). https://sdg.esa.int/activity/space-mission-planning-advisory-group-smpag-4311 Accessed 15 October 2020.

IAWN, 2020. IAWN's Functions Are:. International Asteroid Warning Network (IAWN). http://iawn.net/about.shtml Accessed 15 October 2020.

NASA, no date. Meteors & Meteorites. Science Solar System Exploration, National Aeronautics and Space Administration (NASA). https://solarsystem.nasa.gov/asteroids-comets-and-meteors/meteors-and-meteorites/overview/?page=0&per_page=40&order=id+asc&search=&condition_1=meteor_shower%3Abody_type Accessed 16 October 2020.

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Williams, M., 2017. We finally understand how meteors explode when they reach Earth's atmosphere. Sciencealert www.sciencealert.com/why-do-meteors-explode-when-they-reach-earth-atmosphere Accessed 15 October 2020.

Coordinating agency or organisation

World Meteorological Organization (WMO) in collaboration with other space weather organisations.

ET0002 / **EXTRATERRESTRIAL / Extraterrestrial**

Geomagnetic Storm (including energetic particles related to space weather, and solar flare radio blackout [R Scale])

Definition

A geomagnetic storm is a worldwide disturbance of the Earth's magnetic field induced by a solar storm (Cannon et al., 2013).

Reference

Cannon, P., M. Angling, L. Barclay, A. Thomson and C. Underwood, 2013. Extreme Space Weather: Impacts on engineered systems and infrastructure. Royal Academy of Engineering. www.raeng.org.uk/publications/reports/space-weather-full-report

Annotations

Synonyms

Space weather, Solar storm, Electromagnetic pulse (natural), Magnetic storm.

Additional scientific description

A geomagnetic storm refers to disturbances of the Earth's magnetosphere, caused by sudden strong variations in the speed, density and magnetic properties of the solar wind. The resulting magnetic field variations within the magnetosphere generate electric currents in long conductors such as power lines and pipelines. The effects of geomagnetic storms range from mild (interference with aeromagnetic surveys) to extreme (electric power grids may experience blackouts or collapse) (NRC, 2019).

The largest recorded solar superstorm is known as the Carrington Event which occurred in 1859. It was associated with a large solar flare and the associated coronal mass ejections took only 17.6 hours to travel from the Sun to the Earth. It caused aurora in many parts of the world where they are not normally seen –even in Hawaii. One consequence of this solar superstorm was that telegraph systems across the world misbehaved with operators able to receive messages despite having disconnected their power supplies (Boteler, 2006; Clauer and Siscoe, 2006).

In March 1989, the third strongest recorded geomagnetic storm struck Earth. In less than a minute, induced current in transmission lines caused overload safety systems to trip closing down sections of the Quebec power network. A cascade effect then caused the network to collapse and the region to fall into darkness. Electricity was unavailable for nine hours, and restoration was made more difficult due to the fact that backup equipment had also been affected by the storm (CAA, 2016).

Examples of national geomagnetic storm scales:

Geomagnetic Storm Scales used by US: The National Oceanic and Atmospheric Administration (NOAA) Space Weather Scales were introduced as a way of communicating to the general public the current and future space weather conditions and their possible effects on people and systems. The scales have numbered levels, analogous to hurricanes, tornadoes, and earthquakes that convey severity. Possible effects at each level are also listed with how often such events happen and give a measure of the intensity of the physical causes (NOAA, 2019).

Geomagnetic Storm Scales used by Canada: At the Earth, magnetic storms are characterised by a K-level index that ranges from 0 to 9. Storms having little effect range from K=0–3, mid-level effects would be K=4–7, and strong storms with lots of impact would occur for K>7 (NRC, 2019).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Not available.

Examples of drivers, outcomes and risk management

A geomagnetic storm is a major disturbance of Earth's magnetosphere that occurs when there is a very efficient exchange of energy from the solar wind into the space environment surrounding the Earth. These storms result from variations in the solar wind that produces major changes in the currents, plasmas, and fields in Earth's magnetosphere. The solar wind conditions that are effective for creating geomagnetic storms are sustained for (several to many hour) periods of high-speed solar wind, and most importantly, a southward directed solar wind magnetic field (opposite to the direction of Earth's field) at the dayside of the magnetosphere. This condition is effective for transferring energy from the solar wind into Earth's magnetosphere (NOAA, 2019).

While geomagnetic storms and disturbances can cause the aurora to be visible in the northern latitudes, there are more serious impacts to be considered. Impacts from geomagnetic storms and disturbances may cause impacts such as: damage to power grids through geomagnetically-induced currents (GIC); in extreme storms, impacts to power grid operations and stability are likely; and impacts on Global Navigation Satellite System (GNSS) accuracy and availability.

Advance notice is possible given that coronal mass ejection (CME) transit times from the Sun to Earth range from just under a day to several days (CMEs being the main driver of significant storms).

References

Boteler, D.H., 2006. The super storms of August/September 1859 and their effects on the telegraph system. Advances in Space Research, 38:159-172.

CAA, 2016. Impacts of Space Weather on Aviation. Civil Aviation Authority (CAA). https://skybrary.aero/bookshelf/books/3702.pdf Accessed 14 October 2020.

Cannon, P., M. Angling, L. Barclay, A. Thomson and C. Underwood, 2013. Extreme Space Weather: Impacts on engineered systems and infrastructure. Royal Academy of Engineering. www.raeng.org.uk/publications/reports/space-weather-full-report

Clauer, C.R. and G.E. Siscoe, 2006. The Great Historical Geomagnetic Storm of 1859: A Modern Look. Advances in Space Research, 38:115-388.

NOAA, 2019. NOAA Space Weather Scales. Space Weather Prediction Center, National Oceanic and Atmospheric Administration (NOAA). www.swpc.noaa.gov/noaa-scales-explanation Accessed 20 November 2019.

NRC, 2019. What is Space Weather? Natural Resources Canada (NRC). https://spaceweather.gc.ca/sbg-en.php#geo-5 Accessed 20 November 2019.

Coordinating agency or organisation

World Meteorological Organization (WMO) in collaboration with other space weather organisations.

ET0003 / **EXTRATERRESTRIAL / Extraterrestrial**

UV Radiation

Definition

UV radiation is the portion of the electromagnetic (EM) spectrum between X-rays and visible light. Depending on its wavelength, UV radiation can penetrate the ozone layer and affect human health in different ways (Government of Canada, 2019).

Reference

Government of Canada, 2019. Ultraviolet Radiation. www.canada.ca/en/health-canada/services/health-risks-safety/radiation/types-sources/ultraviolet.html Accessed 25 November 2019.

Annotations

Synonyms

None identified.

Additional scientific description

All radiation is a form of energy, most of which is invisible to the human eye. Ultraviolet (UV) radiation is only one form of radiation and is measured on a scientific scale called the EM spectrum (US FDA, 2019).

UV radiation is invisible energy in the wavelength range 100 to 400 nm (a nanometre is one billionth of a metre). UV radiation has a shorter wavelength and is more energetic than visible light. UV radiation comes from natural sources (such as the Sun), and artificial sources (such as black lights, welding equipment, lasers, and tanning equipment) (Government of Canada, 2019).

The shorter the wavelength, the more harmful the UV radiation. However, shorter wavelength UV radiation is less able to penetrate the skin (EU, 2019; Government of Canada, 2019).

UV radiation is divided into three wavelength ranges and all three bands are classified as a probable human carcinogen (Government of Canada, 2019; EU, 2019):

UVA is long-range UV radiation between 320 and 400 nm. Although not as energetic as UVB, UVA can penetrate deep into the skin (dermis). This can cause immediate tanning and premature skin aging and play a role in the development of certain skin cancers. UVA is not readily absorbed by the ozone layer; about 95% gets through.

UVB is short-wave UV radiation between 280 and 320 nm. It can just penetrate the outer protective layer of the skin and is responsible for delayed tanning, sunburn and most skin cancers. A large amount of UVB is absorbed by the ozone layer; only 5% reaches the Earth's surface.

UVC, with wavelengths between 100 and 280 nm, is very energetic. It is very dangerous to all forms of life (even with short exposures). However, UVC radiation is filtered out by the ozone layer, and never reaches Earth. It is created artificially to kill bacteria.

Metrics and numeric limits

The UV Index developed by the U.S. Environmental Protection Agency (US EPA, 2004).

The Electromagnetic radiation spectrum described by the Government of Canada (2019).

Key relevant UN convention / multilateral treaty

The Montreal Protocol on Substances that Deplete the Ozone Layer (UNEP, 2020a,b).

The UN Sustainable Development Goals (SDG)s, Goal 3 'Good Health and Well-Being' (UN, 2015).

The United Nations Convention on the Rights of the Child (UN, 1989).

Examples of drivers, outcomes and risk management

A period when solar UV radiation exceeds a certain threshold with the need to increase awareness to the potential negative impacts of UV radiation on health is usually associated with ozone levels lower than the long-term average and cloudless or at most partially cloudy conditions. Negative impacts of UV radiation can be monitored with the help of the UV index. A threshold can be defined according to geographical location and season in order to raise awareness on the potential danger for health. A practical guide is available from the World Health Organization (WHO, 2002).

The rise in incidence of skin cancers over recent decades is strongly related to increasingly popular outdoor activities and recreational exposure (WHO, 2003). Overexposure to sunlight is widely accepted as the underlying cause for harmful effects on the skin, eyes and immune system. Experts believe that four out of five cases of skin cancer could be prevented, as UV damage is mostly avoidable. Adopting the following simple precautions, adapted from the Sun Wise School Program can make all the difference (WHO, 2003).

Shade, clothing and hats provide the best protection – applying sunscreen becomes necessary for those parts of the body that remain exposed like the face and hands. Sunscreen should never be used to prolong the duration of sun exposure.

- Limit time in the midday sun: The sun's UV rays are the strongest between 10 am and 4 pm. To the extent possible, limit exposure to the sun during these hours.
- Watch for the UV index: This important resource helps to plan outdoor activities in ways that prevent overexposure to the sun's rays. While always taking precautions against overexposure, take special care to adopt sun safety practices when the UV Index predicts exposure levels of moderate or above.
- Use shade wisely: Seek shade when UV rays are the most intense, but keep in mind that shade structures such as trees, umbrellas or canopies do not offer complete sun protection. Remember the shadow rule: 'Watch your shadow – Short shadow, seek shade!'
- Wear protective clothing: A hat with a wide brim offers good sun protection for eyes, ears, face, and the back or neck. Sunglasses that provide 99% to 100% UVA and UVB protection will greatly reduce eye damage from sun exposure. Tightly woven, loose fitting clothes provide additional protection.
- Use sunscreen: Apply a broad-spectrum sunscreen of SPF 15+ liberally and re-apply every two hours, or after working, swimming, playing or exercising outdoors.
- Avoid sunlamps and tanning parlours: Sunbeds damage the skin and unprotected eyes and are best avoided entirely.

Sun protection programmes are urgently needed to raise awareness of the health hazards of UV radiation, and to achieve changes in lifestyle that will stop the trend towards increasing numbers of skin cancers. Beyond the health benefits, effective education programmes can strengthen national economies by reducing the financial burden on health care systems caused by skin cancer and cataract treatments. Children are in a dynamic state of growth and are therefore more susceptible to environmental threats than adults. Many vital functions such as the immune system are not fully developed at birth, and unsafe environments may interfere with their normal development. Schools are vitally important settings to promote sun protection, and effective programmes can make a difference (WHO, 2003).

Children require special protection. The United Nations Convention on the Rights of the Child states that children, including all developmental stages from conception to age 18, have the right to enjoyment of the highest attainable standard of health and to a safe environment (UN, 1989). Children are in a dynamic state of growth and are more susceptible to environmental threats than adults because: Sun exposure during childhood and adolescence appears to set the stage for the development of both melanoma and non-melanoma skin cancers in later life; a significant part of a person's lifetime exposure occurs before age 18; and children have more time to develop diseases with long latency, more years of life to be lost and more suffering to be endured as a result of impaired health (WHO, 2003).

References

EU, 2019. Ultraviolet Radiation. European Union (EU). https://ec.europa.eu/health/scientific_committees/opinions_layman/glossary/tuv/uv-radiation.htm Accessed 25 November 2019.

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UN, 2015. Goal 3: Ensure healthy lives and promote well-being for all at all ages. www.un.org/sustainabledevelopment/health Accessed 7 October 2020.

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US EPA, 2004. A Guide to the UV Index. U.S. Environmental Protection Agency (US EPA). www.epa.gov/sites/production/files/documents/uviguide.pdf Accessed 25 November 2019.

US FDA, 2019. Ultraviolet (UV) Radiation. United States Food and Drug Administration (US FDA). www.fda.gov/radiation-emitting-products/tanning/ultraviolet-uv-radiation

WHO, 2002. Global Solar UV Index: A Practical Guide. World Health Organization (WHO). www.who.int/uv/publications/en/UVIGuide.pdf Accessed 25 November 2019.

WHO, 2003. Radiation: Sun Protection. World Health Organization (WHO). www.who.int/news-room/q-a-detail/sun-protection Accessed 7 October 2020.

Coordinating agency or organisation

World Meteorological Organization (WMO), World Health Organization (WHO) and other space weather organisations.

ET0004 / **EXTRATERRESTRIAL / Extraterrestrial**

Meteorite Impact

Definition

A meteorite is an object that survives a trip through Earth's atmosphere and hits the ground (adapted from NASA, no date).

Reference

NASA, no date. Meteors & Meteorites: What's the difference between a meteor, meteoroid and meteorite. Science Solar System Exploration, National Aeronautics and Space Administration (NASA). https://solarsystem.nasa.gov/asteroids-comets-and-meteors/meteors-and-meteorites/overview/?page=0&per_page=40&order=id+asc&search=&condition_1=meteor_shower%3Abody_type Accessed 14 October 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

Meteoroids are objects in space that range in size from dust grains to small asteroids. Think of them as 'space rocks'. When meteoroids enter Earth's atmosphere (or that of another planet, like Mars) at high speed and burn up, the fireballs or 'shooting stars' are called meteors. When a meteoroid survives a trip through the atmosphere and hits the ground, it's called a meteorite (NASA, no date).

On 15 February 2013, a meteor exploded in the sky over Chelyabinsk, southern Russia. Although no people or buildings were hit by the resulting meteorite, the shockwave from the exploding object injured about 1500 people and caused damage to 7200 buildings in the region. The fireball was captured on video, mainly by dash cameras, and posted on the internet by news organisations and individuals (Nelson, 2018).

Although the Chelyabinsk meteorite probably weighed about 12,000 to 13,000 tonnes and measured 17 to 20 metres in diameter before it exploded, scientists were quick to state that it was very small compared to other objects that could potentially hit the Earth. The explosion released energy estimated at about 500 kilotons of TNT (about 20 to 30 times more energy than the Hiroshima atomic bomb). The event brought to the world's attention the very real hazards associated with the impact of objects from outer space (Nelson, 2018).

Metrics and numeric limits

Not identified.

Key relevant UN convention/multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Meteorite impacts produce an array of impact effects that can harm human populations: wind blast, overpressure shock, thermal radiation, cratering, seismic shaking, ejecta deposition, and tsunami. Rumpf et al. (2017) quantified the contributions of each of these effects on overall losses due to a meteorite impact of a given size in a global setting.

References

NASA, no date. Meteors & Meteorites: What's the difference between a meteor, meteoroid and meteorite. Science Solar System Exploration, National Aeronautics and Space Administration (NASA). https://solarsystem.nasa.gov/asteroids-comets-and-meteors/meteors-and-meteorites/overview/?page=0&per_page=40&order=id+asc&search=&condition_1=meteor_shower%3Abody_type Accessed 14 October 2020.

Nelson, S.A., 2018. Meteorites, Impacts, and Mass Extinction. www.tulane.edu/~sanelson/Natural_Disasters/impacts.htm Accessed 14 October 2020.

Rumpf, C., H. Lewis and P. Atkinson, 2017. Asteroid impact effects and their immediate hazards for human populations. Geophysical Research Letters, 44. https://doi.org/10.1002/2017GL073191.

Coordinating agency or organisation

World Meteorological Organization (WMO) in collaboration with other space weather organisations.

ET0005 / **EXTRATERRESTRIAL / Extraterrestrial**

Ionospheric Storms

Definition

An ionospheric storm is defined as turbulence in the F region of the ionosphere, usually due to a sudden burst of radiation from the Sun (WMO, 1992).

NB. The F region is the highest region of the ionosphere, at altitudes greater than 160 km (100 miles).

Reference

WMO, 1992. International Meteorological Vocabulary. World Meteorological Organization (WMO), Report No. 182. https://library.wmo.int/doc_num.php?explnum_id=4712 Accessed 16 October 2020.

Annotations

Synonyms

None identified.

Additional scientific description

'Ionospheric storm' is the term used to denote the major changes that take place in the ionosphere as a result of geomagnetic activity. Ionospheric storms are closely associated with magnetic storms and can lead to severe disruptions of radio-wave propagation, particularly at high latitudes (AMS, 2012).

The Ionosphere is part of Earth's upper atmosphere, between 80 and about 600 km where extreme ultraviolet (EUV) and x-ray solar radiation ionise the atoms and molecules. The ionosphere is important because it reflects and modifies radio waves used for communication, navigation and radar tracking of space objects. Other phenomena such as energetic charged particles and cosmic rays also have an ionising effect and can contribute to the ionosphere (NOAA, 2019a).

The atmospheric atoms and molecules are impacted by the high energy EUV and X-ray photons from the sun. The photon flux at these wavelengths varies by nearly a factor of ten over the 11-year solar cycle. The density of the ionosphere changes accordingly. Due to spectral variability of the solar radiation and the density of various constituents in the atmosphere, layers are created within the ionosphere, called the D, E, and F-layers. Other solar phenomena, such as flares, and changes in the solar wind and geomagnetic storms also affect the state of the ionosphere. Since the largest amount of ionisation is caused by solar irradiance, the night-side of the Earth, and the pole pointed away from the sun (depending on the season) have much less ionisation than the day-side of the Earth, and the pole pointing towards the sun (NOAA, 2019b).

In general, there are two phases of an ionospheric storm, an initial increase in electron density (the positive phase) lasting a few hours, followed by a decrease lasting a few days. During night-time this decrease can result in the effective disappearance of the ionosphere and hence is another process that can cause High-frequency (HF) blackout. At low latitudes only the positive phase is usually seen. Individual storms can vary, and their behaviour depends on geomagnetic latitude, season, and local time (NASA, 2019).

Metrics and numeric limits

The ionospheric storm scale called 'I-scale' [ái skéil] is used in ionospheric storm plots and for the classification of phenomena. See ISES (2019) for further details on the I-scale.

Key relevant UN convention / multilateral treaty

None identified.

Examples of drivers, outcomes and risk management

Ionospheric storms are caused by solar activity such as flares and coronal mass ejections, which result in large variations in the particle and electromagnetic radiation incident upon the Earth. Thus, it is important to monitor such storms, and if possible forecast their evolution (NASA, 2019).

References

AMS, 2012. Ionospheric storm. Glossary of Meteorology, American Meteoroidal Society (AMS). http://glossary.ametsoc.org/wiki/Ionospheric_storm Accessed 25 November 2019.

ISES, 2019. Ionospheric storm scale. International Space Environment Service (ISES). http://swc.nict.go.jp/en/knowledge/i-scale.html Accessed 25 November 2019.

NASA, 2019. Ionospheric storms. National Aeronautics and Space Administration (NASA). https://iono.jpl.nasa.gov/storm.html Accessed 25 November 2019.

NOAA, 2019a. Ionosphere. Space Weather Prediction Center, National Oceanic and Atmospheric Administration (NOAA). www.swpc.noaa.gov/phenomena/ionosphere Accessed 25 November 2019.

NOAA, 2019b. Space Weather Glossary. Space Weather Prediction Center, National Oceanic and Atmospheric Administration (NOAA). www.swpc.noaa.gov/content/space-weather-glossary Accessed 25 November 2019.

Coordinating agency or organisation

World Meteorological Organization (WMO) in collaboration with other space weather organisations.

ET0006 / **EXTRATERRESTRIAL / Extraterrestrial**

Radio Blackout

Definition

Radio blackout is a prolonged period of fading or faded radio communications, primarily in the high frequency range from ionospheric changes because of increased solar activity, in particular solar flares of C-class level or higher on the sunlit side of Earth (AMS, 2018).

Reference

AMS, 2018. Radio blackout. American Meteorological Society (AMS). http://glossary.ametsoc.org/wiki/Radio_blackout Accessed 15 October 2020.

Annotations

Synonyms

D region absorption.

Additional scientific description

Radio blackouts due to solar flares can last from minutes to hours. Solar proton events can also cause long-term radio blackouts over the polar regions for days; these are known as polar cap absorption events (PCAs). Radio blackouts due to solar flares of the M-class level and higher are classified using the NOAA R-Scale (AMS, 2018).

Radio blackouts due to solar flares of the M-class level and higher are classified using the National Oceanic and Atmospheric Administration R-Scale (AMS, 2018).

Solar flare intensities cover a large range and are classified in terms of peak emission in the 0.1–0.8 nm spectral band (soft X-rays) (NOAA, 2019). The X-ray flux levels start with the 'A' level (nominally starting at 10–8 W/m2). The next level, ten times higher, is the 'B' level (≥10–7 W/m2); followed by 'C' flares (10–6 W/m2), 'M' flares (10–5 W/m2), and finally 'X' flares (10–4 W/m2).

The UK Civil Aviation Authority reported that during moderate and above solar storms, high frequency communications on the sunlit side of the Earth are prejudiced through radio blackouts associated with sudden ionospheric disturbances due to the flare (UK CAA, 2020). They noted that at very high latitudes high frequency communications can be prejudiced as a consequence of the radiation storm which causes polar cap absorption, and at auroral latitudes rapid fading and further absorption can occur as a secondary effect associated with the geomagnetic storm. They reported that the various events can last for periods of minutes to hours. As a consequence, aircraft crossing the Atlantic have well established procedures for coping with a loss of high frequency communications which allows aircraft to continue their intended flight plan (UK CAA, 2020).

Metrics and numeric limits

Radio blackouts are classified using a five-level scale by the United States National Oceanic and Atmospheric Administration (NOAA, no date; see chart below). Each level is directly related to the flare's maximum peak in soft X-rays reached or expected (NOAA, 2019).

The Space Weather Prediction Center currently forecasts the probability of C, M, and X-class flares and relates it to the probability of an R1-R2, and R3 or greater event as part of its three-day forecast and forecast discussion products. The Space Weather Prediction Center also issues an alert when an M5 (R2) flare occurs (NOAA, 2019).

Scale	Description	Effect	Physical measure	Average Frequency (1 cycle = 11 years)
R 5	Extreme	HF Radio: Complete HF (high frequency) radio blackout on the entire sunlit side of the Earth lasting for a number of hours. This results in no HF radio contact with mariners and en route aviators in this sector. Navigation: Low-frequency navigation signals used by maritime and general aviation systems experience outages on the sunlit side of the Earth for many hours, causing loss in positioning. Increased satellite navigation errors in positioning for several hours on the sunlit side of Earth, which may spread into the night side.	X20 (2 x 10-3)	Less than 1 per cycle
R 4	Severe	HF Radio: HF radio communication blackout on most of the sunlit side of Earth for one to two hours. HF radio contact lost during this time. Navigation: Outages of low-frequency navigation signals cause increased error in positioning for one to two hours. Minor disruptions of satellite navigation possible on the sunlit side of Earth.	X10 (10-3)	8 per cycle (8 days per cycle)
R 3	Strong	HF Radio: Wide area blackout of HF radio communication, loss of radio contact for about an hour on sunlit side of Earth. Navigation: Low-frequency navigation signals degraded for about an hour.	X1 (10-4)	175 per cycle (140 days per cycle)
R 2	Moderate	HF Radio: Limited blackout of HF radio communication on sunlit side, loss of radio contact for tens of minutes. Navigation: Degradation of low-frequency navigation signals for tens of minutes.	M5 (5 x 10-5)	350 per cycle (300 days per cycle)
R 1	Minor	HF Radio: Weak or minor degradation of HF radio communication on sunlit side, occasional loss of radio contact. Navigation: Low-frequency navigation signals degraded for brief intervals.	M1 (10-5)	2000 per cycle (950 days per cycle)

Key relevant UN convention / multilateral treaty

Not applicable.

Examples of drivers, outcomes and risk management

Solar flares are large eruptions of electromagnetic radiation from the Sun lasting from minutes to hours. The sudden outburst of electromagnetic energy travels at the speed of light, therefore any effect upon the sunlit side of Earth's exposed outer atmosphere occurs at the same time the event is observed. The increased level of X-ray radiation results in ionisation in the lower layers of the ionosphere on the sunlit side of Earth.

Under normal conditions, high frequency (HF) radio waves are able to support communication over long distances by refraction via the upper layers of the ionosphere. When a strong enough solar flare occurs, ionisation is produced in the lower, more dense layers of the ionosphere (the D-region), and radio waves that interact with electrons in layers lose energy due to the more frequent collisions that occur in the higher density environment of the D-region.

This can cause HF radio signals to become degraded or completely absorbed. This results in a radio blackout – the absence of HF communication, primarily impacting the 3 to 30 MHz band (NOAA, 2019).

References

AMS, 2018. Radio blackout. American Meteorological Society (AMS). http://glossary.ametsoc.org/wiki/Radio_blackout Accessed 15 October 2020.

NOAA, 2019. Solar flares (Radio blackouts). Space Weather Prediction Center, National Oceanic and Atmospheric Administration (NOAA). www.swpc.noaa.gov/phenomena/solar-flares-radio-blackouts Accessed 15 October 2020.

NOAA, no date. NOAA Space Weather Scales. Space Weather Prediction Center, National Oceanic and Atmospheric Administration (NOAA). www.swpc.noaa.gov/noaa-scales-explanation

UK CAA, 2020. Impacts of space weather on aviation. UK Civil Aviation Authority (UK CAA). https://publicapps.caa.co.uk/docs/33/CAP1428%20Issue2%20OCT2020.pdf Accessed 15 October 2020.

Coordinating agency or organisation

World Meteorological Organization (WMO) in collaboration with other space weather organisations.

ET0007 / **EXTRATERRESTRIAL / Extraterrestrial**

Solar Storm (Solar Radiation Storm) (S Scale)

Definition

Solar radiation storms occur when large quantities of charged particles, primarily protons, accelerated by eruptive processes at or near the Sun reach the near-Earth environment (NOAA, 2019).

Reference

NOAA, 2019. Solar Radiation Storm. Space Weather Prediction Center, National Oceanic and Atmospheric Administration (NOAA). www.swpc.noaa.gov/phenomena/solar-radiation-storm Accessed 16 October 2020.

Annotations

Synonyms

Solar energetic particle events, Solar proton events.

Additional scientific description

The Earth's magnetic field and atmosphere generally protect life on Earth from this particle radiation, but that shielding depends on latitude, magnetic field strength and direction. In the polar regions, the magnetic field lines intersecting the Earth's surface allow lower energy particles to penetrate into the atmosphere. Solar radiation storms thus often result in polar cap events (PCA), which occur in limited areas around geomagnetic poles; they may last more than a week (NOAA, 2019).

Higher energy particles can penetrate the magnetic field and reach spacecraft orbiting at lower latitudes, in particular the International Space Station. High altitude orbits such as the geosynchronous orbit used by spacecraft delivering many commercial and governmental services are not protected by the magnetic field.

A factor of criticality in a radiation storm is the energy spectrum of the solar protons. High-energy protons cause single event upsets in spacecraft electronics and increase the harmful radiation dose of exposed human beings, such as in manned spaceflights. Lower energy protons have a severe impact on the polar ionosphere and affect High Frequency propagation at high latitude. The severity of radiation storms can thus be characterised by the flux of charged particles (typically as a 5-minute average) above a given energy threshold such as 10 or 100 MeV. For example, the National Oceanic and Atmospheric Administration (NOAA) scale characterises a radiation storm as extreme when the 5-minute flux above 10 MeV exceeds 105 particles•s-1•sr-1•cm-2. In large magnitude solar eruptions, high-energy events may last only a few hours while low-energy events may last up to a week (NOAA, 2019).

Solar radiation storms occur when a large-scale magnetic reconfiguration, causing a coronal mass ejection and often an associated solar flare, accelerates charged particles in the solar atmosphere to very high velocities. The most common particles are protons, but ions of other low mass (helium to iron) elements are often present and contribute significantly to radiation damage. All these ions can be accelerated to large fractions of the speed of light. At these velocities, the particles can traverse the 150 million km from the Sun to Earth in just tens of minutes or less. When they reach Earth, the fast-moving ions penetrate the magnetosphere that shields Earth from lower energy charged particles. Once inside the magnetosphere, low energy (<1 GeV) particles are guided down the magnetic field lines and penetrate into the atmosphere near the north and south poles (NOAA, 2019).

Metrics and numeric limits

NOAA categorises solar radiation storms using the NOAA Space Weather Scale on a scale from S1 to S5 (NOAA, 2011; see graphic below). The scale is based on measurements of energetic protons taken by the GOES satellite in geosynchronous orbit. The start of a solar radiation storm is defined as the time when the flux of protons at energies ≥10 MeV equals or exceeds 10 proton flux units (1 pfu = 1 particle•cm-2•s-1•ster-1). The end of a solar radiation storm is defined as the last time the flux of ≥10 MeV protons is measured at or above 10 pfu. This definition allows multiple injections from flares and interplanetary shocks to be encompassed by a single solar radiation storm. A solar radiation storm can persist for periods ranging from hours to days.

Scale	Description	Effect	Physical measure (Flux level of >= 10 MeV particles)	Average Frequency (1 cycle = 11 years)
S 5	Extreme	Biological: Unavoidable high radiation hazard to astronauts on EVA (extra-vehicular activity); passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk. Satellite operations: Satellites may be rendered useless, memory impacts can cause loss of control, may cause serious noise in image data, star-trackers may be unable to locate sources; permanent damage to solar panels possible. Other systems: Complete blackout of HF (high frequency) communications possible through the polar regions, and position errors make navigation operations extremely difficult.	105	Fewer than 1 per cycle
S 4	Severe	Biological: Unavoidable radiation hazard to astronauts on EVA; passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk. Satellite operations: May experience memory device problems and noise on imaging systems; star-tracker problems may cause orientation problems, and solar panel efficiency can be degraded. Other systems: Blackout of HF radio communications through the polar regions and increased navigation errors over several days are likely.	104	3 per cycle
S 3	Strong	Biological: Radiation hazard avoidance recommended for astronauts on EVA; passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk. Satellite operations: Single-event upsets, noise in imaging systems, and slight reduction of efficiency in solar panel are likely. Other systems: Degraded HF radio propagation through the polar regions and navigation position errors likely.	103	10 per cycle
S 2	Moderate	Biological: Passengers and crew in high-flying aircraft at high latitudes may be exposed to elevated radiation risk. Satellite operations: Infrequent single-event upsets possible. Other systems: Small effects on HF propagation through the polar regions and navigation at polar cap locations possibly affected.	102	25 per cycle
S 1	Minor	Biological: None. Satellite operations: None. Other systems: Minor impacts on HF radio in the polar regions.	10	50 per cycle

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Solar radiation storms cause several impacts near Earth. When energetic protons collide with satellites or humans in space, they can penetrate deep into the object that they collide with and cause damage to electronic circuits or biological DNA. Also, when the energetic protons collide with the atmosphere, they ionise the atoms and molecules thus creating free electrons. These electrons create a layer near the bottom of the ionosphere that can absorb HF radio waves making radio communication difficult or impossible.

NOAA's Space Weather Prediction Center currently forecasts the probability of S1 (minor radiation storm) occurrence as part of their 3-day forecast and forecast discussion products and issues a warning for an expected S1 or higher event; as well as a warning for when the 100 MeV proton level is expected to reach 1 pfu. It also issues alerts for when each NOAA Space Weather Scale Radiation Storm level is reached (S1–S5) and/or when the 100 MeV protons reach 1 pfu (NOAA, 2019).

Some impacts from solar radiation storms can impair the health and operation of satellites and International Space Station operations and crew, and impact HF communication in the polar regions, affecting transpolar commercial airline operations.

In 2019, the International Civil Aviation Organization established a global network to feed space weather advisories into the existing global aviation system (ICAO, 2019). It currently comprises three centres: one operated by a consortium of Australia, Canada, France and Japan, another by a consortium comprising Austria, Belgium, Cyprus, Finland, Germany, Italy, Netherlands, Poland and the United Kingdom; and a third operated by the United States. Further centres are planned to be in operation by 2022.

References

ICAO, 2019. New global aviation space weather network launched. International Civil Aviation Organization (ICAO). www.icao.int/Newsroom/Pages/New-global-aviation-space-weather-network-launched.aspx Accessed 11 April 2020.

NOAA, 2011. Solar Radiation Storm scale. Space Weather Prediction Center, National Oceanic and Atmospheric Administration (NOAA). www.swpc.noaa.gov/noaa-scales-explanation Accessed 15 October 2020.

NOAA, 2019. Solar Radiation Storm. Space Weather Prediction Center, National Oceanic and Atmospheric Administration (NOAA). www.swpc.noaa.gov/phenomena/solar-radiation-storm Accessed 16 October 2020.

Coordinating agency or organisation

World Meteorological Organization (WMO) in collaboration with other space weather organisations.

ET0008 / **EXTRATERRESTRIAL / Extraterrestrial**

Space Hazard / Accident

Definition

A space accident is any accident involving space objects that causes damage (adapted from UNGA, 1971).

Reference

UNGA, 1971. Resolution 2777 (XXVI). 1998th plenary meeting, 29 November 1971. United Nation's General Assembly (UNGA). www.unoosa.org/pdf/gares/ARES_26_2777E.pdf Accessed 14 October 2020.

Annotations

Synonyms

None identified.

Additional scientific description

The term 'damage' refers to loss of life, personal injury or other impairment of health, or loss of or damage to property of States or of persons, natural or juridical, or property of international intergovernmental organisations. The term 'space objects' includes component parts of a space object as well as its launch vehicle and parts thereof (UNGA, 1971:Article I).

Space debris is defined as all man-made objects, including fragments and elements thereof, in Earth orbit or re-entering the atmosphere, that are non-functional. As the population of debris continues to grow, the probability of collisions that could lead to potential damage will consequently increase supporting the common understanding that the current space debris environment poses a risk to spacecraft in Earth orbit. In addition, there is also the risk of damage on the ground, if debris survives Earth's atmospheric re-entry. The prompt implementation of appropriate debris mitigation measures is therefore considered a prudent and necessary step towards preserving the outer space environment for future generations (UN OOSA, 2010).

Metrics and numeric limits

None available.

Key relevant UN convention / multilateral treaty

The Convention on International Liability for Damage Caused by Space Objects (Liability Convention) 1972 was considered and negotiated by the Legal subcommittee from 1963 to 1972. Agreement was reached in the General Assembly in 1971 (UNGA, 1971), and the Convention entered into force in September 1972 (UN OOSA, 1972). Elaborating on Article 7 of the Outer Space Treaty, the Liability Convention provides that a launching State shall be absolutely liable to pay compensation for damage caused by its space objects on the surface of the Earth or to aircraft, and liable for damage due to its faults in space. The Convention also provides for procedures for the settlement of claims for damages.

Examples of drivers, outcomes and risk management

The international Association for the Advancement of Space Safety (IAASS) is an association that seeks internationally to advance space safety through advancing the science and application of space safety. The IAASS website contains numerous resources on the topic (IAASS, no date).

References

IAASS, no date. International Association for the Advancement of Space Safety. http://iaass.space-safety.org

UN OOSA, 1972. Convention on International Liability for Damage Caused by Space Objects (Liability Convention), 1972. www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introliability-convention.html Accessed 14 October 2020.

UN OOSA, 2010. Space Debris Mitigation Guidelines of the Committee on the Peaceful Uses of Outer Space. United Nations Office for Outer Space Affairs (UN OOSA). www.unoosa.org/pdf/publications/st_space_49E.pdf Accessed 14 October 2020.

UNGA, 1971. Resolution 2777 (XXVI). 1998th plenary meeting, 29 November 1971. United Nation's General Assembly (UNGA). www.unoosa.org/pdf/gares/ARES_26_2777E.pdf Accessed 14 October 2020.

Coordinating agency or organisation

World Meteorological Organization (WMO) in collaboration with other space weather organisations.

ET0009 / **EXTRATERRESTRIAL / Extraterrestrial**

Near-Earth Object

Definition

A near-Earth object (NEO) is an asteroid or comet whose trajectory brings it to within 1.3 astronomical units of the Sun and hence within 0.3 astronomical units, or approximately 45 million kilometres, of the Earth's orbit (UN OOSA, no date).

References

UN OOSA, no date. UN-SPIDER knowledge Portal, Near-Earth Objects. United Nations Office for Outer Space Affairs (UN OOSA). www.un-spider.org/disaster-type/near-earth-objects Accessed 14 October 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

The definition above includes objects that will come close to Earth at some point in their future orbital evolution. Near-Earth objects (NEOs) generally result from objects that have experienced gravitational perturbations from nearby planets, moving them into orbits that allow them to come near to Earth.

Metrics and numeric limits

A near-Earth asteroid is said to be a potentially hazardous asteroid when its orbit comes within 0.05 astronomical units of the Earth's orbit and it has a measured absolute magnitude H<22 mag (an estimated diameter greater than 140 meters) (NASA, no date).

Key relevant UN convention / multilateral treaty

The Committee on the Peaceful Uses of Outer Space (COPUOS) was set up by the United Nations General Assembly in 1959 to govern the exploration and use of space for the benefit of all humanity: for peace, security and development (COPUOS, no date)). The Committee was tasked with reviewing international cooperation in peaceful uses of outer space, studying space-related activities that could be undertaken by the United Nations, encouraging space research programmes, and studying legal problems arising from the exploration of outer space.

Examples of drivers, outcomes and risk management

The International Asteroid Warning Network (IAWN) was established in 2013 as a result of the UN-endorsed recommendations for an international response to a potential NEO impact threat, to create an international group of organisations involved in detecting, tracking, and characterising NEOs. IAWN is tasked with developing a strategy using well-defined communication plans and protocols to assist governments in the analysis of asteroid impact consequences and in the planning of mitigation responses. Currently, IAWN includes members from Europe, Asia, South and North America (IAWN, 2020).

IAWN has proposed the following definition of an NEO: An asteroid, meteoroid, or a comet as it passes near Earth, enters the Earth's atmosphere, and/or strikes the Earth, or provokes changes in inter-planetary conditions that affect the Earth's magneto-sphere, ionosphere, and thermosphere. The criteria and thresholds related to this definition are as follows (UN OOSA, no date):

- The probability that an NEO will impact Earth (either 1% for warning and 10% for terrestrial preparedness planning).
- The probable size, or at least its luminosity in the night sky (greater than 10 meters or at least absolute magnitude 28).
- How far in the future the NEO will impact Earth (20 years).

The European Space Agency's (ESA) Space Situational Awareness (SSA) programme partners with many countries, organisations and individuals. In particular, it has strong links to COPUOS, which facilitates the Space Mission Planning Advisory Group (SMPAG) and IAWN. SMPAG and IAWN were both established in response to the need for an international response to the threat of NEO impacts. SMPAG coordinates the technological know-how of agencies, including ESA, recommending specific responses to asteroid threats, including basic research and development, impact mitigation measures and deflection missions. Depending on the capabilities and specific technologies available to each agency, options are made to ensure the best use of skills within each organisation. ESA's primary projects are the SSA programme – in particular, the dedicated NEO segment, mapping of threat scenarios to mission types, as well as AIM – ESA's Asteroid Impact Mission (ESA, 2018).

IAWN and SMPAG have agreed on the following criteria and thresholds for impact-response actions:

1. IAWN shall warn of predicted impacts exceeding a probability of 1% for all objects characterised to be greater than 10 meters in size, or roughly equivalent to absolute magnitude of 28 if only brightness data can be collected.

   Rationale: Impact probabilities greater than 1% are rare. Most objects greater than 10 meters in size will have effects (air blast and pieces) that could reach the Earth's surface. IAWN is compelled to warn populations if bodies will have effects that reach the ground. Setting the threshold at 1% is a compromise between not being overly alarmist and not warning too late for necessary action to be initiated. It is a probability figure that individuals and governments can comprehend. An alert such as this demonstrates that the IAWN is functioning. Further, it ensures the flow of communication from IAWN to the public and the United Nations.
2. Terrestrial preparedness planning is recommended to begin when warned of a possible impact is predicted to be within 20 years; the probability of impact is assessed to be greater than 10%; and the object is characterised to be greater than 20 meters in size, or roughly equivalent to absolute magnitude of 27 if only brightness data can be collected.

   Rationale: Terrestrial preparedness and the increased potential for impact will also involve determination of a 'risk corridor' from objects with 10% impact probabilities and impacts in less than 20 years. This provides populations and population centres on Earth with information to begin preparations for emergency preparedness if needed. The surprising effects of the Chelyabinsk event in 2013 from an object ~18 meters in size, in turn led to the establishment of a lower limit (20 meters) in these threshold criteria.
3. SMPAG should start mission option(s) planning when warned of a possible impact predicted to be within 50 years; where the probability is assessed to be greater than 1%; and if the object is characterised to be greater than 50 meters in size, or roughly equivalent to absolute magnitude of 26 if only brightness data can be collected.

   Rationale: Several decades warning, if available, enables sufficient lead time to mount characterisation missions. If a 1% probability on a 100-meter object is assessed, SMPAG will be informed immediately following verification of the precise orbit. Part of such a characterisation mission would likely deploy a transponder with the object.

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UN OOSA, no date. UN-SPIDER knowledge Portal, Near-Earth Objects. United Nations Office for Outer Space Affairs (UN OOSA). www.un-spider.org/disaster-type/near-earth-objects Accessed 14 October 2020.

Coordinating agency or organisation

World Meteorological Organization (WMO) in collaboration with other space weather organisations.

GEOHAZARDS

GH0001 / **GEOHAZARDS / Seismogenic (Earthquakes)**

Earthquake

Definition

Earthquake is a term used to describe both sudden slip on a fault, and the resulting ground shaking and radiated seismic energy caused by the slip, or by volcanic or magmatic activity, or other sudden stress changes in the Earth (USGS, no date).

Reference

USGS, no date. Earthquake glossary. United States Geological Survey (USGS). https://earthquake.usgs.gov/learn/glossary/?term=earthquake Accessed 14 October 2020.

Annotations

Synonyms

Earth tremor.

Additional scientific description

Earthquake hazards are the physical phenomena that result from the occurrence of an earthquake. Primary earthquake hazards are those phenomena that occur most directly from an earthquake: ground shaking, landslides (and debris flow), liquefaction, surface rupture (and fissures), and subsidence/uplift. Secondary earthquake hazards are those that are caused by primary hazards, and include tsunami, seiche, flooding, fire and ground gases (PNSN, no date).

Metrics and numeric limits

Earthquake magnitudes are given using one of several broadly equivalent scales. The 'Moment magnitude' (Hanks and Kanamori, 1979) scaling is the preferred measure of an earthquake's size, as it quantifies the energy released by the earthquake and unlike other scales, does not saturate for large-magnitude events. Magnitude scales are a logarithmic scale; each increase of 1 magnitude unit (i.e., 4.3 to 5.3) represents an order of magnitude (factor of 10) increase in the amplitude of seismic measurements, and a factor of 32 increase in the energy release of an earthquake (USGS, no date a).

Earthquakes of magnitude 7.0 and above can be expected to cause widespread, intense ground shaking as well as other primary and secondary hazards; earthquakes of magnitudes 6.0 to 6.9 may cause local damage, while smaller earthquakes can cause damage to vulnerable structures at near-source distances. Note that damage may be more severe and widespread for an earthquake of a given magnitude and other characteristics in regions of fragile buildings, high-density populations or regions with local soil conditions that promote the amplification of ground shaking.

There are many different metrics for measuring the effects of earthquakes at a particular location. Qualitative intensity measures, like the Modified Mercalli intensity (MMI) scale (Wood and Neumann, 1931), and similar scales such as the Medvedev-Sponheuer-Kárník (MSK) scale or the European Macrointensity Scale (EMS-98) (Grünthal, 1998), describe the severity of an earthquake in terms of its effects on the Earth's surface, the infrastructure and the population (USGS, no date b). Modified Mercalli intensity values range from I (not felt) to XII (Total Damage), and the threshold for structural damage begins at VI, although this varies according to the fragility of buildings in a given region. For some earthquake reporting agencies, MMI XI and XII are no longer assigned and MMI X is available but has not been applied in recent times. Since 1931, it has become clear that many of the phenomena described by Wood and Neumann (1931) were less related to ground shaking, and more to other factors that would promote widespread destruction (Dewey et al., 1995).

Some of the other quantitative measures of ground shaking by seismic instruments include: the global map of earthquake hazard and risk produced by the Global Earthquake Model Foundation (GEM, 2018), the metric 'European Macroseismic Scale' for measuring the effects of earthquakes at a particular location (Grünthal, 1998), and ShakeMap®, developed by the U.S. Geological Survey (USGS, no date b).

Key relevant UN convention/multilateral treaty

Sendai Framework for Disaster Risk Reduction 2015-2030 (UNDRR, 2015).

Examples of drivers, outcomes and risk management

Earthquakes and associated (primary and secondary) hazards killed nearly 750,000 people between 1994 and 2013, more people than all other natural hazard disasters combined (CRED, 2015).

While technology does not yet exist for reducing earthquake hazards, the risk to buildings and infrastructure and human population can be mitigated by seismic retrofitting of existing buildings, improved compliance with seismic safety building guidelines, and avoidance of building on cliff faces, soft soils or next to an active fault.

The most common and effective measure for mitigating earthquake risk is by implementing building codes with provisions for earthquake safety. For example, the US Federal Emergency Management Agency (FEMA, 2020) hosts a useful website on Seismic Building Codes.

The Global Earthquake Model Foundation recently produced a global map of earthquake hazard and risk (GEM, 2018) and is releasing the underlying national and regional models. Many of GEM's hazard models have been developed by or in collaboration with national governments for seismic design regulations in building codes

Some success has also been achieved in the development of early warning systems, which detect earthquakes close to the source or fault rupture, and trigger warnings to more distant locations, providing seconds to minutes of advance warning (Gasparini et al., 2007). Examples include the warning system for Japan's bullet trains, and Mexico City's warning system for evacuating vulnerable buildings.

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Wood, H.O. and F. Neumann, 1931. Modified Mercalli intensity scale of 1931. Bulletin of the Seismological Society of America, 21:277-283.

Coordinating agency or organisation

Global Earthquake Model Foundation (GEM).

GH0002 / **GEOHAZARDS / Seismogenic (Earthquakes)**

Ground Shaking (Earthquake)

Definition

Earthquake ground shaking is the movement of the Earth's surface produced by seismic waves that are generated when an earthquake occurs (adapted from USGS, no date).

Reference

USGS, no date. Earthquake glossary. United States Geological Survey (USGS). earthquake.usgs.gov/learn/glossary/?term=ground%20motion Accessed 14 October 2020.

Annotations

Synonyms

Seismicity, Shaking intensity, Ground motion, Ground vibration, Local ground response, Vibration.

Additional scientific description

Earthquake ground shaking is produced by waves that are generated by sudden slip on a fault that travel through the Earth and along its surface (USGS, no date a). All earthquakes, both natural and man-made, generate seismic waves. Seismic waves radiate outward from the earthquake origin, forming a circular wave front that causes shaking over an extended region (Stein and Wysession, 2003).

The strength and duration of the ground shaking at any given location depends on many factors, predominantly the magnitude of the earthquake, distance to earthquake origin, and local soil conditions. Thus, at each site, ground shaking from an earthquake is unique and can vary significantly from location to location (USGS, no date b).

Ground shaking is the predominant seismic hazard (secondary seismic hazards include liquefaction, surface rupture, landslides etc.), causing more than 90% of earthquake damage and losses (National Institute of Building Sciences Building Seismic Safety Council, 2010).

Earthquake ground shaking scales with the source earthquake's magnitude, as well as the distance from the earthquake to a particular location, the depth of the earthquake, and the properties of the rock and soil between the earthquake and a given observation site.

Earthquake magnitudes are given using one of several broadly equivalent scales, with the 'moment magnitude' scaling being the preferred measure of an earthquake's size, as it quantifies the energy released by the earthquake (USGS, no date c). The magnitude scale is logarithmic; each increase of 1 magnitude unit (i.e., 4.3 to 5.3) represents an order of magnitude (factor of 10) increase in the amplitude of seismic measurements, and a factor of 32 increase in the energy release of an earthquake (USGS, no date a). Earthquakes of Magnitude 7.0 and above tend to cause widespread, intense ground shaking; while earthquakes of Magnitudes 6.0 to 6.9 may cause local damage. Note that damage may be more severe and widespread for an earthquake of a given magnitude and other characteristics in regions of fragile buildings and high-density populations.

Metrics and numeric limits

Although there is no globally agreed metric available, there is a global earthquake risk model (GEM, 2018) and other initiatives from the Global Earthquake Model Foundation (GEM) including a Global Exposure Database for Multi-Hazard Risk Analysis. The Peak Ground Acceleration method for measuring ground shaking is the preferred approach (Pagani et al., 2018), but global use is limited by the distribution of instrumentation.

There are many different metrics for measuring ground shaking at a particular location:

Qualitative intensity measures, like the Modified Mercalli intensity (MMI) scale, and similar scales such as the Medvedev-Sponheuer-Kárník (MSK) scale or the European Macrointensity Scale (EMS-98) (Grünthal, 1998) describe the severity of an earthquake in terms of its effects on the Earth's surface and on people and structures (USGS, no date a). MMI values range from I (not felt) to XII (Total Damage), and the threshold for structural damage begins at VI, although this varies with the fragility of buildings in a given region. For some earthquake reporting agencies, MMI XI and XII are no longer assigned and MMI X is available but has not been applied in recent times. Since 1931, it has become clear that many of the phenomena described by Wood and Neumann (1931) were less related to ground shaking, and more to other factors that would promote widespread destruction (Dewey et al., 1995).

Quantitative measures are direct measures of ground shaking by seismic instruments. A widely used and preferred metric for the strength of ground shaking is Peak Ground Acceleration (PGA). PGA is calculated as the greatest increase in velocity recorded by a particular station during an earthquake (USGS, no date a), and typically given in units of g (Earth's gravitational acceleration on its surface; 9.81 m/s2). It is an appropriate measure because the physical force exerted by the ground motions against any object on the surface is proportional to the peak acceleration. For engineering purposes, additional metrics such as spectral acceleration, which measure the forces experienced by structures at specified frequencies to which the structures may be particularly vulnerable. Generally, PGA values of less than 0.1 g are not expected to cause much damage, while values of between 0.2 g and 0.8 g may cause moderate damage; anything above this is expected to be very damaging (USGS, no date b). It is important to note that the amount of damage caused by ground motions of any given intensity in an area are highly dependent on the strength of infrastructure in that area. The largest recorded ground motion to date was 4.3 g in the 2008 Iwate-Miyagi earthquake, Japan (Yamada et al., 2010).

Ground shaking can last from a few seconds in small earthquakes to several minutes in the largest earthquakes.

Key relevant UN convention/multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Earthquakes are part of the natural tectonic process and will always occur (Stein and Wysession, 2003). Earthquakes, and therefore earthquake ground shaking, cannot be prevented, but their impacts on life, property, and the economy can be managed (National Institute of Building Sciences Building Seismic Safety Council, 2010).

Seismic risk from ground shaking is best managed through accurate estimation of the likelihood of seismic ground shaking at damaging levels, implementation of and conformance to appropriate building codes, and governmental and popular awareness and preparation for earthquakes.

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Coordinating agency or organisation

Global Earthquake Model Foundation (GEM).

GH0003 / **GEOHAZARDS / Seismogenic (Earthquakes)**

Liquefaction (Earthquake Trigger)

Definition

Soil liquefaction occurs when soil is transformed from a solid to a liquid state as a result of increased pore pressure and reduced effective stress. It is typically caused by rapid loading of the soil during earthquake shaking (AGI, 2017).

Reference

AGI, 2017. Liquefaction [soil]. American Geosciences Institute (AGI). www.americangeosciences.org/word/liquefaction-soil Accessed 14 October 2002.

Annotations

Synonyms

Not identified.

Additional scientific description

For liquefaction to occur, the shear strength of the soil volume (e.g., the strength due to contact between individual soil grains) must be reduced to near-zero. In the case of earthquakes, strong shaking applies a cyclic load to the soil body. If the soil body compresses under this load, the pore-water pressure will increase, causing the grains to separate thus reducing soil strength (Kramer, 1996).

Soil compression increases the pore-water pressure, causing the water to move toward the Earth's surface where pressure is lower. Under typical loading (e.g., from temperature changes, increased groundwater), the water then drains, and contact between grains retain their strength. However, when loading cycles occur rapidly, such as during an earthquake, intermittent drainage is prohibited, and liquefaction may initiate (Kramer, 1996).

The following characteristics are common to deposits most susceptible to liquefaction (Kramer, 1996):

- Loose, sandy soils (but liquefaction has occasionally been observed in gravels and coarse silts)
- Rounded, well-sorted grains (e.g., uniform grain size); these compact most easily
- Recently deposited, especially of Holocene age (<11.7 ky), uncompacted soils including human-made deposits
- Soils that are saturated, below sea level, or within a few meters of groundwater.

Some of the most common landforms in which liquefaction occurs are marshlands, riverbanks, beaches, and floodplains. Post-earthquake field studies have shown that earthquake-triggered liquefaction often recurs at the same locations (Kramer, 1996). Earthquake-induced liquefaction can have varied effects on the surrounding built environment. Buildings, infrastructure, and utilities normally supported by the soil may sink, or undergo cracking or other structural damage; pile foundations may buckle or tilt; and lightweight, buried masses such as pipelines may become buoyant and float to the surface. Liquefaction can also cause rapid settling of sediments, flooding (including breaches of earthen embankments or other retaining structures), and lateral spreading of soils (Kramer, 1996).

In general, sites closer to an earthquake's epicentre are more likely to liquefy, while the distance at which sites are susceptible to liquefaction increases with moment magnitude (MW) and the duration (or number of cycles) of ground motion.

The smallest earthquake for which liquefaction records exist was MW ~ 5, with the most distant observed liquefaction reaching only ~2 km; by contrast, the most distant liquefaction for an earthquake of MW >7, may exceed 100 km (Ambraseys, 1988). During the 2011 MW 9.0 Tohoku earthquake, damage due to liquefaction occurred at least 250 km from the epicentre (Yamaguchi et al., 2012).

Liquefaction susceptibility can be assessed in advance of earthquakes (e.g., Lirer at al., 2019). Often, this is based on a simplified indication of a site's likelihood to liquefy. A common approach is the liquefaction potential index (LPI), which considers a factor of safety against liquefaction, the layers of earth that might liquefy, and the proximity of these layers to the ground surface (Iwasaki et al., 1984). While several methods are available for determining the factor of safety, they generally reflect the ability of the soil to resist the power of an earthquake. Soil resistance is either measured in situ or estimated based on the surficial deposits and hydrological conditions (Kramer, 1996; Witter et al., 2006). The comparison to earthquake power can be deterministic for the worst-case scenario earthquake (Orhan et al., 2013), or probabilistic for the range of possible earthquakes that could occur (Witter et al., 2006).

Metrics and numeric limits

Liquefaction susceptibility maps (also called liquefaction hazard maps) are currently not available on a global scale but are often provided by the geological agencies in a region. See USGS (no date) for an example of a liquefaction map for the San Francisco Bay Area.

Key relevant UN convention/multilateral treaty

Not relevant.

Examples of drivers, outcomes and risk management

In-situ testing of liquefaction resistance using standard penetration tests, cone penetration tests, shear wave velocity recordings, and dilatometer tests (Kramer, 1996); land microzonation via LPI or another assessment parameter that prohibits building on susceptible deposits (Lirer et al., 2019); and soil stabilisation via compaction methods or injection of grout, such as vibro stone columns and dynamic compaction (Shenthan et al., 2004).

References

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Coordinating agency or organisation

Global Earthquake Model Foundation.

GH0004 / **GEOHAZARD / Seismogenic (Earthquakes)**

Earthquake Surface Rupture, Fissures, and Tectonic Uplift/Subsidence

Definition

Earthquake surface ruptures and fissures are localised ground displacements that develop during and immediately after an earthquake, where the fault which hosted the earthquake intersects the Earth's surface. Surface ruptures represent the upward continuation of fault slip at depth, while fissures are smaller displacements, or more distributed deformation in and around the rupture area (adapted from USGS, no date and PNSN, no date).

Tectonic uplift and subsidence are the distributed vertical permanent ground deformations (warping) that result from displacement on a dipping (inclined) fault (Styron, 2019).

References

PNSN, no date. Surface rupture. Pacific Northwest Seismic Network (PNSN). pnsn.org/outreach/earthquakehazards/surface-rupture Accessed 24 November 2019.

Styron, R., 2019. Coseismic uplift and subsidence: An underappreciated seismic threat. Global Earthquake Model Foundation (GEM) Hazard Blog. blogs.openquake.org/hazard/2019/11/19/coseismic-uplift-subsidence Accessed 24 November 2019.

USGS, no date. Surface faulting. United States Geological Survey (USGS). earthquake.usgs.gov/learn/glossary/?term=surface%20faulting Accessed 24 November 2019.

Annotations

Synonyms

Fault scarp, Fault displacement, Fault offset, Ground deformation, Surface faulting, Coseismic subsidence.

Additional scientific description

Most earthquakes are caused by displacement (sliding) of the Earth's crust at a fault. The relative motion of the crust on either side of the fault results in persistent or permanent deformation of the Earth's surface, in addition to the ground shaking resulting from the sudden release of energy during the earthquake. Surface ruptures, fissures, and uplift and subsidence are all manifestations of this longer-term deformation, and although less dramatic, may all pose hazards during and after earthquakes (Styron, 2019).

Metrics and numeric limits

The size and spatial extent of surface ruptures, fissures and uplift/subsidence depend on the type, magnitude and depth of the earthquake as well as the distance from the earthquake.

Surface ruptures are expected in about half of continental Magnitude 6 earthquakes, with an expectation that increases to 100% for continental earthquakes at Magnitude 8 and greater (Biasi and Weldon, 2006). Displacements vary from a few centimetres for earthquakes at the low end of this range and near the edges of larger earthquakes, up to 15–20 m for the largest possible continental earthquakes, around Magnitude 8 (Biasi and Weldon, 2006). Fissures are generally much smaller and more spatially distributed than surface ruptures.

Tectonic uplift and subsidence are generally as large or larger than the displacement of the surface rupture; moderate to large earthquakes in the crust that do not rupture to the surface will still broadly warp the region. The magnitude of the displacement will decrease with increasing distance from the earthquake, but in the case of ruptures on inclined faults such as subduction zones (rather than vertical strike-slip faults) uplift or subsidence of at least 1 m may extend more than 200 km from the fault trace for the largest earthquakes (Styron, 2019).

Both of these effects will extend along the length of the earthquake fault, a distance of a few kilometres for Magnitude 6 earthquakes to more than 1000 km for Magnitude 9 earthquakes.

Key relevant UN convention/multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Earthquake surface ruptures, fissures, and tectonic uplift/subsidence are caused by earthquakes of sufficient magnitude and proximity to the Earth's surface to cause permanent ground deformation. Surface ruptures and fissures are generally limited to the area near the causative fault's intersection with the Earth's surface, while uplift and subsidence can occur over a much broader region (Styron, 2019).

Surface ruptures and fissures can cause damage to buildings, roads, and utility infrastructure (e.g., gas and water lines). In addition to the immediate, local risk posed by collapsing infrastructure, this damage may hamper rescue and rebuilding efforts by impeding transportation and utility delivery. In the worst cases, damage to lifelines may cause local flooding (e.g., water lines), environmental impacts (e.g., oil pipelines) and even highly destructive fires (gas lines) that may be more damaging than the initial earthquake. There is also potential for disruption due to flooding or re-routing of rivers if the river channel is sufficiently modified (Holbrook and Schumm, 1999).

While no technology exists for reducing these or other earthquake hazards, the risk to infrastructure posed by surface rupture and fissures can be partly mitigated by not building on known fault traces, seismic retrofitting of existing buildings, and engineering of pipelines with enough flexibility to absorb the displacement by bending and flexing, rather than breaking (e.g., USGS, 2003).

Tectonic uplift and subsidence are not generally destructive, with the exception of earthquakes on coastal faults. These events, particularly large subduction zone earthquakes, can cause persistent (decades-long) or permanent reconfigurations of a coastline. Uplift during an earthquake can lead to dramatic decreases in the depth and utility of harbours. Subsidence during a Magnitude 8–9 subduction zone earthquake can cause coastal communities, highways, and other infrastructure to sink below sea level, and the establishment of a new shoreline inland by several tens to hundreds of metres.

References

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Styron, R., 2019. Coseismic uplift and subsidence: An underappreciated seismic threat. Global Earthquake Model Foundation (GEM) Hazard Blog. blogs.openquake.org/hazard/2019/11/19/coseismic-uplift-subsidence Accessed 24 November 2019.

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Coordinating agency or organisation

Global Earthquake Model Foundation (GEM).

Subsidence and Uplift, Including Shoreline Change (Earthquake Trigger)

Definition

Tectonic uplift and subsidence are the distributed vertical permanent ground deformations (warping) that result from earthquake displacements on a dipping (inclined) fault (Styron, 2019). This includes changes to the shoreline as a result of uplift and subsidence.

Reference

Styron, R., 2019. Coseismic uplift and subsidence: An underappreciated seismic threat. Global Earthquake Model Foundation (GEM) Hazard Blog. blogs.openquake.org/hazard/2019/11/19/coseismic-uplift-subsidence Accessed 24 November 2019.

Annotations

Synonyms

Coseismic uplift/subsidence.

Additional scientific description

Most earthquakes are caused by displacement (sliding) of the Earth's crust at a fault. The relative motion of the crust on either side of the fault results in persistent or permanent deformation of the Earth's surface, in addition to the ground shaking resulting from the sudden release of energy during the earthquake. Tectonic uplift and subsidence are manifestations of this longer-term deformation, and though less dramatic, they may all pose hazards during and after earthquakes (Styron, 2019).

Metrics and numeric limits

The size and spatial extent of tectonic uplift or subsidence depends on the type, magnitude and depth of the earthquake as well as the distance from the earthquake.

Tectonic uplift and subsidence are generally as large or larger than the displacement of the surface rupture; moderate to large earthquakes in the crust that do not rupture to the surface will still broadly warp the region. The magnitude of the displacement will decrease with increasing distance from the earthquake, but in the case of ruptures on inclined faults such as subduction zones (rather than vertical strike-slip faults) uplift or subsidence of at least 1 m may extend more than 200 km from the fault trace for the largest earthquakes (Styron, 2019).

These effects will extend along the length of the earthquake fault, a distance of a few kilometres for Magnitude 6 earthquakes to more than 1000 km for Magnitude 9 earthquakes.

Key relevant UN convention/multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Tectonic uplift and subsidence are caused by earthquakes of sufficient magnitude and proximity to the Earth's surface to cause permanent ground deformation. Tectonic uplift and subsidence can occur over a broad region around the causative fault (GEM, 2019).

Tectonic uplift and subsidence are not generally destructive, with the exception of earthquakes on coastal faults. These events, particularly large subduction zone earthquakes, can cause persistent (decades-long) or permanent reconfigurations of a coastline. Uplift during an earthquake can lead to dramatic decreases in the depth and utility of harbours. Subsidence during a Magnitude 8–9 subduction zone earthquake can cause coastal communities, highways, and other infrastructure to sink below sea level, and the establishment of a new shoreline inland by several tens to hundreds of metres (Plafker, 1965).

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Coordinating agency or organisation

Global Earthquake Model Foundation (GEM).

GH0006 / **GEOHAZARDS / Seismogenic (Earthquakes)**

Tsunami (Earthquake Trigger)

Definition

Tsunami is the Japanese term meaning wave ('nami') in a harbour ('tsu'). It is a series of travelling waves of extremely long length and period, usually generated by disturbances associated with earthquakes occurring below or near the ocean floor (IOC, 2019).

Reference

IOC, 2019. Tsunami Glossary, 2019. Intergovernmental Oceanographic Commission (IOC), Technical Series, 85. Fourth Edition. IOC/2008/TS/85 rev.4. https://unesdoc.unesco.org/ark:/48223/pf0000188226?posInSet=1&queryId=aeb846ae-edfb-4d66-a03a-385a5d5897f0

Annotations

Synonyms

Not found.

Additional scientific description

A tsunami may also be referred to as a 'seismic sea wave' and, incorrectly, a 'tidal wave'. Volcanic eruptions, submarine landslides, and coastal rock falls can also generate tsunamis, as can a large meteorite impacting the ocean. These waves may reach enormous dimensions and travel across entire ocean basins with little loss of energy. They proceed as ordinary gravity waves with a typical period of between 10 and 60 minutes. Tsunamis steepen and increase in height on approaching shallow water, inundating low-lying areas, and where local submarine topography causes the waves to steepen, they may break and cause great damage (IOC, 2019).

Tsunami-like phenomena generated by meteorological or atmospheric disturbances are known as meteotsunami (UNESCO and IOC, 2019).

The Intergovernmental Oceanographic Commission (IOC) uses the following terms to assess the scale and impact of a tsunami (IOC, 2019):

Travel time: Time required for the first tsunami wave to propagate from its source to a given point on a coastline.

Arrival time: Time of the first maximum of the tsunami waves.

Inundation or Inundation-distance: The horizontal distance inland that a tsunami penetrates, generally measured perpendicularly to the shoreline.

Inundation (maximum): Maximum horizontal penetration of the tsunami from the shoreline. A maximum inundation is measured for each different coast or harbour affected by the tsunami.

Inundation area: Area flooded with water by the tsunami.

Inundation height: Elevation reached by seawater measured relative to a stated datum such as mean sea level or the sea level at the time of tsunami arrival, at a specified inundation distance. Inundation height is the sum of the flow depth and the local topographic height. Sometimes referred to as tsunami height.

Inundation line: Inland limit of wetting measured horizontally from the mean sea level line. The line between living and dead vegetation is sometimes used as a reference. In tsunami science, the landward limit of tsunami run-up.

Leading wave: First arriving wave of a tsunami. In some cases, the leading wave produces an initial depression or drop in sea level, and in other cases, an elevation or rise in sea level. When a drop in sea level occurs, sea level recession is observed.

Mean height: Average height of a tsunami measured from the trough to the crest after removing the tidal variation.

Run-up

- Difference between the elevation of maximum tsunami penetration (inundation line) and the sea level at the time of the tsunami. In practical terms, run up is only measured where there is clear evidence of the inundation limit on the shore.
- Elevation reached by seawater measured relative to some stated datum such as mean sea level, mean low water, sea level at the time of the tsunami event, etc., and measured ideally at a point that is a local maximum of the horizontal inundation. Where the elevation is not measured at the maximum of horizontal inundation, this is often referred to as the inundation height.

Tsunami amplitude: Usually measured on a sea level record, it is (1) the absolute value of the difference between a particular peak or trough of the tsunami and the undisturbed sea level at the time, (2) half the difference between an adjacent peak and trough, corrected for the change of tide between that peak and trough. It is intended to represent the true amplitude of the tsunami wave at some point in the ocean. However, it is often an amplitude modified in some way by the tide gauge response.

Tsunami period: Amount of time that a tsunami wave takes to complete a cycle, or one wavelength. Tsunami periods typically range from 5 to 60 minutes. Tsunami period is often measured as the difference between the arrival time of the highest peak and the next one measured on a water level record.

Tsunami wavelength: The horizontal distance between similar points on two successive waves measured perpendicular to the crest. The wavelength and the tsunami period give information on the tsunami source. For tsunamis generated by earthquakes, the typical wavelength ranges from 20 to 300 km. For tsunamis generated by landslides, the wavelength is much shorter, ranging from hundreds of metres to tens of kilometres.

For more terms see IOC (2019).

Metrics and numeric limits

Not available.

Key relevant UN convention/multilateral treaty

Not available.

Examples of drivers, outcomes and risk management

Tsunamis are created by an underwater disturbance such as an earthquake, landslide, volcanic eruption, and meteorite or generated by meteorological or atmospheric disturbances.

Primary hazards/damage. Damage and destruction from tsunamis is the direct result of three factors: inundation, wave impact on structures, and erosion. Deaths occur by drowning and physical impact or other trauma when people are caught in the turbulent, debris-laden tsunami waves. Strong tsunami-induced currents have led to the erosion of foundations and the collapse of bridges and seawalls. Floatation and drag forces have moved houses and overturned railroad cars (IOC, 2019:6).

Tsunami associated wave forces have demolished frame buildings and other structures. Considerable damage is also caused by floating debris, including boats, cars, and trees that become dangerous projectiles that may crash into buildings, piers, and other vehicles. Ships and port facilities have been damaged by surge action caused by even weak tsunamis. Fires resulting from oil spills or combustion from damaged ships in port, or from ruptured coastal oil storage and refinery facilities, can cause damage greater than that inflicted directly by the tsunami (IOC, 2019:6).

Secondary hazards/damage can result from sewage and chemical pollution following the destruction. Damage of intake, discharge, and storage facilities can also present dangers. Of increasing concern is the potential effect of tsunami drawdown, when receding waters uncover cooling water intakes associated with nuclear power plants (IOC, 2019:7).

Risk management for tsunamis includes guidelines on tsunami risk assessment/management. Examples include IOC (2015) and UNDRR (2017).

Regional Coordination and Centres: The IOC is coordinating the implementation of a global tsunami warning system, building upon its experiences in the Pacific to establish regional warning systems for the Indian Ocean (IOTWMS); Caribbean Sea (ICG-CARIBE-EWS); and the North-eastern Atlantic, the Mediterranean and connected seas (ICG-NEAMTWS). The regional systems coordinate international tsunami warning and mitigation activities, including the issuance of timely and understandable tsunami bulletins to IOC Member States.

The Intergovernmental Coordination Group for Tsunamis addresses tsunami risk globally through the following groups:

ICG-PTWS Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System, formerly ICG/ITSU, was renamed by Resolution EC-XXXIX.8 of the IOC Executive Council in 2006 as proposed by the International Coordination Group for the Tsunami Warning System in the Pacific at its 20th Session in 2005 (Recommendation ITSU-XX.1). There are presently 46 Member States in the ICG-PTWS. ICG/ITSU, the International Coordination Group for the Tsunami Warning System in the Pacific was established by Resolution IV-6 of the 4th Session of the IOC Assembly in 1965. The Pacific Tsunami Warning Center (PTWC) serves as the Tsunami Service Provider (TSP) for the Pacific Ocean. Other TSPs for specific regions of the Pacific Ocean are the North West Pacific Tsunami Advisory Center (NWPTAC) and the South China Sea Tsunami Advisory Center (SCSTAC). The ICG-PTWS presently comprises over 40 Member States and oversees warning system operations and facilitates coordination and cooperation in all international tsunami mitigation activities.

ICG-IOTWMS The Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG-IOTWMS) was formed in response to the tragic tsunami on December 26th 2004, in which over 230,000 lives were lost around the Indian Ocean region. The ICG-IOTWMS comprises 28 Member States. There are three TSPs in the Indian Ocean, hosted by the governments of Australia, Indian and Indonesia.

ICG-NEAMTWS The Intergovernmental Coordination Group for the Tsunami Early Warning and Mitigation System in the North-eastern Atlantic, the Mediterranean and connected seas (ICG-NEAMTWS) was formed in response to the tragic tsunami on 26 December 2004, in which over 230,000 lives were lost around the Indian Ocean region (Indian Ocean Tsunami Information Centre, no date). The ICG-NEAMTWS consists of Member States bordering the North-eastern Atlantic and those bordering and within the Mediterranean and connected seas. There are currently five accredited Tsunami Service Providers (France, Greece, Italy, Portugal, Turkey) in the NEAM region providing tsunami services and alerts to subscribing Member States.

ICG-CARIBE-EWS The Intergovernmental Coordination Group for the Tsunami and Other Coastal Hazards Warning System for the Caribbean and Adjacent Regions (ICG-CARIBE-EWS) was established in 2005 and currently comprises 32 Member States and 16 Territories in the Caribbean.

Tsunami Service Providers (TSPs) are centres that monitor seismic and sea level activity and issue timely tsunami threat information within an ICG framework to National Tsunami Warning Centres (NTWCs) / Tsunami Warning Focal Points (TWFPs) and other TSPs operating within an ocean basin. The NTWCs / TWFPs may use these products to develop and issue tsunami warnings for their countries. TSPs may also issue public messages for an ocean basin and act as NTWCs providing tsunami warnings for their own countries. Currently there are nine operational TSPs.

National Tsunami Warning Centres (NTWCs) are a centre officially designated by the government to monitor and issue tsunami warnings and other related statements within their country according to established national Standard Operating Procedures.

World Tsunami Awareness Day, 5 November every year: The United Nations, through UN Resolution 70/203 adopted on 22 December 2015, has designated 5 November as World Tsunami Awareness Day (UNDRR, 2020). The day aligns with the International Day for Disaster Reduction (13 October) and the seven targets of the Sendai Framework for Disaster Risk Reduction 2015–2030 (ITIC, 2020). The IOC is a key international partner of the UNDRR on World Tsunami Awareness Day.

Tsunami Ready is a voluntary community recognition programme that promotes tsunami hazard preparedness as an active collaboration among federal, state/territorial and local emergency management agencies, community leaders and the public. The main goal of the programme is to improve public safety before, during and after tsunami emergencies. It aims to do this by establishing guidelines for a standard level of capability to mitigate, prepare for and respond to tsunamis, and working with communities to help them meet the guidelines and ultimately become recognised as 'tsunami ready' by the National Weather Service. It was first implemented in the United States .To date, there are 26 IOC-UNESCO Tsunami Ready recognised communities in 18 countries and territories, excluding those implemented in the United States.

Community engagement with evacuation zones and the 'blue lines' project In New Zealand, the Wellington Region Emergency Management Office has developed the Blue Line Project in collaboration with communities in Wellington's southern coastal suburbs. In this project, the local community helps to plan evacuation routes and safe locations based on indicative evacuation zone mapping, and blue lines are painted on the road surface at the maximum estimated tsunami inundation extent. Accompanying evacuation signage is installed. Community members are engaged early in the project, publicising the work and helping to develop blue line locations, evacuation zone maps and information boards. The communities participating in the Blue Line Project can be considered to have a higher degree of public education regarding tsunami evacuation than other communities (Fraser et al., 2016). Other communities around the world have used similar community engagement strategies.

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Coordinating agency or organisation

United Nations Educational, Scientific and Cultural Organization (UNESCO), Intergovernmental Oceanographic Commission (IOC-UNESCO) and the British Geological Survey.

Landslide or Debris Flow (Earthquake Trigger)

Definition

Landslide is the downslope movement of soil, rock and organic materials under the effects of gravity, which occurs when the gravitational driving forces exceed the frictional resistance of the material resisting on the slope. Landslides could be terrestrial or submarine (Varnes, 1978).

Reference

Varnes, D.J., 1978. Slope movement types and processes. In: Schuster, R.L. and R.J. Krizek (eds), Landslides, Analysis and Control. Special report 176: Transportation research board, National Academy of Sciences, Washington, DC. pp. 11-33.

Annotations

Synonyms

Mass Movement, Mass wasting, Slip.

Additional scientific description

A landslide is the movement of a mass of rock, debris, or earth down a slope; a type of 'mass wasting', which denotes any down-slope movement of soil and rock under the direct influence of gravity. The term 'landslide' encompasses five modes of slope movement: falls, topples, slides, spreads, and flows. These are subdivided according to the type of geologic material (bedrock, debris, or earth). Slope movement occurs when forces acting down-slope (mainly due to gravity) exceed the strength of the earth materials that compose the slope (Varnes, 1978).

Earthquake triggered landslides typically affect steep slopes and slopes underlain by sediments that are prone to liquefaction. Rock falls are the most abundant landslides in seismic events and occur in virtually all types of rocks on slopes steeper than 40° (Keefer, 1984). The behaviour of material on hillsides is highly dependent on the amplitudes of seismic waves that reach them, and this will vary with the epicentre distance and depth, as well as the magnitude (M) of an earthquake. Keefer (1984) from a study of historic earthquakes showed that the maximum area likely to be affected by landslides in a seismic event ranges from 0 km2 at M=4 to 500,000 km2 at M=9.2. Materials most susceptible to earthquake-induced landslide were found to include weakly cemented rocks, more indurated rocks with pervasive discontinuities, residual and colluvial sand, volcanic soils with sensitive clays (e.g., Iburi–Tobu earthquake, Hokkaido; Kameda et al., 2019), loess, alluvium and deltaic deposits. First-time slides were more common than landslide reactivation. Rock falls, rockslides, soil falls and disrupted soil slides were initiated by weak shaking; coherent deeper-seated landslides required stronger shaking; lateral spreads and flows required even stronger shaking, and rock and soil avalanches required the strongest shaking (Keefer, 1984).

Within a given region, it is possible to discriminate, earthquake-triggered landslides from landslides initiated by other triggering processes. For example, Lee (2012) reported that earthquake-induced landslides in Taiwan are mostly located on steeper, longer slopes and at a higher position of the slope when compared to storm-induced shallow landslides, suggesting that topographic amplification plays an important role in earthquake-induced landslides. In hard rock terrains, earthquakes trigger a higher proportion of rock fall landslides. Zhang et al. (2014) compared earthquake-triggered landslides with rainfall-triggered landslides in the Wenchuan area of China and found that the earthquake landslides were steeper, larger landslides dominated in areas underlain by harder rocks compared with areas underlain by alluvium. In contrast, the rainfall-induced landslides were characterised by a greater volume of channelled deposits and were of a higher density but smaller area and were characterised by debris slides and debris flows. In areas that are underlain by weak rocks that are saturated, strong earthquake-induced ground shaking will result in more landslides than normal (Fan et al., 2019).

Earthquake shaking and other factors can also induce landslides underwater. These are called submarine landslides. Submarine landslides sometimes cause tsunamis that damage coastal areas (Hungr et al., 2014).

Metrics and numeric limits

Landslide movement is likely to range from moderate in velocity (1.5 metres per day) to extremely rapid. With increased velocity, the landslide mass of translational failures may disintegrate and develop into a debris flow (Varnes, 1978).

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Landslides can be extremely destructive, especially when failure is large, sudden and (or) the velocity is rapid.

Rapid soil flows, rock avalanches, and rock falls together caused more than 90% of the reported landslide deaths in the 40 historical earthquakes reported on by Keefer (1984). Rock avalanches and rapid soil flows, the two leading causes of death, are relatively uncommon, high velocity landslides that occur on slopes of a few degrees. Most deaths caused by these landslides were due to burial of cities or villages located on gently sloping ground several kilometres from the sites of landslide initiation. All but one death caused by soil slumps, block slides, or lateral spreads were due to disruption of foundations and subsequent collapse of buildings, most likely related to liquefaction. Aftershocks can be a significant trigger for further earthquake-induced landslides as reported by Liang and Zhou (2016) for the Gorkha earthquake, Nepal in 2015.

Earthquake triggered landslide impacts can cascade to dam rivers and impound lakes, which can collapse days to centuries later. They can cause extensive mountain valley flooding and leave a geomorphology that may be prone to remobilisation during heavy rainfall, potentially evolving as debris flows. Cracks and fractures can form and widen on mountain crests and flanks, conditioning the landscape for an increased frequency of landslides that lasts for decades. Increased debris load delivery to rivers can cause bank erosion and floodplain accretion as well as stream channel switching that affect flooding frequency, settlements, ecosystems, and infrastructure (Fan et al., 2019).

Instrumental monitoring to detect movement and the rate of movement can be implemented, for example, extensometers, global positioning system (GPS), seismometers, aerial photography, satellite images, LiDaR (Highland and Bobrowsky, 2008) with varying degrees of success.

While the physical damage of landslides is well documented, health impacts are complex. The risk of an increase in infectious diseases is of concern during the response and recovery phase after any major disaster. Displacement of people due to the destruction of their homes and other infrastructure can place them in unfamiliar surroundings which, if they conflict with traditional beliefs and practices with regard to water supply and hygiene, can result in unsafe behaviours. The medium- to long-term effects of changes to the environment caused by landslides, such as deforestation, and changes to river courses, can increase the risk of vector-borne diseases, and as a result, the health impacts can extend long after the initial disaster is over. Disruption of soil can also increase exposure to infectious organisms (Kennedy et al., 2015). The psychosocial and mental health impacts on survivors and rescue personnel from landslides are increasingly recorded. The prevalence of psychiatric disorders and wider support needed to reduce misuse of substances has been identified (Kennedy et al., 2015; Dell'Aringa et al., 2018). Landslides commonly occur in poor countries with steep terrain, such as the southern edge of the Himalayan arc. Increasingly, the science of landslide physics is allowing the nature of these hazards to be understood, which is leading to better techniques through which they can be managed and mitigated.

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Coordinating agency or organisation

British Geological Survey.

GH0008 / **GEOHAZARDS / Seismogenic (Earthquakes)**

Ground Gases (Seismogenic)

Definition

Ground gases generated in the ground from magma (molten or semi-molten natural material derived from the melting of land or oceanic crust) include carbon dioxide, sulphur dioxide, hydrogen sulphide and hydrogen halides (adapted from IVHHN, 2020 and USGS, no date).

References

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Annotations

Synonyms

Soil gases, Radon, Volcanic gases, Magmatic gases, Landfill gas, Gas-contaminated land.

Additional scientific description

Volcanogenic gases escape from magma as a consequence of the pressure relief that occurs as the magma rises to the surface. These gases are also released via geothermal systems and fault systems activated by earthquakes. King et al. (2006) found elevated concentrations of soil gases such as carbon dioxide, helium, hydrogen, mercury vapour and radon in fault zones associated with earthquakes. These gases are released in combination with water vapour and particulate matter during volcanogenic events, or via fumaroles, and hydrothermal systems, as well as faults activated by earthquake events. It has been suggested that radon monitoring might be used for earthquake early warning systems.

Earthquakes can also trigger the release of soil gases derived from other sources, such as the chemical or biological processes that generate ground gases, including the breakdown of uranium-bearing minerals releasing radon from granite or by oxidation and/or biogenic reduction (releasing hydrogen sulphide) as well as the release of anthropogenic stores of gas. For example, rupture of tanks and pipes (WHO, 2018), as well as landfill gas, a product of the largely biogenic decomposition of anthropogenic waste. Its composition reflects that of the waste, but is dominated by methane and carbon dioxide, becoming more carbon dioxide rich as the waste ages, and with a small amount of non-methane organic compounds. Methane is a potent greenhouse gas (US EPA, no date a).

Ground gases from material decay (natural or anthropogenic) typically include radon, methane, carbon dioxide, and hydrogen sulphide, but may also include the breakdown products of other compounds, such as nitrogen, alcohols, alkanes, cycloalkanes and alkenes, aromatic hydrocarbons (monocyclic or polycyclic); esters and ethers, as well as halogenated compounds and organosulphur (US EPA, no date b; USGS, no date).

Ground gases are a hazard owing to the risk to human health and/or their flammability. As an example, the UK limits for several gases are summarised below from sources other than earthquake triggered gases:

Methane is a colourless, odourless flammable gas. When the concentration of methane in air (oxygen 20.9% by volume, % v/v) is between the limits of 5% v/v and 15% v/v, an explosive mixture is formed. The Lower Explosive Limit (LEL) of methane is 5% v/v, which is equivalent to 100% LEL. The 15% v/v limit is known as the Upper Explosive Limit (UEL), but concentrations above this level cannot be assumed to represent safe concentrations, owing to the potential for dilution to the UEL (PHE, 2015).

Carbon dioxide is a colourless, odourless gas, which, although non-flammable, is both a toxic gas and an asphyxiant. As carbon dioxide is denser than air, it will collect in low points and depressions, which can be an extreme hazard during foundation construction and earth movements on development sites. the Long-Term Exposure Limit (LTEL, 8-hour period) and the Short Term Exposure Limit (STEL, 15-minute period), are 0.5% v/v and 1.5% v/v carbon dioxide, respectively (HSE, no date).

Radon is a colourless, odourless radioactive gas derived from the radioactive decay of radium, itself from radioactive decay of uranium. The UK target level for homes is 100 Bq/m3 (PHE, no date).

Levels of hydrogen sulphide of 100 ppm and higher are considered immediately dangerous to life and health (WorkSafe BC, no date).

Radon species, concentration and flux emitted in soil gas in active fault zones near Beijing have been reported by Chen et al. (2018), with a maximum flux of 334.56 mBq/m2/s being observed in the Fengnan district located at the epicentre of the 28 July 1976 earthquake. Chen et al. (2018) reported that these concentrations warrant mitigation measures and advised that fault zones in earthquake regions should be monitored as part of the pre-development land planning procedure.

Another source of ground gas with a potential for release by earthquake is methane hydrates associated with continental margins (Geology.com, 2005-2020).

Metrics and numeric limits

No globally agreed limits for ground gases (earthquake trigger).

Key relevant UN convention/multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Ground gases are a hazard in terms of risk to human health, flammability and climate change (greenhouse gases). For these reasons, where possible, ground gas is monitored and controlled. Where buildings may come into contact with ground gases, specialist construction techniques are deployed to protect human health (e.g., Claire, 2021).

In the case of earthquake-triggered gases, consideration should also be given to the associated particulate matter. Landfill gas management has been a focal point for national-scale reductions in carbon dioxide emissions. For example, in 2018 waste management-related carbon dioxide formed 4.6% of UK carbon dioxide emissions (BEIS, 2020).

Ground gases occur in mining environments, for example, in the mining of coal (carbon dioxide and methane), potash (methane and nitrogen) and shale gas (BGS, no date). In the UK, control measures in these environments are guided by the Health and Safety Executive.

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Coordinating agency or organisation

Global Earthquake Model Foundation.

GH0009 / **GEOHAZARD / Volcanogenic (volcanoes and geothermal)**

Lava Flows (Lava Domes)

Definition

A lava flow or lava dome is a body of lava that forms during an eruption, or main eruptive episode. Lava flows are outpourings of fluid, relatively low-viscosity molten rock, whereas a lava dome is a pile of relatively viscous lava that cannot flow far from the vent (Calder et al., 2015; Kilburn, 2015).

References

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Annotations

Synonyms

Lava effusions, Lavas.

Additional scientific description

A lava flow may comprise smaller bodies of lava known as 'lava flow units', or 'lava flow lobes'; a lava flow comprising multiple lava flow units is known as a 'lava flow field'. Pillow lavas are lava flows formed under water. Lava domes may be described as a type, such as Peléan domes. Lava coulées are a hybrid between lava domes and flows, they are short, thick, viscous lava flows that typically form on a slope.

Most volcanoes erupt lava flows and/or domes during their lifetimes (Kilburn, 2015). Effusions of lava commonly continue from days to months, but occasionally for decades. Lava flows damage and destroy land and property but usually (not always) advance slowly enough for populations to escape. Understanding where future lava may be erupted from (the vent or vents), how far a lava flow may advance, the velocity of the flow front and the area that may be covered are critical for hazard assessments (Kilburn, 2015). Viscous lava flows and lava domes can generally be avoided but they may collapse to generate very hazardous pyroclastic density currents (Calder et al., 2015; Carr et al., 2019). The main factors controlling how a lava flow or dome develops are the lava's rheological properties, effusion (or extrusion) rate and underlying topography.

The rheological properties of lava are influenced by chemical composition. Fluid and mobile lava flows tend to be low in silica (e.g., mafic compositions such as basalt); lava with moderate silica content is more viscous and tends to form short blocky lava flows or lava domes (e.g., intermediate compositions such as andesite); the most silica-rich lava is most likely to form a lava dome (e.g., felsic compositions such as rhyolite). The Cordón Caulle eruption in 2011–2012, shows that rhyolitic and basaltic compound lava flows may have much in common in terms of physical processes, despite very different rheologies (Tuffen et al., 2013).

Parts of lava flows and lava domes can remain molten after an eruption has ended (e.g., Calder et al., 2015; Pederson et al., 2017) and this may lengthen the timescale of hazardous lava flow advance or potential for lava dome collapse.

Lava flow characteristics: Surface morphology of subaerial basaltic lava flows may be described as pāhoehoe (Hawaiian meaning 'smooth, unbroken') or aʻā (Hawaiian meaning 'stony, rough lava'), whereas intermediate or silica-rich lava is more likely to have a blocky surface morphology (Harris et al., 2017). Basaltic pāhoehoe flows commonly have the highest eruption temperatures of 1100 to 1200°C, whereas rhyolitic lavas are typically 650–750°C (Kilburn, 2015). The unique 'natrocarbonatite' lava flows at Ol Doinyo Lengai volcano in Tanzania are dominated by carbonates rather than silicates and form very fluid, relatively low temperature lavas (500–600°C) (Pinkerton et al., 1995).

At the start of an eruption, basaltic lavas may advance at several kilometres per hour, but slow to walking pace or less within a few hours (Kilburn, 2015). On steep slopes some lavas may reach higher velocities of tens of kilometres per hour. Exceptionally, in 1977, lava flowed down the slopes of Nyiragongo with a maximum velocity of up to 100 km/h (Balagizi et al., 2018). Viscous lavas may typically advance at rates of 0.1 km/day or less.

Typically, basaltic lava flows may reach lengths of 1–10 km, but occasionally more than 30 km (e.g., the Laki eruption in Iceland between 1783 and 1785; Thordarsson and Self, 1993) and some pāhoehoe flows have reached 50 km (Kilburn, 2015). Basaltic lava flows may be 3–20 m thick and typical volumes of historical lava flows on land are between 0.01 and 0.1 km3 (flow fields can exceptionally exceed 10 km3). Intermediate and silicic lavas are usually shorter in length, typically up to 5 km but some are up to 15 km. They may be 20–300 m thick and volumes are typically 0.01 and 0.1 km3 but can be up to 10–20 km3 (Kilburn, 2015).

Models: The simplest empirical models are volcano-specific and link effusion rate to runout length but more complex models account for cooling-induced changes in rheology as a lava flows over topography (e.g., Harris et al., 2013). New methodologies are constantly developing (e.g., Gallant et al., 2018) and generally have a two-step process: statistical analysis to establish known vent distributions and identify most likely future vent sites, followed by an estimation of the areas of inundation by lavas flowing from those vents (e.g., Connor et al., 2012). Outputs are highly sensitive to topography, as well as estimated volume of lava and flow dynamics (e.g., Dietterich et al., 2017). High resolution Digital Elevation Models are necessary (e.g., Turner et al., 2017) but in urban and man-made environments Digital Surface Models may be more appropriate (e.g., Tsang et al., 2020).

Probabilistic hazard assessments for lava flows can anticipate inundation so are useful for long-term planning (e.g., hazard maps) and short-term forecasting (e.g., Vicari et al., 2011). However, more study is required at many volcanoes that lack important metrics such as recurrence interval, or volume of previous lava flows (e.g., Wantim et al., 2018).

Lava flow and dome collapses: Viscous lava flows and domes may exhibit various collapse styles from persistent rock falls to partial or total collapse of a lava dome. Lava flow or dome collapse may generate potentially deadly pyroclastic density currents and associated hazards such as tephra and gas emissions (Calder et al., 2015; Harnett et al., 2019). Lava dome collapse hazard assessments are rarely in place but are needed (Harnett et al., 2019).

Metrics and numeric limits

Not identified.

Key relevant UN convention/multilateral treaty

Sendai Framework for Disaster Risk Reduction 2015-2030 (UNDRR, 2015).

Examples of drivers, outcomes and risk management

Primary hazards. Lava flows may cause damage to buildings, infrastructure, communications, agriculture and environment by inundation, burial, transport, fire and explosion (e.g., Jenkins et al., 2017). Damage may not be complete but partial burial or inundation by lava generally makes buildings, infrastructure and land unusable (Jenkins et al., 2017). Buried infrastructure may also be destroyed due to thermal impacts (Tsang et al., 2020). Injuries may occur if individuals walk on a lava carapace with molten lava below. Health impacts may include burns, gas and aerosol inhalation. Viscous lava flows and domes in particular may be associated with episodes of explosive volcanic activity and additional primary volcanic hazards such as pyroclastic density currents, tephra and volcanic gases which in combination worsen the overall impact (Wantim et al., 2018).

Secondary hazards. Escape routes may be cut off, or the lavas may trigger explosions on meeting snow, ice and water, or flammable fluids. For example, in Goma in 2002, around 300,000 people self-evacuated and there were roughly 140 deaths, most caused by explosions at a petrol station that had been surrounded by lava (Balagizi et al., 2018). Lava flows may ignite forest or urban fires (e.g., Wantim et al., 2018). Volcanic gases and aerosols (air pollution) need to be considered, possibly over large areas (Barsotti et al., 2020). Evacuation to emergency accommodation may lead to permanent displacement, which if combined with loss of livelihoods and homes, may cause longer term mental and physical health impacts, and the long-term cascading effects can be more severe than immediate impacts (Wantim et al., 2018).

Between 1500 AD and 2017 there were 25 documented fatal incidents and 659 fatalities caused directly by lava flows, with fatalities occurring between 1 and 29 km of the volcanic source (median distance 11 km) (Brown et al., 2017). Fatalities and casualties occur when eruptions begin from vents close to towns and/or lavas are very fluid, on steep slopes and fast moving. For example, the 1977 eruption of Nyiragongo generated lava flows that killed about 70 people (Balagizi et al., 2018).

Viscous lava flows and lava domes do not directly cause fatalities and injuries, but their collapse may generate pyroclastic density currents which cause more fatalities than any other volcanic hazard (e.g., Calder et al., 2015; Brown et al., 2017).

If a volcanic area is well-monitored, the movement of magma in the subsurface may be detected days, weeks or even years before an eruption (e.g., Pederson et al., 2017; Pallister et al., 2019) enabling planning, preparation and emergency actions such as evacuation. Effective monitoring of the emplacement of lava flows and domes over time enables forecasting of inundation and the anticipation of hazardous events such as lava dome collapse (e.g., Vicari et al., 2011; Pallister et al., 2013, 2019; Pederson et al., 2017; Carr et al., 2019).

Probabilistic hazard maps can enable appropriate land-use planning policies before eruption avoiding development in areas with high probability of inundation (Tsang and Lindsay, 2020).

Attempts during ongoing eruptions to halt or divert flows (by erecting barriers, spraying lava with water, or breaking the margins of lava channels) have had mixed success (e.g., Barberi and Carapezza, 2004) nevertheless, in Hawaii, barriers have been constructed alongside new high value assets (Tsang and Lindsay, 2020). Evacuation remains the most effective strategy for protecting life and health from primary and secondary hazards (Tsang and Lindsay, 2020).

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Coordinating agency or organisation

International Association of Volcanology and Chemistry of the Earth's Interior) (IAVCEI) /Global Volcano Model (GVM) / International Volcanic Health Hazard Network (IVHHN).

GH0010 / **GEOHAZARDS / Volcanogenic (Volcanoes and Geothermal)**

Ash/Tephra Fall (Physical and Chemical)

Definition

Tephra is a collective term for fragmented magma and old (i.e., pre-existing) rocks ejected into the atmosphere from volcanic vents during an explosive eruption, irrespective of size, composition and shape (BGS, no date). The term 'volcanic ash' refers to the finest particles of tephra (less than 2 mm diameter).

Reference

BGS, no date. Tephra/ash fall. British Geological Survey (BGS). www.bgs.ac.uk/discovering-geology/earth-hazards/volcanoes/volcanic-hazards/#tephraash Accessed 22 April 2021.

Annotations

Synonyms

Lapilli, Pyroclast, Blocks, Bombs.

Additional scientific description

The term 'volcanic ash' is often used loosely to include larger fragments, more correctly termed 'lapilli' (2 to 64 mm in diameter). The largest tephra clasts (> 64 mm) are called blocks and bombs. Fragments of all sizes generated during fragmentation of magma and lava are also known as 'pyroclasts', whether they travel through the atmosphere or are directly entrained in lateral moving flows.

Along with emissions of gas, tephra is the most frequent and widespread volcanic hazard. It is ejected into the atmosphere and transported laterally by wind and/or lateral gravitational spreading of umbrella clouds before falling out under gravity. Fine tephra (mainly volcanic ash) also rises convectively above pyroclastic density currents and lava fountains (Bonadonna et al., 2015, 2021; Jenkins, 2015). Tephra can affect very large areas; volcanic ash can remain airborne for days and can be transported for thousands of kilometres and may disrupt air traffic. Blocks and bombs mostly follow a ballistic trajectory, and so are not strongly affected by wind; nonetheless, the smallest blocks can also be entrained within convective plumes impacting a larger area than ballistic clasts. Tephra can cause fatalities directly, owing to ballistic impact, and indirectly due to collapse of buildings (mostly roofs) and trees due to tephra load. In addition, public health threats, clean-up and disruption to critical infrastructure services, aviation and primary production can lead to substantial societal impacts and costs, even at thicknesses on the ground of a few millimetres. Hot tephra (e.g., large lapilli and blocks and bombs) can also trigger fires if falling on ignitable material (e.g., dry vegetation, wooden structures). Intense tephra fall reduces visibility and may cause complete darkness during daylight hours, creating significant hazards for driving, for example (USGS, no date).

Lightning may be generated by friction between the fine airborne particles, which can be localised above the volcano or accompany large ash plumes as they move downwind. The impacts can be experienced across wide areas and can be long-lived, since eruptions can last from hours to years (IVHHN, 2021).

Tephra-fall deposits may also be the source of secondary hazards (e.g., lahars) and can be remobilised into the atmosphere by wind, traffic and human activities, prolonging the impacts. Tephra varies in appearance depending upon the composition of the magma and the style of the eruption (Bonadonna et al., 2015).

Various analytical and numerical models have been developed that forecast tephra dispersal and deposition from the finest fractions to ballistic blocks (e.g., Folch, 2012; Bonadonna et al., 2015; Biass et al., 2016; Osman et al., 2019). The International Civil Aviation Organization (ICAO) leads operational forecasting of ash cloud transport for the benefit of the aviation sector (ICAO, 2012; Lechner et al., 2017).

To assess severity at a site, tephra falls are most commonly described (e.g., eyewitness accounts) or measured according to their thickness. Increasingly though, loading (mass per unit area; kg/m2) is more informative for assessing impact to structures and agriculture, and enables consideration of water saturation (Jenkins et al., 2015). For respiratory health exposure and hazard assessment, monitoring of airborne concentrations of fine particulates is preferable, alongside physicochemical and toxicological characterisation of the ash particles (e.g., Horwell et al., 2013).

There were 52 recorded fatal incidents as a result of tephra (not including ballistics) between 1500 AD and 2017 resulting in 4315 fatalities and these occurred between 0.5 and 170 km from the source volcano at a median distance of 10 km (Brown et al., 2017). Over the same period, there were 57 fatal incidents due to ballistics, with 367 recorded fatalities 0 to 7 km from the volcanic source (Brown et al., 2017).

Approximate tephra thicknesses (hazard intensities) that relate to key damage and functionality states for a range of building types, critical infrastructure and agricultural categories are given by Jenkins et al. (2015).

Metrics and numeric limits

Not applicable.

Key relevant UN convention/multilateral treaty

Sendai Framework for Disaster Risk Reduction 2015–2030 (UNDRR, 2015).

Examples of drivers, outcomes and risk management

Tephra particles can have acid coatings which may react with rain to damage vegetation and cause corrosion. The acid coating is rapidly removed by rain, which may then pollute local water supplies. Tephra can increase river turbidity leading to environmental problems.

Finer particles of ash may irritate the lungs and eyes (humans and animals) and exacerbate the symptoms of existing respiratory conditions (e.g., asthma and bronchitis) (Horwell and Baxter, 2006; IVHHN, 2020a).

In most eruptions, volcanic ash causes relatively few health problems, but generates much anxiety. However, there is insufficient evidence to be certain whether ash can trigger chronic diseases such as lung cancer and silicosis (if crystalline silica is a major component) (Horwell et al., 2012; IVHHN, 2020a), and all fine particulate matter (e.g., PM2.5) is considered to negatively impact mortality and morbidity, particularly for respiratory and cardiovascular diseases (WHO, 2013).

Livestock should ideally be under cover during tephra falls and veterinary services may be needed for respiratory, ingestion, eye and dental problems (USGS, 2020).

Medical services can expect an increase in the number of patients with respiratory and eye symptoms during and after a tephra-fall event, which can be measured by existing syndromic surveillance or by application of the International Volcanic Health Hazard Network standardised epidemiological protocols (IVHHN, 2020b; Mueller et al., 2020).

The fertility of the soils around many volcanoes is due to the weathering of old ash deposits, and the addition of thin tephra falls to soil can be beneficial in the long term. In many cases though, volcanic ash needs to be removed from urban and agricultural areas to prevent remobilisation and repeated impacts, as well as to prevent it from washing into drainage networks. Therefore, sites need to be identified to dispose of the ash, preferably before an eruption. Cleaning tephra from roofs, roads, agricultural land, and critical infrastructure may require significant volumes of water, trucks, diggers, etc., and can have significant associated costs (Hayes et al., 2015).

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Coordinating agency or organisation

International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI, Global Volcano Model network (GVM) and International Volcanic Health Hazard Network (IVHHN).

GH0011 / **GEOHAZARD / Volcanogenic (Volcanoes and Geothermal)**

Ballistics (Volcanic)

Definition

Ballistics comprise fragments of magma and old (i.e., pre-existing) rocks ejected during an explosive eruption at variable velocity and angle on cannon ball-like trajectories; they are not entrained within the volcanic plume and are dispersed in proximity to the vent (typically <5 km) (adapted from Biass et al., 2016 and Bonadonna et al., 2021).

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Annotations

Synonyms

Projectiles.

Additional scientific description

Ballistics may be a few centimetres to several metres in diameter. In most cases, the range of ballistics is a few hundred metres to 5 km, but they can be thrown to distances over 10 km in the most powerful explosions (Blong, 1984). Some blocks and bombs (i.e., tephra clasts >64 mm) can also be entrained within the volcanic plume and sedimented at larger distances than ballistics (Osman et al., 2019).

Fragments of all sizes generated during fragmentation of magma and lava are also known as 'pyroclasts' whether they travel through the atmosphere or are directly entrained in lateral moving flows.

Various analytical and numerical models have been developed that forecast ballistic dispersal (e.g., Fitzgerald et al., 2014; Biass et al., 2016).

Primary hazards. The high kinetic energies of ballistics when they land makes them hazardous to people, buildings, infrastructure and other assets. Ballistics may be ejected at over 300 m/s but slow down during flight, with terminal velocities typically <150 m/s (Walker et al., 1971). Impact energy (kinetic energy at the moment of impact) is strongly controlled by the size of a ballistic because this limits both its terminal velocity and mass (Williams et al., 2017). Alatorre-Ibargüengoitia et al. (2012) modelled impact energies of ballistics 0.2–0.6 m in diameter during small explosive eruptions (VEI 2–3) to be up to 106 J, well over the threshold required to penetrate reinforced concrete slabs (Jenkins et al., 2014).

Fragments of lava can be over 1100°C so, although they cool during flight, they may retain sufficient thermal energy on landing to burn certain building materials or other flammable materials (Vanderkluysen et al., 2012).

Secondary hazards. Ballistics may cause indirect fatalities and damage owing to the collapse of buildings (mostly roofs) or damage to infrastructure (power, roads). Hot ballistics can start fires if falling on ignitable material (e.g., dry vegetation, wooden structures).

Intense volcanic explosions that generate ballistics may cause shock and infrasonic waves in the atmosphere, which can shatter windows and damage delicate equipment (e.g., electronic doors) at distances of several kilometres from the volcano.

Ballistics and other loose fragmentary material may be remobilised in lahars or landslides.

Metrics and numeric limits

Not applicable.

Key relevant UN convention/multilateral treaty

Sendai Framework for Disaster Risk Reduction 2015–2030 (UNDRR, 2015).

Examples of drivers, outcomes and risk management

Ballistics are associated with all types of explosive volcanic eruption (Fitzgerald et al., 2017). Explosions may be sudden with no precursory signs, especially if triggered by steam interaction with hot rocks or magma. Tourists and scientists have proven particularly vulnerable to unexpected explosive eruptions, as they tend to get close to volcanic vents. The sudden explosion of Mount Ontake, Japan, on 27 September 2014, resulted in the deaths of 58 hikers, 56 of whom were killed by ballistic rocks (Oikawa et al., 2016; Tsunematsu et al., 2016).

There were 57 fatal incidents due to ballistics between 1500 AD and 2017, with 367 recorded fatalities 0–7 km from the volcanic source (Brown et al., 2017). Many more people have been injured due to ballistic impacts, frequently suffering from blunt force trauma (broken bones), lacerations, burns, abrasions and bruising (Blong, 1984; Baxter and Gresham, 1997).

The high kinetic and thermal energy of ballistics can cause damage to buildings, infrastructure, agriculture and the environment through knock down, puncturing, crushing, burning and melting (Fitzgerald et al., 2017).

There have been studies of impact energy thresholds to perforate buildings (Blong et al., 1981; Pomonis et al., 1999) and the first fragility functions were presented by Biass et al. (2016). A combination of field data and experiments are enabling building design recommendations for emergency situations, but reducing exposure to ballistics is the best risk reduction measure (Williams et al., 2017).

As with other volcanic hazards, a combination of probabilistic volcanic hazard assessment and risk assessment combined with effective communication among scientists, emergency managers, local communities and other stakeholders can lead to effective management of risk (Fitzgerald et al., 2017).

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Coordinating agency or organisation

IAVCEI (International Association of Volcanology and Chemistry of the Earth's Interior) / GVM (Global Volcano Model network) / IVHHN (International Volcanic Health Hazard Network).

GH0012 / **GEOHAZARD / Volcanogenic (Volcanoes and Geothermal)**

Pyroclastic Density Current

Definition

Pyroclastic density currents are hot, fast-moving mixtures of volcanic particles and gas that flow according to their density relative to the surrounding medium and the Earth's gravity. They typically originate from the gravitational collapse of explosive eruption columns, lava domes or lava-flow fronts, and from explosive lateral blasts (adapted from Branney and Kokelaar, 2002 and Cole et al., 2015).

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Annotations

Synonyms

Pyroclastic flow, Nuée ardente, Ash flow, Hot avalanche.

Additional scientific description

The following terms may be considered sub-types of pyroclastic density currents (PDCs): pyroclastic flow, block-and-ash flow, pumice flow, lateral blast, pyroclastic surge. The pyroclastic flow and surge are two end members (dense and dilute end, respectively). The term 'ignimbrite' is commonly used as a general term describing pumice- and ash-rich PDC deposits of very varied volumes (Druitt, 1998; Branney and Kokelaar, 2002), but has also been used to refer, predominantly, to the large-volume end of this spectrum (e.g., Wilson and Hildreth, 2003).

PDCs are produced from volcanic eruptions across many orders of magnitude, from small-volume events (<0.001 to 1 km3) to caldera-forming eruptions with volumes around 101–103 km3 of erupted material (Druitt, 1998; Dufek et al., 2015). PDCs are hot, unstoppable, gas-particle mixtures that move extremely quickly across the ground surface at velocities of tens to hundreds of kilometres per hour and have temperatures of typically between 200 and 600°C (Cole, 2015; Dufek et al., 2015). Most PDCs propagate to distances of between a few to tens of kilometres from the source (Ogburn, 2012). For exceptionally large-magnitude events, PDCs may travel over 100 km and cover areas of up to 103–104 km2 (Takarada and Hoshizumi, 2020). Many of the aforementioned variables can be used as hazard metrics for PDCs: flow speed, flow density, temperature, dynamic pressure, flow and deposit thickness, maximum runout, invasion area, etc.

Two different flow parts commonly form PDCs: a dense, basal undercurrent dominated by particle-particle interactions; and a dilute, upper part whose motion is mainly dominated by turbulence (Branney and Kokelaar, 2002; Sulpizio et al., 2014; Cole, 2015). The dense basal part strongly interacts with (and is controlled by) the topographic surface as it erodes and deposits material along its path (Doronzo, 2012). The dilute upper part tends to be less controlled by topography and may decouple from the main dense undercurrent, overcoming topographic obstacles and following diverse propagation paths (e.g., Fisher, 1995; Ogburn et al., 2014). Extensive numerical modelling of PDCs has been conducted over recent decades, to better understand PDCs and quantify their hazard (Sulpizio et al., 2014; Dufek et al., 2015). Most past efforts have focused on simulating either the dense basal (e.g., Patra et al., 2005) or the dilute upper part of PDCs (e.g., Bursik and Woods, 1996), but several multiphase flow models have also been presented (e.g., Suzuki et al., 2005).

Between 1500 and 2017 AD, PDCs were the most deadly of all volcanic hazards: there were 102 fatal incidents and 59,958 fatalities caused directly by PDCs. 50% of PDC fatalities were recorded up to 10 km from a volcano and 90% up to 20 km (Brown et al., 2017). The 1883 eruption from Krakatau volcano (Indonesia) resulted in PDC fatalities up to 80 km from the volcano, aided by the passage of PDCs over the sea (Carey et al., 1996).

Metrics and numeric limits

Not available.

Key relevant UN convention/multilateral treaty

Sendai Framework for Disaster Risk Reduction 2015–2030 (UNDRR, 2015).

Examples of drivers, outcomes and risk management

PDCs can kill all living things and destroy structures by abrasion, impact, burial and heat.

Risk to building structures has not been systematically assessed but dense PDCs can bury buildings and destroy their openings (windows, doors) and, in dilute PDCs, dynamic pressures of a few kilopascal can cause moderate to heavy damage to buildings (Valentine, 1998; Zuccaro et al., 2008).

Deaths commonly result from thermal injury (including laryngeal and pulmonary oedema), asphyxiation and impact or blast trauma (Baxter, 1990). Survivors of PDC inundation can suffer from severe burn injuries requiring specialist treatment (Loughlin et al., 2002).

Indirect casualties can include accidents, for example related to evacuation or unsafe driving conditions, heart attacks and cascading hazards such as fires, famine and disease. Indirect deaths can dwarf the numbers of direct deaths (Brown et al., 2017).

High resolution (spatial and temporal) monitoring of lava-dome extrusion rates, and topography, can enable dome collapse PDCs to be anticipated, resulting in timely evacuation (Pallister et al., 2013). Probabilistic volcanic hazard assessments of PDCs (e.g., Sandri et al., 2018) are increasing in number and methods are improving.

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Coordinating agency or organisation

International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) / Global Volcano Model (GVM) / International Volcanic Health Hazard Network (IVHHN).

GH0013 / **GEOHAZARD / Volcanogenic (Volcanoes and Geothermal)**

Debris Flow/Lahars/Floods

Definition

Lahars are discrete, rapid, gravity-driven, water-saturated flows containing water and solid particles of volcanic rock, sediment, ice, wood, and other debris that originate at volcanoes (Gudmundsson, 2015; Vallance and Iverson, 2015).

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Annotations

Synonyms

Debris flow, Volcanic mudflow.

Additional scientific description

Lahars are sometimes referred to as debris flows and colloquially as volcanic mudflows. The word 'lahar' is a generic term for a complex flow phenomenon encompassing a wide range of flow types with different physical parameters. Sub-glacial eruptions can produce floods and lahars, known as 'Jökulhlaups' in Iceland (Gudmundsson, 2015).

Lahars can be extremely mobile, flowing at high speeds on steep volcanic terrains and for long distances (tens of kilometres) along valleys. A single lahar can consist of multiple alternating phases of flow with differing characteristics (Vallance and Iverson, 2015).

Lahars are typically topographically confined flows, so existing channel networks often control the dominant flow routing. However, lahars can be much larger than typical streamflows (both in the depth of the flow and the flow rate) so that overbank-ing is possible for lahars. Lahars are generally categorised as primary (syn-eruption) and secondary (post-eruption) (Vallance and Iverson, 2015).

Primary lahars are caused directly by volcanic eruptions through a range of processes including the disruption of crater lakes, the melting/erosion of glacial ice and snow by volcanic flows (e.g., pyroclastic density currents), the mixing of tephra with rain and ground water, and the incorporation of ground water into debris avalanches. Primary lahars may be hot for an extended time during their motion (Pierson and Major, 2014).

Secondary lahars occur due to the remobilisation of erupted pyroclastic deposits, often during intense and/or long-lasting rainfall, as a volcano's drainage system responds to the surface deposits added during eruptions and can continue for many years after an eruption with a decreasing frequency over time (Pierson and Major, 2014).

However, eruptive activity and secondary lahars can occur contemporaneously during long-lived eruptions at persistently active volcanoes.

Measurable and modellable parameters include flow speed, flow density, temperature, dynamic pressure, flow and deposit thickness, maximum runout, area of invasion, triggering factors (e.g., rainfall), solids volume concentration, eroded depth, friction coefficients.

There is little correlation between the magnitude of an eruption and the volume of primary lahars. An example is the 1985 eruption of Nevado del Ruiz, Colombia, which was a relatively small eruption in terms of erupted volume, but pyroclastic density currents flowing over an extensive summit ice and snow cap resulted in substantial glacial and snow melting (2×107 m3), initiating large (peak discharge <48,000 m3/s), fast (<17 m/s) lahars simultaneously in several drainages (Pierson et al., 1990). The devastating consequences included the loss of more than 24,000 lives (Brown et al., 2017). The magnitude of secondary lahars is dependent on rainfall intensity and duration, as well as sediment availability, so the largest lahar can occur a long time (possibly years) after an eruption (Pierson and Major, 2014).

Metrics and numeric limits

Not available.

Key relevant UN convention/multilateral treaty

Sendai Framework for Disaster Risk Reduction 2015–2030 (UNDRR, 2015).

Examples of drivers, outcomes and risk management

The impact of lahars varies greatly depending on the flow type and magnitude, the weather conditions, the geomorphology, and the characteristics of the exposed assets. Fatalities are caused by burying, impact injury or drowning. There were 72 fatal incidents as a result of lahars between 1500 AD and 2017, with a total of 49,938 fatalities that occurred between 1 and 100 km from the source volcano (Brown et al., 2017). Infrastructure (including critical facilities), personal property, agricultural lands and livestock can be destroyed, buried or damaged. Lahars can erode and remove top-soils from farmlands.

Emergency response and clean-up can be difficult due to the material left behind by lahars. Lahar hazard mitigation has included evacuation before eruptions or storms, channel and dam engineering, land management and early warning systems (Pierson et al., 2014). Mapping the possible paths and dynamics of lahars can help to identify exposed communities and assets. The strong topographic control means that simple flow routing models (e.g., Iverson et al., 1998) can be effective, although models that incorporate flow dynamics provide additional useful information such as arrival time and dynamic pressure (Manville et al., 2013).

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Coordinating agency or organisation

International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI), Global Volcano Model network (GVM) and International Volcanic Health Hazard Network) (IVHHN).

GH0014 / **GEOHAZARDS / Volcanogenic (Volcanoes and Geothermal)**

Landslide (Volcanic Trigger)

Definition

A landslide is the downslope movement of soil, rock and organic materials under the effects of gravity, which occurs when the gravitational driving forces exceed the frictional resistance of the material resisting on the slope. Landslides could be terrestrial or submarine (Varnes, 1978).

Reference

Varnes, D.J., 1978. Slope movement types and processes. In: Schuster, R.L. and R.J. Krizek (eds.), Landslides, Analysis and Control. Special report 176: Transportation Research Board. National Academy of Sciences, pp. 11-33.

Annotations

Synonyms

Mass movement, Mass wasting, Slip.

Additional scientific description

The term 'landslide' encompasses five modes of slope movement: falls, topples, slides, spreads, and flows. These are subdivided according to the type of geological material (bedrock, debris, or earth). Slope movement occurs when forces acting down-slope (mainly due to gravity) exceed the strength of the earth materials that compose the slope.

Landslides are common on volcanic cones because they are tall, steep, and weakened by the rise and eruption of molten rock. Magma releases volcanic gases that partially dissolve in groundwater, resulting in a hot acidic hydrothermal system that weakens rock by altering minerals to clay (USGS, no date).

Volcano landslides (debris avalanches) range in size from less than 1 km3 to more than 100 km3 (USGS, no date). They comprise masses of rock, soil and snow that are mobilised when the flank of a volcano collapses and slides downslope. The mobilised sediment can be very destructive and entrain more sediment (as well as vegetation or structures) along its path. The high velocity and momentum allows them to cross valleys and run up slopes several hundred metres high. The larger landslides are generally more deep-seated, involving weak hydrothermal and magmatic systems in the volcano.

The landslides leave a hummocky terrain that reflects the initial structure of the edifice (de Vries and Davies, 2015). The sediment largely comprises unsorted and unstratified angular-to-subangular debris (Siebert, 1996). Runout lengths are commonly many times the height of the volcano. Many landslides contain or incorporate water that leads to secondary debris flow and lahar generation. Runout varies with the extent of air or fluid entrainment; however, the physical basis of the long runouts is not fully understood. Most are the result of several factors, including volcanic flank failures. Landslides on volcanic islands such as Hawaii, Reunion and Tristan da Cunha are characterised by long runout distances and volumes exceeding 1000 km3 (Hürlimann et al., 2000).

Metrics and numeric limits

Landslide movement is likely to be moderate in velocity (1.5 metres per day) to extremely rapid. With increased velocity, the landslide mass of translational failures may disintegrate and develop into a debris flow (Varnes, 1978). For example, the landslide at Mount St. Helens on 18 May 1980, with a volume of 2.5 km3, reached speeds of 50–80 m/s, with the energy to surge up and over a 400-m-tall ridge located about 5 km from the volcano (de Vries and Davies, 2015).

Key relevant UN convention / multilateral treaty

Not applicable.

Examples of drivers, outcomes and risk management

Landslides can be extremely destructive, especially when failure is large, sudden and (or) the velocity is rapid. Rock avalanches pose some of the most dangerous and expensive geological hazards in mountainous terrain. The Mount St Helens eruption was triggered by landsliding as a consequence of structural instability of the volcano. The eruption caused the death of 57 people, 53 through direct impacts including asphyxiation, thermal injuries, and trauma. Snowmelt led to extensive river flooding (Oregon State University, 2020).

As well as the potential to trigger hydrothermal or magmatic eruptions and if the debris avalanches enter water bodies, tsunami may be generated (de Vries and Davies, 2015). As with other types of landslide, rock avalanche can cascade to form river dams with the potential for subsequent release and flooding.

The size of volcanos is such that remote sensing techniques can be used for monitoring, for example, GPS, aerial photography, and satellite imageries including InSAR (radar). At the local scale, ground-based techniques such as LiDAR and seismometers can be deployed (Moss et al., 1999; Highland and Bobrowsky, 2008) with varying degrees of success.

While the physical damage of landslides is well documented, health impacts are complex. The risk of an increase in infectious diseases is of concern during the response and recovery phase after any major disaster. Displacement of people due to the destruction of their homes and other infrastructure can place them in unfamiliar surroundings, which, if they conflict with traditional beliefs and practices with regard to water supply and hygiene, can result in unsafe behaviours. The medium- to long-term effects of changes to the environment caused by landslides, such as deforestation, and changes to river courses, can increase the risk of vector-borne diseases, and as a result, the health impacts can extend long after the initial disaster is over. Disruption of soil can also increase exposure to infectious organisms (Kennedy et al., 2015).

The psychosocial and mental health impacts on survivors and rescue personnel from landslides are increasingly recorded (e.g., Oregon State University, 2020). The prevalence of psychiatric disorders and wider support needed to reduce misuse of substances has been identified (Kennedy et al., 2015; Dell'Aringa et al., 2018).

Increasingly, the science of landslide physics is allowing the nature of these hazards to be understood, which is leading to better techniques through which they can be managed and mitigated.

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Coordinating agency or organisation

British Geological Survey.

GH0015 / **GEOHAZARD / Volcanogenic (Volcanoes and Geothermal)**

Ground Shaking (Volcanic Earthquake)

Definition

Ground shaking is the movement of the Earth's surface from earthquakes. Ground shaking is produced by waves that travel through the earth and along its surface (USGS, no date).

A volcanic earthquake is any earthquake that results from tectonic forces which occur in conjunction with volcanic activity (UN-SPIDER, no date).

References

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Annotations

Synonyms

Ground movement, Ground motion, Ground acceleration, Ground velocity.

Additional scientific description

Seismic activity is a common feature of volcanic eruptions. Often, there are many thousands of earthquakes recorded during an eruption. Most volcanic earthquakes are small but significant (moderate and large) volcanic earthquakes do occur (Zobin, 2001). Volcanic earthquakes, like all earthquakes, can cause shaking, damage to buildings and other structures, as well as changes in the surrounding environment. This shaking depends on the size of the earthquake, the distance from the source and the soil conditions (Bormann et al., 2013).

Metrics and numeric limits

The size of a volcanic earthquake is measured using the same magnitude scales as other earthquakes.

Magnitude is not a direct measure of ground shaking but, along with the distance from the earthquake source and geological conditions, decides the shaking at any point. There are many magnitude scales, but they should all yield approximately the same value for any given earthquake (USGS, no date). During the 20th century there were three large (magnitude greater than 7) earthquakes directly associated with volcanic eruptions (Zobin, 2001).

The effect of ground shaking on people and buildings is characterised by its macroseismic intensity. The three most important intensity scales in current use are the European Macroseismic Scale (EMS-98), the Modified Mercalli Scale (MM or MMI) and the JMA scale (Musson and Cecić, 2013). These scales rate the shaking at a given point by the observed effects, ranging from not felt to total damage (e.g., Grünthal, 1998). A magnitude 7 earthquake would be expected to have an intensity, near to the epicentre, of about EMS-98 9 (normally written IX to avoid confusion with magnitude). This is described by the scale as 'Destructive' with the description 'Many weak constructions collapse. Even well-built ordinary buildings show very heavy damage' (Grünthal, 1998).

Instrumental measures of shaking include peak ground velocity (PGV) and peak ground acceleration (PGA). Although it has been found that earthquake damage is much more closely correlated with PGV than with PGA (Wu et al., 2003), PGA continues to be the more used of these parameters. An often used relationship between intensity and PGA and PGV (Wald et al., 2019) suggests that shaking below 0.0005 g or 0.002 m/s will not be felt and that above 0.4 g or 0.4 m/s structural damage can be expected. A magnitude 7 earthquake could be expected to cause ground shaking of over 0.8 g or 0.9 m/s near the epicentre.

Key relevant UN convention / multilateral treaty

Sendai Framework for Disaster Risk Reduction 2015–2030 (UNDRR, 2015).

Examples of drivers, outcomes and risk management

Volcanic seismicity is often the first sign of a volcanic eruption. It can also occur at a volcano which does not subsequently erupt (Sparks, 2003).

Ground shaking on volcanoes is more likely to result in secondary hazards than elsewhere. These include landslides, lahars and pyroclastic density currents. Aggravating factors are the time of the event and the number and intensity of aftershocks. Compound hazards include fire and tsunami (WHO, no date).

A community can mitigate ground shaking damage by adopting and enforcing a building code with appropriate seismic design and construction standards (FEMA, 2010).

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Coordinating agency or organisation

British Geological Survey.

GH0016 / **GEOHAZARD / Volcanogenic (Volcanoes and Geothermal)**

Volcanic Gases and Aerosols

Definition

Volcanic gas includes any gas-phase substance that is emitted by volcanic or volcanic-geothermal activity. Volcanic aerosols include liquid or solid particles that are small enough to be suspended in the air, and that are emitted by volcanic or volcanic-geothermal activity (adapted from Baxter and Horwell, 2015, Fischer and Chiodini 2015, and Williams-Jones and Rymer 2015).

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Annotations

Synonyms

Volcanic gases: Vapours, Volatiles, Fumes.

Aerosols: Particles, Droplets, Particulate matter, PM. Vog (a term for volcanic gas and aerosol air pollution, used mostly in Hawaii).

Additional scientific description

Volcanic gases can be emitted directly into the atmosphere from magma or by magma interacting with crustal rocks. They can be observed with spectroscopic instruments from ground and space, and their future dispersion can be modelled, allowing forecasts of gas and aerosol concentrations to be made. Volcanic gas composition and concentrations can be modified through interaction with ground or surface waters; gases generated by heating and vaporising groundwater in volcanic-geothermal areas. Volcanic gases can also remain pressurised in the subsurface or within lakes (Oregon State, no date).

Volcanic aerosol sizes range from a few nanometres (nm) to several hundred micrometres (µm). Volcanic aerosol refers to particles formed through condensation of volcanic gases, or through reaction of the gases with the atmosphere and sunlight and is thereby distinct from 'ash' or 'tephra' that is formed through fragmentation of magma or lava. Aerosols can be in liquid or solid form and evolve between these states with time (Oregon State, no date).

Volcanic gases and aerosols are emitted by almost any type of volcanic activity:

- Emissions from explosive eruptions: Depending on the explosive power, emissions can be injected into the stratosphere or stay in the troposphere and spread around the globe in the most powerful events. Typical emission duration is hours to days (Rose and Durant, 2009).

- Emissions from effusive lava eruptions, open vents and lava lakes: Emission durations can last from days up to several decades or longer. Emissions are typically confined to the troposphere and have been instrumentally detected up to thousands of kilometres from the source (Rose and Durant, 2009).
- Emissions from crater lakes, and volcanic-geothermal systems: These low-energy and relatively low-temperature emissions (typically <100°C) are usually confined to the immediate vicinity of the source. However, large and highly hazardous emissions can occur if gases accumulate in the bottom of a lake and then rapidly release (Schmid et al., 2005).

The chemical composition of volcanic gas and aerosol emissions is highly heterogeneous. The composition changes continuously as the emissions drift away from their source and react with the atmosphere and sunlight. Typically, the most abundant volcanic gas is water vapour (80% or more of the gas mass). Other common gases are carbon dioxide (CO2), sulphur dioxide (SO2), hydrogen sulphide (H2S) and hydrogen halides (hydrogen chloride [HCl] and hydrogen fluoride [HF]). Radon and carbon monoxide (CO) are also emitted in trace amounts (Oregon State, no date).

Aerosol forms by condensation of volcanic gases, both near-instantaneously after emission, and on the timescale of hours to days. Sulphate, a common aerosol component, forms through conversion of SO2 gas. Aerosol contains a variety of trace components, including elements collectively classified as metal pollutants by environmental and health protection agencies (Oregon State, no date).

The abundance of emitted volcanic gases and aerosol varies greatly among eruptions. Recent large eruptions of Holuhraun in Iceland 2014–2015 and Kīlauea Hawaii in 2018, emitted as much SO2 per day as anthropogenic activities in China (50–200 kt/day) over several months (Pfeffer et al., 2018; Kern et al., 2020). A larger-scale emission scenario, which may occur in the coming decades or centuries, includes a 'Laki-type' eruption in Iceland which can emit ten times more SO2 than the recent eruptions described above. There are tens, or potentially hundreds, of volcanoes worldwide which emit smaller amounts of SO2 (0.5–5 kt/day) (Carn et al., 2016) but sustain the emissions over years-to-decades (e.g., Mt Etna; Aiuppa et al. 2008).

Volcanic gas and aerosol exposure is listed as the cause of 1% of total volcanic hazard fatalities (2283 people; Brown et al., 2017). This estimate includes only fatalities due to extreme direct exposure and does not include premature mortality caused by long-term air and environmental pollution. It has been estimated that 800 million people live within 100 km of a volcano that has erupted in the last 10,000 years (Auker et al., 2013), a range within which they could be exposed to this hazard.

Metrics and numeric limits

Not available.

Key relevant UN convention/multilateral treaty

Sendai Framework for Disaster Risk Reduction 2015–2030 (UNDRR, 2015).

Examples of drivers, outcomes and control measures of the hazard

SO2, particulate matter <2.5 µm in diameter (PM2.5) and, in some cases, H2S, are the only volcanic gas and aerosol pollutants that are monitored and forecasted operationally. The monitoring and forecasting capacity is present almost exclusively in high-income countries where the emission source is located (e.g., US, Japan, Italy, Iceland). The impacts of volcanic gas/aerosol emissions on air quality and human health are challenging to constrain and are generally absent from local hazard assessments and mitigation plans in lower-income countries.

Multiple chemical species in volcanic gases and aerosols may cause a human and/or environmental impact.

- Health impacts: The common effects of volcanic gases, in particular SO2, H2S, HCl and HF are: (i) irritation to the respiratory tract, eyes and skin; (ii) chest tightness, shortness of breath, and headaches; and (iii) asthma aggravation. SO2 is the greatest respiratory hazard, causing health impacts, especially for asthmatics, up to thousands of kilometres from the source. High concentrations of fluoride (from HF) causes damage to teeth and bones; it is especially dangerous to grazing animals. All of the listed gas species, as well as CO2 and CO, can cause death in high concentrations. Volcanic aerosol is typically PM2.5, an air pollutant with no known safe exposure limits (WHO, 2013a). Both acute and chronic exposure to PM2.5 causes respiratory and cardiovascular morbidity and premature mortality (WHO, 2013b). More information on the health hazards and impacts of volcanic gases and aerosols can be found on the International Volcanic Health Hazard Network website (IVHHN, 2020a).
- Environmental impacts: Acid rain is commonly caused by mixing of atmospheric water with volcanic gas and aerosol and leads to degradation of plant health and diversity, crop damage and damage to infrastructure. Metal pollutants can contaminate rainfall and accumulate in soils, surface waters and plants (Bourassa et al., 2012).
- Climate impacts: Large explosive eruptions can form an aerosol blanket in the stratosphere which leads to cooling at the surface of ~0.5°C. The effect may last for about 2 years (Bourassa et al., 2012).

Owing to the multiple impacts of volcanic gases, agencies in Hawaii provided a public dashboard which summarises the various impacts as well as providing access to monitoring and forecasting data (IVHHN, 2020b). The dashboard was accessed more than 50,000 times per week during the 2018 Kīlauea volcanic crisis.

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Coordinating agency or organisation

International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) / (Global Volcano Model (GVM) / International Volcanic Health Hazard Network (IVHHN).

GH0017 / **GEOHAZARDS / Volcanogenic (Volcanoes and Geothermal)**

Tsunami (Volcanic Trigger)

Definition

Volcano tsunamis (pronounced soo-ná-mees), are a series of waves created when water surrounding a volcano is displaced following an eruption, a landslide, or failure of a volcanic edifice into surrounding water. If the generating mechanism is large enough, the waves can be significant on local, regional or even transoceanic scales (Day, 2015).

Reference

Day, S., 2015. Volcanic Tsunamis. The Encyclopedia of Volcanoes, 2nd Ed.

Annotations

Synonyms

Not found.

Additional scientific description

Tsunami is the Japanese term meaning wave ('nami') in a harbour ('tsu'). Tsunamis are a series of gravity waves of extremely long (up to hundreds of kilometres) length with periods of 10 to 60 minutes that can travel across ocean basins with little loss of energy. They are usually generated by earthquakes occurring below or near the ocean floor. Approximately 80% of tsunamis are caused by earthquakes, but also by volcanic eruptions, submarine landslides, and coastal rock falls. Tsunami waves, on entering shallow water steepen and increase in height attaining elevations (or runups) of tens to hundreds of meters, inundating low-lying areas and, where local submarine topography causes the waves to steepen, they may break and cause great damage. Tsunamis have no connection with tides; the popular name, tidal wave, is entirely misleading (IOC, 2019).

Volcanic tsunamis are defined as those with source mechanisms from erupting and quiescent volcanoes, and include explosions, pyroclastic flows and lahars entering the water, earthquakes preceding or during a volcanic eruption, flank failure (from rock falls to massive debris avalanches), collapse of coastal lava benches, caldera collapse and shock waves from large explosions. Of these mechanisms, only pyroclastic flows, flank failures and caldera subsidence generate damaging tsunamis, as their volumes are larger than one km3. Wavelengths of volcanic tsunamis are shorter than those from earthquakes and undergo more rapid dispersion during propagation. These tsunamis are more hazardous on coastlines close to the volcano. Because of the different potential mechanisms and their possible interactions, numerical simulations of volcano tsunamis, and model-based assessments of hazards from volcano tsunamis, are challenging, compared to those from earthquakes (Day, 2015).

The Intergovernmental Oceanographic Commission (IOC) uses the following terms to assess the scale and impact of a tsunami (IOC, 2019):

- Travel time: Time required for the first tsunami wave to propagate from its source to a given point on a coastline.
- Arrival time: Time of the first maximum of the tsunami waves.
- Inundation or Inundation-distance: The horizontal distance inland that a tsunami penetrates, generally measured perpendicularly to the shoreline.
- Inundation (maximum): Maximum horizontal penetration of the tsunami from the shoreline. A maximum inundation is measured for each different coast or harbour affected by the tsunami.
- Inundation area: Area flooded with water by the tsunami.
- Inundation height Elevation reached by seawater measured relative to a stated datum such as mean sea level or the sea level at the time of tsunami arrival, at a specified inundation distance. Inundation height is the sum of the flow depth and the local topographic height. Sometimes referred to as tsunami height.

- Inundation line: Inland limit of wetting measured horizontally from the mean sea level line. The line between living and dead vegetation is sometimes used as a reference. In tsunami science, the landward limit of tsunami run-up.
- Leading wave: First arriving wave of a tsunami. In some cases, the leading wave produces an initial depression or drop in sea level, and in other cases, an elevation or rise in sea level. When a drop in sea level occurs, sea level recession is observed.
- Mean height: Average height of a tsunami measured from the trough to the crest after removing the tidal variation.
- Run-up
  - Difference between the elevation of maximum tsunami penetration (inundation line) and the sea level at the time of the tsunami. In practical terms, run up is only measured where there is a clear evidence of the inundation limit on the shore.
  - Elevation reached by seawater measured relative to some stated datum such as mean sea level, mean low water, sea level at the time of the tsunami attack, etc., and measured ideally at a point that is a local maximum of the horizontal inundation. Where the elevation is not measured at the maximum of horizontal inundation, this is often referred to as the inundation-height.
- Tsunami amplitude: Usually measured on a sea level record, it is (1) the absolute value of the difference between a particular peak or trough of the tsunami and the undisturbed sea level at the time, (2) half the difference between an adjacent peak and trough, corrected for the change of tide between that peak and trough. It is intended to represent the true amplitude of the tsunami wave at some point in the ocean. However, it is often an amplitude modified in some way by the tide gauge response.
- Tsunami period: Amount of time that a tsunami wave takes to complete a cycle, or one wavelength. Tsunami periods typically range from 5 to 60 minutes. Tsunami period is often measured as the difference between the arrival time of the highest peak and the next one measured on a water level record.
- Tsunami wavelength: The horizontal distance between similar points on two successive waves measured perpendicular to the crest. The wavelength and the tsunami period give information on the tsunami source. For tsunamis generated by earthquakes, the typical wavelength ranges from 20 to 300 km. For tsunamis generated by volcanic mechanisms wavelengths are much shorter than those from earthquakes, ranging from hundreds of meters to tens of kilometres.
- Meteotsunami: Volcanic eruptions, submarine landslides, and coastal rock falls can also generate tsunamis, as can a large meteorite impacting the ocean. Tsunami-like phenomena generated by meteorological or atmospheric disturbances.

For more terms see IOC (2019).

Metrics and numeric limits

Not available.

Key relevant UN convention/multilateral treaty

Not found.

Examples of drivers, outcomes and risk management

Volcanic tsunamis are relatively infrequent, and unpredictable, hazards that are caused by rapid, mainly vertical, ground displacements (earthquakes and landslides) or eruptive activity at a volcano. Their hazard is mainly to coastal communities within a few tens of kilometres of active volcanoes, although more infrequent, larger volume, volcano flank collapse landslides, and explosive eruptions are a hazard at greater distances of hundreds of kilometres. At present, there is no defined management structure to mitigate the hazard because of the complex range of volcanic tsunami mechanisms. Through analysis of geological and historical evidence of past behaviour at a volcano, however, it is possible to identify volcanoes that generate tsunamis and investigate these to determine whether risk management measures (such as changes to coastal land use patterns) can be formulated. Monitoring volcanic activities and their local environments (for example ground stability and changes in ground motion), has the potential to identify imminent eruptive activity, or changes at a volcano (such as increased seismicity), that could make it more susceptible to instabilities, such as landslides or collapse, with the potential for initiating tsunamis. Thus, in contrast to risks from earthquake-generated tsunamis, that require management through rapid responses based on the detection of large magnitude events, the risks from volcanic tsunamis could, to some extent, be addressed by anticipatory measures, such as coastal evacuations, in response to increased volcanic activity, on which early warning system messaging is based (Day, 2015).

Primary hazards/damage. Damage and destruction from tsunamis are the direct result of three factors: inundation, wave impact on structures, and erosion. Deaths occur by drowning and physical impact or other trauma when people are caught in the turbulent, debris-laden tsunami waves. Strong tsunami-induced currents have led to the erosion of foundations and the collapse of bridges and seawalls. Floatation and drag forces have moved houses and overturned railroad cars (IOC, 2019:6).

Tsunami associated wave forces have demolished frame buildings and other structures. Considerable damage is also caused by floating debris, including boats, cars, and trees that become dangerous projectiles that may crash into buildings, piers, and other vehicles. Ships and port facilities have been damaged by surge action caused by even weak tsunamis. Fires resulting from oil spills or combustion from damaged ships in port, or from ruptured coastal oil storage and refinery facilities, can cause damage greater than that inflicted directly by the tsunami (IOC, 2019:6).

Secondary hazards/damage. Secondary hazard/damage includes sewage and chemical pollution following the tsunami destruction. Damage to intakes, discharge, storage facilities and flooding of cooling generators are also major potential problems. During tsunami drawdown, there is the potential for the receding flood waters to uncover cooling water intakes associated with nuclear power plants, leading to overheating and explosion of nuclear facilities (IOC, 2019:7).

Environmental damage and damage to coastal croplands can result from deposition of sediments over inundated areas and salt water contamination. This could be a particular problem with tsunamis associated with volcanic eruptions, from the transport and deposition of floating pumice onto land, and the erosion, transport and redeposition of volcanic tephra deposited in phases of the eruption prior to the tsunami inundation. Clean-up efforts can be complicated by contamination of sediment and debris with salt and with spilt oil fuels and other chemicals.

Risk management for tsunamis includes a number of guidelines on tsunami risk assessment/management are available. Examples include IOC (2015) and UNDRR (2017).

Regional Coordination and Centres: The IOC is coordinating the implementation of a global tsunami warning system, building upon its experiences in the Pacific to establish regional warning systems for the Indian Ocean (IOTWMS); Caribbean Sea (ICG-CARIBE-EWS); and the North-eastern Atlantic, the Mediterranean and connected seas (ICG-NEAMTWS). The regional systems coordinate international tsunami warning and mitigation activities, including the issuance of timely and understandable tsunami bulletins to IOC Member States.

The Intergovernmental Coordination Group for Tsunamis addresses tsunami risk globally through the following groups:

ICG-PTWS Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System, formerly ICG/ITSU, was renamed by Resolution EC-XXXIX.8 of the IOC Executive Council in 2006 as proposed by the International Coordination Group for the Tsunami Warning System in the Pacific at its 20th Session in 2005 (Recommendation ITSU-XX.1). There are presently 46 Member States in the ICG-PTWS. ICG/ITSU, the International Coordination Group for the Tsunami Warning System in the Pacific was established by Resolution IV-6 of the 4th Session of the IOC Assembly in 1965. The Pacific Tsunami Warning Center (PTWC) serves as the Tsunami Service Provider (TSP) for the Pacific Ocean. Other TSPs for specific regions of the Pacific Ocean are the North West Pacific Tsunami Advisory Center (NWPTAC) and the South China Sea Tsunami Advisory Center (SCSTAC). The ICG-PTWS presently comprises over 40 Member States and oversees warning system operations and facilitates coordination and cooperation in all international tsunami mitigation activities.

ICG-IOTWMS The Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG-IOTWMS) was formed in response to the tragic tsunami on December 26th 2004, in which over 230,000 lives were lost around the Indian Ocean region. The ICG-IOTWMS comprises 28 Member States. There are three TSPs in the Indian Ocean, hosted by the governments of Australia, Indian and Indonesia.

ICG-NEAMTWS The Intergovernmental Coordination Group for the Tsunami Early Warning and Mitigation System in the North-eastern Atlantic, the Mediterranean and connected seas (ICG-NEAMTWS) was formed in response to the tragic tsunami on 26 December 2004, in which over 230,000 lives were lost around the Indian Ocean region (Indian Ocean Tsunami Information Centre, no date). The ICG-NEAMTWS consists of Member States bordering the North-eastern Atlantic and those bordering and within the Mediterranean and connected seas. There are currently five accredited Tsunami Service Providers (France, Greece, Italy, Portugal, Turkey) in the NEAM region providing tsunami services and alerts to subscribing Member States.

ICG-CARIBE-EWS The Intergovernmental Coordination Group for the Tsunami and Other Coastal Hazards Warning System for the Caribbean and Adjacent Regions (ICG-CARIBE-EWS) was established in 2005 and currently comprises 32 Member States and 16 Territories in the Caribbean.

Tsunami Service Providers (TSPs) are centres that monitor seismic and sea level activity and issue timely tsunami threat information within an ICG framework to National Tsunami Warning Centres (NTWCs) / Tsunami Warning Focal Points (TWFPs) and other TSPs operating within an ocean basin. The NTWCs / TWFPs may use these products to develop and issue tsunami warnings for their countries. TSPs may also issue public messages for an ocean basin and act as NTWCs providing tsunami warnings for their own countries. Currently there are nine operational TSPs.

National Tsunami Warning Centres (NTWCs) are a centre officially designated by the government to monitor and issue tsunami warnings and other related statements within their country according to established national Standard Operating Procedures.

World Tsunami Awareness Day, 5 November every year: The United Nations, through UN Resolution 70/203 adopted on 22 December 2015, has designated 5 November as World Tsunami Awareness Day (UNDRR, 2020). The day aligns with the International Day for Disaster Reduction (13 October) and the seven targets of the Sendai Framework for Disaster Risk Reduction 2015–2030 (ITIC, 2020). The IOC is a key international partner of the UNDRR on World Tsunami Awareness Day.

Tsunami Ready is a voluntary community recognition programme that promotes tsunami hazard preparedness as an active collaboration among federal, state/territorial and local emergency management agencies, community leaders and the public. The main goal of the programme is to improve public safety before, during and after tsunami emergencies. It aims to do this by establishing guidelines for a standard level of capability to mitigate, prepare for and respond to tsunamis, and working with communities to help them meet the guidelines and ultimately become recognised as 'tsunami ready' by the National Weather Service. It was first implemented in the United States .To date, there are 26 IOC-UNESCO Tsunami Ready recognised communities in 18 countries and territories, excluding those implemented in the United States.

Community engagement with evacuation zones and the 'blue lines' project In New Zealand, the Wellington Region Emergency Management Office has developed the Blue Line Project in collaboration with communities in Wellington's southern coastal suburbs. In this project, the local community helps to plan evacuation routes and safe locations based on indicative evacuation zone mapping, and blue lines are painted on the road surface at the maximum estimated tsunami inundation extent. Accompanying evacuation signage is installed. Community members are engaged early in the project, publicising the work and helping to develop blue line locations, evacuation zone maps and information boards. The communities participating in the Blue Line Project can be considered to have a higher degree of public education regarding tsunami evacuation than other communities (Fraser et al., 2016). Other communities around the world have used similar community engagement strategies.

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Coordinating agency or organisation

United Nations Educational, Scientific and Cultural Organization (UNESCO), Intergovernmental Oceanographic Commission (IOC-UNESCO) and the British Geological Survey.

GH0018 / **GEOHAZARD / Volcanogenic (Volcanoes and Geothermal)**

Lightning (Volcanic Trigger)

Definition

Volcanic lightning is an electrical discharge caused by a volcanic eruption. It is typically associated with ash-rich eruption plumes but can also arise from a range of volcanic processes including ground-hugging ash flows and lava-ocean entry (adapted from Mather and Harrison, 2006; Behnke and McNutt, 2014; and McNutt and Thomas, 2015).

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Annotations

Synonyms

Dirty thunderstorm, Plume lightning, Vent discharges, Near-vent lightning.

Additional scientific description

Explosive injection of volcanic ash and gas into the atmosphere produces a wide range of electrical activity (Behnke and McNutt, 2014). The most hazardous electrical phenomenon is cloud-to-ground volcanic lightning, which creates a transient channel of hot plasma between a volcanic cloud and the ground. Exactly like ordinary thunderstorms, cloud-to-ground lightning from volcanic eruptions can produce thunder, trigger wildfires and destroy unshielded monitoring equipment or other infrastructure. Despite its potential impact, there are only a handful of documented cases where volcanic lightning resulted in injury or death (McNutt and Thomas, 2015).

In general, the hazards of volcanic lightning increase with eruptive intensity (McNutt and Williams, 2010; Behnke et al., 2013):

- Small eruptions: Low plumes (<1 km high) have been observed to create lightning (Cimarelli et al., 2016), including low-level steam plumes from lava flows entering the ocean. However, these flashes are sparse and only measurable with close-range sensors.
- Moderate eruptions: Slightly larger eruptions with plume heights 1–10 km (and ground-hugging ash flows if present) are likely to produce some lightning activity, but it tends to be weak and restricted to areas within about 20 km of the volcano (Behnke et al., 2013; Van Eaton et al., 2020).
- Large eruptions: Plumes exceeding heights of 10–15 km above the vent tend to produce the highest rates of volcanic lightning. These volcanic events occur only a few times per year worldwide, and in some instances are capable of transporting lighting-rich plumes over 100 km from the volcano (Van Eaton et al., 2016). Volcanic lightning from large eruptions is detectable on a global scale using worldwide networks.

The origin of volcanic plume electrification is a topic of active investigation, but it is clear that at least two distinct processes are involved. Silicate charging occurs close to the eruptive vent, during magma fragmentation and high-energy collisions among airborne rock particles (Mather and Harrison, 2006). At higher altitudes, ice charging—which is responsible for lightning in ordinary thunderstorms—becomes active if the volcanic plume rises well above the freezing level (approximately -20°C), creating a mixed-phase region of ice crystals, soft hail, and supercooled liquid water (Behnke et al., 2013; Van Eaton et al., 2020). Once the particles undergo either or both of these charging mechanisms, they accumulate in oppositely charged regions due to turbulent flow and gravitational separation of particles based on their different sizes and settling speeds (Behnke et al., 2013). Charge separation builds an electric field until it exceeds the local breakdown threshold of surrounding air, resulting in lightning discharges.

Metrics and numeric limits

Not identified.

Key relevant UN convention/multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

The hazards of cloud-to-ground volcanic lightning are nearly always of second-order importance compared to the other volcanic hazards of ground-hugging ash flows, lahars, and ashfall (Blong, 2000). The exception is rare situations when a large eruption transports a lightning-rich cloud directly over a populated area, exposing people and infrastructure to cloud-to-ground lightning. In areas of the world where ordinary thunderstorms are rare (e.g., high latitudes), the local population may not be accustomed to moving immediately indoors during lightning activity.

Current methods for mitigating this hazard include developing near-real time alerts for volcanic thunderstorms using global or regional networks of radio antennas (Behnke and McNutt, 2014).

A well-established example includes the World Wide Lightning Location Network's volcanic lightning monitor, which generates an alert when lightning initiates near an active volcano and progresses outward through time (University of Washington, no date) .

Detection of radio emissions from electrical discharges can provide early warning of a lightning-rich eruption because the signal travels at the speed of light.

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Coordinating agency or organisation

United States Geological Survey.

GH0019 / **GEOHAZARD / Volcanogenic (Volcanoes and Geothermal)**

Urban Fire (During/Following Volcanic Eruption)

Definition

Urban fires are fire involving buildings or structures in cities or towns with potential to spread to adjoining structures. Triggers of urban fires are numerous, from human actions (e.g., knocking over a candle) and technological triggers (e.g., power surge overloading appliances), to natural triggers (e.g., wildland fires interacting with urban areas). Triggers from volcanic eruptions include lava flows, pyroclastic density currents, tephra, and ground shaking (adapted from Baxter et al., 2005 and ISO, 2020).

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Annotations

Synonyms

Urban conflagration.

Additional scientific description

All fires, regardless of trigger, need three elements to sustain themselves: fuel, oxygen, and heat. The heat thermally decomposes (pyrolysis) the fuel into a hot gas (volatiles) which mixes with the oxygen which then creates a combustible gas namely the flame, the edge of which is where the combustion reaction happens. The flame can then transfer the heat through: radiation to other objects that it has a line of sight to; convection of hot gases; and conduction through the fuel that is pyrolysing (Drysdale, 2011).

Most cellulosic materials pyrolyse between 150 and 500°C to producing volatiles (Zhou et al., 2013). These volatiles will spontaneously ignite if the surface of the pyrolysing object reaches between 450 and 600°C, or between 300 and 450°C if there is a flame already present (Drysdale, 2011).

As the fire grows within a room, the rate at which fuel is consumed increases if there is sufficient oxygen within the room. If oxygen levels are low, then the fire will 'move' towards more oxygen-rich environments, this causes a phenomenon called flashover, where flames (typically about 1 m long under laboratory conditions for a standard door and a 9 m2 room) are ejected from compartment openings (Drysdale, 2011). In windier conditions, these can increase up to 3 m for a standard door-sized opening (de Koker et al., 2020), however this is not a linear relationship, and above a certain wind speed (dependent on the size of flame and other spatial and material properties) the length of the flame will not increase any further as convective cooling due to the wind reduces the amount of heat energy within the flame. If the spatial distribution of homes is close, then fires can spread from one building to another. The separation distance will be determined by the specific typology of the compartment/room, its openings, and the fuel therein.

Four areas should be considered in relation to fire triggered specifically by volcanic eruptions: lava flows, pyroclastic density currents (PDCs), hot tephra, and ground shaking.

- Lava flows: high temperature lava (1000–1200°C), moving usually in the order of 4–5 km/hr but exceptionally up to tens of kilometres per hour (e.g., the lava lake at Nyiragongo; Tedesco et al., 2007; Balagizi et al., 2018) may interact with combustible materials in its path and cause ignitions.
- Pyroclastic Density Currents: PDCs are hot, unstoppable, gas-particle mixtures that race across the ground surface at velocities of tens to hundreds of kilometres per hour and have temperatures typically between 200 and 600°C (Dufek et al., 2015). At these temperatures pyrolysis will occur for most cellulosic materials and fire damage will be observed (Baxter et al., 2005). The noxious gases often replace oxygen within the PDCs and this, combined with the flow speed which takes energy away from the pyrolysing surface (Babrauskus, 2003), limits the probability of ignition during the immediacy of the current. However, the energy stored in the materials and residual temperatures when oxygen is present can cause ignitions. PDCs can cause large amounts of structural damage creating openings and breaking of windows for hot ash to ingress and they can also redistribute fuel load (trees etc.) facilitating urban fire spread. PDCs can also cause ignitions in a similar manner to ground shaking (see below).
- Hot tephra: large lapilli, rocks and bombs, have the ability to cause ignition of dry combustible materials in and around urban structures, while the accumulation of hot volcanic ash (>300–400°C) could accumulate on surfaces to cause fires and as for fire brands created by wildfires, could ingress into structures through openings and cause ignitions (Baxter et al., 2005).
- Ground shaking: caused by the eruption and potential to be felt over large distances, ground shaking can unsettle open flames or disrupt energy supplies within buildings and could thus be a triggering event for a fire.

If fires are triggered in one or more rooms in a home, then homes can be severely affected by fire damage during/following a volcanic eruption.

Urban fires during/following a volcanic eruption have not been systematically recorded in detail to date. Baxter et al. (2005) have created a six-point damage scale which incorporates fire as an observed effect for PDCs.

Metrics and numeric limits

Not available.

Key relevant UN convention/multilateral treaty

Sendai Framework for Disaster Risk Reduction 2015–2030 (UNDRR, 2015).

Examples of drivers, outcomes and risk management

Urban fires can cause large losses of life and livelihood: 95% of global deaths (180,000 to 300,000 people per year) and injury (10 million Disability-Adjusted Life Years lost each year) from fire occur in low and middle income countries (Mock et al., 2008; WHO, 2018); fire costs 1% of global GDP (The Geneva Association, 2014); and those who are at greatest risk (the urban poor) generally have little in means of protection against losses. In addition, those at greatest risk of death and injury are the old and the young due to lack of knowledge in how to respond and lack of mobility when trying to respond (Rush et al., 2020).

Urban fires are linked to density of structures and type of construction. Highly dense settlements (i.e., informal settlements or slums) are likely to have large areas of structures that are in close proximity to one another which will facilitate fire spread. This, when combined with combustible construction can lead to large-scale fire events. Combustible construction here refers not only to the material used in construction but also how the structure is sealed against the weather. For instance, a steel walled structure that has any gaps at joints sealed with paper or plastic materials would be susceptible to fire attack from another structure (Walls et al., 2017, 2018; Kahanji et al., 2019).

The density of settlements and the construction of the buildings is also inextricably linked to the wealth of the inhabitant with the urban poor being less able to live in space and less able to live in non-combustible buildings or to maintain buildings in such a way that fire events are more readily controlled. There are also areas, historic in nature, that have high structure density and combustible construction such as the fire in Shangri-La that occurred on 11 January 2014 (Associated Press, 2014).

Baxter et al., (2005) gave a good summary of urban fires known to have followed volcanic eruptions. Volcanic eruptions which create PDCs can break windows in homes. This will allow hot ash and other tephra to ingress the homes and, if combustible materials are present, can cause large fires to occur. The high temperatures of the PDCs can also pyrolyse and char roof structures. This was seen at the Montagne Pelée and St Vincent eruptions in 1902, Vesuvius in AD79, Montserrat in 1997; while extensive scorch zones were observed 1–3 km from the periphery of the PDC margin following the eruptions at both Mount St Helens in 1980 and Mt Lamington in 1951.

Jenkins et al. (2017) noted a few instances of fires caused by the lava flow following the Fogo eruption in 2014–2015. They highlighted that although minimal damage due to fire occurred in this eruption due to lava flows, this could have been greater if the urban area were made of more flammable construction (such as seen in Hawai'i) and fuel (such as gas canisters) had not been removed in a timely manner.

During the 2002 eruption of Nyiragongo volcano, between 60 and 100 people were killed owing to the explosion of a gas station surrounded by lava, and about 470 were injured with burns, fractures and/or gas intoxication (Tedesco et al., 2007; Balagizi et al., 2018).

Use of non-combustible construction materials and ensuring that buildings remain well sealed during volcanic eruptions are key control measures. This combined with preparedness in dealing with lava flows and securing energy supplies can reduce the impact of urban fires during/following volcanic eruptions.

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Coordinating agency or organisation:

School of Engineering, University of Edinburgh.

GH0020 / **GEOHAZARD / Volcanogenic**

Subsidence and Uplift, Including Shoreline Change (Magmatic/Volcanic Trigger)

Definition

Volcanic uplift and subsidence are deformations of the ground associated with volcanic unrest and eruptions (Dzurisin, 2007).

Reference

Dzurisin, D., 2007. Volcano Deformation. Springer.

Annotations

Synonyms

None.

Additional scientific description

Uplift and subsidence may occur before, during and after volcanic eruptions (Dzurisin, 2007). Before eruptions, uplift and/or subsidence may be among the first signs that a magmatic system is restless, so monitoring and understanding ground deformation is critical to attempts to understand magmatic systems, forecast eruptions and mitigate volcanic risk (Dzurisin, 2007; Acocella et al., 2015).

'Volcanic unrest' is defined as any deviation of ground deformation, seismicity, gas emission, and/or other geophysical and geochemical indicators from normal baselines, increasing the probability of eruption (Acocella, 2019). Volcanic unrest may typically last from hours to months but at some caldera volcanoes, unrest episodes may last for years to decades (Acocella et al., 2015). Some volcanoes that have not erupted for tens to hundreds of years may experience repeated episodes of unrest over several years before a critical threshold is reached and an eruption occurs (e.g., Sigmundsson et al., 2010).

During unrest at volcanoes, ground deformation is usually on the order of millimetres to centimetres per year and it is not uncommon for the centre of uplift to move (e.g., Di Vito et al., 2016). Some caldera volcanoes may show deformation rates of metres per year (e.g., Acocella, 2019) and some calderas show very long-term ground deformation ('resurgence') which may cause uplift of up to 1 km over hundreds to thousands of years (e.g., Galetto et al., 2017; Acocella, 2019).

Volcanic calderas are some of the most dangerous volcanoes on Earth and many have large populations living in and around the caldera (Acocella et al., 2015). They have surface depressions from ~1 km to tens of kilometres across, and up to several kilometres in topographic change from rim to floor (Acocella et al., 2015). Some contain lakes (e.g., Taal, Philippines) and some are semi-submarine (e.g., Santorini, Greece; Krakatau, Indonesia). Most calderas have large (over 1000 km3), long-lived, heterogeneous and active magmatic systems and about 20 caldera volcanoes show unrest each year, most driven by magma intrusion (Acocella et al., 2015).

For example, the Campi Flegrei caldera (Italy) is 12 km across and lies under the outskirts of Naples. At least 5 m of uplift was observed in the hours to days before the last eruption at Campi Flegrei in 1538 (from Monte Nuovo) resulting in the seaward retreat of the shoreline by '200 paces' (Parascandola, 1947; Dvorak and Gasparini, 1991). Campi Flegrei experienced major uplifts in 1950–1951, 1969–1972 and 1982–1984 which cumulatively raised the town of Pozzuoli by 4 m. Pozzuoli experienced a maximum of 1.8 m of uplift during unrest in 1982–1984 (Berrino et al., 1984).

Metrics and numeric limits

Not identified.

Key relevant UN convention/multilateral treaty

Sendai Framework for Disaster Risk Reduction 2015–2030 (UNDRR, 2015).

Examples of drivers, outcomes and risk management

Uplift is typically associated with pressurisation ('inflation') of a shallow (few kilometres below the surface) magmatic system caused by the injection of magma but may also be caused by volatile degassing of a magma body (e.g., Lowenstern et al., 2006; Dzurisin, 2007; Sparks et al., 2012; Reath et al., 2020). Subsidence is associated with depressurisation ('deflation') of a magmatic system and may be caused by magma cooling and solidification, or the outflow of magma (during eruption or lateral migration into dykes or sills, e.g., Sigmundsson et al., 2015). Subsurface hydrothermal systems at volcanoes may also cause ground deformation (Gottsmann et al., 2006), as may tectonic events such as large earthquakes (Battaglia et al., 1999; Pritchard et al., 2019).

Near real-time ground deformation monitoring may enable scientists to anticipate the start of eruptions and key hazardous events during eruptions (e.g., Sparks et al., 2012; Sigmundsson et al., 2015; Fernández et al., 2017; Pallister et al., 2019). Satellite technologies such as InSAR have the potential to make a significant contribution to volcano ground deformation monitoring, especially in the form of regional surveys and for remote volcanoes with limited monitoring infrastructure (Ebmeier et al., 2018). Numerical simulations of 'inflation' and 'deflation' at volcanoes are generally carried out to understand and interpret observed ground deformation in terms of the dynamics and shape of the pressure source (e.g., Gottsmann et al., 2006).

Damage can be caused to buildings (Pingue et al., 2011), transport networks, critical infrastructure and facilities hampering response and mitigation efforts. Coastal regions affected by uplift/subsidence may be unable to use harbours and ferries for evacuation purposes (e.g., Alberico et al., 2012). Most damage during unrest at Campi Flegrei in 1982–1984 occurred within 2 km of the centre of uplift where total vertical movement exceeded about 60% of its maximum value of about 1.8 m but there was also intense volcanic earthquake activity (Barberi et al., 1984; Berrino et al., 1984; Charlton et al., 2020). Multiple hazards will occur before, during and after eruptions leading to cascading impacts, so risk mitigation measures need to account for this (e.g., Charlton et al., 2020).

Volcanic unrest associated with uplift and/or subsidence may cause significant distress to residents, with associated evacuations causing permanent displacement for some and loss of livelihoods (e.g., Barberi et al., 1984; Longo, 2019). A risk perception study at Campi Flegrei showed that residents who remembered the unrest episodes of the 1970s and 1980s were more concerned about unrest than an eruption (Ricci et al., 2013). Testing and practicing evacuation procedures for future response may enhance the awareness and preparedness of populations (e.g., Commune di Napoli, 2019).

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Coordinating agency or organisation

British Geological Survey (BGS).

GH0021 / **GEOHAZARDS / Other Geohazard**

Ground Shaking (induced earthquake, reservoir fill, dams, cavity collapse, underground explosion, impact, hydrocarbon fields, shale exploration, etc.)

Definition

Induced seismic ground shaking comprises non-tectonic (i.e., non-natural) earthquakes which result from human activities that alter the stresses and strains on the Earth's crust. Most induced seismicity is of a low magnitude and higher frequency than larger magnitude events with longer wavelengths and lower frequencies (USGS, 2016).

Reference

USGS, 2016. EarthWord – Induced Seismicity. United States Geological Survey (USGS). www.usgs.gov/news/earthword-%E2%80%93-induced-seismicity Accessed 21 October 2020.

Annotations

Synonyms

Seismicity, Shaking intensity, Ground motion, Ground vibration, Peak ground acceleration (PGA), Local ground response, Earth tremor, Vibration.

Additional scientific description

An earthquake is the sudden release of energy and ground shaking resulting from rocks breaking and moving along a fault line. Earthquake ground shaking is produced by seismic waves that travel through the Earth and along its surface. All earthquakes, both natural and man-made, generate seismic waves. Seismic waves radiate outward from the earthquake origin, forming a circular wave front that causes shaking over an extended region (Stein and Wysession, 2003). Ground shaking is a predominant seismic hazard, causing more than 90% of earthquake-related damage and loss (National Institute of Building Sciences Building Seismic Safety Council, 2010).

The strength and duration of the ground shaking at any location depends on many factors, predominantly the magnitude of the earthquake, the earthquake mechanism (i.e., the fault orientation and direction of slip), the distance to the earthquake origin, and local soil conditions (Kramer, 1996; USGS, no date a). Thus, ground shaking at each site from an earthquake is unique and can vary significantly from location to location. There are many human activities that can cause induced earthquakes including: wastewater disposal, mining, development of artificial lakes, extraction of fossil fuels, extraction of groundwater, development of geothermal energy, hydraulic fracturing, and subsurface storage of carbon dioxide.

Earthquake magnitudes are given using one of several broadly equivalent scales, with the 'moment magnitude' scaling being the preferred measure of an earthquake's size, as it quantifies the energy released by the earthquake (USGS, no date b). The magnitude scale is logarithmic; each increase of 1 magnitude unit (i.e., 4.3 to 5.3) represents an order of magnitude (factor of 10) increase in the amplitude of seismic measurements, and a factor of 32 increase in the energy release of an earthquake (USGS, no date b). Earthquakes of Magnitude 7.0 and above can be expected to cause widespread, intense ground shaking; earthquakes of Magnitudes 6.0 to 6.9 may cause local damage. Note that damage may be more severe and widespread for an earthquake of a given magnitude and other characteristics in regions of fragile buildings and high-density population (USGS, no date b).

Metrics and numeric limits

Although there is no globally agreed metric available, there is a global earthquake risk model (Silva et al., 2018) and there are several other Global Earthquake Model Foundation initiatives including a Global Exposure Database for Multi-Hazard Risk Analysis (GEM, no date). The Peak Ground Acceleration method (USGS, no date c; see below for explanation) for measuring ground shaking is the preferred approach, but global use is limited by the distribution of instrumentation.

There are many metrics for measuring ground shaking at a particular location:

- Qualitative intensity measures, like the Modified Mercalli intensity (MMI) scale (Wood and Neumann, 1931), and similar scales such as the Medvedev-Sponheuer-Kárník (MSK) scale or the European Macrointensity Scale (EMS-98) (Grünthal, 1998), describe the severity of an earthquake in terms of its effects on the Earth's surface, the infrastructure and the population (USGS, no date c). MMI values range from I (not felt) to XII (Total Damage), and the threshold for structural damage begins at VI, although this varies with the fragility of buildings in any given region. For some earthquake reporting agencies, MMI XI and XII are no longer assigned and MMI X is available but has not been applied in recent times. Since 1931, it has become clear that many of the phenomena described by Wood and Neumann (1931) were less related to ground shaking and more to other factors that would promote widespread destruction (Dewey et al., 1995).
- Quantitative measures are direct measures of ground shaking by seismic instruments. A widely used and preferred metric for the strength of ground shaking is Peak Ground Acceleration (PGA). PGA is calculated as the greatest increase in velocity recorded by a particular station during an earthquake (USGS, no date c), and typically given in units of g (the Earth's gravitational acceleration on its surface; 9.81 m/s2). It is an appropriate measure because the physical force exerted by the ground motions against any object on the surface is proportional to the peak acceleration. For engineering purposes, additional metrics such as spectral acceleration, which measures the forces experienced by structures at specified frequencies to which the structures may be particularly vulnerable. Generally, PGA values of <0.1 g are not expected to cause much damage, while values of between 0.2 g and 0.8 g may cause moderate damage; anything above this is expected to be very damaging (USGS, no date a). It is important to note that the amount of damage caused by ground motions of any given intensity in an area is highly dependent on the strength of infrastructure in that area. The greatest recorded ground motion to date was 4.3 g in the 2008 Iwate-Miyagi earthquake, Japan (Yamada et al., 2010).

Ground shaking can last from a few seconds in small, nearby earthquakes to several minutes in the largest earthquakes. HiQuake is a human induced earthquake database with more than 700 entries across the world for the period 1868 to 2016 (Foulger et al., 2018).

Key relevant UN convention/multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

On 21 October 2020 the HiQuake database had 1196 recorded events (HiQuake database, no date). These were linked to activities in the following percentages: fracking 33%; mining 25%; water reservoir impoundment 16%; conventional oil and gas 11%; geothermal 6%; waste fluid disposal 4%; nuclear explosion 2%; research 1%; unspecified oil and gas / waste fluid disposal 1%; groundwater extraction 0.6%; deep penetrating bomb 0.3%; construction 0.2%; carbon capture and storage 0.2%; coal bed methane 0.1%; and chemical explosions 0.1%.

Seismic risk from ground shaking is best managed through accurate estimation of the likelihood of seismic ground shaking at damaging levels, the implementation of and conformance to appropriate building codes, and governmental and popular awareness and preparation for earthquakes. Monitoring can be used as a tool to manage anthropogenic activities that cause micro-seismicity, such as rates of fluid or gas discharge into or abstraction from the ground (USGS, no date d).

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Coordinating agency or organisation

British Geological Survey.

GH0022 / **GEOHAZARD / Other Geohazard**

Liquefaction (Groundwater Trigger)

Definition

Liquefaction is the term applied to the loss of strength experienced in loosely packed, saturated or close to saturated sediments at or near the ground surface in response to strong ground shaking, such as earthquakes, cyclic loading, and vibration from machinery, or due to the development of excess pore pressure resulting from a change in head or confining pressures. The loss of strength causes the soil to behave like a viscous fluid, sometimes referred to as 'running sand', until the excess pore pressure returns to hydrostatic (USGS, no date).

References

USGS, no date. Science Explorer: Liquefaction. United States Geological Survey (USGS). www.usgs.gov/science-explorer-results?es=liquefaction Accessed 12 October 2020.

Annotations

Synonyms

Quick sand, Running sand, Boiling sand.

Additional scientific description

Soil propensity to liquefaction has been related to grading, uniformity of grain size and relative density or voids ratio. A uniformly graded soil is more susceptible to soil liquefaction than a well-graded soil because the resistance to volumetric strain of a well-graded soil decreases the amount of excess pore pressure that can develop under undrained conditions. Historically, sands were considered to be the only type of soil susceptible to liquefaction. Yet, liquefaction also occurs in gravel and silt (Seed et al., 2003). 'Running sand' or 'boiling sand' is a product of the liquefaction process that can also occur in peat.

Liquefaction susceptibility is also influenced by particle shape; soil deposits with rounded particles being more susceptible to liquefaction than soils with angular particles. Structureless anthropogenic soils, such as those placed during land reclamation are susceptible to liquefaction. During construction, liquefaction occurs when the groundwater conditions reduce the effective stress of the soil to zero. At this point, the seepage pressure can disturb the soil structure and mobilise the sediment as quick, running or boiling sand (BRANZ Seismic Resilience, no date).

Liquefaction, as a secondary hazard associated with earthquakes, can also manifest via surface ruptures and fissures, as seen in Christchurch, New Zealand in 2011 (Cubrinovski, 2013).

The liquefaction associated with the Christchurch earthquakes caused significant disruption to transport infrastructure, and to storm- and wastewater networks, and posed physical and mental health hazards for the exposed community and clean-up (Villemure et al., 2012). From a human health perspective, the liquefaction material posed several hazards. Due to the extensive damage to the sewage disposal networks from lateral spreading and differential settlement, there was a risk that much of the liquefaction ejecta had been contaminated with raw sewage creating a long-term health risk to the population. During hot and windy conditions, the dry finer portions of silt were mobilised by the wind creating a possible respiratory health hazard. Many volunteers were involved in the clean-up operations. Indeed, the much-celebrated Student-Army was successfully used to coordinate the work around the city (Villemure et al., 2012).

Metrics and numeric limits

Areas that are most prone to earthquakes tend to undertake earthquake hazard susceptibility mapping, which usually embraces zones that are prone to liquefaction (USGS, no date). These commonly include more recently deposited lithologies such as Alluvium or Quaternary deposits.

Key relevant UN convention/multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

The consequences to structures and infrastructure of liquefaction include: differential settlement of structures often resulting in cracking; loss of bearing support; flotation of buried structures such as sewer lines, tanks, and pipes; strong lateral forces against retaining structures such as seawalls; lateral spreading (limited lateral movement); and lateral flows (extensive lateral movement), particularly impacting on slopes or valley sides (e.g., Cubrinovski, 2013).

The primary mitigation measure is to use planning to avoid development over liquefiable soils. Other types of mitigation are incorporated in building design (NZGS and MB IE, 2017). During construction, controlling both the rate of excavation and the head, or increasing seepage flow paths to reduce seepage forces are the key methods used to minimise liquefaction (Pane et al., 2015).

Health impacts are associated with primary consequences of liquefaction material both when wet and when material is dry and dusty; as well as secondary impacts from damage to infrastructure such as water and sewage pipes and health care facilities (Cubrinovski, 2013).

References

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Coordinating agency or organisation

British Geological Survey.

GH0023 / **GEOHAZARD / Other Geohazard**

Ground Fissuring

Definition

Ground fissures form in response to tensional stresses, most commonly in unconsolidated sediment, but also in rock (Arizona Geological Survey, 2020).

Reference

Arizona Geological Survey, 2020. Earth Fissures and Ground Subsidence. https://azgs.arizona.edu/center-natural-hazards/earth-fissures-ground-subsidence#:~:text=Earth%20Fissures%20are%20open%20ground,sinking%20of%20the%20Earth's%20surface Accessed 20 October 2020.

Annotations

Synonyms

Ground deformation, Subsidence, Surface faulting.

Additional scientific description

Natural or anthropogenic ground desiccation associated with subsidence can lead to ground fissuring. Ground fissures may also form as incipient indicators of coastal land sliding, ground spreading or cambering, for example, induced by mining or karst subsidence.

Ayalew et al. (2004) suggested that ground fissures in the Ethiopian rift valley may be related to aseismic tectonic strain, piping and hydraulic compaction.

Surface fissures are also associated with earthquakes.

The size and spatial extent of surface rupture, fissures and uplift/subsidence depends on the type and context. In Arizona, fissures range from discontinuous hairline fractures to open ground cracks that exceed 3 km in length, are up to 7 m wide, and tens of metres deep. In this context, fissure depth is likely to reflect the depth to the groundwater (Arizona Geological Survey, 2020).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Ground fissures can cause loss of agricultural land, and damage to buildings, roads, canals and utility infrastructure (e.g., gas, oil and water lines). In addition to the immediate, local risk posed by collapsing infrastructure, this damage may hamper rescue and rebuilding efforts by impeding transportation and utility delivery. In the worst cases, damage to lifelines may cause local flooding (e.g., water lines), environmental impacts (e.g., contamination) and fires (gas lines) (Arizona Geological Survey, 2020).

The potential also exists for disruption due to flooding or re-routing of rivers if the river channel has been sufficiently modified (Holbrook and Schumm, 1999).

Livestock and wildlife injury or death have been reported as well as impacts on humans (Arizona Geological Survey, 2020).

Ground subsidence and resulting earth fissures affect more than 3000 square miles in Arizona, including expanding areas of Phoenix and Tucson (Arizona Geological Survey, 2020). The cost to the Arizona economy is not known, but probably reaches the millions of dollars annually. Repairs to an irrigation canal near Scottsdale Airpark in 2007 were estimated at USD 820,000, and that is just a single incident involving one canal. During construction of the Red Mountain Highway in Phoenix, the cost of mitigating an earth fissure that impinged on the road bed was USD 200,000 (Arizona Geological Survey, 2020).

Suggested remedial measures include reducing the dependence on groundwater by using alternative sources; planning to avoid fissures when constructing infrastructure or buildings; manage drainage to avoid losses into fissures and monitor water infrastructure for flow reversal (Arizona Geological Survey, 2020).

References

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Coordinating agency or organisation

British Geological Survey.

GH0024 / **GEOHAZARD / Other Geohazard**

Subsidence and Uplift Including Shoreline Change

Definition

Subsidence is a lowering or collapse of the ground (BGS, 2020). Uplift is the converse.

References

BGS, 2020. Subsidence and shrinking and swelling soils. British Geological Survey (BGS). www.bgs.ac.uk/geology-projects/shallow-geohazards/clay-shrink-swell Accessed 27 September 2020.

Annotations

Synonyms

Uplift, Subsidence, Ground deformation, Surface faulting, Coseismic subsidence.

Additional scientific description

Subsidence and uplift are caused by many factors, including the impacts of mining or tunnelling, consolidation, sinkholes, or of groundwater and moisture changes on expansive soils (BGS, 2020). Such near-surface, relatively shallow crustal, or human-generated processes, are often localised. Several crustal scale processes also drive subsidence and uplift that tend to be more regional in scale. Crustal movements occur in response to several different mechanisms, including tectonic, glacio-isostatic (Milne et al., 2006), erosional isostatic (denudation; Watts, 2001) and hydro-isostatic (Watts, 2001) processes. These operate over different timescales and different wavelengths. Crustal movements, climate change-driven sea-level rise and erosion-derived sedimentation can result in shoreline change. Tectonic uplift and subsidence are the distributed vertical permanent ground deformations (warping) that result from displacement on a dipping (inclined) fault (Styron, 2019). Earthquake surface ruptures and fissures are localised ground displacements that develop during and immediately after an earthquake, where the fault which hosted the earthquake intersects the Earth's surface. Surface ruptures represent the upward continuation of fault slip at depth, while fissures are smaller displacements, or more distributed deformation in and around the rupture area (PNSN, no date). Volcanic uplift and subsidence are deformations of the ground associated with volcanic unrest and eruptions (Dzurisin, 2007). Hydro-isostatic and erosional-isostatic deformation occur in response to the stress changes induced by changing ground water levels and load (erosion). Hydro-isostatic movements are largely anthropogenic or climatic and therefore commonly seasonal.

Ground-level rise is commonly associated with plate subduction zones, such as the Himalayas where the Eurasian and Indian plates converge (USGS, 2015). Uplift can also be driven by swelling, or mantle plumes, such as the Iceland Plume form in higher temperature regions of the Earth's mantle. Subsidence may be associated with plates moving apart, for example in rift valleys such as the Ethiopian rift valley. The relative motion of the crust on either side of faulting associated with earthquakes results in persistent or permanent deformation of the Earth's surface. Surface ruptures, fissures, and uplift and subsidence are all manifestations of this longer-term deformation, and although less dramatic, may all pose hazards during and after earthquakes. Lithospheric flexure also responds to extensional and compressional tectonic forces, including movement associated with the formation of rift valleys (commonly associated with plate boundaries) and mountain belts as well as strike slip faults and fault zones (Watts, 2001).

In the coastal environment, as well as the potential tectonic impacts, sediment and global sea-level rise impact on shore-line change. Sediment loading can exacerbate regional subsidence, thereby increasing the relative sea-level rise. In coastal areas where accelerated glacial wasting has been reported, glacio-isostatic rebound results in a relative rise in ground level, as exemplified in the wasting of the Laurentide Ice Sheet (Simon et al., 2016).

Local-to-regional scale subsidence and uplift resulting from changes in groundwater or porewater pressures occur in areas that are underlain by compressible and elastically deforming soils responding to groundwater withdrawal. Cohesive soils commonly exhibit seasonal changes in moisture content that can be associated with local subsidence (e.g., Simic et al., 2015).

Anthropogenic impacts on ground level, primarily result from dewatering for potable supply or for subsurface mining or engineering (Cigna et al., 2017).

Metrics and numeric limits

Rates of uplift in the Himalayas are reported to be in the order of 1 cm/yr (USGS, 2015). Global sea-level rise is in the order of 1.8 mm/yr, but relative sea-level rise varies considerably in accordance with other processes such as sedimentation or subsidence (USGS, no date a). High rates of uplift in Iceland (25–29 mm/yr) have been related to glacial isostatic adjustment with a feedback on plume evolution as a consequence of reduced pressure increasing magma production rates (Schmidt et al., 2013).

The size and spatial extent of surface rupture, fissures and uplift/subsidence associated with earthquakes depends on the type, magnitude and depth of the earthquake as well as the distance from the earthquake (Biasi et al., 2006; USGS, no date b).

Tectonic uplift and subsidence are generally as large or larger than the displacement of the surface rupture; moderate to large earthquakes in the crust that do not rupture to the surface will still broadly warp the region. The magnitude of the displacement will decrease with increasing distance from the earthquake, but in the case of ruptures on inclined faults such as subduction zones (rather than vertical strike-slip faults) uplift or subsidence of at least 1 m may extend for more than 200 km from the fault trace for the largest earthquakes (Styron, 2019). Both effects will extend along the length of the earthquake fault, a distance of a few kilometres for Magnitude 6 earthquakes to more than 1000 km for Magnitude 9 earthquakes.

Ground-level response to groundwater dewatering is a global issue (USGS, no date c). Values of up to 53 mm/yr have been determined using InSAR monitoring of Kabul (Meldebekova, 2020).

Key relevant UN convention/multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Surface ruptures and fissures can cause damage to buildings, roads, and utility infrastructure (e.g., gas and water lines). In addition to the immediate, local risk posed by collapsing infrastructure, this damage may hamper rescue and rebuilding efforts by impeding transportation and utility delivery. In the worst cases, damage to lifelines may cause local flooding (e.g., water lines), environmental impacts (e.g., oil pipelines) and even highly destructive fires (gas lines) that may be more damaging than the initial earthquake. Potential also exists for disruption due to flooding or re-routing of rivers if the river channel has been sufficiently modified (Holbrook and Schumm, 1999).

Shoreline change poses a threat to coastal settlements, businesses and tourism. There is also potential for impacts on coastal stability and groundwater resources, such as saline intrusion (USGS, no date d). Potential impacts are especially significant for atoll islands with shallow unsaturated zones. These islands are particularly susceptible to impacts on groundwater resources and populations (UNESCO, 2019).

While no technology exists for reducing these or other earthquake hazards, the risk to infrastructure posed by surface rupture and fissures can be mitigated to some degree by not building on known fault traces, seismic retrofitting of existing buildings, and engineering of pipelines with enough flexibility to absorb the displacement by bending and flexing, rather than breaking (e.g., USGS, 2003).

Coastal change can impact harbour water depth and damage infrastructure. In these zones, modelling to enable adaptive planning is the best form of mitigation (Steven et al., 2020).

In areas where stopping anthropogenic groundwater dewatering leads to rising ground levels, as well as potential impacts on infrastructure, consideration should be given to impacts on water quality, such as where mine water rebound results in the mixing of mining and potable water (Boak et al., 2007).

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Coordinating agency or organisation

British Geological Survey.

GH0025 / **GEOHAZARD / Other Geohazard**

Shrink-Swell Subsidence

Definition

Subsidence is a lowering or collapse of the ground, caused by various factors, including groundwater lowering, sub-surface mining or tunnelling, consolidation, sinkholes, or changes in moisture content in expansive soils. Shrink-swell is the term applied to the behaviour of expansive soils, which are a group of soils that exhibit volumetric change in response to changes in moisture content, such that they shrink in response to desiccation and swell by hydration, resulting in ground subsidence and ground heave respectively (BGS, 2020).

Reference

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Annotations

Synonyms

Problem soils, Expansive clay subsidence, Clay shrink-swell, Pipe clays (American term).

Additional scientific description

The properties of expansive soils are attributable to the presence of swelling clay minerals. These clays range in their potential to absorb water according to their different structures. Expansive clay groups with increasing susceptibility to swelling include kandites (e.g., kaolinite, haloysite), illites (e.g., phengite, glauconite), vermiculites and smectites (e.g., montmorillonite, talc). These minerals are a product of weathering, commonly formed on land and then transported to the oceans. Their distribution reflects the underlying source rock geology, its diagenesis and stress history (e.g., stress-induced smectite to illite transformations) and the nature of the weathering, for example, wet climates are associated with kaolinite rich soils and dry environments are characterised by smectite clays (Eberl, 1984).

Metrics and numeric limits

For the most expansive clays, expansions of 10% are common (Nelson and Miller, 1992). In the field, expansive clay soils are recognisable in the dry season by the deep cracks that form in roughly polygonal patterns. The zone of seasonal moisture content fluctuation can extend from one to tens of metres in depth. This creates cyclic shrink/swell behaviour in the upper part of the soil column, and cracks can extend to considerable depths.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Beneath the depth of influence of atmospheric change in moisture content, the water demand of vegetation, particularly trees on clay soils dominates the moisture content changes that lead to the soils shrinking (subsidence) and swelling (heave). Where subsidence and heave occur beneath or close to properties and infrastructure this can result in damage (Florida Department of Environmental Protection, 2020). The most obvious way in which expansive soils can damage foundations is by uplift as they swell with moisture increases. Swelling soils lift up and crack lightly-loaded, continuous strip footings, and frequently cause distress in floor slabs. Uplift is commonly differential, reflecting the different resisting forces across the structural foundations.

The extensive distribution of these soils across the world has necessitated characterisation through index testing to inform remedial measures. At its simplest, the plasticity indices are utilised to define inorganic clays with inherent swelling capacity (e.g., BRE, 1993). Expansion of soils can also be measured in the laboratory directly, by immersing a remolded soil sample and measuring its volume change or using LiDAR techniques (Hobbs et al., 2014).

The best way to avoid damage from expansive soils is to extend building foundations beneath the zone of water content fluctuation as modified to reflect the presence of vegetation (Rogers et al., no date).

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Coordinating agency or organisation

British Geological Society.

Sinkhole

Definition

A sinkhole is a closed depression in karst (a landscape resulting from the dissolution of soluble rock) by current or palaeo internal drainage, also known as a doline. This is one of several hazards that result in subsidence, i.e., lowering or collapse of the ground (adapted from USGS, no date; and BGS, no date).

References

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Annotations

Synonyms

Doline cenote, Sink, Sink-hole, Swallet, Swallow.

Additional scientific description

Dolines (sinkholes) are part of the hydrological system that shapes karst landscapes and can be considered in terms of fluid recharge, through-flow and discharge (e.g., springs and discharge points). Their rates of formation reflect the lithological and hydrological conditions (head and discharge). For example, of the soluble rocks and given a comparable hydrogeological setting, the rate of dissolution of salt > gypsum > Mesozoic limestone > Palaeozoic limestone (Waltham et al., 2004). There is an increasing awareness that dissolution may result from both meteoric recharge and groundwater or hypogene fluid flow (water or other fluids and gases) (Dublyansky, 2014).

Groundwater chemistry is also important in influencing the rate and distribution of sinkholes. For example, while limestone is only very weakly soluble in water of neutral pH, its solubility increases in acidic conditions, such as due to the input of carbon dioxide from biological transpiration or due to the oxidation of pyrite. Commonly, the mixing of water from different flow paths results in increased dissolution potential.

Sinkholes are classified in accordance with the mode of formation, including but not limited to the following (e.g., Waltham et al., 2004): a dissolution sinkhole is formed by dissolutional lowering of the exposed soluble rock surface in and around zones of water recharge to soluble rock; a subsidence sinkhole results from recharge water mobilisation of sediment into underlying cavernous rock; a suffosion sinkhole is formed due to recharge water mobilisation of sediment through unconsolidated sediment cover over karst; a collapse sinkhole results from the collapse of insoluble capping rock into underlying cavernous rock; a buried sinkhole is sediment filled; while a drop out sinkhole is formed rapidly due to soil cover collapse.

The triggering of sinkholes can also be the result of either surface or subsurface changes in load or groundwater conditions.

Other types of karst hollow (EPA, 2002) with internal drainage include karst geomorphological features referred to as uvala (a closed depression with multiple recharge points), polje (a closed depression with a wide flat-floored and long axis developed parallel to major structural trends), and cockpit (a star-shaped depression with a concave floor and surrounded by steep convex hill slopes).

The manifestation of collapse subsidence associated with mining can be comparable to that of sinkholes. Sinkholes can also occur in specific non-soluble rock settings such as lava tubes or pseudokarst.

Although a natural process, the formation of sinkholes is often accelerated or triggered by human action.

Many new sinkholes have been correlated to land-use practices, especially from groundwater pumping and construction and development practices. Sinkholes can also form when natural water-drainage patterns are changed, and new water-diversion systems are developed. Some sinkholes form when the land surface is changed, such as when industrial and runoff-storage ponds are created. The substantial weight of the new material can trigger an underground collapse of supporting material, causing a sinkhole (USGS, no date).

The overburden sediments that cover buried cavities in some aquifer systems are delicately balanced by groundwater fluid pressure, whereby the water below ground is actually helping to keep the surface soil in place. Groundwater pumping for urban water supply and for irrigation can produce new sinkholes in sinkhole-prone areas. If pumping results in a lowering of groundwater levels, then underground structural failure, and thus, sinkholes, can occur (USGS, no date).

Broken land drains, water mains and sewerage pipes, increased rainfall, storm events, modified drainage and diverted surface water can all help wash sediment into the underlying limestone, causing subsidence. There have been many well documented occurrences of sinkholes forming beneath broken water mains, unlined storm-water culverts and leaking swimming pools (BGS, 2017).

Metrics and numeric limits

The size and density of sinkholes reflects the distribution of recharge or flow paths, for example, surface karst with numerous small recharge points (diffuse flow) over heavily fractured, more permeable rock, or fewer large recharge points in lower permeability strata. Similarly, where groundwater flow dominates, sinkhole formation processes are focused on structural and lithological boundaries. The size of sinkholes ranges from a few centimetres to hundreds of metres in diameter, and depths of decametres to a hundred metres or more.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

The surface expression of sinkholes can be triggered by rainfall, changing groundwater levels (natural and anthropogenic), inundation (e.g., flooding or pipe leakage), loading (e.g., flooding or construction), erosion, and weathering and ground vibration. Sinkholes may also be triggered by sub-surface activity such as mining or tunnelling. In many landscapes, sinkholes form imperceptibly slowly (USGS, no date; BGS, 2017).

However, if collapse subsidence occurs, they can express themselves rapidly. This is particularly significant in urban landscapes where the surface rupture can damage buildings and infrastructure, occasionally associated with loss of life (Waltham et al., 2004).

The best form of control is avoidance through planning: various remote sensing, geophysical and intrusive ground investigation techniques can be applied to locating sinkholes to enable the design of construction methods, for example, transferring load to more competent strata with piles, or the incorporation of span distances for rafts or geotextiles (Waltham et al., 2004).

Some construction techniques focus on void filling, for example, types of grouting are used to prevent or remediate sinkholes (Waltham et al., 2004).

Any remediation solution should fully consider the hydrological and hydrogeological context.

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Coordinating agency or organisation

British Geological Survey.

GH0027 / **GEOHAZARD / Other Geohazard**

Ground Gases (CH4, Rn, etc.)

Definition

Ground gases that result from material decay (natural or anthropogenic) typically include radon, methane, carbon dioxide, hydrogen sulphide, but may also include the break down products of other compounds, such as nitrogen, alcohols, alkanes, cycloalkanes and alkenes, aromatic hydrocarbons (monocyclic or polycyclic); esters and ethers, as well as halogenated compounds and organosulphur. Ground gases derived from magma (molten or semi-molten natural material derived from the melting of land or oceanic crust) include carbon dioxide, sulphur dioxide, hydrogen sulphide and hydrogen halides. Ground gases are gases released in combination with water vapour and particulate matter during volcanogenic events, or via fumaroles, and hydrothermal systems (adapted from NHBC (UK), 2007; IVHHN, 2020; US EPA, no date; and USGS, no date).

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Annotations

Synonyms

Volcanic gases, Magmatic gases, Landfill gas, Gas-contaminated land.

Additional scientific description

Volcanogenic gases escape from magma as a consequence of the pressure relief that occurs as the magma rises to the surface. These gases are also released via geothermal systems.

Chemical or biological processes generate ground gases, for example, the breakdown of uranium-bearing minerals releasing radon from granite or by oxidation and or biogenic reduction (releasing hydrogen sulphide). In addition, naturally occurring ground gases are generated by the biogenic decay of organic matter, for example methane, carbon dioxide and phosphine gas.

Landfill gas is a product of the largely biogenic decomposition of anthropogenic waste. Its composition reflects that of the waste, but is dominated by methane and carbon dioxide, becoming more carbon dioxide rich as the waste ages, and with a small amount of non-methane organic compounds. Methane is a potent greenhouse gas (US EPA, no date).

Ground gases comprise a hazard because of the risk to human health and or their flammability. As an example, the UK limits for the following gases are summarised below from sources other than earthquake triggered gases:

- Methane is a colourless, odourless flammable gas. When the concentration of methane in air (oxygen 20.9% by volume [% v/v]) is between the limits of 5% v/v and 15% v/v, an explosive mixture is formed. The Lower Explosive Limit (LEL) of methane is 5% v/v, which is equivalent to 100% LEL. The 15% v/v limit is known as the Upper Explosive Limit (UEL), but concentrations above this level cannot be assumed to represent safe concentrations, because of the potential for dilution to the UEL (NHBC, 2007).
- Carbon dioxide is a colourless, odourless gas, which, although non-flammable, is both a toxic gas and an asphyxiant. As carbon dioxide is denser than air, it will collect in low points and depressions, which can be an extreme hazard during foundation construction and earth movements on development sites. The Long-Term Exposure Limit (LTEL, 8-hour period) and the Short-Term Exposure Limit (STEL, 15-minute period), are 0.5% v/v and 1.5% v/v carbon dioxide, respectively (HSE, no date).
- Radon is a colourless, odourless radioactive gas derived from the radioactive decay of radium, itself from radioactive decay of uranium. The UK target level for homes is 100 Bq m3 (PHE, no date).
- Levels of hydrogen sulphide of 100 ppm and higher are considered immediately dangerous to life and health (NHBC, 2007).

Another source of ground gas associated with continental margins is methane hydrates (Geology.com, 2005-2020). Similarly, ground gases and vapours are emitted from volcanogenic sources.

Metrics and numeric limits

No globally agreed limits for ground gases (earthquake trigger).

Key relevant UN convention/multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Ground gases are a hazard in terms of risk to human health, flammability and climate change (greenhouse gases). For these reasons, where possible, ground gas is monitored and controlled. Where buildings may come into contact with ground gases, specialist construction techniques are deployed to protect human health (e.g., NHBC, 2007). In the case of earthquake-triggered gases, consideration should also be given to the associated particulate matter.

Landfill gas management has been a focal point for national scale reductions in carbon dioxide emissions. For example, in 2018 waste management-related carbon dioxide formed 4.6% of UK carbon dioxide emissions (BEIS, 2020).

Ground gases occur in mining environments, for example in mining for coal (carbon dioxide, methane), potash (methane, nitrogen) and shale gas (BGS, no date). In the UK, in these environments, control measures are guided by the Health and Safety Executive.

References

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Coordinating agency or organisation

British Geological Survey.

GH0028 / **GEOHAZARD / Other Geohazard**

Riverbank Erosion

Definition

Riverbank erosion is the removal of material from the banks of rivers when flowing water forces exceed bank resisting forces by the soil and vegetation, for example, when river levels are sufficiently high, primarily due to fluvial energy and atmospheric processes and secondarily because of the resultant geotechnical instability and consequential riverbank failure. Riverbank failure can also occur as a consequence of Earth hazards, such as volcanos and earthquakes (USDA, no date).

Reference

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Annotations

Synonyms

Stream bank deterioration, Stream bank disintegration.

Additional scientific description

Riverbank erosion primarily comprises corrasion (abrasion) and mass wasting. River energy, the primary driver for erosion, differs between, along and seasonally within river systems. The speed at which failed sediment masses are mobilised as fluvial sediment load affects the rate of exposure of the riverbank to further erosion. Consequently, riverbank erosion is a discontinuous process, strongly associated with higher energy events such as flooding (Das et al., 2014).

Background weathering that facilitates erosion includes processes that are subject to seasonality, and include flooding, precipitation, crack formation, cryogenic processes, poaching and anthropogenic changes to the natural geomorphology (Darby et al., 2007).

Bhuiyan et al. (2017) reported that the rivers of Bangladesh are responsible for cumulative annual erosion of up to 10,000 hectares of land. They pointed out that as well as floodplains and settlements, Bangladesh also loses several kilometres of roads, railways, and flood control embankments each year. They stated that no other issues are as disastrous as riverbank erosion with regard to long-term effects on people and society in Bangladesh (Bhuiyan et al., 2017).

Metrics and numeric limits

Riverbank erosion results in significant land loss. Hooke (1980) presented the results from published data that demonstrate a relationship between erosion rates (m/yr) and catchment area (km2), with annual erosion rates ranging from 0.5 m to 1000 m for drainage areas of 4 to 1000,000 km2 respectively.

Key relevant UN convention/multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

While riverbank erosion is accelerated by flood events, because of both the hydraulic conditions and the sediment load that increases the erosional power of a given stream; antecedent conditions contribute to conditioning of the riverbank (Darby et al., 2007). In addition to the loss of land and infrastructure, the consequences of stream erosion and riverbank mass wasting are increased suspended sediment loads in streams, which impacts on water quality with consequential implications for human and ecological health (Grove et al., 2015).

Stream erosion is also associated with river scour, whereby bed sediment is eroded and may be redistributed. River scour is commonly focused on changes in bedform, which may be natural or artificial. For example, the impacts of scour on bridge foundations and other engineered infrastructure are well documented (Ozaukee County, no date).

Riverbank vegetation, for example mangroves, contributes to riverbank resilience to erosion, as do alluvial sediments. Mitigation of the impacts of bank erosion include planning and avoidance, and soft and engineered protection or renaturing. Some examples are presented by the Scottish Environment Protection Agency (SEPA, 2020).

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Coordinating agency or organisation

British Geological Survey.

GH0029 / **GEOHAZARD / Other Geohazard**

Sand Encroachment

Definition

Sand encroachment occurs generally in arid to semi-arid regions when grains of sand are carried by winds and form sandy accumulation on coasts, along water courses and on cultivated or uncultivated land. As the accumulations of sand (dunes) move, they bury towns, roads, oases, crops, market gardens, irrigation channels and dams, thus causing major material and socioeconomic damage (FAO, 2010).

Reference

FAO, 2010. Fighting sand encroachment. Lessons from Mauritania. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/3/a-i1488e.pdf Accessed 26 November 2019.

Annotations

Synonyms

Not applicable.

Additional scientific description

Different factors and processes foster the formation and movement of sand masses, such as violent wind blowing over large areas, sparse or stunted vegetation, and degraded soil that is mobile, dry or bare (Khalaf and Al-ajmi, 1993; FAO, 2010).

Sand particles in movement are the site of various interactions, the main ones being:

- Avalanche effect - the avalanche effect is the result of saltation. As the grains of sand fall back, they cause the displacement of a larger quantity of particles, so that the more intense the saltation process caused by the wind, the greater the number of particles set in motion, until a maximum or saturation point is reached, where the quantity lost is equal to the quantity gained at any given moment. The distance needed to reach the saturation point depends on the sensitivity of a soil to erosion: on a very fragile soil, it can occur over a distance of about 50 m, but requires more than 1000 m on a very cohesive soil (FAO, 2010).
- Sorting - the sorting mechanism concerns the wind's displacement of the finest and lightest particles, leaving behind the larger particles. This process gradually impoverishes the soil, since the organic matter made up of small light elements is the first to be removed (FAO, 2010).
- Corrosion - corrosion is the mechanical attack on the surface as the sand-laden wind blows over it. In arid regions, it is the aggravating cause of soil erosion and is seen in parallel streaks or the polishing of rocks (FAO, 2010).

When the wind grows lighter, it loses its capacity to carry sand particles, which are then dropped (FAO, 2010).

Forms of sandy accumulation vary widely, depending on landform, the nature of the soil on which they encroach, the presence or lack of vegetation, and the size of the grains of sand (Hamdan et al., 2016).

Metrics and numeric limits

The scale of the event varies depending on the wind speed, which is an essential factor, for it determines the force of sand removal; the greater the speed, the greater the carrying capacity. The second factor is the size and density of sand particles. Sandy encroachments can vary from 50 cm in height, 150 cm in length and 40 cm in breadth, to 20 to 40 km long and 50 to 200 m wide (Al-Helal and Al-Awadhi, 2006). Sand encroachment reporting should indicate the accumulation location, scale, sand sources, and transport zones.

Key relevant UN convention / multilateral treaty

Not applicable.

Examples of drivers, outcomes and risk management

All types of sand encroachment, no matter the size or duration, can create hazardous conditions affecting especially soil, vegetation, villages, roads (Boulghobra et al., 2015), railways and irrigation channels:

- The wind first carries off the finer parts of the soil, thus weakening the soil structure. As the soil becomes sandier, it is more vulnerable to the wind and has a reduced water retention capacity. Its colour turns from grey to white and then to red as it is scoured. The terrain is gradually broken up by the creation of small mounds surrounding the woody and grassy vegetation as this degrades. The land gradually becomes unsuitable for cultivation (FAO, 2010).
- The wind has both mechanical and physiological effects on vegetation:
  - Mechanical effects. The soil particles that are carried off collide with stalks and leaves with a force that abrades their tissue. In the zones from which the particles are carried off, roots are uncovered, and the vegetation risks being uprooted, while in zones where the particles are deposited the vegetation is steadily buried (FAO, 2010).
  - Physiological effects. The wind increases evaporation and dries out plants, mainly in the Kuwait dry season. The air's evaporating power is proportional to the square root of the wind speed. Moreover, the soil's water retention capacity is reduced, leading to water stress. The surrounding or moving mass of dry air tends to absorb humidity and exacerbate water deficit and this deficit is the main factor determining local vegetation, inasmuch as the latter has to adapt to the severe shortage of water (Khalaf and Al-ajmi, 1993).

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Coordinating agency or organisation

Food and Agriculture Organization of the United Nations.

GH0030 / **GEOHAZARD / Other Geohazard**

Aquifer Recharge (Systems Failure/ Outages)

Definition

An aquifer is a water-bearing rock that readily transmits water to wells and springs. It can be recharged either naturally (precipitation including rainfall or snow) or artificially (e.g., pumped river recharge via wells). Failure or outage can be due to derogation, well failure or contamination (USGS, no date).

Reference

USGS, no date. Aquifers and Groundwater. United States Geological Survey (USGS). www.usgs.gov/special-topic/water-science-school/science/aquifers-and-groundwater?qt-science_center_objects=0#qt-science_center_objects Accessed 20 October 2020.

Annotations

Synonyms

Groundwater recharge.

Additional scientific description

Groundwater is a finite but renewable resource. The amount of available groundwater is limited by the porosity and permeability of the aquifer, but it can be renewed by meteoric water or artificial recharge. Aquifers may be unconfined or confined. While the water table in an unconfined aquifer will be in hydraulic continuity with adjacent water courses, a confined aquifer may be isolated from adjacent watercourses by a capping of lower permeability strata. Consequently, meteoric recharge to unconfined aquifers is more direct and generally, depending on the thickness of the unsaturated zone, more rapid than to confined aquifers. Groundwater abstraction via water wells causes a reduction in the water table that is referred to as a cone of depression. Cones of depression are rarely truly cone shaped; the shape being influenced by aquifer permeability, which is rarely isotropic. If groundwater abstraction exceeds recharge, over-abstraction will result in aquifer depletion and potentially outages of supply. Outages can also result from damage to the abstraction well. This could be due to physical damage, for example, pipe fracture or physical blocking by a trapped object, such as a jammed pump. Alternatively, it might occur because of clogging of the permeable part of the well, most likely due to a form of geochemical precipitation. Derogation of supply can also be caused by abstraction from neighbouring parts of an aquifer, either for potable supply or dewatering for mineral extraction or construction. Physical changes to an aquifer and its permeability can be brought about by earthquake activity. More commonly, groundwater infrastructure may be prone to rupture or damage by ground shaking induced by earthquake or volcanic activity (US EPA, 2020).

Groundwater contamination can result from surface or sub-surface contaminants resulting from poor waste management, industry, mining and agriculture. Aquifer vulnerability to contamination reflects the extent of lower permeability materials that cover/ protect the aquifer. Potential contaminants include a very wide range of natural (volcanic) or anthropogenic chemical contaminants, as well as biological contaminants, such as Cryptosporidium (a microscopic parasite; Morris and Foster, 2000) and saline intrusion (USGS, no date).

Metrics and numeric limits

There is no internationally recognised definition of a groundwater aquifer or methods for assessing failure. An example of a metric is the Groundwater Directive 2006/118/EC to meet Article 17 of the European Water Framework (2000) (European Commission Environment, 2020). This states that, the definition of a groundwater body is its capacity to supply 10 m3 of water per day as an average or 50 persons or to support the ecological quality of a surface water body or groundwater dependent terrestrial ecosystem (UKTAG, 2011). Giordano (2009) reported that global groundwater extraction is in excess of 650 km3 per year, with India, the United States, China, Pakistan, Iran, Mexico, and Saudi Arabia collectively accounting for 75% of this total amount.

Key relevant UN convention/multilateral treaty

While there is no multilateral treaty, there are in the order of 200 transboundary aquifers and more than 3600 agreements and treaties pertaining to transboundary water (UNDESA, 2014).

Examples of drivers, outcomes and risk management

According to Fienen and Arshad (2016) issues include seawater intrusion and groundwater depletion.

- Seawater intrusion has particularly affected groundwater quality in major coastal irrigation regions such as Queensland in Australia, Florida in the United States, the southern Atlantic coastline of Spain, and Lebanon.
- Groundwater depletion has been particularly experienced in southern and central parts of Asia, northern China, the Middle East and North Africa, North America, parts of Australia, and many localised areas in southern Europe.

Groundwater protection requires effective planning and monitoring for resource management with regular reviews and provision for additional resources to meet increasing demand to meet growing demands in the context of population growth, urbanisation and climate change (Bricker et al., 2017). Planning is more effective when supported by groundwater resource mapping (e.g., MacDonald et al., 2012). For zones that are prone to earthquakes, effective planning is required to avoid zones of high susceptibility, or mitigation through engineering, construction material selection and possibly ground improvement (US EPA, 2018).

Some countries, such as the UK define source protection zones that show the risk of contamination from any activities that might cause pollution in the area (Environment Agency, 2018).

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Coordinating agency or organisation

British Geological Survey.

GH0031 / **GEOHAZARD / Other Geohazard**

Submarine Landslide

Definition

A submarine landslide is a downslope movement of sediment or rock under the effect of gravity, which occurs when the stresses acting downslope exceed the available strength of the sediment on the slope (Lee et al., 2007).

Reference

Lee, H.J., J. Locat, P. Desgagnés, J,.D. Parsons, B.G. McAdoo, D.L. Orange, P. Puig, F. Wong, P. Dartnell and E. Boulanger, 2007. Submarine mass movements on continental margins. In: Continental Margin Sedimentation. pp. 213-274. Wiley.

Annotations

Synonyms

Mass movement, Slump, Mudflow, Debris flow, Liquefaction flow, Turbidity current.

Additional scientific description

Submarine landslides occur preferentially in particular environments, including fjords, active river deltas, submarine canyons, volcanic islands and the open continental slope. Evaluating the relative stability of different types of seabed sediment requires an understanding of driving stresses and sediment strength. Stresses can be caused by gravity, earthquakes and storm waves. Resisting strength can be reduced by pore water and gas pressures, groundwater seepage, rapid sediment deposition, cyclic loading and human activity. Once slopes have become unstable or have failed, sediment strength may continue to decrease so, following slope failure, the failed mass moves downslope under the influence of gravity and possibly other forces. If the moving sediment is a viscous fluid, this is termed a mass flow (gravity flow). If the movements are essentially rigid, internally undeformed masses along discrete slip planes, they are termed slides. If the movement is formed of 'blocks' of failed material which rotate along curved slip, they are termed slumps. Another kind of landslide involves movement on a planar surface and is termed a translational slide. In each type, movement can be fast or slow. Extremely slow movement is called creep. Submarine slides can become mass flows (gravity flows) as the failed mass progressively disintegrates and continuous downslope movement occurs. End members of disintegrating slides have different terms. Debris flows are where the sediment is heterogeneous and may include larger clasts supported by a matrix of fine sediment. Mud flows are predominantly muddy sediment. Turbidity currents involve the downslope transport of a relatively dilute suspension of sediment grains that are supported by an upward component of fluid turbulence. Recent submarine landslide research has: (i) shown that landslides and sediment waves may generate similar deposits, which require careful interpretation; (ii) expanded knowledge of how strength develops in marine sediment; (iii) improved techniques for predicting sediment rheology; and (iv) developed methodologies for mapping and predicting the medium- to large-scale regional occurrence of submarine landslides. Based on the identification of the different submarine sediment failures identified above and the classification of subaerial landslides (Varnes, 1958; Hungr, 2014), submarine landslides may be classified as mass sediment movements termed slides (translational and rotational slumps) and mass flows (mudflow, debris flow, liquefaction and turbidity current).

Almost all submarine landslides have multiple causes, which differ significantly to their subaerial counterparts, for example, seabed slope is not that important as shown by the largest volume submarine landslides being located on the shallowest slopes. Submarine landslides are triggered either by an increase in the driving stresses, a decrease in sediment strength, or a combination of the two. The following triggers show the interplay of these factors, but their relative importance is not well understood. For example, in some environments one of these triggers will dominate, whereas in others a different trigger will be most significant. The main triggers identified for submarine landslides are erosion (undercutting the landslide foot), a rapid rate of sedimentation and earthquakes. Erosion is common in deep-sea channels, submarine canyons and other active sediment-transport systems. When seabed surfaces are undercut, this can decrease the stability by increasing shear stress and/or decreasing the shear strength. With underwater earthquakes, the earthquake-induced shear stresses are large relative to sediment shear strength because the earthquake must accelerate all the sediment column including the interstitial water. The sediment shear strength is relatively low because it builds up in proportion to the submerged unit weight of the sediment and may be even lower if there are excess pore pressures. The ratio of driving stress to resisting strength is high relative to that on land. Rapid sediment accumulation contributes to failure in several ways. Because most of the weight of newly added sediment is carried by pore-water pressures. The shear stress acting downslope increases more rapidly. The shear stress may also increase because more sediment may be deposited at the head of the sloping surface than at the toe. In addition, the following may result in failure: retarded sediment shear strength development, increased development of shear stress because of thickness of the sediment body, and increased development of shear stress because of increases in the slope steepness.

Metrics and numeric limits

Landslide sediment movement has been measured in two events from breakage of submarine telephone cables. These indicate velocities of up to 28 m/s or 101 km/h (Grand Banks, 1929) and 5 to 16 m/s (18–57 km/h) in the Strait of Luzon between Taiwan and the Philippines between 2006 and 2015.

Key relevant UN convention/multilateral treaty

Not found

Examples of drivers, outcomes and risk management

In coastal and offshore regions, submarine landslide impacts threaten submarine installations such as oil platforms, pipelines, cables, and wind installation. Mass submarine sediment failures are also one of the most important sources of sedimentation from shallow to deep-water environments and of shaping continental margins (McAdoo et al., 2000). Hence, a better understanding of submarine landslides is of great importance in the development of offshore resources exploration and protection, sustainable flood risk management, hazard assessments for engineering and environmental projects, and also in hydrocarbon reservoir managements (McAdoo and Watts, 2004; Masson et al., 2006).

Key relevant UN convention / multilateral treaty

Not applicable.

Examples of drivers, outcomes and risk management

Development of ideas and understanding of submarine landslides has been based mainly on their role in generating tsunamis, with one example in 1969 where an oil platform in the Gulf of Mexico collapsed when the soft seabed was destabilised during a hurricane. The most important historical event with significant loss of life was in 1998 in Papua New Guinea when a slump generated tsunami killed over 2200 people on the nearby coast. Other important events include the 1929 Grand Banks landslide tsunami in which 27 people died, and in 1964 during the Great Alaska earthquake, when submarine landslides in Resurrection Bay and Port Valdez caused tsunamis that killed 45 people. An additional risk from submarine landslides are submarine telegraph and fibre optic cables. As noted, in 1929 trans-Atlantic telegraph cables off Newfoundland were broken by the Grand Banks landslide, and between 2006 and 2015 submarine telecommunication cables in the Strait of Luzon were broken by turbidite currents.

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Coordinating agency or organisation

British Geological Survey.

GH0032 / **GEOHAZARD / Other Geohazard**

Rockfall

Definition

Rockfall is a fragment of rock (a block) detached by sliding, toppling, or falling, that falls along a vertical or sub-vertical cliff, and proceeds down slope by bouncing and flying along ballistic trajectories or by rolling on talus or debris slopes (Highland and Bobrowsky, 2008).

Reference

Highland, L.M. and P. Bobrowsky, 2008. The Landslide Handbook – A guide to understanding landslides. U.S. Geological Survey Circular 1325.

Annotations

Synonyms

Rock fall (Varnes, 1978), Rock free fall, Block fall, Boulder fall.

Additional scientific description

Falls are abrupt, downward movements of rock or earth, or both, that detach from steep slopes or cliffs. The falling material usually strikes the lower slope at angles less than the angle of fall, causing bouncing. The falling mass may break on impact, may begin rolling on steeper slopes, and may continue until the terrain flattens (Sassa et al., 2018).

Metrics and numeric limits

Very rapid to extremely rapid, free-fall; bouncing and rolling of detached soil, rock, and boulders. The rolling velocity depends on slope steepness (Hungr et al., 2014).

Key relevant UN convention / multilateral treaty

Not applicable.

Examples of drivers, outcomes and risk management

Drivers for rockfall include undercutting of slopes by natural processes such as streams and rivers or differential weathering (such as the freeze/thaw cycles), human activities such as excavation during road building and (or) maintenance. Volcanic activities and earthquake shaking or other intense vibration are also drivers for rockfall (Hungr et al., 2014).

Falling material can be life-threatening. Falls can damage property beneath the fall-line of large rocks. Boulders can bounce or roll great distances and damage structures or kill people. Damage to roads and railroads is particularly high: rockfalls can cause deaths in vehicles hit by rocks and can block highways and railroads (Highland and Bobrowsky, 2008).

Mitigation measures for rockfall include rock curtains or other slope covers, protective covers over roadways, retaining walls to prevent rolling or bouncing, explosive blasting of hazardous target areas to remove the source (scaling), removal of rocks or other materials from highways and railroads can be used to minimise risk (Sassa et al., 2018).

Rock bolts or other similar types of anchoring used to stabilise cliffs, as well as scaling, can lessen the hazard. Warning signs are recommended in hazardous areas for awareness. Stopping or parking under hazardous cliffs should be warned against (Highland and Bobrowsky, 2008).

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Coordinating agency or organisation

British Geological Survey.

Landscape Creep

Definition

Landscape creep is the imperceptibly slow, steady, downward movement of slope-forming soil or rock. Movement is caused by shear stress, sufficient to produce permanent deformation, but too small to produce shear failure (adapted from Hutchinson, 1968; and Varnes, 1978).

References

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Annotations

Synonyms

Soil creep, Solifluction.

Additional scientific description

Extremely slow movement of surficial soil layers on a slope (typically less than 1 m deep), commonly as a result of climate-driven cyclical volume changes (wetting and drying, frost heave). There are generally three types of creep: seasonal creep, where movement is within the depth of soil affected by seasonal changes in soil moisture and soil temperature; continuous creep, where shear stress continuously exceeds the strength of the material; and progressive creep, associated with slopes that are reaching the point of failure due to other types of mass movement. Creep is indicated by curved tree trunks, bent fences or retaining walls, tilted poles or fences, and small soil ripples or ridges (HIghland and Bobrowsky, 2008).

Metrics and numeric limits

Creep can be regional in nature (tens of square kilometres) or confined to small areas. The rates of movement are extremely slow, usually less than 0.5 m per decade (0.5 to 15 mm/yr) (Saunders and Young, 1983).

Key relevant UN convention / multilateral treaty

Not relevant.

Examples of drivers, outcomes and risk management

Rainfall and snowmelt are typical triggers for landscape creep, whereas for other types of creep there could be numerous causes, such as chemical or physical weathering, leaking pipes, poor drainage, destabilising types of construction (Highland and Bobrowsky, 2008).

Because it is hard to detect in some places owing to the slowness of movement, creep is sometimes not recognised when assessing the suitability of a building site. Creep can slowly pull apart pipelines, buildings, highways, and fences, and can lead to more significant ground failures that are potentially more destructive and faster moving than those resulting from creep alone. The most common mitigation for creep is to ensure proper drainage of water, especially for seasonal creep. Slope modification such as flattening or removing all or part of the landslide mass, can be attempted, as well as the construction of retaining walls (Highland and Bobrowsky, 2008).

References

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Coordinating agency or organisation:

British Geological Survey.

GH0034 / **GEOHAZARD / Other Geohazard**

Sediment Rock Avalanche

Definition

Rock avalanches are a translational form of mass movement where the transported material is dry rock that is fragmented before or during slope failure. They are rapid with long runouts and large volumes and often involve the entrainment of slope material, commonly therefore, giving rise to debris slides or flows. The motion of rock avalanches is massive such that the bulk of the rock fragments move together as a largely coherent mass (adapted from Collins, 2014 and USGS, no date).

References

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Annotations

Synonyms

Rock fall-debris avalanche.

Additional scientific description

Volcanos and earthquakes are commons triggers for rock avalanches. They can occur in all rock types but are associated with rock that is more competent. Large rock avalanches are hypermobile and exhibit more movement than predicted from frictional models incorporating air entrainment, pore pressures or fine bed layers (Hungr et al., 2001, 2014).

Metrics and numeric limits

Rock avalanches pose some of the most dangerous and expensive geological hazards in mountainous terrain. Typical of these was the Frank Landslide, which occurred on 29 April 1903, and involved 110 million tonnes of limestone released from the summit of Turtle Mountain, Alberta. The rock mass that fell was 150 m deep, 425 m high and 1 km wide (Frank Slide Interpretive Centre, no date).

Key relevant UN convention/multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

A database of 20th-century worldwide catastrophic landslides (USGS, no date) includes six rock slide-debris avalanche events, including one volcano-triggered landslide (St Helens) and three earthquake triggered landslides. The earthquake triggered events resulted in river dams with loss of entire villages Bairaman, Papua, New Guinea in 1986 and Tadzhik Republic: Usoy, 1911 and Khait, 1949.

The Frank Landslide occurred at night. It was triggered by unusual weather conditions influenced also by subsurface mining. The rockslide buried part of the town of Frank with most of the 110 people in its path losing their lives (Frank Slide Interpretive Centre, no date).

As with other types of landslide, rock avalanche can cascade to form river dams with the potential for subsequent release and flooding. Climate change impacts on permafrost have been associated with increasing incidence of rock slide initiation triggered by melting ice or thawing permafrost (USGS, 2018).

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Coordinating agency or organisation

British Geological Survey.

GH0035 / **GEOHAZARD / Other Geohazard**

Tsunami (Submarine Landslide Trigger)

Definition

Tsunami is a Japanese term meaning wave ('nami') in a harbour ('tsu'). It is a series of travelling waves of extremely long length and period. They are usually generated by seabed disturbances associated with earthquakes occurring below or near the ocean floor, but also by other mechanisms such as submarine landslides (IOC, 2019).

Reference

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Annotations

Synonyms

Not found.

Additional scientific description

Tsunamis are also called seismic sea waves and, incorrectly, tidal waves. Submarine landslides, volcanic eruptions and coastal rock falls also generate tsunamis, as can large meteorites impacting the ocean. Tsunamis are gravity waves that may attain wavelengths of hundreds of miles with periods of 10 to 60 minutes; which allow them to travel across the largest ocean basins with little loss of energy. Tsunami waves steepen and increase in height up to tens and hundreds of meters on entering shallow water, inundating low-lying areas. Where local submarine topography causes the waves to oversteepen, they may break and cause great damage. Tsunamis have no connection with tides; the popular name, tidal wave, is entirely misleading (IOC, 2019).

Approximately 80% of tsunami are caused by earthquakes, but more recently it has been recognised that submarine landslides are also a significant tsunami mechanism. The size of the landslides varies from a few (one to six), to thousands of cubic kilometres. The size of the initial wave caused by the submarine landslide varies from a few to hundreds of meters. This initial wave rapidly collapses, and then travels away from the source at speeds of hundreds of kilometres per hour, depending on the water depth, with the deeper the water, the faster the velocity. There are usually a number of tsunami waves, of extremely long (hundreds of kilometres) wavelength, but small (less than one metre) elevation. When the waves approach land, and water depths shallow, they can build to tens or, more rarely, hundreds of metres in height, which can inundate low-lying areas and cause great damage. The tsunami waves caused by submarine landslides, compared to those from earthquakes, are of higher frequency so are very dispersive; unless the landslide is large volume, they do not travel as far. Near to the source mechanism, on striking land they can be elevated (tens to hundreds of metres high), and can be very destructive (Tappin, 2017, 2021).

The Intergovernmental Oceanographic Commission (IOC) uses the following terms to the describe the scale and impact of a tsunami (IOC, 2019):

Travel time: Time required for the first tsunami wave to propagate from its source to a given point on a coastline.

Arrival time: Time of the first maximum of the tsunami waves.

Inundation or Inundation-distance: The horizontal distance inland that a tsunami penetrates, generally measured perpendicularly to the shoreline.

Inundation (maximum): Maximum horizontal penetration of the tsunami from the shoreline. A maximum inundation is measured for each different coast or harbour affected by the tsunami.

Inundation area: Area flooded with water by the tsunami.

Inundation height Elevation reached by seawater measured relative to a stated datum such as mean sea level or the sea level at the time of tsunami arrival, at a specified inundation distance. Inundation height is the sum of the flow depth and the local topographic height. Sometimes referred to as tsunami height.

Inundation line: Inland limit of wetting measured horizontally from the mean sea level line. The line between living and dead vegetation is sometimes used as a reference. In tsunami science, the landward limit of tsunami run-up.

Leading wave: First arriving wave of a tsunami. In some cases, the leading wave produces an initial depression or drop in sea level, and in other cases, an elevation or rise in sea level. When a drop in sea level occurs, sea level recession is observed.

Mean height: Average height of a tsunami measured from the trough to the crest after removing the tidal variation.

Run-up

- Difference between the elevation of maximum tsunami penetration (inundation line) and the sea level at the time of the tsunami. In practical terms, run up is only measured where there is a clear evidence of the inundation limit on the shore.
- Elevation reached by seawater measured relative to some stated datum such as mean sea level, mean low water, sea level at the time of the tsunami attack, etc., and measured ideally at a point that is a local maximum of the horizontal inundation. Where the elevation is not measured at the maximum of horizontal inundation, this is often referred to as the inundation-height.

Tsunami amplitude: Usually measured on a sea level record, it is (1) the absolute value of the difference between a particular peak or trough of the tsunami and the undisturbed sea level at the time, (2) half the difference between an adjacent peak and trough, corrected for the change of tide between that peak and trough. It is intended to represent the true amplitude of the tsunami wave at some point in the ocean. However, it is often an amplitude modified in some way by the tide gauge response.

Tsunami period: Amount of time that a tsunami wave takes to complete a cycle, or one wavelength. Tsunami periods typically range from 5 to 60 minutes. Tsunami period is often measured as the difference between the arrival time of the highest peak and the next one measured on a water level record.

Tsunami wavelength: The horizontal distance between similar points on two successive waves measured perpendicular to the crest. The wavelength and the tsunami period give information on the tsunami source. For tsunamis generated by earthquakes, the typical wavelength ranges from 20 to 300 km. For tsunamis generated by landslides, the wavelength is much shorter, ranging from hundreds of meters to tens of kilometers.

Meteotsunami: Volcanic eruptions, submarine landslides, and coastal rock falls can also generate tsunamis, as can a large meteorite impacting the ocean. Tsunami-like phenomena generated by meteorological or atmospheric disturbances.

For more terms see (IOC, 2019).

Metrics and numeric limits

Tsunamis from submarine landslides, depending on their mechanism (slump or translational landslide) and volume can attain onland heights of up to hundreds of metres. The PNG tsunami of 1998, from a slump, attained a maximum height of 15 m. The tsunami from the Storegga translational landslide off Norway was 20–30 m on the Shetlands. Volcanic collapse tsunamis on the Hawaiian Islands are up 300–400 m high.

Key relevant UN convention/multilateral treaty

Not found

Examples of drivers, outcomes and risk management

Submarine landslide tsunamis are rare and unpredictable. They are mainly triggered by earthquakes, which often results in problems identifying the actual tsunami mechanism. They can also be triggered by volcanic activity. The primary tsunami hazard is to coastal communities within a few tens of kilometres of the source mechanism. At present, there is no management structure to mitigate the hazard, except where there is an identified associated earthquake which could act as a warning (if an earthquake warning system is in place). The identification of past submarine landslides events, from mapping of nearshore areas with steep slope gradients, could be used as a basis for identifying the potential submarine landslide tsunami hazard, on which mitigation strategies could be based. Volcanic submarine landslides can be mitigated through the monitoring of volcanic activity and from past events. In contrast to risks from earthquake-generated tsunamis, that can be managed through rapid response based on the rapid detection of tsunamigenic earthquakes, risks from, and warning of, submarine landslide tsunamis could, to some extent, be addressed by anticipatory coastal evacuations in response to earthquake warning system messages.

Primary hazards/damage. Damage and destruction from tsunamis is the direct result of three factors: inundation, wave impact on structures, and erosion. Deaths occur by drowning and physical impact or other trauma when people are caught in the turbulent, debris-laden tsunami waves. Strong tsunami-induced currents have led to the erosion of foundations and the collapse of bridges and seawalls. Floatation and drag forces have moved houses and overturned railroad cars (IOC, 2019:6).

Tsunami associated wave forces have demolished frame buildings and other structures. Considerable damage is also caused by floating debris, including boats, cars, and trees that become dangerous projectiles that may crash into buildings, piers, and other vehicles. Ships and port facilities have been damaged by surge action caused by even weak tsunamis. Fires resulting from oil spills or combustion from damaged ships in port, or from ruptured coastal oil storage and refinery facilities, can cause damage greater than that inflicted directly by the tsunami (IOC, 2019:6).

Secondary hazards/damage. Secondary hazard/damage includes sewage and chemical pollution following the tsunami destruction. Damage to intakes, discharge, storage facilities and flooding of cooling generators are also major potential problems. During tsunami drawdown, there is the potential for the receding flood waters to uncover cooling water intakes associated with nuclear power plants, leading to overheating and explosion of nuclear facilities (IOC, 2019:7).

Environmental damage and damage to coastal croplands can result from deposition of sediments over inundated areas and salt water contamination. This could be a particular problem with tsunamis associated with volcanic eruptions, from the transport and deposition of floating pumice onto land, and the erosion, transport and redeposition of volcanic tephra deposited in phases of the eruption prior to the tsunami inundation. Clean-up efforts can be complicated by contamination of sediment and debris with salt and with spilt oil fuels and other chemicals.

Risk management for tsunamis: A number of guidelines on tsunami risk assessment/management are available. Examples include IOC (2015) and UNDRR (2017).

Regional Coordination and Centres: The IOC is coordinating the implementation of a global tsunami warning system, building upon its experiences in the Pacific to establish regional warning systems for the Indian Ocean (IOTWMS); Caribbean Sea (ICG-CARIBE-EWS); and the North-eastern Atlantic, the Mediterranean and connected seas (ICG-NEAMTWS). The regional systems coordinate international tsunami warning and mitigation activities, including the issuance of timely and understandable tsunami bulletins to IOC Member States.

The Intergovernmental Coordination Group for Tsunamis addresses tsunami risk globally through the following groups:

ICG-PTWS Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System, formerly ICG/ITSU, was renamed by Resolution EC-XXXIX.8 of the IOC Executive Council in 2006 as proposed by the International Coordination Group for the Tsunami Warning System in the Pacific at its 20th Session in 2005 (Recommendation ITSU-XX.1). There are presently 46 Member States in the ICG-PTWS. ICG/ITSU, the International Coordination Group for the Tsunami Warning System in the Pacific was established by Resolution IV-6 of the 4th Session of the IOC Assembly in 1965. The Pacific Tsunami Warning Center (PTWC) serves as the Tsunami Service Provider (TSP) for the Pacific Ocean. Other TSPs for specific regions of the Pacific Ocean are the North West Pacific Tsunami Advisory Center (NWPTAC) and the South China Sea Tsunami Advisory Center (SCSTAC). The ICG-PTWS presently comprises over 40 Member States and oversees warning system operations and facilitates coordination and cooperation in all international tsunami mitigation activities.

ICG-IOTWMS The Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG-IOTWMS) was formed in response to the tragic tsunami on December 26th 2004, in which over 230,000 lives were lost around the Indian Ocean region. The ICG-IOTWMS comprises 28 Member States. There are three TSPs in the Indian Ocean, hosted by the governments of Australia, Indian and Indonesia.

ICG-NEAMTWS The Intergovernmental Coordination Group for the Tsunami Early Warning and Mitigation System in the North-eastern Atlantic, the Mediterranean and connected seas (ICG-NEAMTWS) was formed in response to the tragic tsunami on 26 December 2004, in which over 230,000 lives were lost around the Indian Ocean region (Indian Ocean Tsunami Information Centre, no date). The ICG-NEAMTWS consists of Member States bordering the North-eastern Atlantic and those bordering and within the Mediterranean and connected seas. There are currently five accredited Tsunami Service Providers (France, Greece, Italy, Portugal, Turkey) in the NEAM region providing tsunami services and alerts to subscribing Member States.

ICG-CARIBE-EWS The Intergovernmental Coordination Group for the Tsunami and Other Coastal Hazards Warning System for the Caribbean and Adjacent Regions (ICG-CARIBE-EWS) was established in 2005 and currently comprises 32 Member States and 16 Territories in the Caribbean.

Tsunami Service Providers (TSPs) are centres that monitor seismic and sea level activity and issue timely tsunami threat information within an ICG framework to National Tsunami Warning Centres (NTWCs) / Tsunami Warning Focal Points (TWFPs) and other TSPs operating within an ocean basin. The NTWCs / TWFPs may use these products to develop and issue tsunami warnings for their countries. TSPs may also issue public messages for an ocean basin and act as NTWCs providing tsunami warnings for their own countries. Currently there are nine operational TSPs.

National Tsunami Warning Centres (NTWCs) are a centre officially designated by the government to monitor and issue tsunami warnings and other related statements within their country according to established national Standard Operating Procedures.

World Tsunami Awareness Day, 5 November every year: The United Nations, through UN Resolution 70/203 adopted on 22 December 2015, has designated 5 November as World Tsunami Awareness Day (UNDRR, 2020). The day aligns with the International Day for Disaster Reduction (13 October) and the seven targets of the Sendai Framework for Disaster Risk Reduction 2015–2030 (ITIC, 2020). The IOC is a key international partner of the UNDRR on World Tsunami Awareness Day.

Tsunami Ready is a voluntary community recognition programme that promotes tsunami hazard preparedness as an active collaboration among federal, state/territorial and local emergency management agencies, community leaders and the public. The main goal of the programme is to improve public safety before, during and after tsunami emergencies. It aims to do this by establishing guidelines for a standard level of capability to mitigate, prepare for and respond to tsunamis, and working with communities to help them meet the guidelines and ultimately become recognised as 'tsunami ready' by the National Weather Service. It was first implemented in the United States .To date, there are 26 IOC-UNESCO Tsunami Ready recognised communities in 18 countries and territories, excluding those implemented in the United States.

Community engagement with evacuation zones and the 'blue lines' project In New Zealand, the Wellington Region Emergency Management Office has developed the Blue Line Project in collaboration with communities in Wellington's southern coastal suburbs. In this project, the local community helps to plan evacuation routes and safe locations based on indicative evacuation zone mapping, and blue lines are painted on the road surface at the maximum estimated tsunami inundation extent. Accompanying evacuation signage is installed. Community members are engaged early in the project, publicising the work and helping to develop blue line locations, evacuation zone maps and information boards. The communities participating in the Blue Line Project can be considered to have a higher degree of public education regarding tsunami evacuation than other communities (Fraser et al., 2016). Other communities around the world have used similar community engagement strategies.

References

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Coordinating agency or organisation

United Nations Educational, Scientific and Cultural Organization (UNESCO), Intergovernmental Oceanographic Commission (IOC-UNESCO) and the British Geological Survey.

ENVIRONMENTAL

EN0001 / **ENVIRONMENTAL / Environmental Degradation**

Household Air Pollution

Definition

Household air pollution is one of the leading causes of disease and premature death and is associated with inefficient cooking practices using polluting stoves paired with solid fuels and kerosene (WHO, 2018).

Reference

WHO, 2018. Household air pollution and health. World Health Organization (WHO). www.who.int/en/news-room/fact-sheets/detail/household-air-pollution-and-health Accessed 20 October 2020.

Annotations

Synonyms

Indoor air pollution.

Additional scientific description

Around 3 billion people still cook using solid fuels (such as wood, crop wastes, charcoal, coal, dung) and kerosene in open fires and inefficient stoves. Most of these people are poor and live in low- and middle-income countries. These cooking practices are inefficient and use fuels and technologies that produce high levels of household air pollution with a range of health-damaging pollutants, including small soot particles that penetrate deep into the lungs. In poorly ventilated dwellings, indoor smoke can be 100 times higher than acceptable levels for fine particles. Exposure is particularly high among women and young children, who spend the most time near the domestic hearth (WHO, 2018a).

Exposure to smoke from cooking fires causes 3.8 million people per year to die prematurely from illness attributable to the household air pollution caused by the inefficient use of solid fuels and kerosene for cooking. Among these 3.8 million deaths: 27% are due to pneumonia; 18% from stroke; 27% from ischaemic heart disease; 20% from chronic obstructive pulmonary disease (COPD); and 8% from lung cancer (WHO, 2018a).

Metrics and numeric limits

The WHO Air Quality guidelines offer recommended exposure levels for particulate matter (PM10 and PM2.5), ozone, nitrogen dioxide and sulphur dioxide, as well as a set of interim targets to encourage a progressive improvement in air quality (WHO, 2006).

Guideline levels for each pollutant (µg/m3)		
PM2.5	1 yr	10
	24 h (99th percentile)	25
PM10	1 yr	20
	24 h (99th percentile)	50
Ozone, O3	8 h, daily maximum	100
Nitrogen dioxide, NO2	1 yr	40
	1 h	200

Sulphur dioxide, SO_2	24 h	20
	10 min	500

Key relevant UN convention/multilateral treaty

None identified.

Examples of drivers, outcomes and risk management

The World Health Organization (WHO) provides technical support to countries in their own evaluations and scale-up of health-promoting household fuels and technologies (WHO, 2018a). This is further complemented by the ongoing development of the Clean Household Energy Solutions Toolkit (CHEST) to support the implementation of WHO Guidelines for indoor air quality: household fuel combustion (WHO, 2014). CHEST is a suite of tools and information resources that help countries identify stakeholders working on household energy and/or public health to design, implement and monitor policies addressing household energy (WHO, 2018a). These are summarised below:

- *Guidelines for indoor air quality: household fuel combustion:* To ensure healthy air in and around the home, these guidelines provide health-based recommendations on the types of fuels and technologies to protect health as well as strategies for the effective dissemination and adoption of such home energy technologies (WHO, 2014).
- *Household energy database:* This database (WHO, no date a) is used to monitor global progress in the transition to cleaner fuels and stove combinations in households. It also supports assessments of disease burden from the household air pollution generated from the use of polluting fuel and technologies. As the custodial agency for Sustainable Development Goal Indicator 3.9.1 (mortality rate from the joint effects of household and ambient air pollution) and 7.1.2 (population with primary reliance on clean fuels and technologies) (WHO, 2018b), the WHO uses the Household energy database to derive estimates for tracking progress towards achieving universal clean energy access and related health impacts (WHO, 2018a).
- *Research and programme evaluation:* WHO is working with countries, researchers and other partners to harmonise methods of evaluation across settings so that health impacts are assessed consistently and rigorously and incorporate economic assessment of health benefits (WHO, 2018a).
- *Leadership and advocacy in the health, energy and climate community:* In May 2015, the World Health Assembly unanimously adopted a resolution on air pollution and health, calling for the integration of health concerns into national, regional and local air pollution-related policies. The following year, the World Health Assembly adopted a 'Roadmap for Enhanced Action' (WHO, no date b), calling for increased cross-sector cooperation to address the health risks of air pollution. WHO emphasises the compelling health arguments for cleaner household energy in a range of global forums addressing maternal and child health issues related to pneumonia as well as forums concerned with noncommunicable diseases (WHO, 2018a).
- *Health and climate change:* The WHO is a partner of the Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants (CCAC). As a member of the CCAC's health task force, the WHO is providing technical support for harnessing health benefits from actions to reduce short-lived climate pollutants and working to scale-up health sector engagement to address such pollutants and improve air quality (WHO, 2018a).
- *Health, energy and sustainable development:* Reductions in air pollution-related disease burden (both for household and outdoor) will be used to monitor the progress towards attaining the Sustainable Development Goal on Health (SDG 3). Achieving the Sustainable Development Goal on energy (SDG 7) (UN, 2015) could prevent millions of deaths and improve the health and well-being of the billions of people relying on polluting technologies and fuels for cooking, heating and lighting. To better assess the health risks of household energy use, as well as differentiated gender impacts from household energy practices, the WHO is leading an effort with countries and surveying agencies (e.g., the United States Agency for International Development Demographic and Health Surveys Program, the United Nations Children's Emergency Fund Multiple Indicator Cluster Surveys, and the World Bank's Living Standards Measurement Study) to better capture information on all the fuels and technologies used in the home for cooking, heating and lighting, as well as other impacts like time lost to fuel collection disaggregated by sex (WHO, 2018a).

The WHO also supports international initiatives to improve air pollution and related health impacts such as the Global Alliance for Clean Cookstoves and the Climate Clean Air Coalition (WHO, 2018a).

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Coordination agency or organisation

World Health Organization.

EN0002 / **ENVIRONMENTAL / Environmental Degradation**

Air Pollution (Point Source)

Definition

A point source of air pollution is an identifiable stationary location or fixed facility from which air pollutants are released, which may be man-made or natural in origin (adapted from Kibble and Harrison, 2005 and Dunne et al., 2014).

References

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Kibble, A. and R. Harrison, 2005. Point sources of air pollution. Occupational Medicine, 55:425-431.

Annotations

Synonyms

Point source emissions, Fugitive emissions.

Additional scientific description

Point source air pollution can be natural or man-made. A human generated point source of air pollution is one that emits a significant amount of an air pollutant from a fixed location such as an explosion, pollutants from a chimney stack or a tyre fire. Examples of point sources include power stations, steel works, foundries, incinerators, wood and pulp processors, paper mills, refineries and chemical production (Kibble and Harrison, 2005; Dunne et al., 2014). Point sources of air pollution from naturally occurring sources include smoke from wildfires, ash from volcanic eruptions and sand particles from deserts lifted and transported in the wind across cities and continents.

Many people, particularly those in poorer populations or with pre-existing vulnerabilities, live near point sources of air pollution such as industrial sites and waste disposal operations. Point sources frequently generate speculation regarding potential association with disease clusters such as cancer, among those living in close proximity to the source location. Suspected disease clusters tend to generate significant public concern and media interest. However, there are currently limited epidemiological methods to enable effective detailed investigations into the impact of point-source air pollution and causal links with the disease of interest in identified clusters. There is a particular challenge with respect to obtaining reliable and accurate population exposure data at a very local level (WHO, no date).

In many cases, the key question is whether releases from a point source result in a significant increase in exposure or whether other sources (background exposure) give rise to the dominant exposure (Kibble and Harrison, 2005). Detailed investigation of these differences requires high spatio-temporal resolution air quality data alongside incidence data obtained from accurate health information systems, such as disease registers or via case control studies.

Metrics and numeric limits

World Health Organization (WHO) Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulphur dioxide (WHO, 2006).

PM2.5 • 10 µg/m3 annual mean • 25 µg/m3 24-hour mean • PM10: 20 µg/m3 annual mean • 50 µg/m3 24-hour mean	**Ozone (O3)** • 100 µg/m3 8-hour mean
Nitrogen dioxide (NO2) • 40 µg/m3 - annual mean • 200 µg/m3 - 1-hour mean	**Sulphur dioxide (SO2)** • 20 µg/m3 - 24-hour mean • 500 µg/m3 - 10-minute mean

Key relevant UN convention/multilateral treaty

WHO International Health Regulations (WHO, 2016).

Examples of drivers, outcomes and risk management

Point source air pollution focuses on acute and chronic sources of such pollution. The WHO considers that all sources of air pollution contribute to early deaths; included in this are the combined effects of ambient (outdoor) and household air pollution which cause approximately seven million premature deaths every year, largely as a result of increased mortality from stroke, heart disease, chronic obstructive pulmonary disease, lung cancer and acute respiratory infections (Health Effects Institute, 2020; WHO, 2020a).

Sources of air pollution are multiple and context-specific. The major ambient pollution sources include biomass fuel combustion for domestic cooking and heating, vehicles, power generation, agriculture/waste incineration, and industry. Policies and investments supporting integrated policies that support sustainable land use, cleaner household energy and transport, energy-efficient housing, power generation, industry, and better municipal waste management can effectively reduce key sources of ambient air pollution (WHO, 2020a).

Incidents such as wildfires and volcanic eruptions can also impact on air quality. For example, research shows that wildfires can cause a large increase in gaseous air pollutants such as carbon monoxide, nitrogen dioxide, acetaldehyde and formaldehyde (Finlay et al., 2012).

Adverse health consequences of air pollution can occur as a result of short- or long-term exposure. The pollutants with the strongest evidence of health effects are particulate matter, ozone, nitrogen dioxide and sulphur dioxide (WHO, 2020b).

Although most emissions of point source air pollution are from local or regional sources, under certain atmospheric conditions air pollution can travel long distances across national borders over time scales of four to six days, thereby affecting people far from its original source. For example, windblown dust from desert regions of Africa, Mongolia, Central Asia and China can carry large concentrations of particulate matter, and fungal spores and bacteria that impact health and air quality in remote areas. Therefore, global cooperation is needed to address international flows and sources of air pollutants, complementary to local and regional efforts in air pollution management (WHO, 2020b).

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Coordinating agency or organisation

World Health Organization.

EN0003 / **ENVIRONMENTAL / Environmental Degradation**

Ambient (Outdoor) Air Pollution

Definition

Ambient (outdoor) air pollution is a leading environmental risk factor affecting urban and rural populations around the world, resulting in an estimated 4.2 million premature deaths in 2016 (WHO, 2018).

Reference

WHO, 2018. Ambient (outdoor) air pollution. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health Accessed 26 October 2020.

Annotations

Synonyms

Poor air quality, Ambient air pollution, Smog.

Additional scientific description

Ambient (outdoor) air pollution is a major cause of death and disease globally. Long-term exposure to air pollution (over years or lifetimes) reduces life expectancy, mainly due to cardiovascular and respiratory diseases and lung cancer. The World Health Organisation (WHO) estimated that ambient air pollution caused 4.2 million premature deaths globally in 2016, of which 58% were due to ischaemic heart disease and strokes, 18% to chronic obstructive pulmonary disease and acute lower respiratory infections respectively, and 6% to lung cancer (WHO, 2018). Short-term exposure (over hours or days) to elevated levels of air pollution can also cause a range of health impacts, including effects on lung function, exacerbation of asthma, increases in respiratory and cardiovascular hospital admissions and mortality. Emerging evidence suggests that air pollution may also affect the brain with possible links to dementia and cognitive decline and may also have an effect on early life, such as low birth weight.

Ambient air pollution contains a range of pollutants (particles and gases) from a variety of sources, both natural and man-made (e.g., transport, industry, agriculture). Pollutants with the strongest evidence for public health concern, include particulate matter (PM), ozone (O3), nitrogen dioxide (NO2) and sulphur dioxide (SO2) (WHO, 2020).

'Particulate matter' is a generic term used to describe a complex mixture of solid and liquid particles of varying size, shape, and composition. Some particles are emitted directly (primary PM); others are formed in the atmosphere through complex chemical reactions (secondary PM). The composition of PM varies greatly and depends on many factors, such as geographic location, emission sources and weather. The size of particles and the duration of exposure are key determinants of potential adverse health effects. Particles larger than 10 μm are mainly deposited in the nose or throat, whereas particles smaller than 10 μm pose the greatest risk because they can be drawn deeper into the lung. The health risks associated with PM of less than 10 and 2.5 microns in diameter (PM10 and PM2.5, respectively) are especially well documented. The strongest evidence for effects on health is associated with fine particles (PM2.5) (WHO, 2018; PHE, 2019).

Although air pollution can be harmful to everyone, some people are more affected because they live in a polluted area, are exposed to higher levels of air pollution in their daily lives, or are more susceptible to health problems caused by air pollution. The most vulnerable face all of these disadvantages. Groups more affected by air pollution include older people, children, individuals with pre-existing cardiovascular or respiratory disease, pregnant women, communities in areas of higher air pollution and low-income communities (PHE, 2018).

Metrics and numeric limits

Guideline values for particulate matter: Fine particulate matter (PM2.5): 10 μg/m3 annual mean and 25 μg/m3 24-hour mean; coarse particulate matter (PM10): 20 μg/m3 annual mean and 50 μg/m3 24-hour mean (WHO, 2006).

In addition to guideline values, the WHO air quality guidelines provide interim targets for concentrations of PM10 and PM2.5 aimed at promoting a gradual shift from high to lower concentrations. If these interim targets were to be achieved, significant reductions in risks for acute and chronic health effects from air pollution can be expected. Achieving the guideline values, however, should be the ultimate objective.

The effects of PM on health occur at levels of exposure currently being experienced by many people both in urban and rural areas and in developed and developing countries – although exposures in many fast-developing cities today are often far higher than in developed cities of comparable size.

The WHO air quality guidelines report that reducing annual average fine particulate matter (PM2.5) concentrations from levels of 35 µg/m3, common in many developing cities, to the WHO guideline level of 10 µg/m3, could reduce air pollution-related deaths by around 15%. However, even in the European Union, where PM concentrations in many cities do comply with guideline levels, it is estimated that average life expectancy is 8.6 months lower than it would otherwise be, due to PM exposures from human sources.

There are serious risks to health not only from exposure to PM, but also from exposure to O3, NO2 and SO2. As with PM, concentrations are often highest largely in the urban areas of low- and middle-income countries. Ozone is a major factor in asthma morbidity and mortality, while NO2 and SO2 also play a role in asthma, bronchial symptoms, lung inflammation and reduced lung function.

Guideline value for ozone: O3 100 µg/m3 8-hour mean (WHO, 2006).

The recommended limit in the 2005 Air Quality Guidelines was reduced from 120 µg/m3 in previous editions of the WHO air quality guidelines based on recent conclusive associations between daily mortality and lower O3 concentrations.

Ozone at ground level – not to be confused with the ozone layer in the upper atmosphere – is one of the major constituents of photochemical smog. It is formed by the reaction with sunlight (photochemical reaction) of pollutants such as nitrogen oxides (NOx) from vehicle and industry emissions and volatile organic compounds (VOCs) emitted by vehicles, solvents and industry. As a result, the highest levels of O3 pollution occur during periods of sunny weather.

Excessive O3 in the air can have a marked effect on human health. It can cause breathing problems, trigger asthma, reduce lung function and cause lung diseases.

Guideline values for nitrogen dioxide: 40 µg/m3 annual mean and 200 µg/m3 1-hour mean (WHO, 2006).

The current WHO guideline value of 40 µg/m3 (annual mean) was set to protect the public from the health effects of gaseous NO2.

As an air pollutant, NO2 has several related impacts. Under short-term exposure to concentrations exceeding 200 µg/m3, it is a toxic gas which causes significant inflammation of the airways.

NO2 is the main source of nitrate aerosols, which form an important fraction of PM2.5 and, in the presence of ultraviolet light, of O3. The major sources of anthropogenic emissions of NO2 are combustion processes (heating, power generation, engines in vehicles and ships).

Epidemiological studies have shown that symptoms of bronchitis in asthmatic children increase in association with long-term exposure to NO2. Reduced lung function growth is also linked to NO2 at concentrations currently measured (or observed) in cities of Europe and North America.

Guideline value for sulphur dioxide: 20 µg/m3 24-hour mean and 500 µg/m3 10-minute mean (WHO, 2006).

An SO2 concentration of 500 µg/m3 should not be exceeded over average periods of 10 minutes' duration. Studies indicate that a proportion of people with asthma experience changes in pulmonary function and respiratory symptoms after periods of exposure to SO2 as short as 10 minutes. Health effects are now known to be associated with much lower levels of SO2 than previously believed. A greater degree of protection is needed. Although the causality of the effects of low concentrations of SO2 is still uncertain, reducing SO2 concentrations is likely to decrease exposure to co-pollutants.

SO2 is a colourless gas with a sharp odour. It is produced from the burning of fossil fuels (coal and oil) and the smelting of mineral ores that contain sulphur. The main anthropogenic source of SO2 is the burning of sulphur-containing fossil fuels for domestic heating, power generation and motor vehicles.

SO2 can affect the respiratory system and lung function and can cause irritation of the eyes. Inflammation of the respiratory tract causes coughing, mucus secretion, aggravation of asthma and chronic bronchitis and makes people more prone to infections of the respiratory tract. Hospital admissions for cardiac disease and mortality, increase on days with higher SO2 levels. When SO2 combines with water, it forms sulphuric acid; this is the main component of acid rain which is a cause of deforestation.

Please note that the WHO Air quality guidelines are currently under revision.

It is also important to note that at present, there is no clear evidence of a safe level of exposure to air pollutants below which there is no risk of adverse health effects. Therefore, further reductions of concentrations of air pollutants below air quality standards are likely to bring additional health benefits. Actions that improve air pollution can also offer wider public health and wellbeing co-benefits.

Key relevant UN convention/multilateral treaty

WHO International Health Regulations (WHO, 2016).

Examples of drivers, outcomes and risk management

Most sources of outdoor air pollution are well beyond the control of individuals and require concerted action by local, national and regional level policy-makers working in sectors such as transport, energy, waste management, urban planning, and agriculture (WHO, 2018).

There are many examples of successful policies in transport, urban planning, power generation and industry that reduce air pollution (WHO, 2018):

- *Industry:* clean technologies that reduce industrial smokestack emissions; improved management of urban and agricultural waste, including capture of methane gas emitted from waste sites as an alternative to incineration (for use as biogas).
- *Energy:* ensuring access to affordable clean household energy solutions for cooking, heating and lighting.
- *Transport:* shifting to clean modes of power generation; prioritising rapid urban transit, walking and cycling networks in cities as well as rail interurban freight and passenger travel; shifting to cleaner heavy-duty diesel vehicles and low-emission vehicles and fuels, including fuels with reduced sulphur content.
- *Urban planning:* improving the energy efficiency of buildings and making cities more green and compact, and thus energy efficient.
- *Power generation:* increased use of low-emission fuels and renewable combustion-free power sources (like solar, wind or hydropower); co-generation of heat and power; and distributed energy generation (e.g., mini-grids and rooftop solar power generation).
- *Municipal and agricultural waste management:* strategies for waste reduction, waste separation, recycling and reuse or waste reprocessing; as well as improved methods of biological waste management such as anaerobic waste digestion to produce biogas, are feasible, low cost alternatives to the open incineration of solid waste. Where incineration is unavoidable, then combustion technologies with strict emission controls are critical.

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Coordinating agency or organisation

World Health Organization.

EN0004 / **ENVIRONMENTAL / Environmental Degradation**

Land Degradation

Definition

Land degradation means reduction or loss, in arid, semi-arid and dry sub-humid areas, of the biological or economic productivity and complexity of rainfed cropland, irrigated cropland or range, pasture, forest and woodlands resulting from land uses or from a process or combination of processes, including processes arising from human activities and habitation patterns such as: soil erosion caused by wind and/or water; deterioration of the physical, chemical and biological or economic properties of soil; and long-term loss of natural vegetation (UNCCD, 1993).

Alternative Definition: Land degradation is the reduction in the capability of the land to produce benefits from a particular land use under a specified form of land management (FAO, 1999).

Alternative Definition: Land degradation is a negative trend in land condition, caused by direct or indirect human-induced processes including anthropogenic climate change, expressed as long-term reduction or loss of at least one of the following: biological productivity, ecological integrity or value to humans. [Note: This definition applies to forest and non-forest land. Changes in land condition resulting solely from natural processes (such as volcanic eruptions) are not considered to be land degradation. Reduction of biological productivity or ecological integrity or value to humans can constitute degradation, but any one of these changes need not necessarily be considered degradation.] (Olsson et al., 2019).

References

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Olsson, L., H. Barbosa, S. Bhadwal and 8 others, 2019. Land degradation. In: Shukla, P.R., J. Skea, E. Calvo Buendia and 19 others (eds.), Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. www.ipcc.ch/site/assets/uploads/sites/4/2019/11/07_Chapter-4.pdf Accessed 18 October 2020.

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Annotations

Synonyms

None identified.

Additional scientific description

In the soil conservation arena, the terms soil degradation and land degradation are sometimes incorrectly used interchangeably, with soil erosion regarded as synonymous to both. However, there is more to soil degradation than just soil erosion, and land represents a broader concept than simply soil. As with its use in the context of land evaluation (FAO, 1976), the term land refers to all-natural resources which contribute to agricultural production, including livestock production and forestry. Land thus covers climate, landforms, water resources, soils and vegetation (including both grassland and forests) (FAO, 1999).

There are a number of interrelated land degradation components, all of which may contribute to a decline in agricultural production. The most important according to Douglas (1994) cited by FAO (1999):

- *Soil degradation:* decline in the productive capacity of the soil as a result of soil erosion and changes in the hydrological, biological, chemical and physical properties of the soil.
- *Vegetation degradation:* decline in the quantity and/or quality of the natural biomass and decrease in the vegetative ground cover.
- *Water degradation:* decline in the quantity and/or quality of both surface and ground water resources.
- *Climate deterioration:* changes in the micro- and macro-climatic conditions that increase the risk of crop failure.
- *Losses to urban/industrial development:* decline in the total area of land used, or with potential, for agricultural production as a result of arable land being converted to urban, industrial and infrastructure uses (FAO, 1999).

Land degradation has both on-site and off-site effects. On-site effects are the lowering of the productive capacity of the land, causing either reduced outputs (crop yields, livestock yields) or the need for increased inputs. Off-site effects of water erosion occur through changes in the water regime, including decline in river water quality, and sedimentation of river beds and reservoirs. The main off-site effect of wind erosion is overblowing, or sand deposition (FAO, 1994).

Examples of causes of different types of land degradation include water erosion, wind erosion, soil fertility decline, waterlogging, salinisation, lowering of the water table, deforestation, forest degradation and rangeland degradation (FAO, 1994).

In their 2019 review on land degradation for the Intergovernmental Panel on Climate Change (IPCC), Olsson et al. (2019) reported that land degradation adversely affects people's livelihoods (very high confidence) and occurs over a quarter of the Earth's ice-free land area (medium confidence). The majority of the 1.3 to 3.2 billion affected people (low confidence) are living in poverty in developing countries (medium confidence). Land-use changes and unsustainable land management are direct human causes of land degradation (very high confidence), with agriculture being a dominant sector driving degradation (very high confidence).

Soil loss from conventionally tilled land exceeds the rate of soil formation by more than 2 orders of magnitude (medium confidence). Land degradation affects humans in multiple ways, interacting with social, political, cultural and economic aspects, including markets, technology, inequality and demographic change (very high confidence). Land degradation impacts extend beyond the land surface itself, affecting marine and freshwater systems, as well as people and ecosystems far from the local sites of degradation (very high confidence) (Olsson et al., 2019).

Studies indicate that land degradation directly affects 1.5 billion people worldwide, with a disproportionate impact on women, children and the poor, and it reduced the productivity of the world's terrestrial surface by about 25% between 1981 and 2003 (FAO, 2020).

Metrics and numeric limits

Nachtergaele et al. (2011) reported that there is a plethora of methods, indicators and recent studies concerning specific aspects of land degradation at local and national levels. An inventory carried out by the United Nations Convention to Combat Desertification (UNCCD) revealed more than 900 different land degradation indicators used in a sample of UNCCD countries. Efforts for harmonisation are ongoing. Eleven indicators have been provisionally defined by the UNCCD, and 22 metrics have been selected to be tested for their measurement. Practical monitoring may use any of the following:

- The Land Degradation Assessment in Drylands (LADA) / World Overview of Conservation Approaches and Technologies (WOCAT) participatory assessment methodology can be used at subnational level. The main parameters describe the state, cause and impact of degradation. At the same time, the type and extent of sustainable land management interventions are inventoried.
- The coupled Human–Environment promotes the integrated consideration of biophysical and socio-economic parameters linking institutional and policy considerations with land degradation. These consider threshold tipping points beyond which systems can no longer be restored.
- Remote sensing approaches have the significant advantage that data are continuously collected objectively and as such are ideally suited for monitoring purposes. Reliability issues and capacity needs remain as weakness points.
- Local sampling techniques and surveys are objective and the most detailed of all, but are more costly and time consuming (Nachtergaele et al., 2011).

Key relevant UN convention/multilateral treaty

United Nations Convention to Combat Desertification (UNCCD) (UNCCD, 1994).

The UNCCD 2018-2030 Strategic Framework (UNCCD, 2017).

Examples of drivers, outcomes and risk management

An estimated 1.5 billion people, or a quarter of the world's population, depend directly on land that is being degraded (FAO, 2008).

The Food and Agricultural Organization of the United Nations (FAO) assists member countries in assessing the physical, socio-economic, institutional and legal potential and constraints on land use, with the aim of achieving the optimal and sustainable use of land resources and empowering people to make informed decisions on the allocation of those resources.

Under the FAO's Strategic Objective 2, major areas of work are being developed with a view to enhancing resource-use efficiency, optimising the use of inputs, sustaining the full range of ecosystem functions (e.g., the provisioning of food, fibre and energy; soil health; water quality; cultural values; and biodiversity conservation) and enhancing climate change adaptation and mitigation (FAO, 2020).

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Coordinating agency or organisation

Food and Agricultural Organization of the United Nations.

EN0005 / **ENVIRONMENTAL / Environmental Degradation**

Soil Degradation

Definition

Soil degradation is defined as a change in soil health status resulting in a diminished capacity of the ecosystem to provide goods and services for its beneficiaries (FAO, 2020).

Reference

FAO, 2020. FAO Soils Portal Key definitions. Food and Agricultural Organization of the United Nations (FAO). www.fao.org/soils-portal/about/all-definitions/en Accessed 19 October 2020.

Annotations

Synonyms

None identified.

Additional scientific description

Soil degradation consists of biological, chemical and physical degradation. Currently, about 33% of world soils are moderately to highly degraded. Forty percent of these degraded soils are located in Africa and most of the rest are in areas that are afflicted by poverty and food insecurity. The strong relationship between soil health and food security calls for strategic and immediate actions, especially at the local level, to reverse soil degradation in order to increase food production and alleviate food insecurity in the areas where it is most needed and in the context of climate change (FAO, 2015).

Soil is an essential component of 'land' and 'ecosystems' that both are broader concepts encompassing vegetation, water and climate in the case of land, and in addition to those three aspects, also social and economic considerations in the case of ecosystems. Degraded soils have a health status such that they do not provide the normal goods and services of the particular soil in its ecosystem (FAO, 2020a).

Soil degradation is the decline in soil condition caused by its improper use or poor management, usually for agricultural, industrial or urban purposes. It is a serious environmental issue. Soils are a fundamental natural resource and are the basis for all terrestrial life. Avoiding soil degradation is crucial to our well-being (NSW Department of Planning, Industry and Environment, 2019).

Soil degradation is the physical, chemical and biological decline in soil quality. It can be the loss of organic matter, decline in soil fertility, and structural condition, erosion, adverse changes in salinity, acidity or alkalinity, and the effects of toxic chemicals, pollutants or excessive flooding. Soil degradation can involve: water erosion (includes sheet, rill and gully erosion); wind erosion; salinity (includes dryland, irrigation and urban salinity); loss of organic matter; fertility decline; soil acidity or alkalinity; structure decline (includes soil compaction and surface sealing); mass movement; and soil contamination (NSW Department of Planning, Industry and Environment, 2019).

Metrics and numeric limits

12 million hectares of agricultural soils are lost globally through soil degradation every year. Soils with soil organic matter content lower than 0.8% are unproductive and often abandoned. Agroforestry systems can reduce soil erosion by as much as 100 times in steep slopes. Growing Faidherbia albida in association with millet (Pennisetum glaucum) increased grain yields by 50% in Burkina Faso and Senegal. In Honduras the adoption of soil conservation practices tripled or quadrupled maize yields for 1200 families (FAO, 2015).

Key relevant UN convention/multilateral treaty

Land Degradation Assessment in Dryland (LADA) (FAO, 2020b)

Global Assessment of Human-Induced Soil Degradation (GLASOD) 1991 (ISRIC, 1991)

United Nations Convention to Combat Desertification (UNCCD) (UNCDD, 1994).

Examples of drivers, outcomes and risk management

The United Nations Environment Assembly during the Third Session in 2017 acknowledged that soils, which contain the second largest active carbon stock (the first being the oceans), are an essential element for climate change mitigation and resilience, and that land pollution leads to a reduction in soil biological activity and is therefore a factor contributing to the reduction of its capacity to act as a carbon sink (UNEP, 2018).

Agroecology is part of the Strategic Framework of the Food and Agricultural Organization of the United Nations (FAO), in particular the Strategic Objectives of making agriculture, forestry and fisheries more productive and sustainable, increasing the resilience of livelihoods and reducing rural poverty (FAO, 2015).

The agroecological approach starts by restoring soil life in order to re-establish and/or enhance the multiple soil-based biological processes. This requires (FAO, 2015):

- *Increasing and monitoring soil organic matter*: Soil organic matter is considered the most common deficiency in degraded soils and the main indicator for soil quality. Practical, accessible indicators can support local decisions and larger landscape monitoring and analyses for district level implementation.
- *Facilitating and monitoring of soil biodiversity*: Soil biological communities are directly responsible for multiple ecosystem functions.
- *Building on local farmers' knowledge*: Participatory scientific approaches to soil ecosystem management, such as Farmer Field Schools, are of great importance to inform farmers' knowledge with researchers' scientific principles in order better locally adapt agroecological systems.

The FAO and its Global Soil Partnership launched a new programme to boost soil productivity and reduce soil degradation for greater food and nutrition security in Africa. The Afrisoils programme aims to increase soil productivity in 47 African countries by 30% and reduce soil degradation by 25% in the next ten years (FAO, 2018).

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Coordinating agency or organisation

Food and Agricultural Organization of the United Nations.

EN0006 / **ENVIRONMENTAL / Environmental Degradation**

Runoff / Nonpoint Source Pollution

Definition

Nonpoint sources of pollution refer to pollution sources that are diffused and without a single point of origin or not introduced into a receiving freshwater or maritime environment from a specific outlet. The pollutants are generally carried off the land by storm-water run-off. The commonly used categories for nonpoint sources are agriculture, forestry, urban areas, mining, construction, dams and channels, land disposal and saltwater intrusion (UN data, no date).

Reference

UN Data, no date. Non-point Source Pollution. UNdata: A world of information. http://data.un.org/Glossary.aspx?q=nonpoint+source+pollution Accessed 15 October 2020.

Annotations

Synonyms

None identified.

Additional scientific description

Nonpoint source pollution generally results from land runoff, precipitation, atmospheric deposition, drainage, seepage or hydrologic modification. Nonpoint source pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources. Nonpoint source pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters and ground waters (US EPA, 2020; NOAA, no date).

Nonpoint source pollution can include: excess fertilisers, herbicides and insecticides from agricultural lands and residential areas; oil, grease and toxic chemicals from urban runoff and energy production; sediment from improperly managed construction sites, crop and forest lands, and eroding streambanks; salt from irrigation practices and acid drainage from abandoned mines; bacteria and nutrients from livestock, pet wastes and faulty septic systems; and atmospheric deposition and hydromodification (US EPA, 2020).

Metrics and numeric limits

Not identified.

Key relevant UN convention/multilateral treaty

The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 (IMO, 1972), the 'London Convention' for short, is one of the first global conventions to protect the marine environment from human activities and has been in force since 1975. Its objective is to promote the effective control of all sources of marine pollution and to take all practicable steps to prevent pollution of the sea by dumping of wastes and other matter. Currently, 87 States are Parties to this Convention.

The International Convention for the Prevention of Pollution from Ships (MARPOL) 1996 (IMO, 1996) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes. The MARPOL Convention was adopted on 2 November 1973. The Protocol of 1978 was adopted in response to a spate of tanker accidents in 1976-1977. As the 1973 MARPOL Convention had not yet entered into force, the 1978 MARPOL Protocol absorbed the parent Convention. The combined instrument entered into force on 2 October 1983. In 1997, a Protocol was adopted to amend the Convention and a new Annex VI was added which entered into force on 19 May 2005. MARPOL has been updated by amendments through the years to the London Convention (the 'London Protocol').

Examples of drivers, outcomes and risk management

Marine debris is defined as any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment. Marine debris takes many forms, including derelict fishing gear and vessels, abandoned recreational equipment, and discarded consumer plastics, metals, rubber, paper, and textiles.

For example, the International Union for Conservation of Nature provides information on marine plastics (IUCN, 2018):

- Over 300 million tons of plastic are produced every year for use in a wide variety of applications.
- At least 8 million tons of plastic end up in the oceans every year and make up 80% of all marine debris from surface waters to deep-sea sediments.
- Marine species ingest or are entangled by plastic debris, which causes severe injuries and deaths.
- Plastic pollution threatens food safety and quality, human health, coastal tourism, and contributes to climate change.
- There is an urgent need to explore the use of existing legally binding international agreements to address marine plastic pollution.
- Recycling and reuse of plastic products, and support for research and innovation to develop new products to replace single-use plastics are also necessary to prevent and reduce plastic pollution.

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Coordinating agency or organisation

Not identified.

EN0007 / **ENVIRONMENTAL / Environmental Degradation**

Salinity

Definition

Saline soils are those which have an electrical conductivity of the saturation soil extract of more than 4 dS/m at 25°C (Richards, 1954). This value is generally used worldwide although the terminology committee of the Soil Science Society of America has lowered the boundary between saline and non-saline soils to 2 dS/m in the saturation extract (FAO, 1988).

Note: dS/m = decisiemens per metre this is equivalent to the measurement of electrical conductivity of the salinity which can also be described as millimho per centimetre, hence 1 dS/m = 1 mmho/cm. Once the dS/m is known this can be converted to either mg/L or parts per million (ppm) (University of California, 2020).

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Annotations

Synonyms

Not identified.

Additional scientific description

Salt-affected soils consist of saline and sodic soils, which occur in all continents and under almost all climatic conditions, but their distribution is relatively more extensive in the arid and semi-arid regions compared to the humid regions. Soil salinisation and sodification are major soil degradation processes threatening ecosystems and are recognised as being among the most important problems at a global level for agricultural production, food security and sustainability in arid and semi-arid regions. There are extensive areas of salt-affected soils on all the continents, but their extent and distribution have not been studied in detail (FAO, 2020a).

Salt-affected soils have serious impacts on soil functions leading to an array of consequences, including significant decreases in agricultural productivity, water quality, soil biodiversity, and soil erosion. Salt-affected soils have a decreased ability to act as a buffer and filter against pollutants. The degradation of soil structure and functions of global ecological systems such as hydrological, nutrient and biogeochemical cycles, impair the provision of ecosystem services, which are critical for supporting human life and biodiversity. Salt-affected soils reduce both the ability of crops to take up water and the availability of micronutrients. They also concentrate ions that are toxic to plants and may degrade the soil structure (FAO, 2020a).

Soluble salts most commonly present are the chlorides and sulphates of sodium, calcium and magnesium. Nitrates are present in appreciable quantities only rarely. Sodium and chloride are by far the most dominant ions, particularly in highly saline soils, although calcium and magnesium are usually present in sufficient quantities to meet the nutritional needs of crops. Many saline soils contain appreciable quantities of gypsum ($CaSO_4$, $2H_2O$) in the profile (FAO, 1988).

Salt that accumulates in soil can come from a number of sources (NSW Department of Planning, Industry and Environment, 2019):

- *Rainfall:* airborne salts from ocean spray and pollution are dissolved in atmospheric moisture and deposited on the land in precipitation.
- *Weathering:* minerals that make up rocks break down and release ions that are able to form salts.
- *Aeolian deposits:* wind picks up and transports dust and salt from soil and lake surfaces and redistributes it across the landscape.
- *Connate salt:* during deposition, salt has been incorporated into marine sediments, or in areas of internal drainage, salt has accumulated over geological time due to transport and evaporative processes. These areas may later become sources of salt.

Salinity affects (NSW Department of Planning, Industry and Environment 2019):

- *Farms:* salinity can decrease plant growth and water quality resulting in lower crop yields and degraded stock water supplies. Excess salt affects overall soil health, reducing productivity. It kills plants, leaving bare soil that is prone to erosion.
- *Wetlands:* as salinity increases over time, wetlands become degraded, endangering wetland species and decreasing biodiversity. Where sulphate salts are present, there is an increased risk of acid sulphate soil formation.
- *Rivers:* increased volume (load) and/or concentration (electrical conductivity) of salinity in creeks and streams degrades urban water supplies, affects irrigated agriculture and horticulture, and adversely impacts on riverine ecosystems.
- *Drinking water:* when a source of drinking water becomes more saline, extensive and expensive treatment may be needed to keep salinity at levels suitable for human use.
- *Buildings, roads and pipes:* salinity damages infrastructure, shortening its life and increasing maintenance costs.
- *Sports grounds:* salty ground may lose all grass cover, making playing fields unusable.

Metrics and numeric limits

The salt concentration in water extracted from a saturated soil (called saturation extract) defines the salinity of this soil. If the salt content of this water is <3 g/l, the soil is said to be non-saline. If the salt concentration of the saturation extract is >12 g/l, the soil is said to be highly saline (FAO, 1985).

Soil salinity classes and crop growth (FAO, 1988):

Soil salinity class	Electrical conductivity of the saturation extract, dS/m	Effect on crop plants
Non saline	0-2	Negligible salinity effects
Slightly saline	2-4	Yields of sensitive crops may be restricted
Moderately saline	4-8	Yields of many crops are restricted
Strongly saline	8-16	Only tolerant crops yield satisfactorily
Very strongly saline	>16	Only a few very tolerant crops yield satisfactorily

Key relevant UN convention/multilateral treaty

Food and Agriculture Organization of the United Nations Global Soil Partnership (GSP) (FAO, 2012).

Food and Agriculture Organization of the United Nations Eurasian Soil Partnership (EASP) (FAO, 2013).

The World Bank Eurasian Center for Food Security (ECFS) (World Bank, 2012).

Examples of drivers, outcomes and risk management

The amount of crop yield reduction depends on such factors as crop growth, the salt content of the soil, climatic conditions, etc. In extreme cases where the concentration of salts in the root zone is very high, crop growth may be entirely prevented. To improve crop growth in such soils the excess salts must be removed from the root zone. The term reclamation of saline soils refers to the methods used to remove soluble salts from the root zone. Methods commonly adopted or proposed to accomplish this include the following (FAO, 1988):

- *Scraping*: Removing the salts that have accumulated on the soil surface by mechanical means has had only a limited success.
- *Flushing*: Washing away the surface accumulated salts by flushing water over the surface is sometimes used to desalinise soils having surface salt crusts.
- *Leaching*: The most effective procedure for removing salts from the root zone of soils. Leaching is most often accomplished by ponding fresh water on the soil surface and allowing it to infiltrate.

The Food and Agriculture Organization of the United Nations (FAO) Global Soil Partnership and the Eurasian Soil Partnership (EASP), in collaboration with the Eurasian Center for Food Security (ECFS), announced a call in 2019 for short-term projects aimed at mitigation of or adaptation to soil salinity through the application of sustainable soil management practices. The objective of this initiative is to establish pilot projects in the field in Central Asian countries to test the viability and usefulness of different soil management practices for the adaptation or mitigation of soil salinity in a sustainable manner, with a duration not exceeding 12 months (FAO, 2019).

In order to achieve its mandate, the FAO Global Soil Partnership addressed five pillars of action to be implemented in collaboration with its regional soil partnerships (FAO, 2020b):

- Promote sustainable management of soil resources for soil protection, conservation and sustainable productivity.
- Encourage investment, technical cooperation, policy, education awareness around salinity in soil.
- Promote targeted soil research and development focusing on identified gaps and priorities and synergies with related productive, environmental and social development actions.
- Enhance the quantity and quality of soil data and information: data collection (generation), analysis, validation, reporting, monitoring and integration with other disciplines.
- Harmonise methods, measurements and indicators for the sustainable management and protection of soil resources.

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Coordinating agency or organisation

Food and Agricultural Organization of the United Nations.

EN0008 / **ENVIRONMENTAL / Environmental Degradation**

Biodiversity Loss

Definition

Biodiversity loss refers to the reduction of any aspect of biological diversity (i.e., diversity at the genetic, species and ecosystem levels) in a particular area through death (including extinction), destruction or manual removal; it can refer to many scales, from global extinctions to population extinctions, resulting in decreased total diversity at the same scale (IPBES, no date).

Reference

IPBES, no date. Glossary: Biodiversity loss. Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). ipbes.net/glossary/biodiversity-loss Accessed 20 December 2019.

Annotations

Synonyms

None identified.

Additional scientific description

Human actions currently threaten more species with global extinction than ever before. An average of around 25% of species in assessed animal and plant groups are threatened, suggesting that around 1 million species already face extinction, many within decades, unless action is taken to reduce the intensity of drivers of biodiversity loss. Without such action, there will be a further acceleration in the global rate of species extinction, which is already at least tens to hundreds of times higher than it has averaged over the past 10 million years (IPBES, 2019:11-12).

Metrics and numeric limits

No global resource identified.

Key relevant UN convention/multilateral treaty

The Convention on Biological Diversity (1992) has three main objectives: the conservation of biological diversity, the sustainable use of the components of biological diversity, and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources. At the time of writing, there were 196 parties to the Convention on Biological Diversity (CBD, 1993).

The Convention on the Conservation of Migratory Species of Wild Animals also referred as the Bonn Convention and the Convention on Migratory Species (1979) is an environmental treaty under the aegis of the United Nations Environment Programme for the conservation and sustainable use of migratory animals and their habitats. At the time of writing, there were 130 parties to the convention (CMS, 1983).

The Convention on Wetlands also referred as the Ramsar Convention (1971) provides the framework for the conservation and use of wetlands and their resources. At the time of writing, almost 90% of UN member states were contracting parties to this intergovernmental treaty (Ramsar, 2014).

The Convention on International Trade in Endangered Species of Wild Fauna and Flora also referred as CITES (1973) is an intergovernmental agreement which aims to ensure that international trade in specimens of wild animals and plants does not threaten their survival. At the time of writing, there were 183 parties to the convention (CITES, 2019).

United Nations Convention to Combat Desertification (1994) links environmental concerns and development issues to sustainable land management practices. At the time of writing, there were 197 parties to the convention (UNCCD, no date).

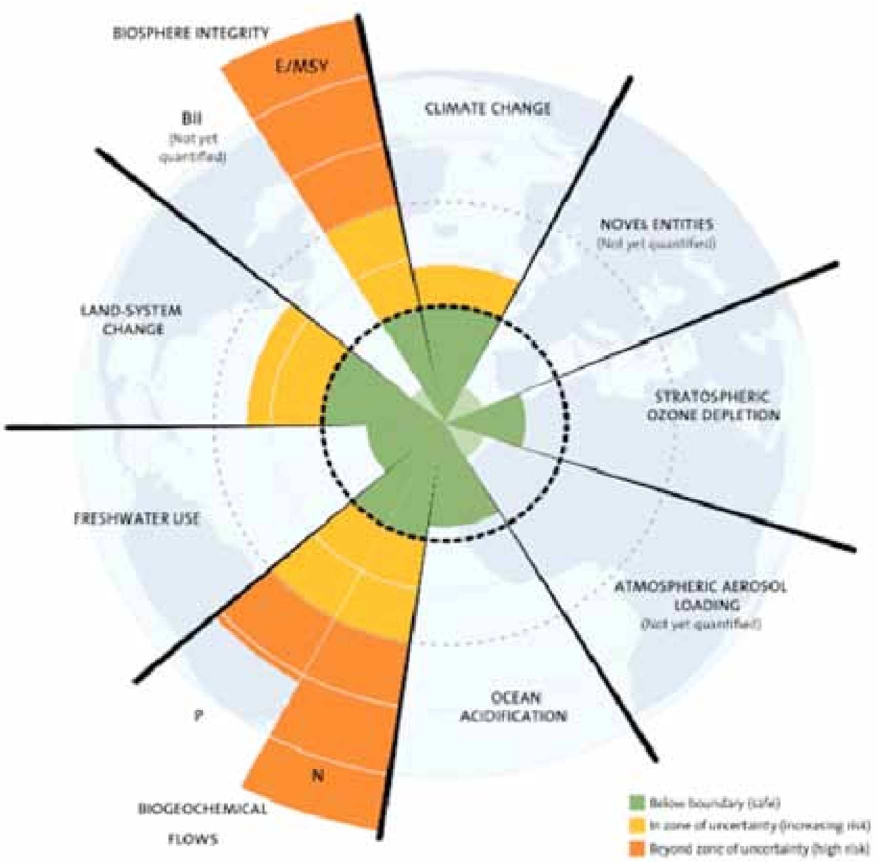
The World Heritage Convention (1972) recognises some World Heritage properties specifically for their outstanding biodiversity values, protecting many of the most important ecosystems, areas of high biodiversity and mitigating against loss. At the time of writing, there were 193 parties to the convention (UNESCO, 2019).

Examples of drivers, outcomes and risk management

The direct drivers of change leading to biodiversity loss include direct exploitation of organisms, changes in land and sea use, climate change, pollution, and invasion of alien species. The direct drivers result from an array of underlying causes (indirect drivers), underpinned by societal values and behaviours such as production and consumption patterns, human population dynamics and trends, trade, technological innovations and local through global governance (IPBES, 2019).

Biodiversity provides numerous ecosystem services that are critical to human well-being at present and in the future. Biodiversity loss can have significant direct human health impacts if ecosystem services are no longer adequate to meet social needs. In parallel, it can also affect indirectly livelihoods, income, local migration and, occasionally, may even lead to or exacerbate political conflict (WHO, no date). In addition, biophysical diversity of microorganisms, flora and fauna provide important benefits for biological, health, and pharmacological sciences. Loss in biodiversity may limit discovery of potential treatments for many diseases and health problems (WHO, no date).

In 2009, a group of internationally renowned scientists identified the nine processes that regulate the stability and resilience of the Earth system (Figure I: the nine planetary boundaries). They proposed quantitative planetary boundaries within which humanity can continue to develop and thrive for generations to come to the extent that the boundaries are not crossed (Stockholm Resilience Center, no date). The scientists highlighted that transgressing one or more planetary boundaries may be deleterious or even catastrophic due to the risk of crossing thresholds that will trigger non-linear, abrupt environmental change within continental-to planetary-scale systems (Rockström et al., 2009). As of 2015, two boundaries including biosphere integrity (biodiversity loss and extinctions) were crossed, while others were in imminent danger of being crossed.



The following main interventions ('levers') to generate transformative change by tackling the underlying causes of the deterioration of nature are suggested by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services: develop incentives and widespread capacity for environmental responsibility and eliminating perverse incentives; reform sectoral and segmented decision-making to promote integration across sectors and jurisdictions; take pre-emptive and precautionary actions in regulatory and management institutions and businesses to avoid, mitigate and remedy the deterioration of nature, and monitor their outcomes; manage for resilient social and ecological systems in the face of uncertainty and complexity, to deliver decisions that are robust in a wide range of scenarios; and strengthen environmental laws and policies and their implementation, and the rule of law more generally (IPBES, 2019).

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WHO, no date. Biodiversity and Health. World Health Organization (WHO). www.who.int/globalchange/ecosystems/biodiversity/en Accessed 20 December 2019.

World Heritage Convention, 1972. http://whc.unesco.org/archive/convention-en.pdf Accessed 19 January 2020.

Coordinating agency or organisation

Not identified. Figure 1 A new analysis of the Planetary Boundaries concept shows that the framing has focused discussion on maximum allowable impacts on the Earth system. This can overshadow an important role of the concept as a 'signpost to a fundamentally different' route to sustainable development. Illustration: J. Lokrantz/Azote based on Steffen et al. (2015).

EN0009 / **ENVIRONMENTAL / Environmental Degradation (Forestry)**

Deforestation

Definition

Deforestation is the conversion of forest to other land use independently of whether human-induced or not (FAO, 2020).

Reference

FAO, 2020. Global Forest Resources Assessment 2020. Terms and Definitions FRA 2020. Food and Agriculture Organization of the United Nations (FAO). Forest Resources Assessment Working Paper No. 188. www.fao.org/3/I8661EN/i8661en.pdf Accessed 19 October 2020.

Annotations

Synonyms

None.

Additional scientific description

The Food and Agriculture Organization of the United Nations (FAO) has monitored the world's forests at 5 to 10 year intervals since 1946. The recent Global Forest Resources Assessments have been produced every five years in an attempt to provide a consistent approach to describing the world's forests and how they are changing (FAO, 2020a).

Deforestation includes the permanent reduction of the tree canopy cover below the minimum 10% threshold. It also includes areas of forest converted to agriculture, pasture, water reservoirs, mining and urban areas. The term specifically excludes areas where the trees have been removed as a result of harvesting or logging, and where the forest is expected to regenerate naturally or with the aid of silvicultural measures. The term also includes areas where, for example, the impact of disturbance, over-utilisation or changing environmental conditions affects the forest to an extent that it cannot sustain a canopy cover above the 10% threshold (FAO, 2020b).

Deforestation and forest degradation continue to take place at alarming rates and contribute significantly to the ongoing loss of biodiversity (FAO and UNEP, 2020). Since 1990, it is estimated that 420 million hectares of forest have been lost through conversion to other land uses, although the rate of deforestation has decreased over the past three decades (FAO, 2020a).

Between 2015 and 2020, the rate of deforestation was estimated at 10 million hectares per year, down from 16 million hectares per year in the 1990s. The area of primary forest worldwide has decreased by over 80 million hectares since 1990 (FAO, 2020a).

Agricultural expansion continues to be the main driver of deforestation and forest degradation and the associated loss of forest biodiversity. Large-scale commercial agriculture (primarily cattle ranching and cultivation of soya bean and oil palm) accounted for 40% of tropical deforestation between 2000 and 2010, and local subsistence agriculture for another 33% (FAO and UNEP, 2020).

Metrics and numeric limits

Deforestation area expressed in thousand hectares per year for the following periods: 1990–2000, 2000–2010, 2010–2015 and 2015–2020 (FAO, 2020a).

The data for the Global Forest Resources assessment are collected using an online tool that also serves as a data dissemination platform. All data countries and territories reported to Forest Resources Assessment 2020 are available (FAO, no date).

Key relevant UN convention/multilateral treaty

Convention on Biological Diversity (CBD): Established in 1992 and entered into force on 29 December 1993, the convention has three main objectives: the conservation of biological diversity; the sustainable use of the components of biological diversity; and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources (CBD, 1992).

United Nations Framework Convention on Climate Change (UNFCCC). Negotiated from February 1991 to May 1992, the Convention entered into force on 21 March 1994. It seeks to reduce atmospheric concentrations of greenhouse gases, with the aim of preventing dangerous anthropogenic interference with the Earth's climate system. At the Conference of the Parties (COP21) in Paris, on 12 December 2015, Parties to the UNFCCC reached a landmark agreement to combat climate change and to accelerate and intensify the actions and investments needed for a sustainable low carbon future (UNFCCC, 2015).

United Nations Convention to Combat Desertification (UNCCD). Established in 1994, this Convention is the sole legally binding international agreement linking environment and development to sustainable land management. The Convention addresses specifically the arid, semi-arid and dry sub-humid areas, known as the drylands, where some of the most vulnerable ecosystems and peoples can be found (UNCDD, 2017).

Examples of drivers, outcomes and risk management

Agricultural expansion is the main driver of deforestation and forest fragmentation and the associated loss of forest biodiversity. In the tropical domain, net annual loss of forest area from 2000 to 2010 was about 7 million hectares, and net annual increase in agricultural land area was more than 6 million hectares. There were significant regional variations: Central and South America, sub-Saharan Africa and South and Southeast Asia all had net losses of forest and net gains in agricultural land. In tropical and subtropical countries, large-scale commercial agriculture and subsistence agriculture accounted for 73% of deforestation, with significant regional variations. For example, commercial agriculture accounted for almost 70% of deforestation in Latin America but for only one-third in Africa, where small-scale agriculture is a more significant driver (FAO and UNEP, 2020).

In economic terms, the tropical forests destroyed each year represent a loss in forest capital valued at USD 45 billion. By destroying the forests, all potential future revenues and future employment that could be derived from their sustainable management for timber and non-timber products disappear (FAO, 2007).

Creation of protected areas has historically been the forest governance instrument most often adopted to pursue biodiversity protection objectives. This approach has achieved positive results in terms of conserving species and establishing barriers to the progress of deforestation (FAO and UNEP, 2020).

It is considered that agri-businesses should meet their commitments to deforestation-free commodity chains and those companies that have not made zero deforestation commitments should do so. Commodity investors should adopt business models that are environmentally and socially responsible. These actions will, in many cases, require a revision of current policies and financial incentives (FAO and UNEP, 2020).

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Coordinating agency or organisation

Food and Agriculture Organization of the United Nations (FAO).

EN0010 / **ENVIRONMENTAL / Environmental Degradation**

Forest Declines and Diebacks

Definition

Forest declines and diebacks are episodic events characterised by premature, progressive loss of tree and stand vigour and health over a given period without obvious evidence of a single clearly identifiable causal factor such as physical disturbance or attack by primary disease or insect (Ciesla and Donaubauer, 1994).

Reference

Ciesla, W.M. and M.E. Donaubauer, 1994. Decline and dieback of trees and forests: a global overview. FAO Forestry Paper No. 120. www.fao.org/3/ap429e/ap429e00.pdf.2 Accessed 13 October 2020.

Annotations

Synonyms

Stand level dieback, Canopy level dieback, Walsterben and Waldschaden.

Additional scientific description

Forest ecosystems are a critical component of the world's biodiversity as many forests are more biodiverse than other ecosystems. Forests cover 31% of the global land area. Approximately half of the forest area is relatively intact, and more than one-third is primary forest (i.e., naturally regenerated forests of native species, where there are no visible indications of human activities and the ecological processes are not significantly disturbed) (FAO and UNEP, 2020).

Forests provide habitat for the vast majority of the terrestrial plant and animal species known to science. Forests are being rapidly and directly transformed in many areas by the impacts of expanding human populations and economies (Allen, 2009). Forests and the biodiversity they contain continue to be under threat from actions to convert the land to agriculture or unsustainable levels of exploitation, much of it illegal (FAO and UNEP, 2020).

Forest decline is characterised by the presence of symptoms such as reduced growth, shortened internodes, root necrosis, premature fall colouring in temperate forests, yellowing and loss of foliage, dieback of twigs and branches generally beginning in the upper crown, sprouting from adventitious buds and(or) increased prevalence and pathogenicity of root decay fungi (Manion and Lachance, 1992).

Decline has been considered a symptom of disease, a distinct class of disease and as part of forest dynamics. Another widely accepted concept describes decline as a result of interaction of predisposing, inciting and contributing factors (Manion and Lachance, 1992). Predisposing factors are often of long-term duration with slowly changing factors such as soil, site and climate. These factors alter the ability of trees to withstand or respond to injury-inducing agents.

Forests generally produce dieback of small branches. Examples include defoliating insects, late spring frost, drought (Steinkamp and Hickler, 2015) and salt spray. The contributory factors are those which further weaken and ultimately kill the tree. Examples include bark beetles, canker fungi and root decay fungi. These factors are persistent and visible and often wrongly blamed for tree death (Ciesla and Donaubauer, 1994).

Less evident are the pervasive effects of ongoing climatic changes on the condition and status of forests around the world. Recent examples of drought and heat-related forest stress and dieback (defined here as tree mortality noticeably above usual mortality levels) are being documented from all forested continents, making it possible to begin to see global patterns. While climate events can damage forests in many ways ranging from ice storms to tornadoes and hurricanes, the emphasis here is on climatic water stress, driven by drought and warm temperatures (Allen, 2009).

It has been estimated that the world is losing 20,000 hectares of forest a day with 835 hectares of forest disappearing every hour, the equivalent of 1140 football pitches (UNEP, FAO and UNFF, 2009).

Metrics and numeric limits

The Food and Agricultural Organization of the United Nations (FAO) has been monitoring the world's forests at 5 to 10 year intervals since 1946. The recent Global Forest Resources Assessments have been produced every five years in an attempt to provide a consistent approach to describing the world's forests and how they are changing.

The guidelines and specifications for the Global Forest Resources Assessments (FAO, 2020) have been adapted both in scope and reporting regularity to better respond to recent developments in the international forest policy arena, such as Agenda 2030 for Sustainable Development (United Nations, 2015), the United Nations Strategic Plan for Forests 2017-2030 (UNDESA, 2017) and the Paris agreement (UNFCCC, 2015). Furthermore, the reporting content has been streamlined and a new online reporting platform has been developed, to make reporting more efficient and to decrease countries' reporting burden (FAO and UNEP, 2020).

Key relevant UN convention/multilateral treaty

UN Climate Change Convention: At the Conference of the Parties (COP21) in Paris, on 12 December 2015, Parties to the United Nations Framework Convention on Climate Change (UNFCCC) reached a landmark agreement to combat climate change and to accelerate and intensify the actions and investments needed for a sustainable low carbon future (UNFCCC, 2015).

Examples of drivers, outcomes and risk management

The total forest area is 4.06 billion hectares, or approximately 5000 m2 (or 50 x 100 m) per person, but forests are not equally distributed around the globe. More than half of the world's forests are found in only five countries (Russian Federation, Brazil, Canada, United States of America, China) and two-thirds of forests are found in ten countries (FAO and UNEP, 2020).

Multiple factors such as insect pest and disease outbreaks, and extreme weather events such as drought are considered the main causes for forest decline and diebacks. However, human activities, such as pollution, urbanisation and encroachments on sensitive habitat, can exacerbate what would ordinarily be cyclical occurrences of these factors. Forest decline can be hastened and worsened as the forest ecosystem becomes less resilient and more sensitive to changes, whether they be natural or anthropogenic (Zhu and Liu, 2004; Martínez-Vilalta et al., 2012; DeSantis et al., 2016).

Risk management includes sustainable forest management practises to establish resilient forest ecosystems, establish early warning and early action systems, and increase community participation in forest management.

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Coordinating agency or organisation

Food and Agricultural Organization of the United Nations (FAO).

EN0011 / **ENVIRONMENTAL / Environmental Degradation**

Forest Disturbances

Definition

Forest disturbance is the damage caused by any factor (biotic or abiotic) that adversely affects the vigour and productivity of the forest and which is not a direct result of human activities. It includes disturbance by insect pests, diseases, severe weather events and fires (FAO, 2018, 2020).

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Annotations

Synonyms

None identified.

Additional scientific description

Forest area is defined by the Food and Agricultural Organization of the United Nations (FAO) as: Land spanning more than 0.5 ha with trees higher than 5 m and a canopy cover of more than 10%, or trees able to reach these thresholds *in situ*. It does not include land that is predominantly under agricultural or urban land use (FAO, 2018).

Forest disturbances include areas of forest affected by: (i) insects: disturbance caused by insect pests; (ii) diseases: disturbance caused by diseases attributable to pathogens, such as bacteria, fungi, phytoplasma or viruses; (iii) severe weather events: disturbances caused by abiotic factors, such as snow, storm, droughts, etc; and (iv) fire: forest area affected by fire (FAO, 2018).

Forest degradation does not have a single commonly agreed definition, but forest degradation is considered to occur when forest ecosystems lose their capacity to provide important goods and services to people and nature (IUCN, 2017). In the context of the United Nations Framework Convention on Climate Change, forest degradation leads to a decline of carbon stocks (UNFCC, 2008).

The world's total forest area is approximately 4.06 billion ha, which is 31% of the total land area. This area is equivalent to 0.52 ha per person. Forests are not distributed equally among the world's people, or geographically. The tropical domain has 45% of the world's forests. It should also be noted that more than half (54%) of the world's forests are in only five countries (Russian Federation, Brazil, Canada, USA, China) (FAO, 2020).

Measuring forest degradation and disturbance is challenging. There is no commonly agreed definition or monitoring method. Degradation and disturbances can entail long-term negative changes in the structure, composition and other characteristics of the forest which can be difficult to detect.

Metrics and numeric limits

The Global Forest Resources Assessment 2020 noted that relatively few data were available for forest disturbance and that it was not possible to estimate accurately the total forest area affected by disturbances globally (FAO, 2020). Only 36 countries and territories, accounting for just 25% of the world's forest area, reported complete time-series data for the forest area disturbed annually by insects (2000–2017). Therefore, further discussion is warranted on how best to obtain and analyse data and whether more information is needed to properly assess forest disturbance (FAO, 2020).

Key relevant UN convention/multilateral treaty

The *Convention on Biological Diversity (CBD)* was established in 1992 and entered into force on 29 December 1993. The convention has three main objectives: the conservation of biological diversity; the sustainable use of the components of biological diversity; and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources (CBD, 1992).

The United Nations Framework Convention on Climate Change (UNFCCC) was negotiated from February 1991 to May 1992 and entered into force on 21 March 1994. It seeks to reduce atmospheric concentrations of greenhouse gases, with the aim of preventing dangerous anthropogenic interference with the Earth's climate system. At the Conference of the Parties (COP21) in Paris, on 12 December 2015, Parties to the UNFCCC reached a landmark agreement to combat climate change and to accelerate and intensify the actions and investments needed for a sustainable low carbon future (UNFCCC, 2015).

Examples of drivers, outcomes and risk management

Over 80% of the world's terrestrial biodiversity can be found in forests. Forest disturbance can threaten the survival of many species and reduce the ability of forests to provide essential services such as clean air and water, healthy soils for agriculture, and climate regulation. Additionally, forests support the livelihoods of 1.6 billion people globally, one billion of whom are among the world's poorest (IUCN, 2017).

Forests face many disturbances that can adversely affect their health and vitality and reduce their ability to provide a full range of goods and ecosystem services.

About 98 million ha of forest were affected by fire in 2015 (the latest available global data set) this was mainly in the tropical domain, where fire burned about 4% of the total forest area in that year. More than two-thirds of the total forest area affected was in Africa and South America (FAO, 2020). In Canada, since 1900, wildfires consume on average 2.5 million ha per year (NRC, no date). In Europe, in 2018, 58,016 fires consumed 350,180 ha compared to an average of 64,261 fires consuming 406,281 ha per year between 2008 and 2017 (JRC, 2018). The Global Forest Resources Assessment 2020 noted the extent of the different types of disturbance in the forests of the world in 2015 (FAO, 2020). Fifty-one countries representing 42% of the world's forest area reported that an area of 6.6. million ha (0.4% of the forest area of the reporting countries) was affected by disease. Sixty-two countries representing 52% of the world's forest area, reported that an area of 30.2 million ha (1.4% of the forest area of the reporting countries) was affected by insects. Forty-eight countries representing 37% of the world's forest area, reported that an area of 3.8 million ha (0.3% of the forest area of the reporting countries) was affected by severe weather events.

Air, water and soil pollution can also contribute to forest degradation. For example, acid rain, resulting from the interaction of sulphur dioxide and nitrogen oxides (mostly produced by the burning of fossil fuels, but can also be from volcanic eruptions) with water in the atmosphere, damages trees and forests. Acid rain leaches aluminium from the soil, and that aluminium can be toxic to plants, including trees. In addition, other nutrients are also removed from the soil by acid rain, limiting tree growth. At high elevations, acidic fog and clouds might strip nutrients from foliage, leaving trees with brown or dead leaves and needles. The trees are then less able to absorb sunlight, making them weak and less able to withstand freezing temperatures (US EPA, no date).

Many countries have developed policies and laws designed to promote the sustainable and multipurpose use of forests and trees. Such policies and laws serve as a foundation for sustainable forest management by, for example, promoting legal timber trade, involving stakeholders in forest management, addressing forest tenure and providing incentives (FAO, 2020).

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Coordinating agency or organisation

Food and Agricultural Organization of the United Nations (FAO).

EN0012 / **ENVIRONMENTAL / Environmental Degradation (Forestry)**

Forest Invasive Species

Definition

Forest invasive species are any species that are non-native to a particular forest ecosystem and whose introduction and spread causes, or are likely to cause, socio-cultural, economic or environmental harm or harm to human health (adapted from FAO, 2015).

Reference

FAO, 2015. Invasive species: impacts on forests and forestry. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/forestry/aliens/en Accessed 24 October 2020.

Annotations

Synonyms

Forest pests (FAO, 2018a).

Additional scientific description

Forest invasive species occur in all major taxonomic groups from micro-organisms to mammals. The invasive species include bacteria, fungi, flatworms, nematodes, insects and arachnids, molluscs, amphibians, reptiles, birds, mammals, grasses, plants, trees and shrubs (FAO, 2009a).

The Food and Agriculture Organization of the United Nations (FAO) in 2009 reported that (FAO, 2009b):

- *For insect pests*, the most commonly reported pest species belong to the orders Coleoptera and Lepidoptera which together made up over 70% of all insect pest species reported. Hemipteran species were the third most important insect order at 16%. In Africa and Asia and the Pacific, both Coleoptera and Lepidoptera made up the majority of pest species reported. Europe reported more lepidopterans and Latin America and the Caribbean reported more coleopterans.
- *For diseases*, the majority of species were members of the phylum Ascomycota which represented almost 60% of all pathogens reported. Basidiomycota species were the next major group at 33%. Four of the regions reported more Ascomycota species while the Near East reported more Basidiomycota species.
- *For the category other pests*, Acarina species were the most common followed by Artiodactyla species (even-toed ungulates) and Santalales (mistletoes and parasitic plants). Nematodes, rodents and primates were also classified as important pests. Africa reported more primate species, Europe more Artiodactyla, Latin America and the Caribbean more mistletoes and parasitic plants, and the Near East more Acarina species. In the Asia and Pacific region, nematodes and rodents were equally reported.

Globally, many forests are continually subject to severe outbreaks of invasive species, which can have huge environmental and sociocultural impacts. Threat of forest invasive species is rising with increasing global trade and travel and is exacerbated by impacts of climate change. Managing invasive species and avoiding new introductions of species with known potential to become invasive require coordinated efforts by many actors, nationally, regionally and globally (FAO and UNEP, 2020).

It is very important to protect the world's forests from harm. The global forest area is just over 4 billion ha, which represents 31% of the total land area (FAO, 2010). Forests are important global resources that provide a wide range of environmental, economic and social benefits. They provide a variety of valuable products, such as timber, fuelwood, fibre and other wood and non-wood forest products, and contribute to the livelihoods of rural communities. They provide vital ecosystem services, such as combating desertification, protecting watersheds, regulating climate, and maintaining biodiversity, and play an important role in preserving social and cultural values (FAO, 2011).

Metrics and numeric limits

No globally delivered solution is available for this complex issue but work continues by several organisations.

FAO Forestry Department activities: data gathered in the global review of the status of invasiveness of forest tree species outside their native habitat is available in database format (FAO, 2009c).

The Global Invasive Species Programme (GISP) was established in 1997 to address global threats caused by invasive species and to provide support to the implementation of Article 8(h) of Convention on Biodiversity. To increase awareness and provide policy advice, the Programme has prepared the Global strategy on invasive alien species, which outlines ten strategic responses to the invasive species problem (Global Invasive Species Database, no date).

Key relevant UN convention/multilateral treaty

The Forest Invasive Species Network for Africa (FISNA) 2004 (FAO, no date).

International Plant Protection Convention (IPPC, 1997).

International Standards for Phytosanitary Measures (IPPC, 2019).

Examples of drivers, outcomes and risk management

The FAO Forestry Department is addressing the pressing global issue of invasive species in the following ways:

- A review of forest insect pests and diseases (including invasive species) in both naturally regenerating forests and planted forests was carried out in 25 countries representing Africa, Asia and the Pacific, Europe, Latin America and the Caribbean and the Near East (FAO, 2020).
- Preparing profiles on a number of important pest species impacting forests and the forest sector worldwide were prepared (FAO, 2018a).
- Publishing a report on global forest health, including insect pests, diseases and invasive species (FAO, 2009b).
- With the financial support of the FAO-Netherlands Partnership Programme, carrying out a number of fact-finding studies to assess the extent and intensity of invasiveness by forest trees (FAO, 2018b).
- Making available the data gathered in the global review of the status of invasiveness of forest tree species outside their native habitat in database format (FAO, 2009c).
- Documenting the benefits and drawbacks of Prosopis spp. which have been introduced in many countries, especially in dry and semi-arid zones, because of its capacity to survive in harsh environments and its potential in the restoration of degraded lands (FAO, 2009d).
- Offering assistance to countries not only in response to pest outbreaks and emergencies but also in establishing long-term prevention and forest protection strategies (FAO, 2021).
- Serving as a neutral forum, bringing countries together to discuss technical and policy issues related to invasive species and the forest sector.
- Helping establish regional networks dedicated to the issue of invasive species and the forest sector (FAO, 2021).
- FAO is a member of the Inter-agency Liaison Group on Invasive Alien Species (IALG-IAS) of the Convention on Biological Diversity (CBD) which facilitates cooperation among relevant organisations to support measures to prevent the introduction and mitigate the impacts of invasive alien species (FAO, 2015).

The Global Invasive Species Database (GISD) is a free, online searchable source of information about alien and invasive species that negatively impact biodiversity. The database is managed by the Invasive Species Specialist Group (ISSG) of the International Union for Conservation of Nature (IUCN) Species Survival Commission. It was developed between 1998 and 2000 as part of the global initiative on invasive species led by the Global Invasive Species Programme (GISP). The United Nations Environment Programme (UNEP) World Conservation Monitoring Centre (UNEP-WCMC) has recently developed a set of issue-based modules summarising country obligations under the Convention on Biological Diversity (CBD) and other conventions, and in 2020 published a report on Building a Multidimensional Biodiversity Index - A Scorecard for Biodiversity Health (Soto-Navarro et al., 2020).

The objectives of the Forest Invasive Species Network for Africa, for example, are to: facilitate exchange of information and provide a link for communication about forest invasive species; alert and provide policy advice on transboundary movement, phytosanitary measures and other relevant information; raise regional awareness on forest invasive species issues; encourage the publication and sharing of research results, management and monitoring strategies; facilitate taxonomic support; act as a link between and among experts, institutions, networks and other stakeholders concerned with forest invasive species; facilitate the mobilisation of resources for critical activities in management of invasive species; and provide technical guides on research and control of invasive species for sustainable forest protection and health issues in Africa (FAO, no date).

Tree Cities of the World is an international effort, promoted by the FAO and the Arbor Day Foundation in the United States of America, to recognise cities and towns that are committed to maintaining, sustainably managing and celebrating their urban forests and trees. To receive recognition, a town or city must meet five core standards: establish authority; set the rules; know what you have; allocate the resources; and celebrate achievements (FAO and UNEP, 2020).

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Coordinating agency or organisation

Food and Agricultural Organization of the United Nations.

EN0013 / **ENVIRONMENTAL / Environmental Degradation (Forestry)**

Wildfires

Definition

Wildfires are any unplanned or uncontrolled fire affecting natural, cultural, industrial and residential landscapes (adapted from FAO, 2010).

Reference

FAO, 2010. FAO Term Portal: Collection: Fire Management (A10.6)/CSCM. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/faoterm/viewentry/en/?entryId=97000 Accessed 27 October 2020.

Annotations

Synonyms

Landscape fire, Vegetation fire, Wildland fire, Forest fire, Bushfire, Brush fire, Scrub fire, Peat fire, Grass fire.

Additional scientific description

Unplanned or uncontrolled landscape fires (wildfires) are either started by natural causes (lightning, occasionally by burning coal seams or volcanic activity) or – predominantly at global level – by human activities and primarily by burning live or dead vegetation in natural or anthropogenically altered ecosystems (Robinne et al., 2018).

These include forests, grasslands, bush (shrub, scrub), and organic terrain (peatlands, wetlands), cultivated lands (agricultural and pasture lands, plantations, abandoned formerly cultivated lands) as well as protected lands (wilderness, conservation sites) (Robinne et al., 2018).

In addition, unplanned landscape fires may affect residential and industrial areas (houses and other structures, peri-urban fringes, infrastructure including critical infrastructure) and remnants of human activities (waste deposits, remediated and un-remediated mine sites, contaminated lands), resulting in co-burning of hazardous / toxic substances (GFMC, no date). Landscape fire attributes and descriptions include: fuel type (type of vegetation / combustible material burned, such as grass, shrub, forest, peat); fire type (ground, surface, crown fire); fire behaviour, energy release and emission characteristics (fire spread, fire intensity, fire severity, radiative power, smouldering vs. flaming combustion, gas and particle emissions); and temporal and spatial dimension (e.g., creeping fires in organic terrain, spotting flashovers, short- to long-lasting events; single vs. multiple fires) (GFMC, 2013; McLauchlan et al., 2020).

There have been a number of glossaries related to wildfires that have been prepared by the Food and Agriculture Organization of the United Nations (FAO) in collaboration with partners, as well as glossaries developed by national bodies in various countries in order to reflect local practices and policies. In 1999, the FAO and the Global Fire Monitoring Center (GFMC) updated the 1986 version of the publication FAO Wildland Fire Management Terminology. The revised version with English definitions and partial translation to French, Spanish, and German became available in December 2003. Translation of terms into Russian and Mongolian were added in 2008 and further revised in 2014. As of September 2010, the collection consists of 1351 concepts with synonyms, variants, definitions, remarks and context fields, where appropriate (FAO, 2010).

Metrics and numeric limits

Satellite data are processed to provide information on fire area and numbers.

FAOSTAT provides data on burned areas and emissions. The burned area data are from the Global Fire Emissions Database Version 3 (GFED3) derived from satellite data of the Moderate Resolution Imaging Spectroradiometer (MODIS) data Collection (5.1 MCD45A1) (FAO, 2020).

The Global Wildfire Information System (GWIS) provides statistics on average area burnt and numbers of fires by region and country (GWIS, 2019).

Key relevant UN convention/multilateral treaty

The only regional legal agreement in place is the Agreement on Transboundary Haze of the Association of South East Asian Nations (ASEAN, 2002).

Examples of drivers, outcomes and risk management

Unlike the majority of the geological and hydro-meteorological hazards – wildfires represent a hazard that is primarily influenced by humans and thus to a degree can be predicted, controlled and, in many cases, prevented. Wildfire occurrence, characteristics and impacts are closely linked to other hazards: droughts, heat waves and extreme weather events can influence fire intensity and severity and thus the duration, size and controllability of wildfires. Damaging wildfires are a symptom of current and past policy, planning and governance decisions that have created a context where fire ignition and spread occurs across the landscape, resulting in damage and loss (Robinne et al., 2018).

The effects of wildfires on vegetation cover and soil stability may create secondary hazards / subsidiary perils, such as post-fire landslides, mudslides, flash floods, erosion and siltation (triggered by post-fire rainfall on fire-disturbed surfaces) or altering / thawing of permafrost sites.

Fires burning on terrain contaminated by radioactivity may lead to uncontrolled re-distribution of radioactive particles. Wildfires burning into residential and industrial areas and waste deposits may generate toxic pollutants. Fires burning on terrain bearing unexploded ordinance and land mines could result in injuries and fatalities (Finlay et al., 2012).

Infrastructure and services, including power, water, and communication lines, roads and railways are damaged by wildfires. As well as the costs of firefighting, there are large financial and economic costs associated with rebuilding homes, businesses, and entire communities that have been damaged or destroyed by a major fire event.

Human health can be severely affected by wildfires. Certain populations are particularly vulnerable. Wood smoke has high levels of particulate matter and toxins. Respiratory morbidity predominates, but cardiovascular, ophthalmic and psychiatric problems can also result. In addition, severe burns resulting from direct contact with the fire require care in special units and carry a risk of multi-organ complications. The wider health implications from spreading air, water and land pollution are of concern. Access to affected areas and communication with populations living within them is crucial in mitigating risk (Finlay et al., 2012).

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Coordinating agency or organisation

Food and Agriculture Organization of the United Nations with input from the Global Fire Monitoring Center.

EN0014 / **ENVIRONMENTAL / Environmental Degradation**

Desertification

Definition

Desertification refers to land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities (UNCCD, 2017).

Reference

UNCCD, 2017. UNCCD Terminology: Desertification. United Nations Convention to Combat Desertification (UNCCD). https://knowledge.unccd.int/taxonomy/term/1338 Accessed 19 October 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

Desertification and land degradation are very serious challenges. They lead to hunger and poverty, drive unemployment, forced migration and conflict, while increasing the risk of extreme weather related to climate change (FAO, 2020a).

The most widely accepted definition in China for desertification is that given by Zhu et al. (1989, cited by FAO, 1997). Zhu describes desertification as the degradation process in environments similar to that of deserts consisting of blown and undulating sand sheets and mobile dunes which occurs when fragile ecosystems such as those with loose sandy surfaces in arid semi-arid and sub-humid zones are exposed to drought and frequent wind. This process reduces biomass productivity and arable land. The environmental changes caused by desertification produce desert-like landscapes in aboriginal non-desert areas or steppes (FAO, 1997).

Desertification is a silent, invisible crisis that is destabilising communities on a global scale. As the effects of climate change undermine livelihoods, inter-ethnic clashes are breaking out within and across states and fragile states are turning to militarisation to control the situation (UNCCD, 2014).

The effects of desertification are increasingly felt globally as victims turn into refugees, internally displaced people and forced migrants or they turn to radicalisation, extremism or resource-driven wars for survival. If peace, security and international stability are to be restored in a context where changing weather events are threatening the livelihoods of increasing numbers of people, survival options are declining and state capacities are overburdened, then more should be done to combat desertification, reverse land degradation and mitigate the effects of drought. Otherwise, many small-scale farmers and poor, land dependent communities face two choices: fight or flight (UNCCD, 2014).

In 2008, food insecurity triggered riots in over 30 countries. Drylands, which make up nearly 34% of the land mass and are a major source of food security especially for the poor, are being degraded daily (UNCCD, 2014).

It is estimated that 135 million people are at risk of being displaced by desertification. The problem is most severe in sub-Saharan Africa, particularly in the Sahel and the Horn of Africa (UNCCD, 2014).

A total of 842 million people, or about one in eight people in the world, were estimated to be suffering from chronic hunger in 2011–2013 and 12 million hectares of productive land become barren every year due to desertification and drought alone, which is a lost opportunity to produce 20 million tons of grain.

Agricultural yields could fall by up to 50% in some African countries if production practices are not changed (UNCCD, 2014).

Metrics and numeric limits

Key facts from Action Against Desertification: land degradation affects almost 2 billion ha of land worldwide, home to 1.5 billion people; every year, 24 billion tons of fertile soils are lost due to erosion; and 12 million ha of land are degraded each year – this is 23 ha per minute (FAO, 2020a).

Key relevant UN convention/multilateral treaty

Established in 1994, the *United Nations Convention to Combat Desertification (UNCCD)* is the sole legally binding international agreement linking environment and development to sustainable land management (UNCCD, 2017). The Convention addresses specifically the arid, semi-arid and dry sub-humid areas, known as the drylands, where some of the most vulnerable ecosystems and peoples can be found. Article 1: 'combating desertification' includes activities which are part of the integrated development of land in arid, semi-arid and dry sub-humid areas for sustainable development which are aimed at prevention and/or reduction of land degradation, rehabilitation of partly degraded land, and reclamation of desertified land (UNCCD, 2017).

Examples of drivers, outcomes and risk management

At the UN General Assembly in 2012, desertification, land degradation and drought were addressed in the Resolution adopted by the General Assembly on 27 July 2012 (UNGA, 2012). Two quotes of particular relevance are included here:

"We stress that desertification, land degradation and drought are challenges of a global dimension and continue to pose serious challenges to the sustainable development of all countries, in particular developing countries."

"We recognize the need for urgent action to reverse land degradation. In view of this, we will strive to achieve a land-degradation neutral world in the context of sustainable development. This should act to catalyse financial resources from a range of public and private sources".

Over 2 billion ha of land have potential for recovery through restoration approaches that combine activities like forestry with farmland re-vegetation. The restoration of over 5 million ha of land by communities that live across Burkina Faso, Niger and Mali has reversed outward migration flows (UNCCD, 2014).

Action Against Desertification (started in 2014) is an initiative of the African, Caribbean and Pacific Group of States (ACP) to restore drylands and degraded lands in Africa, the Caribbean and the Pacific to tackle the detrimental social, economic and environmental impact of land degradation and desertification (FAO, 2020b).

Action Against Desertification supports local communities, government and civil society in six African countries – Burkina Faso, Ethiopia, The Gambia, Niger, Nigeria and Senegal – as well as Fiji and Haiti to restore degraded land and to manage fragile ecosystems in a sustainable way. It is using a mix of the following activities (FAO, 2020b):

- *Land restoration:* putting rural communities at the heart of restoration and upscaling interventions to meet the massive needs.
- *Non-timber forest products:* support economic growth and sustainable management of natural resources.
- *Capacity development*: strengthening capacities in sustainable land management and land restoration.
- *Monitoring and evaluation:* collecting data, keeping track of progress, measuring impact.
- *Information sharing:* knowledge exchange and awareness raising about land degradation and desertification.
- *South-south cooperation:* sharing lessons learned on how to reverse land degradation.

In sub-Saharan Africa where half a billion inhabitants are rural, the majority lives off the land and desertification is a constant threat to their livelihoods. More than 1.5 billion people in the world depend on degraded land for their livelihoods, and 74% of them are poor. Under the United Nations Convention to Combat Desertification (UNCCD), the international legal framework for tackling desertification, land degradation and drought, 169 of its 194 Parties have declared that they are affected by desertification.

Key results to date from Action Against Desertification (FAO, 2020c) are summarised in the table:

Africa	Caribbean	Pacific
35,000 ha under restoration 2700,000 seedlings used 82,700 kg of seeds used 100 species used 500,000 people reached	7925 ha under restoration 593,000 seedlings used 3000 people reached	2000 ha under restoration 8000 kg of seeds used 1000,000 seedlings used 6200 people reached

Action Against Desertification is a key partner of the Great Green Wall initiative, Africa's flagship programme to combat the effects of climate change and desertification across North Africa, the Sahel and the Horn of Africa (FAO, 2020b).

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Coordinating agency or organisation

Food and Agricultural Organization of the United Nations.

EN0015 / **ENVIRONMENTAL / Environmental Degradation**

Loss of Mangroves

Definition

Mangroves and the destruction of mangrove habitat is caused by both human and natural causes. Human activities in the form of farming, aquaculture, urban development and natural stressors such as erosion and extreme weather have driven mangrove habitat loss. The hazard of loss of mangroves and their ecosystem services has devastating socio-economic and environmental consequences for coastal communities, especially in those areas with low mangrove diversity and low mangrove area (adapted from Ellison et al., 1996; Polidoro et al., 2010; and Goldberg, 2020).

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Annotations

Synonyms

Mangrove loss, Mangrove deforestation.

Additional scientific description

Mangroves are distinctive tropical plant communities that occupy the intertidal zone between sea and land, or in areas that are subject to the indirect influence of tides (Tomlinson, 2016). Fewer than 10 mangrove species are found in the New World tropics, while 36 species have been reported for the Indo-West-Pacific region. These species communities together make up a forest, which can be categorised as fringe, riverine, overwash, basin, or dwarf (Lugo and Snedaker, 1974). The ecosystem services that healthy mangrove stands provide include climate regulation, water purification, coastal protection, timber and fuel supply, fisheries generation, and eco-tourism support (Worthington et al., 2020).

Metrics and numeric limits

The Global Mangrove Watch (GMW), an initiative of the Global Mangrove Alliance, is an online platform that provides the remote sensing data and tools for monitoring mangroves. The GMW is made up by Japan Aerospace Exploration Agency Kyoto & Carbon Initiative by Aberystwyth University, solo Earth Observation, The Nature Conservancy, and Wetlands International. The GMW maps also constitute the official mangrove datasets used by the United Nations Environment Programme (UNEP) for reporting on Sustainable Development Goal 6.6.1 (change in the extent of water-related ecosystems over time) (GMW, no date).

The most recent global extent maps are for 2016, and historical assessments span as far back as 1996. Between 1996 and 2016, global mangrove extent decreased by 6057 km2. Total loss during these 20 years amounted to 15,261 km2.

The availability of GMW has resulted in the Mangrove Restoration Potential Map (MRP Map), a unique interactive tool developed to explore potential mangrove restoration areas worldwide and model the potential benefits associated with such restoration. The mapping tool was developed by The Nature Conservancy and the International Union for Conservation of Nature (IUCN), in collaboration with the University of Cambridge (IUCN, University of Cambridge and The Nature Conservancy, no date).

The MRP Map includes assessments of global maximum mangrove extent, mangrove deforestation, and potential restorable area. From 1996 to 2016, 1389 km2 of mangroves have been degraded, and a total of 8120 km2 of area have potential for mangrove restoration.

Data suggest an average loss rate of 0.13% annually from 1996 to 2016, higher than the average for tropical and subtropical forest losses (Goldberg et al., 2020). At national levels, losses are recorded in 97% of the countries and territories with mangroves (105 out of 108), while degradation is recorded in 76% (82 out of 108).

Key relevant UN convention/multilateral treaty

The Convention on Biological Diversity (1992) has three main objectives: the conservation of biological diversity, the sustainable use of the components of biological diversity and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources. At the time of writing, there were 196 parties to the Convention on Biological Diversity (UNEP, 1993).

The Convention on the Conservation of Migratory Species of Wild Animals also referred as the Bonn Convention and the Convention on Migratory Species (1979) is an environmental treaty under the aegis of UNEP for the conservation and sustainable use of migratory animals and their habitats. At the time of writing, there were 130 parties to the convention (JNCC, 1983).

The Convention on Wetlands also referred to as the Ramsar Convention (1971) provides the framework for the conservation and use of wetlands and their resources. At the time of writing, almost 90% of UN member states were contracting parties to this intergovernmental treaty (UNESCO, 1971).

The World Heritage Convention (1972) recognises some World Heritage properties specifically for their outstanding biodiversity values, protecting many of the most important ecosystems, areas of high biodiversity and mitigating against loss. At the time of writing, there were 193 parties to the convention (UNESCO, 2019).

The Strategic Plan for Biodiversity 2011-2020, including the Aichi Biodiversity Targets, Annex part IV (adopted on 29 October 2010 UNEP/CBD/COP/DEC/X/2) (UNEP, no date).

The United Nations Framework Convention on Climate Change (United Nations, 1992).

The United Nations Sustainable Development Goals (United Nations, 2015). The conservation and restoration of mangroves most directly address the Sustainable Development Goal 14 - to conserve and sustainably use the oceans, seas, and marine resources for sustainable development.

The Sendai Framework for Disaster Risk Reduction 2015-2030: although not stated explicitly, mangrove coastal protection can help to reduce coastal disaster risk (UNDRR, 2015).

The UNFCCC Paris Agreement. Several countries incorporate the role of mangroves in climate mitigation (carbon storage and sequestration) and adaptation (coastal protection, sediment trapping) in their Nationally Determined Contributions (NDCs) to the Paris Agreement (Gallo et al., 2017).

Examples of drivers, outcomes and risk management

Mangrove loss is primarily due to the deforestation of existing mangrove areas (Hamilton and Casey, 2016). An estimated 62% of global mangrove loss is due to land-use conversion, namely into aquaculture and agriculture (including rice, oil palm and coconut plantations) and urbanisation (Friess et al., 2019; Goldberg et al., 2020). The importance of these specific mangrove deforestation drivers varies regionally, with southeast Asia a particular hotspot for mangrove loss (UNEP-WCMC, 2014).

Mangrove extent is further threatened by increased rates of sea-level rise (Lovelock et al., 2015). Mangroves are vulnerable to sea-level rise when they are unable to build surface elevations commensurate with the rate of sea-level rise, which results in their submergence and subsequent loss (Krauss et al., 2014). This is compounded by their inability to migrate inland to higher elevations when suitable migration space is lacking due to coastal development or natural barriers, resulting in coastal squeeze (Alongi, 2015; Schuerch et al., 2018).

Mangroves are also sensitive to other climatic events, such as storms (Krauss and Osland, 2019), high water events, precipitation and drought, and climate fluctuations such as the El Niño-Southern Oscillation (ENSO) (Field, 1995; Sippo et al., 2018). Mangroves are most vulnerable when they experience combinations of these climatic events; for example, mangroves along a 1000-km length in northern Australia recently experienced substantial dieback after an ENSO event led to a temporary sea-level drop and a marked reduction in precipitation (Duke et al., 2017).

Outcomes involve reduced capacity to provide ecosystem services to local coastal communities and global populations (Duke et al., 2007; Estoque et al., 2018). These include reduced ability to mitigate climate change as a sink of atmospheric carbon; reduced disaster risk reduction and lower protection of coastal communities from hazards such as sea-level rise and storm surges; reduced adaptive capacity of coastal populations through reduced access to sources of food, fibres, timber, chemicals, and medicines. The loss of these resources often translates into loss of revenue, as local fisheries, tourism, and related industries are sustained by the forests. In addition, as mangroves store a large amount of carbon in their soils, mangrove deforestation can release 25–100% of the total cleared biomass as carbon dioxide (CO_2) emissions and that as much as 45% of soil carbon is lost within three years (Pendleton et al., 2012; Lovelock et al., 2017). Emissions from wetlands are explicitly considered in national greenhouse gas emissions reporting through the Intergovernmental Panel on Climate Change (Hiraishi et al., 2014). Mangrove loss may also have unintended impacts on other connected coastal ecosystems (UNEP-WCMC, 2006).

Mangrove loss can be reduced or managed by efforts to stabilise existing mangrove extent and restoring (replanting) mangroves that have been lost. Mangrove coverage can be stabilised by increased protected area management, enforcement of national laws that prohibit mangrove loss, integration of local knowledge and community participation, and promotion of flexible and robust governance in dealing with uncertainty, complexity, and dynamics of mangroves and ecosystems (e.g., adaptive management). Investigating, monitoring, and mitigating drivers of mangrove loss on regional and national levels are critical to maintaining existing mangrove forests.

Mangrove coverage can be increased by rehabilitation of previously deforested mangrove areas, such as the rehabilitation of abandoned aquaculture ponds. Potentially 800,000 hectares globally may be biophysically suitable for rehabilitation (Worthington and Spalding, 2018), although several socioeconomic and governance challenges exist (Wodehouse and Rayment, 2019) that may reduce the area that is ultimately feasible to rehabilitate. The success of these interventions requires an expansion of research on the basic ecology and hydrology of mangroves and social sciences of human-mangrove interactions. Understanding local enabling conditions (social equity, environmental sustainability, and economic viability) are key to successful mangrove management and its associated blue economy (Cisneros-Montemayor et al., 2021).

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Coordinating agency or organisation

Not Identified.

EN0016 / **ENVIRONMENTAL / Environmental Degradation**

Wetland Loss/Degradation

Definition

Wetland loss/degradation is a negative trend in wetland condition, caused by physical or direct/indirect human-induced processes expressed as long-term reduction or loss of at least one of the following: biological productivity, ecological role or value to humans (Craig et al., 1979; Olsson et al., 2019). Where wetlands are defined as areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres (Ramsar Convention 1971: Article 1.1). Wetlands may incorporate riparian and coastal zones adjacent to the wetlands, and islands or bodies of marine water deeper than six metres at low tide lying within the wetlands (Ramsar Convention 1971: Article 2.1).

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Annotations

Synonyms

Not identified.

Additional scientific description

The Ramsar Classification of Wetland Type includes 42 types of wetland grouped into three categories: marine and coastal wetlands, inland wetlands, and human-made wetlands. The five major wetland types are generally recognised as: *marine* (coastal wetlands including coastal lagoons, rocky shores, and coral reefs); *estuarine* (including deltas, tidal marshes, and mangrove swamps); *lacustrine* (wetlands associated with lakes); *riverine* (wetlands along rivers and streams); and *palustrine* (meaning 'marshy' – marshes, swamps and bogs). In addition, there are *human-made wetlands* such as fish and shrimp ponds, farm ponds, irrigated agricultural land, salt pans, reservoirs, gravel pits, sewage farms and canals (Ramsar, 1971).

Conversion of freshwater wetlands to agricultural land has historically been a common way of increasing the area of arable land (Olsson et al., 2019). However, wetlands with organic and wet soils are crucial in maintaining the Earth's carbon balance as they contain soils with high organic carbon content. Human activities on wetlands (e.g., drainage, agriculture, forestry, peat extraction, aquaculture) and their effects (e.g., oxidation of soil organic matter) may significantly affect the carbon and nitrogen balance and, thus, the greenhouse gas emissions from these lands. The degradation of peatland ecosystems, for example, is particularly relevant in the context of climate change given their very high carbon storage and their sensitivity to changes in soils, hydrology and/or vegetation. Human activity, either draining or mining approximately takes up 10% of global peatlands, releasing 80.8 Gt carbon and 2.3 Gt nitrogen. This corresponds to an annual greenhouse gas emission of 1.91 (0.31–3.38) Gt CO_2-equivalent. that could be saved with peatland restoration. Drainage induces peatland degradation and alters peatlands, globally, from a net sink to a net source of greenhouse gases in the land-use sector (Joosten, 2009; IPCC, 2014; Leifeld and Menichetti, 2018; Olsson et al., 2019).

Wetland loss/degradation results in associated reduction in ecosystem services delivered by wetlands such as: provisioning services including food and freshwater; regulating services such as flood control, storm protection, drought buffering, groundwater recharge and discharge, and carbon sequestration; cultural services such as recreation; and supporting services such as purification of water supplies, shoreline stabilisation and erosion control; retention of nutrients, sediments, and pollutants; and stabilisation of local climate conditions – particularly rainfall and temperature. The ecosystem services related to human health primarily cover supply of water, food, nutrition, and medicine, purification of waste products, and buffering against adverse flooding and climate effects (Ramsar, 2005, 2016).

Metrics and numeric limits

Approximately 1% of the Earth's surface is freshwater wetlands. They provide a very large number of ecosystem services, such as groundwater replenishment, flood protection and nutrient retention, and are biodiversity hotspots. Over two-thirds of the world's fish harvest is linked to the health of coastal and inland wetland areas. Agriculture is also impacted by wetlands through the maintenance of water tables and nutrient retention in floodplains. In addition, rice, a common wetland plant, is the staple diet of more than half of the global population. The loss of wetlands since 1900 has been estimated at about 55% globally (Davidson, 2014) and 35% since 1970 (Ramsar, 2016; Hu et al., 2017; Darrah et al., 2019; Olsson et al., 2019).

Coastal wetlands around the world are sensitive to sea level rise. Studies and projections of the impacts on global coastlines are inconclusive, with suggestions that between 0% to 90% (depending on sea level rise scenario) of present-day wetlands will disappear during the 21st century (Olsson et al., 2019).

Despite their importance, coastal wetlands are listed among the most heavily damaged natural ecosystems worldwide. However, coastal wetland restoration and preservation is an extremely cost-effective strategy for society, for example, the preservation of coastal wetlands in the USA provides storm protection services worth 23.2 billion USD per year. Coastal wetlands function as valuable, self-maintaining 'horizontal levees' for storm protection (Costanza et al., 2008; Olsson et al., 2019).

Globally, approximately 1.1 Gha of land is affected by salt, with 14% of this categorised as forest, wetland or some other form of protected area (Olsson et al., 2019).

Key relevant UN convention / multilateral treaty

The Convention on Wetlands [Ramsar, Iran, 1971] is an intergovernmental treaty whose mission is the conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world (Ramsar, 2016). By October 2020, 171 nations had joined the Convention as Contracting Parties, and more than 2220 wetlands around the world, covering over 214 million ha, have been designated for inclusion in the Ramsar List of Wetlands of International Importance. The United Nations Educational, Scientific and Cultural Organization (UNESCO) serves as the Depositary for the Convention, but the Ramsar Convention is not part of the United Nations and UNESCO system of environmental conventions and agreements. The Convention is responsible only to its Conference of the Contracting Parties (COP), and its day-to-day administration has been entrusted to a Secretariat under the authority of a Standing Committee elected by the COP. The Ramsar Secretariat is hosted under contract by the International Union for Conservation of Nature (IUCN) in Gland, Switzerland (Ramsar, 2016).

The Convention on Wetlands of International Importance Especially as Waterfowl Habitat, 2 February 1971 (Ramsar, 1971).

Examples of drivers, outcomes and risk management

Overexploitation of freshwater resources jeopardises human well-being and the environment. Access to safe water, human health, food production, economic development and geopolitical stability are made less secure by the degradation of wetlands driven by the rapidly widening gap between water demand and supply. Even with current attempts to maintain minimum water flows for ecosystems, the capacity of wetlands to continue to deliver benefits to people and biodiversity, including clean and reliable water supplies, is declining. Efforts to support water allocation to ecosystems, such as environmental flow requirements, placing upper limits on water allocations, and new water management legislation, must be strengthened (Ramsar, 2016).

Many Contracting Parties to the Ramsar Convention, recognising the importance of the conservation and wise use of wetlands, have adopted some form of an avoid-mitigate-compensate approach to wetland loss and degradation. In this context, national, regional, and local laws and policies emphasise that negative wetland impacts should be avoided if at all possible. If such negative impacts cannot be avoided or prevented, actions should be taken to mitigate (minimise or reduce) this wetland loss or degradation. Finally, if wetland loss or degradation remains after such mitigation, actions should be taken to compensate for (i.e., offset) these residual impacts (Gardner et al., 2012).

Wetlands constitute a resource of great economic, cultural, scientific and recreational value to human life. Wetlands and people are ultimately interdependent. Furthermore, wetlands are an essential component of the global water cycle and play a key role in climate regulation. As such, the progressive encroachment on and loss of wetlands needs to be stopped, and measures must be taken to conserve and make wise use of wetland resources. To achieve this at a global level requires cooperative, intergovernmental action. The Ramsar Convention on Wetlands provides the framework for such international, as well as for national and local, action (Ramsar, 2016).

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Coordinating agency or organisation

Not identified.

EN0017 / **ENVIRONMENTAL / Environmental Degradation**

Coral Bleaching

Definition

Corals are subject to 'bleaching' when the seawater temperature is too high: they lose the symbiotic algae that give coral its colour and part of its nutrients. Severe, prolonged or repeated bleaching can lead to the death of coral colonies (United Nations, 2017).

Reference

United Nations, 2017. The First Global Integrated Marine Assessment: World Ocean Assessment I. Cambridge University Press. www.un.org/Depts/los/global_reporting/WOA_RPROC/WOACompilation.pdf Accessed 14 October 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

Coral bleaching was a relatively unknown phenomenon until the early 1980s, when a series of local bleaching events occurred, principally in the eastern tropical Pacific and Wider Caribbean regions. Severe, prolonged or repeated bleaching can lead to the death of coral colonies. An increase of only 1°C to 2°C above the normal local seasonal maximum can induce bleaching. Although most coral species are susceptible to bleaching, their thermal tolerance varies. Many heat-stressed or bleached corals subsequently die from coral diseases (United Nations, 2017).

Increasingly frequent severe coral bleaching is among the greatest threats to coral reefs posed by climate change. Global climate models project great spatial variation in the timing of annual severe bleaching conditions; a point at which reefs are certain to change and recovery will be limited (UNEP, 2017).

Warmer water temperatures can result in coral bleaching. When water is too warm, corals will expel the algae (zooxanthellae) living in their tissues causing the coral to turn completely white. This is called coral bleaching. When a coral bleaches, it is not dead. Corals can survive a bleaching event, but they are under more stress and are subject to mortality (NOAA, no date a).

In 2005, the USA lost half of its coral reefs in the Caribbean in one year due to a massive bleaching event. The warm waters centred around the northern Antilles near the Virgin Islands and Puerto Rico and extended southward. Comparison of satellite data from the previous 20 years confirmed that thermal stress from the 2005 event was greater than the previous 20 years combined (NOAA, no date a).

There is great spatial variation in the timing of annual severe bleaching conditions; a point at which reefs are certain to change and recovery will be limited. The onset of annual severe coral bleaching is defined as the annual exceedance of more than eight degree-heating weeks accumulating during any three-month period. With more than eight weeks with an extra degree of heat it is possible to have confidence that thermal stress will be enough for bleaching to occur (van Hooidonk et al., 2016).

Metrics and numeric limits

Not globally available.

Key relevant UN convention/multilateral treaty

Not identified.

Examples of drivers, outcomes and control measures of the hazard

The National Oceanic and Atmospheric Administration Coral Reef Watch programme uses satellite data to provide current reef environmental conditions to identify quickly areas at risk for coral bleaching (NOAA, no date b). Coral Reef Watch also offers a modelled outlook that predicts the likelihood of coral bleaching heat stress on a week-by-week basis, up to four months into the future (the typical length of a bleaching season).

Continuous satellite monitoring of sea surface temperature at global scales and modelled projections of approaching bleaching-level heat stress provide resource managers, scientific researchers, and other coral reef ecosystem stakeholders with tools to understand and better manage the complex interactions leading to coral bleaching. When bleaching conditions occur, these tools can be used to trigger bleaching response plans and support appropriate management decisions and communication with the public (NOAA, no date b).

References

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van Hooidonk, R., J. Maynard, J. Tamelander, J. Gove, G. Ahmadia, L. Raymundo, G. Williamd, S.F. Heron and S. Planes, 2016. Local-scale projections of coral reef futures and implications of the Paris Agreement. Scientific Reports, 6:39666. doi:10.1038/srep39666

Coordinating agency or organisation

Not identified.

EN0018 / **ENVIRONMENTAL / Environmental Degradation**

Compressive Soils

Definition

Compressible soils include both compressive and collapsible soils. Compressive soils are soils that are prone to volumetric change when subject to mechanical loading (USDA, 1990:30). Collapsible soils are metastable in that they are prone to volumetric change (collapse) on wetting and loading (Rogers, 1995).

Reference

Rogers, C.D.F., 1995. Types and distribution of collapsible soils. In: Derbyshire, E., T. Dijkstra and I.J. Smalley (eds), Genesis and Properties of Collapsible Soils. NATO ASI Series C, vol 468. Springer. doi.org/10.1007/978-94-011-0097-7_1

USDA, 1990. Elementary soil engineering. In: Engineering Field Manual. Engineering. United States Department of Agriculture (USDA). https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17543.wba Accessed 26 October 2020.

Annotations

Synonyms

Consolidation, Compaction, Settlement, Poaching, Land degradation, Peat erosion.

Additional scientific description

Volume change when a soil is subject to load, results from changes in pore volume, initially as a result of the loss of air and water from the voids and then as a consequence of more ordered grain packing. Organic matter in the soil may be highly compressible; peat soils being particularly susceptible to consolidation. Consolidation is the gradual reduction in soil volume resulting from an increase in compressive stress. The resulting increase in density is compaction (USDA, 1990).

Consolidation is the gradual reduction in soil volume resulting from an increase in compressive stress. It consists of initial consolidation, which is a comparatively sudden reduction in volume resulting from the expulsion and compression of gas; primary consolidation, which results principally from a squeezing out of water and is accompanied by a transfer of load from the soil water to the soil solids; and secondary consolidation, resulting principally from the adjustment of the internal structure of the soil mass after initial consolidation. Settlement is the displacement of a structure due to the compression and deformation of the underlying soil. Compaction is the densification of a soil by means of mechanical manipulation (USDA, 1990).

Collapsible soils differ from compressible soils in that they are low density soils with a structure that collapses upon wetting. They may have considerable strength when dry or moist. They lose strength and undergo sudden compression when they are saturated. Some will collapse under their own weight when saturated; others, only when loaded (USDA, 1990).

Compaction reduces the volume of void available for water, potentially affecting water infiltration into soil, crop root moisture uptake and penetration, and consequential crop yield. Soil compaction can lead to surface ponding of water and water logging, leading to chemical deterioration in soil quality. The potential for increased surface water run-off can lead to soil erosion (USDA, 1990).

The Food and Agriculture Organization of the United Nations (FAO) and Intergovernmental Technical Panel on Soils estimate that 33% of land is moderately to highly degraded due to the erosion, salinisation, compaction, acidification and chemical pollution of soils (FAO and ITPS, 2015). They noted that compaction-related soil degradation is increasing in Asia, Latin America and the Near East and North Africa; it is variable in Europe and Eurasia, the SW Pacific and North America (FAO and ITPS, 2015).

Metrics and numeric limits

The FAO and its partners in the Global Soil Partnership (GSP) are designing SoilSTAT, a system for monitoring, forecasting and reporting periodically on the status of global soil resources. The name of the system mirrors the FAOSTAT family of global status databases and monitoring. SoilSTAT is part of the Global Soil Information System. It will be built under GSP Pillar 4 as part of spatial data infrastructure for the exchange of web-based soil data services. The basic data elements of Pillar 4 include soil profiles, soil polygon maps and soil grids; SoilSTAT will be based on indicators describing the current condition of, and trends in, soil quality. According to the Status of the World's Soil Resources report, indicators will address soil threats such as erosion, compaction, salinisation and the loss of soil organic matter. SoilSTAT will therefore be an important mediator in the harmonised reporting of national soil information for the Sustainable Development Goals (FAO and ITPS, 2015).

Key relevant UN convention/multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Causes of compaction include agricultural vehicle tracks and poaching with farm mechanisation considered the primary cause on both agricultural and forestry land (Forest Research, 2020). Extensive poaching is also caused by livestock and herds of wild animals. Soil compaction on construction sites occurs either deliberately when foundations and sub-grades are prepared for construction or as an unintended result of vehicular traffic and excavation (cut and fill) works (DEFRA, 2006).

Compressible soils commonly occur in river estuaries where they may be associated with flooding. Building in these areas may necessitate the use of building platforms to avoid flooding. However loads with shallow foundations may be subject to large settlement over long durations. Methods such as the installation of sand drains can be used to manage the settlement. Where the compressible soils are relatively thin, foundations may be taken down to bear into more competent strata at depth. This scenario can lead to differential settlement. These soils are also sensitive to ground lowering as a consequence of dewatering (USDA, 1990).

Compressible soils can be characterised using consolidation testing in the laboratory and static cone testing in the field (USDA, 1990).

Collapsible soil foundations cause problems when they are saturated after being loaded by a structure. Examples are settlement of a dam foundation resulting in cracking of the dam when stored water saturates the foundation; settlement and cracking of an irrigation ditch, dike or lining when seepage from the ditch saturates the foundation; or settlement of a building when the foundation soil is saturated with water from a downspout or leaks in water or sewer pipes (USDA, 1990).

Many loessic soils are collapsible. Low density soils above the water table in this situation should be suspected of being collapsible. They can be identified by modified consolidation testing of undisturbed samples. In testing, samples are loaded in a moist condition, then saturated collapsible soils will show sudden settlement upon wetting (USDA, 1990).

For example, it is important to check the foundations of earth dams for strength, permeability, compressibility, dispersive clays (piping), water table elevation, and depth to bedrock (USDA, 1990).

Collapsible soils commonly occur as alluvial fans in sub-humid to arid areas. Consequential threats include salinisation, nutrient imbalance and loss of biodiversity that may result from soil compaction. Compacted soil may contribute to atmospheric warming through increased emissions of carbon dioxide, methane and nitrogen dioxide from such soils (USDA, 1990).

References

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Coordinating agency or organisation

British Geological Survey.

EN0019 / **ENVIRONMENTAL / Environmental Degradation**

Soil Erosion

Definition

Soil erosion is defined as the accelerated removal of topsoil from the land surface through water, wind and tillage (FAO, 2020).

Reference

FAO, 2020. Global Symposium on Soil Erosion. Food and Agricultural Organization of the United Nations (FAO). www.fao.org/about/meetings/soil-erosion-symposium/key-messages/en Accessed 20 October 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

Soil erosion occurs naturally under all climatic conditions and on all continents, but is significantly increased and accelerated by unsustainable human activities (up to 1000 times) through intensive agriculture, deforestation, overgrazing and improper land use changes. The Status of the World's Soil Resources report identified soil erosion as one of the major soil threats (FAO, 2015a). Soil erosion rates are much higher than soil formation rates; soil is a finite resource, meaning its loss and degradation is not recoverable within a human lifespan (FAO, 2020).

Soil erosion decreases agricultural productivity, degrades ecosystem functions, amplifies hydrogeological risk such as landslides or floods, causes significant losses in biodiversity, damage to urban infrastructure and, in severe cases, leads to displacement of human populations (FAO, 2020).

Soil erosion and land degradation pose a major threat to global food security and to the achievement of the Sustainable Development Goals (SDGs) (UN, 2015) on ensuring the well-being of at least 3.2 billion people around the world (FAO, 2020).

Soils are an essential and non-renewable natural resource hosting goods and services vital to ecosystems and human life. Soils are fundamental for producing crops, feed, fibre, fuel, and they filter and clean tens of thousands of cubic kilometres of water each year. As a major storehouse for carbon, soils also help regulate emissions of carbon dioxide and other greenhouse gases, which is fundamental for regulating climate (FAO, 2017).

The World Soil Charter presents a series of nine principles that summarise current understanding of the soil, the multi-faceted role it plays, and the threats to its ability to continue to serve these roles (FAO, 2015b):

- *Principle 1*: Soils are a key enabling resource, central to the creation of a host of goods and services integral to ecosystems and human well-being.
- *Principle 2*: Soils result from complex actions and interactions of processes in time and space and hence are themselves diverse in form and properties and the level of ecosystems services they provide.
- *Principle 3*: Soil management is sustainable if the supporting, provisioning, regulating, and cultural services provided by soil are maintained or enhanced without significantly impairing either the soil functions that enable those services or biodiversity.
- *Principle 4*: The implementation of soil management decisions is typically made locally and occurs within widely differing socio-economic contexts.
- *Principle 5*: The specific functions provided by a soil are governed, in large part, by the suite of chemical, biological, and physical properties present in that soil.

- *Principle 6*: Soils are a key reservoir of global biodiversity, which ranges from micro-organisms to flora and fauna. This biodiversity has a fundamental role in supporting soil functions and therefore ecosystem goods and services associated with soils.
- *Principle 7*: All soils – whether actively managed or not – provide ecosystem services relevant to global climate regulation and multi-scale water regulation.
- *Principle 8*: Soil degradation inherently reduces or eliminates soil functions and their ability to support ecosystem services essential for human well-being.
- *Principle 9*: Soils that have experienced degradation can, in some cases, have their core functions and their contributions to ecosystem services restored through the application of appropriate rehabilitation techniques.

Metrics and numeric limits

Of the Earth's soils, 33% are already degraded and over 90% could become degraded by 2050 (FAO, 2015a, 2020).

Worse, most future land degradation is predicted to occur in the areas with the largest amount of arable land remaining. If current trends continue, experts estimate that by 2050, more than 90% of the Earth's land areas will be substantially degraded, 4 billion people will live in drylands, 50–700 million people will be forced to migrate, and global crop yields will be reduced by an average of 10% and up to 50% in some regions (Nachtergaele et al., 2012 cited by Little, 2019; IUCN, 2015; Gomiero, 2016; IPBES, 2018).

A total of 75 billion tons of fertile soil is removed every year from the global soilscape by erosion. As a result, precious soil resources, which should be preserved for future generations, are continuously reduced. Every year approximately 12 million ha of land are lost (FAO and IAEA, 2017).

Key relevant UN convention/multilateral treaty

Food and Agriculture Organization of the United Nations Global Soil Partnership (GSP) (FAO, 2012).

United Nations Convention to Combat Desertification (UNCCD, 1994).

Examples of drivers, outcomes and risk management

Because 95% of the food consumed globally comes from the soil, soil erosion mitigation through the application of sustainable soil management (SSM) is critical for protecting soil while ensuring a sustainable and food secure world (FAO, 2020).

Sustainable soil management is an integral part of sustainable land management, as well as a basis for addressing poverty eradication, agricultural and rural development, promoting food security and improving nutrition. Sustainable soil management is a valuable tool for climate change adaptation and a pathway for safeguarding key ecosystem services and biodiversity. Due to the incalculable value soils provide to society through ecosystem services, widespread adoption of sustainable soil management practices generates multiple socioeconomic benefits, especially for smallholder farmers and large-scale agricultural producers worldwide whose livelihoods directly depend on their soil resources (FAO, 2017).

The Status of the World's Soil Resources report identified ten key threats that hamper the achievement of sustainable soil management. These threats are soil erosion by water and wind, soil organic carbon loss, soil nutrient imbalance, soil salinisation, soil contamination, acidification, loss of soil biodiversity, soil sealing, soil compaction and waterlogging. These threats vary in terms of intensity and trend depending on geographical context, although they all need to be addressed in order to achieve sustainable soil management (FAO, 2017).

One of the key messages from the Assessment Report on Land Degradation and Restoration prepared by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services is to eliminate perverse incentives that promote degradation and to devise positive incentives that reward the adoption of sustainable land management practices in order to avoid, reduce and reverse land degradation (IPBES, 2018).

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Coordinating agency or organisation

Not Identified.

EN0020 / **ENVIRONMENTAL / Environmental Degradation**

Coastal Erosion and Shoreline Change

Definition

Coastal erosion is the physical reduction of land mass at the coast that results from the interfacing of marine, fluvial and landsliding (driven by the interactions between groundwater and the soil or rock) processes with the coast (Mentaschi et al., 2018).

References

Mentaschi, L., M.I. Vousdoukas, J. Pekel, E. Voukouvalas and L. Feyen, 2018. Global long-term observations of coastal erosion and accretion. Scientific Reports, 8:12876. doi.org/10.1038/s41598-018-30904-w

Annotations

Synonyms

Shoreline process, Coastal landslides, Coastal morphology.

Additional scientific description

The coast is a dynamic environment that is subject to constantly changing energy inputs. This leads to variable process rates as reflected in the changing ratios of weathering to erosion. The land-based processes deliver sediment to the shoreline environment that marine processes mobilise and transport. The sediment may lead to local accretion. Rates of erosion reflect the consequences of environmental change (human modifications and climate change) superimposed on the natural variability in the underlying process-driven rates of erosion (Mentaschi et al., 2018). While zones of high sediment accretion mitigate against erosion in some areas, the landward movement of the coastline can be as high as several metres per year. Therefore, understanding patterns of sediment migration is fundamental to modelling coastal erosion. Processes at the coast are wide-ranging and both the marine and land processes (landsliding and fluvial processes) present hazards to coastal environments including infrastructure, business, people, and ecosystem services in the coastal zone (Wong et al., 2014; Mentaschi et al., 2018).

Marine processes include tides and tidal range, tidal surges, coastal flooding, waves, tsunamis, long-shore drift and a range of types of current. Landsliding processes are comparable with on-shore processes, including falls, topples, slides and flows reflecting the local geological and groundwater conditions. While estuarine environments naturally dominate the context for the fluvial processes, anthropogenic impacts are commonly further inland. For example, Mentaschi et al. (2018) found that dams are among the most prominent contributors to erosion because they retain sediment that would otherwise naturally supply the coastal zone with beach sediment.

Metrics and numeric limits

Mentaschi et al. (2018) used satellite data to evaluate global coastal morphodynamics over the period 1984 to 2015. They established a land loss of 28,000 km2; gained land of 14,000 km2; an increase in the active zone (essentially the intertidal zone together with areas frequently inundated by other causes, such as rivers or waves) of 25,000 km2, and a loss in the active zone of 11,500 km2. The region with the highest change per unit coast was the Caspian Sea with an average cross-shore erosion of 600 m, followed by southern Asia, Pacific Asia, South America, eastern Africa and western Australia with an average cross-shore erosion of 50 m.

Key relevant UN convention/multilateral treaty

None identified.

Examples of drivers, outcomes and control measures of the hazard

Coastal environments host a range of infrastructure, including the landing points for telecommunications, ecosystem services and in the order of 40% of the world's population (Mentaschi et al., 2018).

Extreme weather events associated with higher intensity storm surges and flooding as well as tsunamis and waves and currents extend the reach and rate of erosion of landforms. Extreme rainfall events contribute to soil saturation and the associated shear strength reduction associated with landsliding. Anthropogenic factors impact most significantly on sediment supply primarily through sediment retention.

Coastal erosion becomes a hazard when society does not adapt to its effects on people, the built environment and infrastructure (UNDRR, 2017). Therefore, adaptation and adaptive pathways are a key policy in managing coastal hazards. In some parts of the world a range of engineered interventions have been successful in protecting specific infrastructure and populations, but the consequences of engineered intervention need to be fully appraised to avoid unplanned consequences. Engineered solutions vary widely, for example: rock armour, breakwaters, groynes and seawalls, wharfs and harbours, offshore barriers, a range of styles of revetments, beach nourishment or replenishment, mangrove protection and dredging (Climate-ADAPT, 2015).

Examples of regional and national programmes for coastal erosion and shoreline change include the first pan-European shoreline-migration map, prepared by the European Marine Observation and Data Network (EMODnet, 2020) and the UK national coastal erosion risk map, prepared by the UK Environment Agency (no date).

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Coordinating agency or organisation

British Geological Survey.

EN0021 / **ENVIRONMENTAL / Environmental Degradation**

Permafrost Loss

Definition

Permafrost is defined as the ground that remains frozen under 0°C for a minimum of two consecutive years. Permafrost loss, also known as permafrost thaw is the progressive loss of ground ice in permafrost, usually due to input of heat. Thaw can occur over decades to centuries over the entire depth of permafrost ground, with impacts occurring while thaw progresses. During thaw, temperature fluctuations are subdued because energy is transferred by phase change between ice and water. After the transition from permafrost to non-permafrost, ground can be described as thawed (IPCC, 2019).

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IPCC, 2019. Annex I: Glossary [Weyer, N.M. (ed.)]. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)]. Intergovernmental Panel on Climate Change (IPCC). www.ipcc.ch/srocc/chapter/glossary Accessed 21 October 2020.

Annotations

Synonyms

Permafrost degradation, Permafrost thaw

Additional scientific description

Permafrost includes the mineral part of the ground (rocks) as well as any organic matter and ice if it is present (IPCC, 2019). The active layer is the uppermost part of permafrost, which thaws during summer and re-freezes during winter.

Permafrost currently covers around 15 million km2, or approximately 24% of the land in the Northern Hemisphere, mostly in the Arctic region, and is very sensitive to climate change (Chadburn et al., 2017).

- *Gradual permafrost loss or thaw* is related to a general increase in the temperature of the ground. Ground temperatures are monitored by the Global Terrestrial Network for Permafrost at over 150 borehole sites across the permafrost regions (Biskaborn et al., 2019). During 2007–2016, continuous-zone permafrost temperatures in the Arctic and Antarctic increased by 0.39 ± 0.15°C and 0.37 ± 0.10°C respectively and at some locations, the temperature is 2–3°C higher than 30 years ago (Biskaborn et al., 2019).
- *Abrupt thaw* happens mainly in regions with excess ice and occurs when the land surface collapses resulting in, for example, thaw slumps, active layer detachments or thermokarst lakes. This can affect many metres of permafrost soil in the period of a few days to years and will impact the hydrological state of the permafrost (Turetsky et al., 2020). Olefeldt et al. (2016) estimated that 20% of the northern permafrost region is covered by ice-rich thermokarst landscapes. Abrupt thaw is not currently well represented by models (Turetsky et al., 2020).

Under future climate change scenarios, the Coupled Model Intercomparison Project Phase 6 (CMIP6) models project a gradual loss of permafrost of between 0.3 and 3.4 million km2 per °C increase in global surface air temperature (5th to 95th percentile; Burke et al., 2020). This is equivalent to a reduction of between 10% and 40% per °C in the annual mean frozen volume in the top 2 m of soil. These estimates are slightly lower than the 4.0 [-1.1; +1.0] million km2 per °C equilibrium sensitivity projected by Chadburn et al. (2017) who derived this using an observational-based relationship.

The permafrost region represents a large, climate sensitive reservoir of organic carbon with approximately twice as much carbon in the soil as is currently contained in the Earth's atmosphere. The top 3 m of permafrost soils contain 1035 ± 150 Pg C (Tarnocai et al., 2009; Hugelius et al., 2014) and could become vulnerable to decomposition under climate change. Schuur et al. (2015) suggested that between 5% and 15% of this permafrost carbon pool may be decayed and released as either carbon dioxide or methane during the 21st century, contributing to further global warming. This feedback could cause an additional warming of between 0.2% and 12% of the change in global temperature by 2100 (Burke et al., 2017). About half of below-ground carbon is stored in thermokarst landscapes vulnerable to abrupt thaw (Olefeldt et al., 2016) and has not been considered in these estimates. Therefore, these estimates may well be a substantial underestimation of carbon emissions from thawing permafrost (Turetsky et al., 2020).

Metrics and numeric limits

The Global Terrestrial Network for Permafrost (GTN-P, Streletskiy et al., 2017) coordinates long-term monitoring of the thermal state of permafrost via an extensive borehole network used to measure ground temperatures at a range of depths from the surface to up to 100 m in depth. It also coordinates the monitoring of the maximum active layer thickness via the Circumpolar Active Layer Monitoring program (CALM, no date). Typically, this is done at the end of the summer on a grid arrangement via mechanical probing of the soil. Currently it is not possible to use Earth Observation data for routine monitoring of permafrost.

Key relevant UN convention/multilateral treaty

The *UN Climate Change Paris Agreement (2015)* builds upon the United Nations Framework Convention on Climate Change and for the first time brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so. As such, it charts a new course in the global climate effort. By October 2020, 189 Parties had ratified of 197 Parties to the Convention (United Nations Climate Change, 2015).

Examples of drivers, outcomes and risk management

Permafrost thaw is one of the leading factors increasing climate-related vulnerability (Murray et al., 2012).

Changes in temperature and precipitation typically act as gradual (i.e., continuous) disturbances that directly affect permafrost by modifying the ground thermal regime. Climate change can also modify the occurrence and magnitude of abrupt physical disturbances such as fire (e.g., Wotton et al., 2017), and soil subsidence and erosion resulting from ice rich permafrost thaw (e.g., Lewkowicz and Way, 2019). These 'pulse' (i.e., discrete) disturbances often are part of the ongoing disturbance and successional cycle in Arctic and boreal ecosystems (Grosse et al., 2011) but changing rates of occurrence have recently been observed altering the landscape distribution of successional ecosystem states (Farquharson et al., 2019).

Recent climate warming has been linked to increased wildfire activity in the boreal forest regions in Alaska and western Canada where this has been studied (Gillett et al., 2004; Veraverbeke et al., 2017). Based on satellite imagery, an estimated 80,000 km2 of boreal area was burned globally per year from 1997 to 2011 (Giglio et al., 2013). There is high confidence that fire will accelerate change in permafrost relative to climate effects alone, if the rates of these disturbances increase. The observed trend of increasing fire is projected to continue for the rest of the 21st century across most of the tundra and boreal region for many climate scenarios (Meredith et al., 2019).

Permafrost thaw causes serious damage to infrastructure (e.g., roads, runways, buildings) and affects different types of infrastructure in radically different ways. The impacts of permafrost thaw on infrastructure have implications for the health, economic livelihood, and safety of affected communities. For example, in Northern Canada, the costs of adapting and/or repairing existing infrastructure can range from several million to many billions of dollars, depending on the extent of the damage and the type of infrastructure that is at risk. The Tibbitt to Contwoyto winter road (Northwest Territories, Canada) experienced climate-related closures in 2006, remaining open for only 42 days compared to 76 in 2005 (Bastedo, 2007). This resulted in residents and businesses having to airlift materials to their communities, costing them millions of dollars.

In the Northwest Territories, 10% of public access buildings have been retrofitted since 2004 to address critical structural malfunctions. In Inuvik, Northwest Territories, a local school suffered a complete roof collapse under a particularly heavy snowfall. As permafrost continues to thaw, resulting in a loss of overall structural integrity, greater impacts will be linked to the increase in snow loads as structures previously weakened by permafrost thaw topple under larger or heavier snowfalls (Bastedo, 2007; Murray et al., 2012).

The rapid changes permafrost is undergoing create challenges for planners, decision makers and engineers by threatening the structural stability and functional capacities of infrastructure (Meredith et al., 2019). Projections of changes in climate and permafrost suggest that a wide range of current infrastructure will be impacted by the changing conditions (Melvin et al., 2017; Schneider von Deimling et al., 2020). For example, a circumpolar study found that approximately 70% of infrastructure (residential, transportation and industrial facilities), including over 1200 settlements (about 40 with a population of more than 5000), is located in areas where permafrost is projected to thaw by 2050 under RCP4.5 (Hjort et al., 2018).

Reducing and avoiding the impacts of climate change on infrastructure will require special attention to engineering, land use planning, maintenance operations, local culture and private and public budgeting. In some cases, relocation of human settlements will be required (Meredith et al., 2019). Subsidence due to thawing permafrost and river and delta erosion makes coastal and rural communities of Alaska and Russia particularly vulnerable, potentially requiring relocation in the future (Bronen, 2015; Romero Manrique et al., 2018).

Permafrost loss also alters ecosystems, for example, the ecology of thaw-impacted lakes and streams is also likely to change with microbiological communities adapting to changes in sediment, dissolved organic matter, and nutrient levels (Vonk et al., 2015).

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Coordinating agency or organisation

Not identified.

EN0022 / **ENVIRONMENTAL / Environmental Degradation**

Sand Mining

Definition

Sand mining (extraction) is defined as the removal of primary (virgin) natural sand and sand resources (mineral sands and aggregates) from the natural environment (terrestrial, riverine, coastal, or marine) for extracting valuable minerals, metals, crushed stone, sand and gravel for subsequent processing (UNEP, 2019).

Reference

UNEP, 2019. Sand and Sustainability: Finding new solutions for environmental governance of global sand resources. GRID-Geneva, United Nations Environment Programme (UNEP). https://wedocs.unep.org/bitstream/handle/20.500.11822/28163/SandSust.pdf Accessed 20 October 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

The United Nations Environment Programme report on Sand and Sustainability (UNEP, 2019) describes the following materials as being extracted or mined from the natural environment:

- Natural sands are all sands extracted from natural environments.
- *Mineral sands* are part of a class of ore deposits that contain heavy metals such as ilmenite, zircon, leucoxene, and rutile. Eroded materials from hard rock sources like granite or basalt accumulate on beaches within river systems and on coastlines. It is these beaches from which these valuable materials are extracted for end-use in jewellery; as pigments in paints, plastics, paper, foods; and in electronics.
- *Aggregates* are crushed rock, sand and gravels used in construction minerals and water filtration.
  - *Primary aggregates* consist of crushed rock extracted in hard rock quarries by blasting and crushing; and sand and gravel extracted from pits by excavation and crushing, from lakes, rivers and from coastal beaches or dredged from the sea.
  - *Recycled aggregates* are crushed rock, sand and gravel produced by sorting, crushing and screening of construction and demolition materials.
  - *Manufactured aggregates* are substitutes to crushed rock, sand and gravel that are produced from wastes from other industries.

The environmental and social impacts of sand extraction are issues of global significance. Eroded materials from hard rock sources, sands and gravels are the unrecognised foundational material of national economies. They are mined all over the world, with aggregates accounting for the largest volume of solid material extracted globally (UNEP, 2014, 2019).

The following is a summary of the environmental degradation caused by sand mining:

- *Loss of biodiversity:* via pollution and direct impacts on the biophysical integrity of ecosystems (UNEP, 2014). Removing significant amounts of material from dynamic environments like rivers and coasts, and static environments such as quarries, results in widespread environmental change (UNEP, 2014). Marine sand mining via benthic dredging causes changes in water turbidity and results in a net decline in faunal biomass and abundance (Desprez et al., 2010) or a shift in species composition (UNEP, 2014).
- *Land losses:* both inland through aggregate extraction and river erosion, and coastal through extraction and erosion. Agricultural production could be affected through loss of agricultural land from river erosion (UNEP, 2014).

- *Hydrological function:* change in water flows, flood regulation and marine currents. River and marine aggregates are the main sources of aggregates for building and land reclamation. Removing sediment from rivers causes the river to cut its channel through the bed of the valley floor both upstream and downstream of the extraction site. This leads to coarsening of bed material and lateral channel instability (UNEP, 2014).
- *Water supply:* mainly through lowering of the water table and pollution, also marine aggregate needs to be thoroughly washed to remove salt (UNEP, 2014). For example, the removal of more than 12 million tonnes of sand per year from the Vembanad Lake catchment in India has led to the lowering of the riverbed by 7–15 cm/y (Padmalal et al., 2008). Sand mining can lead to a loss of aquifer storage (Kondolf, 1997). The lowering of the water table can affect agricultural production (Kondolf, 1997).
- *Climate:* directly through transport emissions, indirectly through cement production (UNEP, 2014).
- *Landscape:* coastal erosion, changes in deltaic structures, quarries, pollution of rivers (UNEP, 2014). Erosion occurs from direct sand removal from beaches. It can also occur indirectly, resulting from near-shore marine dredging, or as a result of sand mining in rivers (Kondolf, 1997). Damming and mining have reduced sediment delivery from rivers to many coastal areas, leading to accelerated beach erosion (Kondolf, 1997).
- *Extreme events:* decline of protection against extreme events (flood, drought, storm surge) (UNEP, 2014).

Metrics and numeric limits

There is a lack of adequate information on sand mining, which is limiting regulation of extraction in many developing countries (Sreebha and Padmalal, 2011). Access to data is difficult, and data are not standardised. This absence of global data on sand mining makes environmental assessment very difficult (UNEP, 2014).

An estimated 40 to 50 billion metric tonnes of crushed rock, sand and gravel is extracted every year (Steinberger et al., 2010; UNEP, 2014, 2019).

One way to estimate the global use of aggregates indirectly is through the production of cement for concrete (concrete is made with cement, water, sand and gravel) (UNEP, 2014, 2019).

Key relevant UN convention/multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Lack of monitoring systems, regulatory policies and environmental impact assessments have led to indiscriminate mining, triggering severe damage to the environment and related ecosystem services (UNEP, 2014).

The absence of global monitoring of aggregates extraction undoubtedly contributes to the gap in knowledge, which translates into a lack of action. As this is a major emerging issue, there is a need for in-depth research (UNEP, 2014).

There is a need to regulate sand extraction in both national and international waters (UNEP, 2014).

Many sand extraction operations in emerging and developing economies are not in line with respective extractives and environmental management regulations. In addition, mining and dredging regulations are often established without scientific understanding of the consequences. For example, the environmental impact of in-stream mining might be avoided if the annual bed load were calculated and the mining of aggregates restricted to that value or less. 'Sand mafias', illegal sand extraction and smuggling has been widely reported (UNEP, 2014, 2019). Most sand from deserts cannot be used for concrete and land reclaiming, as the wind erosion process forms round grains that do not bind well (Zhang et al., 2006).

Direct safety risks for those working in this sector and living in the communities where this takes place include industrial accidents such as drowning of workers removing sand from riverbeds; health effects of particulate (dust) and hydrocarbon pollution; forced child labour; transport accidents; subsidence and landslides in extraction areas (Asolekar, 2006; Maya et al., 2012; UNEP, 2014, 2019).

The training of architects and engineers, new laws and regulations, taxation and positive incentives are required in order to lower the dependency on sand. Renewable and recycled materials need to be targeted for building houses and roads (UNEP, 2014).

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Coordinating agency or organisation

Not identified.

EN0023 / **ENVIRONMENTAL / Environmental Degradation**

Sea Level Rise

Definition

Sea-level change (sea-level rise / sea-level fall) is a change to the height of sea level, both globally and locally (relative sea-level change) at seasonal, annual, or longer time scales due to: a change in ocean volume as a result of a change in the mass of water in the ocean (e.g., due to melt of glaciers and ice sheets); to changes in ocean volume as a result of changes in ocean water density (e.g., expansion under warmer conditions), and to changes in the shape of the ocean basins and changes in the Earth's gravitational and rotational fields, and local subsidence or uplift of the land (IPCC, 2019).

Reference

IPCC, 2019. Annex I: Glossary [Weyer, N.M. (ed.)]. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)]. Intergovernmental Panel on Climate Change (IPCC). www.ipcc.ch/srocc/chapter/glossary Accessed 21 October 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

Global mean sea-level change resulting from change in the mass of the ocean is termed *barystatic*. The amount of barystatic sea-level change due to the addition or removal of a mass of water is referred to as its sea-level equivalent (SLE). Sea-level changes, both globally and locally, resulting from changes in water density are termed *steric*. Density changes induced by temperature changes only are termed *thermosteric*, while density changes induced by salinity changes are termed *halosteric*. Barystatic and steric sea-level changes do not include the effect of changes in the shape of ocean basins induced by the change in the ocean mass and its distribution (IPCC, 2019).

Global mean sea level rose by 0.19 m (0.17–0.21 m) between 1901 and 2010 (Abram et al., 2019).

The rate of sea-level rise increased from 1.4 mm yr–1 over the period 1901–1990, to 2.1 mm yr–1 over the period 1970–2015, to 3.2 mm yr–1 over the period 1993–2015, to 3.6 mm yr–1 over the period 2006–2015 (Oppenheimer et al., 2019).

The Intergovernmental Panel on Climate Change (IPCC) projects future global mean sea level rise to be between 0.43 m (0.29–0.59 m, likely range; RCP2.6) and 0.84 m (0.61–1.10 m, likely range; RCP8.5) by 2100 (medium confidence) relative to 1986–2005 (Oppenheimer et al., 2019). Local or relative seal-level rise will depart from this global mean due to local/regional conditions (e.g., local oceanic water currents or local land uplift/subsidence).

Sea-level rise is projected to increase the frequency of extreme sea-level events, leading to more frequent inundation. In several regions of the world, current inundation with a return period of one century could become annual events as soon as 2050 (Oppenheimer et al., 2019) and flooding frequency could increase exponentially, doubling every five years in the future (Taherkhani et al., 2020).

Global sea level is projected to continue to rise after 2100, up to 2.3–5.4 m by 2300 under the high IPCC emission scenario (RCP8.5).

There are large uncertainties about the level of contribution of the melting ice sheets from Greenland and Antarctica to global mean sea-level rise. Recent observations indicate an acceleration of melting and raise questions about a tipping point being reached that makes the melting irreversible over time (e.g., Lenton et al., 2019; King et al., 2020).

Metrics and numeric limits

According to Oppenheimer et al. (2919), in discussing sea-level rise and implications for low-lying islands, coasts and communities in the IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (Oppenheimer et al., 2019), 'sea level' means the time-average height of the sea surface, thus eliminating short duration fluctuations like waves, surges and tides. They add:

- *Global mean sea level (GMSL)* rise refers to an increase in the volume of ocean water caused by warmer water having a lower density, and by the increase in mass caused by loss of land ice or a net loss in terrestrial water reservoirs. Spatial variations in volume changes are related to spatial changes in the climate. In addition, mass changes due to the redistribution of water on the Earth's surface and deformation of the lithosphere leads to a change in the Earth's rotation and gravitational field, producing distinct spatial patterns in regional sea-level change. In addition to the regional changes associated with contemporary ice and water redistribution, the solid Earth may cause sea-level changes due to tectonics, mantle dynamics or glacial isostatic adjustment.
- These processes cause *vertical land motion* (VLM) and sea surface height changes at coastlines.
- Hence, *relative sea level rise* (RSL) change is defined as the change in the difference in elevation between the land and the sea surface at a specific time and location (Farrell and Clark, 1976). Here, regional sea level refers to spatial scales of around 100 km, while local sea level refers to spatial scales smaller than 10 km. In most places around the world, current annual mean rates of RSL change are typically on the order of a few mm yr–1.
- Risk associated with changing sea level is also related to individual events that have a limited duration, superimposed on the background of these gradual changes. As a result, the gradual changes in time and space have to be assessed together with processes that lead to flooding and erosion events. These processes include storm surges, waves and tides or a combination of these processes and lead to *extreme sea-level events* (ESL).
- Newly emerging understanding of these different episodic and gradual aspects of sea-level change are assessed, within a context of sea-level changes measured directly over the last century, and those inferred for longer geological time scales. This longer-term perspective is important for contextualising future projections of sea level and providing guidance for process-based models of the individual components of SLR, in particular the ice sheets. In addition, anthropogenic subsidence may affect local sea level substantially in many locations, but this process is not taken into account in values reported here for projected SLR unless specifically noted (Oppenheimer et al., 2019).

Key relevant UN convention/multilateral treaty

UN Climate Change Paris Agreement (2015) The Paris Agreement builds on the United Nations Framework Convention on Climate Change (UNFCCC) (UN and UNFCCC, 2011) and for the first time brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so. As such, it charts a new course in the global climate effort. By October 2020, 189 Parties had ratified of 197 Parties to the Paris Agreement (United Nations Climate Change, 2015).

UN Convention on the Law of the Sea (UNCLOS) lays down a comprehensive regime of law and order in the world's oceans and seas establishing rules governing all uses of the oceans and their resources. It enshrines the notion that all problems of ocean space are closely interrelated and need to be addressed as a whole. UNCLOS entered into force in accordance with its Article 308 on 16 November 1994 (UNCLOS, 2018).

Examples of drivers, outcomes and risk management

Sea-level rise is controlled by different drivers that act at different timeframes: for example, storms and tsunamis generate sea-level rise at the coast on short timeframes while global warming or geo-isostatic adjustment (vertical movement of the continents in response to change in overlying ice mass) generate sea-level rise over longer timeframes.

Sea-level rise generates a variety of impacts on coastal areas: change in coastline (erosion and accretion), coastal inundation and degradation of coastal vegetation.

Sea-level rise will modify sediment transport along the coast through changing water currents, and different sources of sediments and deposition areas. As a result, erosion and accretion can occur at different locations and at different rates. Although erosion is expected to occur more widely and to be an existential threat for the atoll islands, it seems atoll islands are responding to rising sea level by changing their shape (e.g., McLean and Kench 2015; Duvat, 2019). Although this does not result in a reduction in the size of the islands, it has impacts on coastal infrastructures and livelihoods in the erosion areas (see EN0020 on coastal erosion).

Sea-level rise also generates inundation in the coastal area through overwash (Ford et al., 2018). This results in damaged infrastructure, salination of groundwater, salination of soil and decreased crop yields. In the case of atoll islands, the increase in frequency of the inundation events caused by overwash could result in the inhabitability of some islands due to the reduction of fresh groundwater supply (Storlazzi et al., 2018).

Sea-level rise in atoll islands may also cause inundation by pushing up the fresh underground water lens (e.g., Habel et al., 2019). Although the consequences are different since the inundation is caused by freshwater, which is less corrosive to infrastructure and slightly less damaging to soils and crops, it is more difficult to manage since the classical coastal protection approach is ineffective against this type of inundation.

Coastal vegetation is distributed along the coast based on its tolerance to salt. Sea level will push the vegetation more inland and if there is no space to accommodate the retreat of the coastal vegetation, this ecosystem can be reduced or disappear (Oppenheimer et al., 2019).

Risk management for sea-level rise may be achieved through the reduction of greenhouse gas emissions; however, there will be a lag of several decades between the reduction of emissions and a decrease of sea-level rise since the processes controlling sea-level rise (thermal expansion from ocean warming and ice sheet melting) have delayed responses to global warming of the atmosphere (Oppenheimer et al., 2019).

Risk management for the impacts of sea-level rise at the coast are similar to the risk management for coastal erosion (EN0020). They include the design and construction of engineering structures (seawalls, revetments, etc.), conservation and development of healthy coastal ecosystems (e.g., coral reefs and mangrove forests), development of legislations and policies on coastal zoning and associated building codes, and integrated coastal management and monitoring of extreme sea-level rise events (Spalding et al., 2014).

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Coordinating agency or organisation

Not identified.

EN0024 / **ENVIRONMENTAL / Environmental Degradation**

Eutrophication

Definition

Eutrophication is the overabundance of nutrients in a body of water that results in harmful algal blooms, fish kills, and in some cases ecosystem collapse. It is a process driven by enrichment of water by nutrients, particularly compounds of nitrogen and/or phosphorus, leading to increased growth, primary production and biomass of algae; changes in the balance of nutrients causing changes to the balance of organisms; and water quality degradation (NOAA, 2007; UNEP, 2015).

References

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UNEP, 2015. Mediterranean Action Plan. Report of the Online Groups on Eutrophication, Contaminants and Marine Litter. United Nations Environment Programme (UNEP). https://wedocs.unep.org/bitstream/handle/20.500.11822/6325/15wg420_inf10_eng.pdf Accessed 14 October 2020.

Annotations

Synonyms

None identified.

Additional scientific description

Eutrophication is the nutrient output (mainly nitrogen and phosphorus), such as from sewage outfalls and fertilised farmland, that accelerates the growth of algae and other vegetation in water. The degradation of organic material consumes oxygen resulting in oxygen deficiency and, in some cases, fish death. Eutrophication translates the quantity of substances emitted into a common measure expressed as the oxygen required for the degradation of dead biomass (FAO, 2017).

Eutrophication resulting from excess inputs of nutrients from both agriculture and sewage causes algal blooms. Those can generate toxins that can make fish and other seafood unfit for human consumption. Algal blooms can also lead to anoxic areas (i.e., dead zones) and hypoxic zones. Such zones have serious consequences from environmental, economic and social perspectives (United Nations, 2017).

Where there are narrow continental shelves, some wind conditions can bring nutrient-rich, oxygen-poor water up into coastal waters, and produce hypoxic (low-oxygen) or even anoxic (no-oxygen) conditions and eutrophication can develop. Changes in ocean circulation appear to be enhancing those effects. Examples of this can be found on the western coasts of the American continent immediately north and south of the equator, the western coast of sub-Saharan Africa and the western coast of the Indian subcontinent (United Nations, 2017).

Marine biota are subject to many different pressures from hazardous substances, including the impact of such substances on reproductive success. Dead zones and low-oxygen zones resulting from eutrophication and climate change can lead to systematic changes in the species structure at established fishing grounds. Either can reduce the extent to which fish and other species used as seafood will continue to reproduce at their historical rates. When those effects are combined with those of excessive fishing on specific stocks, there are risks that the traditional levels of food provision from the sea will not be maintained (United Nations, 2017).

Metrics and numeric limits

It is unclear if there is a standard global metric for measuring the effects of eutrophication.

Key relevant UN convention/multilateral treaty

Not found.

Examples of drivers, outcomes and risk management

Excessive nutrient levels (eutrophication) lead to anoxic and hypoxic zones in the aquatic environment. The hypoxic and anoxic zones created by eutrophication drive fish away and kill the benthic wildlife. Where those zones are seasonal, any recovery is usually at lower trophic levels, and the ecosystems are therefore degraded. This seriously affects the maritime economy, both for fishermen and, where tourism depends on the attractiveness of the ecosystem (for example, around coral reefs), for the tourist industry too. Social consequences are then easy to see, both through the economic effects on the fishing and tourism industries and in depriving the local human populations of food.

References

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Coordinating agency or organisation

Not identified.

CHEMICAL

CH0001 / **CHEMICAL / Gases**

Ammonia

Definition

Ammonia (NH3) is a colourless acrid-smelling reactive gas at ambient temperature and pressure and is considered a significant public health hazard (WHO, 1986; PHE, 2019).

References

WHO, 1986. Environmental Health Criteria 54: Ammonia. 10.4, Accidental exposure. International Programme on Chemical Safety, World Health Organization(WHO). www.inchem.org/documents/ehc/ehc/ehc54.htm#SectionNumber:10.4 Accessed 2 December 2019.

PHE, 2019. Ammonia: Health effects, incident management and toxicology. Public Health England (PHE). www.gov.uk/government/publications/ammonia-properties-incident-management-and-toxicology Accessed 3 September 2020.

Annotations

Synonyms

Anhydrous ammonia, Ammonia gas, Spirit of hartshorn, Azane.

Additional scientific description

Ammonia is a non-flammable gas but is treated as flammable because it can form explosive mixtures with air. Ammonia dissolves readily in water. Solutions of ammonia are alkali and can be corrosive when concentrated or mixed with water. In addition to irritation symptoms, delayed onset of serious respiratory symptoms may present, including corrosive damage to the mucous membranes of both the upper and lower respiratory tract (WHO, 1986; PHE, England 2019).

Although ammonia is lighter than air, the vapours from a leak will initially hug the ground. Long-term exposure to low concentrations or short-term exposure to high concentrations may result in adverse health conditions from inhalation. Prolonged exposure of containers to fire or heat may result in their violent rupturing and rocketing. Both liquid and vapours are extremely irritating, especially to the eyes (Cameo Chemicals, no date).

Ammonia is an extensively used industrial chemical. It is commonly used in the production of fertilisers, fibres and plastics, and explosives and is also widely used as a cleaning and descaling agent and in food additives and as industrial refrigerant (WHO, 1986).

High gaseous ammonia concentrations may be encountered locally, both in domestic and occupational environments, as a result of gaseous emissions and/or spillages of concentrated solutions, and respiratory (and skin and eye) injury may result. On a larger scale, spillage from stock or transport tanks or refrigeration plant of concentrated ammonia liquor or anhydrous ammonia would constitute severe environmental damage and would cause serious injury to people, animals, and plants in the vicinity. Owing to its low density and short bio-persistence, major spillages would be expected to disperse rapidly and not to persist in the environment (WHO, 1990).

Ammonia can be stored and transported as a liquid at a pressure of 10 atm at 25°C. Ammonia dissolves readily in water where it forms, and is in equilibrium with ammonium ions (NH4+). The sum of ammonia and ammonium concentrations is termed 'total ammonia' and, owing to the slightly different relative molecular masses, may be expressed as 'total ammonia-nitrogen (NH3-N)'. In most waters, NH4+ predominates, but increased pH or temperature or decreased ionic strength may materially increase levels of non-ionized ammonia (WHO, 1986).

Metrics and numeric limits

Drinking-water: There is no health-based standard proposed by the World Health Organization (WHO) for ammonia in drinking-water. This is because the odour threshold (1.5 mg/l) and taste threshold (35 mg/l) are considered to be below levels of health concern (WHO, 2011). However, ammonia has the potential to reduce the effectiveness of some water treatment techniques and so some countries do prescribe a guideline value.

Air: There are no air quality guidelines for ambient levels of ammonia and public health. However, individual countries may develop occupational exposure limits and adopt acute/emergency guidelines.

Emergency response and acute exposure: Emergency Response Planning Guidelines (ERPG) (NOAA, 2016) and Acute Exposure Guideline Values for Airborne Chemicals (AEGLs) (US EPA, no date) exist for ammonia as a result of health risks associated with larger releases of ammonia in accident scenarios.

Key relevant UN convention / multilateral treaty

United Nations Economic Commission for Europe (UNECE) Convention on Long-range Transboundary Air Pollution (UNECE, no date).

Examples of drivers, outcomes and risk management

Breathing in low levels of ammonia may cause irritation to the eyes nose and throat. High levels of ammonia may cause burns and swelling in the airways, lung damage and can be fatal. Ingestion of ammonia solutions can cause pain and burns throughout the digestive tract. In severe cases the respiratory system, stomach and heart may be damaged, and death may follow. Strong ammonia solutions may cause serious burns if splashed on the skin. At high concentrations, gases and fumes of ammonia can also cause corrosive damage to the skin. Splashes in the eye may cause damage which may be irreversible in some cases and can lead to loss of sight. The health effects of ammonia are usually immediate and long-term effects would not be expected after exposure to small amounts (PHE, 2019).

Anhydrous ammonia (liquid or gas) reacts with tissue water to form the corrosive solution ammonium hydroxide. Following body surface exposure, it is advised to disrobe, and improvised wet decontamination should be considered. Spillages and decontamination run-off should be prevented from entering watercourses (PHE, 2019).

Risk management

- Consider evacuation where spillage or leakage has occurred.
- Improving wet decontamination should be considered in the case of skin contamination as ammonia reacts with tissue water to form the corrosive solution ammonium hydroxide (PHE, 2019).
- Spillages and decontamination run-off should be prevented from entering watercourses (PHE, 2019) due to potential damage to plants and animals.
- Encourage the avoidance of agricultural land during the use of ammonia fertilisers (ATSDR, 2004).
- Harmonised labelling and transport approaches should be considered.

References

ATSDR, 2004. Public Health Statement: Ammonia (CAS#: 7664-41-7). Agency for Toxic Substances & Disease Registry (ATSDR). www.atsdr.cdc.gov/phs/phs.asp?id=9&tid=2 Accessed 2 December 2019.

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WHO, 2011. Guideline for Drinking Water Quality, Fourth Edition. World Health Organization(WHO). apps.who.int/iris/bitstream/handle/10665/44584/9789241548151_eng.pdf?sequence=1 Accessed 2 December 2019.

Coordinating agency or organisation

World Health Organization (WHO).

CH0002 / **CHEMICAL / Gases**

Carbon Monoxide

Definition

Carbon monoxide is a colourless, odourless gas that can be poisonous to humans and is considered a significant public health hazard (WHO, 1999).

Reference

WHO, 1999. Environmental Health Criteria 213: Carbon monoxide. Second Edition. International Programme on Chemical Safety, World Health Organization (WHO). www.who.int/ipcs/publications/ehc/ehc_213/en Accessed 2 December 2019.

Annotations

Synonyms

None.

Additional scientific description

Carbon monoxide (CO) is one of the most common and widely distributed air pollutants. It is a colourless, odourless and tasteless gas that is poorly soluble in water. Carbon monoxide has a slightly lower density than air. In the human body, it reacts readily with haemoglobin to form carboxyhaemoglobin. Small amounts of carbon monoxide are also produced endogenously. Carbon monoxide exposure is still one of the leading causes of unintentional and suicidal poisonings, and causes a large number of deaths annually (WHO, 2000).

It is a product of the incomplete combustion of carbon-containing fuels and is also produced by natural processes or by biotransformation of halomethanes within the human body. With external exposure to additional carbon monoxide, subtle effects can begin to occur, and exposure to higher levels can result in serious symptoms and death. The health effects of carbon monoxide are largely the result of the formation of carboxyhaemoglobin (COHb), which impairs the oxygen-carrying capacity of the blood (WHO, 1999).

The total annual global emissions of carbon monoxide into the atmosphere have been estimated to be as high as 2600 million tonnes, of which about 60% are from human activities and about 40% from natural processes. Anthropogenic emissions of carbon monoxide originate mainly from the incomplete combustion of carbonaceous materials. The largest proportion of these emissions are produced as exhaust gases from internal combustion engines, especially by motor vehicles with petrol engines. Other common sources include various industrial processes, power plants using coal, and waste incinerators. Petroleum-derived emissions have greatly increased over the past few decades. Some widespread natural non-biological and biological sources, such as plants, oceans and oxidation of hydrocarbons, give rise to the background concentrations outside urban areas. In indoor environments, space heaters fuelled with oil, gas or kerosene, gas stoves and some other combustion appliances (e.g., wood stoves), and tobacco smoking are also responsible for significant emissions of carbon monoxide (WHO, 2000).

Metrics and numeric limits

Indoor air: 100 mg/m3 (87 ppm) for 15 minutes, 35 mg/m3 (30 ppm) for 1 hour, 10 mg/m3 (8.7 ppm) for 8 hours, 7 mg/m3 (6.1 ppm) for 24 hours (WHO, 2010).

Emergency response and acute exposure: Emergency Response Planning Guidelines (ERPG) (NOAA, 2016) and Acute Exposure Guideline Values for Airborne Chemicals (AEGLs) (US EPA, no date) exist for carbon monoxide.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Carbon monoxide is produced when fossil fuels burn without enough oxygen. The most important source of exposure to carbon monoxide for the general public is from cooking or other fuel-burning appliances which are poorly installed, faulty or used inappropriately (including inadequate ventilation). For example, home boilers that are installed incorrectly, and the use of BBQs and portable generators inside homes, caravans and tents. Inhaling smoke from a house fire may lead to carbon monoxide exposure. For smokers, cigarettes are the major source of carbon monoxide. Use of shisha/hookah pipes may also lead to exposure. Exposure to low levels of carbon monoxide can occur outdoors, as it is produced by vehicle exhausts and industrial processes (PHE, 2019).

In emergency situations where power is lost, using an improperly vented generator inside a home or building or using gas grills, charcoal grills, or hibachis indoors can lead to dangerous levels of carbon monoxide. Breathing high levels of carbon monoxide can be fatal. Breathing lower levels of carbon monoxide can permanently harm the heart and brain. Carbon monoxide tends to be more harmful to people with heart or lung disease (ATSDR, 2012).

Risk management

- Encourage means to reduce exposure in the home and indoor environment by discouraging the use of solid fuels, such as charcoal and biomass and encouraging cooking in well ventilated spaces.
- Educate emergency services, volunteers and others to eliminate the use of generators in confined spaces where people may be exposed. This is particularly relevant during emergency and disaster response and recovery activities where main power supplies are lost.
- Consider regulating for safe installation of indoor heating appliances.
- Separate dwelling spaces from vehicle garages.
- Discourage the indoor running of combustion engine vehicles or require adequate ventilation where this is not possible.
- Avoid cigarette smoke and smoking (particularly pregnant women and children) as these are a source of carbon monoxide (and other hazardous chemicals).

References

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WHO, 2010. Guidelines for indoor air quality: Selected pollutants. World Health Organization (WHO). www.euro.who.int/__data/assets/pdf_file/0009/128169/e94535.pdf Accessed 2 December 2019.

Coordinating agency or organisation

World Health Organization (WHO).

CH0003 / **CHEMICAL / Heavy Metals**

Arsenic

Definition

Arsenic is a toxic heavy metal widely distributed throughout the Earth's crust, generally as arsenic sulphide or as metal arsenates and arsenides. Human exposure to arsenic compounds represents a major public health concern as it has been associated with a range of acute and long-term adverse health effects and diseases (WHO, 2019).

Reference

WHO, 2019. Preventing Disease through Healthy Environments – Exposure to arsenic: A major public health concern. World Health Organization (WHO). apps.who.int/iris/bitstream/handle/10665/329482/WHO-CED-PHE-EPE-19.4.1-eng.pdf?ua=1 Accessed 21 November 2019.

Annotations

Synonyms

Not identified.

Additional scientific description

Arsenic (chemical symbol As, atomic number 33) can be released into the atmosphere and water in the following ways: natural activities, such as volcanic activity, dissolution or desorption of minerals (particularly into groundwater), exudates from vegetation and wind-blown dusts; human activities, such as metal smelting, combustion of fossil fuels (especially coal), mining, timber treatment with preservatives and, historically, agricultural pesticide production and use; remobilisation of historic sources, such as mine drainage water; and mobilisation into drinking-water from geological deposits by drilling of tube wells (WHO, 2019).

In water, arsenic occurs in one of two main forms: arsenite As(III) under reducing conditions and arsenate As(V) if the water is oxygenated. It can be released to the atmosphere, primarily as the trioxide, mainly by high-temperature processes or through volatilisation from aerated soils. In the atmosphere, it is mainly adsorbed onto particles, which are dispersed by winds and deposited on land and water (WHO, 2019).

Soluble inorganic arsenic is highly acutely toxic. Intake of inorganic arsenic over a long period can lead to chronic arsenic poisoning (arsenicosis). Effects, which can take years to develop depending on the level of exposure, include skin lesions, peripheral neuropathy, gastrointestinal symptoms, diabetes, cardiovascular disease, developmental toxicity, and cancer of the skin and internal organs (IARC, 2018). Organic arsenic compounds, which are abundant in seafood, are less harmful to health and are rapidly eliminated by the body.

Human exposure to arsenic and arsenic compounds can occur through environmental or occupational routes. Human exposure to elevated levels of inorganic arsenic occurs mainly through the intake of groundwater containing naturally high levels of inorganic arsenic, food prepared with this water, and food crops irrigated with high-arsenic water sources. Public health actions need to be continued to reduce human exposure to arsenic, particularly in areas with naturally high levels in groundwater (WHO, 2019).

Metrics and numeric limits

In 2002, the World Health Organization (WHO) reported that at least 140 million people in 50 countries were estimated to have been drinking water containing arsenic at levels above the WHO provisional guideline value of 10 μg/l (WHO, 2019). Inorganic arsenic is naturally present at high levels in the groundwater of several countries, such as Argentina, Chile, China, India (West Bengal), Mexico, the USA, and particularly Bangladesh, where it was estimated that in 2012 approximately 19 million people were exposed to drinking-water concentrations above the national standard of 50 μg/l and 39 million people were drinking water with levels of arsenic above 10 μg/l. In 2010, 21.4% of all deaths in a highly affected area of Bangladesh were attributed to arsenic levels of above 10 μg/l in drinking-water, while another analysis published in 2012 for all districts indicated an annual total of nearly 43,000 deaths (about 5.6% of all deaths) attributable to chronic arsenic exposure (WHO, 2019).

The WHO has published arsenic guidelines for tolerable intake levels, drinking-water and air (WHO, 2019):

- Tolerable daily intake level: In a review of the latest scientific evidence conducted in 2010, the Joint Food and Agriculture Organization of the United Nations (FAO)/WHO Expert Committee on Food Additives (JECFA) determined the lower limit on the benchmark dose for a 0.5% increased incidence of lung cancer (BMDL0.5) from epidemiological data to be 3.0 μg/kg body weight per day (2–7 μg/kg body weight per day based on the range of estimated total dietary exposure). No new tolerable intake level could be established. In areas where levels in water are below the WHO drinking-water guideline value, human health effects are unlikely.
- Drinking-water: The provisional guideline value is 10 μg/l, in light of practical difficulties in removing arsenic in drinking-water, every effort should be made to keep concentrations as low as reasonably possible and below the guideline value when resources are available.
- Air: A safe level of arsenic in air cannot be established.

Key relevant UN convention / multilateral treaty

International Labour Organization C042 - Workmen's Compensation (Occupational Diseases) Convention (Revised), 1934 (ILO, 1934).

Examples of drivers, outcomes and risk management

Drinking-water poses the greatest threat to public health from arsenic (WHO, 2019).

Most arsenic in industrial processes is used to produce antifungal wood preservatives, which can lead to soil contamination. Other current or historical uses occur within the pharmaceutical and glass industries, in the manufacture of alloys, sheep dips, leather preservatives, arsenic-containing pigments, antifouling paints and poison baits and, to a diminishing extent, in the production of agrochemicals (especially for use in orchards and vineyards). Arsenic compounds are also employed in limited amounts in the microelectronics and optical industries. High arsenic levels in air can be found in the working environment as well as the general environment around non-ferrous metal smelters, where arsenic trioxide may be formed, and some coal-fired power plants (especially those using low-grade brown coal) (WHO, 2019).

In areas where arsenic is not naturally present at high levels, food usually contributes most to the daily intake of arsenic. Fish, shellfish, meat, poultry, dairy products and cereals are the main sources of dietary intake. However, the arsenic in fish and shellfish is usually in the form of organic compounds (e.g., arsenobetaine) that are of low toxicity. In areas where arsenic is naturally present at high levels, food (e.g., rice) prepared with high arsenic-containing water and food crops irrigated with contaminated water also contribute to total daily intake (WHO, 2019).

Exposure of smokers to arsenic arises from the natural inorganic arsenic content of tobacco. Exposures were higher in the past when tobacco plants were treated with lead arsenate insecticide (WHO, 2019).

Long-term actions are required to reduce exposure to arsenic from mining, metal smelting and refining, combustion of low-grade coal, pesticide use and timber treatment. In particular, action is needed to reduce the intake of arsenic from drinking-water and food in areas with naturally high levels in the groundwater (WHO, 2019).

The WHO factsheet on preventing disease through healthy environments (WHO, 2019) includes the following risk mitigation recommendations:

- Make available drinking-water with arsenic concentrations below the WHO provisional drinking-water guideline value of 10 μg/l in areas where the level is higher. Possible measures include:
  - Testing water for arsenic levels and informing users of the results.
  - Installing arsenic removal systems, either centralised or domestic, and ensuring appropriate disposal of the removed arsenic.
  - Substituting high-arsenic sources, such as groundwater, with low-arsenic, microbiologically safe sources such as rainwater and treated surface water. Low-arsenic water can be used for drinking, cooking and irrigation purposes, whereas high-arsenic water can be used for other purposes such as bathing and washing clothes.

  - Discriminating between high-arsenic and low-arsenic sources by testing water for arsenic levels and painting tube wells or hand pumps different colours (e.g., red and green).
  - Blending low-arsenic water with higher-arsenic water to achieve an acceptable arsenic concentration level.
- Reduce occupational exposure to arsenic and its compounds.
- Make both the general public and the health sector aware of the harmful effects of high arsenic intake and the sources of exposure (including use of high-arsenic water for crop irrigation or food preparation) and how to avoid these sources.
- Monitor high-risk populations for early signs of arsenic poisoning, usually skin problems. It should be noted that total urinary arsenic does not differentiate between inorganic arsenic, which is toxic, and organic arsenic, some of which is not. Where possible, arsenic speciation should be attempted in order to differentiate these two forms (and their metabolites).
- The WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene monitors progress towards global targets on drinking-water. In addition, under the new 2030 Agenda for Sustainable Development, the indicator of 'safely managed drinking water services' calls for tracking the population accessing drinking-water that is free of faecal contamination and priority chemical contaminants, including arsenic (UN Water, no date; Council of Europe, 2021).

References

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Coordinating agency or organisation

World Health Organization (WHO).

CH0004 / **CHEMICAL / Heavy Metals**

Cadmium

Definition

Cadmium is a toxic heavy metal which is widely distributed in the Earth's crust (soil and rocks), air and water; however, human activity has greatly increased levels in environmental media relevant to population exposure. Human exposure to cadmium represents a major public health concern as it has been associated with a range of acute and long-term adverse health effects and diseases (WHO, 2019).

Reference

WHO, 2019. Preventing disease through healthy environments – Exposure to cadmium: A major public health concern. World Health Organization (WHO). https://apps.who.int/iris/bitstream/handle/10665/329480/WHO-CED-PHE-EPE-19.4.3-eng.pdf?ua=1 Accessed 25 November 2019.

Annotations

Synonyms

Not relevant.

Additional scientific description

Cadmium (chemical symbol Cd, atomic number 48) is an element that exists as a number of compounds due to it combining with other elements, including oxygen to form cadmium oxide, chlorine to form cadmium chloride, or sulphur to form cadmium sulphide and cadmium sulphate. Cadmium oxide and cadmium sulphide are most commonly found in the air, whereas cadmium chloride and cadmium sulphate dissolve in water (PHE, 2016).

Cadmium is generally present in the environment at low levels; however, human activity has greatly increased levels in environmental media relevant to population exposure. Cadmium can travel long distances from the source of emission by atmospheric transport. It is readily accumulated in many organisms, notably molluscs and crustaceans. Lower concentrations are found in vegetables, cereals and starchy roots (WHO, 2019). Cadmium compounds can be released to the environment in a number of ways, including:

- Natural activities, such as volcanic activity (both on land and in the deep sea), weathering and erosion, and river transport (WHO, 2019).
- Human activities, such as tobacco smoking, mining, smelting and refining of non-ferrous metals, fossil fuel combustion, incineration of municipal waste (especially cadmium-containing batteries and plastics), use of cadmium containing phosphate fertilisers, and recycling of cadmium-plated steel scrap and electric and electronic waste (WHO, 2019).
- Remobilisation of historic sources, such as the contamination of watercourses by drainage water from metal mines or from waste sites (WHO, 2019).

Cadmium exerts toxic effects on the kidney, the skeletal system and the respiratory system and is classified as a human carcinogen (IARC, 1993). Osteomalacia (softening of the bones) and osteoporosis may occur in those exposed through living or working in cadmium-contaminated areas; for example, in an area of Japan where water and soil were contaminated with cadmium from zinc/lead mines, itai-itai ('ouch-ouch') disease (characterised by osteomalacia, osteoporosis, painful bone fractures and kidney dysfunction) used to be widespread (WHO, 2019).

Human exposure occurs mainly from consumption of contaminated food, active and passive inhalation of tobacco smoke, and inhalation by workers in a range of industries. National, regional and global actions are needed to decrease global environmental cadmium releases and reduce occupational and environmental exposure (WHO, 2019).

Metrics and numeric limits

The World Health Organization (WHO) has published cadmium guidelines for provisional tolerable monthly intake levels, drinking-water and air (WHO, 2019).

- Provisional tolerable monthly intake: The Joint Food and Agriculture Organization of the United Nations (FAO)/WHO Expert Committee on Food Additives (JECFA) established a provisional tolerable monthly intake for cadmium in 2010 of 25 µg/kg body weight, based on meta-analysis of epidemiological studies on the relationship between urinary cadmium and beta-2-microglobulin (a marker of renal tubular effects). In light of the long half-life of cadmium in humans, JECFA decided to express the tolerable intake as a monthly value.
- Drinking-water: The guideline for cadmium in drinking-water is 3 µg/l.
- Air: The guideline for cadmium in air is 5 ng/m3 (annual average).

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Cadmium contained in soil and water can be taken up by certain crops and aquatic organisms and accumulate in the food chain. Food constitutes the main environmental source of cadmium for non-smokers. Highest cadmium levels are found in the kidney and liver of mammals when fed with cadmium-contaminated feed, and in certain species of oyster, scallop, mussel and crustacean (WHO, 2019).

The tobacco plant naturally accumulates relatively high concentrations of cadmium in its leaves. Thus, smoking tobacco is an important source of exposure and – in the case of heavy smokers – daily intake may exceed that from food. Cigarette smoking can cause significant increases in the concentration of cadmium in the kidney, the main target organ for cadmium toxicity (WHO, 2019).

Inexpensive jewellery, toys and plastics can be significant sources of exposure to cadmium, especially for children; however, many countries have moved to restrict or ban cadmium in such products (WHO, 2019).

In terms of occupational exposure through industrial processes, principal uses are currently in nickel-cadmium batteries, pigments, coatings and plating, as a stabiliser in plastics and other materials (including non-ferrous alloys, semiconductors and photovoltaic devices). The highest potential occupational exposures occur in cadmium production and refining, nickel-cadmium battery manufacture, cadmium pigment manufacture and formulation, cadmium alloy production, mechanical plating, zinc smelting, brazing with silver-cadmium-silver alloy solder and polyvinylchloride compounding (WHO, 2019).

The WHO factsheet on preventing disease through healthy environments (WHO, 2019) includes the following risk mitigation recommendations:

- Implement the WHO Framework Convention on Tobacco Control, including providing for protection from exposure to tobacco smoke in indoor workplaces, public transport, indoor public places and, as appropriate, other public places (WHO, 2003).
- Reduce, as far as is practicable, emissions of cadmium – particularly into surface waters – from mining and smelting, waste incineration, application of sewage sludge to the land, and use of phosphate fertilisers and cadmium-containing manure. Develop techniques for the safe disposal of cadmium-containing wastes and effluents.
- Washing fruit and vegetables and peeling roots and tubers can help reduce cadmium contamination.
- Promote safe and effective measures to increase recycling of cadmium and to restrict non-recyclable uses.
- Promote the elimination of use of cadmium in products such as toys, jewellery and plastics.
- Reduce cadmium exposure by, for instance, improving working conditions in the non-ferrous metal smelting industry and disseminating information on the proper selection of fertilisers (which sometimes contain high levels of cadmium).
- Raise global awareness on the importance of minimising waste discharges of cadmium.

References

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Coordinating agency or organisation

World Health Organization (WHO).

CH0005 / **CHEMICAL / Heavy Metals**

Lead

Definition

Lead is a naturally occurring highly toxic heavy metal. Its widespread use has caused extensive environmental contamination and health problems in many parts of the world. It is a cumulative toxicant that affects multiple body systems, including the neurological, haematological, gastrointestinal, cardiovascular and renal systems. Children are particularly vulnerable to the neurotoxic effects of lead, and even relatively low levels of exposure can cause serious and, in some cases, irreversible neurological damage (WHO, 2010).

Reference

WHO, 2010. Preventing Disease through Healthy Environments – Exposure to lead: A major public health concern. World Health Organization (WHO). www.who.int/ipcs/features/lead..pdf?ua=1 Accessed 15 November 2019.

Annotations

Synonyms

None

Additional scientific description

Lead (chemical symbol Pb, atomic number 82) is found at low levels in the Earth's crust, mainly as lead sulphide (WHO, 2010). However, the widespread occurrence of lead in the environment is largely the result of human activity, such as mining, smelting, refining and informal recycling of lead; use of leaded petrol (gasoline); production of lead-acid batteries and paints; jewellery making, soldering, ceramics and leaded glass manufacture in informal and 'cottage' (home-based) industries; electronic waste; and use in water pipes and solder (WHO, 2010). Other sources of lead in the environment include natural activities, such as volcanic activity, geochemical weathering and sea spray emissions, and remobilisation of historic sources, such as lead in soil, sediment and water from mining areas. As lead is a natural element, once it is released into the environment, it persists. Owing to lead's persistence and potential for global atmospheric transport, atmospheric emissions affect even the most remote regions of the world (WHO, 2010).

Acute exposures to lead may cause gastrointestinal disturbances (anorexia, nausea, vomiting, abdominal pain), hepatic and renal damage, hypertension and neurological effects (malaise, drowsiness, encephalopathy) that may lead to convulsions and death. Chronic exposure effects include haematological effects, such as anaemia, or neurological disturbances, including headache, irritability, lethargy, convulsions, muscle weakness, ataxia, tremors and paralysis. Pregnant women are particularly vulnerable, for example, in-utero exposure of the foetus at maternal blood lead levels of less than 5 mg/dl can lead to reduced foetal growth and lower birth rate, and the mother may experience eclampsia and decreased renal function at these blood lead levels. Developing children are particularly vulnerable to lead exposure, with learning disorders and other neurological and developmental disorders occurring at blood lead levels lower than those of adults (US Department of Health and Human Services, 2012).

It has been estimated that lead exposure was responsible, in 2004, for 143,000 deaths and 0.6% of the global burden of disease (expressed in disability-adjusted life years, or DALYs), taking into account mild mental retardation and cardiovascular outcomes resulting from exposure to lead. Young children absorb four to five times as much lead as adults (apart from pregnant women). Infants, young children (especially those less than 5 years of age) and pregnant women are most susceptible to the adverse effects of lead. The most critical effect of lead in young children is that on the developing nervous system. Subtle effects on intelligence quotient (IQ) are expected from blood lead levels at least as low as 5 μg/dl (50 μg/l), and the effects gradually increase with increasing levels of lead in blood (WHO, 2010).

Metrics and numeric limits

The World Health Organization (WHO) has published lead guidelines for drinking-water and air (WHO, 2010):

Drinking-water: 10 μg/l.

Air: 0.5 μg/m3 (annual average).

Key relevant UN convention / multilateral treaty

International Labour Organisation C013 - White lead (painting) convention, 1921 (ILO, 1921).

Examples of drivers, outcomes and risk management

Significant sources of exposure to lead still remain, particularly in developing countries (WHO, 2010).

Further efforts are required to continue to reduce the use and release of lead and to reduce environmental exposures, particularly for children and women of child-bearing age (WHO, 2010). Recent reductions in the use of lead in petrol (gasoline), paint, plumbing and solder have resulted in substantial reductions in lead levels in the blood.

In terms of industrial processes, lead is used mainly in the production of lead-acid batteries, plumbing materials and alloys. Other uses are in cable sheathing, paints, glazes and ammunition. Mining, smelting, and informal processing and recycling of electric and electronic waste can also be significant sources of exposure. Lead has been used widely in the form of tetraethyl and tetramethyl lead as antiknock and lubricating agents in petrol, although the majority of lead is emitted from vehicles in the form of inorganic particles. This use has been phased out in most countries, which has resulted in a significant reduction of human exposure and mean blood lead levels. In the few parts of the world where leaded petrol is still in use, however, it continues to be a major source of exposure. Old industrial hotspots that have not been cleaned up can also represent a hazard.

Even years after contamination has stopped, particularly to children who might ingest contaminated soil or dust as a result of their hand-to-mouth behaviour (WHO, 2010).

For the non-smoking general population, the largest contribution to the daily intake of lead is from the ingestion of food, dirt and dust. The amount of lead in food plants depends on soil concentrations and is highest around mines and smelters. Cereals can contain high levels of lead, and spices may be contaminated with lead. Use of lead-soldered food and beverage cans (which is now diminishing) may considerably increase the lead content of the food or beverage, especially in the case of acidic foods or drinks. As fruit juices and various alcoholic drinks tend to be acidic, the use of any lead-containing products in their manufacture, distribution or storage will raise lead levels. Migration of lead into food from lead-glazed ceramic or pottery dinnerware is also a source of exposure. Smoking tobacco increases lead intake (WHO, 2010).

Lead present at elevated levels in tap water is rarely the result of its dissolution from natural sources but is often due to old household plumbing systems containing lead pipes, solders and fittings. Soft acidic water dissolves the most lead (WHO, 2010).

Contaminated dust may be the main source of exposure for infants in countries that no longer use leaded petrol. The weathering, peeling or chipping of lead-based paints, mainly found in older houses, plays a role in children's exposure, especially as some young children eat the fragments or lick dust-laden fingers. Lead-containing dust may be brought into the home on the clothes of those who work in industries where such dust is generated. Some toys are either made from lead or contain lead (e.g., some plastics or paints). Some traditional medicines and makeup (e.g., kohl) contain lead (WHO, 2010).

Primary prevention (i.e., the elimination of exposure to lead at its source) is the single most effective intervention against childhood lead poisoning (WHO, 2010).

The following actions for eliminating use are needed:

- Phase out the use of lead additives in motor fuels in countries where this has not yet been done.
- Phase out the use of lead in paints on a worldwide basis.
- Eliminate the use of leaded solder in food and drink cans, as well as in water pipes.
- Eliminate the use of lead in homes, schools, school materials and children's toys.

- Eliminate the use of lead glazing for pottery intended for cooking, eating or drinking.
- Encourage the removal of plumbing and fittings containing lead (as this is costly, other measures, such as corrosion control and minimising the dissolving of lead in water systems, should be implemented in the meantime).
- Identify and eliminate lead use in traditional medicines and cosmetics.
- Establish sentinel systems that include human biomonitoring, possibly most easily facilitated via a network of recognised analytical laboratories.

The WHO provides recommendations (WHO, 2010) on preventing exposure to lead from electric and electronic waste (e.g., lead-acid batteries, computers), particularly for children, which include:

- Ensure that the recycling of lead-containing waste is undertaken only in the presence of appropriate industrial hygiene measures and that informal recycling and use of lead-containing waste are discouraged.
- Identify contaminated sites and take necessary action to prevent human exposure to lead from these areas.
- Prevent pica of paint chips in homes previously painted with lead-based paint.
- Follow good practices, including personal protective equipment and barriers, during rehabilitation, deconstruction, decommissioning, and other work in and near buildings and structures that may have been painted with lead-based paint.

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Coordinating agency or organisation

World Health Organization (WHO).

CH0006 / **CHEMICAL / Heavy Metals**

Mercury

Definition

Mercury is a naturally occurring element that is found in air, water and soil. Exposure to mercury – even small amounts – may cause serious health problems and is a threat to the development of the foetus in utero and for children early in life (WHO, 2017).

Reference

WHO, 2017. Mercury and Health. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/mercury-and-health Accessed 25 November 2019.

Annotations

Synonyms

Quicksilver.

Additional scientific description

Mercury (chemical symbol Hg, atomic number 80) exists in various forms: elemental mercury (metallic or vapour) and inorganic mercury compounds (to which people may be exposed, for example, through their occupation); and organic mercury compounds (for example, methylmercury, to which people may be exposed through their diet). These forms of mercury differ in their degree of toxicity and toxic effects (WHO, 2017).

Mercury occurs naturally in the Earth's crust (UNEP, 2018). It is released into the environment from volcanic activity, weathering of rocks and as a result of human activity. Human activity is the main cause of mercury releases, particularly coal-fired power stations, residential coal burning for heating and cooking, industrial processes, waste incinerators and as a result of mining for mercury, gold and other metals (WHO, 2017). Mercury has been used in dental amalgam for tooth fillings. Methylmercury has a history as fungicide. Organic mercury compounds are used as protective agents in biochemistry.

Mercury may have toxic effects on the nervous, digestive and immune systems, and on lungs, kidneys, skin and eyes. The World Health Organization considers mercury to be one of the top ten chemicals or groups of chemicals of major public health concern. People are mainly exposed to mercury in the form of methylmercury, an organic compound, when they eat fish and shellfish that contain this compound (WHO, 2017).

Once in the environment, elemental mercury can be transformed into methylmercury and consumed by phytoplankton in seawater and by sulphate-reducing bacteria in freshwater sediments. Methylmercury then bioaccumulates (the process by which an organism contains progressively higher concentrations of the substance than its surroundings) in fish and shellfish. Methylmercury also biomagnifies up food chains: for example, large predatory fish are more likely to have high levels of methylmercury as a result of eating many smaller fish that have acquired methylmercury through ingestion of plankton (WHO, 2017).

Use of elemental mercury in some traditional therapies, religions and practices (e.g., Santería, Espiritismo) represents a risk of exposure due to the practice itself or from accidental spills. However, the extent of the problem is unknown. Use of mercury-containing beauty creams, hair treatment and other cosmetic products may cause significant exposure (WHO, 2017).

Health effects from mercury (WHO, 2007) are summarised as follows:

- Inhalation of mercury vapour can produce harmful effects on the nervous, digestive and immune systems, lungs and kidneys, and may be fatal. The inorganic salts of mercury are corrosive to the skin, eyes and gastrointestinal tract, and may induce kidney toxicity if ingested.

- Neurological and behavioural disorders may be observed after inhalation, ingestion or dermal application of different mercury compounds. Symptoms include tremors, insomnia, memory loss, neuromuscular effects, headaches and cognitive and motor dysfunction. Mild subclinical signs of central nervous system toxicity can be seen in workers exposed to an elemental mercury level in the air of 20 μg/m^3 or more for several years. Kidney and immune effects have been reported. There is no conclusive evidence linking mercury exposure to cancer in humans.
- Children are especially vulnerable to mercury and may be exposed directly by eating contaminated fish. Methylmercury bioaccumulated in fish and consumed by pregnant women may lead to neurodevelopmental problems in the developing foetus. Transplacental exposure is the most dangerous, as the foetal brain is very sensitive. Neurological symptoms include mental retardation, seizures, vision and hearing loss, delayed development, language disorders and memory loss. In children, a syndrome characterised by red and painful extremities called acrodynia has been reported to result from chronic mercury exposure.

Metrics and numeric limits

Guidance values are complex but in summary the following may be helpful:

- Drinking-water: 0.006 mg/l (6 μg/l) for inorganic mercury (WHO, no date).
- Provisional tolerable weekly intake: for methylmercury in food of 1.6 μg/kg body weight (JECFA, 2007).
- Air: lowest-observed-adverse-effect level (LOAELs) for mercury vapour are around 15–30 μg/m3 (WHO, 2000).

Key relevant UN convention / multilateral treaty

Minamata Convention on Mercury (UNEP, 2013).

Examples of drivers, outcomes and risk management

All humans are exposed to mercury. Factors that determine whether health effects occur, and their severity include: the chemical form of mercury concerned; the dose; the age or developmental stage of the person exposed (the foetus is most susceptible); the duration of exposure; and the route of exposure (inhalation, ingestion or dermal contact) (WHO, 2017).

Generally, two groups are more sensitive to the effects of mercury. Foetuses are most susceptible to developmental effects due to mercury potentially leading to impaired neurological development with cognitive thinking, memory, attention, language, and fine motor and visual spatial skills affected. The second group is people who are regularly exposed (chronic exposure) to high levels of mercury (such as populations that rely on subsistence fishing or people who are occupationally exposed). Among selected subsistence fishing populations, between 1.5/1000 and 17/1000 children showed cognitive impairment (mild mental retardation) associated with the consumption of fish containing mercury (WHO, 2017).

A significant example of mercury exposure affecting public health occurred in Minamata, Japan, between 1932 and 1968, where a factory producing acetic acid with a mercury catalyst discharged inorganic mercury into Minamata Bay. The bay was rich in fish and shellfish, providing the main livelihood for local residents and fishermen from other areas. For many years, no one realised that the fish were contaminated with mercury, and that it was causing a strange disease in the local community and in other districts. At least 50,000 people were affected to some extent and more than 2000 cases of Minamata disease were certified. Minamata disease peaked in the 1950s, with severe cases suffering brain damage, paralysis, incoherent speech and delirium. The continued release of mercury into the environment from human activity, the presence of mercury in the food chain, and the demonstrated adverse effects on humans are of such concern that in 2013 governments agreed to the Minamata Convention on Mercury. The Convention obliges Parties to take a range of actions, including to address mercury emissions to air and to phase-out certain mercury-containing products (WHO, 2019).

There are several ways to prevent adverse health effects of mercury, including promoting clean energy, stopping the use of mercury in gold mining, eliminating the mining of mercury and phasing out non-essential mercury-containing products.

- Promote the use of clean energy sources that do not burn coal. Burning coal for power and heat is a major source of mercury. Coal contains mercury and other hazardous air pollutants that are emitted when the coal is burned in coal-fired power plants, industrial boilers and household stoves (WHO, 2017).
- Eliminate mercury mining and use of mercury in gold extraction and other industrial processes. Mercury is an element that cannot be destroyed; therefore, mercury already in use can be recycled for other essential uses, with no further need for mercury mining. Mercury use in artisanal and small-scale gold mining is particularly hazardous, and health effects on vulnerable populations are significant. Non-mercury (non-cyanide) gold-extraction techniques need to be promoted and implemented, and where mercury is still used, safer work practices need to be employed to prevent exposure (WHO, 2017).
- Phase out use of non-essential mercury-containing products and implement safe handling, use and disposal of remaining mercury-containing products including batteries, measuring devices, such as thermometers and barometers, electric switches and relays in equipment, lamps (including some types of light bulbs), dental amalgam (for dental fillings), skin-lightening products and other cosmetics and pharmaceuticals (WHO, 2017).
- Establish a sentinel system to detect hazardous substances.

References

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Coordinating agency or organisation

World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO).

CH0007 / **CHEMICAL / Food Safety**

Levels of Contaminants in Food and Feed

Definition

A contaminant in food and feed is defined as any substance not intentionally added to food or feed for food-producing animals, which is present in such food or feed as a result of the production (including operations carried out in crop husbandry, animal husbandry and veterinary medicine), manufacture, processing, preparation, treatment, packing, packaging, transport or storage, or as a result of environmental contamination. Note: The term includes toxins, such as moulds, but does not include insect fragments, rodent hairs and other extraneous matter (FAO and WHO, 2019).

Reference

FAO and WHO, 2019. Codex Alimentarius Commission – Procedural Manual twenty-seventh edition. Food and Agriculture Organization of the United Nations (FAO) and World Health Organization (WHO). www.fao.org/3/ca2329en/CA2329EN.pdf

Annotations

Synonyms

Not identified.

Additional scientific description

With an estimated 600 million cases of foodborne illnesses annually, unsafe food is a threat to human health, food security, nutrition and economies globally. Ensuring food safety is a public health priority and an essential step to achieving food and nutrition security. Effective national food safety and quality control systems are key not only to safeguarding the health and well-being of people, but also to fostering economic development and improving livelihoods by promoting access to domestic, regional and international markets (FAO and WHO, 2020).

Metrics and numeric limits

Maximum Level: The maximum level for a contaminant in a food or feed commodity is the maximum concentration of that substance recommended by the Codex Alimentarius Commission to be legally permitted in that commodity. There are also national regulations for maximum levels.

Guideline Level: A guideline level is the maximum level of a substance in a food or feed commodity which is recommended by the Codex Alimentarius Commission to be acceptable for commodities moving in international trade. When the guideline level is exceeded, governments should decide whether and under what circumstances the food should be distributed within their territory or jurisdiction.

Note: A contaminant in food or feed is considered a risk for human health when above the maximum/guideline level established by the Codex Alimentarius Commission.

Key relevant UN convention/multilateral treaty

Joint Food and Agriculture Organization of the United Nations (FAO) and World Health Organization (WHO) Food Standards Programme Codex Alimentarius Commission.

Examples of drivers, outcomes and risk management

Drivers: Environmental, industrial and agricultural pollution, intensification of agricultural production, poor hygiene practices along the food chain, International trade.

Outcomes: Safe food, ensured public health, ensured fair practices in food trade.

Risk management: A national legislation and food control system, including food import control, export control, and national monitoring programmes.

Risk management measures: Science-based harmonised texts such as Codex standards, recommendations, guidelines, codes of practice, analytical monitoring, national and international monitoring networks, warning of consumers, retraction from the market.

Normative work to support ensuring safe levels of contaminants in food and feed: Relevant standard setting bodies and a selection of mechanisms, guidance, tools and other resources developed by the FAO, in collaboration with the WHO and a range of partners, aiming to advise and support the delivery of safe levels of contaminants in food and feed are as follows:

- The FAO Food Safety and Quality Programme and FAO Food Systems and Food Safety Division.
- Codex Alimentarius Commission.
- Codex Committee on Contaminants in Food.
- General Standard for Contaminants and Toxins in Food and Feed (CXS 193-1995).
- Joint FAO / WHO Expert Committee on Food Additives (JECFA).
- Risk Based Imported Food Control Manual.
- Food safety risk management: Evidence-informed policies and decisions, considering multiple factors.

Food Safety and Quality Programme: The FAO is a recognised leader in the development of global food safety initiatives and guidance translating these into country level action. The Food Safety and Quality Programme supports an integrated and multidisciplinary approach to food safety risk management through holistic and feasible 'food chain' solutions to specific food safety problems as laid out in its strategy for improving food safety globally (FAO, 2014). The foundations for this approach are based on science (FAO, no date).

The Food Systems and Food Safety Division of the FAO supports the strengthening of systems of food safety and quality control at national, regional and international levels. This involves (FAO, no date):

- Strengthening national food control regulatory capacities and global trade facilitation by providing leadership in supporting countries in the assessment and progressive improvement of food control systems, including food safety policy and food control regulatory frameworks.
- Supporting the development of institutional and individual capacities for food control and food safety management, including the management of and risk communication in food safety emergencies with international dimension.
- Supporting science-based food safety governance and decisions by providing sound scientific advice (through the JECFA and Joint FAO/WHO Expert Meetings on Microbiological Risk Assessment (JEMRA) expert bodies and thematic ad hoc Intergovernmental Task Forces) to underpin food safety standards application at national, regional and international levels.
- Enhancing food safety management along food chains to prevent diseases and trade disruptions by supporting developing countries to apply risk-based food safety management along food chains that are appropriate for national and local production systems and in compliance with Codex texts.
- Providing food safety platforms, databases and mechanisms which support networking, dialogue and global access to information and facilitating effective communication internationally on key food safety issues.
- Developing food safety intelligence and foresight to identify emerging food safety issues and becoming a major actor in the collection, analysis and communication of food chain intelligence. Evaluating new technologies to improve food safety and protect public health. The FAO's Food Systems and Food Safety Division works in partnership with national and international bodies and organisations where such partnerships are mutually beneficial and where there is a compatibility of mandate and guiding principles (FAO, no date).

The provision of scientific advice in support of setting international food standards is a foundational element of global food safety governance. Without the authoritative and globally-relevant advice from the Joint FAO/WHO expert bodies, the setting of many Codex standards would not be possible. Beyond that, member countries and partners call on the FAO for independent scientific opinions and advice, for example regarding food safety implications of new technologies, such as nanotechnologies and biotechnologies (FAO and WHO, 2014).

The FAO and WHO General Standard for Contaminants and Toxins in Food and Feed (CXS 193-1995) (FAO and WHO, 2019) applies to any substance that meets the terms of the Codex definition for a contaminant, including contaminants in feed for food-producing animals, except:

- Contaminants having only food and feed quality significance (i.e., copper), but no public health significance, in the food(s) given that the standards elaborated within the Committee on Contaminants in Foods (CCCF) has the objective to protect public health.
- Pesticide residues, as defined by the Codex definition that are within the terms of reference of the Committee on Pesticide Residues (CCPR).
- Residues of veterinary drugs, as defined by the Codex definition, and residues of feed additives that are within the terms of reference of the Committee on Residues of Veterinary Drugs in Foods (CCRVDF).
- Microbial toxins, such as botulinum toxin and staphylococcus enterotoxin, and microorganisms that are within the terms of reference of the Committee on Food Hygiene (CCFH).
- Residues of processing aids that are within the terms of reference of the Committee on Food Additives (CCFA).

FAO Risk Based Imported Food Control Manual: In 2013, food products accounted for more than 80% of total agricultural exports. They are the third most valuable commodity group traded internationally, after fuels and non-pharmaceutical chemical products. The manual is intended to provide guidance, which countries can consult in designing imported food controls for their specific context. It can be used to develop programme and procedural directives at the regional or national level. It provides options for competent authorities with respect to designing, evaluating and managing imported food controls, consistent with the FAO's Codex Alimentarius mandates (FAO, 2016).

Safety risk management: Evidence-informed policies and decisions, considering multiple factors: The FAO guidance material was developed to support food safety risk managers and policy-makers in applying structured, evidence-informed processes to decision-making. Food safety issues can have widespread impacts beyond public health. They may contribute to, or detract from the achievement of goals in areas including nutrition, food security, food trade and market access, and economic and rural development. The risk analysis paradigm guides risk managers to ensure their decisions are based on an assessment of risks to health, and consideration of other factors in choosing the appropriate risk management options. The guidance assists decision-makers in applying a multi-factor approach and is applied to two key decision areas – setting food safety priorities and selecting risk management options. The principles and approaches can be applied to all food safety decisions. Using this guidance will lead to improved capacity for food safety decisions, where decision-makers can demonstrate how evidence was used and any trade-offs are made. It also facilitates stakeholder engagement, transparency and accountability throughout the decision-making process.

References

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Coordinating agency or organisation

Joint Food and Agriculture Organization of the United Nations (FAO) / World Health Organization (WHO) Food Standards Program (Codex Alimentarius Commission) for the establishment of food safety standards i.e. MLs for contaminants (quantitative levels above which there is a risk to consumer's health).

Scientific inputs for ML standards setting are provided by the Food and Agriculture Organization of the United Nations (FAO) / World Health Organization (WHO) Expert Committee on Food Additives (JECFA).

CH0008 / **CHEMICAL / Pesticides**

Pesticides – Highly Hazardous

Definition

Pesticide means any substance, or mixture of substances of chemical or biological ingredients intended for repelling, destroying or controlling any pest, or regulating plant growth. Pesticides are inherently toxic, and among them, a small number of Highly Hazardous Pesticides, cause disproportionate harm to the environment and human health. The Food and Agriculture Organization (FAO) and the World Health Organization (WHO) Guidelines on Highly Hazardous pesticides (UNEP, 2021) adopted the following definition:

"Highly Hazardous Pesticides means pesticides that are acknowledged to present particularly high levels of acute or chronic hazards to health or environment according to internationally accepted classification systems such as WHO or Global Harmonized System (GHS) or their listing in relevant binding international agreements or conventions. In addition, pesticides that appear to cause severe or irreversible harm to health or the environment under conditions of use in a country may be considered to be and treated as highly hazardous."

Reference

UNEP, 2021. Highly Hazardous Pesticides (HHPs). www.unep.org/explore-topics/chemicals-waste/what-we-do/emerging-issues/highly-hazardous-pesticides-hhps Accessed 7 May 2021.

Annotations

Synonyms

Not identified.

Additional scientific description

Pesticides can also be grouped according to the types of pests which they kill: insecticides (insects); herbicides (plants); rodenticides (rodents); bactericides (bacteria); fungicides (fungi); and larvicides (larvae).

A pesticide is considered to be highly hazardous if it has one (or more) of the following characteristics:

- High acute toxicity
- Long-term toxic effects at chronic exposure
- High environmental concern either through ubiquitous exposure, bioaccumulation or toxicity
- Known to cause a high incidence of severe or irreversible adverse effects on human health or the environment (Pesticide Action Network, 2009).

Internationally accepted classification of highly hazardous pesticides

- Criterion 1: Acute Toxicity – WHO Recommended Classification of Pesticides by Hazard Classes Ia or Ib.
- Criteria 2–4: Chronic Toxicity
  - GHS Carcinogenicity Categories 1A and 1B
  - GHS Mutagenicity Categories 1A and 1B
  - GHS Reproductive Toxicity Categories 1A and 1B.
- Criterion 5: Stockholm Convention – Pesticides listed in Annexes A and B.
- Criterion 6: Rotterdam Convention – Pesticides listed in Annex III.
- Criterion 7: Montreal Protocol – Pesticides listed.
- Criterion 8: High incidence of severe or irreversible adverse effects (WHO, 2019).

Metrics and numeric limits

Available data are too limited to estimate the overall global health impacts of pesticides; however, the global impact of self-poisoning (suicides) from preventable pesticide ingestion was estimated to be 155,488 deaths and 7362,493 Disability Adjusted Life Years (DALYs) for 2016 (WHO, 2019).

The WHO provides maximum residue limits (MRLs) for pesticides in food and levels in drinking-water as follows (WHO, 2019):

- Maximum residue limits in food: The Joint Food and Agriculture Organization of the United Nations (FAO) / WHO Meeting on Pesticide Residues (JMPR) evaluates those pesticides likely to contaminate food. MRLs are published by the Codex Alimentarius Commission. Guidance for individual pesticides or pesticide components – including for a number of highly hazardous pesticides – can be accessed via the FAO, WHO, Codex Alimentarius Commission or National Framework for Chemicals Environmental Management (INCHEM) websites and in hard-copy publications.
- Drinking-water: WHO water quality guidelines exist for some pesticides used in agriculture and public health – including for some highly hazardous pesticides – where there is a likelihood of drinking-water contamination.

Key relevant UN convention / multilateral treaty

The Stockholm Convention on persistent organic pollutions (POPs) (UNEP, 2001). At the time of writing, there were 183 parties.

The Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Pesticides (1998). At the time of writing there were 161 parties.

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989). At the time of writing, there were 187 parties.

The Montreal Protocol on Substances that Deplete the Ozone Layer (1987) has been ratified by all 197 UN Member States.

Examples of drivers, outcomes and risk management

Outcomes of exposure to highly hazardous pesticides include (WHO, 2019):

- Unintentional and self-inflicted (suicide) acute poisonings by pesticides are a serious public health concern in many parts of the world.
- The acute hazard is highly variable depending on the pesticide and includes peripheral and central neurotoxicity and reduced blood clotting capacity. The specific pesticide formulation can significantly affect both exposure and toxicity. Short-term exposure can cause harmful effects on the liver, kidneys, blood, lungs, nervous system, immune system and gastrointestinal tract.
- Chronic exposure to highly hazardous pesticides can affect the skin, eyes, nervous system, cardiovascular system, gastrointestinal tract, liver, kidneys, reproductive system, endocrine system, immune system and blood. Some highly hazardous pesticides may cause cancer, including childhood cancer.
- Toddlers and children are considered more vulnerable to exposure to pesticides due to their smaller size, hand to mouth activity, different metabolism, and because they are still developing.

Risk mitigation measures are critical. In 2015, the Strategic Approach to International Chemicals Management (SAICM) International Conference on Chemicals Management adopted a resolution that recognised highly hazardous pesticides as an issue of concern and called for concerted action by countries to address these substances, with emphasis on promoting agro-ecologically based alternatives and strengthening national regulatory capacity to conduct risk assessment and risk management (WHO, 2019). Several initiatives undertaken by international organisations, including the WHO/FAO, support this resolution. These include the publication of guidelines to support the International Code of Conduct on Pesticide Management, including those on highly hazardous pesticides, Good Labelling Practice for Pesticides, Pesticide Legislation and other important resources and guidance documentation to assist in the implementation of best practices, which have been brought together in a toolkit (FAO, 2018).

The highly hazardous pesticides risk reduction process consists of three main consecutive steps: identification of highly hazardous pesticides by checking registered pesticides against the FAO/WHO criteria; assessment of highly hazardous pesticides by assessing each product for risks and needs to determine whether action is desirable; and mitigation of highly hazardous pesticides risks by determining for each product whether risk mitigation measures are required, and if so, which options would be most appropriate (WHO, 2019).

To reduce exposure to highly hazardous pesticides and their health impacts, the WHO summarised actions required in the following areas: handling, storage, use and disposal; elimination and replacement of pesticide use; education; and regulation, monitoring and surveillance (WHO, 2019).

References

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989). www.basel.int/TheConvention/Overview/TextoftheConvention/tabid/1275/Default.aspx

FAO, 2018. Pesticide registration toolkit: Identification of highly hazardous pesticides. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/pesticide-registration-toolkit/tool/page/pret/hhp/identification-of-hhps Accessed 19 November 2019.

Pesticide Action Network, 2009. PAN International List of Highly Hazardous Pesticides. www.rapaluruguay.org/agrotoxicos/Prensa/PAN_HHP-List_090116.pdf Accessed 7 May 2021.

Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (1998). https://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-14&chapter=27

UNEP, 2001. Stockholm Convention on Persistent Organic Pollutants. UN Environment Programme Available at www.pops.int/TheConvention/Overview/tabid/3351/Default.aspx

WHO, 2019. Preventing Disease Through Healthy Environments. World Health Organization (WHO). https://apps.who.int/iris/bitstream/handle/10665/329501/WHO-CED-PHE-EPE-19.4.6-eng.pdf?ua=1 Accessed 7 May 2021.

Coordinating agency or organisation

Food and Agriculture Organization of the United Nations (FAO), World Health Organization (WHO).

CH0009 / **CHEMICAL / Pesticides**

Residue of Pesticides

Definition

Pesticide residue means any specified substance in food, agricultural commodities, or animal feed resulting from the use of a pesticide. The term includes any derivatives of a pesticide, such as conversion products, metabolites, reaction products, and impurities considered to be of toxicological significance (FAO and WHO, no date, 2019).

References

FAO and WHO, no date. Codex Alimentarius. Database for Maximum Residue Limits for Pesticides in Food and Feed. Food and Agriculture Organization of the United Nations (FAO) and World Health Organization (WHO). www.fao.org/fao-who-codexalimentarius/codex-texts/dbs/en Accessed 2 November 2020.

FAO and WHO, 2019. Codex Alimentarius Procedural Manual. 27th Edition. Food and Agriculture Organization of the United Nations (FAO) and World Health Organization (WHO). www.fao.org/fao-who-codexalimentarius/sh-proxy/en/?lnk=1&url=https://workspace.fao.org/sites/codex/Shared%20Documents/Publications/Procedural%20Manual/Manual_27/PM27_2019e.pdf Accessed 2 November 2020.

Annotations

Synonyms

Not applicable.

Additional scientific description

Pesticide residue refers to the pesticides that may remain on or in food after they are applied to food crops or owing to their persistence in the environment or because of other uses such as vector control to combat endemic pests such as mosquitos transmitting malaria. Risk of pesticide residues mainly concerns occupational health of field workers, food safety (consumer health) and the environment. The maximum allowable levels of pesticide residues in foods are often stipulated by national regulatory bodies and by the Joint Food and Agriculture Organization of the United Nations (FAO) / World Health Organization (WHO) Food Standards Programme (Codex Alimentarius Commission).

The following definitions are relevant to the Codex Alimentarius (FAO, no date):

Pesticide: means any substance intended for preventing, destroying, attracting, repelling, or controlling any pest including unwanted species of plants or animals during the production, storage, transport, distribution and processing of food, agricultural commodities, or animal feeds or which may be administered to animals for the control of ectoparasites. The term can also include substances intended for use as a plant growth regulator, defoliant, desiccant, fruit-thinning agent, or sprouting inhibitor and substances applied to crops either before or after harvest to protect the commodity from deterioration during storage and transport. The term normally excludes fertilisers, plant and animal nutrients, food additives, and animal drugs.

Maximum residue limit (MRL) for pesticide residues: is the maximum concentration of a pesticide residue (expressed as mg/kg), recommended by the Codex Alimentarius Commission to be legally permitted in or on food commodities and animal feeds. MRL setting is based on good agricultural practices data, and foods derived from commodities that comply with the respective MRLs are intended to be toxicologically acceptable.

Extraneous maximum residue limit (EMRL) for pesticide residues: refers to a pesticide residue or a contaminant arising from environmental sources including former agricultural uses but excluding use of the pesticide directly or indirectly on the food or feed. It is the maximum concentration of a pesticide residue that is recommended by the Codex Alimentarius Commission to be legally permitted or recognised as acceptable in or on a food, agricultural commodity or animal feed. Pesticides for which EMRLs are most likely to be needed are persistent in the environment for a relatively long period after uses have been discontinued and are expected to occur in foods or feeds at levels of sufficient concern to warrant monitoring. The concentration is expressed in milligrams of pesticide residue or contaminant per kilogram of the commodity (mg/kg).

Note: A pesticide in food or feed is considered to be a risk for human health when above the limits established by the Codex Alimentarius Commission.

Metrics and numeric limits

Maximum Residue Limits for Pesticides in Food and Feed as set by the Codex Alimentarius Commission (FAO and WHO, no date a).

Key relevant UN convention / multilateral treaty

Codex Alimentarius (FAO and WHO, no date b).

Examples of drivers, outcomes and risk management

Drivers: Ensuring food security and food safety, international food trade, ensuring sustainable agriculture.

Outcomes: Increased horticulture production, protection of public health, safe food, facilitated trade flow.

Risk management: A national legislation and food control system, including food import control, export control, and national monitoring programmes.

Risk management measures: science-based harmonised texts such as Codex standards, recommendations, guidelines, codes of practice, food safety and fair practices in food trade.

Control measures include reducing use of chemical pesticides, setting pre-harvest intervals and establishing MRLs based on exposure risk assessment and good agricultural practices. Scientific inputs for pesticide MRL standards setting are provided by the FAO / WHO Joint Meeting on Pesticides Residues (JMPR).

References

FAO, no date. Definitions for the Purposes of the Codex Alimentarius. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/3/w5975e/w5975e07.htm

FAO and WHO, no date a. Codex Alimentarius. Database for Maximum Residue Limits for Pesticides in Food and Feed. Food and Agriculture Organization of the United Nations (FAO) and World Health Organization (WHO). www.fao.org/fao-who-codexalimentarius/codex-texts/dbs/en Accessed 2 November 2020.

FAO and WHO, no date b. About Codex Alimentarius. Food and Agriculture Organization of the United Nations (FAO) and World Health Organization (WHO). www.fao.org/fao-who-codexalimentarius/about-codex/en Accessed 2 November 2020.

Coordinating agency or organisation

Joint Food and Agriculture Organization of the United Nations (FAO) / World Health Organization (WHO) Food Standards Program (Codex Alimentarius Commission).

CH0010 / **CHEMICAL / Persistent Organic Pollutants (POPs)**

Hazardous Pesticide Contamination in Soils

Definition

Hazardous pesticide contamination in soils often results from improper storage of (obsolete) agrochemicals, as a result of which pesticides are spilled in the surroundings of the storage site, where they seep into the soil or are dispersed by wind. In some cases, pesticide spillage has been ongoing for many years. Such spillage may cause serious soil or groundwater contamination. In addition, highly toxic and persistent compounds have been used in agriculture for decades to control pests and diseases, which are proven to cause harm to non-target species. Although international agreements are put in place to regulate the production and use of those highly toxic and persistent compounds they will still remain in soils for several more decades. Moreover, in some countries, the international agreements are not yet being implemented or fully implemented, and therefore toxic pesticides are still being used. When soil and groundwater are contaminated, crops, livestock and drinking water may become affected and, when they are consumed by people, health risks may occur (FAO, 2000).

Reference

FAO, 2000. Assessing Soil Contamination: A reference manual. FAO Pesticide Disposal Series 8. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/fileadmin/templates/agphome/documents/Pests_Pesticides/Obsolete/Assessing_contamination_-_A_reference_manual.pdf Accessed 29 October 2020.

Annotations

Synonyms

Contaminated land, Special sites, ‘Brownfield’ sites, Soil contamination, Soil pollution.

Additional scientific description

Human activities over thousands of years have left a legacy of polluted soils worldwide. Much of it is local soil contamination, which frequently occurs in connection with past and present industrial activities, waste management and disposal, including remnants of hazardous materials such as obsolete pesticides. The unsustainable application of pesticides in agricultural fields has also contributed to the spread of diffuse pollution in many areas (FAO, 2018).

Half a million tonnes of obsolete pesticides are scattered throughout the developing world. These toxic chemicals, often stored outdoors in leaking containers, are seeping into the soil and water. Eliminating these dangerous stocks is a development priority. Rural communities cannot hope to develop if the soil and water are contaminated with pesticides. People cannot hope to prosper if they are suffering from severe illnesses caused by pesticide poisoning. The Food and Agriculture Organization of the United Nations (FAO) Programme on the Prevention and Disposal of Obsolete Pesticides is working to inform the world about the dangers of obsolete pesticide stocks. It collaborates with developing countries to prevent more obsolete pesticides from accumulating and assists them in disposing of their existing stockpiles (FAO, no date a).

Obsolete pesticides include insecticides, fungicides, herbicides, larvicides, acaricides, rodenticides, molluscides, nematocides, and aphicides. Around a thousand active ingredients are used to manufacture the wide array of pesticides in countries all over the world. Pesticide ingredients come in many thousands of different formulations. All these formulations degrade over time although some are more persistent in the environment than others. The chemical by-products that form as the pesticide deteriorates can be more toxic than the original product (FAO, no date b).

Once pesticides enter soil, their fate depends on the physico-chemical characteristics of the soil, such as moisture, texture, and soil organic matter content, as well as the pesticide properties. A relatively small amount of spilled pesticides can therefore create a much larger volume of polluted soil. For example, approximately 30 tonnes of pesticides buried at a site in Yemen in the 1980s contaminated over 1500 tonnes of soil. This can pose a serious health and environmental threat to nearby communities (FAO, no date c).

Every site is different. First, the extent of the contamination and the impact on the local environment must be determined. This requires an understanding of the chemical properties of the pesticides and the characteristics of the soil. Often the quantity of pesticides is unknown, and soil samples must be analysed. Depending on the results of the chemical analysis and risk assessment, there are three ways of dealing with polluted soil and water: (i) removing the contamination by excavating the soil and pumping-up of groundwater; (ii) containing the contamination by covering polluted soil with buildings, asphalt or another impermeable layer, and preventing contaminated groundwater from flowing downstream; and (iii) preventing human contact with the contamination by covering the polluted soil with clean soil, fencing-off polluted areas and closing contaminated wells (FAO, no date c).

Removing pollution is more expensive than containing it, which in turn is more expensive than taking protective measures. Additionally, excavated polluted soil represents a hazardous waste that needs to be properly managed to avoid the pollution being transferred to other areas. Containment and protective measures are effective only for as long as they are maintained, and their proper maintenance may be difficult to ensure over a long period of time (FAO, no date c).

The FAO has published a reference manual for assessing soil contamination to help developing countries make sound decisions about how to deal with the problem in the most cost-effective manner. The FAO is also working to develop cost-effective methods for dealing with pesticide contaminated soil in developing countries (FAO, 2000).

Wherever pesticides are used, there are discarded pesticide containers. These old containers can be as dangerous as the pesticides themselves. In developing countries, they are often used to store food or water. The FAO's Programme on the Prevention and Disposal of Obsolete Pesticides assists developing countries in dealing with these toxic containers (FAO, no date c).

Despite the identification efforts conducted in many regions of the world to estimate the extent of soil pollution, the lack of a global assessment presents an obstacle to the mobilisation of economic resources to minimise soil pollution and to achieving public and private commitment to combating soil pollution. Stronger linkages between scientific evidence and decision-making processes are required to support actions to prevent, control and remediate soil pollution (FAO, 2018).

Contaminated land is assessed in the context of national or state methods for deriving soil guidance values. There is no international standard. For example, Jennings (2013) compared the range of American standards with standards used elsewhere in the world. 5949 guidance values for 57 elements were identified across the US regulatory authorities and it was established that guidance values have also been published in at least 71 other United Nations member states.

Metrics and numeric limits

No globally agreed metrics have been identified.

Key relevant UN convention / multilateral treaty

United Nations (2015) Sustainable Development Goals. Preventing soil pollution could reduce soil degradation, increase food security, contribute substantially to the adaptation and mitigation of climate change, and contribute to the avoidance of conflict and migration. Therefore, taking immediate actions to combat soil pollution contributes to the achievement of almost all Sustainable Development Goals (SDGs) (FAO, 2018).

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989). At the time of writing, there were 187 parties to the Basel Convention (United Nations Treaty Collection 2019). At its fourteenth meeting, the Conference of the Parties to the Basel Convention (COP-14, 29 April - 10 May 2019) adopted decision BC-14/12 by which it amended Annexes II, VIII and IX to the Convention with the objectives of enhancing the control of the transboundary movements of plastic waste and clarifying the scope of the Convention as it applies to such waste.

The Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (1998). The Convention promotes shared responsibility between exporting and importing countries in protecting human health and the environment from the harmful effects of such chemicals and provides for the exchange of information about potentially hazardous chemicals that may be exported and imported.

The Stockholm Convention on Persistent Organic Pollutants (2001). The Convention is a global treaty to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have harmful impacts on human health or on the environment.

Examples of drivers, outcomes and risk management

The roles of soils in food production and food quality, in climate regulation and in the provision of raw materials and services is vital. Notwithstanding the enormous scientific progress made to date, protection and monitoring of soil condition at national and global levels still face complex challenges impeding effective on-the-ground policy design and decision making (FAO, 2018).

The FAO has prepared a manual on assessing soil contamination which focuses on pesticide disposal. It aims to help the user determine if pesticide spills have caused soil or groundwater contamination and, if so, whether or not that contamination implies risks for human health (FAO, 2000). Not every spill of pesticides implies health risks. Some important factors determining the risks of a spill are: (i) the characteristics of the stored pesticides; some pesticides are more toxic than others, some degrade rapidly into harmless compounds, while others are more persistent; (ii) how much of a pesticide has been spilled and for how long the spillage has been occurring. It takes time for contamination to reach the high levels at which health risks may occur; and (iii) the physico-chemical characteristics of the soil matrix, such as the type and content of clay, the content of soil organic matter, the soil moisture, or the diversity of soil microorganisms, which are involved in the degradation of pesticides and their by-products. Taking these and other relevant aspects into account, this manual provides users with a simple method for reaching three conclusions: whether it is likely that the soil or groundwater in the surroundings of the storage facility are contaminated; whether such a possible contamination is a risk for human health; and what measures can be taken to reduce these risks (FAO, 2000).

As an example of the FAO programme on hazardous pesticide contamination in soils, they reported that large amounts of pesticides were shipped to Africa for desert locust control from the 1950s, but some did not arrive at the correct site or time, and so became obsolete. Stockpiles of these pesticides have created a serious problem. A site-specific remediation plan was developed for each location on the basis of analytical data and environmental surveys. Remediation typically involved the addition of organic matter and land-farming to enhance local biodegradation of pesticides. In cases where a high environmental risk existed and the contaminants were considered too persistent to be left in situ, the contaminated soil was isolated in treatment cells.

The principle of all treatments was to facilitate and, where possible accelerate the natural degradation of the pesticides in the soil. In the case of organophosphate and carbamate insecticides, this has been very successful. However, organochlorine insecticides are persistent and degrade very slowly. Where these are present in high concentrations and pose a high risk, the soil has been isolated, adsorbent carbon barriers (made from local activated charcoal) have been used and in some low risk cases, the soil has been left in place. All sites were regularly monitored and encouraging results have been obtained (FAO, no date d).

Remediation of polluted soils is essential, and research continues to develop novel, science-based remediation methods. Increasingly expensive physical remediation methods such as chemical inactivation or sequestration in landfills are being replaced by science-based biological methods such as enhanced microbial degradation or phytoremediation (Rodríguez-Eugenio et al., 2018). Maintenance of soil health and the prevention and reduction of soil pollution are possible through promoting sustainable soil management practices, environmentally friendly industrial processes, reduction of waste generation, recycling and reuse of goods, and sustainable waste storage (FAO, 2018).

A key outcome of the global symposium on soil pollution Be The Solution To Soil Pollution (FAO, 2018) was a recommendation for the active and effective implementation of the Voluntary Guidelines for Sustainable Soil Management, which were developed through an inclusive process and endorsed by the 155th session of the FAO Council (Rome, 5 December 2016). Their implementation is important in order to progress with the accomplishment of several of the sustainable soil management objectives, such as: to ensure that the availability and flows of nutrients are appropriate to maintain or improve soil fertility and productivity, and to reduce their losses to the environment; to reduce soil salinisation, sodification and alkalinisation; to ensure that water is efficiently infiltrated and stored to meet the requirements of plants and ensure the drainage of any excess; to ensure that contaminants are below toxic levels, i.e., those which would cause harm to plants, animals, humans and the environment; to guarantee that soil biodiversity provides a full range of biological functions; and to undertake soil management (FAO, 2018).

References

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989). www.basel.int/TheConvention/Overview/TextoftheConvention/tabid/1275/Default.aspx Accessed 7 November 2019.

FAO, note date a. Prevention and disposal of obsolete pesticides. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/agriculture/crops/obsolete-pesticides/prevention-and-disposal-of-obsolete-pesticides/en/ Accessed 29 October 2020.

FAO, no date b. Obsolete pesticides. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/agriculture/crops/obsolete-pesticides/what-dealing/obs-pes/en/ Accessed 29 October 2020.

FAO, no date c. Prevention and disposal of obsolete pesticides: contaminated soil. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/agriculture/crops/obsolete-pesticides/what-dealing/contaminated/en/ Accessed 29 October 2020.

FAO, no date d. An African Approach for Risk Reduction of Soil Contaminated by Obsolete Pesticides. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/agriculture/crops/obsolete-pesticides/what-now/soil-remediation/en/ Accessed 29 October 2020.

FAO, 2018. Be The Solution To Soil Pollution: Outcome Document of the Global Symposium on Soil Pollution 2–4 MAY 2018, Rome Italy. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/3/ca0362en/CA0362EN.pdf Accessed 28 October 2020.

Jennings, A.A., 2013. Analysis of worldwide regulatory guidance values for the most commonly regulated elemental surface soil contamination. Journal of Environmental Management, 118:72-95.

Rodríguez-Eugenio, N., M. McLaughlin and D. Pennock, 2018. Soil Pollution: A Hidden Reality. Food and Agriculture Organization of the United Nations, Rome. www.fao.org/3/i9183en/i9183en.pdf Accessed 28 October 2020.

Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (1998). https://treaties.un.org/pages/ViewDetails.aspx?src=TREATY&mtdsg_no=XXVII-14&chapter=27 Accessed 23 October 2020.

Stockholm Convention on Persistent Organic Pollutions (POPs) (2001). http://chm.pops.int/TheConvention/Overview/TextoftheConvention/tabid/2232/Default.aspx Accessed 23 October 2020.

United Nations, 2015. Sustainable Development Goals. https://sdgs.un.org/goals Accessed 28 October 2020.

Coordinating agency or organisation

Food and Agriculture Organization of the United Nations (FAO).

CH0011 / **CHEMICAL / Pesticides**

Insecticides

Definition

Insecticides are chemicals used to control insects by killing them (CDC, 2019).

Reference

CDC, 2019. Pesticide Exposures. Centres for Disease Control and Prevention (CDC). https://ephtracking.cdc.gov/showpesticideFungicides Accessed 25 October 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

The term 'pesticide' is considered to embrace active ingredients in any form, irrespective of whether, or to what extent, they have been formulated for application. The term is usually associated with materials intended to kill or control pests (insecticides, fungicides, herbicides, etc.) (WHO and FAO, 2016). Pesticides are used in many different sectors (e.g., agriculture, forestry, food industry, domestic etc.).

Insecticides are classified based on their structure and function. They include:

- Carbamates/Organophosphates: Although carbamates and organophosphates are structurally distinct, they have a similar mechanism of action – they kill insects by inhibiting the enzyme cholinesterase, which is essential in the functioning of the nervous system. While highly effective insecticides, they are also toxic to non-target species, including humans. Humans may be exposed via inhalation, ingestion or through skin contamination; and acute and chronic exposure can produce varying levels of toxicity. Similar to the insects exposed, these pesticides disrupt the function of the human nervous system, mainly the brain. They have also been linked to cancer risk. Their toxicity to humans has led to bans and use restrictions in many countries (CDC, 2019).
- Organochlorines: These are a group of chlorinated compounds that typically affect the central nervous system. They are known for their high toxicity, slow degradation and bioaccumulation. Examples include dichlorodiphenyltrichlorethane (DDT), methoxychlor, chlordane, and lindane. Human exposure may occur via inhalation, ingestion or through skin contamination. Many organochlorines have been banned in many countries, although a few are still registered for use (CDC, 2019).
- Boric acid: This type of pesticide comes in many forms (most commonly in pellets or tablets or a finely ground powder) and has many uses. It is a combination of boron and other elements. Toxicity depends on the amount of boron in the product. In addition to controlling insects, boric acid can be used to control growth of moulds, fungi and weeds. Boric acid is low in toxicity, but can still cause irritation to the skin or eyes, and nausea, vomiting, stomach aches and diarrhoea if ingested (CDC, 2019).
- Pyrethroids/Pyrethrins: Pyrethrum is a naturally occurring mixture of chemicals found in certain chrysanthemum flowers. Pyrethrum was first recognised as having insecticidal properties around 1800 in Asia and was used to kill ticks and various insects such as fleas and mosquitos. From pyrethrum extract, individual chemicals called pyrethrins which have active insecticidal properties were developed. Pyrethroids are manufactured chemicals that are very similar in structure to the pyrethrins, but are often more toxic to insects, as well as to mammals, and last longer in the environment than pyrethrins (ATSDR, 2003). These insecticides are used widely in households, agriculture, on pets, and in mosquito control. While they are generally less toxic to mammals than some other insecticides, they can still have harmful health effects (CDC, 2019).

Metrics and numeric limits

Available data are too limited to estimate the overall global health impacts of pesticides including insecticides. However, the global impact of self-poisoning (suicides) from preventable pesticide ingestion was estimated to amount to 155,488 deaths and 7362,493 Disability Adjusted Life Years (DALYs) in 2016 (WHO, 2019a).

In a report on exposure to highly hazardous pesticides (WHO, 2019a), the World Health Organization (WHO) gave the following guidance values for pesticides:

Maximum residue limits (MRLs) in food: The Joint FAO / WHO Meeting on Pesticide Residues (JMPR) evaluates those pesticides likely to contaminate food. MRLs are published by the Codex Alimentarius Commission. Guidance is available for individual pesticides or pesticide components – including for a number of highly hazardous pesticides (FAO, no date).

Drinking-water: The WHO provides guidelines for drinking-water quality (WHO, 2011) and this includes guidance for various insecticides.

Key relevant UN and regional convention / multilateral treaty

The Montreal Protocol on Substances that Deplete the Ozone Layer is a global agreement to protect the Earth's ozone layer by phasing out the chemicals that deplete it. This phase-out plan includes both the production and consumption of ozone-depleting substances. The landmark agreement was signed in 1987 and entered into force in 1989 (UNEP, 2020).

The Stockholm Convention on Persistent Organic Pollutants was adopted by the Conference of Plenipotentiaries on 22 May 2001 in Stockholm, Sweden. The Convention entered into force on 17 May 2004. It is a global treaty to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have harmful impacts on human health or on the environment. Exposure to persistent organic pollutants (POPs) can lead to serious health effects including cancers, birth defects, dysfunctional immune and reproductive systems, and greater susceptibility to disease and damage to the central and peripheral nervous systems. Given their long-range transport, no single government acting alone can protect its citizens or its environment from POPs (UNEP, 2019).

The Rotterdam Convention on hazardous chemicals including severely hazardous pesticide formulations was adopted on 10 September 1998 by a Conference of Plenipotentiaries in Rotterdam, the Netherlands. The Convention entered into force on 24 February 2004. The objectives of the Convention are to promote shared responsibility and cooperative efforts among Parties in the international trade of certain hazardous chemicals in order to protect human health and the environment from potential harm; and to contribute to the environmentally sound use of those hazardous chemicals, by facilitating information exchange about their characteristics, by providing for a national decision-making process (UNEP, 2010).

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989). At the time of writing, there were 187 parties to the Basel Convention (www.basel.int).

Examples of drivers, outcomes and risk management

Outcomes of exposure to pesticides including insecticides include:

- Unintentional and self-inflicted (suicides) acute poisonings by pesticides are a serious public health concern in many parts of the world (WHO, 2019a).
- The acute hazard is highly variable depending on the pesticide and includes peripheral and central neurotoxicity and reduced blood clotting capacity. The specific pesticide formulation can significantly affect both exposure and toxicity. Short-term exposure can cause harmful effects on the liver, kidneys, blood, lungs, nervous system, immune system and gastrointestinal tract (WHO, 2019a).
- Chronic exposure to pesticides including insecticides can result in effects on the skin, eyes, nervous system, cardiovascular system, gastrointestinal tract, liver, kidneys, reproductive system, endocrine system, immune system and blood. Some pesticides, including insecticides, may cause cancer, including childhood cancer (WHO, 2019a).
- Toddlers and children are considered more vulnerable to exposure to pesticides, including insecticides, due to their smaller size, hand to mouth activity, different metabolism, and still developing internal organs (WHO, 2019a).

Risk mitigation measures are critical. In 2015, the Strategic Approach to International Chemicals Management (SAICM) International Conference on Chemicals Management adopted a resolution that recognised highly hazardous pesticides as an issue of concern and called for concerted action among countries to address these substances, with emphasis on promoting agro-ecologically based alternatives and strengthening national regulatory capacity to conduct risk assessment and risk management (WHO, 2019a).

Several initiatives undertaken by international organisations, including WHO/FAO, support this resolution. These include the publication of several guidelines to support the International Code of Conduct on Pesticide Management, including those on highly hazardous pesticides, good labelling practice for pesticides, pesticide legislation and numerous other resources and guidance documentation to assist in the implementation of best practices, which have been brought together in a toolkit (FAO, 2015).

Pesticide, including insecticide, risk reduction processes comprise three main consecutive steps: identification of the pesticide by checking registered pesticides against the FAO/WHO criteria; mitigation of pesticide risks by determining for each product whether risk mitigation measures are required, and if so, which options would be most appropriate (WHO, 2019a).

To reduce exposure to pesticides, including insecticides and their health impacts, the WHO summarises actions required in the following areas: handling, storage, use and disposal; elimination and replacement of pesticide use; education; and regulation, monitoring and surveillance (WHO, 2019a).

For example, fungicide classification and labelling, as with all pesticides, is an essential part of control (WHO, 2019b). The report describes the principles and content that aim to generate uniformity in the statement on the nature of the risk (by phrase and/or symbol) on the label of the product, irrespective of the country of origin or use. Labels of products classified in classes Ia (extremely hazardous) and Ib (highly hazardous), should bear a symbol indicating a high degree of hazard (usually a type of skull and crossbones) and a signal word or phrase, such as POISON or TOXIC. The presentation of the symbol and word or phrase, in terms of colour, size and shape should ensure that they are given sufficient prominence on the label. The text should be in the local language and for all formulations should include the approved name of the active ingredient or ingredients, the method of use, and precautions to be taken in use. For classes Ia and Ib, symptoms and immediate treatment of poisoning should also be included. The detailed precautions necessary for the use of a pesticide depend on the nature of the formulation and the pattern of use, and are best decided by a pesticide registration authority when accepting a commercial label. There are international agreements on symbols to denote hazards from materials which are inflammable, corrosive, explosive, etc., and these should be consulted and used where appropriate (WHO, 2019b).

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Coordinating agency or organisation

World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO).

CH0012 / CHEMICAL / Pesticides

Fungicides

Definition

Fungicides are chemicals that kill or slow the growth of fungi and their spores. They can be used on plants or other surfaces where mould or mildew grow (CDC, 2019).

Reference

CDC, 2019. Pesticide Exposures. Centres for Disease Control and Prevention (CDC). https://ephtracking.cdc.gov/showpesticideFungicides. Accessed 25 October 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

The term 'pesticide' is considered to embrace active ingredients in any form, irrespective of whether, or to what extent, they have been formulated for application. The term is usually associated with materials intended to kill or control pests (insecticides, fungicides, herbicides, etc.) (WHO and FAO, 2016).

Fungicides are pesticides that kill or slow the growth of fungi and their spores. They can be used to control fungi that damage plants, including rusts, mildews and blights. They might also be used to control mould and mildew in other settings. Fungicides work in a variety of ways, but most of them damage fungal cell membranes or interfere with energy production within fungal cells (NPIC, 2019).

Fungi are the primary cause of crop loss worldwide. Diseases are a common occurrence on plants, often having a significant economic impact on yield and quality, thus managing diseases is an essential component of production for most crops. Broadly, there are three main reasons that fungicides are used: (i) to control a disease during the establishment and development of a crop; (ii) to increase productivity of a crop and to reduce blemishes. Diseased food crops may produce less because their leaves, which are needed for photosynthesis, are affected by the disease; and (iii) to improve the storage life and quality of harvested plants and produce. Some of the greatest disease losses occur post-harvest (APS, no date).

As an example, banana and plantain (Musa spp.) are grown throughout the tropical and subtropical regions of the world. They are a key staple food in many developing countries and a source of income for subsistence farmers. Banana and plantain are attacked by different pathogens that affect plant development, cause yield losses and reduce fruit quality. From an economic point of view, banana and plantain leaf spots caused by Mycosphaerella fijiensis Morelet (black Sigatoka/black leaf streak) and by M. musicola Leach ex Mulder (yellow Sigatoka), can be considered the two most serious diseases of Musa spp. Fungicides (as a xenobiotic) help to reduce the impact but fungal resistance to fungicide usage is now being recognised (FAO, 2013).

People may be exposed to fungicides by breathing in, eating, or drinking the product, or by touching plants or surfaces that have recently been treated (CDC, 2019). A recent peer-reviewed paper summarised toxicologically harmful fungicides (Lopez and Sudakin, 2017). A summary of these compounds and some of the chemical incidents associated with the use of these fungicides follows.

Organomercury compounds (methylmercury, phenylmercuric acetate) are a class of fungicide formulated as dusts and aqueous solutions that are used primarily as seed protectants. Although their use has been banned or greatly restricted in many countries, they are of historical importance owing to their severe toxicity in humans. Lopez and Sudakin (2017) reported that a poisoning epidemic in rural Iraq in 1971 was the result of people ingesting bread prepared from wheat treated with methylmercury – acting as a fungicide. The outbreak resulted in 50,000 exposures and at least 439 deaths.

Chlorinated phenols, particularly pentachlorophenol, continue to have wide industrial application as fungicides and wood preservatives. There have been several historical accounts of acute poisoning caused by pentachlorophenol exposures. Lopez and Sudakin (2017) reported that in 1967, a cluster of cases of critical illness in a newborn nursery occurred through the misuse of sodium pentachlorophenate as an anti-mildew agent in the hospital laundry; nine poisoning cases and two fatalities were reported.

Substituted benzenes including hexachlorobenzene. Lopez and Sudakin (2017) reported that although the acute toxicity from ingestion or inhalation exposure is low with hexachlorobenzene, the systemic effects from chronic exposure are well documented. They reported that an epidemic of 5000 cases of porphyria cutanea tarda was described in Turkey between 1955 and 1959, where the cause was traced to the consumption of wheat treated with a seed protectant containing 10% hexachlorobenzene.

Dithiocarbamates (metam sodium, thiram, ethylene bisdithiocarbamate compounds). As a class of general- and restricted-use fungicides, the dithiocarbamates are available in a variety of formulations, including water suspensions, wettable powders, and dusts. They have many agricultural applications, including the protection of seedlings, turf, vegetables, fruits, and ornamentals from fungal growth. Compared with the known toxicity of several of the classes of fungicides described above, dithiocarbamates have considerably lower acute toxicity due to their rapid metabolism and lack of persistence in mammalian systems but have the potential to cause acute illness. Of note was the report of the clean-up of an accidental metam sodium spill into the Sacramento River where workers developed erythema, rash, itching, and scaling of the lower extremities (the areas that had come into contact with contaminated water). The same chemical spill resulted in the emergency triage of 360 individuals, most of whom had mild irritant upper airway symptoms that did not require hospitalisation.

A follow-up study of adults living within 0.5 miles of the site of the accident identified 20 cases of persistent irritant-induced asthma and 10 cases of persistent asthma exacerbations (Lopez and Sudakin, 2017).

Copper compounds (copper sulphate). Several copper compounds are available as fungicides for commercial use. Intentional and accidental ingestion of copper compounds has historically been a common cause of morbidity and mortality (Lopez and Sudakin, 2017).

Organotin compounds are formulated as wettable and flowable powders and used throughout the world as fungicides in a variety of agricultural and industrial settings. Tributyltin oxide had been registered for use as an anti-mildew control agent in interior and exterior paints, but is now severely restricted in many countries due to its potent irritant properties. Tributyltin oxide continues to be used as an antifouling agent in marine paints, due to its ability to prevent the growth of barnacles, algae, and marine organisms (Lopez and Sudakin, 2017).

Metrics and numeric limits

Available data are too limited to estimate the overall global health impacts of pesticides including fungicides; however, the global impact of self-poisoning (suicides) from preventable pesticide ingestion was estimated to be 155,488 deaths and 7362,493 Disability Adjusted Life Years (DALYs) in 2016 (WHO, 2019a).

In a report on exposure to highly hazardous pesticides (WHO, 2019a), the World Health Organization (WHO) gave the following guidance values for pesticides:

Maximum residue limits (MRLs) in food: The Joint FAO / WHO Meeting on Pesticide Residues (JMPR) evaluates those pesticides likely to contaminate food. MRLs are published by the Codex Alimentarius Commission. Guidance is available for individual pesticides or pesticide components – including for a number of highly hazardous pesticides (FAO, no date).

Drinking-water: The WHO provides guidelines for drinking-water quality (WHO, 2011) and this includes guidance for various fungicides including hexachlorobenzene and copper.

Key relevant UN and regional convention / multilateral treaty

The Montreal Protocol on Substances that Deplete the Ozone Layer is a global agreement to protect the Earth's ozone layer by phasing out the chemicals that deplete it. This phase-out plan includes both the production and consumption of ozone-depleting substances. The landmark agreement was signed in 1987 and entered into force in 1989 (UNEP, 2020).

The Stockholm Convention on Persistent Organic Pollutants was adopted by the Conference of Plenipotentiaries on 22 May 2001 in Stockholm, Sweden. The Convention entered into force on 17 May 2004. It is a global treaty to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have harmful impacts on human health or on the environment. Exposure to persistent organic pollutants (POPs) can lead to serious health effects including cancers, birth defects, dysfunctional immune and reproductive systems, greater susceptibility to disease, and damage to the central and peripheral nervous systems. Given their long-range transport, no single government acting alone can protect its citizens or its environment from POPs (UNEP, 2019).

The Rotterdam Convention on hazardous chemicals including severely hazardous pesticide formulations was adopted on 10 September 1998 by a Conference of Plenipotentiaries in Rotterdam, the Netherlands. The Convention entered into force on 24 February 2004. The objectives of the Convention are to promote shared responsibility and cooperative efforts among Parties in the international trade of certain hazardous chemicals in order to protect human health and the environment from potential harm; and to contribute to the environmentally sound use of those hazardous chemicals, by facilitating information exchange about their characteristics, by providing for a national decision-making process (UNEP, 2010).

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989). At the time of writing, there were 187 parties to the Basel Convention (www.basel.int).

Examples of drivers, outcomes and risk management

Fungicides are a diverse group of structurally unrelated compounds that are widely used for agricultural, industrial, and domestic purposes. As with all pesticides, risk management is critical to reducing harm.

In 2015, the International Conference on Chemicals Management adopted a resolution that recognised highly hazardous pesticides as an issue of concern and called for concerted action among countries to address these substances, with emphasis on promoting agro-ecologically based alternatives and strengthening national regulatory capacity to conduct risk assessment and risk management (WHO, 2019a).

Several initiatives undertaken by international bodies, including the WHO and the Food and Agriculture Organization of the United Nations (FAO), support this resolution. These include the publication of guidelines to support the International Code of Conduct on Pesticide Management, including those on highly hazardous pesticides, good labelling practice for pesticides, pesticide legislation and numerous other resources and guidance documentation to assist in the implementation of best practices, which have been brought together in a toolkit (FAO, 2015).

The highly hazardous pesticides risk reduction process consists of three main consecutive steps: identification of highly hazardous pesticides by checking registered pesticides against the FAO/WHO criteria; mitigation of highly hazardous pesticide risks by determining for each product whether risk mitigation measures are required, and if so, which options would be most appropriate (WHO, 2019a).

To reduce exposure to highly hazardous pesticides and their health impacts, the WHO summarised actions required in the following areas: handling, storage, use and disposal; elimination and replacement of pesticide use; education; and regulation, monitoring and surveillance (WHO, 2019a).

For example, fungicide classification and labelling, as with all pesticides, is an essential part of control (WHO, 2019b). The report describes the principles and content that aim to have a uniformity in the statement on the nature of the risk (by phrase and/or symbol) on the label of the product, irrespective of the country of origin or use. Labels of products classified in classes Ia (extremely hazardous) and Ib (highly hazardous) should bear a symbol indicating a high degree of hazard (usually a type of skull and crossbones) and a signal word or phrase, such as POISON or TOXIC. The presentation of the symbol and word or phrase, in terms of colour, size and shape should ensure that they are given sufficient prominence on the label. The text should be in the local language and for all formulations should include the approved name of the active ingredient or ingredients, the method of use, and precautions to be taken in use. For classes Ia and Ib, symptoms and immediate treatment of poisoning should also be included. The detailed precautions necessary for the use of a pesticide depend on the nature of the formulation and the pattern of use and are best decided by a pesticide registration authority when accepting a commercial label. There are international agreements on symbols to denote hazards from materials which are inflammable, corrosive, explosive, etc., and these should be consulted and used where appropriate (WHO, 2019b).

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Coordinating agency or organisation

World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO).

CH0013 / **CHEMICAL** / **Persistent Organic Pollutants (POPs)**

Dioxins and Dioxin-like Substances

Definition

Dioxins and dioxin-like substances, including polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) are persistent organic pollutants (POPs) and are unwanted by-products of combustion and various industrial processes, such as chlorine bleaching of paper pulp and smelting. They can travel long distances from the source of emission, and bioaccumulate in food chains These substances represent a major public health concern. They have been associated with a range of acute and long-term adverse health effects and diseases (WHO, 2019).

References

WHO, 2019. Preventing disease through healthy environments: Exposure to dioxins and dioxin-like substances: A major public health concern. World Health Organization (WHO). apps.who.int/iris/bitstream/handle/10665/329485/WHO-CED-PHE-EPE-19.4.4-eng.pdf?ua=1 Accessed 25 November 2019.

Annotations

Synonyms

Not applicable.

Additional scientific description

Dioxins and dioxin-like substances' are three- or two-ring structures chlorinated to varying degrees. Polychlorinated biphenyls (PCBs) can have up to 10 chlorine atoms substituting for hydrogen atoms, and polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) can have up to eight. The compounds tend to have similar toxicity profiles and common mechanisms of action and are generally considered together as a group to set guidelines (WHO, 2019).

PCDDs and PCDFs are widely present in the environment, occurring naturally, but mainly as unwanted by-products of combustion and of various industrial processes. 2,3,7,8-Tetrachlorodibenzodioxin (TCDD) was a contaminant of a herbicide (2,4,5-T) and chlorodibenzofurans (CDFs) were major contaminants of PCBs, but neither PCDDs nor PCDFs have ever been manufactured or used for commercial purposes other than for scientific research. PCBs were globally manufactured and used in the past (WHO, 2019).

Although PCB manufacture is now prohibited under the Stockholm Convention, release into the environment still occurs from the disposal of large-scale electrical equipment and waste, from metallurgical uses, and from some chemical manufacture and processing (WHO, 2019).

Human exposure to dioxins and dioxin-like substances has been associated with a range of toxic effects, including chloracne; reproductive, developmental and neurodevelopmental effects; immunotoxicity; and effects on thyroid hormones, liver and tooth development. Dioxins are also carcinogenic. Developmental effects are the most sensitive human health endpoint, making children – particularly breastfed infants – a population at elevated risk (WHO, 2019).

Metrics and numeric limits

Toxic equivalency factors (TEFs) have been derived to relate the toxicities of individual PCDDs, PCDFs and PCBs to the most toxic of these compounds: TCDD, which is used as a reference and given a TEF of 1. The common mechanism of action for these substances means that their effects are additive, and TEFs for individual compounds can be used to establish the summed toxicity of a mixture. This approach has proved robust as a method for establishing the relative toxicities of these compounds (WHO, 2019), and has resulted in the development of guideline values as follows:

Provisional tolerable monthly intake: In 2002, the Joint Food and Agriculture Organization of the United Nations (FAO)/WHO Expert Committee on Food Additives (JECFA) established a provisional tolerable intake of 70 pg/kg body weight per month for PCDDs, PCDFs and coplanar PCBs expressed as TEFs.

Air: An air quality guideline for PCBs was not established because direct inhalation exposures constitute only a small proportion of the total exposure – in the order of 1–2% of the daily intake from food (WHO, 2019).

Key relevant UN convention / multilateral treaty

The Stockholm Convention on Persistent Organic Pollutants was adopted by the Conference of Plenipotentiaries on 22 May 2001 in Stockholm, Sweden (UNEP, 2001). The Convention entered into force on 17 May 2004. By September 2019, 183 UN member states and the European Union had adopted the Stockholm Convention.

Examples of drivers, outcomes and risk management

Dioxins and dioxin-like substances exposure occurs in the following ways (WHO, 2019):

- Associated with natural hazards: Dixons can be generated by natural events, such as volcanic eruptions and forest fires.
- Industrial processes: PCDDs and PCDFs are by-products of industrial processes, particularly waste incineration, cement kilns firing hazardous waste, chlorine bleaching of pulp, and thermal processes in the metallurgical industry, as well as the manufacture of chlorophenols and phenoxy herbicides.
- Environmental media and food: Dioxin releases into air from inadequate incineration and releases into air, water or soil from industrial and waste sites contaminate soil and aquatic sediments, leading to bioaccumulation and bioconcentration through food chains. Most general population exposure is through ingestion of contaminated foods of animal origin.
- Waste disposal: Any source of organic materials in the presence of chlorine or other halogens will generate dioxins and furans during combustion. PCDDs and PCDFs are generated through the incineration of waste (domestic, industrial and health-care facilities) at low to moderate temperatures; guidance has been developed to identify and quantify releases from various incineration processes.

Actions to reduce emissions of these substances are required by the Stockholm Convention (UNEP, 2001). Interventions to reduce human exposure include: identifying and safely disposing of material containing or likely to generate dioxins and dioxin-like substances, such as electrical equipment; ensuring appropriate combustion practices to reduce emissions; implementing FAO/WHO strategies to reduce contamination in food and feed; and monitoring of food items, human breastmilk and air, as well as exposures in workers likely to be exposed to higher levels.

References

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Coordinating agency or organisation

Not identified.

CH0014 / **CHEMICAL / Persistent Organic Pollutants (POPs)**

Microplastics

Definition

Microplastics are small plastic pieces less than five millimetres in length which can be harmful to the environment especially marine life. They originate from a variety of sources, including larger plastic debris that degrades into progressively smaller pieces (adapted from UNEP, 2016 and NOAA, no date).

References

UNEP, 2016. Marine plastic debris and microplastics: Global lessons and research to inspire action and guide policy change. United Nations Environment Programme (UNEP). https://wedocs.unep.org/handle/20.500.11822/7720?show=full Accessed 14 October 2020.

NOAA, no date. What are microplastics? National Oceanic and Atmospheric Administration (NOAA). https://oceanservice.noaa.gov/facts/microplastics.html Accessed 14 October 2020.

Annotations

Synonyms

Nanoparticles, Marine debris.

Additional scientific description

Microplastics are routinely defined as small particles or fragments of plastic measuring less than 5 mm in length. Some microplastics are intentionally manufactured for industrial and domestic purposes ('primary' microplastics). These include 'microbeads' used in cosmetic and personal healthcare products, such as toothpaste. 'Secondary' microplastics are created by the weathering and fragmentation of larger plastic objects. Weathering and fragmentation are enhanced by exposure to ultraviolet (UV) irradiation. These processes become extremely slow in the absence of UV radiation, as is the case in much of the ocean. Plastics marked as 'biodegradable' degrade more slowly in the ocean (UNEP, 2016).

Nanoparticles are a form of marine debris, the significance of which is only now emerging. They are minuscule particles with dimensions of 1 to 100 nanometres (a nanometre is one millionth of a millimetre).

A large proportion of the nanoparticles found in the ocean are of natural origin. It is the anthropogenic nanoparticles that are of concern. These originate from two sources: (i) nanoparticles created intentionally for use in industrial processes and cosmetics and (ii) from the breakdown of plastics in marine debris, from fragments of artificial fabrics discharged into urban wastewater, and through leaching from land-based waste sites (NOAA, 2021).

Recent scientific research has highlighted the potential environmental impacts of plastic nanoparticles. For example, they appear to reduce primary production and the uptake of food by zooplankton and filter-feeders. Nanoparticles of titanium dioxide, which is widely used in paints and metal coatings and in cosmetics, are of particular concern. When nanoparticles of titanium dioxide are exposed to UV radiation from the sun, they transform into a disinfectant and have been shown to kill phytoplankton, which are the basis of primary production in the ocean. The scale of the threat from nanoparticles is unknown, and further research is required (UN, 2017).

About half the global population lives within 100 km of a coastline, and population growth is greatest in that zone. This means the amount of plastic debris entering the ocean from land-based sources is likely to increase unless significant changes are made to waste management practices on land (UNEP, no date).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972, the 'London Convention' for short, is one of the first global conventions to protect the marine environment from human activities and has been in force since 1975 (IMO, 1972). Its objective is to promote the effective control of all sources of marine pollution and to take all practicable steps to prevent pollution of the sea by dumping of wastes and other matter. Currently, 87 States are Parties to this Convention.

The International Convention for the Prevention of Pollution from Ships (MARPOL) is the main international convention covering prevention of pollution of the marine environment by ships from operational or accidental causes (IMO, 1996). The MARPOL Convention was adopted on 2 November 1973. The Protocol of 1978 was adopted in response to a spate of tanker accidents in 1976–1977. As the 1973 MARPOL Convention had not yet entered into force, the 1978 MARPOL Protocol absorbed the parent Convention. The combined instrument entered into force on 2 October 1983. In 1997, a Protocol was adopted to amend the Convention and a new Annex VI was added which entered into force on 19 May 2005. MARPOL has been updated by amendments through the years.

Examples of drivers, outcomes and risk management

To better assess human health risks and inform management actions, a number of research gaps need to be filled. With respect to exposure, there is a need to better understand microplastics occurrence throughout the water supply chain, using quality-assured methods to determine the numbers, shapes, sizes, composition and sources of microplastics and to better characterise the effectiveness of water treatment. Research is also needed to better understand the significance of treatment-related waste streams as contributors of microplastics to the environment.

With respect to potential health effects, quality-assured toxicological data are needed on the most common forms of plastic particles relevant for human health risk assessment. Further, a better understanding is needed on the uptake and fate of microplastics and nanoplastics following ingestion. Finally, given that humans can be exposed to microplastics through a variety of environmental media, including food and air, a better understanding of overall exposure to microplastics from the broader environment is needed (WHO, 2020).

The human health risk from microplastics in drinking-water is a function of both hazard and exposure. Potential hazards associated with microplastics come in three forms: the particles themselves which present a physical hazard, chemicals (unbound monomers, additives, and sorbed chemicals from the environment), and microorganisms that may attach and colonise on microplastics, known as biofilms. Based on the limited evidence available, chemicals and microbial pathogens associated with microplastics in drinking-water pose a low concern for human health. Although there is insufficient information to draw firm conclusions on the toxicity of nanoparticles, no reliable information suggests it is a concern (WHO, 2020).

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WHO, 2020. Microplastics in Drinking Water. World Health Organization (WHO). www.who.int/publications/i/item/9789241516198 Accessed 30 April 2021.

Coordinating agency or organisation

Not identified.

CH0015 / **CHEMICAL / Gases**

Phosphine

Definition

Phosphine (PH_3) is a colourless, flammable, and explosive gas at room temperature. The major uses of phosphine are as a rodenticide and fumigant for agricultural products and in the manufacture of semi-conductors for the electronics industry. Exposure to low doses causes non-specific symptoms, such as nausea, vomiting, stomach pain, diarrhoea, thirst, muscle pain, difficulty breathing and fluid in the lungs. Exposure to higher doses may cause more severe effects, even death (adapted from PHE, 2017 and CDC, 2019).

References

CDC, 2019. Phosphine. Centres for Disease Control and Prevention (CDC). www.cdc.gov/niosh/topics/phosphine/default.html Accessed 20 October 2020.

PHE, 2017. Phosphine: Health effects, incident management and toxicology. Public Health England (PHE). www.gov.uk/government/publications/phosphine-properties-incident-management-and-toxicology Accessed 20 October 2020.

Annotations

Synonyms

Hydrogen phosphide, Phosphorus hydride, Phosphorus trihydride, Phosphoretted hydrogen, Phosphane.

Additional scientific description

Phosphine (PH_3) reacts violently with air, oxygen, oxidants such as chlorine and nitrogen oxides, metal nitrates, halogens and many other substances causing fire and explosion hazard. Pure phosphine is odourless, although most commercially available grades have the odour of garlic or decaying fish.

It attacks many metals. Phosphine decomposes on heating or burning, producing fumes including phosphorus oxides and liberates hydrogen when passed over heated metal (PHE, 2017a).

The major uses of phosphine are as a rodenticide and fumigant for stored agricultural products such as nuts, seeds, grains, coffee and tobacco, and in the manufacture of semi-conductors for the electronics industry. Phosphine is also used in the production of some chemicals and metal alloys and is an unintentional by-product in the illegal manufacture of the drug methamphetamine. Phosphine is also used as a condensation catalyst and in the manufacture of some polymers (PHE, 2017a).

Phosphine is rarely found in nature. Small amounts can be formed during the breakdown of organic matter, although it is rapidly degraded. Phosphine is released into the air via emissions from various manufacturing processes and from the use of metal phosphides (magnesium, aluminium, zinc), phosphide fumigants and pesticides (PHE, 2017a).

Metrics and numeric limits

Emergency response and acute exposure – there are Emergency Response Planning Guidelines (ERPGs) (NOAA, 2016) and Acute Exposure Guideline Values for Airborne Chemicals (AEGLs) (US EPA, no date).

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Phosphine is acutely toxic; exposure to high levels causes immediate effects. Exposure to low doses of phosphine causes non-specific symptoms such as headache, dizziness, numbness, general fatigue, breathing difficulties (tightness around the chest, pain in the region of the diaphragm, cough) and gastrointestinal disturbance (pain, nausea, vomiting, diarrhoea). At higher doses, subjects may experience lung irritation, persistent coughing, tremors and convulsions, leading to pulmonary oedema, myocardial injury, kidney damage and coma, and sometimes death due to cardiovascular failure, usually within the first few hours or after a delay of up to two weeks in the case of liver failure (ATSDR, 2011; PHE, 2017a).

Chronic exposure to phosphine is unlikely to occur in the general population but may occur in an occupational setting. Symptoms of chronic exposure include anaemia, bronchitis, gastrointestinal disorders, speech and motor disturbances, weakness, weight loss, toothache, swelling of the jaw, mandibular necrosis, and spontaneous fractures. Some chronic effects can be confused with symptoms of acute poisoning (PHE, 2017a).

Phosphine is very highly toxic by inhalation. Major accidental release of stored phosphine presents a serious explosion/fire hazard and an acute toxic hazard for humans and animals. Chemical accidents associated with phosphine exposure have been reported in many countries. Accidental exposure of the general population to phosphine has occurred in association with fumigation operations and on-board ships carrying cargo capable of releasing phosphine (IPCS, 1988).

The most important factor in the safe handling of phosphine and metal phosphides, and in their formulation, is proper work practices (PHE, 2017b); evacuation should be considered in a written emergency plan for releases of phosphine (ILO/WHO, 2017) and harmonized labelling and transport approaches should be adhered to (ILO/WHO, 2017).

References

ATSDR, 2011. Medical Management Guidelines for Phosphine. Agency for Toxic Substances & Disease Registry (ATSDR). www.atsdr.cdc.gov/MMG/MMG.asp?id=1013&tid=214 Accessed 20 October 2020.

ILO/WHO, 2017. Phosphine. International Labour Organization / World Health Organization (ILO/WHO). www.ilo.org/dyn/icsc/showcard.display?p_version=2&p_card_id=0694&p_lang=en Accessed 20 October 2020

IPCS, 1988. Environmental Health Criteria 73: Phosphine and Selected Metal Phosphides. International Programme on Chemical Safety (IPCS). www.inchem.org/documents/ehc/ehc/ehc73.htm Accessed 20 October 2020.

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US EPA, 2018. Acute Exposure Guideline Levels for Phosphine. United States Environmental Protection Agency (US EPA). www.epa.gov/aegl/phosphine-results-aeglprogram Accessed 20 October 2020.

Coordinating agency or organisation

Not identified.

CH0016 / **CHEMICAL / Gases**

Chlorine

Definition

Chlorine is a reactive pale green gas with many uses including disinfection of water that is approximately three times heavier than air and has a characteristic odour similar to bleach. Most significant exposures to chlorine result from loss of containment of chlorine during storage and transport. Human exposure can result in symptoms ranging from mild irritation to rapid death related to pulmonary oedema. It is considered a significant public health hazard (adapted from IPCS, 1982 and PHE, 2019).

References

IPCS, 1982. Environmental Health Criteria 21: Chlorine and hydrogen chloride. International Programme on Chemical Safety (IPCS). www.inchem.org/documents/ehc/ehc/ehc21.htm Accessed 2 December 2019.

PHE, 2019. Chlorine: health effects, incident management and toxicology. Public Health England (PHE). www.gov.uk/government/publications/chlorine-properties-incdent-management-and-toxicology Accessed 2 December 2019.

Annotations

Synonyms

None identified.

Additional scientific description

Chlorine (chemical symbol Cl, atomic number 17) reacts violently with bases and is a corrosive, strong oxidant. It also reacts violently with combustible substances and reducing agents and most organic and inorganic compounds, causing a fire and explosion hazard. It may also combine with water or steam to produce toxic and corrosive fumes of hydrochloric acid (PHE, 2019).

Chlorine is used in the disinfection of water and in the production of bleach and chlorinated hydrocarbon solvents, polyvinyl chloride and other industrial processes. Large quantities are also used in the bleaching of pulp and paper.

Bleach contains sodium hypochlorite, which, if (inadvertently) mixed with acidic chemicals can result in the generation and release of chlorine gas. If chlorine is released from a tank into the air, the chlorine will evaporate very quickly, forming a highly toxic greenish-yellow cloud (ATSDR, 2010).

Metrics and numeric limits

Drinking water: 5 mg/L (WHO, 2011).

Emergency response and acute exposure: there are Emergency Response Planning Guidelines (ERPG) (NOAA, 2016) and Acute Exposure Guideline Values for Airborne Chemicals (AEGLs) (US EPA, no date) as a result of health risks associated with releases and spills of chlorine.

Key relevant UN convention / multilateral treaty

World Health Organization (WHO) International Health Regulations (WHO, 2016).

Examples of drivers, outcomes and risk management

Minor exposures to chlorine may result in a burning sensation of the eyes and throat. More substantial exposure may cause coughing or breathing difficulties. Exposure to high concentrations of chlorine gas can damage the lungs and airways, hours after the exposure, potentially without preceding warning symptoms; this may cause a build-up of fluid in the lungs (oedema) which can be fatal. Following severe injuries from inhaling chlorine, there may be a shock, coma and death, or when surviving, a chronic disorder of the lungs. Those exposed during physical exertion appear especially vulnerable (IPCS, 1982; PHE, 2019).

Owing to its hazardous nature, the majority of chlorine is transported by rail (ILO, 2004).

The modern use of chemical weapons began with World War I, when both sides in the conflict used poisonous gas to inflict agonising suffering and cause significant battlefield casualties. Such weapons basically consisted of well-known commercial chemicals put into standard munitions such as grenades and artillery shells. Chlorine was a common chemical used in this way historically and still presents a risk (United Nations Office for Disarmament Affairs, no date).

Spillages and run-off should be prevented from entering watercourses as chlorine is harmful to the natural environment; evacuation should be considered in a written emergency plan for significant spills and leaks of chlorine such as from tanks; and harmonised labelling and transport approaches should be adhered to.

References

ATSDR, 2010. Toxicological Profile For Chlorine. Agency for Toxic Substances & Disease Registry (ATSDR). www.atsdr.cdc.gov/ToxProfiles/tp172.pdf Accessed 2 December 2019.

ILO, 2004. Transport and Storage. International Labour Organization (ILO). www.ilo.org/legacy/english/protection/safework/cis/products/safetytm/transpo.htm Accessed 2 December 2019.

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WHO, 2016. International Health Regulations (2005), Third Edition. World Health Organization (2016). www.who.int/ihr/publications/9789241580496/en/ Accessed 26 September 2020.

Coordinating agency or organisation

Not identified.

CH0017 / **CHEMICAL / Hydrocarbons**

Oil Pollution

Definition

Oil pollution includes the accidental or deliberate, operational spills of oil from ships, especially tankers, offshore platforms and pipelines (Global Marine Oil Pollution Information Gateway, no date).

Reference

Global Marine Oil Pollution Information Gateway, no date. Sources. http://oils.gpa.unep.org/facts/sources.htm#NOAA Accessed 19 October 2020.

Annotations

Synonyms

Oil spill.

Additional scientific description

Oil discharges to the marine environment may occur from natural seeps, and ocean-based and land-based sources. Examples of ocean-based discharges are oil spills from ships/tankers and offshore platforms and pipelines. Examples of land-based sources are untreated sewage and storm water, rivers, coastal industries, coastal refineries, oil storage facilities, oil terminals and reception facilities. Hydrocarbons can also enter the marine environment as gaseous air pollutants from vapour derived from loading and unloading of oil (UNEP, no date).

Constant sources of a large and ongoing oil input to the marine environment include oil-polluted stormwater and sewage from municipalities, discharges from numerous sources in coastal facilities, gaseous hydrocarbons from cars and motor boats, and many more such on-land or recreational coastal activities that are not always linked to marine oil pollution (Global Marine Oil Pollution Information Gateway, 2005).

Oil spills can have strong negative environmental and socio-economic impacts (UNEP, no date). Marine and coastal habitats, wildlife species, recreational activities and fisheries, are among the resources and sectors that can be negatively affected by oil spills. Oil harms wildlife in two main ways: through toxic contamination (inhalation or ingestion) or by physical contact, for example:

- Seabirds spend much of their time on or near the sea. This makes them vulnerable to oil spills and they can suffer from hypothermia because the oil destroys the structure of their protective layer of feathers and insulating down; drowning due to their increased weight when oil covers their bodies; poisoning through ingestion or inhalation; and loss of flight, which could affect their reproductive capacity (UNEP, no date).
- Marine mammals, including manatees, dolphins, porpoises, and whales are vulnerable to oil spills owing to their amphibious habits and dependence on air. The consequences of exposure to oil include hypothermia, poisoning from ingestion of oil, congested lungs and damaged airways, and gastrointestinal ulceration and haemorrhaging (UNEP, no date).
- Fish can absorb oil that is dissolved in water though their gills, accumulating it within the liver, stomach, and gall bladder. Although they are able to cleanse themselves of contaminants within weeks of exposure, there may be a period when they are unfit for human consumption (UNEP, no date).
- Sea turtles can be affected when oil enters their eyes and damages airways and/or lungs, from poisoning by absorption through the skin, through the ingestion of contaminated food, and from contamination of the nesting sites, eggs and newly hatched turtles (UNEP, no date).

Oil spills also affect the coastal environment and habitats. Coral reefs and the marine organisms, especially juvenile organisms that live within and around the reefs are at risk from exposure to the toxic substances within oil as well as from smothering. On beaches oil can soak into sand and gravel. Coating on the roots of mangrove trees can kill the trees, and marsh grasses and seagrasses are also affected.

Negative socio-economic impacts include decreased tourism and the closure of recreational, fishing and shellfish areas. Boats and fishing gear may be damaged and human health can be affected through direct contact or inhalation of the oil or by eating contaminated seafood (UNEP, no date).

It may take several years or even decades, before an area or ecosystem has fully recovered from a major oil spill (UNEP, no date).

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

The following information is as summarised by the Global Marine Oil Pollution Information Gateway (no date):

Global political commitments: initiatives, declarations, action plans, programmes

- Agenda 21. World Summit on Sustainable Development (WSSD 2002).
- Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA).

International conventions

- Convention on the Law of the Sea (UNCLOS).
- MARPOL 73/78: International Convention for the Prevention of Pollution from Shipping.
- London Convention: Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter.
- International Oil Pollution Compensation Funds (IOPC Funds), 1971 and 1992.
- Civil Liability Convention: International Convention on Civil Liability for Oil Pollution Damage (CLC).
- International Convention on Civil Liability for Bunker Oil Pollution Damage.
- OPRC: International Convention on Oil Pollution Preparedness, Response and Cooperation.
- SOLAS: International Convention for the Safety of Life at Sea.

Examples of drivers, outcomes and risk management

Actions are needed at a number of levels depending on the source of the oil. Globally, international action, such as within the UN International Maritime Organization (IMO), is needed to further control the operational discharges and emissions of oil and waste, as well as air pollutants, from shipping (MARPOL 73/78), and to reduce the risks of major accidents (SOLAS). Measures should build on the regulations set out in these and other conventions with global coverage (UNEP, no date).

Transboundary air pollution (e.g., volatile organic compounds and polyaromatic hydrocarbons from the handling and use of oil products) could be further controlled at the global or regional level via agreements such as the UN Framework Convention on Climate Change, the UN ECE Convention on Long-range Transboundary Air Pollution (Europe and North America), and others (UNEP, date).

The IMO oil pollution manual (IMO, 2005–2019) provides a useful guide for governments of developing countries and for those persons directly associated with the sea transportation and transfer of oil. The manual is divided into six sections: prevention, contingency planning, salvage, combating oil spills, administrative aspects of oil pollution response, and guidelines for sampling and identification of oil spills.

At an individual level, the United Nations Environment Programme recommends a range of actions (UNEP, no date) including: never pour oil into a drain or onto the ground; maintain vehicles to make sure there are no oil leaks; recycle all used oil from, for example, a car; limit paved surfaces since they prevent natural percolation into the ground causing water runoff that ends up at the sea without natural cleaning through filtration; and report oil spills – note date, time and location of the incident.

References

Global Marine Oil Pollution Information Gateway, no date. Global Action. http://oils.gpa.unep.org/framework/global-action.htm Accessed 19 October 2020.

Global Marine Oil Pollution Information Gateway, 2005. http://oils.gpa.unep.org Accessed 19 October 2020.

IMO, 2005–2019. Manual on Oil Pollution: Combating oil spills. International Maritime Organization (IMO). www.imo.org/en/OurWork/Environment/Pages/List-of-IMO-OPRC-HNS-related-guidance-and-manuals.aspx Accessed 25 October 2020.

UNEP, no date. Oil (hydrocarbons). United Nations Environment Programme (UNEP). https://www.unenvironment.org/cep/oils-hydrocarbons Accessed 19 October 2020.

Coordinating agency or organisation

Not identified.

CH0018 / **CHEMICAL / Hydrocarbons**

Benzene

Definition

Benzene is a clear, colourless, highly flammable and volatile, liquid aromatic hydrocarbon (molecular formula C6H6) with a gasoline-like odour (WHO, 2019).

Reference

WHO, 2019. Preventing disease through healthy environments: Exposure to benzene: a major public health concern. World Health Organization (WHO). apps.who.int/iris/bitstream/handle/10665/329481/WHO-CED-PHE-EPE-19.4.2-eng.pdf?ua=1 Accessed 19 November 2019.

Annotations

Synonyms

Not identified.

Additional scientific description

Benzene is a stable colourless liquid at room temperature and normal atmospheric pressure. Benzene melts at 5.5°C and boils at 80.1°C; and has a characteristic aromatic odour. It has a high vapour pressure, which causes it to evaporate rapidly at room temperature, and is highly flammable. It is slightly soluble in water but miscible with most other organic solvents (IPCS, 1993).

Benzene is used as a solvent in the chemical and pharmaceutical industries. It also occurs naturally in petroleum products (e.g., crude oil and gasoline) at levels up to 4 g/l. The primary route of benzene exposure and subsequent toxicity is via inhalation. The highest exposures have typically been in the workplace – for example, in industries that make or use benzene. The general population may be exposed through the inhalation of contaminated air, particularly in areas of heavy automobile traffic, gas stations and areas near industrial sources. Other sources include cigarette smoking, second-hand smoke, off-gassing from building material and structural fires. People also may be exposed to benzene in contaminated drinking water and some foods (American Cancer Society, 2016; WHO, 2019).

The compulsory introduction of catalytic converters on car exhausts and legislation to reduce benzene levels in car fuels has contributed to a reduction of benzene emissions. Other interventions to prevent or reduce exposures to airborne benzene include promoting the use of alternative solvents in industrial processes, developing and implementing policies and legislation to remove benzene from consumer products, discouraging domestic use of benzene-containing products, promoting building codes requiring detached garages, and implementing the World Health Organization (WHO) Framework Convention on Tobacco Control (WHO, 2003), including providing for protection from exposure to tobacco smoke in workplaces and public areas (WHO, no date).

Metrics and numeric limits

Drinking-water: The WHO guideline value for benzene is 0.01 mg/l. This is based on extrapolation of modelled excess lifetime risk for leukaemia from epidemiological studies involving inhalation exposure; guideline values corresponding to modelled excess lifetime cancer risks* of 10-4, 10-5 and 10-6 are 0.1, 0.01 and 0.001 mg/l, respectively (WHO, 2019).

*An excess lifetime cancer risk of 10-4, 10-5 or 10-6 means the risk of one new cancer case above background levels per 10,000, 100,000 or 1 million people, respectively.

Air: No specific WHO guideline value has been developed for benzene in air. Benzene is carcinogenic to humans and no safe level of exposure can be recommended. For general guidance, the concentrations of airborne benzene associated with an excess lifetime risk of leukaemia of 10-4, 10-5 and 10-6 are 17, 1.7 and 0.17 µg/m3, respectively (WHO, 2019).

Key relevant UN convention / multilateral treaty

The Benzene Convention, 1971 (ILO, 1971).

The International Health Regulations 2005 (WHO, 2008).

Examples of drivers, outcomes and risk management

Benzene causes a range of acute effects such as acute occupational exposure to benzene which may cause narcosis: headache, dizziness, drowsiness, confusion, tremors and loss of consciousness (use of alcohol enhances the toxic effect). It is also irritating to the eyes, skin and respiratory tract (WHO, 2019).

Benzene is a well-established cause of cancer in humans. The International Agency for Research on Cancer (IARC) has classified benzene as carcinogenic to humans (Group 1). The evidence in humans is considered sufficient for acute non-lymphocytic leukaemia, including acute myeloid leukaemia, while the evidence in humans is limited for non-Hodgkin lymphoma, chronic lymphoid leukaemia, multiple myeloma, chronic myeloid leukaemia, acute myeloid leukaemia in children, and lung cancer (WHO, 2019).

The WHO factsheet on Preventing disease through healthy environments - exposure to Benzene: a major public health concern (WHO, 2019) includes the following risk mitigation recommendations:

Eliminate use

- Promote the use of alternative solvents in industrial processes, glues and paints.
- Develop and implement policies and legislation to remove benzene from consumer products.

Reduce exposure

- Reduce exposure at petrol filling stations as far as possible by following best practice in location, design and extraction.
- Minimise emissions from vehicle exhausts by improved design and regular monitoring of engine settings.
- Separate dwelling spaces from areas where vehicles and benzene-containing products are kept. In particular, isolate children from indoor exposure to vehicle emissions.
- Avoid domestic use of benzene-containing products.
- Discourage indoor use of unflued oil and gasoline heating.
- Implement the WHO Framework Convention on Tobacco Control (WHO, 2003), including providing for protection from exposure to tobacco smoke in indoor workplaces, public transport, indoor public places and, as appropriate, other public places.

Education

- Raise public awareness regarding sources of exposure to benzene – especially exposure through smoking – and awareness of risk mitigation measures.
- Conduct educational activities to discourage the use of benzene or petrol for cleaning and degreasing in industry, including in the informal sector.

References

American Cancer Society, 2016. Benzene and Cancer Risk. What is Benzene? www.cancer.org/cancer/cancer-causes/benzene.html Accessed 7 May 2021.

ILO, 1971. ILO C136 - Benzene Convention, 1971 (No. 136). International Labour Organization (ILO). www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:12100:0::NO::P12100_ILO_CODE:C136 Accessed 18 November 2019.

IPCS, 1993. Benzene environmental health criteria 150. International Programme on Chemical Safety (IPCS). www.inchem.org/documents/ehc/ehc/ehc150.htm Accessed 19 November 2019.

WHO, no date. International Programme on Chemical Safety. Benzene. World Health Organization (WHO). www.who.int/ipcs/assessment/public_health/benzene/en Accessed 19 November 2019.

WHO, 2003. Who Framework Convention on Tobacco control. World Health Organisation (WHO). http://apps.who.int/iris/bitstream/handle/10665/42811/9241591013.pdf;jsessionid=1E987E56292F6623A337129E2C1D0E27?sequence=1 Accessed 7 May 2021.

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WHO, 2019. Preventing disease through healthy environments: Exposure to benzene: a major public health concern. World Health Organization (WHO). apps.who.int/iris/bitstream/handle/10665/329481/WHO-CED-PHE-EPE-19.4.2-eng.pdf?ua=1 Accessed 19 November 2019.

Coordinating agency or organisation

Not identified.

CH0019 / **CHEMICAL / CBRNE (Chemical, Biological, Radiological, Nuclear and Explosive)**

Chemical Warfare Agents

Definition

Chemical agents or 'chemical warfare agents' (chemical weapons) are chemicals used to cause intentional death or harm through their toxic properties. Munitions, devices and other equipment specifically designed to weaponise toxic chemicals also fall under the definition of chemical weapons. The Chemical Weapons Convention (CWC) prohibition against the use of toxic chemicals and their precursors and also covers toxins of biological origin (OPCW, 2019a,b).

References

OPCW, 2019a. What is a chemical weapon? Organisation for the Prohibition of Chemical Weapons (OPCW). www.opcw.org/our-work/what-chemical-weapon Accessed 1 December 2019.

OPCW, 2019b. Chemical Weapons Convention: Annex on Chemicals: Schedule 1: A: Toxic Chemicals. Organisation for the Prohibition of Chemical Weapons (OPCW). www.opcw.org/chemical-weapons-convention/annexes/annex-chemicals/schedule-1 Accessed 21 August 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

The relevant toxic chemicals are listed in the Chemical Weapons Convention's Annex on Chemicals (OPCW, 2019b) and, in principle, the understanding and application of a so-called General Purpose Criterion (GPC) and include:

- Blistering agents: These toxic compounds act via inhalation and contact, affecting the eyes, respiratory tract, and skin, first as an irritant and then as a cell poison. Exposure to blister agents causes large and often life-threatening skin blisters which resemble severe burns, and often results in blindness and permanent damage to the respiratory system. Examples include mustard gas.
- Blood agents: These agents inhibit the ability of cells to transfer and use oxygen, effectively causing the body to suffocate. Blood agents generally enter the body through inhalation and are distributed via the blood. Examples include hydrogen cyanide and cyanogen chloride.
- Choking agents: Inflicting injury mainly on the respiratory tract, choking agents irritate the nose, throat, and especially the lungs. When inhaled, these agents cause alveoli (air sacs in the lungs) to secrete fluid, essentially drowning those affected. Chlorine and phosgene gas are examples.
- Nerve agents: Nerve agents block impulses between nerve cells or across synapses and are highly toxic with rapid effects. They act primarily by absorption through the lungs and skin inhibiting the action of critical enzymes required for the normal functioning of the nervous system, causing seizures, loss of body control, muscle paralysis (including heart and diaphragm), and ultimately death. Sarin and VX gas are examples.

Metrics and numeric limits

None identified

Key relevant UN convention / multilateral treaty

The General Purpose Criterion (GPC), which is embodied in the Chemical Weapons Convention's definition of a 'chemical weapon', prohibits all toxic chemicals and their precursors except for non-prohibited purposes (OPCW, 2019a,b). This mechanism ensures that the Chemical Weapons Convention's prohibitions remain comprehensive in scope, including in terms of scientific and technological developments.

Examples of drivers, outcomes and risk management

Drivers have been wars and civil wars, associated with death, injury and often life-long disabilities (Australia Group, 2018a,b).

Control measures include import-export control of relevant chemical agents and precursors (Australia Group, 2018a,b). A key factor in ensuring that toxic chemicals and their precursors are not meant to cause death or other harm (i.e., as a 'method of warfare') is the application of the General Purpose Criterion. A given activity or programme may be for 'defensive' (i.e., permitted) or 'offensive' (i.e., prohibited) purposes.

The intent of the activity or programme must therefore be determined. It is not always possible for governments to agree on the nature of a given activity or programme within a multilateral disarmament and arms control framework, including the Chemical Weapons Convention (Krutzsch et al., 2014).

In addition an international network of specialised analytical laboratories, able to detect potential chemical warfare agents in the environment and in exposed human bodies are likely to be of benefit (EU, 2009).

References

Australia Group, 2018a. Australia Group common control list handbook: Volume 1: Chemical weapons-related common control lists, revision 4. australiagroup.net/en/documents/Australia-Group-Common-Control-List-Handbook-Volume-I.pdf Accessed 1 December 2019.

Australia Group, 2018b. Australia Group common control list handbook: Volume 2: Biological weapons-related common control lists, revision 4. australiagroup.net/en/documents/Australia-Group-Common-Control-List-Handbook-Volume-II.pdf Accessed 1 December 2019.

EU, 2009. Council regulation (EC) No 428/2009: Setting up a community regime for the control of exports, transfer, brokering and transit of dual-use items (Recast). Official Journal of the European Union (EU), OJ L 134, 29.5.2009, p. 1. eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02009R0428-20171216&from=EN Accessed 1 December 2019.

Krutzsch, W., E. Myjer and R. Trapp (eds.), 2014. The Chemical Weapons Convention: A commentary. Oxford University Press.

OPCW, 2019a. Chemical Weapons Convention: Article II: Definitions and criteria. Organisation for the Prohibition of Chemical Weapons (OPCW). www.opcw.org/chemical-weapons-convention/articles/article-ii-definitions-and-criteria Accessed 1 December 2019.

OPCW, 2019b. Chemical Weapons Convention: Verification Annex, Part IV(A), paras. 15-19. Organisation for the Prohibition of Chemical Weapons (OPCW). www.opcw.org/sites/default/files/documents/VER/DEB/declarations_handbook/2013/Sections_A_B_C_K_L_and_M___App_1and3_to_8.pdf Accessed 1 December 2019.

Coordinating agency or organisation

Not identified.

CH0020 / **CHEMICAL / Other Chemical Hazards and Toxins**

Asbestos

Definition

Asbestos is the term for a group of naturally occurring minerals widely used historically in building materials and other products (WHO, no date). All types of asbestos cause lung cancer, mesothelioma, cancer of the larynx and ovary, and asbestosis (fibrosis of the lungs) (WHO, no date).

Reference

WHO, no date. International Programme on Chemical Safety: Asbestos. World Health Organization (WHO). www.who.int/ipcs/assessment/public_health/asbestos/en Accessed 18 November 2019.

Annotations

Synonyms

Not identified.

Additional scientific description

Asbestos has current or historical commercial use due to its extraordinary tensile strength, poor heat conduction, and relative resistance to chemical attack. For these reasons, asbestos is used for insulation in buildings and as an ingredient in a number of products, such as roofing shingles, water supply lines, and fire blankets, as well as clutches and brake linings, gaskets, and pads for automobiles (WHO, no date).

The main forms of asbestos are chrysotile (white asbestos) and crocidolite (blue asbestos). Other forms include amosite, anthophylite, tremolite and actinolite (WHO, no date).

All forms of asbestos are carcinogenic to humans. Exposure to asbestos, including chrysotile, causes cancer of the lung, larynx, and ovaries, and also mesothelioma (a cancer of the pleural and peritoneal linings). Asbestos exposure is also responsible for other diseases such as asbestosis (fibrosis of the lungs), and plaques, thickening and effusion in the pleura (WHO, no date).

Metrics and numeric limits

According to the World Health Organization (WHO), globally about 125 million people are currently exposed to asbestos at the workplace. In 2004, asbestos-related lung cancer, mesothelioma and asbestosis from occupational exposure resulted in 107,000 deaths and 1523,000 Disability Adjusted Life Years (DALYs) (WHO, no date). In addition, nearly 400 deaths have been attributed to non-occupational exposure to asbestos. The burden of asbestos-related diseases is still rising, even in countries that banned its use in the early 1990s. Owing to the long latency periods attached to the diseases in question, stopping the use of asbestos now will only result in a decrease in the number of asbestos-related deaths after a number of decades (WHO, 2014).

The WHO air quality guidelines for Europe estimate likely lifetime exposure for asbestos based on typical environmental concentrations and the associated health risk factors such as mesothelomia and lung cancer (WHO, 2000:38).

Key relevant UN convention / multilateral treaty

Asbestos Convention, 1986 (ILO, 1962).

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (Basel Convention, 1989). At the time of writing, there were 187 parties to the Basel Convention.

Examples of drivers, outcomes and risk management

In many disaster-prone areas, asbestos cement is widely used as a building material and when the material corrodes due to aging or is damaged it releases harmful asbestos fibres. Fires in buildings can release large amounts of dust and fibres from asbestos and fibreglass insulation (WHO, 2018).

The WHO, in collaboration with the International Labour Organization and other intergovernmental organisations and civil society, works with countries towards elimination of asbestos-related diseases by (WHO, no date):

- Recognising that the most efficient way to eliminate asbestos-related diseases is to stop the use of all types of asbestos.
- Providing information about solutions for replacing asbestos with safer substitutes and developing economic and technological mechanisms to stimulate its replacement.
- Taking measures to prevent exposure to asbestos in place and during asbestos removal (abatement).
- Improving early diagnosis, treatment, and rehabilitation services for asbestos-related diseases.
- Establishing registries of people with past and/or current exposures to asbestos and organising medical surveillance of exposed workers.
- Providing information on the hazards associated with asbestos-containing materials and products, and by raising awareness that waste containing asbestos should be treated as hazardous waste.

Cost-effective interventions for preventing occupational lung diseases from exposure to asbestos are among the policy options for implementing the Global Action Plan for the Prevention and Control of Noncommunicable Diseases (2013-2020), as endorsed by the Sixty-sixth World Health Assembly in 2013 (WHO, 2013).

Asbestos is a proven human carcinogen (International Agency for Research on Cancer [IARC] Group 1). No safe level can be proposed for asbestos because a threshold is not known to exist. Exposure should therefore be kept as low as possible (IARC, 1987/1998).

References

Basel Convention, 1989. Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989). At the time of writing, there were 187 parties to the Basel Convention. Official website: www.basel.int Accessed 18 November 2019.

IARC, 1987. Asbestos (Actinolite, amosite, anthophyllite, chrysotile, crocidolite, tremolite) (Group 1). Summaries & Evaluations Supplement 7:106. Last updated 1998. International Agency for Research on Cancer (IARC). www.inchem.org/documents/iarc/suppl7/asbestos.html Accessed 18 November 2019.

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WHO, 2013. Global action plan for the prevention and control of noncommunicable diseases 2013-2020. World Health Organization (WHO). apps.who.int/iris/bitstream/handle/10665/94384/9789241506236_eng.pdf;jsessionid=431E06013F1E86614BB088F7CCA30759?sequence=1 Accessed 18 November 2019.

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WHO, 2000. Air Quality Guidelines for Europe, Second Edition. World Health Organization (WHO) Regional Office for Europe. European Series, No. 91. www.euro.who.int/__data/assets/pdf_file/0005/74732/E71922.pdf?ua=1 Accessed 18 November 2019.

Coordinating agency or organisation

World Health Organization (WHO), International Programme on Chemical Safety (IPCS).

CH0021 / **CHEMICAL / Other Chemical Hazards and Toxins**

Aflatoxins

Definition

Aflatoxins are mycotoxins – toxic compounds that are naturally produced by certain types of mould (fungi). Aflatoxins are among the most poisonous mycotoxins and are produced by certain moulds (Aspergillus flavus and A. parasiticus) that grow in soil, decaying vegetation, hay, and grains. Aflatoxins pose a serious health risk to humans and livestock (WHO, 2018a,b).

References

WHO, 2018a. Mycotoxins. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/mycotoxins Accessed 8 October 2020.

WHO, 2018b. Aflatoxins. Food Safety Digest. Ref. No. WHO/NHM/FOS/RAM/18.1. World Health Organization (WHO). www.who.int/foodsafety/FSDigest_Aflatoxins_EN.pdf Accessed 8 October 2020.

Annotations

Synonyms

None identified.

Additional scientific description

Aflatoxins are among the most poisonous of the mycotoxins and place communities as well as individuals at risk. Mycotoxins are toxic compounds that are naturally produced by certain types of mould (fungi). Moulds that can produce mycotoxins grow on many foodstuffs such as cereals, dried fruits, nuts and spices. Mould growth can occur either before harvest or after harvest, during storage, on/in the food itself often under warm, damp and humid conditions. Most mycotoxins are chemically stable and survive food processing (WHO, 2018a).

Several hundred different mycotoxins have been identified, but the most commonly observed mycotoxins that present a concern to human health and livestock include aflatoxins, ochratoxin A, patulin, fumonisins, zearalenone and nivalenol/deoxynivalenol. Mycotoxins appear in the food chain as a result of mould infection of crops both before and after harvest. Exposure to mycotoxins can happen either directly by eating infected food or indirectly from animals that are fed contaminated feed, especially from milk (WHO, 2018a).

Aflatoxins are produced by certain moulds (Aspergillus flavus and A. parasiticus) which grow in soil, decaying vegetation, hay, and grains and the crops that are frequently affected by Aspergillus spp. include cereals (corn, sorghum, wheat, rice), oilseeds (soybean, peanut, sunflower, cotton seeds), spices (chili peppers, black pepper, coriander, turmeric, ginger) and tree nuts (pistachio, almond, walnut, coconut, Brazil nut). Large doses of aflatoxins can lead to acute poisoning (aflatoxicosis) and can be life-threatening, usually through damage to the liver (WHO, 2018a). Aflatoxins have been classified as human carcinogens by the International Agency for Research on Cancer (IARC, 2002).

Metrics and numeric limits

The United Nations food standards body Codex Alimentarius Commission has set the maximum levels for aflatoxin in foods, including various nuts, grains, dried figs and milk (in the range 0.5–15 μg/kg; a microgram is one billionth of a kilogram) (WHO, 2018a).

Key relevant UN convention/multilateral treaty

Codex Alimentarius (FAO/WHO, no date).

Examples of drivers, outcomes and risk management

Large doses of aflatoxins lead to acute poisoning (aflatoxicosis) that can be life-threatening, usually through damage to the liver. Outbreaks of acute liver failure (jaundice, lethargy, nausea, death), identified as aflatoxicosis, have been observed in human populations since the 1960s (WHO, 2018b).

Aflatoxins also pose a significant economic threat, causing an estimated 25% or more of the world's food crops to be destroyed annually (WHO, 2018b).

The World Health Organization (WHO) in collaboration with the Food and Agriculture Organization of the United Nations (FAO), is responsible for assessing the risk to humans of mycotoxins – through contamination in food – and for recommending adequate protection. Risk assessments of mycotoxins in food done by the Joint FAO/WHO Expert Committee on Food Additives (JECFA) are used by governments and by the Codex Alimentarius Commission to establish maximum levels in food or provide other risk management advice to control or prevent contamination. Codex standards are the international reference for national food supplies and for trade in food, so that people everywhere can be confident that the food they buy meets the agreed standards for safety and quality, no matter where it was produced (WHO, 2018b).

The outcome of such health risk assessments can either be a maximum tolerable intake (exposure) level, or other guidance to indicate the level of health concern (such as the Margin of Exposure), including advice on risk management measures to prevent and control contamination, and on the analytical methods and monitoring and control activities. Tolerable daily intakes are used by governments and international risk managers, such as the Codex Alimentarius Commission, to establish maximum levels for mycotoxins in food. The maximum levels for mycotoxins in food are very low due to their severe toxicity (WHO, 2018b).

Exposure to mycotoxins needs to be kept as low as possible to protect human health. Mycotoxins not only pose a risk to both human and animal health, but also affect food security and nutrition by reducing access to healthy food. The WHO encourages national authorities to monitor and ensure that levels of mycotoxins in foodstuff on their market are as low as possible and comply both with national and international maximum levels, conditions and legislation (WHO, 2018b).

References

FAO/WHO, no date. Codex Alimentarius. Food and Agriculture Organization of the United Nations (FAO), World Health Organization (WHO). www.fao.org/fao-who-codexalimentarius/about-codex/en Accessed 19 September 2020.

IARC, 2002. AFLATOXINS (Group 1) - Summaries & Evaluations. International Agency for Research on Cancer (IARC). www.inchem.org/documents/iarc/vol82/82-04.html Accessed 8 October 2020.

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WHO, 2018b. Aflatoxins. Food Safety Digest. Ref. No. WHO/NHM/FOS/RAM/18.1. World Health Organization (WHO). www.who.int/foodsafety/FSDigest_Aflatoxins_EN.pdf Accessed 8 October 2020.

Coordinating agency or organisation

World Health Organization, Food and Agriculture Organization of the United Nations.

CH0022 / **CHEMICAL / Other Chemical Hazards and Toxins**

Fluoride - Excess or inadequate intake

Definition

Fluoride is a naturally occurring mineral to which the public are often exposed via drinking-water. Depending on dose intake fluoride may have both beneficial effects (reducing the incidence of dental caries) or negative effects (causing tooth enamel and skeletal fluorosis following prolonged high exposure) (adapted from NCBI, 2020 and WHO, no date).

References

NCBI, 2020. PubChem Fluoride Compound Summary for CID 19800730. National Center for Biotechnology Information (NCBI). https://pubchem.ncbi.nlm.nih.gov/compound/fluoride Accessed 8 October 2020.

WHO, no date. Inadequate or excess fluoride. World Health Organization (WHO). www.who.int/ipcs/assessment/public_health/fluoride/en Accessed 8 October 2020.

Annotations

Synonyms

Not available.

Additional scientific description

Fluoride can be released into the environment in several ways: (i) natural activities, such as volcanic emissions, weathering of minerals and dissolution, particularly into groundwater; (ii) human activities, such as the production and use of phosphate fertilisers; manufacture and use of hydrofluoric acid and production of aluminium, steel and oil; and (iii) remobilisation of historic sources, such as water flow and sediment movement from aluminium production plants.

It is estimated that caries of the permanent teeth is the most prevalent of all conditions assessed, with 2.4 billion people globally suffering from caries of permanent teeth and 486 million children from caries of primary teeth. Public health actions are needed to provide sufficient fluoride intake in areas where this is lacking, so as to minimise tooth decay. This can be done through drinking-water fluoridation or, when this is not possible, through salt or milk fluoridation or use of dental care products containing fluoride, and by advocating a low-sugar diet (WHO, no date).

Excessive fluoride intake usually occurs through the consumption of groundwater naturally rich in fluoride, particularly in warm climates where water consumption is greater, or where high-fluoride water is used in food preparation or crop irrigation. Such exposure may lead to dental fluorosis or crippling skeletal fluorosis, which is associated with osteosclerosis, calcification of tendons and ligaments, and bone deformities. While the global prevalence of dental and skeletal fluorosis is not entirely clear, it is estimated that excessive fluoride concentrations in drinking water have caused tens of millions of dental and skeletal fluorosis cases worldwide. Although removal of excessive fluoride from drinking water may be difficult and expensive, low-cost solutions that can be applied at a local level do exist (WHO, no date).

The range in intakes producing detrimental or beneficial effects are not far apart (WHO, no date). Public health actions are needed to provide sufficient fluoride intake in areas where this is lacking, so as to minimise tooth decay. This can be done through drinking-water fluoridation or, when this is not possible, through salt or milk fluoridation or use of dental care products containing fluoride. Excessive fluoride intake usually occurs through the consumption of groundwater naturally rich in fluoride, particularly in warm climates where water consumption is greater, or where high-fluoride water is used in food preparation or irrigation of crops such as rice. In these areas, means should be sought to manage intakes by providing drinking-water with a moderate (i.e., safe) fluoride level or using alternative sources of water for drinking, cooking or irrigation. Although removal of excessive fluoride from drinking-water may be difficult and expensive, low-cost solutions that can be applied at a local level do exist. The preparation of food using fluoride-rich coal also contributes to excessive fluoride intake via ingestion and inhalation (WHO, 2019).

Metrics and numeric limits

World Health Organization (WHO) fluoride guideline values (WHO, 2019):

Drinking-water: The guideline value for fluoride in drinking water is 1.5 mg/l, based on increasing risk of dental fluorosis at higher concentrations and that progressively higher levels of fluoride lead to increasing risk of skeletal fluorosis. This value is higher than that recommended for artificial fluoridation of water supplies for prevention of dental caries, which is usually 0.5–1.0 mg/l. The WHO recommends that, in setting a standard, Member States should take into account drinking-water consumption and fluoride intake from other sources.

Air: The guideline value is 1 µg/m3 (developed to prevent effects on livestock and plants, and is also considered sufficiently protective of human health).

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Two worldwide public health concerns related to fluoride need to be addressed: the need to reduce dental caries and the need to mitigate the effects of excessive fluoride intake. Thus, public health actions are required to provide sufficient fluoride intake where this is lacking, so as to minimise tooth decay, as well as to provide drinking-water with a moderate (i.e., safe) fluoride level in areas where groundwater contains high fluoride levels (WHO, 2019).

To provide guidance on the need to control population exposure to fluoride and establish the balance between caries prevention and protection against adverse effects of fluoride, community health programmes can estimate total exposure by measuring renal fluoride excretion and compare these levels with established optimal levels using methods published by the WHO. However, risk mitigation measures implemented should also take into consideration local contexts and sensitivities (WHO, 2019).

The WHO recommends (WHO, 2019) that the following actions are required to provide adequate fluoride or control excess fluoride:

Adequate fluoride

Reduce the incidence of dental caries by:

- Fluoridating low-fluoride drinking-water where practicable, as well as considering alternatives, such as salt or milk fluoridation.
- Developing effective and affordable fluoridated toothpastes for use in developing countries.
- Promoting optimal oral hygiene, based on the use of effective fluoridated toothpaste; guidance on the amount of fluoridated toothpaste to and exposure to other sources of fluoride in the community.
- Supporting the use of silver diamine fluoride and atraumatic restoration treatment, and other minimally invasive techniques, using glass ionomer cement to stabilise caries lesions.
- Irrespective of fluoride exposure, advocating a low-sugar diet in accordance with the WHO recommendation that free (added) sugars should not exceed 10% of total energy intake by both adults and children (strong recommendation); the WHO further suggests reduction to below 5% of total energy intake (conditional recommendation).

Excess fluoride

- Where practicable, monitor the prevalence of enamel fluorosis using scoring guidance systems such as those developed by the WHO.
- Provide drinking-water with fluoride levels that do not produce adverse health effects, by:
  - seeking alternative water sources in areas with fluoride-rich groundwater, particularly where water consumption is high due to elevated temperatures;
  - defluoridating water for drinking and cooking, where an alternative source is not an option, using methods such as bone charcoal adsorption, contact precipitation, coagulation–flocculation/ sedimentation using aluminium sulphate (Nalgonda process), activated alumina adsorption and clay taking into account local context. Research the appropriateness of community fluoridation schemes in view of natural fluoride levels in water.

- Monitor fluoride levels in the environment, especially in areas where there is exposure to elevated fluoride levels due to human activities, and determine the overall exposure to fluoride.
- Encourage mothers to breastfeed, even in areas with high fluoride intake because breast milk is optimal for infant health and usually low in fluoride.
- Discourage the use of fluoride-rich coal for cooking purposes.

References

NCBI, 2020. PubChem Fluoride Compound Summary for CID 19800730. National Center for Biotechnology Information (NCBI). https://pubchem.ncbi.nlm.nih.gov/compound/fluoride Accessed 8 October 2020.

WHO, no date. Inadequate or excess fluoride. World Health Organization (WHO). www.who.int/ipcs/assessment/public_health/fluoride/en Accessed 8 October 2020.

WHO, 2019. Inadequate or excess fluoride: A major public health concern. World Health Organization (WHO). WHO/CED/PHE/EPE/19.4.5. https://apps.who.int/iris/bitstream/handle/10665/329484/WHO-CED-PHE-EPE-19.4.5-eng.pdf?ua=1 Accessed 8 October 2020.

Coordinating agency or organisation

World Health Organization.

CH0023 / **CHEMICAL / Other Chemical Hazards and Toxins**

Methanol

Definition

Methanol is a colourless fairly volatile liquid with a faintly sweet pungent odour similar to ethyl alcohol. Outbreaks of methanol poisoning arise from the consumption of adulterated counterfeit or informally produced spirit drinks (adapted from NCBI, 2020 and WHO, 2014).

Reference

NCBI, 2020. PubChem Compound Summary for CID 887, Methanol. National Center for Biotechnology Information (NCBI). https://pubchem.ncbi.nlm.nih.gov/compound/Methanol Accessed 8 October 2020.

WHO, 2014. Methanol poisoning outbreaks. Information Note, World Health Organization (WHO). www.who.int/environmental_health_emergencies/poisoning/methanol_information.pdf Accessed 8 October 2020.

Annotations

Synonyms

Methyl alcohol, Wood alcohol, Wood spirits, Carbinol.

Additional scientific description

Methanol belongs to the class of organic compounds known as primary alcohols. Methanol's chemical formula is CH3OH. Methanol is the primary alcohol that is the simplest aliphatic alcohol, comprising a methyl and an alcohol group. It has a role as an amphiprotic solvent, a fuel, a human metabolite, an Escherichia coli metabolite and a mouse metabolite. It is an alkyl alcohol, a one-carbon compound, a volatile organic compound and a primary alcohol (NCBI, 2020).

Methanol is a widely available chemical. It has many industrial applications and is also found in various household products, including varnishes, antifreeze, windscreen wash, and fuel for model aircraft. Globally, approximately 225 million litres of methanol are used each day (WHO, 2014a).

Methanol has a relatively low intrinsic toxicity; however, it is metabolised to highly toxic compounds, which can cause blindness, coma and severe metabolic disturbances that can be life-threatening (WHO, 2014a).

Methanol is well-absorbed through the gastrointestinal tract and is also absorbed through the skin and by inhalation. Methanol is only mildly inebriating; its toxic effects arise from its metabolism to formaldehyde and formic acid. Humans have a limited ability to detoxify formic acid and this metabolite therefore accumulates and causes toxic effects. The toxic dose of methanol varies depending on the individual and on the provision of treatment. Blood methanol concentrations above 500 mg/l are associated with severe toxicity, and concentrations above 1500–2000 mg/l will lead to death in untreated patients. Because patients with methanol poisoning often need intensive medical care, outbreaks of methanol poisoning can rapidly overwhelm medical facilities (WHO, 2014a).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

None identified.

Examples of drivers, outcomes and risk management

Outbreaks of methanol poisoning arise from the consumption of adulterated counterfeit or informally produced spirit drinks. There have been numerous outbreaks in recent years, including in Cambodia, Czech Republic, Ecuador, Estonia, India, Indonesia, Kenya, Libya, Nicaragua, Norway, Pakistan, Turkey and Uganda. The size of these outbreaks has ranged from 20 to over 800 victims, with case fatality rates of over 30% in some instances (WHO, 2014a). Shokoohi and co-workers (2020) reported on an outbreak in Iran due to individuals ingesting methanol who thought it might prevent or treat COVID-19.

The informal and illicit production of alcoholic drinks is practised in many parts of the world, including in countries where alcohol is banned. Some common names for these drinks include hooch/moonshine (USA), chang'aa/kumi kumi (Kenya), tonto/waragi (Uganda), tuak/tapai (Malaysia), samogon (Russia), and talla (Ethiopia). Such drinks are often sold in unlabelled containers in markets and at illegal drinking venues. Illicitly- or informally produced alcohol may also be sold in legitimate bars, particularly in some tourist areas. Consumers may choose these drinks because of their low cost compared to taxed alcohol (WHO, 2014s).

Some illicitly produced drinks are made to appear legitimate through bottle design and labelling and consumers can be misled into believing that they are buying a genuine brand of alcohol. Bottles may be sold in shops, markets and bars, often at a 'bargain' price (WHO, 2014a).

The WHO guidance on methanol poisoning outbreaks (WHO, 2014a) recommends the following risk management for prevention and control:

What can individuals do to protect themselves?

- Refrain from purchasing or producing illegal alcoholic drinks.
- Be suspicious about alcoholic drinks offered for sale in informal settings that are not licensed to sell alcohol, such as market stalls, and/or that are offered at a cheap price.
- Do not buy alcoholic drinks sold in unlabelled containers.
- Check branded products for labels that are poorly printed or with typographical errors, or bottles with broken seals. Do not buy these.
- Be aware of the symptoms of methanol poisoning and seek medical attention immediately if exposure is suspected.

What measures can countries take?

- Put in place a national strategy and legal framework to reduce the harmful use of alcohol.
- Use public health campaigns to promote awareness of the dangers of informally produced and illicit alcoholic drinks. These can be targeted towards particular high-risk groups, such as alcohol-dependent individuals, tourists.
- Since early recognition of an outbreak is vital to improve outcome, ensure that medical professionals are trained in the diagnosis and management of methanol poisoning.
- Where mass methanol poisonings have the potential to occur, establish a protocol for the management of these outbreaks.
- The ability of laboratories to undertake blood methanol analysis can help identify and guide clinical management of poisoned patients.
- Ensure accessible and affordable treatment is available for all, including antidotes (e.g., fomepizole, ethanol).
- Provide support to victims particularly those at risk of recurrent events, such as alcohol-dependent individuals.

The WHO is committed to reducing the health burden resulting from the harmful use of alcohol (WHO, 2014b). In 2010, the World Health Assembly endorsed a global strategy to reduce the harmful effects of alcohol. Ten recommended target areas were identified, including one addressing the need to reduce the public health impact of illicit alcohol and informally produced alcohol. Several policy options and interventions are suggested, including: developing good quality control with regard to production and distribution of alcoholic beverages; regulating sales of informally produced alcohol and bringing it into the taxation system; creating an efficient control and enforcement system, including tax stamps; developing or strengthening tracking and tracing systems for illicit alcohol; ensuring necessary cooperation and exchange of relevant information on combating illicit alcohol among authorities at national and international levels; and issuing relevant public warnings about contaminants and other health threats from informal or illicit alcohol (WHO, 2014b).

See WHO (2014b) for information on consumption and patterns of alcohol drinking, health consequences and policy responses in Member States.

References

NCBI, 2020. PubChem Compound Summary for CID 887, Methanol. National Center for Biotechnology Information (NCBI). https://pubchem.ncbi.nlm.nih.gov/compound/Methanol Accessed 8 October 2020.

Shokoohi, M., N. Nasiri, H. Sharifi, S. Baral and S. Stranges, 2020. A syndemic of COVID-19 and methanol poisoning in Iran: Time for Iran to consider alcohol use as a public health challenge? Alcohol, 87:25-27.

WHO, 2014a. Methanol poisoning outbreaks. Information Note, World Health Organization (WHO). www.who.int/environmental_health_emergencies/poisoning/methanol_information.pdf Accessed 8 October 2020.

WHO, 2014b. Global Status Report on Alcohol and Health, 2014. World Health Organization (WHO). https://apps.who.int/iris/bitstream/handle/10665/112736/9789240692763_eng.pdf

Coordinating agency or organisation

World Health Organization.

CH0024 / **CHEMICAL / Other Chemical Hazards and Toxins**

Substandard and Falsified Medical Products

Definition

Substandard and falsified medical products are defined as those that may cause harm to patients and fail to treat the diseases for which they were intended (WHO, 2018).

Reference

WHO, 2018. Substandard and falsified medical products. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/substandard-and-falsified-medical-products Accessed 8 October 2020.

Annotations

Synonyms

Counterfeit medicines.

Additional scientific description

Substandard and falsified medical products lead to loss of confidence in medicines, healthcare providers and health systems. They affect every region of the world. Substandard and falsified medical products from all the main therapeutic categories have been reported to the World Health Organization (WHO) and include medicines, vaccines and in vitro diagnostics. Anti-malarials and antibiotics are among the most commonly reported substandard and falsified medical products. Both generic and innovator medicines can be falsified, ranging from very expensive products for cancer to very inexpensive products for treatment of pain (WHO, 2018).

Substandard and falsified medical products can be found in illegal street markets, via unregulated websites through to pharmacies, clinics and hospitals. An estimated one in ten medical products in low- and middle-income countries is substandard or falsified. Substandard and falsified medical products contribute to antimicrobial resistance and drug-resistant infections (WHO, 2018).

Falsified medical products may contain no active ingredient, the wrong active ingredient or the wrong amount of the correct active ingredient. They are also commonly found to contain corn starch, potato starch or chalk. Some substandard and falsified medical products have been found to be toxic with either fatal levels of the wrong active ingredient or other toxic chemicals (WHO, 2018).

Substandard and falsified medical products are often produced in very poor and unhygienic conditions by unqualified personnel and contain unknown impurities and are sometimes contaminated with bacteria (WHO, 2018).

Substandard and falsified medical products are difficult to detect. They are often designed to appear identical to the genuine product and may not cause an obvious adverse reaction, however they often will fail to properly treat the disease or condition for which they were intended and can lead to serious health consequences including death (WHO, 2018).

The WHO has adopted definitions of substandard, unregistered / unlicensed and falsified medical products (WHO, 2018):

- Substandard (also called ‘out of specification’) medical products, are authorised medical products that fail to meet either their quality standards or specifications, or both.
- Unregistered/unlicensed medical products are those that have not undergone evaluation and/or approval by the national or regional regulatory authority for the market in which they are marketed/distributed or used, subject to permitted conditions under national or regional regulation and legislation.
- Falsified medical products are those that deliberately/fraudulently misrepresent their identity, composition or source.

Metrics and numeric limits

Not available.

Key relevant UN convention/multilateral treaty

Not available.

Examples of drivers, outcomes and risk management

Many countries and the media frequently report successful action against manufacturers of substandard and falsified medical products. Some reports refer to large-scale manufacturing and others to small back-street operations. With the availability of tableting machines, ovens, specialist equipment, ingredients and packaging materials, clandestine manufacturing facilities are quick and easy to assemble (WHO, 2018).

No countries remain untouched by this issue – from North America and Europe through to sub-Saharan Africa, South East Asia, and Latin America. What was once considered a problem limited to developing and low-income countries has now become an issue for all. With the exponential increase in internet connectivity, those engaged in the manufacture, distribution and supply of substandard and falsified medical products have gained access to a global market place. However, it is in low- and middle-income countries and those in areas of conflict, or civil unrest, where healthcare systems are weak or non-existent that bear the greatest burden of substandard and falsified medical products. Substandard and falsified medical products are most likely to reach patients in situations where there is constrained access to quality and safe medical products, poor governance and weak technical capacity (WHO, 2018).

An estimated one in ten medical products in low- and middle-income countries is substandard or falsified (WHO, 2018).

The Member State Mechanism is the global platform where countries can convene, coordinate, decide and organise actions to address substandard and falsified medical products. It was established in order to protect public health and promote access to affordable, safe, efficacious and quality medical products, through effective collaboration between Member States and the WHO to prevent and control substandard and falsified medical products and associated activities (WHO, 2018).

In 2013, the WHO launched the Global Surveillance and Monitoring System to encourage countries to report incidents of substandard and falsified medical products in a structured and systematic format, to help develop a more accurate and validated assessment of the problem. The system provides technical support in emergencies, links incidents between countries and regions, and issues WHO medical product alerts; and gathers a validated body of evidence to more accurately demonstrate the scope, scale and harm caused by substandard and falsified medical products and identify vulnerabilities, weaknesses and trends (WHO, 2018).

The structured reporting system allows for a fast response to emergencies and the issue of alerts in the most serious cases. It also facilitates in-depth analyses of the medical products most at risk, the vulnerabilities and weaknesses in health systems, the harm caused to public health and the need for investment, training and stronger regulations and standards (WHO, 2018).

The WHO provides guidance (WHO, 2018) for identifying substandard and falsified medical products, both as the products but also for those purchased from the Internet.

- Identifying a substandard or falsified medical product: Some falsified medical products are visually almost identical to the genuine product and very difficult to detect. However, many can be identified by examining the packaging for condition, spelling mistakes or grammatical errors; checking the manufacture and expiry dates and ensuring any details on the outer packaging match the dates shown on the inner packaging; ensuring the medicine looks correct, is not discoloured, degraded or has an unusual smell; discussing with your pharmacist, doctor or other healthcare professional as soon as possible if you suspect the product is not working properly or you have suffered an adverse reaction; and reporting suspicious medical products to your National Medicines Regulatory Authority.
- Substandard and falsified medical products and the Internet: Unregulated websites, social media platforms, and smartphone applications can also be direct conduits of substandard and falsified medical products. Risks to consumers are significantly increased when obtaining medical products from unlicensed and unregulated sources.

The falsification of medical products is a crime affecting all regions of the world and addressing it requires greater cooperation along the entire supply chain. To support countries in enacting or strengthening domestic legislation in this area and in protecting public health, the United Nations Office on Drugs and Crime (UNODC) released a guide to good legislative practices on combating falsified medical product-related crime (UNODC, 2019).

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Coordinating agency or organisation

World Health Organization (WHO).

CH0025 / **CHEMICAL / Fisheries and Aquaculture**

Marine Toxins

Definition

Marine toxins (biotoxins) are naturally occurring chemicals, mostly caused by certain types of toxic algae, but also by bacteria. These toxins can accumulate in fish and shellfish and present a human health hazard (WHO, no date). When people consume such contaminated aquatic products, depending on the toxins, they can evoke a variety of gastrointestinal and neurological illnesses (paralytic shellfish poisoning, amnesic shellfish poisoning, diarrhoeic shellfish poisoning, neurotoxic shellfish poisoning, azaspiracid shellfish poisoning and ciguatera poisoning).

Reference

WHO, no date. Marine biotoxins. World Health Organization (WHO). www.who.int/foodsafety/areas_work/chemical-risks/MarineBiotoxin/en/ Accessed 12 October 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

Marine toxins are produced by algae or bacteria and are concentrated in contaminated fishery and aquaculture products. When people consume these contaminated products, depending on the toxin, the symptoms can be diarrheic, paralytic, amnesic, or neurologic, some of which result in high mortality and long-term morbidity (Sobel and Painter, 2005; WHO, no date).

Routine clinical diagnostic tests are not available for these toxins; diagnosis is based on clinical presentation and a history of eating fishery and aquaculture products in the preceding 24 hours (Sobel and Painter, 2005). There is no antidote for any of the marine toxins, and supportive care is the mainstay of treatment. Paralytic shellfish poisoning, and puffer fish poisoning can cause death within hours of consuming the toxins and may require immediate intensive care (Sobel and Painter, 2005).

A Joint FAO/IOC/WHO expert meeting classified the toxins into eight groups based on their chemical structure (FAO/WHO, 2016): the Azaspiracid (AZA) group, Brevetoxin group, Cyclic Imines group, Domoic Acid (DA) group, Okadaic Acid (OA) group, Pectenotoxin (PTX) group, Saxitoxin (STX) group, and Yessotoxin (YTX) group.

The Food and Agriculture Organization of the United Nations (FAO) reports that they can also be classified by the type of poisoning they cause (FAO, 2004):

Paralytic shellfish toxins causing paralytic shellfish poisoning (PSP): PSP poisoning in humans is caused by ingestion of shellfish containing PSP toxins. These PSP toxins are accumulated by shellfish grazing on algae producing these toxins. Symptoms of human PSP intoxication vary from a slight tingling or numbness to complete respiratory paralysis. In fatal cases, respiratory paralysis occurs within 2 to 12 hours of consuming the PSP-contaminated food. PSP toxins are produced mainly by dinoflagellates belonging to the genus Alexandrium, which may occur in both in the tropical and temperate climatic zones. Shellfish grazing on these algae can accumulate the toxins but the shellfish itself is rather resistant to the harmful effects of these toxins. PSP is well documented throughout the Southern Hemisphere in South Africa, Australia, India, Thailand, Brunei Darussalam, Sabah (Malaysia), the Philippines and Papua New Guinea (FAO, 2004).

Diarrhoeic shellfish toxins causing diarrhoeic shellfish poisoning (DSP). In humans, DSP poisoning is caused by the ingestion of contaminated bivalves such as mussels, scallops, oysters or clams. The fat-soluble DSP toxins accumulate in the fatty tissue of the bivalves. DSP symptoms include diarrhoea, nausea, vomiting and abdominal pain starting 30 minutes to a few hours after ingestion and complete recovery occurs within three days. DSP toxins can be divided into different groups depending on chemical structure. The first group, acidic toxins, includes okadaic acid and its derivatives named dynophysistoxins. The second group, neutral toxins, consists of polyether-lactones of the pectenotoxin group. The third group includes a sulphated polyether and its derivatives the yessotoxins (FAO, 2004).

Amnesic shellfish toxins causing amnesic shellfish poisoning (ASP). In humans, ASP is also known as domoic acid poisoning (DAP) because amnesia is not always present. It was first recognised in 1987 on Prince Edward Island, Canada. At this time, ASP caused three deaths and 105 cases of acute human poisoning following the consumption of blue mussels. The symptoms included abdominal cramps, vomiting, disorientation and memory loss (amnesia). The causative toxin (the excitatory amino acid domoic acid or DA) was produced by the diatom species Pseudo-nitzschia pungens f. multiseries (Nitzschia pungens f. multiseries) (FAO, 2004).

Neurotoxic shellfish toxins causing neurotoxic shellfish poisoning (NSP). NSP is caused by polyether brevetoxins produced by the unarmoured dinoflagellate Gymnodinium breve (also called Ptychodiscus breve, since 2000 called Karenia brevis). The brevetoxins are toxic to fish, marine mammals, birds and humans, but not to shellfish. Until 1992/1993, neurologic shellfish poisoning was considered to be endemic to the Gulf of Mexico and the east coast of Florida, where 'red tides' had been reported as early as 1844. An unusual feature of G. breve is the formation by wave action of toxic aerosols which can lead to asthma-like symptoms in humans. In 1987, a major Florida bloom event was dispersed by the Gulf Stream northward into North Carolina waters where it has since continued to be present. In early 1993, more than 180 human shellfish poisonings were reported from New Zealand caused by an organism similar to G. breve. Most likely, this was a member of the hidden plankton flora (previously present in low concentrations), which developed into bloom proportions triggered by unusual climatic conditions (higher than usual rainfall, lower than usual temperature) coincident with an El Niño event (FAO, 2004).

Azaspiracid shellfish toxins causing azaspiracid shellfish poisoning (AZP). In November 1995, at least eight people in the Netherlands became ill after eating mussels (Mytilus edulis) cultivated at Killary Harbour, Ireland. Although the symptoms resembled those of diarrhoeic shellfish poisoning (DSP), concentrations of the major DSP toxins were very low. The known organisms producing DSP toxins were not observed in water samples collected at that time. In addition, a slowly progressing paralysis was observed in the mouse assay using the mussel extracts. These neurotoxic symptoms were different from typical DSP toxicity. It was then that azaspiracid (formerly called Killary Toxin-3 or KT3) was identified and the new toxic syndrome was called azaspiracid poisoning (AZP) (FAO, 2004).

Ciguatoxins causing ciguatera poisoning: Ciguatera poisoning (CP) has been known for centuries. It was reported in the West Indies by Peter Martyr de Anghera in 1511, in islands of the Indian Ocean by Harmansen in 1601, and in the various archipelagos of the Pacific Ocean by De Quiros in 1606. Endemic areas are mainly the tropical and subtropical Pacific and Indian Ocean insular regions and the tropical Caribbean, but continental reef areas are also affected. The name ciguatera was given by Don Antonio Parra in Cuba in 1787 to intoxication following ingestion of the 'cigua', the Spanish trivial name of a univalve mollusc, Turbo pica, reputed to cause indigestion. The term cigua was somehow transferred to an intoxication caused by the ingestion of coral reef fish species. The causative toxins, the ciguatoxins, accumulate through the food chain, from small herbivorous fish grazing on the coral reefs to organs of the bigger carnivorous fish that feed on them (FAO, 2004).

Metrics and numeric limits

Not available.

Key relevant UN convention/multilateral treaty

Not available.

Examples of drivers, outcomes and risk management

The substantial increase in the consumption of the fishery and aquaculture products in recent years, together with globalisation of trade, has increased the potential for human exposure to these marine biotoxins. Monitoring programmes for the toxins and their source organisms, and rapid notification of food safety issues by the authorities is essential to avoid foodborne intoxications. Extensive environmental monitoring and sometimes seasonal quarantine of a harvest are used to reduce risk of exposure (Sobel and Painter, 2005).

It is difficult to predict when a bloom will develop. Climatic and environmental conditions such as changes in salinity, rising water temperature, and increased nutrient levels and sunlight can influence population growth.

Control measures include the establishment of national monitoring programmes for marine biotoxins and their source organisms and their continuous update to include new and emerging toxins when necessary.

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Coordinating agency or organisation

Food and Agriculture Organization of the United Nations (FAO), World Health Organization (WHO).

BIOLOGICAL

BI0001 / **BIOLOGICAL / Fisheries and Aquaculture**

Harmful Algal Blooms

Definition

Harmful algal blooms result from noxious and/or toxic algae that cause direct and indirect negative impacts on aquatic ecosystems, coastal resources, and human health (Kudela et al., 2015).

Reference

Kudela, R., E. Berdalet, S. Bernard, M. Burford, L. Fernand, S. Lu, S. Roy, G. Usup, P. Tester, R. Magnien, D. Anderson, A. Cembella, M. Chinain, G. Hallegraeff, B. Reguera, A. Zingone, H. Enevoldsen and E. Urban, 2015. Harmful Algal Blooms. A scientific summary for policy makers. https://unesdoc.unesco.org/ark:/48223/pf0000233419 Accessed 11 October 2020.

Annotations

Synonyms

HABs.

Additional scientific description

Harmful algal blooms (HABs) are present in nearly all aquatic environments (freshwater, brackish, marine), as naturally occurring phenomena (Kudela et al., 2015).

Many HABs are increasing in severity and frequency, and biogeographical range. Causes are complex, but in some cases can be attributed to climate change and human impacts, including eutrophication, habitat modification, and human-mediated introduction of exogenous species (Kudela et al., 2015).

Photosynthetic algae support healthy aquatic ecosystems and form the base of the food web, fixing carbon and producing oxygen. Under certain circumstances, some species can form high-biomass and/or toxic proliferations of cells (or 'blooms'), thereby causing harm to aquatic ecosystems, including plants and animals, and to humans via direct exposure to water-borne toxins or by toxic seafood consumption. Ecosystem damage by high-biomass blooms may include disruption of food webs, fish-killing by gill damage, or contribution to low oxygen 'dead-zones' after bloom degradation. Some HAB species also produce potent natural chemicals (toxins) that can persist in the water or enter the food web, leading to illness or death of aquatic animals and/or human seafood consumers (Kudela et al., 2015).

Even non-toxic algal blooms can have devastating impacts when they lead to kills of fish and invertebrates by generating anoxic conditions. Some algal species, although non-toxic to humans, can produce exudates that cause damage to the delicate gill tissues of fish (such as the raphidophytes Chattonella, Heterosigma, and dinoflagellates Karenia, Karlodinium). Aquaculture stocks (caged fish, molluscs, crustaceans) are trapped and, thus, can suffer devastating mortalities, which could lead to economic and food losses, and may eventually became a food security issue (FAO and WHO, 2020).

Of greatest concern to human society are algal species that produce potent neurotoxins that can find their way through shellfish and fish to human consumers, where they cause a variety of gastrointestinal and neurological illnesses (FAO, 2012).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

None.

Examples of drivers, outcomes and risk management

It is difficult to predict when a HAB will develop. Climatic and environmental conditions such as changes in salinity, rising water temperature, and increased nutrient levels and sunlight can influence population growth for HAB species. In some cases, these changes can be attributed to human impacts, including habitat modification, and human-mediated introduction of exogenous species (NOAA, 2016).

Harmful algal blooms are recognised as one facet of complex ecosystem interactions with human society. Research, monitoring, and management of HABs must be closely integrated with policy decisions that affect the global oceans (Kudela et al., 2015).

There is no plan, and no realistic possibility of eliminating HABs and/or their dependent consequences. Nevertheless, decades of research and monitoring have improved understanding of HAB events, leading to better monitoring and prediction strategies (Kudela et al., 2015).

New technologies and approaches to monitoring, control and management of HABs are now available, highlighting molecular probes for cell detection, rapid and sensitive toxin assays, remote sensing detection and tracking of blooms, bloom control and mitigation strategies, and the use of large-scale physical/biological models to analyse past blooms and forecast future events (Anderson, 2009).

Many islands and countries in arid regions, where freshwater resources are limited, are increasingly dependent on desalination to provide water to rapidly growing coastal populations and to meet the social and economic demands that underpin development in those areas. Evidence is now showing that HABs pose a threat to the desalination industry and to water security in those areas. Studying HABs in the vicinity of desalination plants is an emerging science because there is limited information on the potential problems that toxic blooms may pose (UNESCO, 2015).

The Intergovernmental Oceanographic Commission (IOC-UNESCO) has been a driver in defining the international research agenda on HABs and their impacts, and is now also addressing how to provide solutions applicable to desalination plants (UNESCO, 2015).

Harmful algal blooms are a worldwide phenomenon requiring an international understanding leading ultimately to local and regional solutions. Continued progress in research, management, mitigation, and prediction of HABs benefits from international coordination. In this spirit, the international community has developed programmes sponsored by the IOC and Scientific Committee on Oceanic Research (SCOR) to coordinate international HAB research, framework activities, and capacity building (Kudela et al., 2015).

New initiatives, such as GlobalHAB sponsored by IOC and SCOR, will continue to provide the mechanisms to further understand, predict, and mitigate HABs. Research, management, and mitigation efforts directed towards HABs must be coordinated with other local, national, and international efforts focused on food and water security, human and ecosystem health, ocean observing systems, and climate change (Kudela et al., 2015).

The establishment of national monitoring programmes for marine biotoxins and their source organisms (HABs) is needed. These programmes require continuous update to include new and emerging toxins when necessary and for harvesting area management.

References

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Coordinating agency or organisation

Food and Agriculture Organization of the United Nations.

BI0002 / **BIOLOGICAL / Insect Infestation**

Insect Pest Infestations

Definition

An insect pest infestation is a recently detected insect pest population, including an incursion, or a sudden significant increase of an established insect, disease agents or weed population in an area leading to damage to plants in production fields, forests or natural habitats and causing substantial damage to productivity, biodiversity or natural resources (adapted from FAO, 2019).

Reference

FAO, 2019. Glossary of phytosanitary terms. International Standard for Phytosanitary Measures No. 5. Food and Agriculture Organization of the United Nations (FAO). www.ippc.int/en/publications/glossary-phytosanitary-terms Accessed 11 October 2020.

Annotations

Synonyms

Invasion, Outbreak, Swarm, Plague.

Additional scientific description

Insects are responsible for significant losses to the world's total crop production annually. Not all insects are pests, but many are harmful to crops, forest trees, livestock and humans. One major reason for the occurrence of these pests is the expansion of monocultures in large areas at the expense of natural habitats, with crops and trees selected for their large size, high yield, nutritious value and economic value. This provides a highly conducive environment for herbivorous insects. In addition to agroecosystem-based integrated management practices during production, good post-harvest management and storage conditions are important in reducing losses caused by insect infestation in agriculture (FAO, no date).

A detailed glossary of phytosanitary terms was developed for the International Standards for Phytosanitary Measures. It was produced by the Secretariat of the International Plant Protection Convention for the Food and Agriculture Organization of the United Nations (FAO). Examples of relevant terms for insect pest infestation are given below (FAO, 2019):

- Biological control agent: A natural enemy, antagonist or competitor, or other organism, used for pest control.
- Incidence (of a pest): Proportion or number of units in which a pest is present in a sample, consignment, field or other defined population.
- Incursion: An isolated population of a pest recently detected in an area, not known to be established, but expected to survive for the immediate future.
- Infestation (of a commodity): Presence in a commodity of a living pest of the plant or plant product concerned. Infestation includes infection.
- Introduction (of a pest): The entry of a pest resulting in its establishment in the environment.
- Official control: The active enforcement of mandatory phytosanitary regulations and the application of mandatory phytosanitary procedures with the objective of eradication or containment of quarantine pests or for the management of regulated non-quarantine pests.
- Outbreak: A recently detected pest population, including an incursion, or a sudden significant increase of an established pest population in an area.
- Pest: Any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products. Note: In the International Plant Protection Convention (IPPC), 'plant pest' is sometimes used for the term 'pest'.

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

The International Plant Protection Convention (1997) is an intergovernmental treaty signed by over 180 countries, aiming to protect the world's plant resources from the spread and introduction of pests, and promote safe trade (FAO, 2011). The Convention introduced international standards for phytosanitary measures as its main tool to achieve its goals, making it the sole global standard setting organisation for plant health (FAO, 2005). The IPPC is one of the 'Three Sisters' recognised by the World Trade Organization's (WTO) Sanitary and Phytosanitary Measures (SPS) Agreement, along with the Codex Alimentarius Commission for food safety standards and the World Organization for Animal Health (OIE) for animal health standards.

The Convention on Biological Diversity (1992) has three main objectives: the conservation of biological diversity, the sustainable use of the components of biological diversity, and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources (United Nations, 1992). At the time of writing, there were 196 parties to the Convention on Biological Diversity (Convention on Biological Diversity, 2021).

Codex Alimentarius (Codex Alimentarius, no date).

WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (1994) (WTO, no date).

Examples of drivers, outcomes and risk management

The agriculture and forestry sectors face many risks, such as climate and market volatility, pests and diseases, extreme weather events, and an ever-increasing number of protracted crises and conflicts. Issues around outbreaks of animal and plant pests and diseases are of major concern due to their role in the biological disasters and in many food chain emergencies. The human food chain is under continuous threat with an alarming increase in the number of outbreaks of transboundary animal and plant pests and diseases. Crop pests, forest pests and animal diseases are among the costliest disasters in Africa – more so than in Latin America and Asia – accounting for over USD 6 billion in agricultural loss between 2005 and 2015, with insect pests ravaging up to 85 million hectares of forests, mainly in temperate North America (FAO, 2018).

There are over a million species of insect. These include some key species causing direct damage to crops and natural vegetation such as locusts, grasshoppers, armyworms and fruit flies as well as those that also function as vectors for the transmission of plant disease agents such as white flies, aphids, spittle bugs and mealybugs (FAO, 2021).

The most recent global-scale insect pest infestation is caused by fall armyworm (FAW) spreading to almost the whole of Africa and south and southeast Asia following its jump from Latin America to Africa in 2016. It is currently causing damage to millions of hectares, particularly on maize but also other crops, creating significant food security risks. The Food and Agriculture Organization of the United Nations (FAO) has launched a Global Action for FAW Control to facilitate international collaboration to combat the insect (FAO, 2020a).

Higher temperatures, severe and extreme weather events and drought stress can all result in reduced vigour of trees, making them more vulnerable to outbreaks of native and introduced pests and diseases. For example, the dieback of millions of hectares of pine forests caused by outbreaks of native bark beetles in Central America, Europe and North America is associated with climate change, impacts of extreme weather events and, in some cases, inadequate forest management practices (FAO, 2020b).

Favourable climatic conditions, disruption of ecosystems and negligence of crop/forest hygiene contribute to growth in insect populations which can cause substantial damage regularly. In many cases, long distance spread of insects results from transportation of infested goods. Following principles of sustainable plant production, sustainable forest management and integrated pest management practices are the best approach for control, focusing on diversified production systems, regular surveillance, preparedness before potential outbreaks, and a rapid response to prevent escalation to unmanageable scales (Guzewich et al., 1997).

Post disaster needs assessment (PDNA) is designed to evaluate immediate needs for recovery and restoration for better disaster response. The focus of this mission, however, is on estimating socioeconomic impact; and currently does not take into account longer-term damage and loss caused to natural environments and forests. In addition, damage caused by small-scale fires, small windthrow events, and localised pest infestations remains largely unreported, despite meeting the universally established definition of a disaster (FAO, 2018).

Regarding insect pest infestations in forests, much of what is currently known about the damage and its assessment is in the form of research reports on the application of remote sensing and does not constitute a solid basis for a rigorous sector-specific assessment (FAO, 2018).

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Coordinating agency or organisation

Food and Agriculture Organization (FAO), International Plant Protection Convention (IPPC).

BI0003 / **BIOLOGICAL / Insect Infestation**

Locust

Definition

Widespread and heavy infestations of crops and natural vegetation by locusts causing significant threats to food security, livelihoods and natural habitats in multiple regions (adapted from FAO, 2009).

Reference

FAO, 2009. Glossary on Desert Locust. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/3/a-as983b.pdf Accessed 10 October 2020.

Annotations

Synonyms

Locust outbreaks, Locust upsurges, Locust plagues

Additional scientific description

Locusts are defined as belonging to a large group of insects commonly called grasshoppers which are recognisable by the large, thickened hind legs that are used for jumping. All grasshoppers belong to the superfamily Acridoidea, and the most significant species are all in the family Acrididae. Locusts differ from grasshoppers in that they have the ability to change their behaviour, physiology, colour and shape (morphology) in response to changes in their population density. The life cycle of all species of locusts and grasshoppers comprises three stages: egg, hopper, adult (FAO, 2009a).

A plague of locusts is defined as a period of one or more years of widespread and heavy locust infestations, the majority of which occur as bands or swarms. A plague can occur when favourable breeding conditions are present and control operations fail to stop a series of local outbreaks from developing into an upsurge that cannot be contained. A major plague exists when two or more regions are affected simultaneously (FAO, 2009a).

The Desert Locust (Schistocerca gregaria) is able to fly long distances and migrate very fast. It is a transboundary pest, whose control requires international collaboration. This is also the case for about a dozen other locust pests, which can produce outbreaks on every continent except Antarctica (FAO, 2015).

The Desert Locust is considered the most dangerous migratory pest in the world to threaten crop production and food security. It might be the oldest registered pest for its danger and ability to live and breed under wide-ranging ecological and climatic regimes, in vast areas covering 29 million km2 and extending from the Atlantic Ocean in the west to India and Pakistan in the east (FAO, 2009a). During plagues, swarms can invade more than 60 of the world's poorest countries, and potentially damage the livelihood of one tenth of the world's population, mostly in Africa, the Middle East and Asia (FAO, 2015).

The worst Desert Locust outbreak in decades is currently underway in the Greater Horn of Africa Region (FAO, 2020a). Tens of thousands of hectares of cropland and pasture have been damaged in Ethiopia, Kenya and Somalia, with potentially severe consequences for agriculture-based livelihoods in contexts where food security is already fragile (FAO, 2020b). Highly mobile and capable of stripping an area's vegetation, locust swarms can cause large-scale agricultural and environmental damage. Even a relatively small locust swarm can eat the same amount of food in one day as about 35,000 people. This can be especially devastating in countries facing food security crises, where every gram of food produced counts towards alleviating hunger (FAO, 2020c).

Locusts are also serious threats to agriculture in The Caucasus and Central Asia. Three main locust pests, the Asian Migratory Locust (Locusta migratoria migratoria), the Italian Locust (Calliptamus italicus) and the Moroccan Locust (Dociostaurus maroccanus) jeopardise food security and livelihoods in both regions as well as in adjacent areas of northern Afghanistan and southern Russian Federation. Over 25 million hectares of cultivated areas are potentially at risk. During outbreaks, upsurges and plagues, these pests attack and destroy pasturelands and a wide range of cultivated crops, including cereals, cucurbits, legumes, sunflower, tobacco, vegetables, vines, fruit trees, cotton and other plants. Locusts have a direct impact on agricultural production systems, which are vital to the viability and growth of the concerned countries, which largely rely on agriculture. The most affected populations are often the most vulnerable communities living in the rural areas. Because these are mainly small landowners, following subsistence agriculture, even limited infestations can cause severe damage at this scale and threaten livelihoods, which can in turn, also lead to adverse social consequences (FAO, 2020d).

Locusts have a high capacity to multiply, form groups, migrate over relatively large distances (they can fly up to 100 km per day) and settle and breed in various habitats. These capacities enhance their prevalence at the regional level. The borders of countries in The Caucasus and Central Asia are often located across traditional locust habitats and breeding areas, and locusts frequently cross countries' political borders. As a result, international collaboration is critical for their control. Locusts are becoming increasingly dangerous in the context of extreme weather events associated with climate change, due to their high capacity to exploit new situations. On average, over the past 15 years, locust affected area as large as almost 4 million hectares have been treated annually in Caucasus and Central Asia.

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

The Food and Agriculture Organization of the United Nations (FAO) Desert Locust Control Committee (FAO, 2020b).

The FAO regional Desert Locust Commissions (FAO, 2009b).

Examples of drivers, outcomes and risk management

Locusts are known as the most destructive invasive plants pests. They have the ability to change their behaviour and appearance under particular environmental conditions (unusually heavy rains) and to transform themselves from harmless individuals to a collective mass of insects that forms swarms. During quiet periods (known as recessions), solitarious locusts are found in low numbers scattered throughout the deserts of North Africa, the Middle East and Southwest Asia (Desert Locust). This arid area is around 16 million km² in size, and includes about 30 countries. It is called the recession area. In severe cases, the swarms can invade an area of land equivalent to about 20% of Earth's surface (FAO, 2015).

Species other than Desert Locust can also cause significant damage under favourable conditions in different parts of the world. These include Italian Locust and Moroccan Locust in The Caucasus and Central Asia, Red Locust in Eastern Africa, Brown Locust in Southern Africa, Migratory Locusts in Africa and Asia, Tree Locust in Africa, and Australian Plague Locust in Australia (FAO, 2020c,d).

The main strategy for locust management, which has been promoted by the FAO for decades, relies on the so-called locust preventive control strategy. This is based on appropriate monitoring of locust habitats at key periods of their development in order to allow early detection of number increase and behaviour change, early warning, and early reaction (FAO, 2020d).

If well implemented, this approach facilitates a reduction in the occurrence and intensity of locust outbreaks and the prevention of their development into major upsurges or plagues.

Over decades, this strategy has been proved to be the most effective, making it possible to react before a significant increase in locust populations can occur. It results in: reduced damage to crops and rangelands and thus increased food security and improved livelihood of highly vulnerable rural communities; reduced negative impacts on human health and the environment (through reduced pesticide sprays); and lower financial costs.

For such transboundary plant pests, this strategy also needs to be coupled with global or regional cooperation. The FAO recommendations for the management of the Greater Horn of Africa Region (FAO, 2020a) include:

- Informing response. Continue to assess the situation through the FAO Desert Locust Information Service and provide early warning, forecasts and advice to affected countries and international partners.
- Control operations. Provide aerial and ground control operations support and enhance national preparedness capacity.
  - Ground control operations (hopper-stage locusts): procurement of chemical and bio-pesticides and equipment, storage, training, human and environmental safety, and disposal of chemical drums and containers.
  - Air control operations (adult-stage locusts): contracting planes, pesticides procurement, human and environmental safety, training, and disposal of chemical drums and containers.
- Ground surveillance and impact assessments. Facilitate ground surveillance, monitoring and continuous assessment in partnership with country governments and the Desert Locust Control Organization for Eastern Africa (DLCO-EA) with the objective of reinforcing region-wide early warning and response.

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Coordinating agency or organisation

Food and Agriculture Organization (FAO); Desert Locust Control Committee (DLCC).

BI0004 / **BIOLOGICAL / Invasive Species**

Invasive Weeds

Definition

An invasive weed is an alien species that by its establishment or spread has become injurious to plants, or that by risk analysis is shown to be potentially injurious to plants (adapted from FAO, 2017).

References

FAO, 2017. Glossary of phytosanitary terms. ISPM 5. International Standards for Phytosanitary Measures. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/fileadmin/user_upload/faoterm/PDF/ISPM_05_2016_En_2017-05-25_PostCPM12_InkAm.pdf Accessed 11 October 2020.

Annotations

Synonyms

Noxious plants.

Additional scientific description

Invasive weeds are plants growing in agricultural lands and natural habitats where they are not wanted and where they compete with plants grown or natural resources causing significant economic or environmental damage. The term also includes any plant that can directly or indirectly injure or cause damage to crops, livestock, poultry, natural habitats or other interests of agriculture, irrigation, navigation or the natural landscapes (USDA, 2016).

In April 2001, the International Collection of Microorganisms from Plants (ICMP) recognised that under the International Plant Protection Convention's existing mandate, to take account of environmental concerns, further clarification should include consideration of the following points relating to the potential environmental risks of pests: reduction or elimination of endangered (or threatened) native plant species; reduction or elimination of a keystone plant species (a species which plays a major role in the maintenance of an ecosystem); reduction or elimination of a plant species which is a major component of a native ecosystem; causing a change to plant biological diversity in such a way as to result in ecosystem destabilization; and resulting in control, eradication or management programmes that would be needed if a quarantine pest was introduced, and impacts of such programmes (e.g., pesticides, non-indigenous predators or parasites) on biological diversity (FAO, 2009).

The Convention on Biodiversity states that invasive plant species have been reported among inter alia seaweeds, trees, shrubs, vines, forbs and grasses. The indicative economic impacts of some invasive alien species are reported to be as follows: the impact of knapweed (Centaurea spp.) and leafy spurge (Euphorbia esula) on the economy of three US states is USD 40.5 million per year (direct costs) and USD 89 million as indirect costs (UNEP, 2001).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

The International Plant Protection Convention (1997) is an intergovernmental treaty signed by over 180 countries, aiming to protecting the world's plant resources from the spread and introduction of pests, and promoting safe trade (FAO, 2011). The Convention introduced International Standards for Phytosanitary Measures as its main tool to achieve its goals, making it the sole global standard setting organisation for plant health. The International Plant Protection Convention (IPPC) is one of the 'Three Sisters' recognised by the World Trade Organization's (WTO) Sanitary and Phytosanitary Measures (SPS) Agreement (WTO, no date), along with the Codex Alimentarius Commission for food safety standards and the World Organization for Animal Health (OIE) for animal health standards.

The Convention on Biological Diversity (1992) has three main objectives: the conservation of biological diversity, the sustainable use of the components of biological diversity, and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources (United Nations, 1992). At the time of writing, there were 196 parties to the Convention on Biological Diversity (Secretariat of the Convention on Biological Diversity, 2013).

The Convention on Biological Diversity Decision adopted by the Conference of the Parties to the Convention on Biological Diversity (UNEP, 2018). Also recognizing the adverse impacts of invasive alien species on biological diversity and its components, especially vulnerable ecosystems, such as wetlands and mangroves, islands and Arctic regions, as well as social aspects and economic and cultural values, including those associated with indigenous peoples and local communities (UNEP, 2018).

International Health Regulations issued by the World Health Organization (WHO, 2016).

Codex Alimentarius (Codex Alimentarius, no date).

WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (1994) (WTO, no date).

The relationship of the WTO with Codex, IPPC and OIE (WTO, 2007).

The UN Recommendations on the Transport of Dangerous Goods (UNECE, no date).

Examples of drivers, outcomes and risk management

Weeds are among the common plant pests affecting crop productivity significantly and being among the major factors in determining the crop production systems. Those that are parasitic or invasive can be an especially significant threat to natural resources such as forests and water resources. Poisonous weeds can also be a danger to livestock or animals in certain cases.

Weed management occurs largely through agronomic measures such as soil tillage, use of certified seeds, manure management or herbicide use. It is essential to avoid movement of contaminated seeds or other reproducible parts to facilitate effective weed management practices.

The Standards and Trade Development Facility (STDF) is a global partnership in Sanitary and Phytosanitary capacity building and technical cooperation established by the Food and Agriculture Organization of the United Nations (FAO), the World Organisation for Animal Health (OIE), the World Bank, the World Health Organization (WHO) and the World Trade Organization (WTO). Their report on International Trade and Invasive Alien Species (WTO, 2013) uses a case study to provide an important summary example of the impact of invasive weeds:

“Native to North America, common ragweed arrived in Europe in the 19th century together with cereals and possibly also clover. Large populations of this weed currently exist in some European countries, particularly in Croatia and Hungary and in parts of Austria, France, Italy and Switzerland. In other countries (notably Poland, Lithuania and Germany), it has occurred only rarely and, in general, has not survived. Common ragweed prefers open spaces and generally grows on waste grounds (e.g., along roadsides, building sites, storage areas and dumps). It is resistant to herbicides and its long seed germination capacity (over 30 years) makes control difficult. It is known to reduce yields in the cultivation of maize, wheat, sunflowers, millet, peanuts, soy, beans and potatoes. It also plays a role as a secondary host for organisms that are harmful to cultivated plants (e.g., fungal pathogens that are harmful to sunflowers). In addition to its indirect effect on plants, pollen from common ragweed can cause severe allergies in humans” (WTO, 2013:11).

Examples of Government leadership on weed management include that produced by the Canadian Ministry of Agriculture, Food and Rural Affairs (2016) and the Australian Government (no date).

The Global Invasive Species Programme (GISP) was established in 1997 to address global threats caused by invasive species and to provide support to the implementation of Article 8(h) of the Convention on Biodiversity. To increase awareness and provide policy advice, GISP has prepared a Global Strategy on Invasive Alien Species, which outlines ten strategic responses to the invasive species problem (FAO, 2017).

The Global Invasive Species Database (GISD) is a free, online searchable source of information about alien and invasive species that negatively impact biodiversity. It aims to increase public awareness about invasive species and to facilitate effective prevention and management activities by disseminating specialist knowledge and experience to a broad global audience. The GISD focuses on invasive alien species that threaten native biodiversity and natural areas, and covers all taxonomic groups from microorganisms to animals and plants (GISD, no date).

The GISD is managed by the Invasive Species Specialist Group (ISSG) of the IUCN Species Survival Commission. It was developed between 1998 and 2000 as part of the global initiative on invasive species led by the GISP (GISD, no date).

Because invasive species are addressed under different agreements and conventions (e.g., CITES, IPPC and the World Trade Organization Agreement on the Application of Sanitary and Phytosanitary Measures), many countries have difficulty in keeping up with the reporting requirements (FAO, 2017). In response, the UNEP World Conservation Monitoring Centre (UNEP-WCMC) has recently developed a set of issue-based modules summarising country obligations under the Convention on Biological Diversity and other conventions and in 2020 published a report on building a multidimensional biodiversity index (Soto-Navarro et al., 2020).

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Coordinating agency or organisation

Food and Agriculture Organization (FAO) with International Plant Protection Convention (IPPC), Convention on Biodiversity.

BI0005 / **BIOLOGICAL** / **Invasive Species**

Invasive Species

Definition

'Invasive species', also known as 'alien invasive species', are species whose introduction, establishment and spread into new areas threaten ecosystems, habitats or other species and cause social, economic or environmental harm, or harm to human health (FAO, 2007:82).

Reference

FAO, 2007. Invasive species. In: State of the World's Forests. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/3/a-a0773e.pdf Accessed 10 October 2020.

Annotations

Synonyms

Alien species, Alien invasive species, Invasive alien species.

Additional scientific description

Invasive species include species, subspecies or lower taxa of invertebrates, plants, microorganisms and vertebrates non-native (alien or exotic or non-indigenous) to a particular ecosystem and whose human mediated or unintentional introduction and spread causes, or are likely to cause, socio-cultural, economic or environmental harm or harm to human health (FAO, 2007). An alien species is a species, subspecies or lower taxon, introduced outside its natural past or present distribution; it includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce (UNEP, 2002).

Increasing international trade and human mobility, exacerbated by impacts of climate change, have increased the introduction of plant and animal species into new areas where they have become invasive (FAO, 2020).

Estimates of the full costs of biological invasions are rare because of the difficulty in assessing the costs of impacts on biodiversity, ecosystem functions and human health, or other indirect costs such as the impact of control measures. The costs of invasive species to the forest sector have not been studied on a global scale. However, based on a study of six countries (Australia, Brazil, India, South Africa, the United Kingdom and the United States of America), it was estimated that as many as 480,000 alien species have been introduced in agriculture and forestry worldwide, with an annual cost of more than USD 1.4 trillion (FAO, 2007). Invasive plant and animal species are now considered one of the most important causes of biodiversity loss, especially in many island countries (CBD, 2009).

Preventing and reducing the harmful effects of invasive species requires an approach that incorporates biological, ecological and social sciences, economics, policy analysis and engineering. National efforts should include early warning systems, eradication and control, as well as increased awareness and political leadership. Global, regional and bilateral efforts include standards and guidelines, monitoring and assessment, and information and action networks (FAO, 2007).

Numerous international and regional programmes and instruments, binding and non-binding, have been developed to address the problem of invasive species (FAO, 2007).

Different countries have different approaches – two of note are the Invasive Species Definition Clarification and Guidance prepared by the United States Department of Agriculture (USDA, 2006) and the Australian Weed Strategy (Australian Government, 2016).

Metrics and numeric limits

Not available.

Key relevant UN and regional convention / multilateral treaty

The Convention on Biological Diversity (1992) has three main objectives: the conservation of biological diversity, the sustainable use of the components of biological diversity, and the fair and equitable sharing of the benefits arising out of the utilisation of genetic resources (United Nations, 1992). At the time of writing, there were 196 parties to the Convention on Biological Diversity.

The Convention on Biological Diversity (CBD) calls on its parties to 'prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats, or species' (Article 8[h]). The parties have adopted a series of 15 guiding principles to lead governments and organisations in developing effective strategies for minimising the spread and impact of invasive alien species (UNEP, 2002). The UN CBD introduced a commitment to endorse these principles in the 2011–2020 Global Biodiversity Strategy by adopting Aichi Target 9 (CBD,2020).

European Commission (Environment) EU Regulation 1143/2014 on Invasive Alien Species (2015). Invasive alien species are animals and plants that are introduced accidentally or deliberately into a natural environment where they are not normally found, with serious negative consequences for their new environment. They represent a major threat to native plants and animals in Europe, causing damage worth billions of Euros to the European economy every year. As invasive alien species do not respect borders, coordinated action at the European level will be more effective than individual actions at the Member State level (European Commission, 2015).

The International Plant Protection Convention (1997) is an intergovernmental treaty signed by over 180 countries, aiming to protecting the world's plant resources from the spread and introduction of pests, and promoting safe trade (FAO, 1999). The Convention introduced International Standards for Phytosanitary Measures (FAO, 2021) as its main tool to achieve its goals, making it the sole global standard setting organisation for plant health. The International Plant Protection Convention (IPPC) is one of the 'Three Sisters' recognised by the World Trade Organization's (WTO) Sanitary and Phytosanitary Measures (SPS) Agreement (WTO, 1998), along with the Codex Alimentarius Commission for food safety standards and the World Organization for Animal Health (OIE) for animal health standards.

The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). In the IPBES Regional Assessments (IPBES, 2018a) and Global Assessment Report (IPBES, 2019), invasive alien species were identified as one of the main direct drivers of biodiversity loss worldwide. The rapidly growing threat that invasive alien species pose to biodiversity, ecosystem services, sustainable development and human well-being is, however, generally poorly quantified and little understood by decision makers (IPBES, 2018b).

The International Union for Conservation of Nature (IUCN). The IUCN Species Survival Commission (SSC) Invasive Species Specialist Group maintains two global databases: the Global Invasive Species Database (GISD, www.iucngisd.org), which contains profiles of key invasive alien species, and the Global Register of Introduced and Invasive Alien Species (Pagad et al., 2018), which was developed with a mandate of the CBD and collates data on alien species in all taxonomic groups for all nations.

Examples of drivers, outcomes and risk management

Drivers: An increase of introduction and spread of invasive species or invasive alien species (insect pests, pathogens, microorganisms, vertebrates and plants) is due to increasing international trade, travel and the impacts of climate change.

Outcomes: Economic, environmental, social and cultural impacts due to the loss of host trees, loss of crops and loss of biodiversity.

Risk management: This includes the establishment of early warning and early action activities; the implementation of phytosanitary standards in the agriculture and forestry sectors; and increased public awareness and community participation in early warning systems.

The Global Invasive Species Programme (GISP) was established in 1997 to address global threats caused by invasive species and to provide support to the implementation of Article 8(h) of the CBD. To increase awareness and provide policy advice, GISP has prepared the Global strategy on invasive alien species, which outlines ten strategic responses to the invasive species issue (FAO, 2007).

The GISD is a free, online searchable source of information about alien and invasive species that negatively impact biodiversity. It aims to increase public awareness about invasive species and to facilitate effective prevention and management activities by disseminating specialist knowledge and experience to a broad global audience. The GISD focuses on invasive alien species that threaten native biodiversity and natural areas and covers all taxonomic groups from microorganisms to animals and plants (GISD, no date).

The GISD is managed by the Invasive Species Specialist Group (ISSG) of the IUCN SSC. It was developed between 1998 and 2000 as part of the global initiative on invasive species led by the GISP (GISD, no date).

Because invasive species are addressed in different agreements and conventions (e.g., the Convention on International Trade in Endangered Species, IPPC and the World Trade Organization Agreement on the Application of Sanitary and Phytosanitary Measures), many countries have difficulty in keeping up with the reporting requirements (FAO, 2007) In response, the UNEP World Conservation Monitoring Centre (UNEP-WCMC) has recently developed a set of issue-based modules summarising country obligations under the CBD and other conventions, and in 2020 published a report on Building a Multidimensional Biodiversity Index (Soto-Navarro et al., 2020).

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Coordinating agency or organisation

Food and Agriculture Organization of the United Nations

BI0006 / **BIOLOGICAL / Human-Animal Interaction**

Snake Envenomation

Definition

A snake envenomation is a potentially life-threatening disease caused by toxins in the bite of a venomous snake. Envenoming can also be caused by having venom sprayed into the eyes by certain species of snake that have the ability to spit venom as a defence measure (WHO, no date).

Reference

WHO, no date. Snakebite Envenoming. World Health Organization (WHO). www.who.int/health-topics/snakebite Accessed 5 October 2020.

Annotations

Synonym

Not identified.

Additional scientific description

Although the exact number of snake bites is unknown, an estimated 5.4 million people are bitten each year with up to 2.7 million envenomings. Around 81,000 to 138,000 people die each year because of snake bites, and around three times as many amputations and other permanent disabilities are caused by snakebites annually. Bites by venomous snakes can cause paralysis that may prevent breathing, bleeding disorders that can lead to a fatal haemorrhage, irreversible kidney failure and tissue damage that can cause permanent disability and limb amputation. Agricultural workers and children are the most affected. Children often suffer more severe effects than adults, due to their smaller body mass (WHO, 2019).

Snake venoms contain a mixture of toxins that are species-specific and tend to have a number of cellular targets in organisms exposed to them, typically prey animals. In humans and animals, snake venoms may precipitate multi-organ system failure caused by (depending on the species of snake, and the classes of toxins present in the venom) haemorrhage and prolonged disruption of haemostasis, neuromuscular paralysis, tissue necrosis, myolysis (muscle degeneration), cardiotoxicity, acute kidney injury, thrombosis, hypovolaemic shock and several other effects. When survived, snake bites may result in life-long disablement of humans (WHO, no date).

Metrics and numeric limits

In 2019, the World Health Organization (WHO) estimated that over 5.8 billion people were at risk of encountering a venomous snake, [and thus] it is not surprising but no less tragic that almost 7400 people every day are bitten by snakes, and 220 to 380 men, women and children die as a result, adding up to about 2.7 million cases of envenoming and 81,000 to 138,000 deaths per year (WHO, 2019).

The WHO has developed a strategy to reduce mortality and disability from snakebite envenoming by 50% before 2030 with a global prevention and control programme, but metrics and numerical limits are not yet defined and data are still to be collected (WHO, 2019).

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Snake bite is a neglected public health issue in many tropical and subtropical countries. Most of these snake bites occur in Africa, Asia and Latin America. In Asia up to 2 million people are envenomed by snakes each year, while in Africa there are an estimated 435,000 to 580,000 snake bites annually that need treatment. Regional engagement by the WHO has taken place and various resources are now available.

- The guidelines for the Prevention and Clinical Management of Snakebite in Africa were developed by the WHO Regional Office of Africa with contributions from technical experts. They are meant to assist health workers to improve medical care for snakebite victims. The guidelines discuss snakes, snake venoms and snakebites and their consequences with emphasis on the medically important snakes, namely those causing serious envenoming. The volume contains over a hundred snake photographs, clinical signs of envenoming and the consequences. The guidelines also feature various annexes and in particular the geographical distribution of African venomous snakes, as well as their classification, habitats and clinical toxinology (WHO, 2010).
- The incidence of snakebite mortality is particularly high in South-East Asia. Rational use of snake anti-venom can substantially reduce mortality and morbidity due to snakebites. These guidelines are a revised and updated version of Regional Guidelines for the Management of Snakebites published by the WHO Regional Office in South-East Asia in 2011 and updated in 2016. These guidelines aim to promote the rational management of snakebite cases in various health facilities where trained health functionaries and quality snake antivenom are available (WHO, 2016).

Envenoming affects women, children and farmers in poor rural communities in low- and middle-income countries. The highest burden occurs in countries where health systems are weakest and medical resources are sparse (WHO, 2019). An increased incidence of snakebite envenoming may be associated with the following hazards: natural disasters (floods, earthquakes, volcanic activity, typhoons, hurricanes and cyclones, landslides, tsunami events), the extractive industry (mining, forestry), and land use (agricultural activity like rice, sugar cane, oil palm, copra, rubber, tea, coffee, banana plantations and other agribusiness involving manual labour).

In contrast to many other serious health conditions, a highly effective treatment exists for envenoming. Most deaths and serious consequences of snake bites are entirely preventable by making safe and effective antivenoms more widely available and accessible. High quality snake antivenoms are the only effective treatment to prevent or reverse most of the venomous effects of snake bites (WHO, 2019). Issues include:

- A significant challenge in manufacturing antivenoms is the preparation of the correct immunogens (snake venoms). At present very few countries have capacity to produce snake venoms of adequate quality for antivenom manufacture, and many manufacturers rely on common commercial sources. These may not properly reflect the geographical variation that occurs in the venoms of some widespread species. In addition, lack of regulatory capacity for the control of antivenoms in countries with significant snake bite problems results in an inability to assess the quality and appropriateness of the antivenoms (WHO, 2019).
- A combination of factors has led to the present crisis. Poor data on the number and type of snake bites have led to difficulty in estimating needs, and deficient distribution policies have further contributed to manufacturers reducing or stopping production or increasing the prices of antivenoms. Poor regulation and the marketing of inappropriate or poor quality antivenoms has also resulted in a loss of confidence in some of the available antivenoms by clinicians, health managers, and patients, which has further eroded demand (WHO, 2019).
- Snake antivenom immunoglobulins (antivenoms) are the only specific treatment for envenoming by snakebites. Antivenoms can prevent or reverse most of the snakebite envenoming effects and play a crucial role in minimising mortality and morbidity. These preparations are included in the WHO List of Essential Medicines and should be part of any primary health care package where snakebites occur. Currently, there is an urgent need to ensure availability of safe, effective and affordable antivenoms, particularly to people in developing countries, and to improve the regulatory control over the manufacture, import and sale of antivenoms (WHO, 2018).

The WHO has taken steps to raise the awareness of health authorities and policymakers on this issue. In December 2015, a programme to evaluate the potential safety and effectiveness of current antivenom products intended for use in sub-Saharan Africa was launched by the WHO. The results of this detailed technical and laboratory assessment will provide procurement agencies with informed guidance on which antivenoms best suit their needs. Following a request by several United Nations member states, the WHO formally listed snakebite envenoming as a highest priority neglected tropical disease in June 2017 (WHO, 2019).

A Snakebite Envenoming Working Group established that same year was tasked with informing the development of a strategic WHO road map on snakebites. This strategy focuses on a 50% reduction in mortality and disability caused by snakebite envenoming by 2030. This aim will be achieved through four key objectives: empower and engage communities; ensure safe, effective treatment; strengthen health systems; and increase partnerships, coordination and resources (WHO, 2019).

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Coordinating agency or organisation

World Health Organization.

BI0007 / **BIOLOGICAL / Human-Animal Interaction**

Human-Wildlife Conflict

Definition

Human-wildlife conflict is defined as struggles that emerge when the presence or behaviour of wildlife poses an actual or perceived, direct and recurring threat to human interests or needs, leading to disagreements between groups of people and negative impacts on people and/or wildlife (IUCN SSC, 2020).

References

IUCN SSC, 2020. What is Human-Wildlife Conflict? International Union for Conservation of Nature (IUCN) Species Survival Commission (SSC) Human-Wildlife Conflict Task Force. www.hwctf.org Accessed 15 October 2020.

Annotations

Synonyms

Animal-human interaction, Human-wildlife interaction.

Additional scientific description

Humans coexist in a complex, interdependent relationship with the companion, production, and wild animals necessary for food, livelihoods, and well-being, as well as the environments required by both (WHO, no date). Human-wildlife conflict occurs when animals pose a direct and recurring threat to the livelihood or safety of people, often leading to the persecution of that species. In many regions these conflicts have intensified as a result of human population growth and changes in land use (FAO and UNEP, 2020). Human-wildlife conflict affects most large carnivores, as well as many other species groups including, but not limited to, elephants, pigs, deer, primates, sharks, seals, birds of prey, crocodiles, rhinos, and otters (IUCN SSC, 2020).

Human-wildlife conflict is a serious global threat to sustainable development, food security, conservation, and health – a concern that is negatively affecting both people and wildlife and hindering the achievement of many of the Sustainable Development Goals (SDGs) (IISD, 2021) and the Aichi Biodiversity Targets (FAO, 2020a). In general, the consequences of human-wildlife conflict include destruction of crops, reduced farm productivity, competition for grazing lands and water, livestock predation, injury and death to farmers, damage to infrastructure and increased risk of disease transmission from wildlife to livestock. Human-wildlife conflict often triggers negative sentiments towards conservation, especially when protected areas are being established or expanded (FAO and UNEP, 2020). With specific reference to forests, a high density of large ungulates, for example deer, can cause severe damage to the forest and can threaten regeneration by trampling or browsing small trees, rubbing against trees or stripping tree bark (FAO, 2016). Forest damage caused by human-wildlife conflict leads to reduced productivity and forest regeneration, and can affect restoration efforts and have serious economic consequences (FAO, 2020b).

In Africa, human-wildlife conflicts are not restricted to a particular geographical location and occur in all areas where wildlife and human populations co-exist and must make use of limited natural resources. Human-wildlife conflicts currently rank among the major threats to the survival of many endangered species as well as to the security and well-being of community livelihoods in Africa (FAO, 2020b). Human-wildlife conflict has also become a major challenge in many countries in the Asia-Pacific region, creating negative sentiments towards conservation, especially when new protected areas are established, or existing protected areas are expanded. Retaliation against the species blamed often ensues, leading to conflict about what should be done to remedy the situation (IUCN SSC, 2019) and may impact conservation efforts.

The interface between humans, domestic animals, and wild animals can also be a source of disease, impacting local and global public health and the social and economic well-being of communities and the world population. Diseases transmissible from animals to humans through direct contact or though food, water, and the environment, are commonly referred to as 'zoonoses' (WHO, no date).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Convention on Biodiversity: preparations for the Post-2020 Biodiversity Framework. Human-wildlife conflict is included in the updated zero draft of the post-2020 global biodiversity framework of the Convention on Biological Diversity, in particular Target 3: By 2030, ensure active management actions to enable wild species of fauna and flora recovery and conservation, and reduce human-wildlife conflict by [X%]. The Post 2020 framework is expected to be endorsed by the 15th meeting of Parties to the Convention on Biological Diversity in China in 2021 (CBD, 2018, 2020).

Examples of drivers, outcomes and risk management

Human-wildlife conflict often severely impacts the livelihoods, security and wellbeing of the people who support wider conservation goals, and affects many nations trying to align with, and benefit from, conservation and development programmes (IUCN SSC, 2020).

As many countries tackle this multi-faceted challenge, the issue of human-wildlife conflict is starting to be considered in national policy and strategies for wildlife, development, and poverty alleviation. However, there is a need to improve the sharing and transfer of knowledge, to adopt a more inclusive and interdisciplinary approach, and to greatly increase cross-sectoral collaboration among forestry, wildlife, agriculture, livestock, and other relevant sectors at the national level (FAO, no date).

The Food and Agriculture Organization of the United Nations (FAO) actively supports the efforts of Member countries to better manage human-wildlife conflicts by facilitating cross-sectoral dialogues among stakeholders for sharing information; generating guidance on good practices; providing technical guidelines for the development of national policies and legal frameworks; and implementing field activities. For example, these activities include:

- In June 2018, at its 21st Session held in Dakar, Senegal, the African Forestry and Wildlife Commission acknowledged the efforts made by Member states in sustainable wildlife management, and requested FAO to:

  (i) provide a platform to exchange good practices and lessons learned from initiatives related to human-wildlife conflict and illegal hunting In response to the 21st Session of the African Forestry and Wildlife Commission's request and recognition of the importance of inter-sectoral collaboration, the FAO organized a Multisectoral dialogue and learning event to address issues at the human-wildlife-livestock-ecosystem interface, in Accra, Ghana, in October 2019 (FAO, 2020c).
- In response to previous human-wildlife conflict related requests by the African Forestry and Wildlife Commission, the FAO has produced a series of educational technical publications, ranging from a general overview of human-wildlife conflict in Africa to more specific reports on elephant, lion, baboon and crocodile conflicts.
- The FAO, in collaboration with the Agricultural Research for Development (CIRAD), Bio-Hub, World Wide Fund for Nature (WWF), and Campfire Association, developed a human-wildlife conflict toolkit in 2012. The toolkit has a range of resources designed for use by rural farmers and local communities and addresses all dimensions of human-wildlife conflict. It has been field-tested in FAO Technical Cooperation Programme projects in Zimbabwe and Mozambique and delivered through training workshops in the Southern, Central and Eastern Africa subregions. To raise awareness in Zimbabwe, a human-wildlife conflict management interpretation centre – funded by the FAO and partners – was established in the Mukuvisi woodlands and officially opened in 2014 (FAO, no date).

Many international organisations are involved in sustainable wildlife management. The FAO Forestry Department has served as the secretariat for the Collaborative Partnership on Sustainable Wildlife Management (CPW) since 2013 and actively engaged in a wide range of the CPW's initiatives as a proactive member of the Partnership. The CPW is a voluntary partnership of 14 international organisations with substantive mandates and programmes to promote the sustainable use and conservation of wildlife resources. The CPW, established in March 2013 in Bangkok, Thailand, provides a platform for addressing wildlife management issues that require national and supra-national responses and also works to promote and increase cooperation and coordination on sustainable wildlife management issues among its members and partners (UNEP, 2018). The CPW mission is to increase cooperation and coordination among its members and other interested parties on sustainable wildlife management, to promote the sustainable use and conservation of terrestrial vertebrate wildlife in all biomes and geographic areas (FAO, 2016). The CPW currently concentrates on four thematic areas: wildlife, food security, and livelihoods; human-wildlife conflicts; unsustainable hunting and wildlife crime; and animal and human health and welfare (UNEP, 2018).

The Collaborative Partnership on Sustainable Wildlife Management provides key messages for sustainable wildlife management and human-wildlife conflict (FAO, 2016). These include:

- Impacts of wildlife on humans and conflicts between groups of humans over wildlife conservation and management are two very different issues that require different approaches.
- The development of human-wildlife conflict response must be created together with the local communities affected by wildlife.
- Human-wildlife conflict can negatively affect human safety and food security, as well as having broader social, economic and political implications.
- Human-wildlife conflict management needs to be flexible, and adapted to local circumstances and approached as a social, as well as a technical, issue.
- Reducing the impact of wildlife or offsetting it through benefits from conservation and sustainable use is likely to improve social outcomes and biodiversity conservation by increasing tolerance towards wildlife.

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Coordinating agency or organisation

Food and Agriculture Organization of the United Nations, World Health Organization, International Union for Conservation of Nature.

BI0008 / **BIOLOGICAL / CBRNE (Chemical, Biological, Radiological, Nuclear and Explosive)**

Biological Agents

Definition

Biological agents, according to the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction (1972), include germs, toxins and viruses that can sicken or kill people, livestock, or crops (UNODA, 1972).

Reference

UNODA, 1972. Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction: Article I. United Nations Office for Disarmament Affairs (UNODA). disarmament.un.org/treaties/t/bwc/text Accessed 1 December 2019.

Annotations

Synonyms

Not available.

Additional scientific description

Because biological material (irrespective of its means of synthesis, production or application) can have both peaceful and non-peaceful purposes, no purely scientific definition of prohibited items is possible; although indicative lists have been developed by the Australia Group (2015) and governments to implement strategic trade controls.

Bacteria: Bacillus anthracis (the bacterium causing Anthrax) is one of the most common biological agents used because its spores are easily found in nature, can be produced in a laboratory, and can persist for a long time in the environment. People get infected with anthrax when spores get into the body. The microscopic spores can be put into powders, sprays, food, and water (WHO, 2008).

Toxins: Botulinum toxin, also known as Agent X is the most toxic agent known to humankind and is a very potent neurotoxin, which blocks the release of critical enzymes from the human nervous system. The lethal dose for humans of such toxins is in the sub-microgram range, which is many times lower (more toxic) than the dosage for nerve agents. Ricin (produced in nature in the seeds of the castor bean plant) and saxitoxin (produced in nature by cyanobacteria) are also listed in Schedule 1 of the Convention, however their toxicity is less than for Botulinum toxin (UNODA, 1972; Nigam and Nigam, 2010).

Viruses: These include virus derived diseases, particularly smallpox which was eradicated in 1980. Although smallpox, caused by variola virus no longer occurs naturally, the threat remains. There are concerns that variola virus, may exist outside of the two World Health Organization (WHO)-designated collaborating centres in the United States and Russia. The risk for an intentional or accidental release of the smallpox virus is believed to be low, but the effects of such an event could be devastating. The potential consequences make planning for a smallpox emergency critical (CDC, no date).

Metrics and numeric limits

Assessment of treaty compliance is partly based on the understanding and application of a so-called General Purpose Criterion (GPC) as it pertains to 'hostile uses' or in 'armed conflict' (Article I). Since the Chemical Weapons Convention (CWC) covers toxins, the international legal prohibition against biological warfare should also be understood to include 'method of warfare' (UNODA, 1972).

Grey areas exist with respect to formulations and applications that differ from those developed by historical state biological weapons programmes, including for behaviour modification or for use in situations outside traditional understanding of state-to-state armed conflict such as peacekeeping or counter-terrorism operations.

Key relevant UN convention / multilateral treaty

The GPC, which is embodied in the Biological and Toxin Weapons Convention's definition of prohibited activities, is the mechanism that ensures the Convention's prohibitions remain comprehensive in scope, including in terms of scientific and technological developments.

Examples of drivers, outcomes and risk management

Not available.

References

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WHO, 2008. Anthrax in humans and animals, 4th edition. World Health Organization (WHO). www.who.int/csr/resources/publications/anthrax_webs.pdf Accessed 1 December 2019.

Coordinating agency or organisation

Not identified.

BI0009 / **BIOLOGICAL / Mental Health**

Suicide Cluster

Definition

The term 'suicide cluster' describes a situation in which more suicides than expected occur in terms of time, place, or both. It is difficult to precisely define a cluster. A suicide cluster usually includes three or more deaths; however, two suicides occurring in a specific community or setting (for example a school) in a short time period should also be taken very seriously in terms of possible links and impacts (even if the deaths are apparently unconnected), particularly in the case of young people (PHE, 2019).

Reference

PHE, 2019. Identifying and Responding to Suicide Clusters: A practice resource. Public Health England (PHE). https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/839621/PHE_Suicide_Cluster_Guide.pdf Accessed 9 October 2020.

Annotations

Synonyms

Suicide pact, Group suicide, Suicide contagion, Suicide imitation, Mass suicide.

Additional scientific description

The term mass suicide can be used to describe situations in which a particular population or social group has reacted to (real or perceived) oppression or exploitation by another group or agent. The act of mass suicide transforms the psychology of a catastrophe from one in which a passive role is played into one constructed actively (Mancinelli et al., 2002). Mass suicides can therefore be classified as either self-induced (perceived) – the motivation is related to a distorted evaluation of reality, without there being either an intolerable situation or a real risk of death; or hetero-induced (real) – typical of defeated and colonised populations that are forced to escape from a reality in which human dignity is not acknowledged and typical of communities with a well-defined historical and cultural identity (Mancinelli et al., 2002).

Few documented examples of mass suicide events exist, and these range from events documented in 113 BC to more recent events and are documented to have occurred in most regions of the world (Mancinelli et al., 2002). Mass suicides prompted by a perceived threat are often religious in nature and can be triggered by a charismatic leader (Dein and Littlewood, 2000). Examples include the People's Temple in 1978 where 909 Americans died in a group led by Jim Jones, and Adam House in Bangladesh where nine members of the same family threw themselves in front of a train in 2007 (Selum, 2010). Mass suicides prompted by real threats most often occur during wartime, particularly among defeated or invaded populations (Goeschel, 2006).

There are reported to be substantial differences in the pattern of suicide methods internationally (Ajdacic-Gross et al., 2008). It is difficult to ascertain how many suicides occur in clusters and the extent to which clusters contribute to overall suicide rates. Approximately 5% of all suicides in New Zealand appeared to occur in point clusters and 2.4% of suicides in Australia. Estimation of such figures is approximate. It is not known how many suicides occur in mass clusters because accurate identification of those affected may be impossible as they tend to be geographically remote; sometimes linked deaths occur in different countries (PHE, 2019).

Many suicides happen impulsively and, in such circumstances, easy access to a means of suicide – such as pesticides or firearms – can make the difference as to whether a person lives or dies (WHO, 2014).

The World Health Organization reported an estimated 793,000 suicide deaths worldwide in 2016 (WHO, 2017). This indicates an annual global age-standardised suicide rate of 10.5 per 100,000 population (WHO, 2017). For every suicide there are many more people who attempt suicide every year (WHO, 2019). Suicide is the third leading cause of death in those aged 15 to 19 years (WHO, 2019). 79% of global suicides occur in low- and middle-income countries with ingestion of pesticide, hanging and firearms among the most common methods of suicide globally (WHO, 2019).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Not relevant.

Examples of drivers, outcomes and risk management

The main drivers of mass suicides are associated with political and religious motivation and mental health (Mancinelli et al., 2002); as well as media reporting of celebrity suicides, and having access to the means of committing suicide. For example, Niederkrotenthaler et al. (2020) showed that reporting of deaths of celebrities by suicide appears to increase the number of suicides by 8–18% in the subsequent 1–2 months, and information on method of suicide was associated with an increase of 18–44% in the risk of suicide by the same method. Studies on the effects of media items covering novel suicide methods have been useful in understanding the interplay between media and suicide methods, for example charcoal burning in parts of Asia (Lee et al., 2014).

Mental disorders and harmful use of alcohol contribute to many suicides around the world (WHO, 2014). Cultural variability in suicide risk is also apparent, with culture having roles both in increasing risk and in protection from suicidal behaviour (WHO, 2014). In the past half-century, many countries have decriminalised suicide, making it easier for those with suicidal behaviours to seek help (WHO, 2014). Public Health England recommends the development of a Suicide Cluster Response Plan (PHE, 2019).

Despite evidence that many deaths are preventable, suicide is often a low priority for governments and policymakers (WHO, 2014).

References

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Coordination agency or organisation

World Health Organization.

BI0010 / **BIOLOGICAL / Food Safety**

Antimicrobial Resistance

Definition

Antimicrobial resistance is the ability of a microorganism to multiply or persist in the presence of an increased level of an antimicrobial agent relative to the susceptible counterpart of the same species (FAO, 2011).

Reference

FAO, 2011. Guidelines for Risk Analysis of Foodborne Antimicrobial Resistance. CAC/GL 77-2011. Food and Agriculture Organization of the United Nations and World Health Organization (FAO). www.fao.org/fao-who-codexalimentarius/sh-proxy/en/?lnk=1&url=https%253A%252F%252Fworkspace.fao.org%252Fsites%252Fcodex%252FStandards%252FCXG%2B77-2011%252FCXG_077e.pdf Accessed 26 October 2020.

Annotations

Synonyms

Not identified.

Notes: In some cases, the terms antibiotic resistance and antimicrobial resistance are used interchangeably which is incorrect. Antibiotic resistance has a narrower definition referring only to resistance to antibiotics which target bacteria while antimicrobial resistance relates to resistance or a broader range of microbes (bacteria, viruses, fungi, protozoa) and to a broader range of agents (antibiotics, antivirals, antifungals, antiprotozoals) (WHO, 2020a,b).

Antimicrobial resistance should be differentiated from antimicrobial residues which are trace amounts of the chemical substances present in foods and in the environment after antimicrobial use or disposal. Antimicrobial residues pose a food safety risk and may contribute to the development of antimicrobial resistance in the environment (CDC, 2021).

Additional scientific description

Antimicrobial resistance (AMR) occurs when microorganisms (bacteria, fungi, viruses, protozoa) evolve to survive and/or proliferate in concentrations of antimicrobial that would otherwise be microbiocidal (kill) or microbiostatic (inhibit the growth) to the organism or other organisms of the same or similar species. This can occur naturally through adaption to the environment but has been exacerbated by inappropriate and excessive use of antimicrobial agents (FAO, 2016).

Microorganisms in food are potential food safety hazards. The relationship between the use of antimicrobial agents in food production (terrestrial and aquatic food-producing animals and crop plants) and the emergence of resistant microorganisms in the food chain is a concern as food can become contaminated with antimicrobial resistant organisms and/or antimicrobial resistance genes. When humans ingest antimicrobial resistant microorganisms in food or water, some of these may cause illness, and in cases where antimicrobial treatment in needed this becomes a challenge. This has been the subject of numerous national and international consultations (FAO and WHO, 2018a).

Data to support risk assessment and risk management, while improving, remains an important challenge in the context of antimicrobial resistance. For example, 118 countries reported quantitative data on antimicrobial use in animals in 2017, an increase from 89 reporting in 2015. However, few countries collect data on antimicrobial use in plant production. Also, according to the World Health Organization (WHO) there are few countries worldwide that have adequate surveillance across the food chain (WHO, 2015a).

In summary antimicrobial-resistant bacteria, antimicrobial residues and antimicrobial resistance genes could be transmitted from animal, clinical, and environmental sources to foods, feeds of animals and plants. There are around 700,000 human deaths each year related to antimicrobial resistance (CDC, 2021).

Metrics and numeric limits

The Food and Agriculture Organization of the United Nations (FAO) and WHO have published maximum residue limits in foodstuffs (FAO and WHO, 2018b,c).

Key relevant UN convention / multilateral treaty

Follow up to the political declaration of the high level meeting of the United Nations General Assembly on antimicrobial resistance (UNGA, 2019).

Joint FAO/WHO Food Standards Program (Codex Alimentarius Commission) (FAO and WHO, 2018a).

The WHO Global Action Plan on Antimicrobial Resistance (WHO, 2015b) and WHO Resolutions (WHO, no date).

Intergovernmental standards on AMR (OIE, no date).

Examples of drivers, outcomes and risk management

Much attention has been focused on human exposure to antimicrobial resistant pathogens in hospitals and similar settings and the implications for public health. However, the presence of antimicrobial resistant microorganisms in food production systems means that the food consumed can also be a source of exposure. Development and transmission of antimicrobial resistance through the food chain is complex with multiple contributing factors, hence addressing it using a coordinated, 'one health' response provides the most effective approach.

Excessive and inappropriate use of antimicrobial agents in a range of sectors (human health, animal health, crop production), together with other aspects, such as lack of proper waste management or appropriate waste treatment, are key drivers in the exacerbation of antimicrobial resistance. The availability and use of antimicrobial drugs for human health as well as in terrestrial and aquatic animals and in crop production is essential to both health and productivity. The increase in antimicrobial resistance is a major global threat of increasing concern to human, animal and plant health. It also has implications for both food safety and food security and the economic wellbeing of millions of farming households (FAO and WHO, 2018a).

Owing to the inter-related multiple dimensions of antimicrobial resistance, the food safety aspects cannot be addressed in isolation. A holistic approach, which takes into account animal and plant production, the environment and food processing should be considered. This can be done using a One Health approach. For example, animal diseases can have major impacts on food production, food security and farming livelihoods. Antimicrobial agents have an important role in treating such diseases, but their misuse in agriculture contributes to the spread of antimicrobial resistance and undermines the effectiveness of veterinary medicines. Similarly, antimicrobials are vital to treat and control plant diseases. Contamination of soils with these products following crop application leads to enrichment of antimicrobial-resistant bacteria and genes in the environment. However, the extent to which the treatment of crops with antimicrobial agents (or copper formulations) promotes antimicrobial resistance in bacteria found on the edible parts of crops is uncertain. Other inputs to plant production, such as water and manure, can also be a source from which plants become contaminated with antimicrobial-resistant organisms or genes. Contamination at the primary production level can lead to exposure to antimicrobial-resistant organisms/genes via the food consumed. Thus, addressing antimicrobial resistance as a food safety hazard is complex and requires an integrated approach (FAO, no date a).

A global Action Plan on antimicrobial resistance adopted in 2016 (WHO, 2015b) has served as a major driver for increased risk management. This was followed by a political declaration of the high level meeting of the United Nations General Assembly on antimicrobial resistance (WHO, 2016) which has been important to gain political commitment to address the risks posed.

At the next level the Codex Alimentarius has developed several texts directly related to antimicrobial resistance (FAO and WHO, 2005, 2011) and is in the process of updating its Code of Practice and developing new Guidelines for surveillance of antimicrobial resistance which are expected to be completed by 2021 (FAO and WHO, no date).

The World Organization for Animal Health (OIE) has developed standards specifically related to the management of antimicrobial resistance in the animal sector (OIE, no date).

On a more practical level the FAO is working closely with the WHO and OIE, and together they share responsibility for addressing and coordinating global activities addressing antimicrobial resistance at the animal-human-ecosystems interface (FAO, 2020).

In this context, the implementation of good practices is key to reducing the risk of developing and transmitting antimicrobial resistance through the food chain. Practical guidance has been and continues to be developed for the different sectors. Examples follow for animal production and health, plant production and health, environment, and food safety.

Animal production and health: While the prudent use of antibiotics is important to treat animal diseases, its overuse and misuse can contribute to antimicrobial resistance and with two-thirds of the estimated future growth of usage of antimicrobials estimated to be within the animal production sector, efforts to reduce use and the related consequences need to be addressed. Addressing antimicrobial resistance effectively requires the livestock sectors to join others in committing to implement practices to minimise the need for and use of antimicrobials. Key actions required include: tracking and monitoring of animal disease to allow a rapid response; applying good husbandry practices; improving animal welfare during all phases including production, transport and slaughter; using animals of locally adapted breeds which are more resistant to diseases and stress or animals bred for disease resistance (resistant animals will require fewer treatments with antimicrobials); ensuring good hygiene, biosecurity measures, and general conditions on farms to prevent the need for any medicines in the first place; applying rigorous disease control measures (e.g., vaccination); using feed ingredients/additives that enhance the efficiency of feed conversion to substitute antibiotics as growth promoters; avoiding feed ingredients with antinutritional properties (such as lectins, and protease inhibitors); and applying good practices for waste management. For further information on management options see FAO (no date a).

Plant production and health: The most effective approach to limit the use of antimicrobials in plant production is through use of the well-established procedures of ‘integrated pest management’ – a systems approach designed to minimise economic losses for crops, as well as to minimise risks to people and the environment through the use of pesticides. Key components of integrated pest management for preventing and managing plant diseases are: accurate and timely diagnosis and monitoring; use of disease-resistant crop varieties; exclusionary practices (biosecurity) that prevent the introduction of pathogens into a crop; careful site selection and soil improvement to maximise plant health and minimise environmental factors that favour pathogens; crop rotation and other cultural practices to prevent pathogen build-up; use of biological and biorational products; and judicious use of antimicrobials (FAO and WHO, 2019). For further information on management options see FAO (no date b).

Environment: Taking action to manage antimicrobial resistance in the environment is now recognised as very important to manage the development of spread of antimicrobial resistance, including through the food chain. However it is only recently that there have been concrete efforts to address this, with the need for policies to tackle this aspect being a key action required. For further information see FAO, WHO and OIE (2020).

Food safety: Good hygiene practices throughout the food chain are key to minimising the transfer of microorganisms through food (FAO and WHO, 2003). Monitoring of residues of veterinary drugs or pesticides in foods is also an important element of the risk management approach. But critical to all of these approaches is the capacity to both implement the relevant measures and have the necessary oversight mechanisms to inspect and enforce their implementation.

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Coordinating agency or organisation

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BI0011 / **BIOLOGICAL / Food Safety**

Foodborne Microbial Hazards (including human enteric virus and foodborne parasite)

Definition

Foodborne microbial hazards include (but are not limited to) pathogenic bacteria, viruses, algae, protozoa, fungi, parasites, prions, toxins and other harmful metabolites of microbial origin (FAO and WHO, 2007).

A human enteric virus is a virus that replicates in the gastro-intestinal tract or in the liver and is excreted in faeces and/or vomitus from humans. It is transmitted mainly by the faecal-oral route and is infectious to humans (FAO and WHO, 2012).

A foodborne parasite is any parasite that can be transmitted to humans by ingesting food (FAO and WHO, 2016).

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Annotations

Synonyms

Not identified.

Additional scientific description

Foodborne diseases caused by foodborne microbial hazards are an important cause of morbidity and mortality, and a significant impediment to socioeconomic development worldwide. The symptoms of foodborne diseases range from mild and self-limiting (nausea, vomiting, diarrhoea) to debilitating and life-threatening (such as kidney and liver failure, brain and neural disorders, paralysis and potentially cancers), leading to long periods of absenteeism and premature death (WHO, 2015).

Human enteric virus refers to viruses that are very small microorganisms, ranging from 0.02 to 0.4 mm in diameter, whereas bacteria generally range in size from 0.5 to 5 mm. In addition to size, other (structural and biological) properties of viruses may also vary greatly, both among viruses and between viruses and bacteria. In contrast to bacteria, which are free living, viruses use the host cells to replicate. Viruses are diverse; for example, the virus genome can be DNA or RNA, in double- or single-stranded form. The virus particle can vary from a relatively simple structure consisting of a non-enveloped genome with a single protein coat, as is the case for most foodborne viruses, to a complex structure consisting of a segmented genome, encapsulated in a complex protein capsid and enveloped by a membrane. The structure of the virus particle is linked to the environmental resistance of the virus, with the more complex structure particles being less resistant (FAO and WHO, 2008).

Foodborne parasites are a major public health concern worldwide, particularly in areas with poor sanitary facilities and in populations that traditionally consume raw and undercooked food dishes. Infections may have prolonged, severe, and sometimes fatal outcomes, and result in considerable hardship in terms of food safety, food security, quality of life, and negative impacts on livelihood (FAO and WHO, 2016).

Metrics and numeric limits

The World Health Organization (WHO) reports that each year worldwide, unsafe food causes 600 million cases of foodborne diseases and 420,000 deaths. 30% of foodborne deaths occur among children under 5 years of age. The WHO estimated that 33 million years of healthy lives are lost due to eating unsafe food globally each year, and that this number is likely to be an underestimate (WHO, no date, 2015).

Key relevant UN convention / multilateral treaties

The Joint Food and Agriculture Organization of the United Nations (FAO) and WHO Food Standards Program (Codex Alimentarius Commission) for the establishment of food safety standards, such as maximum levels for food additives (quantitative levels above which there is a risk for consumer's health) (FAO and WHO, no date).

The WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (WTO, no date).

Examples of drivers, outcomes and risk management

Foodborne microbial hazards: Diseases caused by foodborne microbial hazards constitute a world-wide public health concern. During recent decades, the incidence of foodborne diseases has increased in many parts of the world. Foodborne threats occur for a number of reasons. These include: microbial adaptation; changes in the food production systems, including new feeding practices and changes in animal husbandry, agronomic process and food technology; increase in international trade, susceptible populations and travel; change in lifestyle and consumers demands; and changes in human demographics and behaviour. The globalisation of food markets has increased the challenge to manage these risks (FAO and WHO, 2007).

The WHO Foodborne Disease Burden Epidemiology Reference Group (FERG), provides the estimates of global foodborne disease incidence, mortality, and disease burden in terms of Disability Adjusted Life Years (DALYs). For the global estimates, 31 foodborne hazards causing 32 diseases are included: 11 diarrhoeal disease agents (1 virus, 7 bacteria, 3 protozoa), 7 invasive infectious disease agents (1 virus, 5 bacteria, 1 protozoon), 10 helminths and 3 chemicals. The most frequent causes of foodborne illness were diarrhoeal disease agents, particularly norovirus and Campylobacter spp. Foodborne diarrhoeal disease agents caused 230,000 deaths, particularly non-typhoidal Salmonella enterica (WHO, 2015).

Foodborne parasites: Foodborne parasites can be transmitted by ingesting fresh or processed foods that have been contaminated with the transmission stages (spores, cysts, oocysts, ova, larval and encysted stages) via the environment; by animals (often from their faeces); or by people (often due to inadequate hygiene). Foodborne parasites can also be transmitted through the consumption of raw and under-cooked or poorly processed meat and offal from domesticated animals, wild game and fish containing infective tissue stages. Despite the fact that the parasite does not replicate outside a live host, food processing techniques in common use can artificially amplify the quantity of contaminated food that reaches the consumer, increasing the number of human cases (e.g., sausage made from meats of different origin) (FAO and WHO, 2012).

The WHO FERG assessed data for the global burden of human foodborne trematodiasis in 2005, and estimated that 56.2 million people were infected by foodborne trematodes, of which 7.8 million suffered from severe sequelae and 7158 died worldwide (FAO and WHO, 2014).

Control of foodborne parasites can be achieved through the prevention of infection of farmed food animals with infective stages, the prevention of contamination of fresh and processed foods with infective stages, and/or the inactivation of parasites in or on foods during processing. Education and awareness-raising are important components of consumer protection from foodborne parasitic diseases and, in many cases, may be the only feasible option available (FAO and WHO, 2014).

Human enteric viruses: Humans become infected with enteric viruses following the ingestion of viruses present in faecally contaminated foods. The viruses enter the gastrointestinal tract, surviving the acidic conditions in the gut, and initiate an infection. Consequently, major foodborne viral disease outbreaks are caused by viruses from humans that are excreted in high numbers in human faeces. Another important factor affecting foodborne transmission is the stability of viruses outside the host. There is considerable potential for food contamination along the food chain continuum. For example, various reports have clearly provided strong evidence of 'food handler' transmission for some specific virus. A separate category is the animal viruses that are able to cause illness in humans. The viruses of potential risk to human health may enter the food chain through animal products, as well as when virus-laden animal manure contaminates food (FAO and WHO, 2012).

Estimates of the proportion of viral illness attributed to food are in the range of a few percent (around 5%) for Hepatitis A virus to 12–47% for Norovirus. This translates to estimated numbers of foodborne viral illness cases ranging from approximately 13,000 per million to 30,000 per million persons. Telephone surveys in the USA and Australia have also shown that such illness is common. No such data are available from developing countries but reports from the literature suggest that foodborne viral illness occurs worldwide (FAO and WHO, 2008).

Control of human enteric viruses such as Norovirus and Hepatitis A virus in food will typically require a stringent application of hygiene control systems, which could be referred to as, for example, Good Hygienic Practices (GHPs) and sanitation standard operation procedures (SSOPs). These prerequisite programmes, together with validated interventions, for example, as part of a hazard analysis and critical control point (HACCP)-based system, provide a framework for the control of enteric viruses (FAO and WHO, 2008).

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Coordinating agency or organisation

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BI0012 / **BIOLOGICAL / Infectious Disease (Plant)**

Bacterial Plant Disease

Definition

A bacterial plant disease is the occurrence of plant diseases caused by bacterial microorganisms over large areas with significant impacts on crop and forest productivity or natural habitat (adapted from FAO, 2018).

Reference

FAO, 2018. 2017: The Impact of Disasters and Crises on Agriculture and Food Security. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/3/i8656en/i8656en.pdf Accessed 31 October 2020.

Annotations

Synonyms

Not applicable.

Additional scientific description

A bacterium is a single-celled, microscopic organism that lacks a nucleus. Some bacteria cause animal or plant diseases (University of California, 2019). Plant diseases caused by bacterial pathogens place major constraints on crop and forest production and cause significant annual losses on a global scale (Sundin et al., 2016).

The Food and Agriculture Organization of the United Nations (FAO) estimates that each year, plant diseases cost the global economy around USD 220 billion (FAO, 2019).

Numerous bacterial diseases affect crop production in many countries and regions. These include fire blight in fruit trees, bacterial wilt in banana, bacterial blight in rice and crown gall in many perennial plants. In some cases, the epidemics caused by bacteria can cause significant economic burden on crops (FAO, 2018).

For example, Xylella fastidiosa is a bacterial disease with many subspecies that in recent years has managed to establish itself in areas along the Mediterranean coast, where it is attacking economically important crops such as olive, citrus, stone fruits, grapevines and forest trees such as oak (FAO, 2020).

- In 2013, Italian researchers made a troubling discovery: one of the world's most destructive plant diseases, normally found in the Americas, had made its way to Italy's olive trees. With no known cure, the pathogen has already affected more than 10 million trees in the south-eastern tip of Italy. If not properly contained, it threatens to spread across the entire Mediterranean basin. The Italian government contracted national research institutes and the International Center for Advanced Mediterranean Agronomic Studies (CIHEAM) to survey and contain X. fastidiosa. Other Mediterranean countries are at great risk if the disease spreads further (FAO, 2020).
- The disease threatens to spread to the Near East and North Africa region. To help smallholders protect their crops and livelihoods, the FAO is supporting efforts in Near East and North African countries to raise awareness of the threat and implement technologies and techniques that can help prevent, detect and contain this deadly disease (FAO, 2020).
- Not only olive trees but also more than 500 other plant and forest tree species are hosts for the various strains of the bacterium. If not prevented, smallholders in the Near East and North African region could have their livelihoods devastated and national economies destabilised by the potential spread into the region. Because of these risks, the FAO has launched a project to support Near East and North African countries in their efforts to prevent the introduction and spread of this disease (FAO, 2020).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

The International Plant Protection Convention (1997) is an intergovernmental treaty signed by over 180 countries, aiming to protect the world's plant resources from the spread and introduction of pests, and promoting safe trade (FAO, 2011). The Convention introduced International Standards for Phytosanitary Measures (FAO, no date) as its main tool to achieve its goals, making it the sole global standard setting organisation for plant health. The IPPC is one of the 'Three Sisters' recognised by the World Trade Organization's (WTO) Sanitary and Phytosanitary Measures (SPS) Agreement, along with the Codex Alimentarius Commission for food safety standards and the World Organization for Animal Health (OIE) for animal health standards.

The Codex Alimentarius (FAO and WHO, no date).

The WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (WTO, no date).

The UN Recommendations on the Transport of Dangerous Goods (UNECE, no date).

Examples of drivers, outcomes and risk management

Although most bacteria existing in the soils and natural environments are beneficial, some cause significant diseases in plants under favourable conditions. Disruption of ecosystems and negligence of crop hygiene contribute to the build-up and spread of the inoculum of bacteria, causing substantive economic damage to crops and natural habitats. Prevention of spread is always easier than responding to outbreaks and control. Control of the diseases caused by bacteria is achieved by following the principles of sustainable plant production and integrated pest management practices.

Disease management approaches include focusing on diversified productions, use of pathogen-free certified planting materials, use of resistant varieties, regular surveillance, crop and forest hygiene and rapid containment and response at initial stages. Some bacteria are transmitted by insect vectors; thus, control of these vectors is important for disease management. Bacteria in agricultural environments can mutate and produce new strains that might be more aggressive than before. Therefore, monitoring and development of resistant varieties to emerging strains is critical for integrated management of the diseases caused.

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Coordinating agency or organisation

Food and Agriculture Organization of the United Nations (FAO).

BI0013 / **BIOLOGICAL / Infectious Diseases (Plant)**

Fungal Plant Disease

Definition

Fungal plant disease is the occurrence of plant diseases caused by fungal agents over large areas with significant impact on crop productivity or natural habitats (Arneson, 2001; Moore et al., 2019).

References

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Annotations

Synonyms

Not identified.

Additional scientific description

Fungi are multi-cellular eukaryotic organisms classified as a separate kingdom, as are animalia and plantae. They include many important species causing plant diseases of local or global significance such as blights, wilts, rots, mildews, canker, smuts or rusts. The fungus structure normally consists of filamentous strands called mycelium and reproduces through spores (CABI, no date).

The list of fungal diseases includes many types: anthracnose; black knot; blight including chestnut blight and late blight; canker; clubroot; damping-off; Dutch elm disease; ergot; Fusarium wilt; leaf blister; mildew including downy mildew and powdery mildew; oak wilt; rot including basal rot, grey mould rot and heart rot; rust including wheat, soybean, pine blister, coffee and cedar-apple rust; scab including apple scab; smut including loose smut and corn smut; snow mould; sooty mould; and Verticillium wilt (Encyclopaedia Britannica, no date).

Collectively, fungi and fungal-like organisms (FLOs) cause plant (forest) diseases with over 8000 species shown to cause disease. Some of the world's great famines and periods of human suffering can be blamed on plant disease-causing fungi and FLOs (Williams et al., 2017).

Numerous fungal disease epidemics have affected crop production and forests in many countries and regions in world history. These include epidemics caused by potato blight, wheat rust diseases, chestnut blight, rice blast and banana Fusarium wilt.

In addition to being agents of pre-harvest and post-harvest diseases and rots, some fungi can produce highly toxic, hallucinogenic and carcinogenic chemicals that have not only affected the lives of millions historically but also continue to cause problems today. In 2006, dozens of dogs perished from food tainted with aflatoxin, a chemical produced by several Aspergillus species. These fungi can grow on many plants such as corn and produce toxins on the grain that not only affect the liver but is also one of the most carcinogenic substances known (Williams et al., 2017).

Some fungi have beneficial roles in soil, but many are the major causal agents of plant diseases both during growth and in post-harvest processing. A wide range of fungicides are used to control fungi and to avoid production losses (FAO, 2017).

Metrics and numeric limits

Not known.

Key relevant UN convention / multilateral treaty

The International Plant Protection Convention (1997) is an intergovernmental treaty signed by over 180 countries, aiming to protecting the world's plant resources from the spread and introduction of pests, and promoting safe trade (FAO, 2011). The Convention introduced International Standards for Phytosanitary Measures as its main tool to achieve its goals, making it the sole global standard setting organisation for plant health. The IPPC is one of the 'Three Sisters' recognised by the World Trade Organization's (WTO) Sanitary and Phytosanitary Measures (SPS) Agreement, along with the Codex Alimentarius Commission for food safety standards and the World Organization for Animal Health (OIE) for animal health standards.

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The WTO and the World Organization for Animal Health (OIE) (WTO, 1998).

The UN Recommendations on the Transport of Dangerous Goods: UN Model Regulations Nature, Purpose and Significance of the Recommendations (UNECE, no date).

Examples of drivers, outcomes and risk management

Favourable climatic conditions, disruption of natural balance and deficiencies in crop and forest hygiene contribute to the build-up and spread of the inoculum of fungi regularly causing substantial damage in crops, forests and other natural habitats. Prevention of spread and outbreaks is always easier than responding to epidemics and control. Adopting the principles of sustainable plant production, sustainable forest management and integrated pest management practices are critical for the control of fungal plant diseases. Specific management methods include a focus on diversified production, use of disease resistant varieties, use of pathogen-free certified planting materials, regular surveillance and rapid containment at initial stages all in an integrated manner.

Fungi mutate frequently and produce new strains that might be more aggressive. Therefore, continuous surveillance and development of resistant varieties to emerging strains is critical for integrated management of fungi and fungal-like organisms.

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Coordinating agency or organisation

Food and Agriculture Organisation (FAO), the International Plant Protection Convention (IPPC) Secretariat.

BI0014 / **BIOLOGICAL / Infectious Diseases (Plant)**

Viral, Mycoplasma and Viroid Plant Disease Epidemics

Definition

Viral, mycoplasma and viroid plant disease epidemics are the occurrence of plant diseases caused by viruses, mycoplasma (syn. phytoplasma, mycoplasma-like organisms) and viroids over large areas with significant impact on crop productivity or natural habitats (adapted from Nakashima and Murata, 1993; Hammond and Owens, 2006; FAO and IPPC, 2016; Rubio et al., 2020).

References

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Annotations

Synonyms

Mycoplasmas are often referred to as mycoplasma-like organisms (MLOs), Phytoplasmas.

Additional scientific description

The terminology ‘outbreak’ is used if the disease occurs in a limited location or area, and ‘pandemic’ if it occurs in multiple regions and at world scale.

Plant diseases are a major concern globally, given their potential economic impact on populations that rely on income from selling crops. The impact in places where there is increased food scarcity is of particular concern, as it exacerbates the insecurity and poverty felt by populations affected by these diseases. Viruses, viroids and mycoplasmas (MLOs) are among the main disease agents causing significant crop losses, depending on crops and local conditions.

Mycoplasma lack cell wall(s) bounded by unit membrane(s) and have cytoplasm ribosomes and strands of nuclear material (Team Agri, 2017). Mycoplasmas are transmitted through insects that feed on plants, including plant hoppers and psyllids (Team Agri, 2017). Plant viruses are small microorganisms without cell walls, containing nucleic acids surrounded by protein coats and replicating only inside living cells (Gergerich and Dolja, 2006). Mycoplasmas are bacteria lacking cell walls and being categorised under the genus Mycoplasma. They are highly resistant to antibiotics and can be saprophytic or parasitic to plants (Britannica, 2019). Viroids are microorganisms that consist of a small circular RNA molecule, and are smaller than viruses and capable of causing certain plant diseases (Britannica, 2020).

The occurrence of mycoplasma in plants is a particularly difficult hazard to address, since they are 'the perfect parasite' and adapt to their host in a way that serves all their nutritional needs (Cleanroom Technology, 2008). While mycoplasma generally do little harm, in the right circumstances they can provoke serious responses from their host causing illness and death in plants (Cleanroom Technology, 2008). Mycoplasmas – and associated wall-less prokaryotes – first came into the global scientific consciousness in the 1960s when Japanese workers noted an increasing prevalence of these organisms in the plants they were working with (Arora and Sinha, 1988). Since then, the association of mycoplasma and other plant virals/viroids with negative agricultural outcomes has shot up, with 100 diseases now being associated with these vectors (Arora and Sinha, 1988).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

The International Plant Protection Convention (IPPC) was approved by the Food and Agriculture Organization of the United Nations (FAO) on 6 December 1951, by Resolution No. 85/51. The IPPC is an intergovernmental treaty signed by over 180 countries, aiming to protect the world's plant resources from the spread and introduction of pests, and promoting safe trade (FAO and IPPC, 1999). The Convention introduced International Standards for Phytosanitary Measures (ISPMs) as its main tool to achieve its goals, making it the sole global standard setting organisation for plant health (FAO and IPPC, 2021). The IPPC is one of the 'Three Sisters' recognised by the World Trade Organization's (WTO) Sanitary and Phytosanitary Measures (SPS) Agreement (WTO,1998), along with the Codex Alimentarius Commission for food safety standards, and the World Organization for Animal Health (OIE) for animal health standards (FAO, no date).

Examples of drivers, outcomes and risk management

Viruses are among the major causes of plant diseases in many plants, some being highly significant. Spread of viruses take place through the movement of infected plant materials or through insect vectors such as aphids, white flies and mealybugs. Some nematodes and fungi are also reported to transmit viruses. Thus, integrated management approaches should consider the control of insect vectors as well as use of virus-free planting materials. Diseases of economic importance caused by viruses include tobacco mosaic virus, cassava viruses, banana bunchy top virus, tomato yellow leaf curl virus, cucumber mosaic virus, potato virus Y, plum pox virus and potato virus X, citrus tristeza virus and barley yellow dwarf virus (Gergerich and Dolja, 2006).

Mycoplasmas and viroids are not considered among the major causes of plant diseases but where circumstances are conducive, they can cause outbreaks or in some cases epidemics causing economic losses under local conditions. Spread of mycoplasmas and viroids occur mostly through either movement of infected plant materials or vectors such as leafhoppers in the case of mycoplasmas, and aphids in the case of viroids. For effective control and integrated management of these pathogens, use of pathogen-free clean planting materials, crop hygiene and control of vectors are important measures (Team Agri Info, 2017).

Major mycoplasma diseases include witches' broom of woody plants, X disease of peaches, coconut lethal decline, grapevine yellows, apple proliferation, while viroids causing significant diseases include potato spindle tuber viroid, citrus infected with citrus exocortis viroid and avocado sunblotch viroid.

References

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Coordinating agency or organisation

Food and Agriculture Organization (FAO), International Plant Protection Convention (IPPC).

BI0015 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Anthrax

Definition

Anthrax is a disease caused by the spore-forming bacteria Bacillus anthracis. Anthrax is primarily a disease of herbivorous animals, although all mammals, including humans can contract it. In humans, anthrax manifests itself in three distinct patterns (cutaneous, gastrointestinal, inhalational) (adapted from WHO, FAO and OIE, 2008; CDC, 2020).

References

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WHO, FAO and OIE, 2008. Anthrax in Humans and Animals. 4th Ed. World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO), World Organisation for Animal Health (OiE). www.who.int/csr/resources/publications/anthrax_webs.pdf Accessed 11 October 2020.

Annotations

Synonym

Not identified.

Additional scientific description

Until the introduction and widespread use of effective veterinary vaccines, Anthrax was a major cause of fatal disease in cattle, sheep, goats, camels, horses, and pigs throughout the world. Anthrax continues to be reported from many countries in domesticated and wild herbivores, especially where livestock vaccination programmes are inadequate or have been disrupted (WHO, no date).

Humans generally acquire the disease directly or indirectly from infected animals, or occupational exposure to infected or contaminated animal products. Control in livestock is therefore the key to reduced incidence in humans. The disease is generally regarded as being non-contagious (WHO, no date).

The infected host sheds the vegetative bacilli onto the ground and these sporulate on exposure to the air. The spores, which can persist in soil for decades, may displace up to the topsoil, following grass growth or flooding, creating favourable conditions for anthrax. Grazing animals may take up the spore and get infected, when germination and multiplication can again take place upon the site of infection. Flies appear to play an important role in large outbreaks in endemic areas. Humans acquire anthrax from handling carcasses, hides, bones, etc. from animals that died of the disease (WHO, FAO and OIE, 2008).

More than 95% of human anthrax cases take the cutaneous form and result from handling infected carcasses or hides, hair, meat or bones from such carcasses. All three forms (cutaneous, gastrointestinal, inhalational) are potentially fatal if untreated, but the cutaneous form is more often self-limiting. Data from pre-antibiotic and vaccine days indicate that 10%–40% of untreated cutaneous cases may be expected to result in death with some geographical and temporal variations (WHO, FAO and OIE, 2008).

Bacillus anthracis has always been high on the list of potential agents with respect to biological warfare and bioterrorism. It has been used in that context on at least two occasions, prepared for use on several other occasions and been the named agent in many threats and hoaxes (WHO, FAO and OIE, 2008).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Codex Alimentarius (FAO and WHO, no date).

International Health Regulations (2005), 3rd ed (WHO, 2016).

WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (WTO, no date).

UN Recommendations on the Transport of Dangerous Goods - UN Model Regulations Model Regulations Nature, Purpose and Significance of the Recommendations (UNECE, no date).

Examples of drivers, outcomes and risk management

The Food and Agriculture Organization of the United Nations provides information on anthrax outbreaks via its guidance on for improved prevention, control and heightened awareness (FAO, 2018). Anthrax provides a good platform for a 'One Health' approach which can be operationalised through locally adapted approaches for prevention and control. These efforts should be supported by enhanced intersectoral collaboration and coordination between the veterinary and medical authorities, particularly at the field level, for information and report exchange, integration of surveillance data, joint case investigations, coordination of community awareness messaging and implementation, and effective delivery of vaccination campaigns (FAO, 2018).

In the World Organisation for Animal Health (OIE) Terrestrial Animal Health Code chapter on anthrax, it is reported that there is no evidence that anthrax is transmitted by animals before the onset of clinical and pathological signs. It provides guidance on early detection of outbreaks, quarantine of affected premises, destruction of diseased animals and fomites, and implementation of appropriate sanitary procedures at abattoirs and dairy factories will ensure the safety of products of animal origin intended for human consumption (OIE, 2019).

References

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Coordinating agency or organisation

Food and Agriculture Organization of the United Nations, World Health Organization, World Organisation for Animal Health (OIE).

BI0016 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Airborne Diseases

Definition

Airborne transmission of infectious agents refers to the transmission of disease caused by dissemination of very small droplets that remain infectious when suspended in air over long distance and time (WHO, 2020).

Reference

WHO, 2020. Transmission of SARS-CoV-2: implications for infection prevention precautions. World Health Organization (WHO). www.who.int/news-room/commentaries/detail/transmission-of-sars-cov-2-implications-for-infection-prevention-precautions Accessed 22 September 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

In its guidelines on Infection prevention and control of epidemic-and pandemic-prone acute respiratory infections in health care (WHO, 2014), the World Health Organization defines airborne transmission as: "The spread of an infectious agent caused by the dissemination of droplet nuclei that remain infectious when suspended in air over long distances and time. Airborne transmission can be further categorized into obligate or preferential airborne transmission:

Obligate airborne transmission refers to pathogens that are transmitted only by deposition of droplet nuclei under natural conditions (e.g., pulmonary tuberculosis).

Preferential airborne transmission refers to pathogens that can initiate infection by multiple routes but are predominantly transmitted by droplet nuclei (e.g., measles and chickenpox)."

Acute respiratory diseases are acute upper or lower respiratory tract diseases, frequently infectious in aetiology, that can result in a spectrum of illnesses, ranging from asymptomatic or mild infection to severe or fatal disease. The severity depends on the causative pathogen, and on environmental and host factors (WHO, 2014).

Three main types of organism can cause infectious related airborne diseases: viruses, bacteria, and fungi. Disease-causing pathogens are organisms that spread from one infected person to another through coughing, talking, and sneezing (WHO, 2014). Pathogens that are transmitted through the airborne route include pulmonary tuberculosis, measles, chickenpox and influenza virus (WHO, 2014).

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

The International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

Infection prevention and control (IPC) is a scientific approach and set of practices designed to prevent harm caused by infection to patients and health workers. Use of appropriate IPC measures is essential for the protection of patients, healthcare workers, and the wider community. Correct implementation of the necessary IPC measures is an essential aspect of safe and successful management of airborne diseases (WHO, no date).

Vaccines are available for various airborne diseases, including measles and influenza, which reduce the risk of getting diseases by working with the body's natural defences to build protection. The Global Vaccine Action Plan 2011–2020, endorsed by the 194 Member States of the World Health Assembly in May 2012, is a framework to prevent millions of deaths by 2020 through more equitable access to existing vaccines for people in all communities (WHO, 2013). The Global Vaccine Action Plan was the product of the Decade of Vaccines Collaboration, an unprecedented effort that brought together development, health and immunisation experts and stakeholders (WHO, 2013).

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Coordinating agency or organisation

World Health Organization.

BI0017 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Blood Borne Viruses

Definition

Blood-borne viruses are viruses transmitted by direct contact with infected blood or other body fluids (WHO, 2012).

Reference

WHO, 2012. Disease information. World Health Organization (WHO). www.who.int/travel-advice/disease-information Accessed 19 September 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

Blood-borne viruses are viruses that some people carry in their blood and which can be spread from one person to another. Those infected with a blood-borne virus may show little or no symptoms of serious disease, while other infected people may be severely ill. An infected person can transmit (spread) blood-borne viruses from one person to another by various routes and over a prolonged time period (HSE, no date a). The most prevalent blood-borne viruses are: human immunodeficiency virus (HIV) – a virus which causes acquired immunodeficiency syndrome (AIDS), a disease affecting the body's immune system; and, hepatitis B (HBV) and hepatitis C (HCV) – blood-borne viruses causing hepatitis, a disease affecting the liver (NHS Ayrshire and Arran, no date).

Exposure to these viruses can also occur through exposure to infected vaginal secretions, semen, and breast milk (HSE, no date a).

Blood-borne viruses are transmitted by blood, or other body fluids containing a virus. This happens when the blood or fluids enter the body of a susceptible person. The rate of viral transmission varies depending on how the person has been exposed to the virus (the route of transmission), the type of virus, how much of the virus the carrier has in their body and the immune status of the exposed person (HSE, no date b). The more common routes of transmission include: sexual intercourse (common for HBV, HIV; inefficient for HCV); sharing injecting equipment; skin puncture by blood-contaminated sharp objects (e.g., needles, instruments or glass); and childbirth (i.e., the mother infects the child either before or during birth, or through breast-feeding) (All Answers Ltd, 2018).

Less common routes of transmission include: contamination of open wounds (e.g., blood injuries during sporting activities); contamination of skin lesions (e.g., eczema); splashing of the mucous membranes of the eye, nose or mouth; and human bites when blood is drawn (this may be more of a problem in certain occupations, such as the prison and police service, where frontline workers may be exposed to violent behaviour) (HSE, no date b).

There is also a risk of acquiring a blood-borne virus infection via blood transfusion. For example, in the UK, all blood donations are screened for HBV, HCV and HIV, meaning the risk is remote (HSE, no date b).

Health care workers are at risk of infection with blood-borne pathogens because of occupational exposure to blood and body fluids. Most exposures are caused by 'sharps' – contaminated sharp objects, such as syringe needles, scalpels and broken glass. The three infections most commonly transmitted to health care workers are HBV, HCV and HIV (WHO, 2002).

Among the 35 million health care workers worldwide, about three million receive percutaneous exposures to blood-borne pathogens each year; 2 million of those to HBV, 0.9 million to HCV and 170,000 to HIV. These injuries may result in 15,000 HCV, 70,000 HBV and 500 HIV infections. More than 90% of these infections occur in developing countries. Worldwide, about 40% of HBV and HCV infections and 2.5% of HIV infections in health care workers are attributable to occupational sharps exposures (WHO, 2002). However, other blood-borne pathogens still pose a risk: for example, in the 2013–2016 Ebola virus disease outbreak, over 890 health-care workers were infected, with a case fatality rate of 57% (Auta et al., 2017).

These infections are for the major part preventable, as shown by the low rates achieved in certain countries that have engaged in serious prevention efforts, including training of health care workers, HBV immunisation, post-exposure prophylaxis and improved waste management. In addition to the disease burden caused to health care workers, the functioning of the health care system may be reduced because of impaired working capacity, especially in developing countries where the proportion of health care workers in the population is already small compared with that in developed countries (WHO, 2005).

Metrics and numeric limits

Not applicable.

Key relevant UN convention/multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

For health care and other emergency workers standard precautions are meant to reduce the risk of transmission of blood-borne and other pathogens from both recognised and unrecognised sources (WHO, 2007). Standard precautions are the basic level of infection control precautions which are to be used, as a minimum, in the care of all patients.

Hand hygiene is a major component of standard precautions and one of the most effective methods to prevent transmission of pathogens associated with health care. In addition to hand hygiene, the use of personal protective equipment should be guided by risk assessment and the extent of contact anticipated with blood and body fluids, or pathogens (WHO, 2007).

In addition to practices carried out by health workers when providing care, all individuals (including patients and visitors) should comply with infection control practices in health-care settings. The control of spread of pathogens from the source is key to avoid transmission. Among source control measures, respiratory hygiene/cough etiquette is now considered as part of standard precautions (WHO, 2007).

Worldwide escalation of the use of standard precautions would reduce unnecessary risks associated with health care. Promotion of an institutional safety climate helps to improve conformity with recommended measures and thus subsequent risk reduction. Provision of adequate staff and supplies, together with leadership and education of health workers, patients, and visitors, is critical for an enhanced safety climate in health-care settings (WHO, 2007).

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WHO, 2016. International Health Regulations (2005), 3rd ed. World Health Organization (WHO). https://apps.who.int/iris/handle/10665/246107 Accessed 26 September 2020.

Coordinating agency or organisation

World Health Organization.

BI0018 / **BIOLOGICAL** / **Infectious Diseases (Human and Animal)**

Waterborne Diseases

Definition

Waterborne diseases are those diseases that are transmitted by ingestion of contaminated water (WHO, 2012).

Reference

WHO, 2012. Disease information. World Health Organization (WHO). https://www.who.int/travel-advice/disease-information Accessed 19 September 2020.

Annotations

Synonyms

Not applicable.

Additional scientific description

Important waterborne diseases include diarrhoeal diseases, cholera, shigella, typhoid, hepatitis A and E, and poliomyelitis (WHO, 2012).

Diarrhoea occurs worldwide and causes 4% of all deaths and 5% of health loss to various forms of disability or loss of function. It is most commonly caused by gastrointestinal infections which kill around 2.2 million people globally each year, mostly children in developing countries. Use of water in hygiene is an important preventive measure but contaminated water is also an important cause of diarrhoea. Cholera and dysentery cause severe, sometimes life-threatening forms of diarrhoea (WHO, 2016a).

Diarrhoea is the passage of loose or liquid stools more frequently than is normal for the individual. It is primarily a symptom of gastrointestinal infection. Depending on the type of infection, the diarrhoea may be watery (for example in cholera) or passed with blood (in dysentery, for example). Diarrhoea due to infection may last a few days, or several weeks, as in persistent diarrhoea. Severe diarrhoea may be life-threatening due to fluid loss in watery diarrhoea, particularly in infants and young children, the malnourished and people with impaired immunity. The impact of repeated or persistent diarrhoea on nutrition and the effect of malnutrition on susceptibility to infectious diarrhoea can be linked in a vicious cycle among children, especially in developing countries. Diarrhoea is also associated with other infections such as malaria and measles. Chemical irritation of the gut or non-infectious bowel disease can also result in diarrhoea (WHO, 2016a).

Diarrhoea is a symptom of infection caused by a host of bacterial, viral and parasitic organisms most of which can be spread by contaminated water. It is more common when there is a shortage of clean water for drinking, cooking and cleaning and basic hygiene is important in prevention. Water contaminated with human faeces, for example, from municipal sewage, septic tanks and latrines is of special concern. Animal faeces also contain microorganisms that can cause diarrhoea. Diarrhoea can also spread from person to person, aggravated by poor personal hygiene. Food is another major cause of diarrhoea when it is prepared or stored in unhygienic conditions. Water can contaminate food during irrigation, and fish and seafood from polluted water may also contribute to the disease (WHO, 2016).

The infectious agents that cause diarrhoea are present or are sporadically introduced throughout the world. Diarrhoea is a rare occurrence for most people who live in developed countries where sanitation is widely available, access to safe water is high and personal and domestic hygiene is relatively good. Worldwide around 1.1 billion people lack access to improved water sources and 2.4 billion have no basic sanitation. Diarrhoea due to infection is widespread throughout the developing world. In Southeast Asia and Africa, diarrhoea is responsible for as much as 8.5% and 7.7% of all deaths, respectively (WHO, 2016a).

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016b).

Examples of drivers, outcomes and risk management

Water safety and quality are fundamental to human development and well-being. Providing access to safe water is one of the most effective instruments in promoting health and reducing poverty. As the international authority on public health and water quality, the World Health Organisation leads global efforts to prevent transmission of waterborne disease. This is achieved by promoting health-based regulations to governments and working with partners to promote effective risk management practices to water suppliers, communities and households (WHO, 2019).

Key measures to reduce the number of cases of waterborne diseases include: access to safe drinking water; improved sanitation; good personal and food hygiene; and health education about how infections spread (WHO, 2016).

References

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WHO, 2016a. Water-related Diseases. World Health Organization (WHO). www.who.int/water_sanitation_health/diseases-risks/diseases/diarrhoea/en Accessed 19 September 2020.

WHO, 2016b. International Health Regulations (2005), 3rd ed. World Health Organization (WHO). https://apps.who.int/iris/handle/10665/246107 Accessed 26 September 2020.

WHO, 2019. Water safety and quality. World Health Organization (WHO). www.who.int/water_sanitation_health/water-quality/en Accessed 19 September 2020.

Coordinating agency or organisation

World Health Organization.

BI0019 / **BIOLOGICAL** / **Infectious Diseases (Human and Animal)**

Foodborne Diseases

Definition

Foodborne diseases are transmitted by consumption of contaminated biological food and drink (WHO, 2012). These diseases are caused by eating food contaminated with bacteria, viruses, parasites or chemical substances (WHO, no date).

Reference

WHO, no date. Foodborne Diseases. World Health Organization (WHO). www.who.int/health-topics/foodborne-diseases#tab=tab_1 Accessed 7 April 2021.

WHO, 2012. Disease information. World Health Organization (WHO). www.who.int/travel-advice/disease-information Accessed 19 September 2020.

Annotations

Synonyms

Not applicable.

Additional scientific description

Over 200 diseases are caused by ingestion of food that is contaminated with bacteria, viruses, parasites or chemical substances such as heavy metals. This growing public health concern causes considerable socioeconomic impacts though strains on health-care systems, lost productivity, and harm to tourism and trade. These diseases contribute significantly to the global burden of disease and mortality (WHO, no date).

The contamination of food, may occur at any stage of the food production, delivery and consumption chain. Foodborne diseases can result from several forms of environmental contamination, including pollution in water, soil or air, as well as unsafe food storage and processing (WHO, no date).

Foodborne diseases encompass a wide range of illnesses from diarrhoea to cancers. Most present as gastrointestinal issues, although they can also produce neurological, gynaecological and immunological symptoms. Diseases causing diarrhoea are a major problem in all countries of the world, although the burden is carried disproportionately by low- and middle-income countries and by children under 5 years of age (WHO, no date).

Every year, nearly one in 10 people around the world fall ill after eating contaminated food, leading to over 420,000 deaths. Children are disproportionately affected, with 125,000 deaths every year in people under 5 years of age. The majority of these cases are caused by diarrhoeal diseases. Other serious consequences of foodborne diseases include kidney and liver failure, brain and neural disorders, reactive arthritis and cancer (WHO, no date).

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Codex Alimentarius (FAO and WHO, no date).

Examples of drivers, outcomes and risk management

Foodborne diseases are closely linked to poverty in low- and middle-income countries but are a growing public health issue around the world. Increasing international trade and longer, more complex food chains increase the risk of food contamination and the transport of infected food products across national borders. Growing cities, climate change, migration and growing international travel compound these issues and expose people to new hazards (WHO, no date).

The World Health Organization (WHO) works to assist Member States in building capacity to prevent, detect and manage foodborne risks. Foodborne diseases are reflected in several targets of United Nations Sustainable Developmental Goal 3 and are a priority area within WHO's work (UNRIC, no date). Activities include research and independent scientific assessments of food-related hazards, foodborne disease awareness programmes, and helping to promote food safety through national healthcare programmes (WHO, no date).

The WHO Five Keys to Safer Food manual provides straightforward tips and guidelines on how to produce, process, handle and consume food, to limit spreading and contracting foodborne illnesses (WHO, 2006).

The Food and Agriculture Organization of the United Nations (FAO) and WHO created the Codex Alimentarius Commission, a nongovernmental interagency organisation tasked with creating food standards, guidelines, and codes of practice that contributes to the safety, quality, and fairness of the international food trade (FAO and WHO, no date). The two agencies also developed the International Food Safety Authorities Network (INFOSAN) to share information rapidly during food safety emergencies.

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WHO, no date. Foodborne diseases. World Health Organization (WHO). www.who.int/health-topics/foodborne-diseases#tab=tab_1 Accessed 19 September 2020.

WHO, 2006. Five Keys to Safer Food Manual. World Health Organization (WHO). www.who.int/publications/i/item/9789241594639 Accessed 19 September 2020.

WHO, 2016. International Health Regulations (2005), 3rd ed. World Health Organization (WHO). https://apps.who.int/iris/handle/10665/246107 Accessed 26 September 2020.

Coordinating agency or organisation

World Health Organization, Food and Agriculture Organization of the United Nations.

BI0020 / **BIOLOGICAL** / **Infectious Diseases (Human and Animal)**

Sexually Transmitted Diseases (Human)

Definition

Sexually transmitted diseases are infections transmitted from an infected person to an uninfected person through sexual contact (WHO, no date).

Reference

WHO, no date. Sexually Transmitted Infections (STIs). Fact Sheet. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/sexually-transmitted-infections-(stis) Accessed 14 September 2020.

Annotations

Synonyms

Sexually transmitted infections, STIs.

Additional scientific description

Sexually transmitted diseases (STDs) are spread predominantly by sexual contact, including vaginal, anal and oral sex. Some sexually transmitted diseases can also be transmitted through non-sexual means such as via blood or blood products. Many sexually transmitted diseases, including syphilis, hepatitis B, human immunodeficiency virus (HIV), chlamydia, gonorrhoea, herpes, and human papillomavirus (HPV), can also be transmitted from mother to child during pregnancy and childbirth (WHO, no date).

More than 30 different bacteria, viruses and parasites are known to be transmitted through sexual contact. Eight of these pathogens are linked to the greatest incidence of sexually transmitted disease. Of these eight infections, four are currently curable: syphilis, gonorrhoea, chlamydia and trichomoniasis. The other four are viral infections which are incurable: hepatitis B, herpes simplex virus (HSV or herpes), HIV, and HPV. Symptoms or disease due to the incurable viral infections can be reduced or modified through treatment (WHO, no date).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016a).

Examples of drivers, outcomes and risk management

More than 1 million sexually transmitted diseases are acquired every day (WHO, no date).

In 2016, it was estimated that there were 376 million new infections attributable to one of four sexually transmitted diseases: chlamydia (127 million), gonorrhoea (87 million), syphilis (6.3 million) and trichomoniasis (156 million) (Rowley et al., 2019).

Sexually transmitted diseases can increase vulnerability to other diseases – for example, herpes and syphilis can increase the risk of HIV acquisition three-fold or more. Furthermore, mother-to-child transmission of sexually transmitted diseases can result in adverse birth outcomes including stillbirth, neonatal death, low-birthweight and prematurity, sepsis, pneumonia, neonatal conjunctivitis, and congenital deformities (WHO, no date).

One important prevention tool against sexually transmitted infections is vaccination. Currently, vaccines are available to protect against infection with HPV, hepatitis A and hepatitis B (WHO, 2016b).

Antimicrobial resistance of sexually transmitted diseases, in particular gonorrhoea, has increased rapidly in recent years, making preventative approaches such as counselling and access to barrier methods an important part of effective risk management for these diseases (WHO, no date).

The World Health Organization is working with countries and partners with regard to sexually transmitted disease prevention and treatment, through the Global Health Sector Strategy on Sexually Transmitted Infections 2016–2021, including the setting of global norms and standards, strengthening surveillance systems (including for antimicrobial resistance) and supporting the delivery of a global research agenda on sexually transmitted diseases (WHO, 2016b).

References

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WHO, 2016a. International Health Regulations (2005), 3rd ed. World Health Organization (WHO). https://apps.who.int/iris/handle/10665/246107 Accessed 26 September 2020.

WHO, 2016b. Global Health Sector Strategy on Sexually Transmitted Infections, 2016-2021. World Health Organization (WHO). http://apps.who.int/gb/ebwha/pdf_files/WHA69/A69_33-en.pdf?ua=1 Accessed 14 September 2020.

Coordinating agency or organisation

World Health Organization.

BI0021 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Neglected Tropical Diseases (Human)

Definition

Neglected tropical diseases (NTDs) are a diverse group of communicable diseases caused by bacteria, viruses or parasites that prevail in tropical and subtropical conditions (WHO, no date). Twenty diseases and disease groups are addressed in the global roadmap for NTDs 2021–2030 (WHO, 2020).

Reference

WHO, no date. Neglected Tropical Diseases. World Health Organization (WHO). www.who.int/neglected_diseases/diseases/en Accessed 14 September 2020.

WHO, 2020. Ending the neglect to attain the sustainable development goals: a road map for neglected tropical diseases 2021–2030: overview. World Health Organization (WHO). https://apps.who.int/iris/handle/10665/332094

Annotations

Synonyms

Not applicable.

Additional scientific description

Neglected tropical diseases (NTDs) affect more than one billion people and cost developing economies billions of dollars every year. They are often termed ‘neglected’ as the people who are most affected are the poorest populations living in rural areas, urban slums and conflict zones (WHO, no date). More than 200,000 people die each year from snakebite envenoming, rabies and dengue alone, and lack of timely access to affordable treatment leaves hundreds of millions severely disabled, disfigured or debilitated (WHO, 2015).

Populations living in poverty, without adequate sanitation and in close contact with infectious vectors and domestic animals and livestock are those worst affected. Affecting the world’s poorest people, neglected tropical diseases impair physical and cognitive development, contribute to mother and child illness and death, make it difficult to farm or earn a living, and limit productivity in the workplace. As a result, neglected tropical diseases trap the poor in a cycle of poverty and disease (WHO, no date).

At present, the World Health Organization (WHO) categorises the following communicable diseases as NTDs: Buruli Ulcer, Chagas Disease, Chromoblastomycosis, Cysticercosis, Dengue Fever, Dracunculiasis (Guinea Worm Disease), Echinococcosis, Fascioliasis, Human African Trypanosomiasis (African Sleeping Sickness), Leishmaniasis, Leprosy (Hansen’s Disease), Lymphatic Filariasis, Mycetoma, Onchocerciasis, Rabies, Schistosomiasis, Soil-transmitted Helminths (Ascaris, Hookworm, and Whipworm), Trachoma, Yaws (WHO, no date).

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

The WHO Roadmap on neglected tropical diseases, underpinned by successive World Health Assembly resolutions, sets out a comprehensive plan for the control, elimination and eradication of neglected tropical diseases by 2030 that succeeded an earlier plan for 2011–2020 (WHO, 2012, 2020).

Effective control of neglected tropical diseases can be achieved when: public health approaches are combined and delivered locally; interventions are guided by the local epidemiology and the availability of appropriate measures to detect, prevent and control diseases; and implementation of appropriate measures with high coverage has the potential to result in the elimination and eradication of a number of neglected tropical diseases (WHO, no date).

The WHO recommends five public-health interventions to accelerate the prevention, control, elimination and eradication of neglected tropical diseases: preventive chemotherapy; innovative and intensified disease management; vector control and pesticide management; safe drinking-water, basic sanitation and hygiene services, and education; and zoonotic disease management (WHO, 2012).

The following neglected tropical diseases can be controlled or even eliminated through mass administration of safe and effective medicines (mass drug administration), or other, effective interventions: dracunculiasis (Guinea Worm Disease); lymphatic filariasis; onchocerciasis; schistosomiasis; soil-transmitted helminths; and trachoma (CDC, no date).

References

CDC, no date. Neglected Tropical Diseases. Centres for Disease Control and Prevention (CDC). www.cdc.gov/globalhealth/ntd/diseases/index.html Accessed 14 September 2020.

WHO, no date. Neglected Tropical Diseases. World Health Organization (WHO). www.who.int/neglected_diseases/diseases/en Accessed 14 September 2020.

WHO, 2012. Accelerating work to overcome the global impact of neglected tropical diseases: a roadmap for implementation. World Health Organization (WHO). www.who.int/neglected_diseases/NTD_RoadMap_2012_Fullversion.pdf#:~:text=Accelerating%20work%20to%20overcome%20the%20global%20impact%20of,%28Director%2C%20WHO%20Department%20of%20Control%20of%20Neglected%20Tropical Accessed 14 September 2020.

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Coordinating agency or organisation

World Health Organization.

BI0022 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Vaccine-Preventable Diseases (Human)

Definition

Vaccine preventable diseases are those infectious diseases that can be prevented by vaccination (WHO, 2012).

Reference

WHO, 2012. Vaccine-preventable diseases and vaccines. In: International Travel and Health, Chapter 6. World Health Organization (WHO). www.who.int/ith/ITH-Chapter6.pdf Accessed 20 September 2020.

Annotations

Synonyms

Not applicable.

Additional scientific description

Immunisation, the use of vaccines to produce immunity to specific diseases, is a global health and development success story, saving millions of lives every year. Vaccination is a highly effective method of preventing certain infectious diseases. Vaccines reduce risks of getting a disease by working with each individual's natural defences to build protection (WHO, no date). Vaccines are generally very safe, and serious adverse reactions are uncommon (WHO, 2012).

Health care now has vaccines to prevent more than 20 life-threatening diseases, helping people of all ages live longer, healthier lives. Immunisation currently prevents 2–3 million deaths every year from diseases such as diphtheria, tetanus, pertussis, influenza and measles (WHO, no date).

Immunisation is a key component of primary health care and an indisputable human right. It is also one of the most cost-effective health investments. Vaccines are also critical to the prevention and control of infectious-disease outbreaks. They underpin global health security and are a vital tool in the battle against antimicrobial resistance (WHO, no date).

Despite considerable progress, many people around the world (including nearly 20 million infants each year) have insufficient access to vaccines. In some countries, progress has stalled or even reversed, and there is a risk that complacency will undermine past achievements (WHO, no date).

Global vaccination coverage – the proportion of the world's children who receive recommended vaccines – has remained the same over the past few years (WHO, no date).

Vaccines train the immune system in humans to create antibodies (WHO, no date).

Vaccines protect against many diseases, including: cervical cancer, cholera, diphtheria, hepatitis B, influenza, Japanese encephalitis, measles, meningitis, mumps, pertussis, pneumonia, polio, rabies, rotavirus, rubella, tetanus, typhoid, varicella, and yellow fever (WHO, no date).

A vaccine against Ebola Virus Disease, which has been prequalified by the World Health Organization (WHO), was developed after disease outbreaks in the Democratic Republic of Congo from 2018 (WHO, 2019).

Not all of these vaccinations are needed in every country (WHO, 2018). Some may only be given prior to travel, in areas of risk, or to people in high-risk occupations. Working with healthcare workers it is important to determine which vaccinations are needed, when and by whom (WHO, no date).

Vaccines contain weakened or inactive parts of a particular organism (antigen) that triggers an immune response within the body. Newer vaccines contain the blueprint for producing antigens rather than the antigen itself. Regardless of whether the vaccine is made up of the antigen itself or the blueprint so that the body will produce the antigen, this weakened version will not cause the disease in the person receiving the vaccine (WHO, 2021).

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

The Global Vaccine Action Plan 2011–2020, endorsed by the 194 Member States of the World Health Assembly in May 2012, is a framework to prevent millions of deaths by 2020 through more equitable access to existing vaccines for people in all communities (WHO, 2013). The Global Vaccine Action Plan was the product of the Decade of Vaccines Collaboration, an unprecedented effort that brought together development, health and immunisation experts, and stakeholders (WHO, 2013).

The WHO is working with countries and partners to improve global vaccination coverage, through the Global Vaccine Action Plan 2011–2020 (WHO, 2013). Through the plan, the WHO:

- Helps all countries to commit to immunisation as a priority, which means it works with them to set national targets and plans, as well as allocate adequate financial and human resources.
- Supports individuals and communities to understand the value of vaccines and demand immunisation as both their right and responsibility.
- Develops plans and materials to ensure every person is reached with vaccines.
- Strengthens immunisation systems so that they can serve as a platform for delivering other health interventions.
- Works to increase funding for immunisation and ensure safe and reliable vaccine supply systems.
- Develops targeted research and development innovations for new and improved vaccines.

The WHO also works with UNICEF each year to produce national immunisation coverage estimates for Member States. In 2020, the WHO worked with Member States to develop the 'Immunization Agenda 2030' (WHO, 2020). With the support of countries and partners, the WHO is leading the co-creation of a new global vision and strategy to address these challenges over the coming decade, to be endorsed by the World Health Assembly. The Immunisation Agenda 2030 envisions a world where everyone, everywhere, at every age, fully benefits from vaccines to improve health and well-being (WHO, 2020).

References

WHO, no date. Vaccines and immunization. World Health Organization (WHO). www.who.int/health-topics/vaccines-and-immunization#tab=tab_1 Accessed 20 September 2020.

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WHO, 2020. Immunization Agenda 2030: A Global Strategy to Leave No One Behind. World Health Organization (WHO). www.who.int/immunization/immunization_agenda_2030/en Accessed 20 September 2020.

WHO, 2021. How do vaccines work? World Health Organization (WHO). www.who.int/news-room/feature-stories/detail/how-do-vaccines-work

Coordinating agency or organisation

World Health Organization.

BI0023 / **BIOLOGICAL / Infectious Disease (Human and Animal)**

Vector Borne Diseases (VBD) (Human)

Definition

Vector borne diseases encompass a variety of illnesses that are caused via the spread of pathogens by living organisms known as vectors. These infectious diseases can be transmitted via vectors among humans (e.g., malaria, dengue), among animals (e.g., African swine fever, East Coast fever), or from animals to humans (e.g., Nipah virus disease). Many of these vectors are bloodsucking insects, and mosquitoes are the best-known disease vector. Other vectors include ticks, flies, sandflies, fleas, triatomine bugs and some species of freshwater aquatic snails (adapted from OIE, 2019; WHO, 2020).

References

OIE, 2019. Manual of Diagnostic Tests and Vaccines for Terrestrial Animals. World Organisation of Animal Health (OIE). www.oie.int/en/standard-setting/terrestrial-manual/access-online Accessed 11 October 2020.

WHO, 2020. Vector-borne Diseases. World Health Organisation (WHO). www.who.int/news-room/fact-sheets/detail/vector-borne-diseases Accessed 11 October 2020.

Annotations

Synonyms

Not applicable.

Additional scientific description

Vectors are living organisms that can transmit infectious pathogens between humans, or from animals to humans. Many of these vectors are bloodsucking insects, which ingest disease-producing microorganisms during a blood meal from an infected host (human or animal) and later transmit it into a new host, after the pathogen has replicated. Often, once a vector becomes infectious, they are capable of transmitting the pathogen for the rest of their life during each subsequent bite/blood meal (WHO, 2020).

Vector-borne diseases are human illnesses caused by parasites, viruses and bacteria that are transmitted by vectors. Every year there are more than 700,000 deaths from diseases such as malaria, dengue, schistosomiasis, human African trypanosomiasis, leishmaniasis, Chagas disease, yellow fever, Japanese encephalitis and onchocerciasis (WHO, 2020).

The burden of these diseases is highest in tropical and subtropical areas, and they disproportionately affect the poorest populations. Since 2014, major outbreaks of dengue, malaria, chikungunya, yellow fever and Zika have afflicted populations, claimed lives, and overwhelmed health systems in many countries. Other diseases such as Chikungunya, leishmaniasis and lymphatic filariasis cause chronic suffering, life-long morbidity, disability and occasional stigmatisation (WHO, 2020).

Vector-borne diseases account for more than 17% of all infectious diseases, causing more than 700,000 deaths annually. They may be caused by parasites, bacteria or viruses (WHO, 2020). Examples of vector borne diseases include:

- Malaria is a parasitic infection transmitted by Anopheline mosquitoes. Malaria causes an estimated 219 million cases globally, and results in more than 400,000 deaths every year. Most of the deaths occur in children under the age of 5 years (WHO, 2020).
- Dengue is the most prevalent viral infection transmitted by Aedes mosquitoes. More than 3.9 billion people in over 129 countries are at risk of contracting dengue, with an estimated 96 million symptomatic cases and an estimated 40,000 deaths every year (WHO, 2020).
- Other viral diseases transmitted by vectors include chikungunya fever, Zika virus fever, yellow fever, West Nile fever, Japanese encephalitis (all transmitted by mosquitoes), and tick-borne encephalitis (transmitted by ticks) (WHO, 2020).
- Other vector-borne diseases such as Chagas disease (transmitted by triatomine bugs), leishmaniasis (sandflies) and schistosomiasis (snails) affect hundreds of millions of people worldwide (WHO, 2020).

The table is a non-exhaustive list of vector-borne diseases, ordered according to the vector by which it is transmitted. The list also illustrates the type of pathogen that causes the disease in humans (WHO, 2020):

Vector		Disease caused	Type of pathogen
Mosquito	Aedes	Chikungunya	Virus
		Dengue	Virus
		Lymphatic filariasis	Parasite
		Rift Valley fever	Virus
		Yellow Fever	Virus
		Zika	Virus
	Anopheles	Lymphatic filariasis	Parasite
		Malaria	Parasite
	Culex	Japanese encephalitis	Virus
		Lymphatic filariasis	Parasite
		West Nile fever	Virus
Aquatic snails		Schistosomiasis (bilharziasis)	Parasite
Blackflies		Onchocerciasis (river blindness)	Parasite
Fleas		Plague (transmitted from rats to humans)	Bacteria
		Tungiasis	Ectoparasite
Lice		Typhus	Bacteria
		Louse-borne relapsing fever	Bacteria
Sandflies		Leishmaniasis	Bacteria
		Sandfly fever (phlebotomus fever)	Virus
Ticks		Crimean-Congo haemorrhagic fever	Virus
		Lyme disease	Bacteria
		Relapsing fever (borreliosis)	Bacteria
		Rickettsial diseases (e.g. spotted fever and Q fever)	Bacteria
		Tick-borne encephalitis	Virus
		Tularaemia	Bacteria
Triatome bugs		Chagas disease (American trypanosomiasis)	Parasite
Tsetse flies		Sleeping sickness (African trypanosomiasis)	Parasite

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (1994) (WTO, 1994).

WTO and the World Organization for Animal Health (OIE) (WTO, 1998).

UN Recommendations on the Transport of Dangerous Goods (UNECE, no date).

Examples of drivers, outcomes and risk management

Previously relatively stable geographical distributions are now changing owing to a range of factors, including climate change, intensive farming, dams, irrigation, deforestation, population movements, rapid unplanned urbanisation, and phenomenal increases in international travel and trade (WHO, 2014).

Many vector-borne diseases are preventable, through protective measures, and community mobilisation (WHO, 2020).

The World Health Organization (WHO) has taken forward the Global Vector Control Response (GVCR) 2017–2030 (WHO, 2017) which was approved by the World Health Assembly in 2017. It provides strategic guidance to countries and development partners for urgent strengthening of vector control as a fundamental approach to preventing disease and responding to outbreaks. To achieve this a re-alignment of vector control programmes is required, supported by increased technical capacity, improved infrastructure, strengthened monitoring and surveillance systems, and greater community mobilisation. Ultimately, this will support implementation of a comprehensive approach to vector control that will enable the achievement of disease-specific national and global goals and contribute to achievement of the Sustainable Development Goals (UN, 2015) and Universal Health Coverage (WHO, 2020). Specifically, the WHO responds to vector-borne diseases by: providing evidence-based guidance for controlling vectors and protecting people against infection; providing technical support to countries so that they can effectively manage cases and outbreaks; supporting countries to improve their reporting systems and capture the true burden of the disease; providing training (capacity building) on clinical management, diagnosis and vector control with support from some of its collaborating centres; and supporting the development and evaluation of new tools, technologies and approaches for vector-borne diseases, including vector control and disease management technologies (WHO, 2020).

A crucial element in reducing the burden of vector-borne diseases is behavioural change. The WHO works with partners to provide education and improve public awareness, so that people know how to protect themselves and their communities from mosquitoes, ticks, bugs, flies and other vectors (WHO, 2020).

Access to water and sanitation is a very important factor in disease control and elimination. The WHO works together with many different government sectors to improve water storage and sanitation, thereby helping to control these diseases at the community level (WHO, 2020).

Rapid progress has been made in recent years in developing policy mandates, operational frameworks and pilot initiatives on health adaptation to climate change, including vector-borne disease as a particular priority. These present an excellent opportunity for a stronger and more coherent connection of applied research and public health policy (Campbell-Lendrum et al., 2015).

Applied research is nevertheless essential to ensure continued progress in reducing the burden of vector-borne diseases in the face of the additional challenges caused by anthropogenic climate change, along with rapid changes in other environmental and social determinants. To increase relevance to current health programming, there is a need to complement current work on detection and attribution of health effects to climate change, and modelling of future scenarios, with a more directly applied approach to assessing and managing climate-related risks in the present (Campbell-Lendrum et al., 2015).

References

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Coordinating agency or organisation

World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO), World Organisation for Animal Health (OIE).

BI0024 / **BIOLOGICAL** / **Infectious Diseases (Human and Animal)**

Viral Haemorrhagic Fevers (Human)

Definition

Viral haemorrhagic fever is a general term for severe illnesses, sometimes associated with bleeding, that may be caused by a number of viruses. The term is usually applied to diseases caused by viruses that belong to the Arenaviridae, Bunyaviridae, Filoviridae and Flaviviridae families (WHO, no date).

Reference

WHO, no date. Haemorrhagic fevers: Viral. World Health Organization (WHO). www.who.int/topics/haemorrhagic_fevers_viral/en Accessed 13 December 2019.

Annotations

Synonyms

Not found.

Additional scientific description

The term ‘viral haemorrhagic fever’ is used to describe a severe multisystem syndrome (multisystem in that multiple organ systems in the body are affected). Characteristically, the overall vascular system is damaged, and the body’s ability to regulate itself is impaired. Symptoms are often accompanied by haemorrhage (bleeding); however, the bleeding is itself rarely life-threatening. While some types of haemorrhagic fever viruses can cause relatively mild illnesses, many of these viruses cause severe, life-threatening disease (CDC, 2014).

Viruses associated with viral haemorrhagic fever naturally reside in animal reservoir hosts or arthropod vectors. They depend on their hosts for survival and so are usually restricted to the geographic area inhabited by those animals or arthropod vectors (PHE, 2018).

Viral haemorrhagic fever (viruses) include:

Arenaviridae

- Argentine haemorrhagic fever (Junin virus)
- Bolivian haemorrhagic fever (Machupo virus)
- Lassa fever (Lassa virus)
- Venezuelan haemorrhagic fever (Guanarito virus)
- Brazilian haemorrhagic fever (Sabia)
- Chapare haemorrhagic fever (Chapare)
- Lujo haemorrhagic fever (Lujo)

Bunyaviridae

- Rift Valley Fever (Rift Valley Fever virus)
- Crimean-Congo haemorrhagic fever (Nairovirus)
- Hanta Virus Haemorrhagic fevers (Hantaviruses)

Flaviviridae

- Yellow fever (Yellow fever virus)

- Dengue fever/dengue haemorrhagic fever (Dengue viruses)
- Omsk haemorrhagic fever (Omsk hemorrhagic fever virus)
- Kyasanur forest disease (Kyasanur Forest disease virus)
- Alkhurma disease (Alkhurma virus)

Filoviridae

- Ebola (Ebolavirus)
- Marburg haemorrhagic fever (Marburgvirus)

Note that this is not an exhaustive list (CDC, 2018).

Humans may acquire viral haemorrhagic fever viruses when they come into close contact with live animal hosts, animal carcasses during slaughtering and/or animal droppings. Tick or mosquito bites can transmit some of the viruses, such as Crimean-Congo fever and yellow fever, between animal species, including humans. Dengue is currently the mosquito borne viral haemorrhagic fever with the highest public health impact worldwide with an estimate of 390 million infections every year in tropical areas where the Aedes mosquitoes are widespread (WHO, 2020).

For other viruses, animals are the host (PHE, 2018). Direct transmission of the virus through contact with the body fluids or secretions of infected patients is also possible for some of the viruses (WHO, no date).

Several viral haemorrhagic fevers are prone to outbreaks and epidemics with high case fatality rates. These include Ebola, Lassa fever and Crimean-Congo haemorrhagic fever. These diseases are part of the priority list for the World Health Organization (WHO) Research and Development Blueprint for Action to Prevent Epidemics (WHO, 2016a).

Because increasing numbers of people travel each year, outbreaks of these diseases are becoming an increasing threat in non-endemic areas (PHE, 2018).

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016b).

Examples of drivers, outcomes and risk management

Viral haemorrhagic fevers occur widely in tropical and subtropical regions (WHO, no date).

Most of them have a non-human natural reservoir, with some transmitted by mosquitoes or ticks. A small number are preventable by vaccine (e.g., yellow fever) and others have potential vaccines and treatments in different stages of development (WHO, no date).

Prevention efforts must concentrate on avoiding contact with host species and they are often focused on controlling animal hosts and vector populations (PHE, 2018).

References

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CDC, 2018. Virus families. Centers for Disease Control and Prevention (CDC). www.cdc.gov/vhf/virus-families/index.html Accessed 13 December 2019.

PHE, 2018. Viral haemorrhagic fevers: origins, reservoirs, transmission and guidelines. Public Health England (PHE). www.gov.uk/guidance/viral-haemorrhagic-fevers-origins-reservoirs-transmission-and-guidelines Accessed 13 December 2019.

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Coordinating agency or organisation

World Health Organization.

BI0025 / **BIOLOGICAL** / **Infectious Diseases (Human and Animal)**

Antimicrobial Resistant Microorganisms (Human)

Definition

Antimicrobial resistant microorganisms are those microorganisms (such as bacteria, fungi, viruses, and parasites) that change when they are exposed to antimicrobial drugs (such as antibiotics, antifungals, antivirals, antimalarials, and anthelmintic). Microorganisms that develop antimicrobial resistance are sometimes referred to as 'superbugs'. As a result, the medicines become ineffective and infections persist in the body, increasing the risk of spread to others (WHO, 2020).

Reference

WHO, 2020. Antimicrobial resistance. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance Accessed 27 September 2020.

Annotations

Synonyms

Superbugs.

Additional scientific description

Antimicrobial resistance occurs naturally over time, usually through genetic changes. However, the misuse and overuse of antimicrobials is accelerating this process. In many places, antibiotics are overused and misused in people and animals, and often given without professional oversight. Examples of misuse include when antibiotics are taken by people with viral infections like colds and flu, and when they are given as growth promoters in animals or used to prevent diseases in healthy animals (WHO, 2020).

Antimicrobial resistant organisms, sometimes referred to as 'superbugs', are found in people, animals, food, and the environment (in water, soil and air). They can spread between people and animals, including from food of animal origin, and from person to person. Poor infection control, inadequate sanitary conditions and inappropriate food-handling encourage the spread of antimicrobial resistance (WHO, 2020).

Present situation (WHO, 2020): Antimicrobial resistance is an increasingly serious threat to global public health that requires action across all government sectors and society. It threatens the effective prevention and treatment of an ever-increasing range of infections caused by bacteria, parasites, viruses and fungi. New resistance mechanisms are emerging and spreading globally, threatening our ability to treat common infectious diseases, resulting in prolonged illness, disability, and death. Without effective antibiotics, the success of major surgery and cancer chemotherapy would be compromised. The cost of health care for patients with resistant infections is higher than care for patients with non-resistant infections due to longer duration of illness, additional tests and use of more expensive drugs. Antimicrobial resistance endangers achievement of the Sustainable Development Goals (UNDESA, 2021).

Resistance in bacteria (WHO, 2020): Patients with infections caused by drug-resistant bacteria are at increased risk of worse clinical outcomes and death and consume more health-care resources than patients infected with non-resistant strains of the same bacteria. Resistance in E. coli to one of the most widely used medicines for the treatment of urinary tract infections (fluoroquinolone antibiotics) is very widespread. Treatment failure to the last resort of medicine for gonorrhoea has been confirmed in at least 10 countries (Australia, Austria, Canada, France, Japan, Norway, Slovenia, South Africa, Sweden, United Kingdom). Resistance to first-line drugs to treat infections caused by Staphylococcus aureus – a common cause of severe infections in health facilities and the community – is widespread. People with MRSA (methicillin-resistant Staphylococcus aureus) are estimated to be 64% more likely to die than people with a non-resistant form of the infection.

Resistance in tuberculosis (TB) (WHO, 2020): In 2016, an estimated 490,000 people developed multi-drug resistant TB (MDR-TB), globally. MDR-TB is a form of tuberculosis that is resistant to the anti-TB drugs. It requires treatment courses that are much longer and less effective than those for non-resistant TB. Globally, only half of MDR-TB patients were successfully treated in 2014. Extensively drug-resistant tuberculosis (XDR-TB), a form of tuberculosis that is resistant to at least four of the core anti-TB drugs, has been identified in 105 countries. An estimated 9.7% of people with MDR-TB have XDR-TB.

Resistance in malaria (WHO, 2020): As of July 2016, resistance to the first-line treatment for P. falciparum malaria (artemisinin-based combination therapies, also known as ACTs) has been confirmed in five countries of the Greater Mekong subregion (Cambodia, the Lao People's Democratic Republic, Myanmar, Thailand, Viet Nam). The spread of resistant strains to other parts of the world could pose a major public health challenge and jeopardise important recent gains in malaria control. A WHO Strategy for Malaria Elimination in the Greater Mekong subregion (2015-2030) was endorsed by all five countries, as well as China (WHO, 2015).

Resistance in human immunodeficiency virus (HIV) (WHO, 2020): In 2010, an estimated 7% of people starting antiretroviral therapy in developing countries had drug-resistant HIV. In developed countries, the same figure was 10–20%. Some countries have recently reported levels at or above 15% among those starting HIV treatment, and up to 40% among people re-starting treatment. This requires urgent attention.

Resistance in influenza (WHO, 2020): Antiviral drugs are important for treatment of epidemic and pandemic influenza. So far, virtually all influenza A viruses circulating in humans are resistant to one category of antiviral drugs – M2 Inhibitors (amantadine and rimantadine). Antiviral susceptibility is constantly monitored through the WHO Global Influenza Surveillance and Response System (WHO, 2021).

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

Need for coordinated action (WHO, 2020): Antimicrobial resistance is a complex problem that affects all of society and is driven by many interconnected factors. Single, isolated interventions have limited impact. Coordinated action is required to minimise the emergence and spread of antimicrobial resistance. All countries need national action plans on Antimicrobial resistance. Greater innovation and investment are required in research and development of new antimicrobial medicines, vaccines, and diagnostic tools.

WHO response (WHO, 2020): The World Health Organization (WHO) is providing technical assistance to help countries develop their national action plans and strengthen their health and surveillance systems so they can prevent and manage antimicrobial resistance. It is collaborating with partners to strengthen the evidence base and develop new responses to this global threat. The WHO is working closely with the Food and Agriculture Organization of the United Nations (FAO) and the World Organisation for Animal Health (OIE) in a 'One Health' approach to promote best practices to avoid the emergence and spread of antibiotic resistance, including optimal use of antibiotics in both humans and animals. A political declaration endorsed by Heads of State at the United Nations General Assembly in New York in September 2016 signalled the world's commitment to taking a broad, coordinated approach to address the root causes of antimicrobial resistance across multiple sectors, especially human health, animal health and agriculture (UNGA, 2016). The WHO has been leading multiple initiatives to address antimicrobial resistance including the following: world Antimicrobial Awareness Week (18–24 November each year); global Antimicrobial Resistance Surveillance System (GLASS); global Antibiotic Research and Development Partnership (GARDP); and the interagency Coordination Group on Antimicrobial Resistance (IACG).

References

UNDESA, 2021. The 17 Goals. United Nations Department of Economic and Social Affairs (UNDESA). https://sdgs.un.org/goals Accessed 6 May 2021.

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WHO, 2016. International Health Regulations (2005), 3rd ed. World Health Organization (WHO). www.who.int/ihr/publications/9789241580496/en Accessed 26 September 2020.

WHO, 2020. Antimicrobial resistance. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance Accessed 27 September 2020.

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Coordinating agency or organisation

World Health Organization.

BI0026 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Animal Diseases (Not Zoonoses)

Definition

Animal disease is an impairment of the normal state of an animal that interrupts or modifies its vital function. Infectious diseases of livestock and wildlife are a major threat to global animal health and welfare and their effective control is crucial for agronomic health, for safeguarding and securing national and international food supplies and for alleviating rural poverty in developing countries. This hazard information profile focusses on animal diseases not including zoonoses (Britannica, 2021; adapted from Tomley and Shirley, 2009).

Reference

Tomley, F.M. and M.W. Shirley, 2009. Livestock infectious diseases and zoonoses. Philosophical Transactions of the Royal Society of London B, 364:2637-2642.

Britannica, 2021. Zoonotic Disease: Pathology. www.britannica.com/science/zoonotic-disease Accessed 30 April 2021.

Annotations

Synonyms

Not identified.

Additional scientific information

Infectious animal diseases remain a major threat to all animals including wildlife and livestock. Some devastating livestock diseases are endemic in many parts of the world and threats from old and new pathogens continue to emerge, with changes to global climate, agricultural practices and demography presenting conditions that are especially favourable for the spread of arthropod-borne diseases into new geographical areas (Tomley and Shirley, 2009).

Transboundary animal diseases are defined as animal diseases of significant economic, trade and/or food security importance for a considerable number of countries; which can easily spread to other countries and reach epidemic proportions; and where control/management, including exclusion, requires cooperation between several countries (FAO, 2016).

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Disease transmission can also occur from humans or domestic animals to wildlife, as documented for endangered mountain gorillas, which have experienced deadly respiratory infections from human metapneumovirus and human measles. Human-facilitated introduction of domestic species to an area may bring in diseases such as rabies or bovine tuberculosis (OIE and IUCN, 2014).

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Coordinating agency or organisation

Not identified.

BI0027 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Zoonotic Diseases

Definition

Zoonotic diseases are a group of communicable diseases that are transmissible from vertebrate animals to humans through direct contact or through food, water, and the environment (WHO, no date).

Reference

WHO, no date. Zoonoses: Managing public health risks at the human-animal-environment interface. World Health Organization (WHO). www.who.int/zoonoses/en Accessed 14 September 2020.

Annotations

Synonyms

Zoonoses.

Additional scientific description

A zoonotic disease is any disease that is naturally transmissible from vertebrate animals to humans. Animals therefore play an essential role in maintaining zoonotic infections in nature. They may be bacterial, viral, or parasitic, or may involve unconventional agents. As well as being a problem for public health many of the major zoonotic diseases prevent the efficient production of food of animal origin and create obstacles to international trade in animal products (WHO, no date).

Zoonotic diseases can be transmitted to humans in a number of different ways which vary depending on the specific disease. In addition to direct contact with animals they may be transmitted by: transmission from person to person; inhalation of spores or contaminated dust; consumption of unpasteurised dairy products or contaminated food; consumption of contaminated water; skin exposure to spores or contaminated water; and animal or insect bites/scratches (CDC, no date).

Zoonotic diseases comprise a large percentage of all newly identified infectious diseases as well as many existing ones. There are over 200 known types of zoonotic disease (WHO, 2020).

Some zoonotic diseases begin as a zoonosis but later mutate into human-only strains, for example human immunodeficiency virus (HIV). Others can cause recurring disease outbreaks, such as Ebola virus disease and salmonellosis (WHO, FAO and OIE, 2019).

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

The World Health Organization (WHO) in partnership with the United Nations Food and Agricultural Organization (FAO) and World Organisation for Animal Health (OIE), leads the development of global norms and standards for zoonotic diseases, as well as technical work on pathogen detection, risk assessment and management (WHO, FAO and OIE, 2019).

Prevention methods for zoonotic diseases differ for each pathogen; however, several practices are recognised as effective in reducing risk at the community and personal levels including safe animal husbandry, increased hygiene measures and standards for clean drinking water and waste removal. Some zoonoses, such as rabies, are 100% preventable through vaccination and other methods (WHO, 2020).

Antimicrobial resistance is a complicating factor in the control and prevention of zoonoses. The use of antibiotics in animals raised for food is widespread and increases the potential for drug-resistant strains of zoonotic pathogens capable of spreading quickly in animal and human populations (WHO, 2020).

Markets selling the meat or by-products of wild animals are particularly high risk due to the large number of new or undocumented pathogens known to exist in some wild animal populations (WHO, 2020).

References

CDC, no date. Zoonotic Diseases. Centers for Disease Control and Prevention (CDC). www.cdc.gov/onehealth/basics/zoonotic-diseases.html Accessed 20 September 2020.

WHO, no date. Zoonoses: Managing public health risks at the human-animal-environment interface. World Health Organization (WHO). www.who.int/zoonoses/en Accessed 14 September 2020.

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WHO, 2020. Zoonoses Fact Sheet. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/zoonoses Accessed 20 September 2020.

WHO, FAO and OIE, 2019. Taking a Multisectoral, One Health Approach: a Tripartite Guide to Addressing Zoonotic Diseases in Countries. World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO), World Organisation for Animal Health (OIE). https://apps.who.int/iris/rest/bitstreams/1236638/retrieve Accessed 20 September 2020.

Coordinating agency or organisation

United Nations Food and Agricultural Organization (FAO), World Organisation for Animal Health (OIE), World Health Organization (WHO).

BI0028 / **BIOLOGICAL** / **Infectious Diseases (Human and Animal)**

Diarrhoeal Diseases (Human)

Definition

Diarrhoeal diseases are infectious diseases, contaminants and other causes of diarrhoea. Diarrhoea is defined as the passage of three or more loose or liquid stools per day, or more frequently than is normal for the individual (WHO, no date). This includes the three clinical types of diarrhoea: acute watery diarrhoea – lasts several hours or days, and includes cholera; acute bloody diarrhoea – also called dysentery; and persistent diarrhoea – lasts 14 days or longer (WHO, 2017).

Reference

WHO, no date. Diarrhoea. World Health Organization (WHO). www.who.int/topics/diarrhoea/en Accessed 20 September 2020.

WHO, 2017. Diarrhoeal disease. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/diarrhoeal-disease Accessed 20 September 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

Diarrhoeal disease is the second leading cause of death in children under five years old. It is both preventable and treatable. Each year diarrhoea kills around 525,000 children under five. A significant proportion of diarrhoeal disease can be prevented through the provision of safe drinking-water and adequate sanitation and hygiene. Globally, there are nearly 1.7 billion cases of childhood diarrhoeal disease every year.

Diarrhoeal diseases can be caused by infectious disease, malnutrition, contaminated water and food, and other causes:

Infection: Diarrheal diseases are usually a symptom of gastrointestinal infection, which can be caused by a variety of bacterial, viral and parasitic organisms, most of which are spread by faeces-contaminated water or from person to person as a result of poor hygiene. Infection is more common when there is a shortage of adequate sanitation and hygiene and safe water for drinking, cooking and cleaning. Rotavirus and Escherichia coli are the two most common etiological agents of moderate-to-severe diarrhoea in low-income countries. Other pathogens such as Cryptosporidium and Shigella species may also be important. Location-specific etiologic patterns also need to be considered (WHO, 2017).

Malnutrition: Children who die from diarrhoea often suffer from underlying malnutrition, which makes them more vulnerable to diarrhoea. Each diarrhoeal episode, in turn, makes their malnutrition even worse. Diarrhoea is a leading cause of malnutrition in children under five years old (WHO, 2017).

Source: Water contaminated with human faeces, for example, from sewage, septic tanks and latrines, is of particular concern. Animal faeces also contain microorganisms that can cause diarrhoea (WHO, 2017).

Other causes: Diarrhoeal disease can also spread from person-to-person, aggravated by poor personal hygiene. Food is another major cause of diarrhoea when it is prepared or stored in unhygienic conditions. Unsafe domestic water storage and handling is an important risk factor. Consumption of fish and seafood from polluted water may also contribute to diarrhoeal disease (WHO, 2017).

Diarrhoea can last several days and can leave the body without the water and salts that are necessary for survival. Severe diarrhoea leads to fluid loss, and may be life-threatening, particularly in young children and people who are malnourished or have impaired immunity. In the past, for most people, severe dehydration and fluid loss were the main causes of diarrhoea deaths. Now, other causes such as septic bacterial infections are likely to account for an increasing proportion of all diarrhoea-associated deaths. Children who are malnourished or have impaired immunity as well as people living with human immunodeficiency virus (HIV) are most at risk of life-threatening diarrhoea (WHO, 2017).

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

The World Health Organization (WHO) recommends the following key measures to prevent diarrhoea: access to safe drinking-water; use of improved sanitation; hand washing with soap; exclusive breastfeeding for the first six months of life; good personal and food hygiene; health education about how infections spread; and rotavirus vaccination (WHO, 2017).

The WHO provides the key measures to treat diarrhoea which include the following (WHO, 2017):

- Rehydration with an oral rehydration salts solution. This is a mixture of clean water, salt and sugar. It costs a few cents per treatment. The oral rehydration salts solution is absorbed in the small intestine and replaces the water and electrolytes lost in the faeces.
- Zinc supplements reduce the duration of a diarrhoea episode by 25% and are associated with a 30% reduction in stool volume.
- Rehydration with intravenous fluids in cases of severe dehydration or shock.
- Nutrient-rich foods: the vicious circle of malnutrition and diarrhoea can be broken by continuing to give nutrient-rich foods – including breast milk – during an episode, and by giving a nutritious diet – including exclusive breastfeeding for the first six months of life – to children when they are well.
- Consulting a health professional, in particular for management of persistent diarrhoea or when there is blood in the stool or if there are signs of dehydration.

The WHO also works with Member States and other partners to: promote national policies and investments that support case management of diarrhoea and its complications as well as increasing access to safe drinking-water and sanitation in developing countries; conduct research to develop and test new diarrhoea prevention and control strategies in this area; build capacity in implementing preventive interventions, including sanitation, source water improvements, and household water treatment and safe storage; develop new health interventions, such as the rotavirus immunisation; and help to train health workers, especially at community level (WHO, 2017).

References

WHO, 2016. International Health Regulations (2005), 3rd ed. World Health Organization (WHO). https://apps.who.int/iris/handle/10665/246107 Accessed 26 September 2020.

WHO, 2017. Diarrhoeal disease. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/diarrhoeal-disease Accessed 20 September 2020.

Coordinating agency or organisation

World Health Organization.

BI0029 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Prion Diseases

Definition

Prion diseases are a family of rare progressive neurodegenerative disorders that affect both humans and animals (CDC, no date).

Reference

CDC, no date. Prion Diseases. Centres for Disease Control and Prevention (CDC). www.cdc.gov/prions Accessed 14 September 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

Prion diseases are a group of rare transmissible disorders characterised by long incubation periods, characteristic spongiform changes associated with neuronal loss, and a failure to induce inflammatory response. They are often difficult to diagnose, untreatable, and ultimately fatal (CDC, no date).

Prion diseases involve accumulation of an abnormal prion protein in the central nervous system with no specific immunological response. Human prion diseases include sporadic, familial, and variant Creutzfeldt-Jakob disease (CJD). Sporadic CJD is the most common, representing an estimated 85% of cases and thought to affect approximately 1 person per million worldwide each year. Sporadic CJD is caused by the spontaneous transformation of normal prions into abnormal ones. Familial CJD is inherited as a result of genetic mutations and counts for 10–15% of cases worldwide. The remaining cases are iatrogenic and variant CJD (WHO, no date).

Bovine spongiform encephalopathy (BSE) is a transmissible spongiform encephalopathy found in cattle. Variant Creutzfeldt-Jakob disease (vCJD), found in humans, is believed to be a zoonotic disease caused by the BSE agent. The route of transmission of vCJD is through exposure to food contaminated by the bovine spongiform encephalopathy agent (WHO, no date).

Scrapie, another animal prion disease is endemic in some sheep and goat flocks of Europe, Asia and North America, with the exception of a small number of countries. Recently other animal prion diseases have been found in elk and deer (chronic wasting disease), mink (transmissible mink encephalopathy) and felines (feline spongiform encephalopathy) (WHO, no date).

The World Health Organization (WHO) has published guidance on case classification and surveillance standards for vCJD and other human-transmissible prion diseases (WHO, 2003).

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

Acquired human prion diseases are rare. In these instances, the most common outside sources are either medical procedures, where an individual may be exposed to the abnormal prion protein via contaminated equipment or certain transplanted human tissues, or via ingestion of meat from cattle infected with BSE (linked to vCJD). Other prion diseases such as scrapie and chronic wasting disease can be transmitted between animals, however transmission from animals to humans has only been observed in BSE/vCJD (WHO, 2003).

Over 180,000 cases of BSE were confirmed in cattle in the United Kingdom between 1986 and October 2004. The disease was also found in several other countries. This epidemic peaked in 1992, with almost 1000 new cases diagnosed each week. Control measures, including restrictions on ruminant feed, have now greatly decreased its prevalence, and cases have become uncommon or rare in many areas. Many countries have also passed new regulations to prevent BSE-containing tissues from entering human food supplies (OIE, 2016).

In some countries, certain prion diseases such as CJD and vCJD may be classified as a routine notifiable disease (WHO, 2003).

References

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OIE, 2016. BSE Technical Disease Card. World Organisation for Animal Health (OIE). www.cfsph.iastate.edu Accessed 20 September 2020.

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WHO, 2003. WHO manual for surveillance of human transmissible spongiform encephalopathies including variant Creutzfeldt-Jakob disease. World Health Organization (WHO). http://whqlibdoc.who.int/publications/2003/9241545887.pdf?ua=1 Accessed 20 September 2020.

WHO, 2016. International Health Regulations (2005), 3rd ed. World Health Organization (WHO). https://apps.who.int/iris/handle/10665/246107 Accessed 26 September 2020.

Coordinating agency or organisation

World Health Organization.

BI0030 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Hepatitis B (Human)

Definition

Hepatitis B is a vaccine-preventable disease, that is endemic and epidemic worldwide, and caused by the Hepatitis B virus (HBV). HBV can cause both acute and chronic liver disease. Chronic infection puts people at high risk of death from cirrhosis and liver cancer (WHO, 2020).

Reference

WHO, 2020. Hepatitis B. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/hepatitis-b Accessed 8 November 2020.

Annotations

Synonyms

Acute hepatitis B, Chronic hepatitis B, Hepatitis B related cirrhosis and hepatocellular carcinoma.

Additional scientific description

Hepatitis B is the most serious type of viral hepatitis. In highly endemic areas, the Hepatitis B virus (HBV), which is highly contagious, is most commonly spread from mother to child at birth (perinatal transmission), or through horizontal transmission (exposure to infected blood), especially from an infected child to an uninfected child during the first five years of life (WHO, 2016a).

Hepatitis B is also spread by needlestick injury, tattooing, piercing and exposure to infected blood and body fluids, such as saliva and, menstrual, vaginal, and seminal fluids. Sexual transmission of hepatitis B may occur, particularly in unvaccinated men who have sex with men and heterosexual persons with multiple sex partners or contact with sex workers (WHO, 2020).

The incubation period of the HBV is 75 days on average but can vary from 30 to 180 days. Most people do not experience any symptoms when newly infected. However, some have acute illness with symptoms that last several weeks, including yellowing of the skin and eyes (jaundice), dark urine, extreme fatigue, nausea, vomiting and abdominal pain. A small subset of persons with acute hepatitis can develop acute liver failure, which can lead to death (WHO, 2020).

In some people, the HBV can also cause a chronic liver infection that can later develop into cirrhosis (a scarring of the liver) or hepatocellular carcinoma (liver cancer). Infection in adulthood leads to chronic hepatitis in less than 5% of cases, whereas infection in infancy and early childhood leads to chronic hepatitis in about 95% of cases (WHO, 2020).

Laboratory confirmation of hepatitis B diagnosis is essential. A number of blood tests are available to diagnose and monitor people with hepatitis B. They can be used to distinguish acute and chronic infections (WHO, 2020).

The World Health Organisation (WHO) has published surveillance standards for hepatitis B (WHO, no date).

Metrics and numeric limits

The prevalence of hepatitis B is highest in the WHO Western Pacific Region and the WHO African Region, where 6.2% and 6.1% of the adult population is infected respectively (WHO, 2020).

In the WHO Eastern Mediterranean Region, the WHO South-East Asia Region and the WHO European Region, an estimated 3.3%, 2.0% and 1.6% of the general population is infected, respectively (WHO, 2020).

In the WHO Region of the Americas, 0.7% of the population is infected (WHO, 2017).

The WHO estimates that in 2015, 257 million people were living with chronic hepatitis B infection (defined as hepatitis B surface antigen positive) (WHO, 2019). It is estimated that about 887,000 people die each year due to consequences of hepatitis B (WHO, 2017).

HBV-HIV coinfection: about 1% of persons living with HBV infection (2.7 million people) are also infected with human immunodeficiency virus (HIV). Conversely, the global prevalence of HBV infection in HIV-infected persons is 7.4% (WHO, 2019).

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016b).

Examples of drivers, outcomes and risk management

Hepatitis B is a major global health problem (WHO, 2018). However, there is still limited access to diagnosis and treatment of hepatitis B in many resource-constrained settings. In 2016, 10.5% (27 million) of those infected were aware of their infection. Of those diagnosed, the global treatment coverage is 16.7% (4.5 million). Many people are diagnosed only when they already have advanced liver disease (WHO, 2019, 2020).

A safe and effective vaccine that offers 98–100% protection against hepatitis B is available and is the mainstay of prevention worldwide (WHO, 2020).

The WHO recommends that all blood donations be tested for hepatitis B to ensure blood safety and avoid accidental transmission to people who receive blood products (WHO, 2020).

For World Hepatitis Day 2020, the WHO focused on the theme ‘Hepatitis-Free Future’ to highlight the importance of addressing the prevention of mother-to-child transmission of HBV; to launch new guidance; and to call for increased domestic and international programming and funding to prevent hepatitis B mother-to-child transmission, as well as to expand access to hepatitis prevention, testing and treatment services, with a view to achieving the 2030 elimination targets (WHO, 2020).

References

WHO, no date. Immunizations, Vaccines and Biologicals: WHO-recommended Surveillance Standard of Acute Viral Hepatitis. World Health Organization (WHO). www.who.int/immunization/monitoring_surveillance/burden/vpd/surveillance_type/passive/hepatitis_standards/en Accessed 21 November 2019.

WHO, 2016a. Technical considerations and case definitions to improve surveillance for viral hepatitis: technical report. World Health Organization (WHO). https://apps.who.int/iris/handle/10665/204501 Accessed 18 February 2020.

WHO, 2016b. International Health Regulations (2005), 3rd ed. World Health Organization (WHO). www.who.int/ihr/publications/9789241580496/en Accessed 26 September 2020.

WHO, 2017. Global Hepatitis Report 2017. World Health Organization (WHO). www.who.int/hepatitis/publications/global-hepatitis-report2017/en Accessed 18 February 2020.

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Coordinating agency or organisation

World Health Organization.

BI0031 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Hepatitis C (human)

Definition

Hepatitis C is a blood-borne liver disease caused by the hepatitis C virus: the virus can cause both acute and chronic hepatitis, ranging in severity from a mild illness lasting a few weeks to a serious, lifelong illness including liver cirrhosis and liver cancer. Hepatitis C is endemic and epidemic worldwide (WHO, 2020).

Reference

WHO, 2020. Hepatitis C. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/hepatitis-c Accessed 8 November 2020.

Annotations

Synonyms

Acute hepatitis C, Chronic hepatitis C, Hepatitis C-related cirrhosis and liver cancer.

Additional scientific description

The most common modes of infection of hepatitis C are through exposure to small quantities of blood. This may happen through injecting drug use, unsafe injection practices, unsafe health care, transfusion of unscreened blood and blood products, and sexual practices that lead to exposure to blood. The incubation period for hepatitis C ranges from two weeks to six months (WHO, 2020).

New hepatitis C infections (approximately 80%) are usually asymptomatic. Those persons who are acutely symptomatic may exhibit fever, fatigue, decreased appetite, nausea, vomiting, abdominal pain, dark urine, grey-coloured faeces, joint pain and jaundice (yellowing of skin and the whites of the eyes). Around 30% (15–45%) of infected persons spontaneously clear the virus within six months of infection without any treatment. The remaining 70% (55–85%) of persons will develop chronic hepatitis C infection. Of those with chronic hepatitis C infection, a significant number will go on to develop cirrhosis (liver scarring) or liver cancer (WHO, 2020).

There is no effective vaccine against hepatitis C; prevention of hepatitis C infection depends upon reducing the risk of exposure to the hepatitis C virus (HCV) in health-care settings and in higher risk populations such as people who inject drugs and men who have sex with other men, particularly those infected with human immunodeficiency virus (HIV) or those who are taking pre-exposure prophylaxis against HIV (WHO, 2020).

Hepatitis C infection is diagnosed in two steps: testing for anti-HCV antibodies with a serological test to identify people who have been infected with the virus; and, if the test is positive for anti-HCV antibodies, a nucleic acid test for HCV ribonucleic acid (RNA) to confirm chronic infection, because those without viral RNA also test positive for anti-HCV antibodies (WHO, 2020).

The World Health Organization (WHO) has published surveillance standards for hepatitis C (WHO, 2016a).

Metrics and numeric limits

The most affected regions by hepatitis C are the WHO Eastern Mediterranean Region and the WHO European Region, with an estimated prevalence in 2015 of 2.3% and 1.5% respectively. Prevalence of hepatitis C infection in other WHO regions varies from 0.5% to 1.0%. Globally, an estimated 71 million people have chronic hepatitis C virus infection. The WHO estimated that in 2016, approximately 399,000 people died from hepatitis C, mostly from cirrhosis and hepatocellular carcinoma (primary liver cancer) (WHO, 2020).

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016b).

Examples of drivers, outcomes and risk management

Depending on the country, hepatitis C virus infection can be concentrated in certain populations. For example, it is estimated that 23% of new HCV infections and 33% of hepatitis C mortality are attributable to drug use through injecting. Yet, people who inject drugs and people in prisons are rarely included in national responses. In countries where infection control practices are or were historically insufficient, HCV infection is often widely distributed in the general population (WHO, 2020).

Early diagnosis can prevent health problems that may result from infection and prevent transmission of the virus. The WHO recommends testing people who may be at increased risk of infection (WHO, 2020).

In July 2018, the WHO updated its Guidelines for the care and treatment of persons diagnosed with chronic hepatitis C virus infection (WHO, 2018). These guidelines are intended for government officials to use as the basis for developing national hepatitis policies, plans and treatment guidelines. These include country programme managers and health-care providers responsible for planning and implementing hepatitis care and treatment programmes, particularly in low- and middle-income countries (WHO, 2020).

References

WHO, 2016a. Technical considerations and case definitions to improve surveillance for viral hepatitis: technical report. World Health Organization (WHO). https://apps.who.int/iris/handle/10665/204501 Accessed 8 November 2020.

WHO, 2016b. International Health Regulations (2005), 3rd ed. World Health Organization (WHO). www.who.int/ihr/publications/9789241580496/en Accessed 26 September 2020.

WHO, 2018. Guidelines for the screening, care and treatment of persons with chronic hepatitis C infection. World Health Organization (WHO). https://www.who.int/hepatitis/publications/hepatitis-c-guidelines-2018/en Accessed 8 November 2020.

WHO, 2020. Hepatitis C. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/hepatitis-c Accessed 8 November 2020.

Coordinating agency or organisation

World Health Organization.

BI0032 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

HIV and AIDS (Human)

Definition

The human immunodeficiency virus (HIV) is a viral sexually transmitted and blood-borne infection which targets the immune system, weakening people's defences against opportunistic infections and some types of cancer. The most advanced stage of HIV infection is acquired immunodeficiency syndrome (AIDS), which can take from 2 to 15 years to develop if not treated, depending on the individual. AIDS is defined by the development of certain cancers, infections or other severe clinical manifestations (WHO, 2019).

Reference

WHO, 2019. HIV/AIDS. World Health Organization (WHO). www.who.int/en/news-room/fact-sheets/detail/hiv-aids Accessed 13 December 2019.

Annotations

Synonyms

None found.

Additional scientific description

The human immunodeficiency virus (HIV) / acquired immunodeficiency syndrome (AIDS) is a global pandemic (WHO, 2019).

The human immunodeficiency virus (HIV) targets the CD4 cells of the immune system leading to immunodeficiency which results in increased susceptibility to a wide range of infections, cancers and other diseases that people with healthy immune systems can fight off. The HIV can be transmitted via the exchange of body fluids from infected people, such as blood, breast-milk, semen and vaginal secretions. It can also be transmitted from a mother to her child during pregnancy and delivery. People at higher risk include gay men and other men who have sex with men; people who inject drugs; people in prisons and other closed settings; sex workers and their clients; and transgender people. Other particularly vulnerable population are adolescents and young women in southern and eastern Africa and indigenous peoples (WHO, 2019).

The symptoms of HIV infection and AIDS vary depending on the stage of infection. Although people living with HIV tend to be most infectious in the first few months following infection, many are unaware of their status until the later stages (WHO, 2019).

In the first few weeks after infection people may experience no symptoms or an influenza-like illness. As the infection progressively weakens the immune system, they may go on to develop severe illnesses such as tuberculosis, cryptococcal meningitis, severe bacterial infections, and cancers such as lymphomas and Kaposi's sarcoma. Notably, among people living with HIV, tuberculosis is the most common illness and is the leading cause of death, responsible for nearly a third of HIV-associated deaths (WHO, 2019).

The HIV can be diagnosed through rapid diagnostic tests that provide results in a very short period of time. This greatly facilitates early diagnosis and linkage with treatment and care. People can also determine their own status using HIV self-tests. While testing for adolescents and adults has been made simple and efficient, this is not the case for infants born to HIV-positive mothers. For children less than 18 months of age, serological testing is not sufficient to identify HIV infection – virological testing must be provided as early as birth or at six weeks of age (WHO, 2019). There is no cure for HIV infection. However, effective antiretroviral therapy can control the virus over the course of a lifetime and help prevent onward transmission to other people.

Metrics and numeric limits

According to the World Health Organization (WHO), in 2018: there were approximately 37.9 million people living with HIV; approximately 770,000 people died from HIV-related causes; and 1.7 million people were newly infected (WHO, no date).

HIV is geographically widespread, but over two-thirds of all people infected live in the WHO African Region (25.7 million), where the disease is prevalent among the general population and incidence is increasing among key population groups, including young urban dwellers (WHO, 2019).

There are global standards, guidelines and tools to improve HIV surveillance (WHO, 2013, 2017). The US Centres for Disease Control and Prevention has also published case definition for HIV infection (CDC, 2014).

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

HIV disease continues to be a major global public health issue, having claimed more than 32 million lives so far (WHO, 2019). Effective antiretroviral treatment enables people with HIV to live long and healthy lives and decreases the risk of transmitting HIV to uninfected sexual partners by 96% (WHO, 2019).

The 90-90-90 testing and treating targets for 2020 were developed by the Joint United Nations Programme on HIV/AIDS in 2013 (UNAIDS, 2017). These are as follows: by 2020, 90% of all people living with HIV will know their HIV status; by 2020, 90% of all people with diagnosed HIV infection will receive sustained antiretroviral therapy; and by 2020, 90% of all people receiving antiretroviral therapy will have viral suppression (UNAIDS, 2017).

In 2018, an estimated 79% of people living with HIV knew their status. 62% were receiving effective antiretroviral treatment and 53% had achieved suppression of the HIV virus with no risk of infecting others (WHO, 2019).

References

CDC, 2014. Revised surveillance case definition for HIV infection. United States. 2014. Recommendations and reports: Morbidity and Mortality Weekly Report 63(RR03):1-10. Centers for Disease Control and Prevention (CDC). www.cdc.gov/mmwr/preview/mmwrhtml/rr6303a1.htm Accessed 13 December 2019.

UNAIDS, 2017. 90-90-90 An ambitious treatment target to help end the AIDS epidemic. Joint United Nations Programme on HIV/AIDS (UNAIDS). www.unaids.org/en/resources/documents/2017/90-90-90 Accessed 3 December 2019.

WHO, no date. HIV/AIDs. www.afro.who.int/health-topics/hivaids Accessed 7 April 2021.

WHO, 2013. Evaluating a national surveillance system: WHO/UNAIDS Working Group on Global HIV/AIDS and STI Surveillance. World Health Organization (WHO). www.who.int/hiv/pub/surveillance/2013package/module7/en Accessed 13 December 2019.

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WHO, 2017. Consolidated guidelines on person-centred HIV patient monitoring and case surveillance: Guidelines. World Health Organization (WHO). www.who.int/hiv/pub/guidelines/person-centred-hiv-monitoring-guidelines/en Accessed 13 December 2019.

WHO, 2019. HIV/AIDS. World Health Organization (WHO). www.who.int/en/news-room/fact-sheets/detail/hiv-aids Accessed 13 December 2019.

Coordinating agency or organisation

World Health Organization (WHO), Joint United Nations Programme on HIV/AIDS (UNAIDS).

BI0033 / **BIOLOGICAL** / **Infectious Diseases (Human and Animal)**

COVID-19 (SARS-CoV-2) (Human)

Definition

COVID-19 is an infectious disease caused by the SARS Coronavirus 2 (SARS CoC2), a virus first identified in human populations in late 2019. Transmission occurs through droplets containing infectious virus, either by direct face to face contact (splash) generated by speaking, singing, coughing or sneezing; or by aerosolisation for up to 1 metre. Virus-containing aerosols that travel further than 1 metre are defined as airborne. The virus is thought to infect humans through the mucus membranes of the eyes, nose and mouth. Living virus has been isolated from faeces and urine but neither is thought to represent a major means of transmission. Fomites are thought to represent a low risk of transmission, but the risk has not yet been quantified. The risk of transmission is greatest in closed, poorly ventilated spaces where humans are in close proximity for ten to fifteen minutes and do not physically distance or wear a protective face covering (WHO, 2020).

Reference

WHO, 2020. Coronavirus disease (Covid-19). World Health Organization (WHO). www.who.int/emergencies/diseases/novel-coronavirus-2019/question-and-answers-hub/q-a-detail/coronavirus-disease-covid-19 Accessed 4 May 2021.

Annotations

Synonyms

Coronavirus, SARS-CoV-2, COVID-19.

Additional scientific description

The majority of infections are asymptomatic or cause mild disease with fever or chills, cough, dyspnoea, fatigue, myalgia, headache, anosmia, ageusia, sore throat, nasal congestion, nausea or vomiting and diarrhoea. Infections cause more severe symptoms with increasing age, with the greatest risk of severe illness and death in those aged 85 years or older. Also at greater risk of serious illness and death are those with pre-existing medical conditions including cancer, chronic kidney disease, chronic obstructive pulmonary disease, and cardiovascular disease (WHO, 2020a,b).

The clinical course for severe illness can be long and often requires supplemental oxygen. A number of persons who have been infected develop lasting symptoms including chronic fatigue and damage to vital organs such as the lungs and heart. This phenomenon is generally referred to as long COVID and at present is not completely understood (WHO, 2020a).

Metrics and numeric limits

As of the end of April 2021 over 3 million deaths from COVID-19 had been reported since the beginning of the pandemic (WHO, 2020c).

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

N.B. As of 23 October 2020, the World Health Organization (WHO) had published many reports and technical documents on COVID-19, including the references indicated below. The science of the coronavirus disease (COVID-19) and its respective drivers, outcomes and control measures continue to evolve. This understanding will inform the elaboration of a Hazard Information Profile in future.

Examples of drivers, outcomes and risk management

Transmission occurs from close person-to-person contact between infected and non-infected persons, and measures to decrease transmission include physical distancing and wearing a mask to cover the nose and mouth as a means of protecting others. Outbreaks can be contained by rigorous public health measures, including contact tracing (WHO 2020a)

References

WHO, 2016. International Health Regulations (2005), 3rd ed. World Health Organization (WHO). https://apps.who.int/iris/handle/10665/246107 Accessed 4 May 2021.

WHO, 2020a. Coronavirus disease (Covid-19). World Health Organization (WHO). www.who.int/emergencies/diseases/novel-coronavirus-2019/question-and-answers-hub/q-a-detail/coronavirus-disease-covid-19 Accessed 4 May 2021.

WHO, 2020b. Coronavirus. World Health Organization (WHO). www.who.int/health-topics/coronavirus#tab=tab_1 Accessed 4 May 2021.

WHO, 2020c. WHO Coronavirus Disease (COVID-19) Dashboard. World Health Organization (WHO). https://covid19.who.int Accessed 4 May 2021.

Coordinating agency or organisation

World Health Organization.

BI0034 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Cholera (Human)

Definition

Cholera is an acute diarrhoeal infection caused by ingestion of food or water contaminated with the bacterium Vibrio cholerae. Cholera remains a global threat to public health (WHO, 2019).

Reference

WHO, 2019. Cholera. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/cholera Accessed 4 November 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

During the 19th century, cholera spread across the world from its original reservoir in the Ganges delta in India. Six subsequent pandemics killed millions of people across all continents. The current (seventh) pandemic started in South Asia in 1961 and reached Africa in 1971 and the Americas in 1991. Cholera is now endemic in many countries (WHO, 2019).

There are many serogroups of V. cholerae, but only two – O1 and O139 – cause outbreaks. V. cholerae O1 has caused all recent outbreaks. V. cholerae O139 – first identified in Bangladesh in 1992 – has caused outbreaks in the past, but recently has only been identified in sporadic cases. It has never been identified outside Asia. There is no difference in the illness caused by the two serogroups. These are extremely virulent, and it usually takes between twelve hours and five days for symptoms to develop following infection (WHO, 2019).

The disease can affect both adults and children. Most of those infected with Vibrio cholera do not develop any symptoms, although the bacteria are present in their faeces for one to ten days after infection, and are shed back into the environment, potentially affecting other people. Among people who develop symptoms, the majority have mild or moderate symptoms, while a minority develop acute watery diarrhoea which can lead to death if untreated. Treatment should be rapid, with intravenous fluids and antibiotics (WHO, 2019).

Cholera diagnosis is confirmed by identifying Vibrio cholera in the stools of affected individuals. Detection can be facilitated by the use of rapid diagnostic tests (RDTs) where one or more positive samples triggers a cholera alert. The samples should be sent to a laboratory for confirmation by culture or polymerase chain reaction (PCR) (WHO, 2019).

Cholera can be endemic or epidemic. A cholera-endemic area is an area where confirmed cholera cases were detected during the last three years with evidence of local transmission (meaning the cases are not imported from elsewhere). A cholera outbreak/epidemic can occur in both endemic countries and in countries where cholera does not regularly occur (WHO, 2019).

In cholera endemic countries an outbreak can be seasonal or sporadic and represents a greater than expected number of cases. In a country where cholera does not regularly occur, an outbreak is defined by the occurrence of at least one confirmed case of cholera with evidence of local transmission in an area where there is not usually cholera (WHO, 2019).

The consequences of a humanitarian crisis – such as disruption of water and sanitation systems, or the displacement of populations to inadequate and overcrowded camps – can increase the risk of cholera transmission, should the bacteria be present or introduced. Uninfected dead bodies have never been reported as the source of epidemics (WHO, 2019).

The number of cholera cases reported to the World Health Organization (WHO) has continued to be high over the last few years. In 2017, 1227,391 cases were notified from 34 countries, including 5654 deaths. The discrepancy between these figures and the estimated burden of the disease is because many cases are not recorded due to limitations in surveillance systems and fear of impact on trade and tourism (WHO, 2019).

Metrics and numeric limits

Researchers have estimated that every year, there are roughly 1.2 to 4.0 million cases, and 21,000 to 143,000 deaths worldwide due to cholera (WHO, 2019).

Cholera can be endemic or epidemic. A cholera-endemic area is an area where confirmed cholera cases were detected during the last three years, with evidence of local transmission (WHO, 2019).

The WHO has published case definitions and recommendations for surveillance (WHO, 2014).

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

Cholera remains a global threat to public health and an indicator of inequity and lack of social development. Provision of safe water and sanitation is critical for the prevention and control of cholera (WHO, 2019).

A multifaceted approach is key to control cholera, and to reduce deaths (WHO, 2019). A combination of surveillance, water, sanitation and hygiene, social mobilisation, treatment, and oral cholera vaccines are used.

Surveillance Cholera surveillance should be part of an integrated disease surveillance system that includes feedback at the local level and information-sharing at the global level. Cholera cases are detected based on clinical suspicion in patients who present with severe acute watery diarrhoea. The suspicion is then confirmed by identifying V. cholerae in stool samples from affected patients. Detection can be facilitated using rapid diagnostic tests where one or more positive samples triggers a cholera alert. The samples are sent to a laboratory for confirmation by culture or PCR. Local capacity to detect (diagnose) and monitor (collect, compile, and analyse data) cholera occurrence, is central to an effective surveillance system and to planning control measures. Countries affected by cholera are encouraged to strengthen disease surveillance and national preparedness to rapidly detect and respond to outbreaks. Under the International Health Regulations, notification of all cases of cholera is no longer mandatory (WHO, 2021). However, public health events involving cholera must always be assessed against the criteria provided in the regulations to determine whether there is a need for official notification (WHO, 2014, 2019).

Water and sanitation interventions. The long-term solution for cholera control lies in economic development and universal access to safe drinking water and adequate sanitation. Actions targeting environmental conditions include the implementation of adapted long-term sustainable WASH solutions to ensure use of safe water, basic sanitation and good hygiene practices in cholera hotspots (WHO, 2021). In addition to cholera, such interventions prevent a wide range of other water-borne illnesses, as well as contributing to achieving Sustainable Development Goals related to poverty, malnutrition, and education. The WASH solutions for cholera are aligned with those of the Sustainable Development Goals (SDG 6) (WHO, 2021).

Treatment. Cholera is an easily treatable disease. The majority of people can be treated successfully through prompt administration of oral rehydration solution. Severely, dehydrated patients are at risk of shock and require the rapid administration of intravenous fluids. These patients are also given appropriate antibiotics to diminish the duration of diarrhoea, reduce the volume of rehydration fluids needed, and shorten the amount and duration of V. cholerae excretion in their stool. Rapid access to treatment is essential during a cholera outbreak. Oral rehydration should be available in communities, in addition to larger treatment centres that can provide intravenous fluids and 24 hour care. With early and proper treatment, the case fatality rate should remain below 1% (WHO, 2021).

Hygiene promotion and social mobilisation. Health education campaigns, adapted to local culture and beliefs, should promote the adoption of appropriate hygiene practices such as hand-washing with soap, safe preparation and storage of food and safe disposal of the faeces of children. Funeral practices for individuals who die from cholera must be adapted to prevent infection among attendees. Further, awareness campaigns should be organised during outbreaks, and information should be provided to the community about the potential risks and symptoms of cholera, precautions to take to avoid cholera, when and where to report cases and to seek immediate treatment when symptoms appear. The location of appropriate treatment sites should also be shared. Community engagement is key to long-term changes in behaviour and to the control of cholera (WHO, 2021).

Oral cholera vaccines. Currently there are three WHO pre-qualified oral cholera vaccines: Dukoral®, Shanchol™, and Euvichol-Plus®. All three vaccines require two doses for full protection. More than 30 million doses of oral cholera vaccines have been used in mass vaccination campaigns. The campaigns have been implemented in areas experiencing an outbreak, in areas at heightened vulnerability during humanitarian crises, and among populations living in highly endemic areas, known as 'hotspots' (WHO, 2014, no date).

A global strategy on cholera control with a target to reduce cholera deaths by 90% was launched in 2017 (WHO, 2017).

References

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WHO, 2021. Cholera. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/cholera#:~:text=Under%20the%20International%20Health%20Regulations%2C%20notification%20of%20all,need%20for%20official%20notification.%20Water%20and%20sanitation%20interventions Accessed 7 April 2021.

Coordinating agency or organisation

World Health Organization.

BI0035 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Cryptosporidium (Human)

Definition

Cryptosporidium is a microscopic parasite that causes the watery diarrhoeal disease cryptosporidiosis (WHO, 2013).

Reference

WHO, 2013. Preventing cryptosporidiosis: the need for safe drinking water. World Health Organization (WHO). www.who.int/bulletin/volumes/91/4/13-119990/en Accessed 28 September 2020.

Annotations

Synonyms

Crypto.

Additional scientific description

Cryptosporidiosis is a disease that causes watery diarrhoea. It is caused by microscopic germs – parasites called Cryptosporidium. Both the parasite and the disease are commonly known as 'Crypto' (CDC, 2017). Although cryptosporidiosis can affect all people, some groups are likely to develop more serious illness. For people with weakened immune systems, symptoms can be severe and could lead to serious or life-threatening illness. Approximately 20 species of Cryptosporidium infect animals, some of which also infect humans. The parasite is protected by an outer shell that allows it to survive outside the body for long periods and makes it very resistant to chlorine disinfection (CDC, 2017).

Symptoms of cryptosporidiosis generally begin two to ten days (average seven days) after becoming infected with the parasite. They include watery diarrhoea (the most common symptom), stomach cramps or pain, dehydration, nausea, vomiting, fever and weight loss. Some people can shed Cryptosporidiosia despite being asymptomatic (CDC, 2017).

Symptoms usually last about one to two weeks (with a range of a few days to a month or more) in persons with healthy immune systems. Occasionally, people may experience a recurrence of symptoms after a brief period of recovery before the illness ends. Symptoms can come and go for up to 30 days.

While the small intestine is the site most commonly affected, in immunocompromised persons Cryptosporidium infections may also affect other areas of the digestive or respiratory tract. The risk of developing a severe disease may differ depending on each person's degree of immune suppression (CDC, 2017).

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

Cryptosporidium lives in the intestine of infected humans or animals. An infected person or animal sheds Cryptosporidium parasites in the stool. Millions of Cryptosporidium parasites can be released in a bowel movement from an infected human or animal. Shedding begins when the symptoms begin and can last for weeks after the symptoms (e.g., diarrhoea) disappear. People become infected after accidentally swallowing the parasite (CDC, 2015).

The reported incidence of Cryptosporidium ranges from <1% in high income countries up to 8% in low- and middle-income countries. In 2016, Cryptosporidium infection was the fifth leading diarrhoeal aetiology in children younger than 5 years, and acute infection caused more than 48,000 deaths and more than 4.2 million disability-adjusted life-years lost (Khalil et al., 2018).

Cryptosporidium may be found in soil, food, water, or surfaces that have been contaminated with faeces from infected humans or animals. Cryptosporidium is not spread by contact with blood. It can be spread by: ingesting something that has come into contact with the stool of a person or animal infected with Cryptosporidium; swallowing recreational water contaminated with Cryptosporidium (e.g., contaminated with sewage or faeces from humans or animals); swallowing unfiltered water or beverages contaminated by stools from infected humans or animals; and eating uncooked food contaminated with Cryptosporidium. All fruit and vegetables eaten raw should be thoroughly washed with uncontaminated water. Hands can become contaminated through a variety of activities, such as: touching surfaces (e.g., toys, bathroom fixtures, changing tables, nappies) that have been contaminated by stools from an infected person; caring for an infected person; and handling an infected animal such as a cow or calf (CDC, 2015).

People with greater exposure to contaminated materials are more at risk for infection. These groups include: children who attend childcare centres, including pre-toilet trained children; childcare workers; parents of infected children; older adults (ages 75 years and over); people who care for other people with cryptosporidiosis; international travellers; backpackers, hikers, and campers who drink unfiltered, untreated water; people who drink from untreated shallow, unprotected wells; people, including swimmers, who swallow water from contaminated sources; people who handle infected cattle; and people exposed to human faeces through sexual contact (CDC, 2015).

Several community-wide outbreaks of cryptosporidiosis have been linked to drinking municipal water or recreational water contaminated with Cryptosporidium. Travellers' to developing countries may be at greater risk for infection because of poorer water treatment and food sanitation, but cryptosporidiosis occurs worldwide (CDC, 2017).

References

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WHO, 2016. International Health Regulations (2005), 3rd ed. World Health Organization (WHO). https://apps.who.int/iris/handle/10665/246107 Accessed 26 September 2020.

Coordinating agency or organisation

World Health Organization.

BI0036 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Paratyphoid fever (Human)

Definition

Paratyphoid fever is a systemic disease caused by the bacterium Salmonella Paratyphi usually through ingestion of contaminated food or water (WHO, 2019).

Reference

WHO, 2019. Typhoid. World Health Organization (WHO). www.who.int/immunization/diseases/typhoid/en Accessed 13 December 2019.

Annotations

Synonym

Not identified.

Additional scientific description

Paratyphoid fever is caused by Salmonella Paratyphi A and B (or uncommonly Paratyphi C) and is similar to Typhoid (WHO, 2019).

Humans are the only source of these bacteria; no animal or environmental reservoirs have been identified (WHO, 2018).

The onset of illness is insidious, with gradually increasing fatigue and a fever that increases daily from low-grade to high. Headache, malaise, and anorexia are nearly universal, and abdominal pain, diarrhoea, or constipation are common (Appiah et al., 2019).

Paratyphoid fever is usually described as less severe than typhoid fever (Appiah et al., 2019; WHO, 2019).

Blood culture is the mainstay of diagnosis in typhoid and paratyphoid fever. Bone marrow and stool cultures can also be used (Gupta et al., 2008; Appiah et al., 2019).

There are no definitive rapid diagnostic tests for paratyphoid fever. Initial diagnosis often has to be made clinically. Paratyphoid and typhoid fevers are clinically indistinguishable (Gupta et al., 2008; Appiah et al., 2019).

The Centers for Disease Control and Prevention (CDC) and World Health Organization (WHO) have published guidance on case classification and surveillance standards (Appiah et al., 2019; WHO, 2019).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Not relevant.

Examples of drivers, outcomes and control measures of the hazard

Paratyphoid fever is acquired through consumption of water or food contaminated by faeces of an acutely infected or convalescent person or a chronic, asymptomatic person (WHO, 2019).

Safe food and water precautions and frequent handwashing (especially before meals) are important preventative measures. Outreach efforts and effective health messaging to communities in high-risk countries are essential for helping prevent paratyphoid fever in these areas (WHO, 2019).

References

Appiah, G.D., M.J. Hughes and K. Chatham-Stephens, 2019. Chapter 4: Travel-related infectious diseases: Typhoid and paratyphoid fever. Centers for Disease Control and Prevention (CDC). wwwnc.cdc.gov/travel/yellowbook/2020/travel-related-infectious-diseases/typhoid-and-paratyphoid-fever Accessed 13 December 2019.

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WHO, 2018. Typhoid. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/typhoid Accessed 8 April 2021.

WHO, 2019. Typhoid. World Health Organization (WHO). www.who.int/immunization/diseases/typhoid/en Accessed on 11 October 2020.

Coordinating agency or organisation

World Health Organization.

BI0037 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Typhoid Fever (Human)

Definition

Typhoid fever is a life-threatening infection caused by the bacterium Salmonella Typhi. It is usually spread through contaminated food or water. An estimated 11–20 million people get sick from typhoid and between 128,000 and 161,000 people die from it every year (WHO, 2018).

Reference

WHO, 2018. Typhoid. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/typhoid Accessed 11 October 2020.

Annotations

Synonym

Not found.

Additional scientific description

Typhoid fever is a life-threatening infection caused by the bacterium Salmonella Typhi. Once Salmonella Typhi bacteria have been ingested, they multiply and spread into the bloodstream. Urbanisation and climate change have the potential to increase the global burden of typhoid. In addition, increasing resistance to antibiotic treatment is making it easier for typhoid to spread through overcrowded populations in cities and inadequate and/or flooded water and sanitation systems (WHO, 2018a).

Improved living conditions and the introduction of antibiotics resulted in a drastic reduction of typhoid fever morbidity and mortality in industrialised countries. In developing areas of Africa, the Americas, South-East Asia and the Western Pacific regions, however, the disease continues to be a public health problem.

The global typhoid fever disease burden is estimated to be 11–20 million cases annually, resulting in about 128,000 to 161,000 deaths per year (WHO, 2018a).

Salmonella Typhi only affects humans. Persons with typhoid fever carry the bacteria in their bloodstream and intestinal tract. Symptoms include prolonged high fever, fatigue, headache, nausea, abdominal pain, and constipation or diarrhoea. Some patients may have a rash. Severe cases may lead to serious complications or even death. Typhoid fever can be confirmed through blood testing (WHO, 2018a).

Typhoid risk is higher in populations that lack access to safe water and adequate sanitation. Poor communities and vulnerable groups including children are at highest risk (WHO, 2018a).

The World Health Organization (WHO) has published guidance on case classification and surveillance standards (WHO, 2018b).

Metrics and numeric limits

Not found.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

Typhoid fever is common in places with poor sanitation and a lack of safe drinking water. Access to safe water and adequate sanitation, hygiene among food handlers and typhoid vaccination are all effective in preventing typhoid fever (WHO, 2018a).

Two vaccines have been used for many years to protect people from typhoid fever: an injectable vaccine based on the purified antigen for people aged over 2 years; and a live attenuated oral vaccine in capsule formulation for people aged over 5 years (WHO, no date).

All travellers to endemic areas are at potential risk of typhoid fever, although the risk is generally low in tourist and business centres where standards of accommodation, sanitation and food hygiene are high. Typhoid fever vaccination should be offered to travellers to destinations where the risk of typhoid fever is high (WHO, 2018a).

The following recommendations will help ensure safety while travelling: ensure food is properly cooked and still hot when served; avoid raw milk and products made from raw milk – drink only pasteurised or boiled milk; avoid ice unless it is made from safe water; when the safety of drinking water is questionable, boil it or if this is not possible, disinfect it with a reliable, slow-release disinfectant agent (usually available at pharmacies); wash hands thoroughly and frequently using soap, especially after contact with pets or farm animals, or after having been to the toilet; and wash fruit and vegetables carefully, particularly if they are eaten raw. If possible, vegetables and fruits should be peeled (WHO, 2018a).

WHO response for typhoid. In December 2017, the World Health Organization (WHO) pre-qualified the first conjugate vaccine for typhoid. This new vaccine has longer-lasting immunity than older vaccines, requires fewer doses and can be given to children from the age of 6 months. This vaccine will be prioritised for countries with the highest burden of typhoid disease. This will help reduce the frequent use of antibiotics for typhoid treatment, which will slow the rise in antibiotic resistance in Salmonella Typhi. In October 2017, the Strategic Advisory Group of Experts (SAGE) on immunisation, which advises the WHO, recommended typhoid conjugate vaccines for routine use in children over 6 months of age in typhoid endemic countries. SAGE also called for the introduction of typhoid conjugate vaccines to be prioritised for countries with the highest burden of typhoid disease or of antibiotic resistance to Salmonella Typhi. Shortly after SAGE's recommendation, the Gavi Board approved USD 85 million in funding for typhoid conjugate vaccines starting in 2019 (WHO, 2018a).

References

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WHO, 2016. International Health Regulations (2005), 3rd ed. World Health Organization (WHO). https://apps.who.int/iris/handle/10665/246107 Accessed 26 September 2020.

WHO, 2018a. Typhoid. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/typhoid Accessed 11 October 2020.

WHO, 2018b. Surveillance standards for vaccine-preventable diseases: Typhoid and other invasive salmonellosis. World Health Organization (WHO). www.who.int/immunization/monitoring_surveillance/burden/vpd/WHO_SurveillanceVaccinePreventable_21_Typhoid_R1.pdf Accessed 19 November 2019.

Coordinating agency or organisation

World Health Organization.

BI0038 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Hepatitis A (Human)

Definition

Hepatitis A is an acute vaccine-preventable viral liver disease caused by the hepatitis A virus. The infection can cause mild to severe illness and is epidemic prone (WHO, 2020).

Reference

WHO, 2020. Hepatitis A. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/hepatitis-a Accessed 8 November 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

The hepatitis A virus (HAV) is primarily spread when an uninfected and unvaccinated person ingests food or water that is contaminated with the faeces of an infected person. It is one of the most frequent causes of foodborne infection. There are also outbreaks among men who have sex with men and persons who inject drugs (ECDC, 2017).

The symptoms of hepatitis A can include fever, malaise, loss of appetite, diarrhoea, nausea, abdominal discomfort, dark-coloured urine and jaundice (a yellowing of the skin and whites of the eyes). Not everyone who is infected will have all of the symptoms. Hepatitis A does not cause chronic liver disease and is rarely fatal, but it can cause debilitating symptoms. In very rare instances it can cause acute liver failure, which is often fatal (WHO, 2020a).

Specific diagnosis is made by the detection of HAV-specific immunoglobulin M (IgM) antibodies in the blood. Additional tests include reverse transcriptase polymerase chain reaction (RT-PCR) to detect the hepatitis A virus RNA and may require specialised laboratory facilities (WHO, 2020b).

Epidemics related to contaminated food or water can erupt explosively, such as the epidemic in Shanghai in 1988 that affected about 300,000 people. Epidemics can also be prolonged, affecting communities for months through person-to-person transmission. Hepatitis A viruses persist in the environment and can withstand food-production processes routinely used to inactivate and/or control bacterial pathogens (WHO, 2020b).

Hepatitis A can lead to significant economic and social consequences in communities. It can take weeks or months for people recovering from the illness to return to work, school, or daily life. The impact on food establishments identified with the virus, and local productivity in general, can be substantial (WHO, 2020b).

The World Health Organization (WHO) has published guidance on case classification and surveillance standards (WHO, 2018).

Metrics and numeric limits

Hepatitis A occurs sporadically and in epidemics worldwide, with a tendency for cyclic recurrences. Epidemics related to contaminated food or water can erupt explosively (WHO, 2019).

In 2016, 7134 persons were estimated to have died from hepatitis A worldwide (accounting for 0.5% of the mortality due to viral hepatitis) (WHO, 2019).

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

Hepatitis A is closely associated with unsafe water or food, inadequate sanitation, poor personal hygiene and oral-anal sex (WHO, 2020b).

The disease is most common in low- and middle-income countries with poor sanitary conditions and hygienic practices. In high-income countries with good sanitary and hygienic conditions, infection rates are low (WHO, 2020b).

Epidemics can be prolonged and cause substantial economic loss (WHO, 2020b).

A safe and effective vaccine is available to prevent hepatitis A (WHO, 2020b).

Safe water supply, food safety, improved sanitation, hand washing, and the hepatitis A vaccine are the most effective ways to combat the disease (WHO, 2020b).

References

ECDC, 2017. Hepatitis A outbreaks in the EU/EEA mostly affecting men who have sex with men. European Centre for Disease Prevention and Control (ECDC). www.ecdc.europa.eu/sites/default/files/documents/RRA-19-May-2017_UPDATE_2-HepatitisA-in-mostly-MSM.pdf Accessed 8 April 2021.

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WHO, 2019. Hepatitis A. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/hepatitis-a Accessed 8 April 2021.

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Coordinating agency or organisation

World Health Organization.

BI0039 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Escherichia Coli (STEC) (Human)

Definition

Escherichia coli (E. coli) is a bacterium commonly found in the gut. Some strains can cause serious food poisoning, leading to diarrhoea and sometimes to life-threatening complications including haemolytic uraemic syndrome (WHO, 2018).

Reference

WHO, 2018. E. coli. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/e-coli Accessed 6 November 2020.

Annotations

Synonyms

Shiga-toxin producing E. coli (STEC), Verocytotoxigenic E. coli (VTEC), Enterohaemorrhagic E. coli (EHEC).

Additional scientific description

Most strains of E. coli are harmless and are commonly found in the lower intestinal tract of humans and warm-blooded animals. Some strains however, such as Shiga-toxin producing E. coli (STEC), are harmful and can lead to serious foodborne infections. E. coli O157:H7 is the most important STEC serotype in relation to public health, although other serotypes have often been involved in sporadic cases and outbreaks (WHO, 2019).

STEC transmission is faecal-oral, with cattle the main reservoir although sheep and goats also carry Enterohaemorrhagic E. coli (EHEC). It is transmitted to humans primarily through the consumption of contaminated water and foods, including raw or undercooked ground meat products (such as hamburgers or dried cured salami), raw milk (such as cheese or yoghurt made from raw milk), and vegetables contaminated with faeces. Contact with animals (e.g., farms and petting zoos) is also a transmission route (WHO, 2019).

Humans are a secondary but significant reservoir for EHEC. People can be asymptomatic carriers of the pathogen (and therefore show no clinical signs of disease) but are capable of infecting others (WHO, 2019).

Symptoms are usually self-limiting, with recovery within ten days of onset. They include abdominal cramps, diarrhoea which may be bloody (haemorrhagic colitis), fever and vomiting. In a small proportion of patients (particularly young children and the elderly), the infection may lead to haemolytic uraemic syndrome (HUS) which can be life-threatening and is characterised by acute renal failure, haemolytic anaemia and thrombocytopenia (low blood platelets) (WHO, 2019).

Antibiotics are not recommended for treatment of EHEC infections because antibiotics can exacerbate the complications of EHEC, leading to HUS. In addition, many strains are multiply resistant to antibiotics such as ampicillin, streptomycin, trimethoprim, sulphonamide and tetracycline (Tadesse et al., 2012).

Laboratory diagnosis is via isolation of the organism on culture and / or detection of the toxin gene in faeces (ECDC, 2018).

The European Centre for Disease Prevention and Control (ECDC) has published case classification for outbreak management and national epidemiological surveillance (ECDC, 2018).

Metrics and numeric limits

Countries in the World Health Organization (WHO) European Region have reported significant numbers of infections from verocytotoxin-producing E. coli O104:H4, resulting in a large number of cases of bloody diarrhoea and HUS in Germany, and in 15 other countries in Europe and North America. More recently, another cluster of cases in the Bordeaux region of France, and a single case in Sweden, have been reported (WHO Regional Office for Europe, no date a).

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

Surveillance for disease outbreaks with timely and detailed investigation is essential. The WHO supports coordination of information sharing through the International Health Regulations (WHO, 2016), the International Food Safety Authority Network (INFOSAN) and other reporting mechanisms; it is monitoring the outbreaks of E. coli O104:H4 infection and providing the latest information. The WHO is working closely with national health authorities and international partners to detect the unusual bacterial strain and track down its source (WHO Regional Office for Europe, no date b).

In partnership with surveillance and rapid response, prevention is key.

- STEC is heat-sensitive. Following the WHO ‘Five keys to safer food’ is a key measure to prevent infections with foodborne pathogens such as STEC in households and restaurants (WHO, 2006).
- Similar to other faecal oral pathogens, safe water management, including protecting water sources from faecal contamination and safely storing and treating water at home, is important for prevention. Water treatment technologies should meet WHO standards for performance. Use of latrines and toilets that safely separate excreta from human contact and safely manage faecal waste including through safe containment, transport and treatment, are important measures for preventing contamination of the environment. It is particularly important that health care facilities treating EHEC patients have basic water, sanitation and hygiene services (WHO, 2008, 2018a,b, 2019).
- The long-term prevention of infection requires control measures at all stages of the food chain, from agricultural production on the farm to processing, manufacturing and preparation of foods in both commercial establishments and household kitchens (WHO, 2019).

References

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WHO Regional Office for Europe, no date a. Food Safety News. World Health Organization (WHO). www.euro.who.int/en/health-topics/disease-prevention/food-safety/outbreaks-of-e.-coli-o104h4-infection Accessed 6 November 2020.

WHO Regional Office for Europe, no date b. Outbreaks of E. coli O104:H4 infection. World Health Organization (WHO). www.euro.who.int/en/health-topics/disease-prevention/food-safety/outbreaks-of-e.-coli-o104h4-infection Accessed 6 November 2020.

Coordinating agency or organisation

World Health Organization.

BI0040 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Listeriosis (Human)

Definition

Listeriosis is a foodborne infection caused by the bacterium Listeria monocytogenes which can be invasive (the more serious form of the disease) or non-invasive (the milder form of the disease). Listeriosis outbreaks occur in all countries and can be a significant public health concern (WHO, 2018).

Reference

WHO, 2018. Listeriosis. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/listeriosis Accessed 19 November 2019.

Annotations

Synonyms

Not identified.

Additional scientific description

There are two main types of listeriosis: a non-invasive form and an invasive form.

Non-invasive listeriosis (febrile listerial gastroenteritis) is a mild form of the disease affecting mainly otherwise healthy people. Symptoms include diarrhoea, fever, headache and myalgia (muscle pain). Outbreaks have generally involved the ingestion of foods containing high doses of Listeria monocytogenes (WHO, 2018).

Invasive listeriosis is a more severe form of the disease and affects certain high-risk groups of the population, including pregnant women, immunocompromised individuals (such as those with HIV/AIDS, leukaemia, cancer, kidney transplant and steroid therapy), elderly people and infants. This form of disease is characterised by fever, myalgia, septicaemia and meningitis, and other severe symptoms, including abortion in pregnant women. It is associated with a high mortality rate (20%–30%). The incubation period of listeriosis is usually one to two weeks but can vary from a few days up to 90 days (WHO, 2018).

Unlike many other common foodborne diseases causing bacteria, L. monocytogenes can survive and multiply at the low temperatures usually found in refrigerators. In past outbreaks, foods involved have included ready-to-eat meat products, such as frankfurters, meat spread (paté), smoked salmon and fermented raw meat sausages, as well as dairy products (including soft cheeses, unpasteurised milk and ice cream) and prepared salads (including coleslaw and bean sprouts) as well as fresh vegetables and fruit. Eating contaminated food with high numbers of L. monocytogenes is the main route of infection (WHO, 2018).

Infection can also be transmitted between humans, notably from pregnant women to unborn babies. Pregnant women are about 20 times more likely to contract listeriosis than other healthy adults. It can result in miscarriage or stillbirth. Newborn babies may also have low birth weight, septicaemia and meningitis. People with HIV/AIDS are at least 300 times more likely to get ill than those with a normally functioning immune system (WHO, 2018).

Owing to the long incubation period, it is challenging to identify the food which was the actual source of the infection (WHO, 2018).

Metrics and numeric limits

Listeriosis is a relatively rare disease with 0.1 to 10 cases per 1 million people per year depending on the countries and regions of the world. Although the number of cases of listeriosis is small, the high rate of death associated with this infection makes it a significant public health concern (WHO, 2018).

The European Centre for Disease Prevention and Control (ECDC) has published case classification for outbreak management and national epidemiological surveillance (ECDC, 2018).

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Codex Alimentarius (FAO and WHO, no date).

Examples of drivers, outcomes and risk management

The control of Listeria monocytogenes is required at all stages in the food chain and an integrated approach is needed to prevent the multiplication of this bacteria in the final food product (WHO, 2018).

The World Health Organization (WHO) and Food and Agriculture Organization of the United Nations (FAO) have published an international quantitative risk assessment of Listeria in ready-to-eat foods. This formed the scientific basis for the Codex Alimentarius Commission Guidelines on the Application of General Principles of Food Hygiene to the Control of Listeria monocytogenes in Food (FAO, 2009).

In general, guidance on the prevention of listeriosis is similar to guidance used to help prevent other foodborne illnesses. This includes practicing safe food handling and following the WHO Five Keys to Safer Food (WHO, 2006).

References

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Coordinating agency or organisation

World Health Organization (WHO), Food and Agricultural Organization of the United Nations (FAO) and International Network of Food Safety Authorities (INFOSAN).

BI0041 / **BIOLOGICAL** / **Infectious Diseases (Human and Animal)**

Shigellosis (Human)

Definition

Shigellosis is an acute invasive enteric infection caused by bacteria belonging to genus Shigella (WHO, 2005).

Reference

WHO, 2005. Guidelines for the control of shigellosis, including epidemics due to Shigella dysenteriae type 1. World Health Organization (WHO). www.who.int/cholera/publications/shigellosis/en Accessed 16 December 2019.

Annotations

Synonyms

Not found.

Additional scientific description

Shigellosis is clinically manifested by diarrhoea that is frequently bloody. Oher common symptoms are abdominal cramps and tenesmus (unproductive, painful straining), fever and loss of appetite (WHO, 2005). The majority of cases and deaths are among children less than five years of age (WHO, 2005).

Shigellosis is endemic in many developing countries and also occurs in epidemics causing considerable morbidity and mortality. It is estimated to cause at least 80 million cases of bloody diarrhoea and 700,000 deaths each year. Ninety-nine percent of infections caused by Shigella occur in developing countries, and the majority of cases (~70%), and of deaths (~60%), occur among children less than five years of age. Probably less than 1% of cases are treated in hospital.

Among the four species of Shigella, Shigella dysenteriae type 1 (Sd1) is especially important because it causes the most severe disease and may occur in large regional epidemics. Major obstacles to the control of shigellosis include the ease with which Shigella spreads from person to person and the rapidity with which it develops antimicrobial resistance (WHO, 2005).

All species of Shigella cause acute bloody diarrhoea by invading and causing patchy destruction of the colonic epithelium. This leads to the formation of micro-ulcers and inflammatory exudates, and causes inflammatory cells (polymorphonuclear leucocytes, PMNs) and blood to appear in the stool. The diarrhoeal stool contains 106–108 Shigellae per gram. Once excreted, the organism is very sensitive to environmental conditions and dies rapidly, especially when dried or exposed to direct sunlight (WHO, 2005).

Definitive diagnosis can only be made by isolating the organism from stool and serotyping the isolate. Culture is also required to determine antimicrobial sensitivity (WHO, 2005).

The World Health Organization (WHO) has published guidance on case classification and surveillance standards (WHO, 2005).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Not relevant.

Examples of drivers, outcomes and risk management

Outbreaks of bloody diarrhoea due to Sd1 are most common in overcrowded, impoverished areas with poor sanitation, inadequate hygiene practices, and unsafe water supplies. Refugees and internally displaced persons are at especially high risk (WHO, 2005). It is spread by direct contact with an infected person, or by eating contaminated food or drinking contaminated water. Flies may also transmit the organism (WHO, 2005).

Prompt detection and reporting of cases of bloody diarrhoea is the essential first step in the monitoring of endemic shigellosis and in the control of epidemic shigellosis. The number of cases of bloody diarrhoea, and of deaths associated with bloody diarrhoea, should be determined and reported for two age groups: under five years, and five years or older. Each health facility should designate a specific individual to be responsible for reporting all cases of, and deaths associated with, bloody diarrhoea. Reports should be provided each week to the district health officer responsible for monitoring the occurrence of cases and detecting outbreaks. For surveillance and reporting purposes, the standard case definition of bloody diarrhoea or dysentery is 'diarrhoea with visible blood in the stool' (WHO, 2005).

Prevention relies on measures that prevent the spread of bacteria, such as handwashing, ensuring availability of safe water, safe human waste disposal, breastfeeding of infants and young children, safe handling and processing of food and control of flies (WHO, 2005).

There is no WHO-recommended vaccine that is effective for preventing infection by Shigella (WHO, 2005).

References

WHO, 2005. Guidelines for the control of shigellosis, including epidemics due to Shigella dysenteriae type 1. World Health Organization (WHO). www.who.int/cholera/publications/shigellosis/en Accessed on 16 December 2019.

Coordinating agency or organisation

World Health Organization.

BI0042 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Avian Influenza (Human and Animal)

Definition

Avian influenza is an infectious disease of birds caused by type A influenza viruses of the Orthomyxoviridae family. Naturally occurring among wild bird populations, avian influenza viruses can infect domestic poultry and other bird species. Some avian influenza viruses can also infect mammals and those affecting humans are called zoonotic. A pandemic can occur when a novel zoonotic avian influenza virus spreads in human populations worldwide (FAO, 2009; WHO, 2018; OIE, 2020).

References

FAO, 2009. Preparing for Highly Pathogenic Avian Influenza. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/3/i0808e/i0808e.pdf Accessed 3 October 2020.

WHO, 2018. Influenza (Avian and other zoonotic). World Health Organization (WHO). www.who.int/en/news-room/fact-sheets/detail/influenza-(avian-and-other-zoonotic) Accessed 3 October 2020.

OIE, 2020. Avian Influenza "at a glance". World Organisation for Animal Health (OIE). www.oie.int/animal-health-in-the-world/avian-influenza-portal Accessed 3 October 2020.

Annotations

Synonyms

Bird Flu, Avian Flu.

Additional scientific description

Avian influenza is transmitted by direct contact with infected birds or through contaminated environments (farms, markets, cages, vehicles, etc.) (OIE, no date a). Live poultry and poultry products trade and movements play an important role in national and cross-border spread. Certain avian influenza strains have also been shown to spread through migratory wild bird movements, sometimes over long distances (FAO, 2016, 2017). Biosecurity measures on farms and in live poultry markets are important to prevent disease introduction or spread (FAO, 2015).

Type A influenza viruses include many different subtypes, classified according to the nature of the two components that make up the virus – haemagglutinin (H) and neuraminidase (N) – proteins found on the surface of influenza viruses. There are 18 haemagglutinin and 11 neuraminidase subtypes of influenza A virus, giving rise to hundreds of variations on the 'HxNy' combination. Avian influenza strains that do not cause significant disease signs in poultry are considered low pathogenic while those leading to severe disease (including severe respiratory syndrome, and nervous signs) and high mortality rates are called highly pathogenic (WHO, 2018). Since the emergence of the H5N1 Highly Pathogenic Avian Influenza (HPAI) virus subtype in 1997 in Asia, several other subtypes have appeared due to the constant evolution and diversification of avian influenza viruses and progressively spread across continents (OIE, 2016; CDC, 2017).

Metrics and numeric limits

Avian influenza viruses of the H5 and H7 subtypes, as well as any influenza A virus with high pathogenicity are notifiable to the World Organisation for Animal Health (OIE) under the Terrestrial Animal Health Code. An intravenous pathogenicity index (IVPI) greater than 1.2 (or as an alternative at least 75% mortality) in chickens determines the strain to be HPAI (OIE, 2017, 2019).

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Codex Alimentarius (FAO, no date).

The WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (WTO, 1994).

The WTO and the World Organization for Animal Health (OIE) G/SPS/GEN/775 (WTO, 1998).

The UN Recommendations on the Transport of Dangerous Goods - UN Model Regulations Model Regulations Nature, Purpose and Significance of the Recommendations (UNECE, no date).

Examples of drivers, outcomes and risk management

Drivers: Introduction of an avian influenza virus to a susceptible flock via poultry trade-related activities or farming and sale (live bird markets), or wild birds and migratory routes (OIE, no date b).

Outcomes: High mortality in poultry with sudden death of birds, may cause severe illness in humans, stamping-out of birds in the affected flock or farm, poultry movement restrictions, trade ban, livelihoods, food security and health implications, in particular women and children who often are the ones caring for poultry (OIE, no date b).

Risk management: Farm and market biosecurity improvement, movement control, depopulation, tracing back/forward, vaccination (prevention, only if the country allows vaccination of birds against avian influenza), compartmentalisation, food hygiene (OIE, no date b).

References

CDC, 2017. Influenza Type A Viruses. Centers for Disease Control and Prevention (CDC). www.cdc.gov/flu/avianflu/influenza-a-virus-subtypes.htm Accessed 3 October 2020.

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FAO, 2015. Biosecurity Guide For Live Poultry Markets. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/3/I5029E/i5029e.pdf Accessed 3 October 2020.

FAO, 2016. Highly pathogenic avian influenza (H5N1 HPAI) spread in the Middle East: Risk assessment. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/3/a-i6155e.pdf Accessed 3 October 2020.

FAO, 2017. Highly pathogenic H5 avian influenza in 2016 and 2017 – observations and future perspectives. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/3/a-i8068e.pdf Accessed 3 October 2020.

OIE, no date a. Avian Influenza “at a glance”. World Organisation for Animal Health (OIE). www.oie.int/animal-health-in-the-world/avian-influenza-portal Accessed 3 October 2020.

OIE, no date b. Avian Influenza. World Organisation for Animal Health (OIE). www.oie.int/en/disease/avian-influenza Accessed 1 May 2021.

OIE, 2016. Avian Influenza: Fowl Plague, Grippe Aviaire. World Organisation for Animal Health (OIE). www.oie.int/fileadmin/Home/eng/Animal_Health_in_the_World/docs/pdf/Disease_cards/HPAI.pdf Accessed 3 October 2020.

OIE, 2017. Infection with avian influenza viruses. In: Terrestrial Animal Health Code. World Organisation for Animal Health (OIE). www.oie.int/index.php?id=169&L=0&htmfile=chapitre_avian_influenza_viruses.htm Accessed 3 October 2020.

OIE, 2019. Terrestrial Animal Health Code. World Organisation for Animal Health (OIE). www.oie.int/standard-setting/terrestrial-code/access-online Accessed 3 October 2020.

UNECE, no date. UN Recommendations on the Transport of Dangerous Goods - UN Model Regulations Model Regulations Nature, Purpose and Significance of the Recommendations. United Nations Economic Commission for Europe (UNECE). www.unece.org/trans/danger/publi/unrec/rev13/13nature_e.html Accessed 3 October 2020.

WHO, 2016. International Health Regulations (2005), 3rd ed. World Health Organization (WHO). www.who.int/ihr/publications/9789241580496/en Accessed 3 October 2020.

WHO, 2018. Influenza (Avian and other zoonotic). World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/influenza-(avian-and-other-zoonotic)

WTO, 1994. The WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement). World Trade Organization (WTO). www.wto.org/english/tratop_e/sps_e/spsagr_e.htm Accessed 3 October 2020.

WTO, 1998. The WTO and the World Organization for Animal Health (OIE). G/SPS/GEN/775. World Trade Organization (WTO). www.wto.org/english/thewto_e/coher_e/wto_oie_e.htm Accessed 3 October 2020.

Coordinating agency or organisation

Food and Agriculture Organization of the United Nations (FAO), World Health Organization (WHO), World Organisation for Animal Health (OIE).

BI0043 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Pandemic Influenza (Human)

Definition

An influenza pandemic is the worldwide spread of a new influenza virus to which there is little or no pre-existing immunity in the human population (WHO, 2021).

Reference

WHO, 2021. World Health Organization (WHO). www.who.int/csr/disease/swineflu/frequently_asked_questions/pandemic/en Accessed June 2021.

Annotations

Synonym

Pan flu.

Additional scientific description

The constantly evolving nature of the influenza virus makes influenza among the top few infectious hazards with significant impact. A pandemic occurs when an influenza virus emerges to which there is little or no immunity in the global human population and which can transmit efficiently among people. The pandemic virus can be a virus strain jumping directly from animals or reassorted from animal viruses with or without human seasonal viruses.

Three influenza pandemics occurred at intervals of several decades during the 20th century, the most severe of which was the so-called 'Spanish Flu' (caused by an A(H1N1) virus), estimated to have caused 20–50 million deaths in 1918–2019. Milder pandemics occurred followed in 1957–1958 ('Asian Flu') caused by an A(H2N2) virus) and in 1968 (the 'Hong Kong Flu' caused by an A(H3N2) virus), which were estimated to have caused 1–4 million deaths each.

The current status of knowledge and technology means that predicting the next influenza pandemic – when, where, which virus strain, and how severe it will be – is impossible. Consequently, pandemic vaccines cannot be developed before the pandemic virus emerges. The World Health Organization (WHO) public health research agenda for influenza as an innovative research mechanism is key to inform and advance pandemic influenza preparedness (WHO, 2017a).

Meanwhile global influenza surveillance, through the WHO Global Influenza Surveillance and Response System (GISRS), assists with timely sharing of virus data and associated information, and national capacity building via seasonal influenza programs that are critical to mitigate the impact of the inevitable next pandemic (WHO, 2017b).

Metrics and numeric limits

The 2009 pandemic was caused by an influenza A (H1N1) virus. It is estimated to have caused between 100,000 and 400,000 deaths globally in the first year alone. Children and young adults were disproportionately affected in comparison to seasonal influenza, which causes severe disease mainly in the elderly, persons with chronic conditions and pregnant women (WHO, 2019a).

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

Influenza pandemics, whether mild, moderate or severe, affect a large proportion of the global population, which puts significant strains on health and other essential services and may result in significant economic losses (WHO, 2019a).

Timely detection, characterisation and sharing of information about the pandemic virus directly affects the outcome of all downstream responses. The WHO GISRS is the foundation of such an operation. In an influenza pandemic, the virus is likely to spread rapidly. Rapid development, production and deployment of vaccines is critical to limit the potential impact on populations and essential services (WHO, 2019a).

Access to the appropriate vaccine in the early phases of a pandemic is greatly influenced by global production capacity and the lead-time required to produce influenza vaccines (WHO, 2019a).

As an influenza pandemic may last months or even years, it may require a sustained response in the health sector but also in other sectors providing essential services, such as energy and food production (WHO, 2019b).

References

WHO, 2016. International Health Regulations (2005), 3rd ed. World Health Organization (WHO). www.who.int/ihr/publications/9789241580496/en Accessed 26 September 2020.

WHO, 2017a. WHO Public Health Research Agenda for Influenza. World Health Organization (WHO). www.who.int/influenza/resources/research/publication_research_agenda_2017/en Accessed 8 November 2020.

WHO, 2017b. How can I avoid getting the flu? World Health Organization (WHO). www.who.int/features/qa/seasonal-influenza/en Accessed 19 November 2019.

WHO, 2019a. Pandemic Influenza. World Health Organization (WHO) Regional Office for Europe. www.euro.who.int/en/health-topics/communicable-diseases/influenza/pandemic-influenza Accessed 19 November 2019.

WHO, 2019b. Pandemic Influenza Preparedness. World Health Organization (WHO). www.who.int/influenza/preparedness/en Accessed 19 November 2019.

Coordinating agency or organisation

World Health Organization.

BI0044 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Seasonal Influenza (Human)

Definition

Seasonal influenza is an acute respiratory infection caused by influenza viruses which circulate in all parts of the world (WHO, 2018).

Reference

WHO, 2018. Influenza (seasonal). World Health Organization (WHO). www.who.int/en/news-room/fact-sheets/detail/influenza-(seasonal) Accessed 8 November 2020.

Annotations

Synonym

Flu.

Additional scientific description

Seasonal influenza is most often caused by type A or B influenza viruses. The constant evolving nature of influenza viruses makes influenza among the top few infectious hazards with significant impact. Epidemics occur mainly during winter, from October to March in the northern hemisphere and April to September in the southern hemisphere. In tropical and subtropical countries, seasonal influenza can happen all year round (WHO, 2020).

Seasonal influenza outbreaks are caused by small changes on the surface of viruses that have already circulated, and to which people have some immunity (WHO, 2018).

Symptoms include sudden onset of fever, cough (usually dry), headache, muscle and joint pain, sore throat and a runny nose. The cough can be severe and can last two or more weeks. Most people recover from fever and other symptoms within a week without requiring medical attention (WHO, 2018).

Seasonal influenza can cause severe illness or death in high-risk groups, such as pregnant women, children younger than five years, people older than 65 years, and people with chronic medical conditions. People with increased risk of exposure to influenza, such as children in day care centres and schools and workers in health care facilities, can transmit infections to others if they become ill (WHO, 2018).

Patients who are not from a high-risk group should be managed with ‘symptomatic treatment’ and are advised, if symptomatic, to stay home to minimise the risk of infecting others in the community. Patients known to be at high risk for developing severe or complicated illness, should be treated with antiviral drugs in addition to symptomatic treatment as soon as possible. Patients with severe or progressive clinical illness associated with suspected or confirmed influenza infection (i.e., clinical syndromes of pneumonia, sepsis or exacerbation of chronic underlying disease) should be treated with antiviral drugs as soon as possible (WHO, 2017, 2018).

Most cases of human influenza are clinically diagnosed. Collection of appropriate respiratory samples and the application of a laboratory diagnostic test is required to establish a definitive diagnosis. Laboratory confirmation of influenza virus from throat, nasal and nasopharyngeal secretions or tracheal aspirate or washings is commonly performed using direct antigen detection, virus isolation, or by reverse transcriptase-polymerase chain reaction (RT-PCR) (WHO, 2018).

The World Health Organization (WHO) recommends annual vaccination with vaccines containing updated formulation for high-risk groups ideally before the season begins. Getting vaccinated at any time during the season can still help prevent flu infections (WHO, 2020).

Metrics and numeric limits

Worldwide, annual epidemics are estimated to result in about 3 to 5 million cases of severe illness, and about 290,000 to 650,000 respiratory deaths (WHO, 2018).

In industrialised countries most deaths associated with influenza occur among people of 65 years of age or older. Epidemics can result in high levels of absenteeism and productivity losses. Clinics and hospitals can be overwhelmed during peak illness periods (WHO, 2018).

The effects of seasonal influenza epidemics in developing countries are not fully known, but research estimates that 99% of deaths in children under five years of age with influenza-associated lower respiratory tract infections are found in developing countries (WHO, 2017).

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

The most effective way to prevent infection with seasonal influenza virus is vaccination. Safe and effective vaccines have been used for more than 60 years. Because the influenza virus continuously mutates, a new vaccine is required each year, and those in risk groups must again be vaccinated (Walsh, 2017).

Globally coordinated surveillance of influenza, timely sharing of influenza virus data and associated information, and innovative research are key to addressing the problem of influenza. Global influenza surveillance has been conducted through the World Health Organization (WHO) Global Influenza Surveillance and Response System (GISRS) since 1952. GISRS is a system fostering global confidence and trust for over half a century, through effective collaboration and sharing of viruses, data and benefits based on Member States' commitment to a global public health model (WHO, no date).

The aim of GISRS is to protect people from the threat of influenza by functioning: as a global mechanism of surveillance, preparedness and response for seasonal, pandemic and zoonotic influenza; as a global platform for monitoring influenza epidemiology and disease; and as a global alert for novel influenza viruses and other respiratory pathogens (WHO, no date).

References

Walsh, B., 2017. The World is Not Ready for the Next Pandemic. https://time.com/4766624/next-global-security Accessed 8 April 2021.

WHO, no date. Influenza: Global Influenza Surveillance and Response System (GISRS). World Health Organization (WHO). www.who.int/influenza/gisrs_laboratory/en Accessed 8 November 2020.

WHO, 2016. International Health Regulations (2005), 3rd ed. World Health Organization (WHO). www.who.int/ihr/publications/9789241580496/en Accessed 26 September 2020.

WHO, 2017. How can I avoid getting the flu? World Health Organization (WHO). www.who.int/features/qa/seasonal-influenza/en Accessed 15 November 2019.

WHO, 2018. Influenza (seasonal). World Health Organization (WHO). www.who.int/en/news-room/fact-sheets/detail/influenza-(seasonal) Accessed 8 November 2020.

WHO, 2020. How can I avoid getting the flu? www.who.int/westernpacific/news/q-a-detail/how-can-i-avoid-getting-the-flu Accessed 8 April 2021.

Coordinating agency or organisation

World Health Organization.

BI0045 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Cysticercosis

Definition

Cysticercosis is a preventable intestinal infection in humans and animals caused by the tapeworm Taenia solium (pork tapeworm). Human cysticercosisi can result in devastating effects on human health resulting in neurocysticercosis with blindness, convulsions, and epileptic seizures, and can be fatal. It is estimated to affect between 2.56 and 8.30 million people, based on the range of epilepsy prevalence data available (adapted from WHO, 2020).

Reference

WHO, 2020. Taeniasis/cysticercosis. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/taeniasis-cysticercosis Accessed 29 September 2020.

Annotations

Synonyms

Taeniasis.

Additional scientific description

Taenia solium causes taeniasis which is acquired by humans through the ingestion of the parasite's larval cysts (cysticerci) in undercooked and infected pork. Human tapeworm carriers excrete tapeworm eggs in their faeces and contaminate the environment when they defecate in open areas. Humans can also become infected with T. solium eggs due to poor hygiene (via the faecal-oral route) or ingesting contaminated food or water. When the parasites enter the central nervous system, they can cause neurological symptoms (neurocysticercosis), including epileptic seizures. Human cysticercosisi can result in devastating effects on human health. The larvae (cysticerci) may develop in the muscles, skin, eyes and central nervous system (WHO, 2020).

Cysticercosis due to T. solium is usually characterised by mild and non-specific symptoms. Abdominal pain, nausea, diarrhoea or constipation may arise when the tapeworms become fully developed in the intestine, approximately 8 weeks after ingestion of meat containing cysticerci. These symptoms may continue until the tapeworm dies following treatment, otherwise it may live for several years. It is considered that untreated infections with T. solium tapeworms generally persist for two to three years. In the case of cysticercosis due to T. solium the incubation period prior to the appearance of clinical symptoms varies, and infected people may remain asymptomatic for many years. In some endemic regions (particularly in Asia), infected people may develop visible or palpable nodules (a small solid bump or node that can be detected by touch) beneath the skin (subcutaneous) (WHO, 2020).

Taenia solium is the cause of 30% of epilepsy cases in many endemic areas where people and roaming pigs live in proximity. In high risk communities it can be associated with as many as 70% of epilepsy cases. More than 80% of the world's 50 million people who are affected by epilepsy live in low and lower-middle income countries. In poor remote settings where the disease is present, epilepsy is difficult to diagnose and treat, and causes major stigma, especially in girls and women (where it is commonly associated with witchcraft) (WHO, 2020).

In 2015, the World Health Organization (WHO) Foodborne Disease Burden Epidemiology Reference Group identified T. solium as a leading cause of deaths from food-borne diseases, and resulting in a total of 2.8 million disability-adjusted life-years (DALYs). The total number of people suffering from neurocysticercosis, including symptomatic and asymptomatic cases, is estimated at 2.56–8.30 million, based on the range of epilepsy prevalence data available. Although 70% of patients with epilepsy could lead a normal life if treated correctly; poverty, ignorance of the disease, inadequate infrastructure in health or lack of access to medication, cause 75% of people with this condition to be treated poorly, if treated at all (WHO, 2020).

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

Cysticercosis mainly affects the health and livelihoods of subsistence farming communities in developing countries of Africa, Asia and Latin America. It also reduces the market value of pigs and makes pork unsafe to eat (WHO, 2020).

To prevent, control and possibly eliminate T. solium, public health interventions with an approach spanning the veterinary, human health and environmental sectors are required. However, reliable epidemiological data on the geographical distribution of T. solium taeniasis/cysticercosis in people and pigs remains scarce (WHO, 2020).

Appropriate surveillance mechanisms should enable new cases of human or porcine cysticercosis to be recorded in order to help identify communities at high risk and to focus prevention and control measures in these areas (WHO, 2020).

There are several interventions for the control of T. solium that can be used in different combinations. In a meeting of experts in 2009, these were identified as (WHO, 2020):

- Core ‘rapid impact’ interventions:
  - treatment of human taeniasis
  - intervention in pigs (vaccination plus anthelmintic treatment).
- Supporting measures:
  - community health education, including hygiene and food safety
  - improved sanitation - ending open defecation.
- Measures requiring more fundamental societal changes:
  - improved pig husbandry - no free-roaming pigs
  - improved meat inspection and processing of meat products.

The WHO response includes: supporting the validation of control programmes; identification of endemic areas (mapping); strengthening prevention and control through a One-Health approach; advocating a multi-sectorial approach with key partners; promoting pig interventions; and improving data on T. solium and identifying endemic and high-risk areas (WHO, 2020).

Indicators are specific variables that assist with data analysis and provide tools for health authorities and people involved in disease control. The WHO has defined a new set of indicators at country and global level for T. solium and is developing reporting systems to guide and assist the countries on data collection and reporting. At the global level, the indicators are the number of endemic countries for T. solium, and the number of countries with intensified control in hyper endemic areas for T. solium. Intensified control means implementation of any core ‘rapid impact’ interventions (WHO, 2020).

References

WHO, 2016. International Health Regulations (2005), 3rd ed. World Health Organization (WHO). https://apps.who.int/iris/handle/10665/246107 Accessed 26 September 2020.

WHO, 2020. Taeniasis/Cysticercosis. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/taeniasis-cysticercosis Accessed on 29 September 2020.

Coordinating agency or organisation

World Health Organization.

BI0046 / **BIOLOGICAL** / **Infectious Diseases (Human and Animal)**

Leptospirosis (Human)

Definition

Leptospirosis is an infectious disease caused by pathogenic Spirochaetes of the genus Leptospira. These bacteria called leptospires affect both humans and animals. Humans become infected through direct contact with the urine of infected animals or with a urine-contaminated environment. It is a zoonosis. Human-to-human transmission occurs only very rarely (adapted from WHO and ILS, 2003 and WHO, 2020).

References

WHO, 2020. Leptospirosis. World Health Organization (WHO). www.who.int/topics/leptospirosis/en Accessed 6 October 2020.

WHO and ILS, 2003. Guidance for Diagnosis, Surveillance and Control. World Health Organization (WHO) and International Leptospirosis Society (ILS). https://apps.who.int/iris/bitstream/handle/10665/42667/WHO_CDS_CSR_EPH_2002.23.pdf;jsessionid=3CA0C2710D780BDEFC35B492EBB4242F?sequence=1 Accessed 6 October 2020.

Annotations

Synonyms

Not applicable.

Additional scientific description

Leptospires are bacteria which can be either pathogenic (i.e., having the potential to cause disease in animals and humans) or saprophytic (i.e., free living and generally considered not to cause disease) (WHO, no date).

Pathogenic leptospires are maintained in nature in the renal tubules of certain animals. Saprophytic leptospires are found in many types of wet or humid environments ranging from surface waters and moist soil to tap water. Saprophytic halophilic (salt-loving) leptospires are found in seawater (WHO and ILS, 2003).

The bacteria enter the body through cuts or abrasions on the skin, or through the mucous membranes of the mouth, nose and eyes. Person-to-person transmission is rare (WHO, 2020a).

In the early stages of the disease, symptoms include high fever, severe headache, muscle pain, chills, redness of the eyes, abdominal pain, jaundice, haemorrhages in the skin and mucous membranes, vomiting, diarrhoea, and rash (WHO, 2020a).

The clinical manifestations are highly variable. Typically, the disease presents in four broad clinical categories: a mild, influenza-like illness; Weil’s syndrome characterised by jaundice, renal failure, haemorrhage and myocarditis with arrhythmias; meningitis/meningoencephalitis; and pulmonary haemorrhage with respiratory failure (YANG, 2007).

Clinical diagnosis is difficult because of the varied and non-specific presentation. Confusion with other diseases, such as dengue and other haemorrhagic fevers, is particularly common in the tropics. It may present with a wide variety of clinical manifestations ranging from a mild ‘flu’-like illness to a serious and sometimes fatal disease. Icterus (jaundice) is a relatively common symptom in leptospirosis but is also found in many other diseases involving the liver such as the various forms of hepatitis (WHO, 2020a).

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

Case-fatality rates in different parts of the world have been reported to range from <5% to 30%. These figures are not reliable because in many areas the occurrence of the disease is not well documented. In addition, mild cases may not be diagnosed as leptospirosis (WHO and ILS, 2003).

Little is currently known regarding the true incidence of leptospirosis. It is estimated that 0.1 to 1 per 100,000 people living in temperate climates are affected each year, with the number increasing to 10 or more per 100,000 people living in tropical climates. If there is an epidemic, the incidence can soar to 100 or more per 100,000 people. Major improvements in the prognosis of severe leptospirosis have been made in recent decades, owing to the use of haemodialysis as a means of supporting the reversible renal failure that may occur in some cases and to aggressive supportive care (WHO, 2020a).

Leptospirosis occurs worldwide but is most common in tropical and subtropical areas with high rainfall (WHO, 2020a).

Leptospirosis is overlooked and under-reported for many reasons including difficulty in distinguishing clinical signs from those of other endemic diseases and lack of appropriate diagnostic laboratory services (WHO, 2003).

The World Health Organization (WHO) has set a number of goals concerning leptospirosis: to provide estimates of the global burden of leptospirosis according to age, sex and region, to increase awareness of and commitment to the disease in developing countries; and to encourage developing countries to undertake active disease surveillance and strengthen control measures (WHO, 2020a).

These efforts will ultimately enable policy makers and other stakeholders to translate knowledge into policy by setting appropriate evidence-based priorities in the area of leptospirosis disease control and prevention.

To coordinate and direct global research and action against human leptospirosis, the WHO has established the Leptospirosis Burden Epidemiology Reference Group (LERG). It has been assigned the following tasks: to review and appraise epidemiological evidence based on commissioned reviews and studies; to develop epidemiological tools to estimate disease burden; to estimate and express disease burden through summary measures of population health (including disability-adjusted life years); and to identify technical gaps for research (WHO, 2020a).

The WHO Secretariat for the LERG is based at the Department of Food Safety and Zoonoses with functions of facilitating, coordinating, guiding and monitoring the work of the LERG. The LERG also partners other international actors including the Global Burden of Disease (GBD 2005) initiative coordinated by the Institute for Health Metrics and Evaluation (WHO, 2020b).

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Coordinating agency or organisation

World Health Organization.

BI0047 / **BIOLOGICAL** / **Infectious Diseases (Human and Animal)**

Plague (Human)

Definition

Plague is an acute febrile infectious disease caused by the zoonotic bacteria Yersinia pestis (Dennis et al., 1999).

Reference

Dennis, D.T., K.L. Gage, N. Gratz, J.D. Poland and E. Tikhomirov, 1999. Plague Manual: Epidemiology, Distribution, Surveillance and Control. WHO/CDS/CSR/EDC/99.2. World Health Organization. www.who.int/csr/resources/publications/plague/WHO_CDS_CSR_EDC_99_2_EN/en Accessed 13 December 2019.

Annotations

Synonyms

Not found.

Additional scientific description

Yersinia pestis is usually found in small mammals, mainly rodents, and their fleas (WHO, 2017).

Plague is one of the most virulent and potentially lethal bacterial diseases known, and fatality rates remain high among patients who are not treated in the early stages of infection (WHO, 2017).

Humans can be infected through the bite of infected vector fleas, unprotected contact with infectious body fluids or contaminated materials and the inhalation of respiratory droplets/small particles from a patient with pneumonic plague (WHO, 2017).

Plague is characterised by a rapid onset of fever and other systemic manifestations of gram-negative bacterial infection. It is diagnosed clinically and through laboratory confirmation (Dennis et al., 1999).

The World Health Organization has published guidance on case classification and surveillance standards (WHO, 2006).

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

Plague is most frequently transmitted by the bites of rat fleas, especially in low hygiene settings. It can be transmitted during the skinning and handling of carcasses of wild animals such as rabbits and hares, prairie dogs, wildcats, and marmots (WHO, 2017). It can also result from the ingestion of undercooked contaminated meat (WHO, 2017).

Plague can also be acquired by inhalation of infective respiratory droplets and perhaps by manual transfer of infected fluids to the mouth during the handling of infected animal tissues (WHO, 2017).

Preventative measures include informing people when zoonotic plague is present in their environment and advising them to take precautions against flea bites and not to handle animal carcasses. People should be advised to avoid direct contact with infected body fluids and tissues (WHO, 2007).

When handling potentially infected patients and collecting specimens, standard precautions should apply (WHO, 2017).

References

Dennis, D.T., K.L. Gage, N. Gratz, J.D. Poland and E. Tikhomirov, 1999. Plague Manual: Epidemiology, Distribution, Surveillance and Control. WHO/CDS/CSR/EDC/99.2. World Health Organization. www.who.int/csr/resources/publications/plague/WHO_CDS_CSR_EDC_99_2_EN/en Accessed 13 December 2019.

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Coordinating agency or organisation

World Health Organization.

BI0048 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Leprosy

Definition

Leprosy is a curable infectious disease, endemic in many countries, caused by the bacterium Mycobacterium leprae (M. leprae). It mainly affects the skin, peripheral nerves, mucosa of the upper respiratory tract and eyes. Untreated, it can lead to permanent disability (WHO, 2019).

Reference

WHO, 2019. Leprosy. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/leprosy Accessed 4 November 2020.

Annotations

Synonyms

Hansen's disease.

Additional scientific description

Leprosy is an age-old disease, described in the literature of ancient civilizations. Leprosy has struck fear into human beings for thousands of years and was well recognised in the oldest civilizations of China, Egypt and India. A cumulative total of the number of individuals who, over the millennia, have suffered its chronic course of incurable disfigurement and physical disabilities can never be calculated (WHO, no date a).

Since ancient times, leprosy has been regarded by the community as a contagious, mutilating and incurable disease. There are many countries in Asia, Africa and Latin America with a significant number of leprosy cases. It is estimated that there are between one and two million people visibly and irreversibly disabled due to past and present leprosy who need to be cared for by the community in which they live (WHO, no date a). Throughout history, people afflicted have often been ostracised by their communities and families (WHO, 2019).

Mycobacterium leprae multiplies slowly, meaning that symptom onset can range from one to twenty years from infection, with an average incubation period of five years. Clinical presentation is characterised by progressive and permanent damage to the skin, nerves, limbs and eyes if untreated, leading to deformities and disabilities. The exact mechanism of transmission of leprosy is not known (WHO, no date b).

Laboratory diagnosis is via the identification of acid-fast bacilli in a slit-skin smear. Other tests (such as serological markers) are associated with low diagnostic accuracy (WHO, 2018).

The first breakthrough for leprosy treatment occurred in the 1940s with the development of the medicine dapsone. The duration of treatment lasted many years, often a lifetime, making compliance difficult. In the 1960s, M. leprae started to develop resistance to dapsone, the only known anti-leprosy medicine at that time. In the early 1960s, rifampicin and clofazimine were discovered and found to be effective (WHO, 2019).

In 1981, the World Health Organization (WHO) recommended multidrug therapy. The currently recommended multidrug therapy regimen consists of medicines: dapsone, rifampicin and clofazimine. This treatment lasts for six months for pauci-bacillary and 12 months for multi-bacillary cases. Multidrug therapy kills the pathogen and cures the patient. Since 1995, the WHO has provided multidrug therapy for leprosy free of cost. Free multidrug therapy was initially funded by The Nippon Foundation, and since 2000 it is donated through an agreement with Novartis until at least 2020. More than 16 million leprosy patients have been treated with multidrug therapy over the past 20 years (WHO, 2019).

The Centers for Disease Control and Prevention has published information on Hansen's Disease/Leprosy case definitions (CDC, 2013).

Metrics and numeric limits

The elimination of leprosy as a public health problem is defined as a registered prevalence of less than 1 case per 10,000 population. This was achieved globally in 2000, but pockets of higher prevalence within some countries continue to persist. Based on 184,212 cases at the end of 2018, the prevalence rate corresponds to 0.2/10,000 (WHO, 2019).

Key relevant UN convention / multilateral treaty

Convention on the rights of persons with disabilities (CRPD) (UNGA, 2007).

International Health Regulations (2005), 3rd ed. (WHO, 2016a).

Examples of drivers, outcomes and risk management

In 2016, the WHO launched the Global Leprosy Strategy 2016–2020, which aims to reinvigorate efforts to control leprosy and avert disabilities, especially among children still affected by the disease in endemic countries. The strategy emphasises the need to sustain expertise and increase the number of skilled leprosy staff, improve the participation of affected persons in leprosy services and reduce visible deformities as well as stigmatisation associated with the disease. It also calls for renewed political commitment and enhanced coordination among partners while highlighting the importance of research and improved data collection and analysis (WHO, 2016b).

The key interventions needed to achieve the targets include: detecting cases early before visible disabilities occur, with a special focus on children as a way to reduce disabilities and reduce transmission; targeting detection among higher risk groups through campaigns in highly endemic areas or communities; and improving health care coverage and access for marginalised populations (WHO, 2016b).

Endemic countries need to include other strategic interventions in their national plans to meet the new targets, namely: screening all close contacts of persons affected by leprosy; promoting a shorter and uniform treatment regimen; and incorporating specific interventions against stigmatisation and discrimination (WHO, 2016b).

References

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Coordination agency or organisation

World Health Organization.

BI0049 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Chikungunya

Definition

Chikungunya is a mosquito-borne viral infection caused by the chikungunya virus. It causes fever and severe arthralgia (joint pain) which is often debilitating. The disease can be endemic and epidemic in countries (WHO, 2020).

Reference

WHO, 2020. Chikungunya. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/chikungunya Accessed 4 November 2020.

Annotations

Synonyms

Not found.

Additional scientific description

Chikungunya is a mosquito-borne viral disease first described during an outbreak in southern Tanzania in 1952. It is an RNA virus that belongs to the Alphavirus genus of the family Togaviridae. The name 'chikungunya' derives from a word in the Kimakonde language, meaning 'to become contorted', and describes the stooped appearance of sufferers with joint pain (arthralgia) (WHO, 2020).

Chikungunya virus is transmitted between humans through the bites of infected mosquitoes – mainly of the Aedes aegypti and A. albopictus species. Both species can also transmit other mosquito-borne viruses, including dengue and Zika fever viruses. The clinical picture of the infection is characterised by abrupt onset of fever frequently accompanied by arthralgia. Other symptoms include muscle pain, headache, nausea, fatigue and a rash usually involving the limbs and trunk (WHO, 2020).

Laboratory diagnosis is via serological and/or virological testing. Serological testing may confirm the presence of anti-chikungunya antibodies. Immunoglobulin M (IgM) antibody levels are highest three to five weeks after onset of symptoms. Virological testing may isolate the virus itself and should be performed on samples collected during the first week after onset of symptoms (WHO, 2020).

Metrics and numeric limits

Chikungunya has been identified in over 60 countries in Asia, Africa, Europe and the Americas (WHO, 2020).

The European Centre for Disease Prevention and Control (ECDC) has published case classifications for outbreak management, epidemiological surveillance, and reporting (ECDC, 2018).

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

The proximity of mosquito vector breeding sites to human habitation is a significant risk factor for chikungunya as well as for other diseases that Aedes mosquito species transmit. At present, the main method to control or prevent the transmission of chikungunya virus is to combat the mosquito vectors. Prevention and control relies heavily on reducing the number of natural and artificial water-filled container habitats that support breeding of the mosquitoes. This requires mobilisation of affected and at-risk communities, to empty and clean containers that contain water on a weekly basis to inhibit mosquito breeding and the subsequent production of adults. Sustained community efforts to reduce mosquito breeding can be an effective tool to reduce vector populations (WHO, 2020).

During outbreaks, insecticides may be sprayed to kill flying mosquitoes, applied to surfaces in and around containers where the mosquitoes land, and used to treat water in containers to kill the immature larvae. This may also be performed by health authorities as an emergency measure to control the mosquito population (WHO, 2020).

For protection during outbreaks of chikungunya, clothing which minimises skin exposure to the day-biting vectors is advised. Repellents can be applied to exposed skin or to clothing in strict accordance with product label instructions. For those who sleep during the daytime, particularly young children, or sick or older people, insecticide-treated mosquito nets afford good protection, because the mosquitoes that transmit chikungunya feed primarily during the day. Basic precautions should be taken by people travelling to risk areas and these include use of repellents, wearing long sleeves and pants and ensuring rooms are fitted with screens to prevent mosquitoes from entering (WHO, 2020).

There is no specific antiviral drug treatment for chikungunya. The clinical management targets primarily to relieving the symptoms. There is no commercial vaccine available to protect against chikungunya virus infection. While there are several vaccine strategies being pursued (as of mid-2020), of which some are in various stages of clinical trials, they are still several years away from being licensed and available to the public. Prevention of infection by avoiding mosquito bites is the best protection (WHO, 2020).

References

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Coordinating agency or organisation

World Health Organization.

BI0050 / **BIOLOGICAL** / **Infectious Diseases (Human and Animal)**

Zika Virus (human)

Definition

Zika virus disease is a disease transmitted primarily by Aedes mosquitoes which can lead to complications (WHO, 2018).

Reference

WHO, 2018. Zika virus. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/zika-virus Accessed 19 November 2019.

Annotations

Synonym

Not found.

Additional scientific description

Zika virus is primarily transmitted to humans and animals through the bite of an infected mosquito from the Aedes genus, mainly A. aegypti, in tropical and subtropical regions. Aedes mosquitoes usually bite during the day, peaking during early morning and late afternoon/evening (WHO, 2018).

Zika virus is also transmitted from mother to foetus during pregnancy, through sexual contact, transfusion of blood and blood products, and organ transplantation (WHO, 2018).

Symptoms are generally mild and include fever, rash, conjunctivitis, muscle and joint pain, malaise or headache. Symptoms typically last for 2 to 7 days. Most people with Zika virus infection do not develop symptoms (WHO, 2018).

Zika virus infection during pregnancy can cause infants to be born with microcephaly and other congenital malformations and neurodevelopmental disorders, known as congenital Zika syndrome. Infection with Zika virus is also associated with other complications of pregnancy including pre-term birth and miscarriage (WHO, 2018).

An increased risk of neurological complications is associated with Zika virus infection in adults and children, including Guillain-Barré syndrome, neuropathy and myelitis (WHO, 2018).

Infection with Zika virus may be suspected based on symptoms of persons living in or visiting areas with Zika virus transmission and/or Aedes mosquito vectors (WHO, 2018).

A diagnosis of Zika virus infection can only be confirmed by laboratory tests of blood or other body fluids, such as urine or semen (WHO, 2018).

The World Health Organization (WHO) has published guidance on case classification and surveillance standards (WHO, 2016a).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016b).

Examples of drivers, outcomes and risk management

Aedes mosquitoes breed in small collections of water around homes, schools, and work sites. It is important to eliminate these mosquito breeding sites (WHO, 2018).

Protection against mosquito bites during the day and early evening is a key measure to prevent Zika virus infection. Special attention should be given to prevention of mosquito bites among pregnant women, women of reproductive age, and young children (WHO, 2018).

Personal protection measures include wearing clothing (preferably light-coloured) that covers as much of the body as possible; using physical barriers such as window screens and closed doors and windows; and applying insect repellent to skin or clothing (WHO, 2018).

Young children and pregnant women should sleep under mosquito nets if sleeping during the day or early evening. Travellers and those living in affected areas should take the same basic precautions (WHO, 2018).

No vaccine is yet available for the prevention or treatment of Zika virus infection (WHO, 2018).

To date, mitigation strategies continue to rely on vector control (Achee et al., 2019).

The WHO is investigating conventional and newer tools for mosquito control (WHO, 2017).

References

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WHO, 2018. Zika virus. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/zika-virus Accessed 19 November 2019.

Coordinating agency or organisation

World Health Organization.

BI0051 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Diphtheria (Human)

Definition

Diphtheria is a widespread severe infectious disease caused by the bacterium Corynebacterium diphtheriae and the toxin they produce. It is a potentially life-threatening, vaccine-preventable disease that primarily affects the throat and upper airways and has the potential for epidemics (WHO, 2018).

Reference

WHO, 2018. Immunization, Vaccines and Biologicals: Diphtheria. World Health Organization (WHO). www.who.int/immunization/diseases/diphtheria/en Accessed 15 November 2019.

Annotations

Synonyms

Not identified.

Additional scientific description

Transmission of Corynebacterium diphtheriae is through direct physical contact or from breathing in the aerosolised secretions from coughs or sneezes of infected individuals. The resulting respiratory illness has an acute onset and the main characteristics are sore throat, low fever and swollen glands in the neck. The diphtheria toxin causes a membrane of dead tissue to build up over the throat and tonsils, making breathing and swallowing difficult. The disease is fatal in 5–10% of cases, with a higher mortality rate in young children (WHO, 2018). Cutaneous infection can also occur, leading to absorption of the toxin and severe and occasionally fatal disease.

Laboratory criteria for diagnosis is through the isolation of C. diphtheriae from a clinical specimen, or a four-fold or greater rise in serum antibody (but only if both serum samples were obtained before the administration of diphtheria toxoid or antitoxin) (WHO, 2014).

Surveillance data can be used to monitor the incidence of disease and levels of vaccination coverage (target more than 90%) as measures of the impact of control programmes.

The World Health Organization has published recommended surveillance standards for diphtheria (WHO, 2014).

Metrics and numeric limits

In 2018, there were 16,648 reported cases of diphtheria globally, compared to 8819 in 2017 (WHO, 2019).

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

Diphtheria remains a significant health problem in countries with poor routine vaccination coverage or pockets of unimmunised (WHO, 2017).

Vaccination against diphtheria has reduced the mortality and morbidity of diphtheria dramatically, however diphtheria is still a significant child health problem in countries with poor coverage. In countries endemic for diphtheria, the disease occurs mostly as sporadic cases or in small outbreaks. Treatment involves administering diphtheria antitoxin to neutralise the effects of the toxin, as well as antibiotics to kill the bacteria (WHO, 2018).

Control of diphtheria is based on the following three measures: primary prevention of disease by ensuring high population immunity through immunisation; secondary prevention of spread by the rapid investigation of close contacts, to ensure their proper treatment; and tertiary prevention of complications and deaths by early diagnosis and proper management (WHO, 2014).

References

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WHO, 2018. Immunization, Vaccines and Biologicals: Diphtheria. World Health Organization (WHO). www.who.int/immunization/diseases/diphtheria/en Accessed 5 November 2020.

WHO, 2019. Global and regional immunization profile. World Health Organization (WHO). www.who.int/immunization/monitoring_surveillance/data/gs_gloprofile.pdf?ua=1 Accessed 15 November 2019.

Coordinating agency or organisation

World Health Organization.

BI0052 / **BIOLOGICAL** / **Infectious Diseases (Human and Animal)**

Measles (Human)

Definition

Measles is a highly contagious, serious disease caused by a virus from the paramyxovirus family. Transmission occurs through direct contact, droplet spread, and airborne spread. The virus initially infects the respiratory tract, then spreads throughout the body (WHO 2019).

Reference

WHO, 2019. Measles. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/measles Accessed 11 September 2020.

Annotations

Synonym

Rubeola.

Additional scientific description

Despite a long-running, global, childhood routine immunisation programme, measles has been resurgent in recent years, and countries which had previously achieved good control have experienced new outbreaks. Even though a safe and cost-effective vaccine is available, in 2018, there were more than 140,000 measles deaths globally, mostly among children under the age of five (WHO, 2019a).

Measles is a highly contagious viral disease which affects susceptible individuals of all ages and remains one of the leading causes of death among young children globally, despite the availability of safe and effective measles-containing vaccines. It is transmitted via droplets from the nose, mouth, or throat of infected persons. Initial symptoms, which usually appear 10 to 12 days after infection, include high fever, usually accompanied by one or more of the following: runny nose, conjunctivitis, cough and tiny white spots on the inside of the mouth. Several days later, a rash develops, starting on the face and upper neck and gradually spreads downwards. A patient is infectious four days before the start of the rash to four days after the appearance of the rash. Most people recover within two to three weeks (WHO, 2019b).

Detection of specific immunoglobulin M (IgM) antibodies in a serum sample collected within the first few days of rash onset can provide presumptive evidence of a current or recent measles virus infection. Serological tests can result in false-negative results when serum specimens are collected too early with respect to rash onset (CDC, 2019).

Serious complications are more common in children under the age of 5 years, or in adults over the age of 30 years. The most serious complications include blindness, encephalitis (an infection that causes brain swelling), severe diarrhoea and related dehydration, ear infections, or severe respiratory infections such as pneumonia (CDC, 2019; WHO, 2019a).

Even with implementation of routine immunisation, measles continues to circulate globally due to suboptimal vaccination coverage and population immunity gaps. Any community with less than 95% population immunity is at risk for an outbreak. If an outbreak response is not timely and comprehensive, the virus will find its way into more pockets of vulnerable individuals and potentially spread within and beyond the affected countries (WHO, 2019b).

The impact on public health will persist until the ongoing outbreaks are controlled, routine immunisation coverage is continuously high (≥95%) and immunity gaps in the population are closed. As long as measles continues to circulate anywhere in the world, no country can be assured to avoid importation. However, countries can protect their populations through high vaccine coverage achieved primarily through routine immunisation programmes, and where necessary through supplemental immunisation activities designed to ensure that susceptible individuals are vaccinated (WHO, 2019b).

Although the measles virus is related to several other viruses that infect animals, humans are the only reservoir for the measles virus. It is therefore theoretically possible that measles, could be eradicated from the world (ECDC, no date).

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

World Health Organization (WHO) advice states that immunisation is the most effective preventive measure against measles. Two doses of measles-containing-vaccine are recommended to ensure immunity. While there is no specific antiviral treatment for measles, prompt provision of vitamin A is recommended by WHO for all children infected with measles. It is critical to quickly recognise and treat complications of measles in order to reduce mortality and severity of disease (WHO, 2019b).

The WHO (2019b) urged all Member States to do the following:

- Maintain high measles vaccination coverage (≥95%) with two doses of measles-containing-vaccine, in every district.
- Offer vaccination to individuals who do not have proof of vaccination or immunity against measles, and who are at risk of infection and transmission of the virus, such as healthcare workers, people working in tourism and transportation, and international travellers.
- Strengthen epidemiological surveillance for cases of 'fever with rash' for timely detection of all suspected cases of measles in public and private healthcare facilities.
- Ensure that collected blood samples from suspect measles cases are appropriately tested by laboratories within five days.
- All countries need to provide a rapid response to imported measles cases to prevent the establishment or re-establishment of endemic transmission.
- Recognise complications early and provide comprehensive treatment to reduce the severity of disease and avoid unnecessary deaths.
- Administer vitamin A supplementation to all children diagnosed with measles to reduce complications and mortality: two doses of 50,000 IU for a child less than 6 month of age, 100,000 IU for children between 6 and 12 months of age or 200,000 IU for children 12 to 59 months of age, immediately upon diagnosis and on the following day.
- Ensure health care workers are vaccinated in order to avoid infections acquired in a health care setting.

The WHO and partners coordinate their support to Member States via their public health response by calling for the following activities: enhancing preparedness for measles outbreak response; strengthening public trust in vaccines; strengthening surveillance, risk assessment and outbreak investigations; improving clinical management of measles cases; implementing outbreak response immunisation activities; and evaluating outbreak response activities (WHO, 2019b).

The WHO has established a measles outbreaks Incident Management Support system to coordinate its support to affected countries (WHO, 2019b).

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Coordinating agency or organization

World Health Organization.

BI0053 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Meningococcal Meningitis (Human)

Definition

Meningococcal meningitis is a bacterial form of meningitis, a serious infection of the thin lining that surrounds the brain and spinal cord, that is caused by the bacterium Neisseria meningitidis. Meningococcal meningitis has the potential to cause large-scale epidemics and is observed worldwide (WHO, 2018).

Reference

WHO, 2018. Meningococcal meningitis. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/meningococcal-meningitis Accessed 3 November 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

Meningococcal meningitis is a bacterial form of meningitis. Of the twelve types of Neisseria meningitidis, called serogroups, six (A, B, C, W, X, Y) can cause epidemics. The bacteria can be carried in the nasopharyngeal tract without causing symptoms and are transmitted through droplets of respiratory or throat secretions upon close and prolonged contact. It is believed that 1% to 10% of the population are asymptomatic carriers (WHO, 2018a).

The average incubation period is four days but can range from two to ten days. The most common symptoms are a stiff neck, high fever, sensitivity to light, confusion, headaches and vomiting. Some cases may develop haemorrhagic rash. Meningococcal meningitis can kill in hours and if untreated, is fatal in 50% of cases. It may result in brain damage, hearing loss or disability in 10% to 20% of survivors (WHO, 2018a).

Diagnosis of meningococcal meningitis relies on lumbar puncture showing a purulent spinal fluid. The bacteria can sometimes be seen in microscopic examinations of the spinal fluid. Diagnosis is confirmed by growing the bacteria from specimens of spinal fluid or blood or by polymerase chain reaction (PCR). Identification of the serogroups and susceptibility testing to antibiotics are important to define control measures (WHO, 2018a).

Meningococcal meningitis is observed in a range of situations, from sporadic cases, to small clusters, to huge epidemics throughout the world, with seasonal variations (WHO, 2018a). International outbreaks have been associated with various mass gatherings.

Meningococcal meningitis is observed worldwide but the highest burden of the disease is in the so-called ‘meningitis belt’ of sub-Saharan Africa, stretching from Senegal in the west to Ethiopia in the east. The geographical distribution and epidemic potential differ according to the serogroup. Estimates of global meningococcal disease burden vary widely from 116,000 to 429,000 cases worldwide (2015). This range reflects uncertainty due to inadequate surveillance in several parts of the world (WHO, 2018a).

Metrics and numeric limits

Surveillance, from case detection to investigation and laboratory confirmation is essential to the control of meningococcal meningitis. The World Health Organization (WHO) has published recommendations on types of surveillance and case definitions for vaccine preventable diseases (WHO, 2018b).

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

The geographic distribution and epidemic potential differ according to the serogroup of Neisseria meningitidis. There are no reliable estimates of global meningococcal disease burden due to inadequate surveillance in several parts of the world. During the dry season between December to June, dust winds, cold nights and upper respiratory tract infections combine to damage the nasopharyngeal mucosa, increasing the risk of meningococcal disease. At the same time, transmission of N. meningitidis may be facilitated by overcrowded housing. This combination of factors explains the large epidemics which occur during the dry season in the meningitis belt (WHO, 2018a).

Infants are at highest risk, but rates decrease after infancy and then increase in adolescence and young adulthood. Surveillance during mass gatherings should be intensified. Risk factors for meningococcal carriage include concomitant upper respiratory tract infections, overcrowded living conditions, smoking and passive smoking, and terminal complement pathway deficiency (WHO, 2018b).

Licensed vaccines against meningococcal disease have been available for more than 40 years, but to date no universal vaccine against meningococcal disease exists (WHO, 2018a). Vaccines are serogroup specific and confer varying degrees of duration and protection. They are used for prevention (routine immunisation) and in response to outbreaks (prompt reactive vaccination) (WHO, 2018a).

Antibiotic prophylaxis for close contacts, when given promptly, decrease the risk of transmission. This is recommended in the meningitis belt in non-epidemic situations (WHO, 2018a).

The WHO promotes a strategy comprising epidemic preparedness, prevention, and outbreak control (WHO, 2018a):

- Preparedness focuses on surveillance, from case detection to investigation and laboratory confirmation.
- Prevention consists of vaccinating individuals from age groups at major risk using a conjugate vaccine targeting appropriate serogroups.
- Epidemic response consists of prompt and appropriate case management and reactive mass vaccination of populations not already protected through vaccination.

Meningitis epidemics in the African meningitis belt constitute an enormous public health burden. In December 2010, a new meningococcal A conjugate vaccine was introduced in Africa through mass campaigns targeting persons 1 to 29 years of age. As of November 2017, more than 280 million persons have been vaccinated in 21 African belt countries (WHO, 2018a).

The vaccine is remarkably safe and cheap; around USD 0.60 per dose while other meningococcal vaccine prices range from USD 2.50 to USD 117.00 per dose. In addition, its thermostability allows its use under Controlled Temperature Chain (CTC) conditions. Its impact on carriage and the reduction in disease and epidemics is significant: a 58% decline in meningitis incidence and 60% decline in the risk of epidemics. It is now introduced into routine infant immunisation programmes. Maintaining high coverage is expected to eliminate meningococcal A epidemics from this region of Africa. However, other meningococcal serogroups such as W, X and C still cause epidemics and around 30,000 cases are reported each year in the meningitis belt (WHO, 2018a).

The WHO is committed to eliminating meningococcal disease as a public health problem and in 2020 published a draft of the proposal for defeating meningitis by 2030 (WHO, 2020).

References

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Coordinating agency or organisation

World Health Organization.

BI0054 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Pertussis (Human)

Definition

Pertussis is a highly contagious disease of the respiratory tract caused by the bacterium Bordetella pertussis (WHO, no date).

Reference

WHO, no date. Pertussis. World Health Organization (WHO). www.who.int/health-topics/pertussis#tab=tab_1 Accessed 15 November 2020.

Annotations

Synonym

Whooping cough.

Additional scientific description

Pertussis, also known as whooping cough, is a highly contagious respiratory infection caused by the bacterium Bordetella pertussis. In 2018, there were more than 151,000 cases of pertussis globally (CDC, 2019).

Pertussis spreads easily from person to person mainly through droplets produced by coughing or sneezing. The disease is most dangerous in infants and is a significant cause of disease and death in this age group (WHO, 2018).

The first symptoms generally appear 7 to 10 days after infection. They include a mild fever, runny nose and cough, which in typical cases gradually develops into a hacking cough followed by whooping (hence the common name of 'whooping cough'). Pneumonia is a relatively common complication, and seizures and brain disease occur rarely. People with pertussis are most contagious up to about 3 weeks after the cough begins, and many children who contract the infection have coughing spells that last 4 to 8 weeks. Antibiotics are used to treat the infection (WHO, no date).

Pertussis is diagnosed clinically by its symptoms and through laboratory confirmation. It should be suspected in anyone with a cough that does not improve within 14 days, a paroxysmal cough of any duration, or any respiratory symptoms after contact with a laboratory-confirmed case of pertussis (WHO, 2020a). Of note the symptoms in infants, in which the highest mortality is seen, may differ strongly from those in older children and adults in that the typical cough may not be present at all.

The World Health Organization (WHO) has published guidance on case classification and surveillance standards (WHO, 2018).

Metrics and numeric limits

Globally, it is estimated that there were 24.1 million pertussis cases and 160,700 deaths from pertussis in children under the age of 5 years in 2014, with periodic epidemics occurring every two to five years (WHO, 2018).

Key relevant UN convention / multilateral treaty

Not relevant.

Examples of drivers, outcomes and risk management

The best way to prevent pertussis is through immunisation. The three-dose primary series diphtheria-tetanus-pertussis (DTP3) (-containing) vaccines decrease the risk of severe pertussis in infancy. During 2019, about 85% of infants worldwide (116 million infants) received three doses of DTP3 vaccine, protecting them against infectious diseases that can cause serious illness and disability or be fatal. By 2019, 125 Member States had reached at least 90% coverage of DTP3 vaccine (WHO, 2020a,b).

The WHO recommends the first dose be administered as early as 6 weeks of age; with subsequent doses given 4 to 8 weeks apart (age 10–14 weeks and 14–18 weeks). A booster dose is recommended, preferably during the second year of life. Based on local epidemiology, further booster doses may be warranted later in life (WHO, no date).

Vaccination of pregnant women is effective in preventing disease in infants too young to be vaccinated. National programmes may consider vaccination of pregnant women with pertussis-containing vaccine as a strategy additional to routine primary infant pertussis vaccination in countries or settings with high or increasing infant morbidity/mortality from pertussis (WHO, no date).

References

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WHO, 2020b. Immunization coverage. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/immunization-coverage Accessed 3 November 2020.

Coordinating agency or organisation

World Health Organization.

BI0055 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Polio (Human)

Definition

Polio (human) is a highly infectious viral disease which mainly affects young children (WHO, 2019).

Reference

WHO, 2019. Poliomyelitis. World Health Organization (WHO). www.who.int/en/news-room/fact-sheets/detail/poliomyelitis Accessed 16 December 2019.

Annotations

Synonyms

Poliomyelitis.

Additional scientific description

Poliomyelitis (polio) is a highly infectious viral disease that largely affects children under 5 years of age. The virus is transmitted by person-to-person spread mainly through the faecal-oral route or, less frequently, by a common vehicle (e.g., contaminated water or food) and multiplies in the intestine, from where it can invade the nervous system and cause paralysis (WHO, 2019).

Polio virus infection is mostly asymptomatic. If there are symptoms these can include fever, malaise, sore throat, anorexia, myalgia, headache, and in less than 1% of infected children illness can progress to paralytic disease. Typically, the paralysis is acute onset and flaccid in nature and asymmetrically involving limbs. One in 200 infections leads to irreversible paralysis. Among those paralysed, 5% to 10% may die due to respiratory paralysis. If the child recovers, paralysis is often permanent (WHO, 2019).

Polio is diagnosed clinically through symptoms and laboratory methods including virus isolation in stool, serological testing and analysis of cerebrospinal fluid (Kasper and Fauci, 2013; WHO, 2019).

Cases due to wild poliovirus have decreased by over 99% since 1988, from an estimated 350,000 cases then, to 33 reported cases in 2018 (WHO, 2019).

There is no cure for polio, but vaccination is highly effective in preventing the disease (WHO, 2019).

Metrics and numeric limits

Polio is targeted for global eradication and since 2017, only two countries (Afghanistan and Pakistan) have detected wild polio transmission. However, in recent years there has been a resurgence of vaccine derived poliovirus (VDPV). This emerges in areas where poor vaccination coverage allows the attenuated vaccine virus to circulate and revert to a pathogenic form due to genetic mutation (GPEI, 2016, 2019).

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

Polio infection is more common in socioeconomically disadvantaged areas, especially in those where conditions are crowded and in tropical areas where hygiene is poor (WHO, 2019).

Conflict and insecurity coupled with fragile health systems are risk factors for ongoing polio transmission particularly when these factors result in children being missed by vaccination programmes due to inaccessibility (WHO, no date).

References

GPEI, 2016. Classification and reporting of vaccine-derived polioviruses (VDPV). Global Polio Eradication Initiative (GPEI). http://polioeradication.org/wp-content/uploads/2016/09/Reporting-and-Classification-of-VDPVs_Aug2016_EN.pdf Accessed 13 September 2020.

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Coordinating agency or organisation

World Health Organization.

BI0056 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Smallpox (Human)

Definition

Smallpox is an acute contagious disease caused by the variola virus (WHO, 2019).

Reference

WHO, 2019. Smallpox. World Health Organization (WHO). www.who.int/csr/disease/smallpox/en Accessed 17 December 2019.

Annotations

Synonyms

Not identified.

Additional scientific description

Smallpox was still endemic in Africa and Asia at the end of the 1960s. Vaccination campaigns, and surveillance and prevention measures were undertaken to contain epidemic hotspots and to better inform affected populations. Smallpox was officially declared eradicated in 1980 and is the first disease to have been fought on a global scale. This extraordinary achievement was accomplished through the collaboration of countries around the world (WHO, 2010).

Before its eradication, smallpox was one of the world's most devastating diseases known and was fatal in up to 30% of cases (WHO, 2019).

Smallpox is transmitted from person to person via infective droplets during close contact with infected symptomatic people (WHO, 2019).

Early symptoms include high fever and fatigue. The virus then produces a characteristic rash, particularly on the face, arms and legs (WHO, 2019).

The disease can be definitively diagnosed by polymerase chain reaction (PCR), genetic sequencing or isolation of the virus from the blood or skin lesions (WHO, 2019).

The World Health Organization (WHO) has published guidance on case classification and surveillance standards (WHO, 2019).

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

Convention on the prohibition of the development, production and stockpiling of bacteriological (biological) and toxin weapons and on their destruction: Article I (UNODA, 1972).

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

Post-eradication, there are concerns about accidental or deliberate release or reconstruction of variola virus that could be deployed as a biological weapon (UNODA, 1972; Thompson, 2016).

Vaccination against smallpox can be used very effectively to prevent infection and disease (WHO, 2019). A global smallpox vaccine stockpile is maintained by the WHO to complement stocks held by a number of countries (WHO, 2017).

A specific treatment for smallpox was licensed in 2018 (WHO, 2019).

Preparedness for smallpox also entails education of health personnel in the differential diagnosis of smallpox, strengthening laboratory capacities for diagnostics, expansion of expertise in the area of laboratory biosafety and biosecurity, and strengthening of national-level biosafety regulations in all countries (WHO, 2019).

References

Thompson, K., 2016. Airborne assassin: why the official stockpiles of the smallpox virus must be destroyed. Emory International Law Review, 31:167-195.

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Coordinating agency or organisation

World Health Organization.

BI0057 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Varicella and herpes zoster (Human)

Definition

Varicella is an acute, highly contagious disease caused by varicella-zoster virus (WHO, 2014).

Reference

WHO, 2014. Biologicals: Varicella. World Health Organization (WHO). www.who.int/biologicals/vaccines/varicella/en Accessed 13 December 2019.

Annotations

Synonyms

Chickenpox.

Additional scientific description

Varicella zoster virus (VZV) is a member of the herpesvirus family. Only one serotype of VZV is known, and humans are the only reservoir (WHO, 2014).

Following infection, the virus remains latent in neural ganglia and in some cases, it is reactivated to cause herpes zoster, or shingles, generally in elderly or immunocompromised individuals (WHO, 2014).

Initial infection with VZV causes varicella (or chickenpox). While mostly a mild disorder in childhood, varicella tends to be more severe in adults. It may be fatal, especially in neonates and in immunocompromised persons. Infection during early pregnancy can rarely lead to destructive lesions in the foetus with shingles-like scarring of tissues (Lamont et al., 2011).

Varicella is characterised by an itchy rash of small blisters, usually starting on the scalp and face and initially accompanied by fever and malaise. The rash gradually spreads to the trunk and limbs but tends to spare the hands and feet. The blisters gradually dry out and crusts appear which then disappear over a period of one to two weeks (WHO, 2014).

The infection may occasionally be complicated by pneumonia or encephalitis (inflammation of the brain), at times with serious or fatal consequences (WHO, 2014).

Shingles is a painful rash, usually affecting a zone on one side of the face or body, that may occasionally result in permanent damage to the nerves or cause visual impairment. In immunosuppressed individuals it is severe and often dangerous but can be treated with antiviral medicines (WHO, 2014).

VZV transmission occurs via droplets, aerosols, or direct contact with respiratory secretions, and almost always produces clinical disease in susceptible individuals. Shingles is less infectious than chickenpox as the rash is limited and respiratory involvement is much less common (WHO, 2014).

The World Health Organization (WHO) has published guidance on case classification and surveillance standards (WHO, 2018).

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

Although varicella is usually self-limiting it may be associated with severe complications, mediated either by VZV or secondary bacterial infection. Extra-cutaneous complications affecting the central nervous system range from cerebellar ataxia to encephalitis (WHO, 2014).

The most common complications in children are secondary bacterial infections. VZV pneumonia frequently with secondary bacterial infection is the most common complication in adults. Groups at higher risk for severe complications are neonates, infants, pregnant women, older adults, and immunocompromised persons – including those who are taking oral corticosteroids (WHO, 2014).

Supportive measures include relief of chickenpox symptoms, prevention of skin infections and prompt treatment for pneumonia which often needs both antivirals and antibiotics as staphylococcal superinfection is very common. Intake of fever medications may help symptoms, but caution must be observed in children (WHO, 2014).

The best way to prevent chickenpox is to get the chickenpox vaccine (WHO, 2014).

Severe or complicated cases including susceptible pregnant women can be treated with appropriate antiviral medicines (WHO, 2014).

References

Lamont, R.F., J.D. Sobel, D. Carrington, S. Mazaki-Tovi, J.D. Kusanovic, E. Vaisbuch and R. Romero, 2011. Varicella-zoster virus (chickenpox) infection in pregnancy. BJOG, 118:1155–1162.

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Coordinating agency or organisation

World Health Organization.

BI0058 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Yellow Fever (Human)

Definition

Yellow fever is an acute viral haemorrhagic disease transmitted by infected mosquitoes (WHO, 2019).

Reference

WHO, 2019. Yellow fever. World Health Organization (WHO). www.who.int/en/news-room/fact-sheets/detail/yellow-fever Accessed 18 November 2019.

Annotations

Synonyms

Not found.

Additional scientific description

Yellow fever virus is an arbovirus of the flavivirus genus and is transmitted by mosquitoes, belonging to the Aedes and Haemogogus genus. The different mosquito species live in different habitats – some breed around houses (domestic), others in the jungle (wild), and some in both habitats (semi-domestic). There are three types of transmission cycles: sylvatic (or jungle) yellow fever; intermediate yellow fever; and urban yellow fever. The virus is endemic in tropical areas of Africa and Central and South America (WHO, 2019).

The 'yellow' in the name refers to the jaundice that affects some patients (WHO, 2019).

Once contracted, the yellow fever virus incubates in the body for 3 to 6 days. Many people do not experience symptoms, but when these do occur, the most common are fever, muscle pain with prominent backache, headache, loss of appetite, and nausea or vomiting. Symptoms disappear after 3 to 4 days (WHO, 2019).

A small proportion of patients may enter a more toxic phase within 24 hours of recovering from initial symptoms. High fever returns and usually the liver and the kidneys are affected. People in this phase are likely to develop jaundice (yellowing of the skin and eyes), dark urine and abdominal pain with vomiting. Bleeding can occur from the mouth, nose, eyes or stomach. Half of the patients in this toxic phase die within 7 to 10 days (WHO, 2019).

Polymerase chain reaction (PCR) testing in blood and urine can sometimes detect the virus in early stages of the disease. In later stages, testing to identify antibodies is needed (WHO, 2019).

The World Health Organization (WHO) has published guidance on case classification and surveillance standards (WHO, 2015).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

Major epidemics of yellow fever occur when infected people introduce the virus into heavily populated areas with high mosquito density and where most people have little or no immunity, due to lack of vaccination. In these conditions, infected mosquitoes of the Aedes aegypti species transmit the virus from person to person (WHO, 2019).

Yellow fever is prevented by an extremely effective vaccine, which is safe and affordable (WHO, 2019). However, there is no specific antiviral therapy, so if severe illness develops, only supportive care is available.

The risk of yellow fever transmission in urban areas can be reduced by eliminating potential mosquito breeding sites, including by applying larvicides to water storage containers and other places where standing water collects (WHO, 2019).

Both vector surveillance and control are components of the prevention and control of vector-borne diseases, especially for transmission control in epidemic situations (WHO, 2019).

Prompt detection of yellow fever and rapid response through emergency vaccination campaigns are essential for controlling outbreaks (WHO, 2019).

Occasionally travellers who visit yellow fever endemic countries may carry the disease to countries free from yellow fever. In order to prevent importation of the disease, many countries require proof of vaccination against yellow fever before they will issue a visa, particularly if travellers come from, or have visited yellow fever endemic areas (WHO, 2019).

References

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Coordinating agency or organisation

World Health Organization.

BI0059 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Dengue (Human)

Definition

Dengue is a mosquito-borne disease that is caused by a virus of the Flaviviridae family and transmitted by female mosquitoes mainly of the species Aedes aegypti and, to a lesser extent, A. albopictus (WHO, 2020).

Reference

WHO, 2020. Dengue and severe dengue. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/dengue-and-severe-dengue

Annotations

Synonyms

Break Bone Fever.

Additional scientific description

Dengue is a mosquito-borne viral disease that is transmitted by female mosquitoes mainly of the species Aedes aegypti and, to a lesser extent, A. albopictus. These mosquitoes are also vectors of chikungunya, yellow fever and Zika viruses. Dengue is widespread throughout the tropics, with local variations in risk influenced by rainfall, temperature, relative humidity and unplanned rapid urbanisation (WHO, 2020).

Dengue is a severe, flu-like illness that affects infants, young children and adults, but seldom causes death. Symptoms usually last for 2–7 days, after an incubation period of 4–10 days after the bite from an infected mosquito. The World Health Organization (WHO) classifies dengue into two major categories: dengue (with / without warning signs) and severe dengue. The global incidence of dengue has grown dramatically in recent decades and about half of the world's population is now at risk. There are an estimated 100–400 million infections each year (WHO, 2020).

Dengue causes a wide spectrum of disease, ranging from subclinical disease (people may not know they are even infected) to severe flu-like symptoms in those infected. Although less common, some people develop severe dengue, which can be any number of complications associated with severe bleeding, organ impairment and/or plasma leakage. Severe dengue has a higher risk of death when not managed appropriately. Severe dengue was first recognised in the 1950s during dengue epidemics in the Philippines and Thailand. Today, severe dengue affects most Asian and Latin American countries and has become a leading cause of hospitalisation and death among children and adults in these regions (WHO, 2020).

Dengue is caused by a virus of the Flaviviridae family and there are four distinct, but closely related, serotypes of the virus that causes dengue (DENV-1, DENV-2, DENV-3, DENV-4). Recovery from infection is believed to provide lifelong immunity against that serotype. However, cross-immunity to the other serotypes after recovery is only partial, and temporary. Subsequent infections (secondary infection) by other serotypes increase the risk of developing severe dengue (WHO, 2020).

Dengue has distinct epidemiological patterns, associated with the four serotypes of the virus. These can co-circulate within a region, and indeed many countries are hyper-endemic for all four serotypes. Dengue has an alarming impact on both human health and the global and national economies. Dengue virus is frequently transported from one place to another by infected travellers; when susceptible vectors are present in these new areas, there is the potential for local transmission to be established (WHO, 2020).

The incidence of dengue has grown dramatically around the world in recent decades. A vast majority of cases are asymptomatic or mild and self-managed, and hence the actual numbers of dengue cases are under-reported. Many cases are also misdiagnosed as other febrile illnesses (WHO, 2020).

This alarming increase in case numbers is partly explained by a change in national practices to record and report dengue to the Ministries of Health, and to the WHO. But it also represents government recognition of the burden, and therefore the pertinence to report dengue disease burden. Therefore, although the full global burden of the disease is uncertain, this observed growth only brings a closer recognition to a more accurate estimate of the full extent of the burden (WHO, 2020).

The WHO recommends three methods of dengue surveillance: epidemiological surveillance, vector surveillance and monitoring behavioural impact (WHO, no date).

Metrics and numeric limits

There was a more than 8-fold increase in the number of dengue cases reported to the WHO over the past two decades, from 505,430 cases in 2000, to over 2.4 million in 2010, and 4.2 million in 2019. Reported deaths between 2000 and 2015 increased from 960 to 4032 (WHO, 2020).

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

Drivers: one modelling estimate indicates 390 million dengue virus infections per year (95% credible interval 284–528 million), of which 96 million (67–136 million) manifest clinically (with any severity of disease). Another study on the prevalence of dengue estimates that 3.9 billion people are at risk of infection with dengue viruses. Despite a risk of infection existing in 129 countries, 70% of the actual burden is in Asia with explosive outbreaks occurring (WHO, 2020).

Vaccination: The dengue vaccine, Dengvaxia® (CYD-TDV) has been shown to be efficacious and safe in persons who have had a previous dengue virus infection (seropositive individuals), but carries an increased risk of severe dengue in those who experience their first natural dengue infection after vaccination (seronegative individuals). As such, the WHO recommends pre-vaccination screening for countries considering vaccination as part of their dengue control programme (WHO, 2019). With this strategy, only persons with evidence of a past dengue infection would be vaccinated (WHO, 2020).

Dengue prevention and control depends on effective vector control measures. Sustained community involvement can improve vector control efforts substantially. There is an ongoing need to adhere to other disease preventive measures such as well-executed and sustained vector control using the WHO Integrated Vector Management (IVM) approach, which is a rational decision-making process for the optimal use of resources for vector control (WHO, 2019). Recently some countries have successfully lowered the incidence of arboviral infections such as dengue through vector control with Wolbachia infection of mosquitoes that decreases their ability to transmit arboviruses.

The WHO responds to dengue in the following ways: supports countries in the confirmation of outbreaks through its collaborating network of laboratories; provides technical support and guidance to countries for the effective management of dengue outbreaks; supports countries to improve their reporting systems and capture the true burden of the disease; provides training on clinical management, diagnosis and vector control at the country and regional level with some of its collaborating centres; formulates evidence-based strategies and policies; supports countries in the development of dengue prevention and control strategies and adopting the Global Vector Control Response (2017–2030); reviews the development of new tools, including insecticide products and application technologies; gathers official records of dengue and severe dengue from over 100 Member States; and publishes guidelines and handbooks for surveillance, case management, diagnosis, dengue prevention and control for Member States (WHO, 2020).

References

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Coordinating agency or organisation

World Health Organization.

BI0060 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Malaria (Human)

Definition

Malaria is a life-threatening disease caused by parasites that are transmitted to people through the bites of infected female Anopheles mosquitoes. It is preventable and curable. In 2018, there were an estimated 228 million cases of malaria worldwide and the estimated number of malaria deaths stood at 405,000 (WHO, 2020).

Reference

WHO, 2020. Malaria. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/malaria Accessed 4 November 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

Malaria is caused by Plasmodium parasites. The parasites are spread to people through the bites of infected female Anopheles mosquitoes, called 'malaria vectors'. There are five parasite species that cause malaria in humans, with two – P. falciparum and P. vivax – posing the greatest threat (WHO, 2020).

In 2018, nearly half of the world's population was at risk of malaria. Most malaria cases and deaths occur in sub-Saharan Africa. In 2018, P. falciparum accounted for 99.7% of estimated malaria cases in the World Health Organization (WHO) African Region, 50% of cases in the WHO South-East Asia Region, 71% of cases in the Eastern Mediterranean and 65% in the Western Pacific. P. vivax is the predominant parasite in the WHO Region of the Americas, representing 75% of malaria cases (WHO, 2020).

Malaria is an acute febrile illness. In a non-immune individual, symptoms usually appear 10 to 15 days after the infective mosquito bite. The first symptoms – fever, headache, and chills – may be mild and difficult to recognise as malaria. If not treated within 24 hours, P. falciparum malaria can progress to severe illness, often leading to death. Children with severe malaria frequently develop one or more of the following symptoms: severe anaemia, respiratory distress in relation to metabolic acidosis, or cerebral malaria. In adults, multi-organ failure is also frequent. In malaria endemic areas, people may develop partial immunity, allowing asymptomatic infections to occur (WHO, 2020).

Some population groups are at considerably higher risk of contracting malaria, and developing severe disease, than others. These include infants, children under 5 years of age, pregnant women and patients with HIV/AIDS, as well as non-immune migrants, mobile populations and travellers. National malaria control programmes need to take special measures to protect these population groups from malaria infection, taking into consideration their specific circumstances (WHO, 2020).

The WHO recommends malaria diagnosis be made using parasite-based diagnostic testing, either by microscopy (allowing visualisation of the parasite) or by malaria rapid diagnostic tests (RDT) that are genus- or species-specific. RDT has been restricted to remote areas with limited access to good quality microscopy services. Diagnosis of all suspected cases should be confirmed by either of these two methods before treatment, as a measure to avoid antimalarial drug resistance (WHO, 2019).

The World Malaria Report 2019 provides a comprehensive update on global and regional malaria data and trends. The report tracks investments in malaria programmes and research as well as progress across all intervention areas: prevention, diagnosis, treatment, elimination and surveillance. It also includes dedicated chapters on the consequences of malaria on maternal, infant and child health, the 'High burden to high impact' approach as well as biological threats to the fight against malaria. The report is based on information received from more than 80 countries and areas with ongoing malaria transmission. This is supplemented by data from national household surveys and databases held by other organizations (WHO, 2019).

The WHO has published guidance on case definitions and classifications, as well as surveillance including vector control monitoring and evaluation (WHO, 2018a).

Metrics and numeric limits

In 2018, an estimated 228 million cases of malaria occurred worldwide (95% confidence interval [CI]: 206–258 million), compared with 251 million cases in 2010 (95% CI: 231–278 million) and 231 million cases in 2017 (95% CI: 211–259 million) (WHO, 2019).

Most malaria cases in 2018 were in the WHO African Region (213 million or 93%), followed by the WHO South-East Asia Region with 3.4% of cases and the WHO Eastern Mediterranean Region with 2.1% (WHO, 2019).

Nineteen countries in sub-Saharan Africa and India carried almost 85% of the global malaria burden. Six countries accounted for more than half of all malaria cases worldwide: Nigeria (25%), the Democratic Republic of the Congo (12%), Uganda (5%), and Cote d'Ivoire, Mozambique and Niger (4% each) (WHO, 2019).

The incidence rate of malaria declined globally between 2010 and 2018, from 71 to 57 cases per 1000 population at risk. However, from 2014 to 2018, the rate of change slowed dramatically, reducing to 57 in 2014 and remaining at similar levels through to 2018 (WHO, 2019).

The WHO South-East Asia Region continued to see its incidence rate fall – from 17 cases of the disease per 1000 population at risk in 2010 to five cases in 2018 (a 70% decrease). In the WHO African Region, case incidence levels also declined from 294 in 2010 to 229 in 2018, representing a 22% reduction. All other WHO regions recorded either little progress or an increase in incidence rate. The WHO Region of the Americas recorded a rise, largely due to increases in malaria transmission in the Bolivarian Republic of Venezuela (WHO, 2019).

Between 2015 and 2018, only 31 countries, where malaria is still endemic, reduced case incidence significantly and were on track to reduce incidence by 40% or more by 2020. Without accelerated change, the Global Technical Strategy for Malaria 2016–2030 (GTS) milestones for morbidity in 2025 and 2030 will not be achieved (WHO, 2019).

Globally, 53% of the P. vivax burden is in the WHO South-East Asia Region, with the majority being in India (47%).

In 2018, there were an estimated 405,000 deaths from malaria globally, compared with 416,000 estimated deaths in 2017, and 585,000 in 2010.

Children aged under 5 years are the most vulnerable group affected by malaria. In 2018, they accounted for 67% (272,000) of all malaria deaths worldwide (WHO, 2019).

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

Epidemics can have severe impacts on population health and economic growth prospects. They are triggered by man-made or natural factors that affect the environment increasing the population of mosquitoes that transmit the parasite. Global climate change may also lead to changes in malaria transmission patterns and may gradually alter the geographical distribution of malaria (WHO, 2018b).

Emergencies, including violent conflicts and natural hazards, often trigger malaria epidemics in displaced populations who may have little or no immunity to malaria. In other cases, epidemics and resurgences can occur as a result of weakened malaria control interventions (WHO, 2018b).

Vector control is the main way to prevent and reduce malaria transmission. If coverage of vector control interventions within a specific area is high enough, then a measure of protection will be conferred across the community. The WHO recommends protection for all people at risk of malaria with effective malaria vector control. Two forms of vector control – insecticide-treated mosquito nets and indoor residual spraying – are effective in a wide range of circumstances. However, management methods can be undermined by emerging insecticide resistance and antimalarial drug resistance (WHO, 2020).

A vaccination against P. falciparum (RTS,S/AS01) is the first and, to date, the only vaccine to show partial protection against malaria in young children and is currently under pilot in certain areas of sub-Saharan Africa (WHO, 2020).

The 25th of April is World Malaria Day. The WHO has been responding to malaria via programmes such as the WHO Global Technical Strategy for Malaria 2016-2030, The Global Malaria Programme, and the 'High burden to high impact approach' (WHO, 2020).

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WHO, 2019. World Malaria Report 2019. World Health Organization (WHO). www.who.int/publications/i/item/9789241565721 Accessed 4 November 2020.

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Coordinating agency or organisation

World Health Organization.

BI0061 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Crimean-Congo Haemorrhagic Fever (Human)

Definition

Crimean-Congo haemorrhagic fever (CCHF) is a tick-borne viral infection caused by the CCHF virus. It causes severe viral haemorrhagic fever outbreaks and epidemics (WHO, 2013).

Reference

WHO, 2013. Crimean-Congo haemorrhagic fever. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/crimean-congo-haemorrhagic-fever Accessed 6 November 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

The Crimean-Congo haemorrhagic fever (CCHF) virus is a tick-borne virus (Nairovirus) of the Bunyaviridae family. The hosts of the CCHF virus include a wide range of wild and domestic animals such as cattle, sheep and goats. Many birds are resistant to infection, but ostriches are susceptible and may show a high prevalence of infection in endemic areas, where they have been at the origin of human cases. There is no apparent disease in these animals (WHO, 2013).

The CCHF virus is transmitted to humans either by tick bites (principally ticks of the genus Hyalomma) or through contact with infected animal blood or tissues during and immediately after slaughter. Human-to-human transmission can occur from close contact with the blood, secretions, organs or other bodily fluids of infected persons. Hospital-acquired infections can also occur due to improper sterilisation of medical equipment and reuse of non-sterile needles (WHO, 2013).

The length of the incubation period depends on the mode of acquisition of the virus. Following infection by a tick bite, the incubation period is usually one to three days, with a maximum of nine days. The incubation period following contact with infected blood or tissues is usually five to six days, with a documented maximum of thirteen days (WHO, 2013).

The disease begins with a sudden onset of influenza-like symptoms which may progress to severe bleeding and death if not treated. The case-fatality rate is 10–40% (WHO, 2019a).

Laboratory diagnosis is via serological and virological testing, either detecting the microorganism itself, or the antibodies produced by the body in response to the infection (WHO, 2013).

The disease was first described in the Crimea in 1944 and given the name Crimean haemorrhagic fever. In 1969 it was recognised that the pathogen causing Crimean haemorrhagic fever was the same as that responsible for an illness identified in 1956 in the Congo. The linkage of the two place names resulted in the current name for the disease and the virus.

Metrics and numeric limits

Crimean-Congo haemorrhagic fever is endemic in Africa, the Balkans, the Middle East and Asian countries south of the 50th parallel north – the current geographical limit of the principal tick vector. There are an estimated 3 billion people at risk, with an estimated 10,000 to 15,000 infections annually (WHO, 2018).

The European Centre for Disease Prevention and Control (ECDC) has published case definitions on Crimean-Congo haemorrhagic fever prevention and control (ECDC, 2008).

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

Containing and preventing outbreaks of CCHF is difficult because of the lack of a safe and effective vaccine (for humans and animals), the widespread presence of tick vectors, and the fact that the infection mostly goes unnoticed in domestic animals. The focus is therefore on awareness and education efforts with regards to reducing transmission risk (WHO, 2019b).

Outbreaks of CCHF constitute a threat to public health services because the virus can lead to epidemics, has a high case fatality ratio (10–40%), potentially results in hospital and health facility outbreaks, and is difficult to prevent and treat (WHO, 2019a).

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WHO, 2016. International Health Regulations (2005), 3rd ed. World Health Organization (WHO). www.who.int/ihr/publications/9789241580496/en Accessed 3 October 2020.

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WHO, 2019b. Crimean-Congo haemorrhagic fever (CCHF). World Health Organization (WHO) Regional Office for the Eastern Mediterranean. www.emro.who.int/health-topics/crimean-congo-haemorrhagic-fever/index.html Accessed 18 November 2019.

Coordinating agency or organisation

World Health Organization.

BI0062 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Ebola (Human)

Definition

Ebola virus disease (EVD) is a rare but severe zoonotic viral infectious disease caused by the Ebola virus. It can lead to haemorrhagic fever and is often fatal in humans. EVD can trigger epidemics with high case-fatality rates (WHO, 2020).

Reference

WHO, 2020. Ebola virus disease. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/ebola-virus-disease Accessed 19 November 2019.

Annotations

Synonyms

Ebola haemorrhagic fever.

Additional scientific description

The Ebola virus causes an acute, serious illness which is often fatal if untreated. Ebola virus disease (EVD) first appeared in 1976 in two simultaneous outbreaks, one in what is now Nzara, South Sudan, and the other in Yambuku, Democratic Republic of the Congo. The latter occurred in a village near the Ebola River, from which the disease takes its name (WHO, 2020a).

The 2014–2016 outbreak in West Africa was the largest Ebola outbreak since the virus was first discovered in 1976. The outbreak started in Guinea and then moved across land borders to Sierra Leone and Liberia. The current 2018–2019 outbreak in eastern Democratic Republic of the Congo is highly complex, with insecurity adversely affecting public health response activities (WHO, 2020a).

The virus family Filoviridae includes three genera: Cuevavirus, Marburgvirus, and Ebolavirus. Within the genus Ebolavirus, six species have been identified: Zaire, Bundibugyo, Sudan, Taï Forest, Reston and Bombali. The virus causing the current outbreak in Democratic Republic of the Congo and the 2014–2016 West African outbreak belongs to the Zaire ebolavirus species (WHO, 2020a).

Ebola is introduced into the human population through close contact with the blood, secretions, organs or other bodily fluids of infected animals such as fruit bats, chimpanzees, gorillas, monkeys, forest antelope or porcupines found ill or dead or in the rainforest (WHO, 2020a).

Ebola then spreads through human-to-human transmission via direct contact (through broken skin or mucous membranes) with blood or body fluids of a person who is sick with or has died from Ebola, or objects that have been contaminated with body fluids (such as blood, faeces, vomit) from a person sick with Ebola or the body of a person who died from Ebola (WHO, 2020a).

Health-care workers have frequently been infected while treating patients with suspected or confirmed EVD. This occurs through close contact with patients when infection control precautions are not strictly practiced. Burial ceremonies that involve direct contact with the body of the deceased can also contribute in the transmission of Ebola. People remain infectious as long as their blood contains the virus. Pregnant women who get acute Ebola and recover from the disease may still carry the virus in breastmilk, or in pregnancy related fluids and tissues. This poses a risk of transmission to the baby they carry, and to others. Women who become pregnant after surviving Ebola disease are not at risk of carrying the virus (WHO, 2020a).

The incubation period is from 2 to 21 days. A person infected with Ebola virus cannot spread the disease until they develop symptoms. The symptoms of EVD can be sudden and include flu-like symptoms followed by diarrhoea, vomiting, rash, internal and external bleeding (such as oozing from the gums or blood in stools), and symptoms of impaired kidney and liver function. The average EVD case fatality rate is around 50%. Case fatality rates have varied from 25% to 90% in past outbreaks (WHO, 2020a).

It can be difficult to clinically distinguish EVD from other infectious diseases such as malaria, typhoid fever and meningitis. Laboratory confirmation that symptoms are caused by Ebola virus infection are made using diagnostic serological and virological tests. Careful consideration should be given to the selection of diagnostic tests, which take into account technical specifications, disease incidence and prevalence, and social and medical implications of test results. It is strongly recommended that diagnostic tests that have undergone an independent and international evaluation be considered for use (WHO, 2020a).

The World Health Organization (WHO) has published case definitions for EVD (WHO, 2014).

Metrics and numeric limits

The 2014–2016 epidemic in West Africa was the largest Ebola outbreak since the virus was first discovered in 1976. A total of 28,616 Ebola cases were reported in Guinea, Liberia and Sierra Leone, with 11,310 deaths (WHO, 2016a).

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016b).

Examples of drivers, outcomes and risk management

There is no proven treatment for EVD but simple interventions early on can significantly improve chances of survival. This includes rehydration with fluids and body salts (given orally or intravenously), and treatment of specific symptoms such as low blood pressure, vomiting, diarrhoea and infections. A range of potential treatments including blood products, immune therapies and drug therapies are currently being evaluated. Health-care workers have frequently been infected while treating patients with suspected or confirmed EVD. This occurs through close contact with patients when infection control precautions are not strictly practiced (WHO, 2020a).

Community engagement is key to successfully controlling outbreaks. Working with communities to reduce risk factors for Ebola transmission is critical to controlling outbreaks. Burial ceremonies that involve direct contact with the body of the deceased can contribute in the transmission of Ebola (WHO, 2020a).

Good outbreak control relies on applying a package of interventions, including case management, surveillance and contact tracing, a good laboratory service, safe burials and social mobilisation. Community engagement is key to successfully controlling outbreaks. Raising awareness of risk factors for Ebola infection and protective measures (including vaccination) that individuals can take is an effective way to reduce human transmission. Risk reduction messaging should focus on several factors: reducing the risk of wildlife-to-human transmission; reducing the risk of human-to-human transmission; outbreak containment measures; reducing the risk of possible sexual transmission; reducing the risk of transmission from pregnancy related fluids and tissue; and controlling infection in health-care settings (WHO, 2020a).

In May 2019, the WHO published a roadmap aiming to coordinate partners' actions and contributions to the licensing and roll-out of Merck's Ebola vaccine (VSV-ZEBOV) in African countries. The vaccine was developed during the West Africa Ebola epidemic of 2014–2016, during which more than 11,000 people lost their lives to the disease. The vaccine was tested in European and African countries at the time and was used under an 'expanded access' protocol in the Democratic Republic of Congo (WHO, 2020b).

Based on regulatory evaluation by the European Medicines Agency and the United States Food and Drug Administration (FAO), the WHO expedited prequalification and coordinated work with countries at risk of Ebola outbreaks to streamline regulatory licensing of the vaccine for use in those countries (WHO, 2020b).

On 12 November 2019, the WHO prequalified an Ebola vaccine for the first time, a critical step that will help speed up its licensing, access and roll-out in countries most at risk of Ebola outbreaks. This is the fastest vaccine prequalification process ever conducted by the WHO. The injectable Ebola vaccine, Ervebo, is manufactured by Merck (known as MSD outside the USA and Canada). The vaccine has been shown to be effective in protecting people from the Ebola Zaire virus and is recommended by the WHO Strategic Advisory Group of Experts (SAGE) for vaccines as part of a broader set of Ebola response tools. The decision is a step towards greater availability of the vaccine in the future, although licensed doses will only be available mid-2020 (WHO, 2020b).

In February 2020, the WHO published a roadmap aiming to coordinate partners' actions and contributions to the licensing and roll-out of Janssen's Ebola vaccine (Ad26.ZEBOV, MVA-BN®-Filo) in African countries. This second vaccine was developed during the West Africa Ebola epidemic of 2014–2016, during which more than 11,000 people lost their lives to the disease. The vaccine was tested in European and African countries at the time. The WHO will expedite prequalification and licensing of the vaccine for use in countries at risk of Ebola outbreaks and will coordinate work between those countries' regulatory authorities and the European Medicines Agency and FAO (WHO, 2020b).

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Coordinating agency or organisation

World Health Organization.

BI0063 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Lassa Fever (Human)

Definition

Lassa fever is a zoonotic disease associated with acute and potentially fatal haemorrhagic illness caused by Lassa virus. It is associated with epidemics particularly where it is endemic in Benin, Ghana, Guinea, Liberia, Mali, Sierra Leone, and Nigeria (WHO, 2017).

Reference

WHO, 2017. Lassa fever. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/lassa-fever Accessed 3 November 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

Although first described in the 1950s, the virus causing Lassa disease was not identified until 1969. The virus is a single-stranded RNA virus belonging to the virus family Arenaviridae. Lassa fever is a zoonotic disease, meaning that humans become infected from contact with infected animals. The animal reservoir, or host, of Lassa virus is a rodent of the genus Mastomys, commonly known as the 'multimammate rat'. Mastomys rats infected with Lassa virus do not become ill, but can shed the virus in their urine and faeces (WHO, 2017). People at greatest risk are those living in rural areas where Mastomys are usually found, especially in communities with poor sanitation or crowded living conditions. Lassa fever occurs in all age groups and both sexes.

About 80% of people who become infected with Lassa virus have no symptoms. One in five infections results in severe disease, where the virus affects several organs such as the liver, spleen and kidneys. Because the clinical course of the disease is so variable, detection of the disease in affected patients has been difficult. When the disease is confirmed to be present in a community, however, prompt isolation of affected patients, good infection prevention and control practices, and rigorous contact tracing can stop outbreaks (WHO, 2017).

The incubation period of Lassa fever ranges from 6 to 21 days. The onset of the disease, when it is symptomatic, is usually gradual, starting with fever, general weakness, and malaise. After a few days, headache, sore throat, muscle pain, chest pain, nausea, vomiting, diarrhoea, cough, and abdominal pain may follow. In severe cases facial swelling, fluid in the lung cavity, bleeding from the mouth, nose, vagina or gastrointestinal tract and low blood pressure may develop. Shock, seizures, tremor, disorientation, and coma may be seen in the later stages. Death usually occurs within 14 days of onset in fatal cases. Deafness occurs in 25% of patients who survive the disease. In half of these cases, hearing returns partially after one to three months. Transient hair loss and gait disturbance may occur during recovery. The disease is especially severe late in pregnancy, with maternal death and/or foetal loss occurring in more than 80% of cases during the third trimester (WHO, 2017).

Transmission is primarily from direct and indirect contact with the urine or faeces of infected Mastomys rats, usually from contaminated surfaces, food and water. Humans usually become infected with Lassa virus from exposure to urine or faeces of infected Mastomys rats. Lassa virus may also be spread between humans through direct contact with the blood, urine, faeces, or other bodily secretions of a person infected with Lassa fever. There is no epidemiological evidence supporting airborne spread between humans. Person-to-person transmission occurs in both community and health-care settings, where the virus may be spread by contaminated medical equipment, such as re-used needles. Sexual transmission of Lassa virus has been reported (WHO, 2017).

Lassa fever is difficult to diagnose because the symptoms are non-specific. Definitive diagnosis requires viral and serological testing available only in reference laboratories. Isolation of the virus is usually done from blood, urine or throat washings (WHO, 2017).

Lassa fever can cause prolonged epidemics and is endemic in Benin, Ghana, Guinea, Liberia, Mali, Sierra Leone and Nigeria (WHO, 2016a). Two recent outbreaks are summarised below:

- Liberia: Lassa fever is endemic. The World Health Organization (WHO) reported that from 1 January 2017 through 23 January 2018, 91 suspected cases were reported from six counties: Bong, Grand Bassa, Grand Kru, Lofa, Margibi, and Nimba. Thirty-three of these cases were laboratory confirmed, including 15 deaths (case fatality rate for confirmed cases = 45.4%) (WHO, 2018).
- Nigeria: The WHO reported that from 1 January through 9 February 2020, 472 laboratory confirmed cases including 70 deaths (case fatality ratio = 14.8%) were reported in 26 out of 36 Nigerian states and the Federal Capital Territory. Of the 472 confirmed cases, 75% were reported from three states: Edo (167 cases), Ondo (156 cases) and Ebonyi (30 cases). The other states reporting cases include: Taraba (25), Bauchi (14), Plateau (13), Kogi (13), Delta (12), Nasarawa (4), Kano (4), Rivers (4), Enugu (4), Borno (3), Kaduna (3), Katsina (3), Benue (2), Adamawa (2), Sokoto (2), Osun (2), Abia (2), Kebbi (2), Gombe (1), Oyo (1), Anambra (1), FCT (1), and Ogun (1) (WHO, 2020).

The Centers for Disease Control and Prevention has published information on case definitions and classification for viral haemorrhagic fevers (CDC, 2011).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016b).

Examples of drivers, outcomes and risk management

Prolonged epidemics cause serious economic and social disruption (WHO, 2017).

The disease is closely associated with inadequate community sanitation and with unsafe water or unsafe food storage where rats have easy access. Prevention of Lassa fever relies on promoting good 'community hygiene' to discourage rodents from entering homes. Effective measures include storing grain and other foodstuffs in rodent-proof containers, disposing of garbage far from the home, maintaining clean households and keeping cats. Because Mastomys are so abundant in endemic areas, it is not possible to completely eliminate them from the environment. Family members should always be careful to avoid contact with blood and body fluids while caring for sick persons (WHO, 2017).

During an outbreak, health care professionals are at high risk of transmission and these are associated with close contact to contaminated surfaces, sample collection, transport and laboratory investigations. In health-care settings, staff should always apply standard infection prevention and control precautions when caring for patients, regardless of their presumed diagnosis. These include basic hand hygiene, respiratory hygiene, use of personal protective equipment (to block splashes or other contact with infected materials), safe injection practices and safe burial practices. The WHO recommends standard infection prevention and control precautions (WHO, 2017).

There have been limited cases of exportation of the virus to the UK, Sweden and Germany and other European countries (WHO, 2016a).

The Ministries of Health of Guinea, Liberia and Sierra Leone, WHO, the Office of United States Foreign Disaster Assistance, the United Nations, and other partners have worked together to establish the Mano River Union Lassa Fever Network. The programme supports these three countries in developing national prevention strategies and enhancing laboratory diagnostics for Lassa fever and other dangerous diseases. Training in laboratory diagnosis, clinical management, and environmental control is also included (WHO, 2017).

The WHO has published recommendations for prevention and control (WHO, 2017).

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Coordinating agency or organisation

World Health Organization.

BI0064 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Tuberculosis (Human and Animal)

Definition

Tuberculosis (TB) is a curable bacterial infectious disease caused by Mycobacterium tuberculosis that most commonly affects the lungs. It causes national epidemics of varied severity worldwide. Forms of TB that are resistant to treatment – multi-drug resistant TB (MDR-TB) and extensively drug-resistant TB (XDR-TB) – are public health crises and threaten health security worldwide (WHO, 2020).

Reference

WHO, 2020. Tuberculosis. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/tuberculosis Accessed 3 November 2020.

Annotations

Synonyms

Drug-resistant tuberculosis (DR-TB), Multidrug-resistant tuberculosis (MDR-TB), Extensively drug-resistant TB (XDR-TB), Rifampicin-resistant (RR-TB).

Additional scientific description

Tuberculosis (TB) is caused by bacteria (Mycobacterium tuberculosis) that most often affect the lungs. Tuberculosis is curable and preventable. It is spread from person to person through the air. When people with lung TB cough, sneeze or spit, they propel the TB germs into the air. A person needs to inhale only a few of these germs to become infected (WHO, 2020).

About one-quarter of the world's population has latent tuberculosis infection (LTBI), which means people have been infected by TB bacteria but are not (yet) ill with the disease and cannot transmit the disease. However, they have a 5–15% lifetime risk of falling ill. Persons with compromised immune systems, such as people living with human immunodeficiency virus (HIV), malnutrition or diabetes, are at higher risk. People living with HIV are 19 times more likely to develop active TB than people without HIV. HIV and TB form a lethal combination, each speeding the other's progress (WHO, 2020).

The symptoms of active TB are coughing (sometimes with sputum or blood), chest pains, weakness, weight loss, fever, and night sweats. When a person develops active TB, the symptoms may be mild for many months. This can lead to delays in seeking care, and results in transmission of the bacteria to others (WHO, 2020).

Diagnostic tests for tuberculosis disease include sputum smear microscopy (a long-used method that allows visualisation of the bacteria, many countries rely on it), rapid molecular tests (endorsed by the World Health Organization [WHO]) and culture-based methods; the latter take up to 12 weeks to provide results but remain the reference standard. TB that is resistant to first-line and second-line anti-TB drugs can be detected using rapid tests, culture methods and sequencing technologies. However, TB is particularly difficult to diagnose in children (WHO, 2020).

Multidrug-resistant tuberculosis (MDR-TB) is a form of drug-resistant TB caused by bacteria that do not respond to the two most powerful first-line anti-TB drugs – rifampicin and isoniazid. MDR-TB is treatable and curable by using second-line treatment options, which are limited and require extensive chemotherapy with medicines that are expensive and toxic. Extensively drug-resistant TB (XDR-TB) is a more serious form of MDR-TB caused by bacteria that do not respond to the most effective second-line anti-TB drugs, often leaving patients without any further treatment options (WHO, 2020).

In 2019, MDR-TB remains a public health crisis and a health security threat. A global total of 206,030 people with multidrug- or rifampicin-resistant TB (MDR/RR-TB) were detected and notified in 2019, a 10% increase from 186,883 in 2018. About half of the global burden of MDR-TB is in three countries – India, China and the Russian Federation (WHO, 2020).

The WHO has published information about case-definitions and classification (WHO, 2014) as well as guidelines for surveillance of drug resistance in tuberculosis (WHO, 2015).

Metrics and numeric limits

According to the WHO (2020):

- TB occurs in every part of the world and is one of the top ten causes of death and the leading cause from a single infectious agent (above HIV/AIDS) worldwide.
- A total of 1.4 million people died from TB in 2019 (including 208,000 people with HIV).
- In 2019, an estimated 10 million people fell ill with TB worldwide: 5.6 million men, 3.2 million women and 1.2 million children. TB is present in all countries and age groups. But TB is curable and preventable.
- Child and adolescent TB is often overlooked by health providers and can be difficult to diagnose and treat.
- In 2019, the 30 high TB burden countries accounted for 87% of new TB cases. Eight countries account for two-thirds of the total, with India leading the count, followed by Indonesia, China, the Philippines, Pakistan, Nigeria, Bangladesh and South Africa.
- Globally, TB incidence is falling at about 2% per year and between 2015 and 2019 the cumulative reduction was 9%. This was less than half way to the End TB Strategy milestone of 20% reduction between 2015 and 2020.
- An estimated 60 million lives were saved through TB diagnosis and treatment between 2000 and 2019.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

WHO recommended strategies for TB prevention include: systematic screening and preventative treatment programmes for LTBI for high-risk population groups in order to reduce the risk of progression from LTBI to active TB; vaccination of children with the bacille Calmette-Guérin (BCG) vaccine (WHO, 2019); infection control measures in health facilities; and social protection, poverty alleviation and action on other determinants of TB.

The BCG vaccine is the only licensed vaccine for TB but is only effective in children. There is currently no vaccine that is effective in preventing TB in adults (WHO, 2019).

The main challenges in treatment of TB disease are the duration and complexity of drug regimens, both of which affect adherence; adverse drug reactions, especially for the drugs used to treat drug-resistant TB; and the absence or limited availability of paediatric drug formulations for second-line treatment (WHO, 2020).

Risk factors for MDR-TB and XDR-TB include: low adherence of patients to treatment, due to length and toxicity of regimen; poor quality or unavailable anti-TB drugs; and incorrect prescription of anti-TB medicines by health care providers (WHO, 2019).

TB treatment for people co-infected with HIV is further complicated by drug–drug interactions between anti-TB drugs and antiretroviral therapies, and by cumulative drug toxicities (WHO, 2019).

There is a pressing need for anti-TB regimens that are more effective, more affordable and nontoxic, and that shorten the duration of treatment (WHO, 2020).

Ending the tuberculosis epidemic by 2030 is among the health targets of the Sustainable Development Goals of UN Agenda 2030 (WHO, 2020).

References

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Coordinating agency or organisation

World Health Organization.

BI0065 / **BIOLOGICAL** / **Infectious Diseases (Human and Animal)**

Middle East Respiratory Syndrome (MERS) (Human)

Definition

Middle East respiratory syndrome (MERS) is a viral respiratory disease caused by MERS-Corona Virus (MERS-CoV) (WHO, 2019).

Reference

WHO, 2019. Middle East respiratory syndrome corona (MERS-CoV). World Health Organization (WHO). www.who.int/en/news-room/fact-sheets/detail/middle-east-respiratory-syndrome-coronavirus-(mers-cov) Accessed 13 December 2019.

Annotations

Synonyms

MERS-CoV disease.

Additional scientific description

Middle East respiratory syndrome (MERS) is a zoonotic disease that can be transmitted between animals and people mostly in countries in the Middle East (WHO, 2019), however, an importation of MERS-CoV into the Republic of Korea in 2015 led to the largest MERS outbreak outside of the Middle East.

Since 2012, 27 countries have reported cases of MERS globally and 12 of them are located in the Eastern Mediterranean Region. Approximately 80% of human cases have been reported by Saudi Arabia (WHO, 2019).

A typical presentation of MERS-CoV disease is fever, cough and shortness of breath. Pneumonia is a common finding. Gastrointestinal symptoms, including diarrhoea, have also been reported. Severe illness can cause respiratory failure. The case fatality rate of MERS is been estimated around 35% (WHO, 2019).

Diagnosis is made with clinical, radiological, or histopathological evidence of pulmonary disease and also related to other confirmed cases and any history of residence or travel in countries where MERS-CoV is known to be circulating (WHO, 2019).

No vaccine or specific treatment is currently available, however several MERS-CoV specific vaccines and treatments are in development. Treatment is supportive and based on the patient’s clinical condition.

The World Health Organization (WHO) has published guidance on case classification and surveillance standards (WHO, 2017).

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

Current scientific evidence suggests that camels are a major reservoir host for MERS-CoV and an animal source of MERS infection in humans (WHO, 2019).

Anyone visiting farms, markets, barns, or other places where dromedary camels and other animals are present should practice general hygiene measures, including regular hand washing before and after touching animals, and should avoid contact with sick animals (WHO, 2019).

Appropriately processing animal products through cooking or pasteurisation or handling to avoid cross-contamination is also essential (WHO, 2019).

Although most human cases of MERS-CoV infections have been attributed to human-to-human infections due to close contact in health care settings of patients, healthcare workers or among family members, human-to-human transmission has been limited to date. About 20% of MERS cases occurred in healthcare workers so infection prevention and control measures are critical to prevent the possible spread of MERS-CoV in healthcare facilities. Healthcare associated outbreaks have occurred in several countries, with the largest outbreaks seen in Saudi Arabia, United Arab Emirates, and the Republic of Korea (WHO, 2019).

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Coordinating agency or organization

World Health Organization.

BI0066 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Monkeypox (Human)

Definition

Monkeypox is a viral zoonotic disease that has symptoms similar to those of smallpox (WHO, 2019).

Reference

WHO, 2019. Monkeypox. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/monkeypox Accessed 13 December 2019.

Annotations

Synonym

Not identified.

Additional scientific description

Monkeypox is a viral zoonosis (a virus transmitted to humans from animals) with symptoms similar to those seen in the past in smallpox patients, although it is clinically less severe. It is caused by an orthopoxvirus, from the family of viruses which also caused human smallpox (WHO, 2018). With the eradication of smallpox in 1980 and subsequent cessation of smallpox vaccination, monkeypox has emerged as the most important orthopoxvirus. Monkeypox occurs in Central and West Africa, often in proximity to tropical rainforests (WHO, 2019a).

Monkeypox is mostly transmitted to people from various wild animals such as rodents and primates, with limited secondary spread through human-to-human transmission. Monkeypox is less contagious than smallpox but can be fatal in 1% to 10% of cases (WHO, 2018).

Common symptoms include fever, intense headache, lymphadenopathy, back pain, myalgia and weakness. Like in smallpox, rashes appear beginning on the face and spreading on the body, including to the palms of the hands and soles of the feet (WHO, 2018).

Human monkeypox was first identified in humans in 1970 in the Democratic Republic of the Congo (then known as Zaire) in a 9-year-old boy in a region where smallpox had been eliminated in 1968. Since then, most cases have been reported from rural, rainforest regions of the Congo Basin, particularly in the Democratic Republic of the Congo, where it is considered to be endemic (WHO, 2019a).

Since 1970, human cases of monkeypox have been reported from 11 African countries – Benin, Cameroon, the Central African Republic, the Democratic Republic of the Congo, Gabon, Ivory Coast, Liberia, Nigeria, the Republic of the Congo, Sierra Leone, and South Sudan. In 2017, Nigeria experienced the largest documented outbreak, 40 years after the last confirmed case. The true burden of monkeypox is not known. For example, in 1996–1997, a major monkeypox outbreak was suspected in the Democratic Republic of Congo but with a lower case fatality and a higher attack rate than usual. Some patient samples tested positive for varicella virus and some contained both varicella and monkeypox viruses. Concurrent outbreaks of chickenpox and monkeypox could explain a change in transmission dynamics in this case (WHO, 2019a).

The virus has been exported from Africa a few times. In spring 2003, monkeypox cases were confirmed in the USA. Most patients were reported to have had close contact with pet prairie dogs that were infected by African rodents that had been imported into the country from Ghana. Recently, monkeypox was carried to Israel in September 2018, to the UK in September 2018 and December 2019, and to Singapore in May 2019 by travellers from Nigeria who fell ill with monkeypox after arrival (WHO, 2019a).

Two distinct genetic clades of the virus have been identified – the Congo Basin and the West African clades – with the former found to be more virulent and transmissible. The geographic division between the two clades is thought to be in Cameroon as this is the only country where both monkeypox virus clades have been detected (WHO, 2019a).

Monkeypox can only be diagnosed definitively in the laboratory by polymerase chain reaction (PCR) on skin lesion specimens, genetic sequencing or by viral isolation (WHO, 2020).

Metrics and numeric limits

The World Health Organization, the US Centers for Disease Control and Prevention, and the governments of Nigeria and the Democratic Republic of Congo have published guidance on case classification and surveillance standards (CDC, 2003; Osadebe et al., 2017; WHO, 2019b; Nigeria Centre for Disease Control, 2020).

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

Exposure to body fluids or skin lesions or eating inadequately cooked meat of infected animals is a possible risk factor (WHO, 2017).

Secondary, or human-to-human, transmission can result from close contact with infected respiratory tract secretions, skin lesions of an infected person or objects recently contaminated by patient fluids or lesion materials. Transmission occurs primarily via respiratory droplets or mucous membranes, usually requiring prolonged face-to-face contact, which puts household members of active cases at greater risk of infection. Transmission can also occur by inoculation or via the placenta as in congenital monkeypox (WHO, 2017).

Surveillance and rapid identification of new cases is critical for outbreak containment (WHO, 2017).

Infection in people can be reduced by raising awareness of the risk factors and educating people about measures they can take to reduce exposure to the virus. Control measures include isolation of affected persons, good respiratory and hand hygiene, and other personal protective measures. Those at highest risk, such as health workers or laboratory personnel, can be protected through vaccination. A vaccine against monkeypox was licensed in 2019 (WHO, 2019b, 2020).

Health workers caring for patients with suspected or confirmed monkeypox virus infection, or handling specimens from them, should implement standard and droplet infection control precautions (WHO, 2018).

References

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Coordinating agency or organisation

World Health Organization.

BI0067 / **BIOLOGICAL** / **Infectious Diseases (Human and Animals)**

Rabies (Animal and Human)

Definition

Rabies is a vaccine preventable zoonotic disease causing acute encephalitis which can progress towards coma and death typically within 7 to 10 days of the first signs if no intensive care is instituted. It is a disease of public health concern (adapted from WHO, 2018, 2020).

Reference

WHO, 2018. WHO Expert Consultation on Rabies. Third report. WHO Technical Report Series, No. 1012. World Health Organization (WHO). https://apps.who.int/iris/bitstream/handle/10665/272364/9789241210218-eng.pdf?ua=1 Accessed 12 October 2020.

WHO, 2020. United Against Rabies collaboration: First annual progress report. World Health Organization (WHO). www.who.int/publications/i/item/WHO-CDS-NTD-NZD-2019.04 Accessed 30 October 2020.

Annotations

Synonyms

None.

Additional scientific description

Rabies is a zoonotic disease (a disease that is transmitted from animals to humans), caused by the rabies virus, of the Lyssavirus genus, within the family Rhabdoviridae. Domestic dogs are the most common reservoir of the virus, with more than 99% of human deaths caused by dog-mediated rabies. Human infection occurs from bites of infected animals (usually dogs) and occasionally via penetrating scratches or licking of broken skin and mucosa. Domestic dogs, wild carnivore species and bats (Carnivora and Chiroptera) present a higher risk for rabies transmission than other mammals, as they are the reservoirs of the virus. Although monkeys, like any other mammal, are susceptible to rabies, the risk of rabies transmission from monkeys is extremely low. Infected animals may not appear rabid (NHS, no date).

Rabies is an acute, invariably fatal viral encephalitis. Initial signs include apprehension, headache, fever, malaise and sensory changes around the bite area. Excitability, hallucinations and abnormal fear of drafts of air (aerophobia) are common, followed in some cases by fear of water (hydrophobia) due to spasms of the swallowing muscles. Days after onset, the disease progresses to delirium, convulsions and death. Paralytic rabies is less common and is characterised by paralysis and loss of sensation, weakness and pain. Once clinical symptoms appear, rabies is virtually 100% fatal (WHO, 2018).

Rabies is present on all continents, except Antarctica, with over 95% of human deaths occurring in the Asia and Africa regions (WHO, 2021).

Although effective human vaccines and immunoglobulins exist for rabies, they are not readily available or accessible to those in need (WHO, 2020).

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Zero by 30: The Global Strategic Plan to Prevent Human Deaths from Dog-Transmitted Rabies by 2030. Until now, efforts to eliminate rabies have been fragmented across sectors and regions. In 2015, the world called for action by setting a global goal of zero human dog-mediated rabies deaths by 2030, worldwide. The World Health Organization (WHO), World Organization for Animal Health (OIE), Food and Agricultural Organization of the United Nations (FAO) and the Global Alliance for Rabies Control have united to deliver a comprehensive strategic plan to reach zero by 2030. A plan has been developed in consultation with relevant global, regional and country stakeholders. It provides a coordinated response to prevent rabies, integrated with strengthening of human and veterinary health systems to reach the world's most underserved populations. This aligns with the United Nations Sustainable Development Goals (WHO, FAO and OIE, 2018).

Examples of drivers, outcomes and risk management

Rabies has the highest case fatality rate of any currently recognised infectious disease. Rabies is present in mammals in most parts of the world. It is one of the Neglected Tropical Diseases (NTD) that predominantly affect poor and vulnerable populations who live in remote rural locations. The large majority of the estimated 59,000 human deaths from rabies per year occurs in Africa and Asia, with 80% in rural areas (WHO, 2019).

Children in regions of low-income countries enzootic for rabies have a higher risk of contracting rabies because of their size and behaviour (e.g., playing with animals, not reporting exposure) (WHO, 2019).

Vaccination against rabies is used to protect those at high risk of rabies exposure and prevent development of clinical rabies after suspected exposure, in conjunction with rabies immunoglobulin (postexposure prophylaxis) (WHO, 2019).

Assessment of individual risk of exposure to rabies virus is recommended for travellers. It should take into consideration: the remoteness of the destination, the prevailing rabies epidemiology and the cumulative duration of the stay(s) in endemic setting(s). In both no- and low-risk areas, proper medical care, rabies vaccine and immunoglobulins should be accessible in a timely manner, and reliable, laboratory-based surveillance of domestic, reservoir and wild species should be available. The level of risk is based on: the presence of animal species in which lyssaviruses are maintained (e.g., dogs, bats or other wildlife); the availability of reliable laboratory-based surveillance data on these species; access to proper medical care; and the availability of modern rabies vaccines (WHO, 2019).

Pre-exposure prophylaxis: Every country has rabies risk levels. These are (WHO 2019):

- Level 1: no risk. No pre-exposure prophylaxis required.
- Level 2: low risk. In both, no- and low-risk areas, proper medical care, rabies vaccine and immunoglobulins should be accessible in a timely manner, and reliable, laboratory-based surveillance of domestic, reservoir and wild species should be available. In countries in category 2 (low risk), pre-exposure prophylaxis should be offered to travellers involved in activities that are likely to bring them into direct contact with bats and wild carnivores. Such travellers include wildlife professionals, cavers, spelunkers, researchers, veterinarians and those visiting areas where bats and wild carnivores are commonly found. For people who regularly visit caves inhabited by bats, casual exposure to cave air is not a concern, but cavers should be warned not to handle bats.
- Levels 3 and 4: medium and high risk. In medium- and high-risk areas, access to proper medical care, rabies vaccines and immunoglobulins depends on the local setting. Timely access is not guaranteed everywhere because of a short supply of recent rabies vaccines or the local availability of older-generation rabies vaccines, which are no longer recommended by the WHO. Partial laboratory-based surveillance data may be available but may not cover all reservoir species or geographical settings in the country. Pre-exposure prophylaxis should therefore be considered for travellers who will undertake considerable outdoor activities in remote rural areas or activities that lead to probable contact with bats. Pre-exposure prophylaxis is also recommended for people with occupational risks, such as veterinarians, dog vaccinators and laboratory staff, and for expatriates living in remote areas with a significant risk of exposure to rabid domestic animals, particularly dogs, bats and wild carnivores.

Post-exposure prophylaxis: Every year, more than 29 million people worldwide receive a post-bite vaccination. This is estimated to prevent hundreds of thousands of rabies deaths annually. Globally, the economic burden of dog-mediated rabies is estimated at USD 8.6 billion per year (WHO, 2019).

Indications for post exposure prophylaxis depend on the type of contact with the confirmed or suspected rabid animal. Strict adherence to the WHO-recommended guidelines for optimal post exposure prophylaxis virtually guarantees protection from the disease. Administration of vaccine, and immunoglobulin if required, must be conducted by, or under the direct supervision of, a physician (WHO, 2019). Rabies immunoglobulin is not required for patients who have previously received two vaccine doses on different days.

Suspected contact in areas at risk of rabies may require post exposure prophylaxis. In this situation, immediate medical advice should be obtained. The category of exposure determines the indicated post-exposure prophylaxis procedure (WHO, 2019):

- Category I: touching or feeding animals, animal licks on intact skin (no exposure).

- Category II: nibbling of uncovered skin, minor scratches or abrasions without bleeding (exposure).
- Category III: single or multiple transdermal bites or scratches, contamination of mucous membrane or broken skin with saliva from animal licks, exposures due to direct contact with bats (severe exposure).

Controlling rabies in dogs: what to do - what to avoid doing? In brief, dog destruction alone is not effective in rabies control. There is no evidence that removal of dogs alone has ever had a significant impact on dog population densities or the spread of rabies. In addition, dog removal may be unacceptable to local communities. However, the targeted and humane removal of unvaccinated, ownerless dogs may be effective when used as a supplementary measure to mass vaccination. Mass canine vaccination campaigns have been the most effective measure for controlling canine rabies. High vaccination coverage (70% or higher) can be attained through comprehensive strategies consisting among others of well-designed educational campaigns, intersectoral cooperation, community participation and local commitment in planning and execution (WHO, no date).

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WHO, FAO and OIE, 2018. Zero by 30: The Global Strategic Plan to Prevent Human Deaths from Dog-Transmitted Rabies by 2030. World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO) and World Organisation for Animal Health (OIE). www.who.int/docs/default-source/ntds/rabies/executive-summary-0by30.pdf?sfvrsn=9e37d550_4 Accessed 5 November 2020.

Coordinating agency or organisation

World Health Organization (WHO), Food and Agriculture Organization of the United Nations (FAO) and World Organisation for Animal Health (OIE).

BI0068 / **BIOLOGICAL** / **Infectious Diseases (Human and Animal)**

Severe Acute Respiratory Syndrome (SARS) (Human)

Definition

Severe acute respiratory syndrome (SARS) is a viral respiratory illness caused by a coronavirus called SARS-associated coronavirus (SARS-CoV) (WHO, 2019).

Reference

WHO, 2019. Preliminary Clinical Description of Severe Acute Respiratory Syndrome. World Health Organization (WHO). www.who.int/csr/sars/clinical/en Accessed 16 December 2019.

Annotations

Synonyms

SARS-CoV.

Additional scientific description

Severe acute respiratory syndrome (SARS) was first identified at the end of February 2003 during an outbreak that emerged in China and spread to four other countries (WHO, 2020). The World Health Organization (WHO) coordinated the international investigation and worked closely with health authorities in affected countries to provide epidemiological, clinical and logistical support and to bring the outbreak under control (WHO, 2019).

Most patients identified with SARS were previously healthy adults aged 25 to 70 years. A few suspected cases of SARS have been reported among children under 15 years of age (WHO, 2020).

SARS is spread is by close person-to-person contact. The virus that causes SARS is thought to be transmitted most readily by respiratory droplets (droplet spread) produced when an infected person coughs or sneezes. The virus can also spread when a person touches a surface or object contaminated with infectious droplets and then touches his or her mouth, nose, or eye(s). In addition, it is possible that the SARS virus might spread more broadly through the air (airborne spread) or by other ways that are not now known. The incubation period of SARS is usually 2 to 7 days but may be as long as 10 days (WHO, 2020).

SARS usually begins with a prodrome of fever (>38°C), which is often high, sometimes associated with chills and rigors and sometimes accompanied by other symptoms including headache, malaise, and myalgias. At the onset of illness, some cases have mild respiratory symptoms (WHO, 2020).

The lower respiratory phase begins after 3 to 4 days with the onset of a dry, non-productive cough or dyspnea that may be accompanied by or progress to hypoxemia. In 10% to 20% of cases, the respiratory illness is severe enough to require intubation and mechanical ventilation (WHO, 2020). There is no cure or vaccine for SARS and treatment should be supportive and based on the patient's symptoms (WHO, 2020).

The case fatality among persons with illness meeting the current WHO case definition for probable and suspected cases of SARS is around 3% (WHO, 2020).

Laboratory diagnosis is key to determine the aetiology of the symptoms including differential diagnosis with other coronaviruses including SARS-CoV-2. Early clinical recognition of SARS-CoV disease still relies on a combination of clinical, laboratory and epidemiologic features. No specific clinical findings can distinguish with certainty SARS-CoV disease from other respiratory illnesses rapidly (CDC, 2004).

No vaccine or specific treatment is available for SARS but it is part of the priority list for the WHO Research and Development Blueprint for Action to Prevent Epidemics (WHO, 2016a).

The WHO has published guidance on case classification and surveillance standards (WHO, 2003a).

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016b).

Examples of drivers, outcomes and risk management

Prevention mainly is through infection control in healthcare, home and community settings (WHO, 2019). Personal preventive measures to prevent spread of the virus include frequent hand washing using soap or alcohol-based disinfectants. For those with a high risk of contracting the disease, such as healthcare workers, use of personal protective equipment, including a mask, goggles and an apron is mandatory. Whenever possible, household contacts should also wear a mask (WHO, 2020).

Control of SARS relies on the rapid identification of cases and their appropriate management, including the isolation of suspect and probable cases and the management of their close contacts (WHO, 2019).

Individuals under investigation should be placed in respiratory isolation and precautions strictly followed (WHO, 2019).

To further reduce the risk that travellers may carry the SARS virus to new areas, international travellers departing from areas with local transmission should be screened for possible SARS at the point of departure (WHO, 2003b).

Controlling outbreaks relies on containment measures including: prompt detection of cases through good surveillance networks and including an early warning system; isolation of suspected or probable cases; tracing to identify both the source of the infection and contacts of those who are sick and may be at risk of contracting the virus; quarantine of suspected contacts for 10 days; exit screening for outgoing passengers from areas with recent local transmission by asking questions and temperature measurement; and disinfection of aircraft and cruise vessels having SARS cases on board using WHO guidelines (WHO, 2020).

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Coordinating agency or organisation

World Health Organization.

BI0069 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Rotavirus (Human)

Definition

Rotaviruses are the most common cause of severe diarrhoeal disease in young children throughout the world. According to WHO estimates in 2013 about 215,000 children aged under 5 years die each year from vaccine-preventable rotavirus infections; the vast majority of these children live in low-income countries (WHO, 2018).

Reference

WHO, 2018. Rotavirus. World Health Organization (WHO). www.who.int/immunization/diseases/rotavirus/en Accessed 10 October 2020.

Annotations

Synonym

Not found.

Additional scientific description

Rotavirus, a member of the reovirus family, causes watery diarrhoea, vomiting and severe dehydration in young children. Rotavirus is common, accounting for 35–60% of acute severe diarrhoea in children less than 5 years of age in countries without rotavirus vaccine, with the highest attributable percentage in infants. Rotavirus diarrhoea is ubiquitous and children are infected at an early age. It often causes nosocomial outbreaks on paediatric wards where handwashing and other infection prevention and control measures are lax (WHO, 2018a).

Rotavirus is highly communicable; it is shed in the stool at high concentration, and transmission is through the faecal-oral route, either person-to-person or through fomites in the environment. The incubation period is one to three days. There is a spectrum of clinical disease with the typical presentation being acute, watery, non-bloody diarrhoea often accompanied by vomiting and fever (WHO, 2018a). Symptoms also include loss of appetite and dehydration due to loss of body fluids (WHO, 2017).

Rotavirus peaks in cool, dry seasons in temperate climates but exhibits less pronounced seasonality in tropical settings (WHO, 2018a).

Rotavirus has a case-fatality rate of approximately 2.5% among children in developing countries who present to health facilities. This case-fatality rate is higher in areas without good access to health care. In 2013, rotavirus caused an estimated 215,000 deaths worldwide (WHO, 2018a).

Rotavirus diarrhoea cannot be distinguished clinically from other types of diarrhoea, but laboratory confirmation can be done if necessary (WHO, 2017).

The World Health Organization (WHO) has published guidance on case classification and surveillance standards (WHO, 2018a).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Key measures to prevent diarrhoea include access to safe drinking-water, use of improved sanitation, hand washing with soap, exclusive breastfeeding for the first six months of life, good personal and food hygiene, health education about how infections spread and rotavirus vaccination (WHO, 2017).

Rotavirus diarrhoeal disease is a vaccine preventable disease (WHO, 2018b). Four oral, live, attenuated rotavirus vaccines, Rotarix™ (derived from a single common strain of human rotavirus); RotaTeq™ (a reassorted bovine-human rotavirus); Rotavac™ (naturally occurring bovine-human reassortant neonatal G9P, also called 116E); and RotaSiil™ (bovine-human reassortant with human G1, G2, G3 and G4 bovine UK G6P[5] backbone) are available internationally and are WHO prequalified. All four vaccines are considered highly effective in preventing severe gastrointestinal disease. In low income countries vaccine efficacy can be lower than in industrialised settings, similar to other live oral vaccines. Even with this lower efficacy, a greater reduction in absolute numbers of severe gastroenteritis and death is seen in lower income countries due to the higher background rotavirus disease incidence (WHO, 2018b).

The WHO recommends that rotavirus vaccines should be included in all national immunisation programmes and considered a priority particularly in countries in South and Southeast Asia and sub-Saharan Africa. The WHO continues to recommend that the first dose of rotavirus vaccine be administered as soon as possible after 6 weeks of age, along with DTP (diptheria, tetanus and pertussis) vaccination. Apart from a low risk of intussusception (up to 6 per 100,000 infants vaccinated) the current rotavirus vaccines are considered safe and well tolerated (WHO, 2018b).

The public health impact of rotavirus vaccination has been demonstrated in several countries. For example, in the USA, a measurable decrease was seen in the number of rotavirus gastroenteritis hospitalisations accompanied by a suggested herd effect protecting older non-vaccinated children, while in Mexico a decline of up to 50% in diarrhoeal deaths in children under 5 years of age was attributed directly to the use of the vaccine (WHO, 2018b).

The WHO reiterates that the use of rotavirus vaccines should be part of a comprehensive strategy to control diarrhoeal diseases with the scaling up of both prevention (promotion of early and exclusive breastfeeding, handwashing with soap, improved water and sanitation) and treatment packages (including low-osmolarity oral rehydration salts and zinc (WHO, 2018b).

References

WHO, 2017. Diarrhoeal disease. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/diarrhoeal-disease Accessed 16 December 2019.

WHO, 2018a. Rotavirus. Vaccine-Preventable Diseases: Surveillance Standards. World Health Organization (WHO). www.who.int/immunization/monitoring_surveillance/burden/vpd/WHO_SurveillanceVaccinePreventable_19_Rotavirus_R2.pdf?ua=1 Accessed 10 October 2020.

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Coordinating agency or organisation

World Health Organization.

BI0070 / **BIOLOGICAL / Infectious Diseases (Animal)**

African Swine Fever (Animal)

Definition

African swine fever is a devastating haemorrhagic viral disease of pigs, affecting domestic and wild pigs of all ages and both sexes (FAO, OiE, and EC, 2019).

Reference

FAO, OiE, and EC, 2019. African Swine Fever in Wild Boar Ecology and Biosecurity. Food and Agriculture Organization of the United Nations (FAO), World Organisation for Animal Health (OiE), European Commission (EC). www.fao.org/3/ca5987en/ca5987en.pdf Accessed 10 October 2020.

Annotations

Synonyms

ASFV.

Additional scientific description

African Swine Fever (ASF) is a highly contagious, generalised disease of pigs caused by an Iridovirus of family Asfarviridae that exhibits varying virulence between strains and is very hardy to physical and chemical inactivation. The agent can remain viable for long periods in blood, faeces and tissues. It can also multiply in its vectors. In view of this, control of ASF is dependent on stamping-out policy and strict quarantine enforcement. It most commonly appears in the acute form as a haemorrhagic fever. Subacute and chronic forms of the disease also exist. Mortality is usually close to 100% and pigs of all ages are affected (FAO, 2019).

The causative agent of ASF is a unique, enveloped, cytoplasmic, double-stranded DNA arbovirus, which is the sole member of the family Asfarviridae. Although it was generally considered that there is only one serotype of ASF virus, recent studies have reported the classification of 32 African Swine Fever virus (ASFV) isolates in eight different serogroups based on a hemadsorption inhibition assay (FAO, 2019).

In the natural sylvatic cycle, the soft-bodied, eyeless Ornithodoros ticks (also known as tampans) are, together with African wild suids, the natural reservoir hosts of ASFV. They can transmit the virus through their bites. All members of the pig family (Suidae) are susceptible to infection, but clinical disease is only seen in domestic and feral pigs, as well as in the closely related European wild boar. Wild African suids are asymptomatic carriers of ASF and act as the reservoir of the virus in parts of Africa. These include warthogs (Phacochoerus africanus and P. aethiopicus), bushpigs (Potamochoerus porcus and P. larvatus) and giant forest hogs (Hylochoerus meinertzhageni) (FAO, 2019).

In domestic pigs, ASF is transmitted mainly through direct contact, via the oronasal route, through excretions from infected pigs, or from ingestion of pork or other contaminated products containing the virus (e.g., swill, waste, carcasses, etc.). Further transmission pathways are indirect contact through fomites or vector-borne transmission through bites from infected Ornithodoros soft ticks, where present.

ASF is present in wild and/or domestic pigs in regions of Asia, Europe and Africa (OIE, 2018). People can transport the virus over large distances through contaminated meat and other sub-products such as skins, skulls, tusks or other hunting trophies (OIE, 2018; FAO, OIE and EC, 2019).

The disease is not a zoonosis, i.e. it does not infect humans.

Metrics and numeric limits

Not found.

Key relevant UN convention / multilateral treaty

WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (WTO, 1994).

WTO and the World Organization for Animal Health (OIE) (WTO, 1998).

UN Recommendations on the Transport of Dangerous Goods - UN Model Regulations Model Regulations Nature, Purpose and Significance of the Recommendations (UNECE, no date).

Examples of drivers, outcomes and risk management

Drivers: lack of biosecurity, swill feeding and transport of live pigs and uncooked port products, presence of the competent vector ticks of the genus Ornithodorous.

Outcomes: death of infected animals, spread of infection and trade ban. The disease is the cause of major economic losses, threatens food security and safe trade, and challenges sustained swine production in affected countries.

Risk management: depopulate infected herd, movement control, improve biosecurity at farms.

Recommendations for countries with ASF (FAO, 2019):

- Prioritise animal disease containment in its broadest sense within the highest levels of government.
- Ensure and enhance preparedness capacities (e.g., contingency planning, standard operating procedures (SoPs), secured financial support) based on the principles of early warning, detection and notification, early reaction/action, and coordination. These need to be reviewed periodically in relation to changing disease situation.
- Apply strict biosecurity measures; frequently clean and disinfect farms and transport vehicles; and improve husbandry practices and production systems.
- Strengthen surveillance and monitor transport of live pigs as well as pork products.
- Good communication and coordination with the swine-producing commercial sector and swine famers are essential to strengthen cooperation in ASF prevention, detection, and control. Ensure awareness and training of all stakeholders, from veterinarians to farmers, intermediaries and other value chain actors.
- Ensure means to communicate to the public are place to avoid rumours leading to food safety perceptions and consumption disruption.
- Farm registries, animal identification and censuses are essential for locating animals in the event of outbreaks and animal health interventions.
- Prohibit swill feeding.
- Strengthen proper disposal of food waste (food services, airports, seaports), which may contain uncooked pork products.
- Put in place sustainable outbreak control strategies. These need to be developed in consultation with the private sector (pig production and allied industries, such as transport, feed operators), which should be actively involved in disease management options.

Recommendations for National Considerations, Inter-Regional Collaboration and Solidarity (FAO, 2019):

- Strengthen intraregional networks on disease management and diagnostic protocols.
- Understanding of pig and pork value chains within the country and with neighbouring countries is essential for improved risk management.

The World organization for Animal Health (OiE) has published the Terrestrial Animal Code with guidance for Infection with African swine fever virus (OIE, 2019)

References

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UNECE, no date. UN Recommendations on the Transport of Dangerous Goods - UN Model Regulations Model Regulations Nature, Purpose and Significance of the Recommendations. United Nations Economic Commission for Europe (UNECE). www.unece.org/trans/danger/publi/unrec/rev13/13nature_e.html Accessed 3 October 2020.

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Coordinating agency or organisation

Food and Agriculture Organization of the United Nations (FAO), World Organisation for Animal Health (OiE).

BI0071 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Vector-borne diseases (VBD) (Animals)

Definition

Vector-borne diseases are diseases transmitted by a living being, usually an arthropod vector, to a vertebrate host (Verwoerd, 2015).

Reference

Verwoerd, D.W., 2015. Definition of a vector and a vector-borne disease. Scientific and Technical Review of the Office International des Epizooties (Paris), 34:29-31. World Organisation for Animal Health OIE. http://boutique.oie.int/extrait/03verwoerd2931ang.pdf Accessed 7 November 2020.

Annotations

Synonym

Not identified.

Additional scientific description

Vector-borne diseases (VBDs) encompass a variety of illnesses that can be transmitted among humans (e.g., malaria, dengue), among animals (e.g., African swine fever, East Coast fever), or from animals to humans (e.g., Nipah virus disease) (OIE, 2015a,b; WHO, 2020).

Many of these vectors are bloodsucking insects, and mosquitoes are the best known disease vector. Others include ticks, flies, sandflies, fleas, triatomine bugs and some species of freshwater aquatic snail (OIE, 2015a,b; WHO, 2020).

Examples of zoonotic VBDs include: Eastern, Western and Venezuelan equine encephalomyelitis; Rift Valley fever; Japanese encephalitis; West Nile fever; Crimean-Congo haemorrhagic fever; Nipah virus disease; Q fever; Tularaemia; African trypanosomosis; and Chagas disease. Some of these VBDs are described in detail in other Hazard Information Profiles: African swine fever (BI0070), Q fever (BI0081), Rift Valley fever (BI0082) and trypanosomosis (BI0083).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (WTO, 1994).

UN Recommendations on the Transport of Dangerous Goods - UN Model Regulations Model Regulations Nature, Purpose and Significance of the Recommendations (UNECE, no date).

Examples of drivers, outcomes and risk management

Drivers: Vector-borne diseases infected mosquitoes (OIE, 2015a).

Outcomes: High fever, abortion, and depending on the pathogen, death of infected animals and humans, spread of infection, trade/travel ban (OIE, 2015b).

Risk management: vaccination programme, movement control, improve biosecurity (OIE, 2015b).

Climate-driven fluctuations in environmental conditions, such as drought, flood, rainfall, wind and unpredictable weather have a direct influence on the disease burden from bacteria, parasites and their vectors. Work is being carried out to improve prevention, preparedness, early detection and early response to animal health threats and emergencies that could be triggered by climate change (FAO, 2020).

Progress has been made in recent years in developing policies, operational frameworks and pilot initiatives on animal health-based adaptation to climate change, with vector-borne diseases as priority. These represent excellent opportunities for stronger and more coherent linkages between applied research and public health policy (Campbell-Lendrum et al., 2015).

References

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UNECE, no date. UN Recommendations on the Transport of Dangerous Goods - UN Model Regulations Model Regulations Nature, Purpose and Significance of the Recommendations. United Nations Economic Commission for Europe (UNECE). www.unece.org/trans/danger/publi/unrec/rev13/13nature_e.html Accessed 4 October 2020.

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WHO, 2020. Vector-borne diseases. www.who.int/news-room/fact-sheets/detail/vector-borne-diseases Accessed 6 May 2021.

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Coordinating agency or organisation

Food and Agriculture Organization of the United Nations (FAO), World Organisation for Animal Health (OIE), World Health Organization (WHO).

BI0072 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Brucellosis (Animal)

Definition

Brucellosis is a bacterial disease caused by various Brucella species, which mainly infect cattle, swine, goats, sheep and dogs (WHO, 2020).

Reference

WHO, 2020. Brucellosis. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/brucellosis Accessed 9 October 2020.

Annotations

Synonyms

Undulant fever, Contagious abortion, Malta fever, Mediterranean fever.

Additional scientific description

Brucellosis is one of the most widespread zoonoses transmitted by animals and in endemic areas human brucellosis has serious public health consequences. Expansion of animal industries and urbanisation, and the lack of hygienic measures in animal husbandry and in food handling, partly account for brucellosis remaining a public health hazard (WHO, 2020).

Brucellosis is found globally and is a reportable disease in most countries. It affects people of all ages and both sexes. In the general population, most cases are caused through direct contact with infected animals, by eating or drinking contaminated animal products or by inhaling airborne agents. Most cases are caused by ingesting unpasteurized milk or cheese from infected goats or sheep (WHO, 2020).

The disease is also considered an occupational hazard for people who work in the livestock sector. People who work with animals and are in contact with blood, placenta, foetuses and uterine secretions have an increased risk of contracting the disease. This method of transmission primarily affects farmers, butchers, hunters, veterinarians and laboratory personnel (WHO, 2020).

Brucellosis is mainly caused by Brucella abortus, biovars 1-6, 9; B. melitensis, biovars 1-6; B. suis, biovars 1-5; and B. canis (WHO, 2001). Worldwide, B. melitensis is the most prevalent species causing human brucellosis, owing in part to difficulties in immunising free-ranging goats and sheep (WHO, 2020).

Brucellosis typically causes flu-like symptoms, including fever, weakness, malaise and weight loss. However, the disease may present in many atypical forms and which, in the absence of specific treatment, may persist for weeks or months. In many patients the symptoms are mild and, therefore, the diagnosis may not be considered. The incubation period of the disease can be highly variable, ranging from 1 week to 2 months, but usually 2 to 4 weeks (FAO, OiE and WHO, 2006; WHO, 2020). Human-to-human transmission is very rare (WHO, 2020).

Metrics and numeric limits

Disability adjusted life years (DALYs) are used as a measure to evaluate the impact of the morbidity caused by brucellosis in humans.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Codex Alimentarius (FAO, no date).

WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (WTO, 1994).

Collaboration between the World Trade Organization (WTO) and the World Organization for Animal Health (OIE) concerning the use of international standards in the context of the SPS Agreement (WTO, 2007).

UN Recommendations on the Transport of Dangerous Goods - UN Model Regulations Model Regulations Nature, Purpose and Significance of the Recommendations (UNECE, no date).

Examples of drivers, outcomes and risk management

Drivers: introduction of sub-clinically infected animals.

Outcomes include abortion in animals; disease in humans after consuming unheated dairy products (e.g., raw milk); and trade implications. These may involve substantial economic losses, including loss of income and manpower, medical care costs, and loss of food due to inadequacy of processing or spoilage. Therefore, public health education should be included among the essential activities to be performed within the framework of brucellosis control programmes or even as an independent activity (FAO, OIE and WHO, 2006).

Risk management includes movement control; treatment with antimicrobials (in humans); tracing back/forward of infected animals, depopulation of infected herds (in cattle); vaccination of animals (prevention). It also involves routine surveillance, particularly among high-risk groups (farmers, shepherds, workers in slaughterhouses, butchers, veterinarians, laboratory personnel). Another element of risk management is the mandatory early case-based reporting by health care providers or laboratories to upper levels of the public health sector as well as to the appropriate level of the animal health sector. In endemic countries where investigation of all reported cases may not be feasible, a representative proportion of reported cases should be investigated routinely.

Control activities must be coordinated and shared between both public health and animal health sectors. Administrative arrangements between the two sectors must facilitate immediate cross-notification of cases, as well as joint investigations and control. Control programmes must be promoted in goat-raising areas (FAO, OiE and WHO, 2006).

Equally important, complementary control of animal and human brucellosis activities on the ground at the community level, where local veterinary and public health services interact and collaborate, are key to ensuring the application of adapted approaches for improving surveillance, enhancing community awareness, promoting milk pasteurisation and hygiene practices and delivering effective vaccination campaigns (FAO, 2014).

Guidance on brucellosis surveillance and standards is available from the Food and Agriculture Organization of the United Nations (FAO), the World Health Organization (WHO), the World Organisation for Animal Health (OIE), and the United States Centres for Disease Control and Prevention (CDC).

The FAO has produced guidelines for coordinated human and animal brucellosis surveillance. The purpose of these general guidelines on surveillance in both human and animal populations is to provide a set of principles and techniques that can be used to develop and monitor new or existing brucellosis control programmes. The guidelines can also help in assessing the effectiveness of regulatory and advisory measures designed to safeguard public health (FAO, 2003).

The WHO provides technical advice to member states through the provision of standards, information and guidance for the management of brucellosis in humans and animals. The WHO works to support the coordination and sharing of information between the public health and animal health sectors. In collaboration with the FAO, the OIE and the Mediterranean Zoonoses Control Programme (MZCP), the WHO supports countries in the prevention and management of the disease through the Global Early Warning System for Major Animal Diseases (GLEWS) (WHO, 2020).

The OIE Terrestrial Animal Health Code provides guidance on infection with Brucella abortus, B. melitensis and B. suis, specifically Article 8.4 on the mitigation of the risk of spread of, and the risk to human health from, Brucella abortus, B. melitensis and B. suis in animals (OIE, 2019).

The CDC Brucellosis Reference Guide: Exposures, Testing, and Prevention is an example of a country approach. This guide includes the Brucella species as one of the biological agents and toxins that may pose a severe threat to public health, stating that the Brucella species are easily aerosolised and have a low infectious dose, cited at levels of between 10 and 100 microorganisms (CDC, 2017).

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WTO, 2007. The WTO and the World Organization for Animal Health (OIE) G/SPS/GEN/775. World Trade Organization (WTO). www.wto.org/english/thewto_e/coher_e/wto_oie_e.htm Accessed 3 October 2020.

Coordinating agency or organisation

Food and Agriculture Organization of the United Nations, World Health Organization, World Organisation for Animal Health (OIE).

BI0073 / **BIOLOGICAL / Infectious Diseases (Animal)**

Classical Swine Fever (Animal)

Definition

Classical swine fever, also known as hog cholera, is a contagious viral disease of domestic and wild swine. It is caused by a virus of the genus Pestivirus of the family Flaviviridae (OiE, 2020).

Reference

OiE, 2020. Classical Swine Fever (CSF). World Organisation for Animal Health (OIE). www.oie.int/en/animal-health-in-the-world/animal-diseases/Classical-swine-fever Accessed 18 October 2020.

Annotations

Synonyms

Hog cholera.

Additional scientific description

Classical Swine Fever (CSF) was first detected in the USA in the 19th century. An outbreak in the Netherlands in 1997 led to the destruction of 11 million pigs and cost USD 2.3 billion (OiE, 2020).

Classical swine fever is a contagious viral disease of domestic and wild swine. It is caused by a virus of the genus Pestivirus of the family Flaviviridae, which is closely related to the viruses that cause bovine viral diarrhoea in cattle and border disease in sheep. There is only one serotype of classical swine fever virus (CSFV) (OiE, 2020).

The most common method of transmission is through direct contact between healthy swine and those infected with CSFV. The virus is shed in saliva, nasal secretions, urine, and faeces. Contact with contaminated vehicles, pens, feed, or clothing may spread the disease. Animals that are chronic carriers of the disease (persistently infected) may show no clinical signs of illness but may shed the virus in their faeces. Offspring of infected sows can become infected in the uterus and once born can shed the virus for months (OiE, 2020).

The disease has acute and chronic forms, and can range from severe, with high mortality, to mild or even unapparent. In the acute form of the disease, in all age groups, there is fever, huddling of sick animals, loss of appetite, dullness, weakness, conjunctivitis, constipation followed by diarrhoea, and an unsteady gait. Several days after the onset of clinical signs, the ears, abdomen and inner thighs may show a purple discoloration. Animals with acute disease die within one to two weeks. Severe cases of the disease appear very similar to African swine fever. With low virulence strains, the only expression may be poor reproductive performance and the birth of piglets with neurological defects such as congenital tremor (OiE, 2020).

Classical swine fever is found in Central and South America, Europe, and Asia and parts of Africa. North America, Australia and New Zealand are currently free of the disease. In the 1990s large CSF outbreaks occurred in the Netherlands (1997), Germany (1993–2000), Belgium (1990, 1993, 1994) and Italy (1995, 1996, 1997). The World Organisation for Animal Health (OiE) standards for surveillance as applied have helped eradicate CSF from North America and much of Western Europe (OIE, 2020).

Classical swine fever virus can survive in pork and processed pork products for months when meat is refrigerated and for years when it is frozen (OiE, 2020). Pigs can become infected by eating CSF-infected pork meat or products (OiE, 2020).

It has been proven that in parts of Europe, the wild boar population may play a role in the epidemiology of the disease. The disease has been spread through legal and illegal transport of animals, and by feeding swill containing infective tissues to pigs (OiE, 2020).

Humans are not affected by this virus. Swine are the only species known to be susceptible (OiE, 2020).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

Codex Alimentarius (FAO, no date)

WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (WTO, 1994).

WTO and the World Organization for Animal Health (OIE) (WTO, 2007).

UN Recommendations on the Transport of Dangerous Goods - UN Model Regulations Model Regulations Nature, Purpose and Significance of the Recommendations (UNECE, no date).

Examples of drivers, outcomes and risk management

Drivers: Lack of biosecurity, swill feeding.

Outcomes: Death of infected animals, spread of infection, trade ban.

Risk management: Vaccination programme, movement control, depopulate infected herd, improve biosecurity at farms.

Classical swine fever is a disease listed in the OIE Terrestrial Animal Health Code and must be reported to the OIE (OiE, 2019).

Classical swine fever disease prevention and control states that treatment if not attempted, affected pigs must be slaughtered and the carcases buried or incinerated.

The first barrier to prevent a CSF outbreak is to apply strict and rigorous sanitary prophylaxis, as defined in the OIE Terrestrial Animal Health Code (OiE, 2019). Good communication between veterinary authorities, veterinary practitioners and pig farmers, a reliable disease reporting system, and hygiene measures protecting domestic pigs from contact with wild boar are the most effective measures to prevent the disease.

When an outbreak occurs, many actions must be set in place urgently: slaughter of all pigs on affected farms; safe disposal of carcasses, bedding, etc.; thorough disinfection; designation of infected zone, with control of pig movements; detailed epidemiological investigation, with tracing of possible sources (up-stream) and surveillance of infected zone, and surrounding area (OIE, 2020).

In areas where the disease is endemic, vaccination can prevent the spread of the disease. Vaccines used should be produced in accordance with the OIE standards for vaccine production (OIE, 2020). As the disease is brought under control, vaccination ceases, with continued surveillance. The OIE Terrestrial Animal Health Code defines the requirements for a country or a zone to be considered free of the disease (OiE, 2019).

In disease-free areas, a stamping-out policy is applied consisting of early detection, movement control, proper disposal of carcasses, and cleaning and disinfection. This policy has led to the elimination of CSF from North America, and much of Western Europe (OIE, 2020).

References

FAO, no date. About Codex Alimentarius. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/fao-who-codexalimentarius/about-codex/en Accessed 19 September 2020.

OIE, 2019. Terrestrial Animal Health Code. Chapter 15.2. Infection with classical swine fever virus. World Organization for Animal Health (OIE). www.oie.int/index.php?id=169&L=0&htmfile=chapitre_csf.htm Accessed 18 October 2020.

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UNECE, no date. UN Recommendations on the Transport of Dangerous Goods - UN Model Regulations Model Regulations Nature, Purpose and Significance of the Recommendations. United Nations Economic Commission for Europe (UNECE). www.unece.org/trans/danger/publi/unrec/rev13/13nature_e.html Accessed 3 October 2020.

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Coordinating agency or organisation

Food and Agriculture Organization of the United Nations (FAO), World Organisation for Animal Health (OIE).

BI0074 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Contagious Bovine Pleuropneumonia (CBPP) (Animal)

Definition

Contagious bovine pleuropneumonia is an infectious and contagious respiratory disease of Bovidae caused by Mycoplasma mycoides subspecies mycoides SC (Mmm) (OIE, 2018).

Reference

OIE, 2018. Contagious bovine pleuropneumonia (infection with Mycoplasma mycoides subsp. mycoides SC). Chapter 3.4.8. World Organisation for Animal Health (OIE). www.oie.int/fileadmin/Home/eng/Health_standards/tahm/3.04.08_CBPP.pdf Accessed 7 November 2020.

Annotations

Synonyms

Pleuropneumonie contagieuse bovine, Perineumonía contagiosa bovina, Контагиозная плевропневмония крупного рогатого скота, □□□

Additional scientific description

Contagious bovine pleuropneumonia (CBPP) attacks the lungs and membranes that line the thoracic cavity (the pleura) causing fever and respiratory signs. It is manifested by anorexia, fever and respiratory signs such as dyspnoea, polypnea, cough and nasal discharges in bovines (OIE, 2018).

Diagnosis requires the isolation of the aetiological agent (OIE, 2018). The name of CBPP has changed to: Mycoplasma mycoides subspecies mycoides SC (Mmm), but at the time of writing this had not been updated in the World Organisation for Animal Health (OIE) Terrestrial Manual (OIE, 2018).

CBPP has been unequivocally identified in Europe since the 18th century and gained a world-wide distribution during the latter half of the 19th century through cattle trade. CBPP was eradicated from many countries at the beginning of the 20th century, mostly through stamping-out strategies (UK, USA) or by vaccination campaigns followed by stamping-out strategies (Australia). Today, CBPP remains enzootic in many Sub-Saharan African countries, while in Europe the last CBPP cases were observed in Portugal in 1999. The situation in some Asian countries is unclear (OIE, 2018)

The main problems for control or eradication are the frequent occurrence of subacute or subclinical infections, the persistence of chronic carriers after the clinical phase and the lack of extensive vaccine coverage. CBPP has a major impact on livestock production and a potential for rapid spread (OIE, 2018).

Countries free of CBPP may pose trade restriction of domestic and wild cattle and buffaloes from countries considered infected with CBPP. CBPP-infected countries are excluded from international trade of live animals (OIE, 2018).

CBPP is a disease listed by the OIE in the Terrestrial Animal Health Code (OiE, 2019).

There is no evidence that humans are infected by Mycoplasma mycoides subspecies mycoides SC (Mmm) (CFSPH, 2015).

Metrics and numeric limits

Contagious bovine pleuropneumonia is included in the OIE list of notifiable diseases (OIE, 2019).

Contagious bovine pleuropneumonia prevention and control strategies (FAO, 2019).

Key relevant UN convention / multilateral treaty

WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (WTO, 1994).

UN Recommendations on the Transport of Dangerous Goods - UN Model Regulations Model Regulations Nature, Purpose and Significance of the Recommendations (UNECE, no date).

Examples of drivers, outcomes and risk management

Drivers: introduction of infected animal to a naive population.

Outcomes: eventual death of infected animals, spread of infection, trade ban.

Risk management: diagnostic, vaccination programme, treatment with antimicrobials, movement control, depopulate infected herd, improve biosecurity at farms.

In their report on the control of contagious bovine pleuropneumonia, the Food and Agriculture Organization of the United Nations (FAO) noted that the policies in addressing the control and management of CBPP are in disarray at both the national and international level (FAO, 2019). There has not been significant improvement in the efficacies of available vaccines or diagnostic assays for several decades while social conditions have evolved and populations have grown, making many traditional quarantine interventions logistically more problematic (FAO, 2019).

Classic strategies of mass vaccination and strict movement control that were once perceived as successful in rolling back the disease are largely ignored due to high costs, concerns of declining impact and growing public resistance (OIE, 2018; FAO, 2019).

Officially, treatment with antibiotics is discouraged or prohibited, yet their use is widespread. CBPP is an enigmatic disease, and research results often lack reproducibility for reasons mainly related to the fundamental pathobiology of the agent. This complicates strategic dialogue and delays decision-making. The regulatory and policy environment is still geared towards expected free public-supported programmes, although the level of implementation is insufficient to be of real service to farmers (FAO, 2019).

Moving forward, a three-point time-bound approach is suggested (FAO, 2019):

- A period of scaling out of integrated control measures designed to optimise the contribution of vaccination, treatment and institutional arrangements for delivery and monitoring of CBPP control. Throughout this period, CBPP control will expand in an evidenced-based manner that incorporates action research.
- An aggressive control phase under government coordination and regulation that seeks to suppress prevalence in endemic areas to the point of elimination of the disease.
- At 10 years in the future, progress will be reviewed to consider the feasibility of eradication. The epidemiological status of the disease, impact of existing control programmes and availability of new tools will be significant factors in the analysis.

References

CFSPH, 2015. Contagious Bovine Pleuropneumonia. Centre for Food Security and Public Health (CFSPH). www.cfsph.iastate.edu/Factsheets/pdfs/contagious_bovine_pleuropneumonia.pdf Accessed 20 April 2021.

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OIE, 2019. Terrestrial Animal Health Code. Chapter 11.5. Infection with Mycoplasma mycoides subsp. mycoides SC (Contagious bovine pleuropneumonia). World Organisation for Animal Health (OIE). www.oie.int/index.php?id=169&L=0&htmfile=chapitre_mycoplasma_mycoides.htm Accessed 7 November 2020.

UNECE, no date. UN Recommendations on the Transport of Dangerous Goods - UN Model Regulations Model Regulations Nature, Purpose and Significance of the Recommendations. United Nations Economic Commission for Europe(UNECE). www.unece.org/trans/danger/publi/unrec/rev13/13nature_e.html Accessed 4 October 2020.

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Coordinating agency or organisation

Food and Agriculture Organization of the United Nations (FAO), World Organisation for Animal Health (OIE).

BI0075 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Contagious Caprine Pleuropneumonia (CCPP) (Animal)

Definition

Contagious caprine pleuropneumonia is a severe disease of goats caused by Mycoplasma capricolum subsp. capripneumonIae (Mccp). The acute form of the disease is characterised by unilateral serofibrinous pleuropneumonia with severe pleural fluid (OIE, 2018).

Reference

OIE, 2018. Terrestrial Manua: Contagious Caprine Pleuropneumonia. Chapter 3.7.4. World Organisation for Animal Health (OIE). www.oie.int/fileadmin/Home/eng/Health_standards/tahm/3.07.04_CCPP.pdf Accessed 3 October 2020.

Annotations

Synonyms

Pleuropneumonie Contagieuse Caprine, Pleuroneumonía contagiosa caprina, контагиозная плевропневмония коз, [illegible]

Additional scientific description

Contagious caprine pleuropneumonia (CCPP) is one of the most severe diseases of goats (Spickler, 2015). It was first reported in Algeria in 1873 (Samiullah, 2013). This disease, which affects the respiratory tract, is extremely contagious and frequently fatal; in some naive flocks, the morbidity and mortality rates may reach 100% (Spickler, 2015).

CCPP affects goats in more than 40 countries of the world thereby posing a serious threat to goat farming around the globe (Yatoo et al., 2019). It causes major economic losses in Africa, Asia and the Middle East, where it is endemic (Spickler, 2015). CCPP is now also known to affect some species of exotic ungulate. This has raised concerns for zoos and for the conservation of some endangered species exposed to goats (Spickler, 2015).

Definitive CCPP diagnosis can be difficult, as the causative agent is one of the most fastidious mycoplasmas and can be missed during routine bacteriological analysis (Spickler, 2015). CCPP is caused by Mycoplasma capricolum subsp. capripneumoniae (Mccp) which belongs to the Mycoplasma mycoides cluster, a group of five closely related Mycoplasmas, pathogenic to ruminants (Samiullah, 2013). In goats it is manifested by anorexia, fever and respiratory signs such as dyspnoea, polypnea, cough and nasal discharges. The acute and subacute disease is characterised by unilateral sero-fibrinous pleuropneumonia with severe pleural effusion. Diagnosis is carried out by clinical and necropsy observations that should be confirmed by laboratory tests (OIE, 2018). Typical signs of CCPP are an accumulation of pleural fluid, unilateral hepatisation, adhesions, pleurisy and pleuropneumonia (Samiullah, 2013).

CCPP is included in the World Organisation for Animal Health (OIE) list of notifiable diseases (Samiullah, 2013). CCPP-free countries may pose trade restriction of domestic and wild goat from countries considered infected with CCPP (OIE, 2019).

There is no evidence that humans are infected by M. capricolum subsp. Capripneumoniae (Mccp) (Spickler, 2015).

Metrics and numeric limits

Contagious caprine pleuropneumonia is a disease listed by the OIE in the Terrestrial Animal Health Code (OIE, 2018).

Key relevant UN convention / multilateral treaty

Sanitary and Physiosanitary Measures: Text of Agreement. The WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (WTO, no date).

Examples of drivers, outcomes and risk management

Drivers: introduction of infected animal to a naive population (OIE, 2009).

Outcomes: spread of infection, trade ban (OIE, 2019).

Risk management: vaccination programme, treatment with antimicrobials, movement control, depopulate infected herd, improve biosecurity at farms (OIE, 2018).

References

OIE, 2009. Contagious Caprine Pleuropneumonia: Aetiology Epidemiology Diagnosis Prevention and Control References. World Organisation for Animal Health (OIE). www.oie.int/fileadmin/home/eng/animal_health_in_the_world/docs/pdf/disease_cards/contagious_caprine_pleuro.pdf Accessed 20 April 2021.

OIE, 2018. Terrestrial Manual: Contagious Caprine Pleuropneumonia. Chapter 3.7.4. World Organisation for Animal Health (OIE). www.oie.int/fileadmin/Home/eng/Health_standards/tahm/3.07.04_CCPP.pdf Accessed 3 October 2020.

OIE, 2019. Terrestrial Animal Health Code. Chapter 14.3 Contagious Caprine Pleuropneumonia. World Organisation for Animal Health (OIE). www.oie.int/index.php?id=169&L=0&htmfile=chapitre_ccpp.htm Accessed 3 October 2020.

Samiullah, S., 2013. Contagious caprine pleuropneumonia and its current picture in Pakistan: a review Veterinarni Medicina, 58:389-398. https://www.agriculturejournals.cz/publicFiles/101699.pdf

Spickler, A.R., 2015. Contagious Caprine Pleuropneumonia. www.cfsph.iastate.edu/Factsheets/pdfs/contagious_caprine_pleuropneumonia.pdf Accessed 3 October 2020.

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Yatoo, M.I., O.R. Parray, S.T. Bashir, et al., 2019. Contagious caprine pleuropneumonia - A comprehensive review. Veterinary Quarterly, 39:1-25. www.ncbi.nlm.nih.gov/pmc/articles/PMC6830973 Accessed 3 October 2020.

Coordinating agency or organisation

Food and Agriculture Organization of the United Nations (FAO), World Organisation for Animal Health (OIE).

BI0076 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Foot and Mouth Disease Virus (Animal)

Definition

Foot-and-mouth disease is caused by a virus of the family Picornaviridae, genus Aphthovirus. It is a highly contagious and economically important disease of cloven-hoofed domestic animals (cattle, buffaloes, pigs, sheep, goats) and wild animals (FAO, 2012; OIE, 2018).

References

FAO, 2012. Foot-and-mouth disease Frequently Asked Questions. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/3/an384e/an384e00.pdf Accessed 3 October 2020.

OIE, 2018. Foot & Mouth disease (FMD). World Organisation for Animal Health (OIE). www.oie.int/en/animal-health-in-the-world/animal-diseases/Foot-and-mouth-disease Accessed 3 October 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

Foot-and-mouth disease (FMD) is a devastating animal disease affecting all cloven-hoofed animals, both domestic and wild species. The viruses that cause FMD are among of the most infectious agents known to veterinary or human medicine, which is why it strikes deep fear into livestock farmers, especially in countries that are free from the disease (FAO, 2012).

FMD is characterised by the formation of vesicles (blisters) in and around the oral cavity, feet and on the teats. It has huge detrimental impact on livelihoods, food security and national economies through loss of milk yields, lowered fertility and reduced or prohibited access to markets (FAO, 2012; OIE, 2018).

The most common way for the FMD virus to spread is by animal movements that bring healthy animals into contact with FMD-infected animals. Secretions from sick animals are extremely infectious. FMD-infected animals grazing together, sharing a similar drinking water point can lead to exchange of contaminated saliva. Cattle, buffaloes, sheep and goats are especially vulnerable to infection transmitted by aerosols (moisture in exhalation), which is the main source of infection in animals living in close quarters (FAO, 2012).

In rare cases, FMD infection has appeared to ‘jump’ over long distances including large bodies of water, but this usually only occurs if many sick animals are densely housed together creating an ‘infected plume’ (FAO, 2012).

The morbidity rate may approach 100% in susceptible cattle populations and death can occur in young animals. FMD is estimated to circulate in 77% of the global livestock population, in Africa, the Middle East and Asia, as well as in a limited area of South America. Low income and lower-middle income countries bear 75% of the global costs of FMD prevention and control and Africa and Eurasia are the regions contributing the most to that cost, accounting for 50% and 33% of the global expenditure of FMD control and prevention, respectively (OIE, 2018). Thus, it threatens the livelihood of millions of poor livestock keepers and food security in the FMD endemic regions. FMD-infected countries are excluded from international trade of live susceptible animals, their meat and meat products (FAO, 2012).

Countries that are currently FMD-free remain under constant threat of an incursion.

Although FMD had been largely controlled in developed nations, in 2001, an outbreak in the UK spread to the Netherlands, with smaller outbreaks in France and Ireland, before being brought under control by widespread culling. The experience left its mark on the psyche of many of the farmers that lived through the tragedy: the UK alone suffered economic losses of more than USD 12 billion, and some 6.5 million sheep, cattle and pigs were slaughtered to halt the spread of the disease (FAO, 2012).

FMD can be controlled by vaccination, however there are seven immunologically distinct serotypes: A, O, C, SAT1, SAT2, SAT3, and Asia1 which do not confer cross immunity (OIE, 2018).

There is no health risk to humans from FMD; regardless, meat, dairy and animal products destined for human consumption should come only from healthy animal sources (FAO, 2012).

Metrics and numeric limits

Foot-and-mouth disease is one of the diseases listed in the OIE Terrestrial Animal Health Code, one of the international standards used for the Sanitary and Phytosanitary (SPS) Agreement (OIE, 2019).

Key relevant UN convention / multilateral treaty

Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction (UNODA, no date).

WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (WTO, 1994).

WTO and the World Organisation for Animal Health (OIE) (WTO, 2007).

Examples of drivers, outcomes and risk management

The Food and Agriculture Organization of the United Nations (FAO) and the World Organisation for Animal Health (OIE) are working together for global control of FMD. In partnership with the FAO-based European Commission for the Control of Foot-and-Mouth Disease (EuFMD), the FAO has developed the Progressive Control Pathway for Foot-and-Mouth Disease control (PCP-FMD), which guides endemic countries through a series of incremental steps to successfully control the disease (FAO, 2012).

At the global level, the FAO and OIE Crisis Management Centre for Animal Health (CMC-AH) is a rapid response unit available to deploy assistance on the ground and guide affected countries in policymaking in the event of an animal disease emergency (FAO, 2012).

Drivers: lack of biosecurity, swill feeding, transport of susceptible animals (cattle, buffaloes, pigs, sheep, goats and other cloven-hoofed ruminants) and uncooked animal products (FAO, 2012).

Outcomes: spread of infection, trade ban, compromise Sustainable Development Goals.

Risk management: vaccination with matching vaccine (prevention), depopulation of infected herds, movement control, improve farm biosecurity (OIE, 2018).

References

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OIE, 2019. Terrestrial Animal Health Code: Infection with Foot and Mouth Disease Virus. Chapter 8.8. World Organisation for Animal Health (OIE). www.oie.int/index.php?id=169&L=0&htmfile=chapitre_fmd.htm Accessed 3 October 2020.

UNODA, no date. Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction. United Nations Office for Disarmament Affairs (UNODA). www.un.org/disarmament/biological-weapons Accessed 3 October 2020.

WTO, 1994. The WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement). World Trade Organization (WTO). www.wto.org/english/tratop_e/sps_e/spsagr_e.htm Accessed 3 October 2020.

WTO, 2007. The WTO and the World Organization for Animal Health (OIE) G/SPS/GEN/775. World Trade Organization (WTO). www.wto.org/english/thewto_e/coher_e/wto_oie_e.htm Accessed 3 October 2020.

Coordinating agency or organisation

Food and Agriculture Organization of the United Nations (FAO), World Organisation for Animal Health (OIE).

BI0077 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Lumpy Skin Disease (Animal)

Definition

Lumpy skin disease is a vector-borne pox disease of domestic cattle and Asian water buffalo and is characterised by the appearance of skin nodules on all body surface including the udder (FAO, 2017).

References

FAO, 2017. Lumpy Skin Disease: A field manual for veterinarians. Food and Agriculture Organization of the United Nations (FAO) Animal Production and Health Manual No. 20. www.fao.org/3/a-i7330e.pdf Accessed 3 October 2020.

Annotations

Synonyms

Dermatose nodulaire contagieuse (fr), Dermatosis nodular contagiosa (es), Заразный узелковый дерматит крс (ru), [illegible] (ar), [illegible] (cn).

Additional scientific description

Lumpy skin disease (LSD) is a poxviral disease with significant morbidity in cattle that has dramatic effects on rural livelihoods (FAO, 2017). Although the mortality rate is generally low, economic losses result from loss of condition, decreased milk production, abortions, infertility and damaged hides.

Lumpy skin disease is caused by the lumpy skin disease virus (LSDV), a member of the genus Capripoxvirus (CaPV) within the family Poxviridae. The LSDV shares the genus with sheep pox virus (SPPV) and goat pox virus (GTPV), which are closely related, but phylogenetically distinct. Although the three viruses are considered to be distinct viral species, they cannot be distinguished by routine serological tests (FAO, 2017).

The causative virus seems to be spread mainly by blood-feeding insects, such as certain species of flies and mosquitoes or ticks, and outbreaks can be widespread and difficult to control (OIE, 2020). LSD spreads mainly through mechanical transmission by arthropod vectors. In addition to vectors, transmission may occur through consumption of contaminated feed or water, direct contact, natural mating or artificial insemination (FAO, 2017).

Although traditionally limited to sub-Saharan Africa, LSD has slowly been invading new territories since 2015 including the Middle East and Turkey, and most of the Balkan countries, the Caucasus and the Russian Federation, causing substantial economic losses and serious threat to the food security. Further, in 2019, LSD was also reported in Bangladesh, China and India and in 2020 it has reached Chinese Taipei (OIE, 2020). LSD can rapidly spread across national borders and reach epidemic proportions, thus requiring regional cooperation in prevention, control and eradication (FAO, 2017).

Large-scale vaccination is the most effective way to prevent and control the disease spread. Effective vaccines against LSD are commercially available and the sooner they are used the less severe the economic impact of an outbreak is likely to be (FAO, 2017).

There is no evidence that LSDV can infect humans (FAO, 2017).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (WTO, 1994).

UN Recommendations on the Transport of Dangerous Goods - UN Model Regulations Model Regulations Nature, Purpose and Significance of the Recommendations (UNECE, no date).

Examples of drivers, outcomes and risk management

Drivers: lack of biosecurity, presence of vectors (FAO, 2017).

Outcomes: death of infected animals, spread of infection, trade ban (FAO, 2017).

Risk management: vaccination programme, vector control, movement control, farm biosecurity (FAO, 2017).

The Food and Agriculture Organization of The United Nations (FAO) provides guidance on prevention measures (FAO, no date). It is difficult to stop cattle being attacked by infected vectors (flies, etc.) once infection is within an area. Risk behaviours increase the probability of infection being carried between locations. Large-scale vaccination is the most effective way to prevent and control the disease spread (FAO, 2017).

The FAO guidance on preventative measures that can improve the level of protection of a herd from LSD and other infectious diseases includes the following (FAO, no date):

- Implement biosecurity measures:
  - As livestock and vehicles can carry live vectors (flies, mosquitoes, etc.) between areas, avoid entry or opening of such vehicles within or close to livestock holdings, unless disinfested with approved products.
  - Protect animals from insects (e.g., treatment with approved repellents, move animals to locations within the holding where fewer biting flies).
  - Change needles when treating animals.
- General measures to reduce the risk of LSD and other diseases:
  - Disinfectant footbath at the entrance of the stable.
  - Disposable boot covers and suit for the visitors.
  - Disinfection and disinfestation of vehicles prior to and after movements.
  - Raise awareness at livestock keepers, field veterinarian and animal health workers levels and encourage reporting to the central veterinary authority.
- Avoid:
  - Contacts between animals of different herds (e.g., on pasture).
  - Grazing areas where nuisance flies are very abundant.
  - Sharing animals, tools, vehicles, personnel with other farms.
- Awareness of herd may be at risk. It is very important to check regularly all the animals and report to a veterinarian or veterinarian service.

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Coordinating agency or organisation

Food and Agriculture Organization of The United Nations (FAO), World Organisation for Animal Health (OIE).

BI0078 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

New World Screwworm (NWS) (Animal)

Definition

New World screwworms are a type of blow fly larvae (maggots) that can infest livestock and other warm blooded animals, including people. They most often enter an animal through an open wound and feed on the animal's living flesh. If not treated, infestations can be fatal (OIE, 2020).

Reference

OiE, 2020. Terrestrial Animal Health Code: New world screwworm (Cochliomyia hominivorax). Chapter 8.12. World Organisation for Animal Health (OIE). www.oie.int/standard-setting/terrestrial-code/access-online Accessed 19 October 2020.

Annotations

Synonyms

None.

Additional scientific description

The New World screwworm, Cochliomyia hominivorax, is a blow fly that is an obligate parasite of warm-blooded animals in tropical and subtropical regions of South America and the Caribbean. Females seek animals and lay their eggs on the skin, often near open wounds. Larvae feed on the animal's tissues, enlarging the wound, which can cause death if not treated. The period between oviposition at a wound site and the expression of disease due to burrowing larvae can be as short as one to two days. After cessation of feeding, larvae leave the animal and pupate in the soil. The life cycle takes approximately three weeks. Infestation of tissue by fly larvae is known as 'myiasis' (OIE, 2013).

Economic losses due to screwworm infestation of livestock are significant. In 2005, it was estimated that in South America alone annual losses were approximately USD 3.6 billion (Scott et al., 2020). New World screwworm eradication programmes have eliminated this myiasis from Curacao, Puerto Rico, the Virgin Islands, the USA, Mexico and in Central America, from Guatemala, Belize, El Salvador, Honduras, Nicaragua, Costa Rica, and Panama. New World screwworm is presently found in the northern countries of South America southwards to Uruguay, northern Chile and northern Argentina. The parasite spread from the Americas to Libya when it was identified in 1988 by Libyan veterinarians in the northwest part of the country. The mode of introduction and the country from which the pest came remain unknown. Positive taxonomic identification of the pest was made by British scientists, and the Food and Agriculture Organization of the United Nations (FAO) confirmed the presence of the screwworm myiasis disease in Libya in March 1989 (Lindquist and Abusowa, 1991).

Many cases of screwworm myiasis have been documented in humans. The disease can quickly become debilitating if it affects the eyes, mouth, nasal or frontal sinuses, or the ears (CFSPH, 2016).

Clinical presentation of screwworm is always associated with a variety of pre-established wounds and should be considered in the event of any myiasis. Wounds may manifest draining, suppuration and/or enlargement; signs of infestation with serosanguineous discharge often accompanied by distinctive odour. Animals with screwworm myiasis often display discomfort and appear unthrifty and depressed; separate from group and may also manifest anorexia and reduced milk production. Morbidity, although variable, in areas with high screwworm populations may reach up to 100% in naval wounds of newborns. If untreated, animals may die within one to two weeks due to toxicity and/or secondary bacterial infection (OIE, 2013).

Laboratory diagnosis is by identification of the parasites under the microscope. Field diagnosis of screwworm larvae, even with a microscope or magnifying glass, is difficult. Adult screwworms are rarely seen. They are also difficult to distinguish from other flies. Other techniques used mainly in research laboratories include cuticular hydrocarbon analysis, analysis of mitochondrial DNA, and random amplified polymorphic DNA polymerase chain reaction (RAPD-PCR) assays. Serology is not used (CFSPH, 2016).

Screwworm infestations can be treated in both endemic and non-endemic regions; euthanasia of the animal is not usually required. Although some wounds may be surgically excised, most are treated with a suitable larvicide and allowed to heal without closure. Treatment is usually repeated at intervals until the wound has healed. Removal of necrotic tissue may be necessary, and antibiotics may be given when secondary bacterial contamination is present. In non-endemic regions, the animal is quarantined until treatment is complete and the wound has healed. Treatment of the environment may also be necessary. Larvae that are removed from the wound must be placed in alcohol preservative or destroyed. If any larvae leave an infested wound and mature into adults, screwworms can become established in an area (CFSPH, 2016).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (WTO, 1994).

WTO and the World Organization for Animal Health (OIE) (WTO, 2007).

Examples of drivers, outcomes and risk management

Drivers: presence/introduction of screwworm fly (Cochliomyia hominivorax), introduction of infected livestock or pet.

Outcomes: death of infected animals, spread of infection, trade ban.

Risk management: control programme using sterile insect technique (SIT), movement control, improved biosecurity at farms.

New World screwworm is a disease listed by the World Organisation for Animal Health (OIE) in its Terrestrial Animal Health Code and must be reported to the OIE (OIE, 2019).

For control of screwworms, the implementation of voluntary and regulatory actions can prevent the introduction of screwworms to pest-free areas. Screwworms can enter non-endemic areas in infested animals or as adult flies. Vehicles that may contain adults or immature screwworms should be sprayed with insecticides. Imported animals (including pets) must be inspected for infestations, and treated if necessary, before they are allowed to enter. As a precaution, wounds that do not appear to be infested may be treated with an insecticide. Animals may also be sprayed or dipped. Any infestations that become apparent after an animal enters the country must be treated promptly (CFSPH, 2016).

To prevent the spread of screwworms beyond their present geographical distribution, strict observation of the requirements for international trade, as set out in the OIE Terrestrial Animal Health Code, is necessary (OIE, 2013).

In endemic areas, animals must be inspected for screwworms every few days. Livestock can also be protected by regular spraying or dipping with insecticides, or by subcutaneous injections of ivermectin and related compounds. Insect growth regulators have also shown good results. Organophosphate insecticides are effective against newly hatched larvae, immature forms and adult flies. Other insecticides, such as carbamates and pyrethroids have also been used. Acaricide resistance can be an issue. In areas where screwworms are seasonal, breeding can be scheduled to avoid births when these flies are numerous. Indirect prevention of screwworm infestation includes: avoidance of wounding procedures at the times of year when screwworm are numerous; careful handling of livestock to minimise wounding; removal of sharp objects (e.g., wire strands) from livestock pens; and use of measures to reduce other wound-causing parasites, in particular ticks (e.g., by dipping and by insecticide impregnated ear-tags) (CFSPH, 2016).

No vaccine is currently available.

Screwworms can be eradicated from a region by repeatedly releasing sterile male flies that mate with wild female screwworms to produce unfertilised eggs. Because it is usually impractical to separate irradiated male and female flies, both males and females are usually released. This technique, known as sterile insect technique (SIT), leads to a reduction in screwworm numbers and eventually results in eradication. In addition, infested animals are treated, and their movements are controlled (CFSPH, 2016).

References

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OiE, 2013. Screwworm (Old World and New World). World Organisation for Animal Health (OIE). www.oie.int/fileadmin/home/eng/animal_health_in_the_world/docs/pdf/disease_cards/screwworm.pdf Accessed 19 October 2020.

OiE, 2019. New World Screwworm and Old World Screwworm. World Organisation for Animal Health (OIE). www.oie.int/index.php?id=169&L=0&htmfile=chapitre_cochliomyia_chrysomya.htm Accessed 19 October 2020.

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WTO, 2007. The WTO and the World Organization for Animal Health (OIE) G/SPS/GEN/775. World Trade Organization (WTO). www.wto.org/english/thewto_e/coher_e/wto_oie_e.htm Accessed 3 October 2020.

Coordinating agency or organisation

Food and Agriculture Organization of the United Nations (FAO), World Organisation for Animal Health (OIE).

BI0079 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Newcastle Disease Virus (Animal)

Definition

Newcastle disease is an infectious disease of birds caused by Newcastle disease virus, of the Paramyxovirdae family. The disease is seen mainly in chickens, but many bird species and even reptiles and mammals are susceptible to infection (OIE, 2018).

Reference

OIE, 2018. Terrestrial Animal Health Code: Newcastle Disease (Infection with Newcstle Virus). Chapter 3.3.14. World Organisation for Animal Health (OIE). www.oie.int/fileadmin/Home/eng/Health_standards/tahm/3.03.14_NEWCASTLE_DIS.pdf Accessed 4 October 2020.

Annotations

Synonyms

Acute viral disease of birds, Fowl plague, Fowl pest, Contagious viral bird disease, Philippine fowl disease, Virulent Newcastle disease, Ranikhet disease, Avian paramyxovirus-1 infection, Goose paramyxovirus infection.

Additional scientific description

Newcastle disease is a viral disease of birds caused by avian paramyxovirus 1 (APMV-1). For official control purposes, this disease is currently defined as the most severe form of the illness, which is caused only by certain viral strains. Many less virulent strains of APMV-1 also circulate among domesticated and wild birds. These viruses usually cause much milder clinical signs or infect birds asymptomatically. However, they can sometimes evolve to become the highly virulent strains that cause Newcastle disease (Spickler, 2016).

Newcastle disease in birds can vary from no signs of illness to sudden death. Affected birds may have coughing, sneezing, nasal discharge, depression, and diarrhoea. Chicken flocks may have a sudden decrease in egg production or produce thin shelled eggs. Signs of severe illness include swelling of the tissues of the head, muscle tremors, drooping wings, twisted head, circling, paralysis or sudden death (CFSPH, 2008).

Newcastle disease is considered to be one of the most important poultry diseases in the world. Chickens are particularly susceptible and may experience morbidity and mortality rates of up to 100% (Spickler, 2016). Since its recognition in 1926, Newcastle disease is regarded as being endemic in many countries. Outbreaks can have a tremendous impact on village chickens in developing countries, where these birds are a significant source of protein and this disease is endemic (FAO, 2004). In developed countries, where highly virulent APMV-1 strains have usually been eradicated from poultry, trade embargoes and restrictions cause significant economic losses during outbreaks (Spickler, 2016).

Newcastle disease can also affect other commercial poultry, game birds, ratites, and various pet, hobby and zoo birds. Some of these birds become ill, while others carry and shed virulent viruses asymptomatically. Subclinically infected birds, particularly illegally imported psittacines, can introduce Newcastle disease into countries where it does not usually exist (Spickler, 2016).

Newcastle disease is transmitted by direct contact with diseased or carrier birds. Biosecurity measures on farms and in live poultry markets are important to prevent disease spread (FAO, 2015; OIE, 2020).

Prophylactic vaccination is practised in all but a few of the countries that produce poultry on a commercial scale (OIE, 2018).

Newcastle disease virus is a human pathogen and the most common sign of infection in humans is conjunctivitis that develops within 24 hours of exposure to the eye. Although the effect on the eye may be severe, infections are usually transient, and the cornea is not affected. There is no evidence of human-to-human spread (OIE, 2018).

Metrics and numeric limits

Newcastle disease in its virulent form, is notifiable to the World Organisation for Animal Health (OIE) under the Terrestrial Animal Health Code. An intracerebral pathogenicity index (ICPI) in day-old chicks of 0.7 or greater or the presence of multiple basic amino acids in the virus genome determines a strain to be virulent (OIE, 2019).

Key relevant UN convention / multilateral treaty

WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (WTO, 1994).

UN Recommendations on the Transport of Dangerous Goods - UN Model Regulations Model Regulations Nature, Purpose and Significance of the Recommendations (UNECE, no date).

Examples of drivers, outcomes and risk management

Drivers: introduction of virus to a susceptible flock, via poultry trade-related activities or wild birds.

Outcomes: high mortality in poultry with sudden death of birds, trade ban, livelihoods and food security implications, gender (women and children are often the ones caring for poultry).

Risk management: farm and market biosecurity, vaccination programme (prevention), movement control, depopulation, tracing back/forward.

References

CFSPH, 2008. Newcastle Disease: Fast Facts. Centre for Food Security and Public Health (CFSPH). www.cfsph.iastate.edu/FastFacts/pdfs/newcastle_F.pdf Accessed 4 October 2020.

FAO, 2004. A Technology Review: Newcastle Disease: With Special Emphasis on its Effects on Village Chickens. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/3/y5162e/y5162e00.htm Accessed 4 October 2020.

FAO, 2015. Biosecurity Guide For Live Poultry Markets. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/3/I5029E/i5029e.pdf Accessed 4 October 2020.

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WTO, 1994. The WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement). World Trade Organization (WTO). www.wto.org/english/tratop_e/sps_e/spsagr_e.htm Accessed 4 October 2020.

Coordinating agency or organisation

Food and Agriculture Organization of the United Nations (FAO) and World Organisation for Animal Health (OIE).

BI0080 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Peste Des Petits Ruminants (Animal)

Definition

Peste des petits ruminants is a highly contagious and devastating disease of goats and sheep. The causative agent, Peste des petits ruminants virus is a member of the genus Morbillivirus, Family Paramyxoviridae and Order Mononegavirales (adapted from FAO, 2020a; OiE, 2020).

References

FAO, 2020. Peste des petits ruminants. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/ppr/en Accessed 18 October 2020.

OIE, 2020. Terrestrial Animal Health Code: Infection with Peste des petits ruminants virus. Chapter 14.7. World Organisation for Animal Health (OIE). www.oie.int/index.php?id=169&L=0&htmfile=chapitre_ppr.htm Accessed 18 October 2020.

Annotations

Synonyms

Sheep and goat plague, Ovine rinderpest.

Additional scientific description

Peste des Petits Ruminants (PPR), also known as sheep and goat plague, is a highly contagious animal disease affecting domestic and wild small ruminants. It is caused by a virus belonging to the genus Morbillivirus, family Paramixoviridae. Once newly introduced, the virus can infect up to 90% of a small ruminant flock, and the disease kills anywhere up to 70% of infected animals (FAO, 2020).

PPR was first described in 1942 in Côte d'Ivoire, West Africa. Since then the disease has spread to large regions of Africa, the Middle East, Asia and Europe. Today, more than 70 countries are affected or at high risk and many more are without an official PPR status. PPR infected and at risk countries are home to approximately 1.7 billion heads – around 80% – of the global population of sheep and goats (FAO, 2020).

PPR causes annual economic losses of up to USD 2.1 billion. Looking beyond this figure, 300 million families are at risk of losing their livelihoods, food security, and employment opportunities. Moreover, small ruminants and their products are internationally traded commodities, particularly in Africa and the Middle East. PPR considerably affects export earnings and creates supply shortages. The inability of families, communities, and institutions to anticipate, absorb, or recover from PPR can compromise national and regional development efforts, and reverse decades of progress (FAO, 2020).

Until recently, this virus was named simply Peste des petits ruminants virus (PPRV); the official name of this virus was changed in 2016 to small ruminant morbillivirus (SRM). However, it is still commonly known as PPRV by people working in the field. It is antigenically similar to rinderpest virus, measles virus and canine distemper virus. It is transmitted by direct contact with diseased animals. PPR also occurs in some wildlife species, which can act as a source of infection for domestic small ruminants. PPR-infected countries are excluded from international trade of live small ruminants (OIE, 2020a).

A PPR outbreak is an emergency due to its rapid spread and high animal mortality rate. Fatal diseases of small ruminants, such as PPR, affect the already vulnerable livelihoods and can decimate the savings of poor populations, especially in pastoral areas. People become desperate when they lose their assets. PPR outbreaks, and the desperation due to the loss, can trigger turmoil, migration, and volatile security situations (FAO, 2020).

Eradicating PPR will increase sustainability, alleviate poverty, improve the resilience of poor pastoralists and their communities, enable them to better cope with other shocks and threats, prevent forced migration and mitigate extremist trends (FAO, 2020).

As an example, Mongolia reported its first-ever PPR outbreaks in sheep and goat populations in September 2016. In the absence of an adequate response by local veterinary services, the disease rapidly spread, devastating rural livelihoods, and disrupting exports and value chains. In December 2016, PPR spilled over to wild antelope species killing up to 60% of the Saiga antelope population, a critically endangered species according to the International Union for Conservation of Nature (IUCN) (FAO, 2020).

Transmission of PPR is mainly by aerosol or direct contact between animals living in close quarters and via fomites spreading infection via bedding, feed, pasture and water troughs (OIE, 2020a).

PPR is not a zoonotic infection. There is no known risk of human infection with PPR virus (FAO, 2020).

Metrics and numeric limits

Peste des Petits Ruminants is notifiable to the World Organisation for Animal Health (OIE) under the Terrestrial Animal Health Code (OIE, 2020b).

Key relevant UN convention / multilateral treaty

Codex Alimentarius (FAO, no date).

WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (WTO, 1994).

WTO and the World Organization for Animal Health (OIE) (WTO, 2007).

UN Recommendations on the Transport of Dangerous Goods - UN Model Regulations Nature, Purpose and Significance of the Recommendations (UNECE, no date).

Examples of drivers, outcomes and risk management

Drivers: introduction of infected animal to a naive population (OIE, 2020a,b).

Outcomes: death of infected animals, spread of infection, trade ban (OIE, 2020a,b).

Risk management: vaccination program, movement control, improve biosecurity (OIE, 2020a,b).

Eradicating PPR is a major advance towards achieving the Sustainable Development Goals (UNDESA, no date). A one-time vaccination can immunise ruminants for life against PPR or sheep and goat plague.

References

FAO, no date. About Codex Alimentarius. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/fao-who-codexalimentarius/about-codex/en Accessed 19 September 2020.

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OIE, 2020a. Peste Des Petits Ruminants Technical Disease Cards. World Organisation for Animal Health (OIE). www.oie.int/fileadmin/Home/eng/Animal_Health_in_the_World/docs/pdf/Disease_cards/PESTE_DES_PETITS_RUMINANTS.pdf Accessed 18 October 2020.

OIE, 2020b. Terrestrial Animal Health Code: Infection with Peste des petits ruminants virus. Chapter 14.7. World Organisation for Animal Health (OIE). www.oie.int/index.php?id=169&L=0&htmfile=chapitre_ppr.htm Accessed 18 October 2020.

UNDESA, no date. Sustainable Development. United Nations Department of Economic and Social Affairs (UNDESA). https://sdgs.un.org/goals Accessed 20 April 2021.

UNECE, no date. UN Recommendations on the Transport of Dangerous Goods - UN Model Regulations Model Regulations Nature, Purpose and Significance of the Recommendations. United Nations Economic Commission for Europe (UNECE). www.unece.org/trans/danger/publi/unrec/rev13/13nature_e.html Accessed on 3 October 2020.

WTO, 1994. The WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement). World Trade Organization (WTO). www.wto.org/english/tratop_e/sps_e/spsagr_e.htm Accessed 3 October 2020.

WTO, 2007. The WTO and the World Organization for Animal Health (OIE) G/SPS/GEN/775. World Trade Organization (WTO). www.wto.org/english/thewto_e/coher_e/wto_oie_e.htm Accessed 3 October 2020.

Coordinating agency or organisation

Food and Agriculture Organization of the United Nations (FAO), World Organisation for Animal Health (OIE).

BI0081 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Q Fever

Definition

Q fever is a widespread zoonosis caused by the bacterium Coxiella burnetii. The respiratory tract is the most common route of infection, which occurs by inhalation of contaminated dust and spray shed from infected animals. Livestock, more specifically dairy goats and cows are considered as the major 'source' for human infections; dairy products from infected goats or cows are also an important source of infection (FAO, no date).

Reference

FAO, no date. The AGRIS Database. Food and Agriculture Organization of the United Nations (FAO). https://agris.fao.org/agris-search/%20search.do?recordID=US%20201301116554 Accessed 4 October 2020.

Annotations

Synonyms

Query Fever, Coxiellosis, Abattoir fever.

Additional scientific description

Q fever was first recognised as a human disease in Australia in 1935 and in the USA in the early 1940s. The 'Q' stands for 'query' and was applied at a time when the cause was unknown (CDC, 2019).

Q fever is a zoonotic disease caused by infection with Coxiella burnetii that affects humans and other animals. C. burnetii is uncommon, but may be found in cattle, sheep, goats, and other domestic mammals, including cats and dogs. Clinical cases seem to be most significant in sheep and goats, with sporadic losses and occasional outbreaks that may affect up to 50–90% of the herd. The infection results from inhalation of a spore-like small-cell variant, and from contact with the milk, urine, faeces, vaginal mucus, or semen of infected animals. Rarely, the disease is tick-borne (Spickler, 2017).

Humans are vulnerable to Q fever, and infection can result from even a few organisms. Some people never get sick; however, those who do usually develop flu-like symptoms including fever, chills, fatigue, and muscle pain (CDC, 2019). The main way of reducing the risk of being infected with Q fever is by avoiding contact with infected animals, especially while animals are giving birth. Be aware that animals can be infected with C. burnetii and appear healthy. People in direct contact with animals during birthing, such as veterinarians and farmers, may be at higher risk for infection. Abattoir workers are also at risk while being in contact with infected carcasses (Spickler, 2017).

Coxiella burnetii can survive for long periods in the environment and may be carried long distances by wind. Windborne outbreaks can affect dozens to hundreds of people who have no direct exposure to animals. In one exceptional incident, more than 4000 clinical cases were recognised in the Netherlands between 2007 and 2010. Efforts to end this outbreak resulted in temporary breeding bans and the culling of more than 50,000 small ruminants. The current state of knowledge about C. burnetii is incomplete, and some aspects of infections in humans and animals are still debated or not well understood (Spickler, 2017).

In humans, the incubation period for acute Q fever ranges from two days to six weeks, with most patients becoming ill within two to three weeks of exposure. Chronic Q fever is reported to develop months to years after infection, although some of the latter cases could result from delayed diagnosis. Studies from recent outbreaks in the Netherlands suggest that most cases of endocarditis can be detected within a few months to a year of infection (Spickler, 2017).

Coxiella burnetii has been found in most countries that have conducted surveillance. However, a few countries or areas, such as New Zealand, Norway, Iceland and French Polynesia, report that they have not found any evidence of this organism in surveys to date (Spickler, 2017).

Animal vaccination has been used in areas where infections are common. More generally, sanitary measures to remove after-birth and birth fluids, and to clean and disinfect areas where animals have given birth can prevent the disease from spreading (OIE, no date).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction (UNODA, no date).

International Health Regulations (2005), 3rd ed. (WHO, 2016).

WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (WTO, 1994).

UN Recommendations on the Transport of Dangerous Goods - UN Model Regulations Model Regulations Nature, Purpose and Significance of the Recommendations (UNECE, no date).

Examples of drivers, outcomes and risk management

Drivers: introduction of infected animal, contaminated environment, dust, consumption of contaminated products.

Outcomes: abortions late in the pregnancy, infect humans.

Risk management: movement control, treatment with antimicrobials, tracing back/forward, vaccination (prevention).

References

CDC, 2019. Q Fever. Centres for Disease Control and Prevention (CDC). www.cdc.gov/qfever/stats/index.html Accessed 4 October 2020.

OIE, no date. General Disease Information Sheet: Q Fever. World Organization for Animal Health (OIE). www.oie.int/doc/ged/D13998.PDF Accessed 4 October 2020.

Spickler, A.R., 2017. Q Fever. www.cfsph.iastate.edu/Factsheets/pdfs/q_fever.pdf Accessed 4 October 2020.

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UNODA, no date. Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction. United Nations Office for Disarmament Affairs (UNODA) www.un.org/disarmament/biological-weapons Accessed 3 October 2020.

WHO, 2016. International Health Regulations (2005), 3rd ed. World Health Organization (WHO). www.who.int/ihr/publications/9789241580496/en Accessed 26 September 2020.

WTO, 1994. The WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement). World Trade Organization (WTO). www.wto.org/english/tratop_e/sps_e/spsagr_e.htm Accessed 3 October 2020.

Coordinating agency or organisation

Food and Agriculture Organization of the United Nations (FAO), World Health Organization (WHO), World Organisation for Animal Health (OIE).

BI0082 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Rift Valley Fever (Animal)

Definition

Rift Valley fever (RVF) is an acute haemorrhagic viral disease, affecting small and large ruminants and camels. RVF virus is a member of the Phlebovirus genus. The disease causes high mortality especially in new borne and mass abortions in pregnant animals. Humans become infected from contact with tissues/blood of infected animals including abortive material and through mosquito bites. Disease in humans presents as influenza like illness, haemorrhagic fever, encephalitis and occasionally death (adapted from FAO, 2003; WHO, 2018; OIE 2020).

References

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OIE, 2020. Rift Valley Fever (RVF). World Organisation for Animal Health (OIE). www.oie.int/en/animal-health-in-the-world/animal-diseases/Rift-Valley-fever Accessed 4 October 2020.

WHO, 2018. Newsroom Fact Sheet Rift Valley fever. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/rift-valley-fever Accessed 4 October 2020.

Annotations

Synonyms

Infectious enzootic hepatitis of sheep and cattle.

Additional scientific description

Rift Valley fever (RVF) is a viral zoonosis that primarily affects animals but also has the capacity to infect humans. Infection can cause severe disease in both animals and humans (WHO, 2018).

RVF is an economically important disease, and affects different species of animals and humans. Immunisation and vector control are the main strategies to reduce the incidence of RVF. It is considered an occupational disease of livestock handlers, dairy farmers, abattoir workers and veterinarians. The direct socio-economic impact of RVF is on livestock producers due to high levels of mortality and morbidity in animals (WHO, 2018).

RVF virus is a member of the Phlebovirus genus. The virus was first identified in 1931 during an investigation into an epidemic among sheep on a farm in the Rift Valley of Kenya (WHO, 2018). Since then, outbreaks have been reported in sub-Saharan Africa. In 1977 an explosive outbreak was reported in Egypt, the RVF virus was introduced to Egypt via infected livestock trade along the Nile irrigation system. In 1997–1998, a major outbreak occurred in Kenya, Somalia and Tanzania following an El Niño event and extensive flooding. After infected livestock trade from the horn of Africa, RVF spread in September 2000 to Saudi Arabia and Yemen, marking the first reported occurrence of the disease outside the African continent and raising concerns that it could extend to other parts of Asia and Europe (WHO, 2018).

RVF is a disease of caused by RVF virus (RVFV), an arbovirus, transmitted by Aedes mosquitoes. RVF epidemic/epizootic has been associated with periods of flooding following heavy rainfall especially after a long drought. These floods create pools of water conducive for hatching/emergence of Aedes mosquitoes, which may be infected with the RVFV and can transmit the virus to ruminants or camels when they drink from or feed close to the water pools (FAO, 2003).

Outbreaks of RVF in animals can be prevented by a sustained programme of animal vaccination. Commercially available veterinary RVF vaccines are important for preventing the spread of RVFV in endemic countries. Three live-attenuated RVF vaccines are available for veterinary use in endemic areas. However, these vaccines have adverse effects in pregnant ewes, resulting in abortion or malformation. On the other hand, three different inactivated RVF vaccines that induce short-term immunity are also available in endemic regions (FAO, 2003).

Rift Valley fever outbreaks in domesticated animals are often accompanied by human disease. The majority of human infections result from contact with the blood or organs of infected animals. Human infections have also resulted from the bites of infected mosquitoes. To date, no human-to-human transmission of RVF virus has been documented (WHO, 2018).

The most common form of the disease in humans is a self-limiting, flu-like illness. Complications in a minority of cases include ocular disease, neurological signs, kidney dysfunction and a life-threatening haemorrhagic syndrome with hepatic dysfunction. Although overall case fatality rates are thought to be low (≤2%), there may be a very large number of cases during some epidemics, resulting in hundreds of serious cases and significant numbers of deaths (Spickler, 2015).

Metrics and numeric limits

None found.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (WTO, 1994).

UN Recommendations on the Transport of Dangerous Goods - UN Model Regulations Model Regulations Nature, Purpose and Significance of the Recommendations (UNECE, no date).

Examples of drivers, outcomes and risk management

Drivers: RVF-infected mosquitoes; flash floods caused by unusual rainfall in an area where RVF occurred in the past; lack of biosecurity in handling aborted foetuses/slaughtered carcasses.

Outcomes: Abortion and/or death of infected animals and humans, spread of infection, trade ban.

Risk management: Vaccination programme, movement control, improved biosecurity, waterbody management.

As an example of a coordinated response, in the 2016 Niger outbreak, the World Health Organization (WHO) sent a multisectoral national rapid response team, including members from the Ministry of Health, veterinary services and Centre de Recherche Médicale et Sanitaire (CERMES). The unit was deployed for field investigation on 31 August 2016. In Niger, the WHO Country Office provides technical and financial support for surveillance, outbreak investigation, technical guidelines regarding case definition, case management, shipment of samples, and risk communication. The Food and Agriculture Organization of the United Nations (FAO), the World Organisation for Animal Health (OIE), and the WHO are coordinating on animal and human health and providing additional support to Niger for the outbreak response (WHO, 2018).

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Coordinating agency or organisation

Food and Agriculture Organization of the United Nations (FAO), World Health Organization (WHO), World Organisation for Animal Health (OIE).

BI0083 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Trypanosomosis (Animal)

Definition

Animal trypanosomosis is a lethal parasitic disease caused by unicellular organisms named trypanosomes. The disease is cyclically transmitted by the bite of infected tsetse flies and it affects both humans 'sleeping sickness' and livestock 'nagana' (FAO, 2020).

Reference

FAO, 2020. Programme Against African Trypanosomosis (PAAT). Food and Agriculture Organization of the United Nations (FAO). www.fao.org/paat/en Accessed 26 October 2020.

Annotations

Synonyms

Nagana, Chagas.

Additional scientific description

Tsetse-transmitted animal trypanosomosis occurs in tropical regions of sub-Saharan Africa, where it constitutes a major obstacle to the development of animal production. The considerable economic and social repercussions make control of this disease a priority for the development of a large part of the African continent. African animal trypanosomosis affects ruminants, swine, camels, equines, carnivores, as well as a broad range of wild animals, but the heaviest economic burden is in cattle. In cattle, the disease is called Nagana. The disease is caused by several species of trypanosome but mainly by Trypanosoma congolense, T. vivax, T. brucei, and T. simiae. T. vivax is also present is Latin America, where in the absence of tsetse flies it is transmitted by other biting flies. It is known as American trypanosomiasis or Chagas disease. A different species (i.e., T. evansi) is also present outside of Africa, including Asia. Control and elimination of animal trypanosomosis as a zoonotic disease would help to improve animal production in Africa considerably and would also contribute to enhance human health (WHO, 2020).

Transmission of trypanosomes by insects occurs through cyclical transmission or mechanical transmission. Cyclical transmission, during which the trypanosomes actively multiply in the vectors, occurs through the intermediary of tsetse flies (Glossina spp.). Mechanical transmission can be caused by various blood-sucking insects such as flies of the family Tabanidae (horse flies) and Stomoxys spp. (FAO, 1983).

Trypanosoma brucei, and in particular the two subspecies T. brucei gambiense and T. brucei rhodesiense are the causes of human African trypanosomosis, also known as sleeping sickness. Animals can host the human pathogen parasites, especially T. brucei rhodesiense, of which domestic and wild animals are the most important reservoir. Animals can also be infected with T. brucei gambiense and probably act as a reservoir to a lesser extent. However, the precise epidemiological role of the animal reservoir in the gambiense form of the disease is not yet well known (WHO, 2020).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (WTO, 1994).

Examples of drivers, outcomes and risk management

Trypanosomosis (tsetse-transmitted) is one of the World Organisation for Animal Health (OIE) Listed diseases, infections and infestations in force in 2020 (OIE, 2020).

Drivers: presence/introduction of Trypanosoma infected tsetse fly.

Outcomes: mortality and morbidity of animals and humans, spread of infection.

Risk management: treatment with trypanocide, vector control program, animal movement control, improved biosecurity.

References

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WHO, 2020. Trypanosomiasis, human African (sleeping sickness). World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/trypanosomiasis-human-african-(sleeping-sickness) Accessed 26 October 2020.

WTO, 1994. The WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement). World Trade Organization (WTO). www.wto.org/english/tratop_e/sps_e/spsagr_e.htm Accessed 3 October 2020.

Coordinating agency or organisation

Food and Agriculture Organization of the United Nations (FAO), World Organisation for Animal Health (OIE), World Health Organization (WHO).

BI0084 / **BIOLOGICAL** / **Infectious Diseases (Human and Animal)**

West Nile Fever (Human)

Definition

West Nile virus disease is a fatal neurological disease caused by a virus transmitted through the bites of infected mosquitoes. The virus is a member of the flavivirus genus and belongs to the Japanese encephalitis antigenic complex of the family Flaviviridae (WHO, 2017).

Reference

WHO, 2017. West Nile virus. World Health Organization (WHO). www.who.int/news-room/fact-sheets/detail/west-nile-virus Accessed 26 October 2020.

Annotations

Synonyms

West Nile Disease.

Additional scientific description

West Nile virus disease can cause neurological disease and death in people. West Nile virus (WNV) is commonly found in Africa, Europe, the Middle East, North America and West Asia. WNV is maintained in nature in a cycle involving transmission between birds and mosquitoes. Humans, horses and other mammals can be infected (WHO, 2017).

WNV was first isolated in a woman in the West Nile district of Uganda in 1937. It was identified in birds (crows and columbiformes) in the Nile delta region in 1953. Before 1997, WNV was not considered pathogenic for birds, but at that time in Israel a more virulent strain caused the death of different bird species presenting signs of encephalitis and paralysis. Human infections attributable to WNV have been reported in many countries for over 50 years. In 1999, a WNV circulating in Israel and Tunisia was imported into New York producing a large and dramatic outbreak that spread throughout the continental USA in the following years. The WNV outbreak in the USA (1999–2010) highlighted that importation and establishment of vector-borne pathogens outside their current habitat represent a serious danger to the world. The largest outbreaks occurred in Greece, Israel, Romania, Russia and the USA. Outbreak sites are on major bird migratory routes. In its original range, WNV was prevalent throughout Africa, parts of Europe, Middle East, West Asia, and Australia. Since its introduction in 1999 into the USA, the virus has spread and is now widely established from Canada to Venezuela (WHO, 2017).

Human infection is most often the result of bites from infected mosquitoes. Mosquitoes become infected when they feed on infected birds, which circulate the virus in their blood for a few days. The virus eventually gets into the mosquito's salivary glands. During later blood meals (when mosquitoes bite), the virus may be injected into humans and animals, where it can multiply and possibly cause illness (WHO, 2017).

The virus may also be transmitted through contact with other infected animals, their blood, or other tissues.

A very small proportion of human infections have occurred through organ transplant, blood transfusions and breast milk. There is one reported case of transplacental (mother-to-child) WNV transmission. To date, no human-to-human transmission of WNV through casual contact has been documented, and no transmission of WNV to health care workers has been reported when standard infection control precautions have been put in place. However, transmission of WNV to laboratory workers has been reported (WHO, 2017).

Infection with WNV is either asymptomatic (no symptoms) in around 80% of infected people or can lead to West Nile fever or severe West Nile disease. About 20% of people who become infected with the WNV will develop West Nile fever. The symptoms of severe disease (also called neuroinvasive disease, such as West Nile encephalitis or meningitis or West Nile poliomyelitis) include headache, high fever, neck stiffness, stupor, disorientation, coma, tremors, convulsions, muscle weakness, and paralysis. It is estimated that approximately 1 in 150 persons infected with the WNV will develop a more severe form of disease. Serious illness can occur in people of any age, however people over the age of 50 years and some immunocompromised persons (for example, transplant patients) are at highest risk for getting severely ill when infected with WNV. The incubation period is usually 3 to 14 days (WHO, 2017).

Diagnosis is by laboratory tests, including molecular tests (PCR) which can detect the virus genome during the acute phase of infection, and by serological tests to detect the individual's immune response to recent or past infection (WHO, 2017).

West Nile Virus is maintained in nature in a mosquito-bird-mosquito transmission cycle. Mosquitoes of the genus Culex are generally considered the principal vectors of WNV, in particular C. pipiens. WNV is maintained in mosquito populations through vertical transmission (adults to eggs). Birds are the reservoir hosts of WNV. In Europe, Africa, Middle East and Asia, mortality in birds associated with WNV infection is rare. In striking contrast, the virus is highly pathogenic for birds in the Americas. Members of the crow family (Corvidae) are particularly susceptible, but the virus has also been detected in dead and dying birds of more than 250 species. Birds can be infected through a variety of routes other than mosquito bites, and different species may have different potential for maintaining the transmission cycle. Horses, just like humans, are 'dead-end' hosts, meaning that while they become infected, they do not spread the infection. Symptomatic infections in horses are also rare and generally mild, but can cause neurological disease, including fatal encephalomyelitis (WHO, 2017).

Metrics and numeric limits

The Centers for Disease Control and Prevention and the European Commission have published guidance on case classification and surveillance standards (CDC, 2015; European Union, 2018).

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

Preventing transmission in horses is important. Since WNV outbreaks in animals precede human cases, the establishment of an active animal health surveillance system to detect new cases in birds and horses is essential to provide early warning for veterinary and human public health authorities. In the Americas, it is important to help the community by reporting dead birds to local authorities (WHO, 2017).

Vaccines have been developed for horses. Treatment is supportive and consistent with standard veterinary practices for animals infected with a viral agent (WHO, 2017).

In the absence of a vaccine (although there are vaccine candidates for a human vaccine under development), the only way to reduce infection in people is by raising awareness of the risk factors and educating people about the measures they can take to reduce exposure to the virus. Public health educational messages should focus on the following (WHO, 2017):

- Reducing the risk of mosquito transmission. Efforts to prevent transmission should first focus on personal and community protection against mosquito bites through the use of mosquito nets, personal insect repellent, by wearing light coloured clothing (long-sleeved shirts and trousers) and by avoiding outdoor activity at peak biting times.
- Reducing the risk of animal-to-human transmission. Gloves and other protective clothing should be worn while handling sick animals or their tissues, and during slaughtering and culling procedures.
- Reducing the risk of transmission through blood transfusion and organ transplant.

Effective prevention of human WNV infections depends on the development of comprehensive, integrated mosquito surveillance and control programmes in areas where the virus occurs. Studies should identify local mosquito species that play a role in WNV transmission, including those that might serve as a 'bridge' from birds to human beings. Emphasis should be on integrated control measures including source reduction (with community participation), water management, chemicals, and biological control methods (WHO, 2017).

Health-care workers caring for patients with suspected or confirmed WNV infection, or handling specimens from them, should implement standard infection control precautions (WHO, 2017).

The World Health Organization (WHO) Regional Office for Europe and the WHO Regional Office for the Americas/Pan American Health Organization are intensively supporting WNV surveillance and outbreak response activities, respectively, in Europe and in North America, Latin America and the Caribbean, together with country offices and international partners (WHO, 2017).

References

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Coordinating agency or organisation

World Health Organization.

BI0085 / **BIOLOGICAL / Infectious Diseases (Animal)**

Rinderpest (Animal)

Definition

Rinderpest was a disease caused by paramyxovirus in the genus Morbillivirus. It was most commonly observed in domestic cattle and buffaloes. The last confirmed outbreak of rinderpest was in 2001 and the disease was declared to have been eradicated globally in 2011 by the Food and Agriculture Organization of the United Nations (FAO) and the World Organisation for Animal Health (OIE). Rinderpest was a highly contagious viral disease of animals that, throughout history, has resulted in the mortality of hundreds of millions of livestock and has caused significant disruption and damage to agricultural supply chains throughout the world. Rinderpest is the first animal disease eradicated worldwide. The last confirmed outbreak of rinderpest was in 2001. Rinderpest was declared as eradicated by 2011. The Rinderpest Secretariat (FAO and OIE joint activity) is engaged in safeguarding the global freedom, similar to what has been done for smallpox by the World Health Organization (OIE, 2019; FAO, 2020).

References

FAO, 2020. Animal Production and Health: Maintaining Global Freedom from Rinderpest. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/ag/againfo/programmes/en/rinderpest/home.html Accessed 4 October 2020.

OIE, 2019. Terrestrial Animal Health Code: Infection with Rinderpest Virus. Chapter 8.16. World Organisation for Animal Health (OIE). www.oie.int/index.php?id=169&L=0&htmfile=chapitre_rinderpest.htm Accessed 4 October 2020.

Annotations

Synonyms

Peste bovine (fr), Peste bovina (es), Чума крс (ru), □□□□□□□ □□□□□ (ar), □□ (cn).

Additional scientific description

The world was officially declared free from rinderpest in 2011 by the Food and Agriculture Organization of the United Nations (FAO) and the World Organisation for Animal Health (OIE), making it the first animal disease to be eradicated in the history of humankind (Myers et al., 2018).

Rinderpest, once the scourge of societies across Asia, Europe and Africa, is only the second infectious disease, after smallpox for humans, to have been eradicated globally thanks to decades of internationally concerted effort (OIE, no date a).

Rinderpest was caused by paramyxovirus in the genus Morbillivirus. The disease was most commonly observed in domestic cattle and buffalos. Many species of wild and domestic cloven-hoofed animals (including sheep and goats) showed only mild symptoms of the disease when infected, but for cattle and buffalo, mortality rates can reach 100% in highly susceptible herds. In cattle, the most susceptible species, classical signs of the disease included fever, erosive lesions in the mouth, discharge from the nose and eyes, profuse diarrhoea and dehydration, often leading to death within 10 to 15 days. In other species rinderpest may show milder clinical signs (FAO, no date).

Rinderpest is spread by effective contact between animals carrying the virus and susceptible animals. The virus was found in nasal secretions a few days before any clinical signs appear. As the disease progressed, the virus was found in most body fluids and either death ensued, or the animal recovered, developed immunity and cleared the virus from the body (FAO, no date).

Asian domestic sway-backed pigs also suffer from and succumb to rinderpest. Infection is also confirmed in many wild even-toed ungulates belonging to the order Artiodactyla: African buffalo, eland, kudu, warthog, bongo, bushbuck, bush pig, chevrotain, dik-dik, duiker, giant forest hog, giraffe, sitatunga, wildebeest in Africa; and banteng, blackbuck, gaur, nilgai and sambar in Asia (FAO, 1996).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (WTO, 1994).

UN Recommendations on the Transport of Dangerous Goods - UN Model Regulations Model Regulations Nature, Purpose and Significance of the Recommendations (UNECE, no date).

Examples of drivers, outcomes and risk management

Although rinderpest no longer occurs in livestock, the rinderpest virus-containing material is being stored in a few laboratories across the world where it poses a risk through inadvertent or malicious release (Myers et al., 2018).

If a rinderpest-like disease is recognised during a disaster situation, it is immediately necessary to alert the Chief Veterinary Officer of the country, the FAO (Rinderpest-Secretariat@fao.org) and the OIE (rinderpest@oie.int) simultaneously.

Drivers: virus escapes from laboratory and introduction to susceptible animals.

Outcomes: death of infected animals, spread of infection, production loss, famine, trade ban, loss of global freedom.

Risk management: strict movement control, contact FAO and OIE as international emergency, implementation of the Global Rinderpest Action Plan (GRAP) The GRAP aims to ensure continued global freedom from rinderpest by outlining the actions necessary to prepare for, respond to and recover from a rinderpest outbreak (Myers et al., 2018).

Before its eradication in 2011, rinderpest was the most impactful of all cattle diseases, since it could be 100% fatal in some herds, rapidly transmissible and affected cattle, buffaloes, yaks and many other domesticated and wild even-toed ungulates. It is reported to have originated in Central Eurasia, and later spread to Europe and Asia, according to trade and migration routes. The disease was also reported in the Americas and Australia in a lower prevalence (OIE, no date b).

Rinderpest triggered extensive famines in Africa and hindered agricultural development in Asia (OIE, no date).

Rinderpest remains a notifiable disease and adequate surveillance systems must be maintained for the early detection of clinical cases, should there be any accidental escape of the virus. The FAO and OIE will ensure the permanent availability of material to raise awareness demonstrating the range of signs associated with rinderpest cases in live animals, as well as post-eradication biothreat reduction activities (OIE, no date a).

In the scope of maintaining global freedom and retaining the memory of Rinderpest, the OIE has launched an exhaustive campaign to be implemented in its 182 Member Countries, to ensure all actors are fully aware of rinderpest challenges. A range of tools will ensure that they know the role they still have to play in the post-eradication era: the keyword for this campaign is Vigilance. Because, only with the continuous vigilance of the key players, at local and national level, will the world stay free of rinderpest (OIE, no date a).

References

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Myers, L., S. Metwally, M. Marrana, C. Stoffel, G. Ismayilova and T. Brand, 2018. Global Rinderpest Action Plan – Rinderpest is eradicated but not forgotten. doi.org/10.4060/ca1965en Accessed 29 April 2021.

OIE, no date a. Rinderpest Portal. 2011 - Global freedom from rinderpest. Rinderpest Portal. World Organisation for Animal Health (OIE). www.oie.int/for-the-media/rinderpest Accessed 4 October 2020.

OIE, no date b. What is Rinderpest? Rinderpest Portal. World Organisation for Animal Health (OIE). www.oie.int/for-the-media/rinderpest/what-is-rinderpest Accessed 4 October 2020.

OIE, no date c. OIE 79th General Session. World Organisation for Animal Health (OIE). www.oie.int/en/for-the-media/79th-general-session Accessed 21 April 2021.

UNECE, no date. UN Recommendations on the Transport of Dangerous Goods - UN Model Regulations Model Regulations Nature, Purpose and Significance of the Recommendations. United Nations Economic Commission for Europe (UNECE). www.unece.org/trans/danger/publi/unrec/rev13/13nature_e.html Accessed 3 October 2020.

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Coordinating agency or organisation

Food and Agriculture Organization of the United Nations (FAO), World Organisation for Animal Health (OIE).

BI0086 / **BIOLOGICAL / Infectious Diseases (Human and Animal)**

Trypanosomiasis (Human)

Definition

Trypanosomiasis, human African (sleeping sickness) is caused by protozoan parasites belonging to the genus Trypanosoma transmitted by infected tsetse flies and is endemic in 36 sub-Saharan African countries. Without treatment, the disease is considered fatal, where there are tsetse flies that transmit the disease (WHO, 2020).

Reference

WHO, 2020. Trypanosomiasis, human African (sleeping sickness). World Health Organization (WHO) www.who.int/news-room/fact-sheets/detail/trypanosomiasis-human-african-(sleeping-sickness) Accessed 26 October 2020.

Annotations

Synonyms

Sleeping sickness.

Additional scientific description

Human African trypanosomiasis, also known as sleeping sickness, is a vector-borne parasitic disease. It is caused by infection with protozoan parasites belonging to the genus Trypanosoma. They are transmitted to humans by tsetse fly (Glossina genus) bites which have acquired their infection from humans or from animals harbouring human pathogenic parasites (WHO, 2020).

Tsetse flies are only found in sub-Saharan Africa and only certain species transmit the disease. For reasons so far unexplained, in many regions where tsetse flies are found, sleeping sickness is not. Rural populations in regions where transmission occurs and which depend on agriculture, fishing, animal husbandry or hunting are the most exposed to the tsetse fly and thus to the disease. The disease develops in areas ranging from a single village to an entire region. Within an infected area, the intensity of the disease can vary from one village to the next (WHO, 2020).

Human African trypanosomiasis takes two forms, depending on the parasite involved:

- T. brucei gambiense is found in 24 countries in west and central Africa. This form currently accounts for 98% of reported cases of sleeping sickness and causes a chronic infection (WHO, 2020).
- T. brucei rhodesiense is found in 13 countries in eastern and southern Africa. The disease develops rapidly and invades the central nervous system. Only Uganda presents both forms of the disease, but in separate zones (WHO, 2020).

Another form of trypanosomiasis occurs mainly in Latin America. It is known as American trypanosomiasis or Chagas disease. The causal organism belongs to a different Trypanosoma subgenus and is transmitted by a different vector (WHO, 2020).

Major human epidemics have occurred in Africa over the past century: one between 1896 and 1906, mostly in Uganda and the Congo Basin; one in 1920 in a number of African countries; and the most recent epidemic started in 1970 and lasted until the late 1990s (WHO, 2020).

The 1920 epidemic was controlled by mobile teams which carried out the screening of millions of people at risk. By the mid-1960s, the disease was under control with less than 5000 cases reported in the whole continent. After this success, surveillance was relaxed, and the disease reappeared, reaching epidemic proportions in several regions by 1970. The efforts of the World Health Organization (WHO), national control programmes, bilateral cooperation and non-governmental organisations (NGOs) during the 1990s and early 21st century reversed the curve (WHO, 2020).

Since the number of new human African trypanosomiasis cases reported between 2000 and 2018 dropped by 95%. The WHO neglected tropical diseases road map targeted its elimination as a public health problem by 2020 and interruption of transmission (zero cases) for 2030. Sleeping sickness threatens millions of people in 36 countries in sub-Saharan Africa. Many of the affected populations live in remote rural areas with limited access to adequate health services, which complicates the surveillance and therefore the diagnosis and treatment of cases. In addition, displacement of populations, war and poverty are important factors that facilitate transmission (WHO, 2020).

Currently, the disease incidence differs from one country to another as well as in different parts of a single country. In the past 10 years, over 70% of reported cases occurred in the Democratic Republic of the Congo (WHO, 2020).

Angola, Central African Republic, Chad, Congo, Gabon, Guinea, Malawi and South Sudan declared between 10 and 100 new cases in 2018. Cameroon, Côte d'Ivoire, Equatorial Guinea, Kenya, Uganda, United Republic of Tanzania, Zambia and Zimbabwe declared between 1 and 10 new cases in 2018. Countries such as Burkina Faso, Ghana, and Nigeria, have reported sporadic cases in the past 10 years. Countries like Benin, Botswana, Burundi, Ethiopia, Gambia, Guinea Bissau, Liberia, Mali, Mozambique, Namibia, Niger, Rwanda, Senegal, Sierra Leone, Swaziland and Togo have not reported any new cases for over a decade. Transmission of the disease seems to have stopped in some of these countries but there are still some areas where it is difficult to assess the exact situation because the unstable social circumstances and/or difficult accessibility hinder surveillance and diagnostic activities (WHO, 2020).

The disease is mostly transmitted through the bite of an infected tsetse fly but there are other ways in which people are infected. These include: mother-to-child infection (the trypanosome can cross the placenta and infect the foetus); mechanical transmission through other blood-sucking insects, however, it is difficult to assess its epidemiological impact; accidental infections in laboratories due to pricks with contaminated needles; and transmission of the parasite through sexual contact (WHO, 2020).

Symptoms of the disease in the first stage start when the trypanosomes multiply in subcutaneous tissues, blood and lymph. This is also called the haemo-lymphatic stage, which entails bouts of fever, headaches, enlarged lymph nodes, joint pains and itching. In the second stage the parasites cross the blood-brain barrier to infect the central nervous system. This is known as the neurological or meningo-encephalic stage. In general, this is when more obvious signs and symptoms of the disease appear: changes of behaviour, confusion, sensory disturbances and poor coordination. Disturbance of the sleep cycle, which gives the disease its name, is an important feature. Without treatment, sleeping sickness is considered fatal although cases of healthy carriers have been reported (WHO, 2020).

Metrics and numeric limits

In 1998, almost 40,000 cases of trypanosomiasis were reported, but estimates were that 300,000 cases were undiagnosed and therefore untreated. During the last epidemic the prevalence reached 50% in several villages in Angola, the Democratic Republic of the Congo, and South Sudan. Sleeping sickness was the first or second greatest cause of mortality in those communities, even ahead of HIV/AIDS. In 2009, after continued control efforts, the number of cases reported dropped below 10,000 (9878) for the first time in 50 years. This decline in number of cases has continued with 997 new cases reported in 2018, the lowest level since the start of systematic global data-collection 80 years ago. The estimated population at risk is 65 million people (WHO, 2020).

Key relevant UN convention / multilateral treaty

International Health Regulations (2005), 3rd ed. (WHO, 2016).

Examples of drivers, outcomes and risk management

The WHO and its partners provide support and technical assistance to national control programmes and provide the anti-trypanosome medicines free of charge to endemic countries through public-private partnerships with Sanofi (pentamidine, melarsoprol, eflornithine, fexinidazole) and Bayer HealthCare (suramin, nifurtimox) (WHO, 2021).

In 2008, the WHO launched the Atlas of human African Trypanosomiasis initiative to map at village level all reported cases (WHO, 2015). This initiative is jointly implemented with the Food and Agriculture Organization of the United Nations (FAO) within the PAAT framework (FAO, 2021). The Atlas is a dynamic database including geographical and epidemiological data, compiled by the WHO through the contribution of SSNCPs, NGOs and research institutes.

In 2014, a coordination network for human African trypanosomiasis was established under WHO leadership to ensure strengthened and sustained efforts to eliminate the disease. The stakeholders include national sleeping sickness control programmes, groups developing new tools to fight the disease, international and NGOs, and donors (WHO, 2020).

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WHO, 2021. Trypanosomiasis, African. World Health Organization (WHO) Regional Office for Africa. www.afro.who.int/health-topics/trypanosomiasis-african Accessed 9 April 2021.

Coordinating agency or organisation

World Health Organization with the Food and Agriculture Organization of the United Nations (FAO) and World Organisation for Animal Health (OIE).

BI0087 / **BIOLOGICAL / Infectious Disease (Aquaculture)**

Shrimp disease (bacterial) - Acute Hepatic pancreatic necrosis

Definition

Shrimp acute hepatopancreatic necrosis disease (AHPND) is caused by virulent strains of Vibrio parahaemolyticus and related Vibrio species. AHPND-associated mortalities occur early in the production cycle, usually within 30 to 35 days of stocking, and because of this AHPND was initially referred to as early mortality syndrome (OIE, 2019).

Reference

OIE, 2019. Aquatic Animal Health Code: Acute hepatopancreatic necrosis disease. Chapter 9.1. World Organisation for Animal Health (OIE). www.oie.int/index.php?id=171&L=0&htmfile=chapitre_ahpnd.htm Accessed 10 October 2020.

Annotations

Synonyms

Early mortality syndrome (EMS), Photorhabdus insect-related (Pir), Hepatopancreas (HP).

Additional scientific description

Acute hepatopancreatic necrosis disease (AHPND) is a bacterial disease that has caused mass mortalities in farmed populations of whiteleg shrimp and giant tiger prawn. The causative agent is virulent strains of Vibrio parahemolyticus and four other Vibrio species (V. harvey, V. campbellii, V. owendii, V. punensis). AHPND was listed by the World Organisation for Animal Health (OIE) as a notifiable disease in 2016 (OIE, 2019a).

AHPND first appeared in the People's Republic of China around 2010 and was called 'covert mortality disease'. It has since been reported from Viet Nam (2010), Malaysia (2011), Thailand (2012), Mexico (2013), the Philippines (2014), Bangladesh (2017), the USA (2017), Taiwan province of China (2018), South Korea (2019) and the Okinawa Prefecture of Japan (2020). It is also suspected to be present in, but unreported, from other countries in Asia and Latin America and the Caribbean (OIE, 2019a).

The causative agents, discovered in 2013, are isolates of V. parahaemolyticus and related Vibrio species that carry a 69-73 kbp plasmid (pVA1) containing pirABvp genes that produce proteins (12.7 kDa and 50.1 kDa) that act together to cause AHPND. The pirABvp toxin genes in these Vibrio species are similar to the pirAB toxin genes of Photorhabdus spp., which are gram-negative, luminescent, rod-shaped bacteria in the Family Enterobacteriaceae (FAO, 2018). The PirAB has an insecticidal property; its toxicity results in severe swelling and shedding of the midgut epithelium in larvae of the moth Plutella xylostella.

Clinical signs and mortality of AHPND can start as early as 10 days post-stocking. Major clinical signs involve shrimp hepatopancreas: significant atrophy, loss of colour, and the presence of black spots or streaks due to melanised tubules. Additional clinical signs include soft shells and empty stomach or near-empty midgut (OIE, 2019a).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Acute hepatopancreatic necrosis disease is caused by unique strains of V. parahaemolyticus and four other Vibrio species. Vibrio bacteria are ubiquitous in marine and brackish-water environments, and their populations are affected in these ecosystems by temperature, salinity, and turbidity. These AHPND-related bacteria can be present in both the cultured shrimp as well as in the water, sediments, and associated organisms in the farm ponds and in the surrounding aquatic environment (OIE, 2019a).

Several therapeutic methods have been tried, with mixed results, to combat AHPND in populations of infected shrimp on farms, but there is a lack of scientific data to corroborate claims of their effectiveness. These include antibiotics, bacteriophage therapy, probiotics, etc (FAO, 2020).

Since the emergence of AHPND, shrimp producers in Southeast Asia and Latin America have changed farm designs and operation to facilitate management of this disease; such changes include the use of: smaller, lined ponds; central drains; prefiltered clean water; tilapia for removal of sediments; increased aeration; frequent feeding regimes to reduce uneaten feed; and probiotics applied to the ponds. These management strategies seem to have been effective, as global shrimp production has shown a gradual recovery since 2016 (FAO, 2020).

Good aquaculture and biosecurity practices include: farm management (screening prior to stocking; pond water and bottom preparation); proper destruction and disposal of diseased shrimp; disinfection of affected premises; vector control; containment through movement control and zoning; and avoiding sources of stress (high stocking density, poor water quality or other less optimal environmental conditions such as suboptimal temperature or salinity) (FAO, 2020).

The World Organisation for Animal Health (OIE) provides recommendations on AHPND that include advice on importation, transit and maintenance of free status from AHPND (OIE, 2019b).

A report jointly published by the Food and Agriculture Organization of the United Nations (FAO) and the Asian Fisheries Society in 2018, aimed at updating knowledge and experience in dealing with AHPND and related topics from the perspective of government, academe and producer sectors (FAO, 2018).

References

FAO, 2018. FAO Technical Assistance Efforts to Deal with Acute Hepatopancreatic Necrosis Disease (AHPND) of Cultured Shrimp. Food and Agriculture Organization of the United Nations (FAO). www.asianfisheriessociety.org/publication/downloadfile.php?id=1217&file=Y0dSbUx6QXhOVFF5TWpNd01ERTFORGMzTXpJM05UZ3VjR1Jt Accessed 10 October 2020.

FAO, 2020. Shrimp acute hepatopancreatic necrosis disease strategy manual. Food and Agriculture Organization of the United Nations (FAO). www.fao.org/3/cb2119en/CB2119EN.pdf Accessed 21 April 2021.

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Coordinating agency or organisation

Food and Agriculture Organization of the United Nations (FAO), World Organisation for Animal Health (OIE).

BI0088 / **BIOLOGICAL / Infectious Diseases (Aquaculture)**

Oyster Disease Aquaculture

Definition

There are a number of causal agents recognised for oyster diseases. Examples of major oyster diseases and their causal protozoan agents are: bonamiosis (Bonamia exitiosa, B. ostreae); marteiliosis (Marteilia refringens); perkinsosis (Perkinsus marinus, P. olseni). These oyster diseases are notifiable OIE-listed diseases and occur worldwide (OIE, 2019).

Reference

OIE, 2019. Manual of Diagnostic Tests for Aquatic Animals. World Organisation for Animal Health (OIE). www.oie.int/standard-setting/aquatic-manual/access-online Accessed 19 October 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

Aquatic food makes an important contribution to human health and development as an essential source of high-quality proteins, vitamins and micronutrients. Global aquaculture production is now a USD 157 billion industry, with USD 20.5 billion of this total representing the production of molluscs for food in the marine environment. The largest share of this represents culture of bivalves such as oysters, clams and scallops. Mollusc culture is a well-developed industry in many countries, notably in the northern hemisphere, such as the USA, Canada, Japan, Korea, France, Spain and the Netherlands (Carnegie et al., 2016).

Oysters are subject to a number of diseases which can impact the local population and reduce harvests in a commercial setup.

The agents causing oyster diseases do not pose any direct human health implications. However, oysters could potentially pose a health concern for humans in cases where they contain high levels of Vibrio spp. (V. parahaemolyticus, V. vulnificus, and choleragenic, V. cholera) and are consumed raw, or where the oysters are produced in an area containing biotoxin or heavy metal contamination (e.g., lead) (WHO, 2005). Bivalve molluscs are filter feeders; therefore they are susceptible to picking up and accumulating toxins, and chemical or bacteriological contaminants from their environment. By filtering a great quantity of water, they may bioaccumulate a high number of microorganisms in their tissues that can be considered infectious for humans and higher vertebrates (Zannella et al., 2017). The causative pathogens live in aquatic environments in both tropical and temperate zones. High temperatures and salinities favour the proliferation of some of the pathogens.

Epizootic diseases have been shown to cause catastrophic mortality among marine bivalves, which can severely affect fisheries and aquaculture activities worldwide. Some of these diseases have become a serious constraint on the development and sustainability of shellfish farming and fishing. Currently, the main cause of epizootic outbreaks is thought to be the transfer of infectious agents through the transport of live shellfish.

Severe outbreaks have resulted in significant economic destruction, with some outbreaks essentially causing the collapse of entire industries. For instance, epizootics of protistan parasites Haplosporidium nelsoni in the 1950s to 1960s and Perkinsus marinus in the 1980s to 1990s devastated the planting industry for oyster Crassostrea virginica in the US mid-Atlantic (Carnegie et al., 2016).

Illness in humans is linked to the consumption of raw oysters.

Metrics and numeric limits

None identified.

Key relevant UN convention/multilateral treaty

Codex Alimentarius (FAO, no date).

WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement) (WTO, 1994).

WTO and the World Organization for Animal Health (OIE) (WTO, 2007).

Examples of drivers, outcomes and risk management

As a consequence of globalisation, urbanisation and global change, the number of emerging diseases of molluscs is increasing. These diseases have a significant impact on aquatic animals resulting from (i) a change of known pathogenic agent or its spread to a new geographical area or species; or (ii) a newly recognised or suspected pathogenic agent. Different scenarios can lead to emergence of diseases, but the cause is often the introduction of infected animals.

The World Organisation for Animal Health (OIE) Aquatic Animal Health Code has set out standards and recommendations to improve the safety of international trade in aquatic animals, including marine bivalve molluscs (OIE, 2019b). The aim is to prevent the pathogen's introduction into an importing country, so as to avoid the onset of disease outbreak rather than to eradicate the pathogen, which would be more difficult and expensive owing to the high-density production systems used in commercial hatcheries and nurseries and the continuous stock movements around the world (Zannella et al., 2017).

The OIE member countries are required to report the detection of listed and emerging diseases (Carnegie et al., 2016).

There is currently no available vaccine, treatment or chemical control agent for the OIE listed diseases of oysters, therefore the surveillance and control plan of these diseases based on their prevention have a key role. For this reason, it is important to implement high levels of on-farm and live-holding facility biosecurity and to restrict stock movements (Zannella et al., 2017).

Maintaining the biosecurity of international aquaculture industries requires control of pathogens of concern. This can include rapid detection in animals proposed for sale or transfer to prevent pathogen introduction to new areas and maintain disease-free facilities and regions, and focused management of pathogens where they do occur, including the use of pathogen-resistant broodstocks to reduce the magnitude of seasonal epizootics (Carnegie et al., 2016).

References

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Zannella, C., F. Mosca, F. Mariani, G. Franci, V. Folliero, M. Galdiero, P.G. Tiscar and M. Galdiero, 2017. Microbial diseases of bivalve mollusks: infections, immunology and antimicrobial defense. Marine Drugs, 15:182. www.ncbi.nlm.nih.gov/pmc/articles/PMC5484132

Coordinating agency or organisation

Food and Agriculture Organization of the United Nations (FAO).

TECHNOLOGICAL

TL0001 / **TECHNOLOGICAL / Radiation**

Radioactive Waste

Definition

Radioactive waste is radioactive material for which no further use is foreseen but still contains, or is contaminated with, radionuclides. Radioactive waste can be in gas, liquid or solid form (IAEA, 2018). It may remain radioactive from a few hours to hundreds of thousands of years.

N.B. For regulatory purposes radioactive waste is defined as material with activity concentrations greater than the clearance levels set by the regulatory authority (IAEA 2018).

Reference

IEAE, 2018. IAEA Safety Glossary: Terminology used in Nuclear Safety and Radiation Protection, 2018 edition. International Atomic Energy Agency (IAEA). www-pub.iaea.org/MTCD/Publications/PDF/PUB1830_web.pdf Accessed 15 November 2019.

Annotations

Synonyms

Nuclear waste.

Additional scientific description

It is common regulatory practice to define terms such as radioactive material and radioactive waste to include only material or waste that is subject to regulation by virtue of the radiological hazard that it poses. Although the exact specifications vary from State to State, this typically excludes material and waste with very low concentrations of radionuclides and those that contain only 'natural' concentrations of naturally occurring radionuclides (IAEA, 2018).

Metrics and numeric limits

The International Atomic Energy Agency (IAEA) Glossary of 2018 for radioactive waste classification uses waste classes recommended in IAEA Safety Standards Series No. GSG-1 (IAEA, 2009): High Level Waste (HLW), Intermediate Level Waste (ILW), Long Lived Waste, Low Level Waste (LLW), Short Lived Waste, Very Low Level Waste (VLLW) and Very Short Lived Waste (VSLW). For a detailed description of each, see IAEA (2009).

Other systems classify waste on other bases, such as according to its origin (e.g., reactor operations waste, reprocessing waste, decommissioning waste and defence waste) (IAEA, 2009).

Key relevant UN convention / multilateral treaty

The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (1972), also referred to as the 'London Convention' prevents dumping of waste (including radioactive waste) at sea. At the time of writing, there were 87 parties to the London Convention (IMO, 2019).

The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management (United Nations, 1997) entered into force in 2001 and addressed the issue of spent fuel and radioactive waste on a global scale. At the time of writing, there were 71 parties to the convention.

Examples of drivers, outcomes and risk management

Radioactive waste containing radioactive material remains hazardous to human, animal and plant health and the environment. External hazards (e.g., causing body damage from overexposure to gamma rays) and/or internal hazards (e.g., causing body damage from alpha and beta particles by contaminated food or air) can be present whenever radioactive materials are found.

Sources of radioactive waste include medical waste, industrial waste, and tailings from naturally occurring radioactive materials in metallic ores, coal, oil, and gas (Rosenfeld and Feng, 2011), as well as decommissioning of nuclear installations and other nuclear facilities, research reactors, research facilities, and from the production and use of radioisotopes (IAEA, 2009). Nuclear wastes are by-products of nuclear weapons production and nuclear power generation, plus residuals of radioactive materials used by industry, medicine, agriculture, and academia (Gee et al., 2005).

In general, exposure to large amounts of radioactivity (from radioactive waste or not) can cause nausea, vomiting, hair loss, diarrhoea, haemorrhage, destruction of the intestinal lining, central nervous system damage, and death. It may also cause DNA damage and increase the risk of cancer, particularly in young children and foetuses. Beyond certain thresholds, radioactivity can impair the functioning of tissues and/or organs and can produce acute effects such as skin redness, hair loss, radiation burns, and/or acute radiation syndrome. These effects are more severe at higher doses and higher dose rates. For instance, the dose threshold for acute radiation syndrome is about 1 Sv (1000 mSv) (IAEA, 1997).

Currently, no method is known to neutralise radioactive waste (Rosenfeld and Feng, 2011) but long-term isolation in a geoenvironment is recommended. Most nuclear waste is radioactive for a few tens of years and is routinely disposed of in near-surface disposal facilities. About 3% of the total volume of radioactive waste is long-lived and highly radioactive requiring isolation from the environment for multiple millennia (World Nuclear Association, 2017).

References

Gee, G.W., P.D. Meyer and A.L. Ward, 2005. Nuclear waste disposal. In: Encyclopedia of Soils in the Environment. pp. 56-63.

IAEA, 1997. Nuclear safety conventions: Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management. International Atomic Energy Agency (IAEA). www.iaea.org/topics/nuclear-safety-conventions/joint-convention-safety-spent-fuel-management-and-safety-radioactive-waste. Accessed on 20 December 2019.

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United Nations, 1997. Joint Convention on the Safety of Spent Fuel Management And on the Safety of Radioactive Waste Management. treaties.un.org/Pages/showDetails.aspx?objid=0800000280088ea3 Accessed 21 November 2019.

World Nuclear Association, 2017. Radioactive Waste - Myths and Realities. www.world-nuclear.org/information-library/nuclear-fuel-cycle/nuclear-wastes/radioactive-wastes-myths-and-realities.aspx Accessed 15 November 2019.

Coordinating agency or organisation

Not identified.

TL0002 / **TECHNOLOGICAL / Radiation**

Radioactive Material

Definition

A substance or a material emitting, or related to the emission of, ionising radiation (either in the form of electromagnetic waves or particle radiation) is radioactive (IAEA, 2018).

Reference

IAEA, 2018. IAEA Safety Glossary: Terminology used in nuclear safety and radiation protection, 2018 edition. International Atomic Energy Agency (IAEA). www-pub.iaea.org/MTCD/Publications/PDF/PUB1830_web.pdf Accessed 15 November 2019.

Annotations

Synonyms

Radioactive substance, Radioactive source, Radionuclide.

Additional scientific description

Radioactive materials (natural and human-made) are widely used in industry, medicine and research. There are various types of ionising and non-ionising radiation, each having different characteristics (IAEA, 2021):

- Alpha-radiation: consists of heavy, positively charged particles emitted by atoms of elements such as uranium and radium. Alpha-radiation cannot penetrate skin and can be stopped by a thin paper sheet. However, alpha-emitting radioactive material entering the body by breathing, eating, or drinking, can affect organs and tissues and cause biological damage.
- Beta-radiation: consists of electrons, is more penetrating than alpha-radiation and can pass through the skin surface. In general, a sheet of aluminium a few millimetres thick will stop beta-radiation.
- *Gamma-rays:* electromagnetic radiation similar to X-rays, light, and radio waves. Depending on their energy, gamma-rays can pass right through the human body, but not through a concrete wall or lead.
- Neutrons: uncharged particles that do not produce ionisation directly. Nevertheless, their interaction with other atoms can give rise to alpha-radiation, beta-radiation, or gamma-rays in the matter they traverse, which then produce a subsequent ionisation. Neutrons are highly penetrating and can only be stopped by thick masses of concrete, water or paraffin.

Depending on the magnitude of exposure, the radioactive substance may become a hazard to human health; as such it is subject to regulatory control by national laws and national regulatory authorities. Radioactive material may also be hazard to animal health, other forms of life and the environment (IAEA, 2018).

Metrics and numeric limits

Although the presence of radiation cannot be seen or felt, it can be detected and measured in extremely small quantities with simple radiation measuring instruments. The biological effects of ionising radiation vary with the type and amount of energy. A measure of the risk of biological harm is the dose of radiation that the tissues receive. The unit of absorbed radiation dose is the Sievert (Sv). One Sievert (1 Sv) is a large quantity of radiation. The whole-body dose of 2.5 Sv can be lethal without medical intervention. Radiation doses are generally in the order of milli-Sievert (mSv) or micro-Sievert (μSv). For example, exposure due to all natural radiation sources amounts to about 2.4 mSv per year, while one chest X-ray amounts to about 0.2 mSv (IAEA, 2021).

Radiation dose defines the level of risk for human health. To accurately assess the dose from an exposure resulting from an emergency situation, multiple factors are taken into account: the amount of radioactive material released into the environment (measured in Becquerels, Bq), the exposure rates per unit of time, the duration of exposure, and the pathways of exposure, etc. In addition, the level of risk will depend on the individual exposed (e.g., young children, pregnant women and their foetuses and lactating mothers are most vulnerable to radiation risk and should be given priority during response to a radiation emergency) (IAEA, 2021).

The severity of a radiation emergency is identified by the International Nuclear and Radiological Event Scale (INES) as demonstrated in the graphic below (IAEA, no date). INES is a standard tool for communicating the magnitude of nuclear and radiological events in a consistent manner (IAEA, no date).

Key relevant UN convention / multilateral treaty

Multiple conventions, treaties and agreements, that have been adopted by States, form part of the international nuclear legal framework. Those relevant to emergency situations include the Convention on Early Notification of a Nuclear Accident (United Nations Treaty Collection, 1986) and the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (United Nations Treaty Collection, 1987).

Examples of drivers, outcomes and risk management

Exposure to radiation may be external, internal, or combined, and can occur through various exposure pathways.

External exposure may occur near an unshielded radioactive source or when airborne radioactive material (such as dust, liquid, or aerosols) is deposited on skin or clothes. This type of radioactive material can often be removed from the body by simply washing (IAEA, 2021).

Internal exposure to ionising radiation occurs when a radionuclide is inhaled, ingested or otherwise enters into the bloodstream (e.g., by injection or through wounds). Internal contamination with most radionuclides needs medical intervention to remove radionuclides from the body (IAEA, 2021).

Exposure to radiation can be classified into three exposure situations: planned exposures (occupational and medical exposures); existing exposures (natural sources such as radon gas or residual radiation from past accidents or industrial activities); and emergency exposures (radiological and nuclear emergencies, accidents in transport, medicine, research, or even malicious acts involving radioactive material) (IAEA, 2021).

Types of emergencies involving radioactive material range from a small-scale radiological incident involving a lost or stolen industrial radioactive source, over-exposure of a person in an occupational or medical setting, or as a result of a transportation incident; to a large-scale nuclear emergency at a nuclear installation such as a nuclear power plant or a research reactor, or a detonation of a military or improvised nuclear device (IAEA, 2021). Examples of nuclear emergencies are nuclear bomb detonations in Japan at the end of the Second World War; the Three Mile Island and Chernobyl nuclear power plant accidents; and the Great Eastern Japan Earthquake which generated a tsunami and resulted in the Fukushima Daiichi nuclear power plant accident.

Protective actions to prevent or reduce radiation exposure in the case of a radiation emergency situation depend on the type of emergency and may include: taking shelter; evacuation or even permanent relocation from an affected area; restriction of consumption of contaminated food or water; administration of iodine thyroid blocking (in the case of radioactive iodine release); monitoring and measuring radiation in affected people and the environment; securing radioactive sources and cleaning up affected areas; as well as providing information, risk communication, psychological support, medical care and long-term follow-up to those in need (IAEA, 2021).

Other risk management measures include (IAEA, 2021):

- Safe siting, design and construction of nuclear power plants as well as controls and back up measures for their safe operation and radioactive waste management and isolation from the geoenvironment.
- Controls, equipment and training to protect personnel working with radioactive sources.
- Security measures to control access to supply and use of radiation sources.
- Facility, local and national multisectoral radiation emergency response plans for a range of scenarios from low-level exposure to a significant release of radioactivity.
- Effective risk communication which is essential to the public and emergency responders.

References

IAEA, no date. International Nuclear and Radiological Event Scale (INES). International Atomic Energy Agency (IAEA). www.iaea.org/resources/databases/international-nuclear-and-radiological-event-scale Accessed 20 December 2019.

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Coordinating agency or organisation

Not identified.

TL0003 / **TECHNOLOGICAL / CBRNE (Chemical, Biological, Radiological, Nuclear and Explosive)**

Radiation Agents

Definition

A substance or a material emitting, or related to the emission of, ionizing radiation (either in the form of electro-magnetic waves or particle radiation) is radioactive. Depending on the magnitude of exposure, the radioactive substance may become a hazard to human health; as such it is subject to regulatory control by national laws and national regulatory authorities. Radioactive material may also be hazard to animal health, other forms of life and the environment (IAEA, 2018).

Reference

IAEA, 2018. IAEA Safety Glossary: Terminology used in nuclear safety and radiation protection, 2018 edition. International Atomic Energy Agency (IAEA). www-pub.iaea.org/MTCD/Publications/PDF/PUB1830_web.pdf Accessed 15 November 2019.

Annotations

Synonyms

Radionucleide.

Additional scientific description

Radioactive materials (natural and human-made) are widely used in industry, medicine and research but can also be used as radiation agents as part of Chemical, Biological, Radiological, Nuclear and Explosive (CBRNE) incidents.

- *Alpha-radiation:* consists of heavy, positively charged particles emitted by atoms of elements such as uranium and radium. Alpha radiation cannot penetrate skin and can be stopped by a thin paper sheet. However, alpha-emitting radioactive material entering the body by breathing, eating, or drinking, can affect organs and tissues and cause biological damage (IAEA, no date a).
- *Beta-radiation:* consists of electrons, is more penetrating than alpha-radiation and can pass through the skin surface. In general, a sheet of aluminium a few millimetres thick will stop beta-radiation (IAEA, no date a).
- *Gamma-rays:* electromagnetic radiation similar to X-rays, light, and radio waves. Depending on their energy, gamma-rays can pass right through the human body, but not through a concrete wall or lead (IAEA, no date a).

Metrics and numeric limits

The magnitude of a source of alpha- or beta-radiation is given by its activity, measured in Curie (Ci) or Becquerel (Bq). 1 Bq corresponds to 1 radioactive decay/second. The impact of radiation on health is measured by the unit 'Sievert' symbolised as Sv. Translation of Sv in the units of Disability Adjusted Life Year (DALY) is possible but rarely done. For a radiological dispersal device, an initial 'hot zone' boundary should be established at ~1600 feet (500 m) in all directions from the point of dispersion until measurements are made. If it is known that the source used in the incident had an activity of <10,000 Ci (370 TBq), then the initial hot zone boundary can be established at a radius of ~800 feet (250 m). Decisions should not be based on the perceived wind direction, especially in an urban setting in which the wind field can be very complex. Projections with environmental models will not provide accurate predictions of consequences on a distance scale of ~1600 feet (500 m). The location of the hot zone boundary shall be adjusted as radiation measurements become available. This boundary definition is appropriate for both alpha-, beta- and gamma-emitting radionuclides (Musolino and Harper, 2006).

Key relevant UN convention / multilateral treaty

The Code of Conduct on the Safety and Security of Radioactive Sources (the Code) was established to achieve and maintain a high level of safety and security of radioactive sources across the globe. The idea for the development of the Code was first discussed at an international conference in Dijon, France, in 1998 that addressed measures necessary for the safe and secure use of radioactive sources. The conference noted that many countries have weak radiation protection programmes and suggested that the establishment of an 'international undertaking' could ensure continuity in regulatory control. The Code was drafted over several meetings. Following the terrorist attacks on 11 September 2001 in the USA, the provisions in the text addressing the security of radioactive sources were enhanced. In September 2003, the Code was approved, and the International Atomic Energy Agency (IAEA) General Conference invited States to make a political commitment to work towards the principles therein and currently 119 States have done so (IAEA, no date b).

The IAEA Preventive Measures for Nuclear and Other Radioactive Material out of Regulatory Control elaborates upon the recommendations given in IAEA Nuclear Security Series No. 15, Nuclear Security Recommendations on Nuclear and Other Radioactive Material out of Regulatory Control, in relation to preventative measures (IAEA, 2019). It serves as a guidance document for Member States interested in strengthening their nuclear security regime as it relates to nuclear and other radioactive material out of regulatory control and in improving their capabilities.

Examples of drivers, outcomes and risk management

Studies following survivors of atomic bomb events and radiation industry workers have confirmed that the radiation exposure increases the risk of cancer, and the risk increases as the dose increases Kodama et al. (2012).

A significant effect from a nuclear explosion is ionising radiation. Intense radiation is produced by the nuclear fission process that creates the explosion and from the decay of radioactive fission products (radionuclides resulting from nuclear fission) (Kodama et al., 2012).

Fission products primarily emit gamma- and beta-radiation. Radiation from a nuclear explosion is categorised as prompt radiation, which occurs within the first minute, and latent radiation, which occurs after the first minute and is mostly emitted by radioactive fallout (NATO, 1996).

Radiological hazards can also occur through accidental spills of radioactive chemicals in laboratories, reprocessing plants or hospitals (such as a spill of uranyl nitrate) or accidents during radiation therapy. Accidents in nuclear power plants can lead to contamination of territories over thousands of square kilometres over tens to hundreds of years by alpha-, beta- and gamma-radiation, requiring zoning and evacuation measures (NCRP, 2010).

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Coordinating agency or organisation

Not identified.

TL0004 / **TECHNOLOGICAL / CBRNE (Chemical, Biological, Radiological, Nuclear and Explosive)**

Nuclear Agents

Definition

Nuclear agents are derived from neutron radiation (n) which is a neutron emitted by an unstable nucleus, in particular during atomic fission and nuclear fusion. Apart from a component in cosmic rays, neutrons are usually produced artificially. Because they are electrically neutral particles, neutrons can be very penetrating and when they interact with matter or tissue, they cause the emission of beta- and gamma-radiation. Neutron radiation therefore requires heavy shielding to reduce exposure (IAEA, 2004).

Reference

IAEA, 2004. Radiation, People and the Environment. International Atomic Energy Agency (IAEA). www.iaea.org/sites/default/files/radiation0204.pdf Accessed 1 December 2019.

Annotations

Synonyms

Not available.

Additional scientific description

Dispersal of neutron radiation through nuclear weapons, including improvised nuclear devices (IND) results in a nuclear yield unlike radiation dispersal devices (RDD). This nuclear yield is measured in kilotons (kT) and one unit has the explosive energy equivalent to a thousand tons of TNT. Nuclear detonations are capable of producing impacts far surpassing that of any conventional explosive (IAEA, 2004).

A significant effect of a nuclear explosion is the blast generated. The blast originates from the rapidly expanding fireball of the explosion, which generates a pressure wave moving rapidly away from the point of detonation. Initially, near the point of detonation (also referred to as 'ground zero') for a surface nuclear burst, the overpressure is extremely high. With increasing distance from ground zero, the overpressure and speed of the blast wave dissipate to a point at which they cease to be destructive. In the case of a nuclear terrorism incident, the thermal pulse can cause skin burns on those people within a few miles of the incident who have a line-of-sight view of the fireball (IAEA, 2004).

There will be many hazards after a nuclear terrorism incident, including widespread fires and the presence of toxic materials, but one of the most significant in terms of human health for a ground level or near ground level nuclear incident, will be the residual radiation from radioactive fallout and neutron activation of materials. Although the radiation levels are most hazardous in the first few hours, some areas within a few miles downwind may still be hazardous days after the incident. Rapid identification of these fallout areas for implementation of protective measures is one of the highest priorities for emergency management and public health authorities (IAEA, 2004).

Metrics and numeric limits

Identifying the dangerous-radiation zone (exposure rate ≥10 R h−1 , ≥0.1 Gy h−1 air-kerma rate) will have critical implications on response activities in or near fallout areas. The dangerous-radiation zone is an area where large doses could be delivered to emergency responders in a short period of time. The relation of dose and health effect is mainly established via the survivors of the bombs of Hiroshima and Nagasaki, assessed in 1950 and continued by the US Atomic Bomb Causality Commission (ABCC) and its successor, the USA–Japan binational Radiation Effects Research Foundation (RERF) (NCRP, 2010).

After a ground-level nuclear terrorism incident, the dangerous-radiation zone will be created by fallout that is deposited in the first few hours and will have boundaries that may extend for 20 miles (~32 km), depending on the yield and weather. The dangerous-radiation zone will rapidly shrink as the fallout decays and may only be a mile or two long after a few days. As an example, an emergency responder working in an area with an initial 10 R h−1 exposure rate (~0.1 Gy h−1 air-kerma rate) 4 hours after the nuclear terrorism incident will receive ~25 R (~0.25 Gy air kerma) in a 4-hour work period (NCRP, 2010).

Key relevant UN convention / multilateral treaty

Effective national and global response arrangements and capabilities are essential to minimise the impacts from nuclear and radiological incidents and emergencies. The International Atomic Energy Agency (IAEA) maintains the international Emergency Preparedness and Response (EPR) framework, which is based on international legal instruments (IAEA, 2019).

As part of these activities, the IAEA develops safety standards, guidelines and technical tools; assists Member States in building the capacity for emergency response; and maintains the IAEA Incident and Emergency System to efficiently implement its role in response to nuclear or radiological incidents and emergencies, regardless of whether they arise from accident, negligence or deliberate act.

The IAEA Preventive Measures for Nuclear and Other Radioactive Material out of Regulatory Control elaborates upon the recommendations given in IAEA Nuclear Security Series No. 15, Nuclear Security Recommendations on Nuclear and Other Radioactive Material out of Regulatory Control, in relation to preventative measures (IAEA, 2019). It serves as a guidance document for Member States interested in strengthening their nuclear security regime as it relates to nuclear and other radioactive material out of regulatory control and in improving their capabilities.

Examples of drivers, outcomes and risk management

A life-span study to investigate the health consequences on a large population after the bombs of Hiroshima and Nagasaki, showed that the survivors within 1500 m of the epicentre (shielded whole body kerma >1 Gy) on average had a reduction of 2.6 years of life expectancy due to radiation-induced cancer (Smith, 2007).

References

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Coordinating agency or organisation

Not identified.

TL0005 / **TECHNOLOGICAL / Construction/Structural Failure**

Building Collapse

Definition

Building collapse is the failure of load-bearing structural elements, causing a building to fall or fail catastrophically / catastrophic failure (adapted from US Department of Labor, no date).

Reference

US Department of Labor, no date. Structural Collapse Guide. Occupational Safety and Health Administration. www.osha.gov/SLTC/emergencypreparedness/guides/structural.html Accessed 30 October 2020.

Annotations

Synonyms

Catastrophic building failure.

Additional scientific description

Progressive structural collapse is defined by the National Institute of Standards and Technology (NIST) as ‘the spread of an initial local failure in a manner analogous to a chain reaction that leads to partial or total collapse of a building’ (Ellingwood et al., 2007).

Metrics and numeric limits

The United Nations Educational, Scientific and Cultural Organization (UNESCO) lists 63 countries that have seismic design building codes (UNESCO, 2008).

Many countries have standards on progressive building collapse, these include UK British Standards, European EUROCODE, Canadian National Building Codes and Swedish Design Regulations (Ellingwood et al., 2007).

Key relevant UN convention / multilateral treaty

The 1954 Hague Convention for the Protection of Cultural Property in the Event of Armed Conflict. This international treaty, in times of peace, requires risk management plans to protect cultural assets when an urgent situation arises such as the failure of a structure and fire (UNESCO, 1954).

The International Labour Organization C167 - Safety and Health in Construction Convention, 1988 (ILO, 1988).

The Sendai Framework for Disaster Risk Reduction 2015-2030 outlines seven clear targets and four priorities for action to prevent new and reduce existing disaster risks including substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030 (UNDRR, 2015).

Examples of drivers, outcomes and risk management

In many low- to middle-income countries building collapse has been attributed to weak foundations, substandard construction-al materials, poor material mixing by construction workers, excessive load on strength of buildings and poor testing of building strength (Figueroa Fernandez, 2014). Building collapse is also caused by structural failures, poor supervision and workmanship, faulty design and disregard for approved drawings (Windapo and Rotimi, 2012). Additional factors include absence of soil testing before construction, lack of coordination between professional bodies and town planning authorities and inadequate enforcement of existing laws regulating physical development (Dimuna, 2010).

The Occupational Safety and Health Administration (OSHA) states that rescue workers and emergency responders may already have experience with entering collapsed structures resulting from construction (or other) catastrophes, earthquakes, fire and weather-related structural failures. Weather-related structural failures typically result from rain/snow accumulations on roofs, hurricanes, tornadoes, landslides and even avalanches. Rescue workers and emergency responders also face the possibility of entering a structure that has collapsed following a terrorist attack. Terrorist activity may add additional hazards such as secondary devices, follow-on attack and residual radiological, biological or chemical contamination. Historically, terrorist activities that have resulted in collapsed structures include crashing commercial jets into the World Trade Towers in New York City (11 September 2001) and vehicular bombs, such as the one used at the Murrah Federal Office Building in Oklahoma City (19 April 1995). Regardless of the root cause of the structural failure, rescue workers and emergency responders who enter a collapsed structure to perform their duties should be able to work safely (OSHA, no date).

On 24 April 2013 the collapse of the Rana Plaza building in Dhaka, Bangladesh which housed five garment factories killed at least 1132 people and injured more than 2500 (ILO, no date). This was due to additional stories being built that ignored the approved construction permits (Hira and Benson-Rea, 2017). Only five months earlier, at least 112 workers had lost their lives in another accident, trapped inside the burning fashions factory on the outskirts of Dhaka. Most of the factories do not meet the standards required by building and construction legislation. As a result, deaths from fire incidents and building collapses are frequent (ILO, no date).

Earthquakes, sinkholes (which cannot easily be identified) and ground subsidence are also drivers of building collapse (WHO, 2019). Fire is another driver that can cause structural failure of steel and concrete buildings that can lead to the death of civilians and fire fighters (Meacham et al., 2010; Ahmadi et al., 2020).

The effects of building collapse include impacts on lives, livelihood and health as well as social, economic and environmental impacts (Babtunde, 2013). Since the United Nations International Strategy for Disaster Reduction launched its campaign kit for making cities resilient (UNDRR, 2010), the United Nations Office for Disaster Risk Reduction has been committed to making cities resilient and has engaged and published widely including sharing the ten essentials for making cities resilient (UNDRR, 2019). Engagement in this campaign is vital for enhancing the drivers for risk management with ‘Essential Four: Pursue Resilient Urban Development and Design’ which calls for integrating resilience into socio-economic development planning and infrastructure to safeguard development investments – which will help reduce the risks of building collapse (UNDRR, 2019).

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Coordinating agency or organisation

Not identified.

TL0006 / **TECHNOLOGICAL / Construction/ Structural Failure**

Building, highrise, cladding

Definition

A building high-rise cladding fire hazard occurs when combustible materials such as cladding on a high-rise building greatly increases risk in the event of a fire and can have a catastrophic outcome (adapted from Rockpanel, no date)

Reference

Rockpanel, no date. What is a high rise or high-risk building? www.rockpanel.co.uk/applications/technical-support/firesafety/high-rise-buildings Accessed 8 November 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

Building height is an important factor in fire safety. The National Fire Protection Association defines a 'high-rise building' as a building greater than 75 feet (25 m) in height where the building height is measured from the lowest level of fire department vehicle access to the floor of the highest occupiable story (OSHA, 2003). The definition of what constitutes a high-rise building differs for many European countries. For example, in Germany, high-rise buildings are those 22 m and above, in Belgium 25 m and above, and in the UK 18 m and above. Despite the exact limit, it is indisputable that risk increases with increasing building height (Rockpanel, no date).

Escaping from tall buildings is more difficult and takes longer than from a single-family house with one floor. Not only do high-rise buildings have more inhabitants or people that work in them, but normal houses also have more escape routes (windows, doors) making escape easier when a fire occurs (Rockpanel, no date).

Composite panels were first developed as a cost-effective, lightweight building material that could be rapidly installed for external cladding or facades of industrial buildings. Following considerable development over recent decades, these panels are now widely used across a vast range of buildings. The main advantage of composite panels is that they are inexpensive, can be easily cut and shaped in any size or dimension, are lightweight, and have excellent insulation characteristics. The products also come with a wide variety of surface finishes to suit architectural designs. The issue of combustible composite panels now concerns both private residences and commercial offices and factories (Chen et al., 2019).

Recent high-profile building fires involving highly-combustible external cladding panels in Australia as well as Dubai, China, and the United Kingdom have created a heightened awareness by the public, government, and commercial bodies of the need to act on the risks associated with non-compliant building structures (Chen et al., 2019). The history of fire incidents involving combustible external composite panels goes back many decades and includes well documented events such as: the Knowsley Heights Fire in Liverpool UK, 1991; the Garnock Court Fire in Scotland, 1999; the Television Cultural Centre Fire in China, 2009; the Shanghai Apartment Fire in China, 2010; the Tecom Building Fire in Dubai, 2012; the Lacrosse Building Fire in Australia, 2014; The Torch in Dubai, 2015; The Address in Dubai, 2016; and Grenfell Tower in the UK, 2017 (Chen et al., 2019).

The Grenfell Tower fire broke out on 14 June 2017 in the 24-storey Grenfell Tower block of public housing flats in North Kensington, West London, United Kingdom. The London Metropolitan Police confirmed that 80 people died as a result. Prior to the incident, Grenfell Tower underwent a major renovation on the exterior of the building which included new windows, a heating system, and the installation of a new exterior cladding for insulation and rainscreen. The fire is believed to have been started from a refrigerator in a 4th floor apartment kitchen. The residents were in the apartment at the time and called the fire brigade. Despite firefighters arriving 6 minutes after the alarm, the fire managed to spread to the exterior cladding before the firefighters suppressed the kitchen fire. The flames spread at an alarming rate up the exterior cladding and the fire quickly became out of control. In addition, the exterior fire re-entered the building, trapping a significant percentage of residents inside the building (Chen et al., 2019).

In its report, the UK Ministry of Housing, Communities and Local Government stated that Aluminium Composite Material (ACM) cladding (and other metal composite material cladding) with an unmodified polyethylene filler (category 3) presents a significant fire hazard on residential buildings at any height with any form of insulation (Ministry of Housing, Communities and Local Government, 2020).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Appropriate exits, alarms, emergency lighting, communication systems, and sprinkler systems are critical for resident and employee safety. When designing and maintaining exits, it is essential to ensure that routes leading to the exits, as well as the areas beyond the exits, are accessible and free from materials or items that would impede individuals from easily and effectively evacuating (OSHA, 2003).

Since the tragedy at Grenfell Tower, the UK government's Building Safety Programme has focussed on identifying and advising on short-term interim and remedial measures for existing high-rise residential buildings with ACM cladding, while developing wider reforms for the future building safety regulatory system (Ministry of Housing, Communities and Local Government, 2020).

In October 2019, Phase 1 of the Grenfell Tower Inquiry reported on the role played by ACM cladding, fitted onto the exterior of the building. Sir Martin Moore-Bick, the Chairman of the Inquiry, found that the "principal reason why the flames spread so rapidly up, down and around the building" was the presence of combustible ACM cladding, "which acted as a source of fuel" (National Audit Office, 2020).

In the wake of the Grenfell Tower disaster, the Ministry of Housing, Communities and Local Government, UK, established the Building Safety Programme (the Programme) "to ensure that residents of high-rise residential buildings are safe, and feel safe from the risk of fire, now and in the future". While remaining clear that it is building owners who are responsible for ensuring the safety of their buildings, the Department has adopted an objective to "oversee and support the remediation of high-rise residential buildings that have unsafe aluminium composite material cladding". The Programme is designed to implement this objective, as well as to reform building regulations and the construction industry in the light of flaws brought to light in the wake of the Grenfell tragedy (National Audit Office, 2020).

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Coordination agency or organisation

Not Identified.

TL0007 / **TECHNOLOGICAL / Construction/Structural Failure**

Structural Failure

Definition

Structural failure corresponds to the exceedance of ultimate limit state in many of the load-carrying elements, which compromise the structural stability of the building (Rossetto, 2013).

Reference

Rossetto, T., 2013. Building failure. In: Bobrowsky, P.T. (ed.), Encyclopaedia of Natural Hazards. Springer. link.springer.com/referenceworkentry/10.1007%2F978-1-4020-4399-4_27 Accessed 29 November 2019.

Annotations

Synonyms

Structural collapse, Structural defects, Progressive collapse.

Additional scientific description

Structural failure affects both standing and underground structures, including bridges, canals, viaducts, buildings, tunnels and pipelines. This exceedance may lead to more widespread progressive collapse. Progressive structural collapse is defined by the National Institute of Standards and Technology (NIST) as the spread of an initial local failure in a manner analogous to a chain reaction that leads to partial or total collapse of a building (Ellingwood et al., 2007). Different types of progressive collapse have been referred to as pancake, zipper, domino, section, instability and mixed (Starossek, 2007).

Metrics and numeric limits

The United Nations Educational, Scientific and Cultural Organization (UNESCO) lists 63 countries with seismic design building codes, both members and non-members (UNESCO, 2019).

Many countries have standards on progressive building collapse, these include the European EUROCODE (European Commission, 2020), Canadian National Building Codes (Government of Canada, 2015), and Swedish Design Regulations (Boverket, 2018).

Key relevant UN convention / multilateral treaty

The 1954 Hague Convention for the Protection of Cultural Property in the Event of Armed Conflict. This international treaty, in times of peace, requires risk management plans to protect cultural assets when an urgent situation arises such as the failure of a structure and fire (UNESCO, 1954).

The International Labour Organization C167 - Safety and Health in Construction Convention, 1988 (ILO, 1988).

The Sendai Framework for Disaster Risk Reduction 2015-2030 outlines seven clear targets and four priorities for action to prevent new and reduce existing disaster risks including to substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030 (UNDRR, 2015)

Examples of drivers, outcomes and risk management

The drivers of structural failure can include design defects by engineers or architects, incorrect or substandard construction materials, inspection failures to identify building and construction problems, as well as natural hazards or a combination of these drivers (Almarwae, 2017).

Three summary examples follow:

- The *Minneapolis bridge collapse* that occurred in 2007 is an example of a structural failure that resulted in people being killed and seriously injured. The root cause of this event was exceeding the original structural load-bearing design by retrofitting additional road transportation lanes at later stages and also the weight of road maintenance equipment on the bridge on the day of the failure (Hao, 2010).
- The *Heathrow tunnel collapse* in 1994 was attributed to the implementation of new project management frameworks, exceeded tolerances of tunnel deflection, inadequate repair to ground settlement, and lack of inspection and monitoring in the construction of the tunnel (Wood, 2000).
- The *Sasago tunnel collapse* took place in 2013, where a large section of the suspended ceiling panels fell onto moving traffic. This caused the deaths of nine people and the failure was identified as the deterioration of the tunnel construction over time and a lack of routine maintenance (Fujino, 2018).

The Occupational Safety and Health Administration (OSHA) states that rescue workers and emergency responders may already have experience with entering collapsed structures resulting from construction catastrophes, earthquakes, fire and weather-related structural failures. Weather-related structural failures typically result from rain/snow accumulations on roofs, hurricanes, tornadoes, landslides and even avalanches. Rescue workers and emergency responders also face the possibility of entering a structure that has collapsed following a terrorist attack. Terrorist activity may add additional hazards such as secondary devices, follow-on attack and residual radiological, biological or chemical contamination. Historically, terrorist activities that have resulted in collapsed structures include crashing commercial jets into the World Trade Towers in New York City (11 September 2001) and vehicular bombs, such as the one used at the Murrah Federal Office Building in Oklahoma City (19 April 1995). Regardless of the root cause of the structural failure, rescue workers and emergency responders who enter a collapsed structure in order to perform their duties should be able to work safely (OSHA, no date).

The effects of building collapse include impacts on lives, livelihood and health as well as social, economic and environmental impacts. Since the United Nations International Strategy for Disaster Reduction launched its campaign kit for making cities resilient (UNDRR, 2010), the United Nations Office for Disaster Risk Reduction has been committed to making cities resilient and has engaged and published widely including sharing the ten essentials for making cities resilient (UNDRR, 2019). Engagement in this campaign is vital for enhancing the drivers for risk management with 'Essential Four: Pursue Resilient Urban Development and Design', which calls for integrating resilience into socio-economic development planning and infrastructure to safeguard development investments – which will help to reduce the risks of building collapse (UNDRR, 2019).

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Coordinating agency or organisation

Not identified.

TL0008 / **TECHNOLOGICAL / Construction/ Structural Failure**

Bridge Failure

Definition

Bridge failure is the inability of a bridge, or its components, to perform as specified by its design and construction requirements (Wardhana and Hadipriono, 2003).

Note: This definition includes bridges that have totally collapsed, partially collapsed and those that experienced distress, such as, exhibiting excessive deformation.

Reference

Wardhana, K. and F.C. Hadipriono, 2003. Analysis of recent bridge failures in the United States. Journal of performance of constructed facilities, 17:144-150.

Annotations

Synonyms

Bridge collapse.

Additional scientific description

Urbanisation leads to a continuous increase in demand for urban infrastructure, including bridges, highways and roads. The service life of infrastructure such as bridges is often shorter than expected due to natural phenomena and lack of sustainable concept in design and construction. Bridge failures are one of the most severe infrastructure problems faced today and pose an imminent threat to life and property. This reinforces the need to conduct sustainability assessments and optimal risk mitigation measures. A key aspect of engineering failures is the relationship between the failure and growth in engineering knowledge, which ensures the sustainable development of society (UNDESA, 2014).

The United States National Bridge Inventory, reports that on average, 188 million trips take place across a structurally deficient bridge per day in the USA. Between 1989 and 2000, a total of 503 bridges failed, resulting in 76 fatalities and 161 injuries. Of the 503 failures, 386 occurred during bridge's service life rather than during construction (US Department of Transportation, 2020).

In August 2018, a large section of the Genoa Morandi bridge in Genoa Italy, collapsed resulting in 43 fatalities and required over 400 people to evacuate the surrounding area. The collapse led to widespread human displacement and created an economic disaster (Bellini and Calevo, 2019). Lack of maintenance work and/or bridge design have been suggested as the reason(s) for the bridge collapse.

Metrics and numerical limits

Not identified.

Key relevant UN convention / multilateral treaty

United Nations Sustainable Development Goals (UNDESA, no date).

United Nations Sendai Framework for Disaster Risk Reduction 2015-2030 (UNDRR, 2015).

Examples of drivers, outcomes and risk management

Lessons identified from past bridge failures should inform the development of new materials, and more efficient forms of substructure and superstructure as well as new technology of construction, are now leading to longer life spans of bridges (Choudhury and Hasnat, 2015). In response to recent bridge failures, research has had a growing focus on three aspects: the general situation and development trend of bridge failures; bridge safety based on structural monitoring and mechanism analysis; and risk assessment and control for sustainability and environmental health (Tan et al., 2020).

Choudhury and Hasnat (2015) classified the more common causes and mechanisms of bridge failures around the world into two groups: natural factors (flood, scour, earthquake, landslide, cyclones etc.) and human factors (poor design and construction method, collision, overloading, fire, corrosion, lack of inspection and maintenance etc.).

However, a bridge designed to current standards and properly maintained can still fail. This is largely due to the gap in research about how exceptional stresses and especially the interaction of different exceptional stresses can compromise bridge integrity. Wardhana and Hadipriono (2003) concluded in the United States, that hydraulics (flooding and flood-related debris strikes), collisions, and overloading failures accounted for 73.4% of bridge failures, with the vast majority caused by external events that subjected the bridges to conditions with which they could not cope. Bridge overload and lateral impact forces from trucks, ships and trains, resulted in 20% of total bridge failures.

To avoid bridge failures in the future, both design countermeasures and management guidelines should be implemented. To improve bridge management, consideration should be given to social, environmental and economic sustainability (Tan et al., 2020). Environmental factors are one of the biggest risk factors engineers must consider in future bridge design. Climate change is a growing concern, with rising sea levels and increased frequency and severity of storms two examples of relevance to bridge design. Adapting to the potential impacts and loads caused by floods, storms and earthquakes are also key considerations for bridge resilience.

The United States National Bridge Inventory, a database of United States bridge failures has been used to estimate the failure rate of bridge collapses. The database shows hazards that have caused bridges to collapse historically throughout the USA and can be used to determine potential failure rates for bridges in other nations (US Department of Transportation, 2020).

Engineering has an important role in the planning, construction and ongoing maintenance of bridges in order to support their function, safety and integrity. Key considerations are ensuring the bridge design: surpasses national standards and guidelines; allows for higher flood levels than experienced historically; and ensures the bridge can withstand significant loads and debris.

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Coordination agency or organisation

Not identified.

TL0009 / **TECHNOLOGICAL / Construction/ Structural Failure**

Dam Failure

Definition

Dam failure is the collapse or movement of part of a dam or its foundation, such that the dam cannot retain water. In general, a failure results in a release of large quantities of water imposing risks on the people or property downstream (ICOLD, 2015).

Reference

ICOLD, 2015. Definition of a Large Dam. International Commission on Large Dams (ICOLD). www.icold-cigb.org/GB/dams/definition_of_a_large_dam.asp Accessed 8 November 2020.

Annotations

Synonyms

Dam break, Dam burst, Outburst, Dam breach.

Additional scientific description

Dams are commonly categorised by a wide range of factors such as composition, height, and reservoir volume. Dams are typically constructed of earth, rock, concrete or tailings (chaff) from mining operations. As a function of upstream topography, even a small dam can impound or detain many acre-feet of millions of gallons of water (FEMA, 2017). The collapse or movement leading to a break in the dam, could produce life-threatening flood situations due to the high velocities and large volumes of water involved. In the event of a dam failure, the potential energy of water stored behind the dam can cause significant damage to property and livelihoods, as well as injuries and loss of life for people downstream of the dam (FEMA, 2017).

Two summary examples of dam failures follow:

- *Brumadinho dam disaster Brazil 2019.* On 25 January 2019, Córrego do Feijão's tailing dam at Brumadinho city breached, leading to at least 12 million cubic metres of tailing spread into Paraopeba River and the surrounding area, leaving more than 250 people dead and many missing, with major environmental impacts on the downstream catchment (Cambridge and Shaw, 2019; Thompson et al., 2020). This was the fifth tailings dam disaster to have occurred in the same region in an 18-year period and is considered the worst documented tailings dam failure to have occurred in the past 30 to 40 years. The failure at Brumadinho showed geotechnical similarities to that at Fundao in 2015, with the characteristic of all foundation zones predisposing the facility to an increased risk of basal liquefaction under increasing stress. Upstream construction, as well as management commitment to quality control and inspection and monitoring during operation are potentially considered for the failure of the Brumadinho dam.
- Ajka Red Sludge Reservoir. On 4 October 2010, the retaining wall of a caustic waste reservoir at the Ajka alumina plant near Kolontar, Hungary, collapsed releasing more than one million cubic metres of highly alkaline sludge containing toxic metals. The waste material flooded several nearby villages, resulting in 10 fatalities, 123 injured people, damage to buildings, and significant ecological and environmental impacts. Reports concluded that a check on the reservoirs stability and statics had not been performed by the relevant authorities (NDGDM, 2010).

A review of failure mode analysis and implications for current and future resilience of flood protection infrastructure in the United States has been undertaken (Primary and Secondary Causes of Dam Failure in the US, no date). Dam failures are classified by date, location, dam type, primary and secondary root causes, cost in year of incident, damage type, and fatalities.

The International Commission on Large Dams (ICOLD) is an international non-governmental organisation dedicated to sharing professional information and knowledge of the design, construction, maintenance, and impact of large dams. ICOLD has 100 member national committees and over 10,000 individual members, (ICOLD, no date). ICOLD has created a World Register of Dams. This is a global database on dams, established based on the national inventories sent by member countries of ICOLD. The register is continuously updated and includes information on more than 55,000 dams. In addition to the dam register, ICOLD has developed a technical dictionary. Between 2000 and 2009, more than 200 notable dam failures happened worldwide (Jonkman and Vrijling, 2008).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

The Convention on the Protection and Use of Transboundary Watercourses and International Lakes (UNECE, 2013).

The United Nations Sustainable Development Goals (SDGs) (UNDESA, 2021). Water resources management and service are essential for sustainable development. Goal 6 focuses on the significance of water supply. The SDGs can also be linked to the proper functioning of dams as a source of municipal and rural water supply (Oyekanmi and Mbossoh, 2018).

The Sendai Framework for Disaster Risk Reduction, 2015-2030 (UNDRR, 2015).

Examples of drivers, outcomes and risk management

Dam failure is likely to occur due to seepage and internal erosion, poor foundation conditions, overtopping, static and seismic instability and for other reasons such as subsidence, structural issues, external erosion and slope instability (Lyu et al., 2019).

Dam safety agencies have generally adopted a common tiered hazard classification structure including Low, Significant, and High hazard potential classifications. Dam safety engineers commonly use the hazard potential classification system as a prioritisation tool to focus attention on those dams with the greatest potential consequences of failure. Two components are used to determine dam failure risk profiles: likelihood of failure and consequences of failure. Hazard classifications are defined as follows (FEMA, 2017):

- The consequences of a *low hazard potential* dam failure should result in no probable loss of human life and low economic and/or environment losses.
- The consequences of a *significant hazard potential* dam failure should result in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns.
- The consequences of a *high hazard potential* dam failure will probably cause loss of human life.

Risk creep also known as hazard creep is a term used to describe the gradual increase in anticipated consequences of a dam failure due to infrastructure development either along the drainage below a dam or within the reservoir area upstream. Although the physical condition of the dam may not change, hazard creep can result in an immediate adverse impact on the overall risk profile of a dam because the consequence component has increased. For example, new residential development within the dam breach floodplain could raise the status of a dam from one with a low hazard potential to one with significant or high hazard potential. Hazard creep can require costly dam safety modifications to address design deficiencies, such as to increase spill way capacity to safely route the probable maximum flood (for high hazard potential dams) (FEMA, 2017).

Following recent dam failure disasters, many countries put safety first and invest in prevention largely using Dam Safety Laws. This includes applying the UNECE's safety standards 'Safety Guidelines and Good Practices for Tailings Management facilities' (UNECE, 2016). Such guidelines, developed by the Joint Expert Group on Water and Industrial Accidents under UNECE's Industrial Accidents Convention and Water Convention, provide authorities with recommendations for practical applications to limit accidents and the severity of their consequences (UNECE, 2016).

The Conference of the Parties to the United Nations Economic Commission for Europe Industrial Accidents Convention sets the future direction for technological disaster risk reduction towards 2030 (UNECE, 2018).

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Coordination agency or organisation

Not identified.

TL0010 / **TECHNOLOGICAL / Construction/ Structural Failure**

Supply Chain Failure

Definition

Supply chain failure refers to an event in the supply chain that disrupts the flow of materials on their journey from initial suppliers through to final customers (Walters, 2007).

Reference

Waters, C.D.J., 2007. Supply Chain Risk Management: Vulnerability and Resilience in Logistics https://eclass.unipi.gr/modules/document/file.php/BDT227/%CE%A5%CE%BB%CE%B9%CE%BA%CF%8C%20%CE%94%CE%B9%CE%B1%CE%BB%CE%AD%CE%BE%CE%B5%CF%89%CE%BD/Supply%20Chain%20Risk%20Management_%20Vulnerability%20and%20Resilience%20in%20Logistics-2007%20%281%29.pdf Accessed 10 November 2020.

Annotations

Synonyms

SCM failure.

Additional scientific description

There is no single best definition of the term supply chain (UNECE, 2016). Supply chains have been defined as a network of connected and interdependent organizations mutually and co-operatively working together to control, manage and improve the flow of materials and information from suppliers to end users (Worldwide Supply Chain Federation, no date).

The Sendai Framework calls for more dedicated action needs to be focused on tackling underlying disaster risk drivers, such as the consequences of poverty and inequality, climate change and variability, unplanned and rapid urbanisation, poor land management and compounding factors such as demographic change, weak institutional arrangements, non-risk-informed policies, lack of regulation and incentives for private disaster risk reduction investment, complex supply chains, limited availability of technology, unsustainable uses of natural resources, declining ecosystems, pandemics and epidemics (UNDRR, 2015: para 6).

The Sendai Framework identified priorities for action (Priority 3: Investing in disaster risk reduction for resilience) for disaster risk reduction:

c. To increase business resilience and protection of livelihoods and productive assets throughout the supply chains, ensure continuity of services and integrate disaster risk management into business models and practices (UNDRR, 2015).

Failure of supply chains reduces resilience in disaster risk management. In today's highly competitive global manufacturing industries, the reality facing most prime or focal manufacturing organisations around the world is one where resources have been reduced, inventory has been drained, technology spending curtailed, and processes that are not core to an organisation's business have been scaled back and/or outsourced. In competitive global marketplaces prime manufacturers cannot afford to have any area of their operations compromised. Supply chain operations need to be robust and resilient in order to retain and increase market share. Supply chain failure is a phenomenon that can potentially cause major issues for many organisations, especially when failure becomes persistent (Karsten, 2018).

International trade is vital to the world economy. Businesses that trade internationally are supported by interlinked global supply chains, which are vital to their competitiveness. But as some recent events highlight, these dynamic, complex systems are vulnerable to numerous risks. Because of their interconnectedness, even small, localised events can escalate rapidly and cause significant disruptions (WEF, 2014). Supply chain performance is critical to business success; hence, supply chain disturbances could have a significant effect and include panic buying which leads to a sudden increase in demand, having the potential to disrupt entire supply chains (Dulam et al., 2020).

Critical infrastructure relies on supply chain supplies in order to provide essential services for community, national, regional and global resilience. This includes water, transportation and telecommunications infrastructure, educational facilities, hospitals and other health facilities that ensure all remain safe, effective and operational during and after disasters in order to provide lifesaving and essential services.

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

The Sendai Framework for Disaster Risk Reduction 2015–2030 (UNDRR, 2015).

Examples of drivers, outcomes and risk management

Over recent decades, supply chains have globalised, specialised and become leaner or just-in-time. They are more efficient, less risky in certain areas, but potentially more exposed to a breakdown of cooperation. In the last decade or so supply chain managers have encountered many shocks such as the Great East Japan Earthquake and tsunami, Thailand's flooding, the Eyjafjallajökull volcano in Iceland, the maritime piracy upsurge, and the E. coli-infected vegetable outbreak; all these shook supply chains across entire regions (Doherty and Botwright, 2020).

A 2012 World Economic Forum survey of supply chain professionals ranked disruptions most likely to provoke significant and systemic effects on supply chain networks. The list included pandemics, natural disasters, extreme weather, conflict, demand shocks, ICT breakdowns, and export/import restrictions such as export restrictions currently being placed on medical supplies. Triggers of supply chain disruption are hard to predict, and sometimes neither controllable nor influenceable. The robustness of networks is paramount to ensuring demand can be met with supply even in extraordinary times (Doherty and Botwright, 2020).

It is clear that a supply chain problem can harm a company's reputation, while proper supply chain management can improve a company's reputation. The Sendai Framework has a strong emphasis on disaster risk management as opposed to disaster management. The scope of disaster risk reduction has been broadened significantly to focus on both natural and man-made hazards and related environmental, technological and biological hazards and risks (UNDRR, 2015).

Following large-scale and catastrophic disasters, local organisations integrate with other responding organisations to form hastily developed disaster relief supply chain networks. Unfortunately, even where sound supply chain management practices are used, supply networks have encountered diverse levels of resilience and adequate disaster relief performance has remained elusive (Day, 2014).

The private sector is a critical participant in the creation of risk-resilient societies. ARISE, the Private Sector Alliance for Disaster Resilient Societies, is a network of private sector entities led by the UN Office for Disaster Risk Reduction (UNDRR). The Philippine Disaster Resilience Foundation (PDRF) provides an example of how ARISE and the impact of its work on supply chain support after the 2013 typhoon. The PDRF reported on a public-private partnership for a livelihood seeding program in a post-disaster context working in a post-disaster scenario in the Province of Leyte:

- The PDRF designed an early recovery programme with national government agencies, local government units, and international non-governmental organisations – leveraging the capabilities of each organisation in support of micro- and small enterprises and the normalisation of the local supply chain.
- The Post Disaster Needs Assessment provided programme partners with a way forward to support affected communities and livelihood outside of relief packages of 'starter kits' including items such as kitchenware, gas stoves and cooking equipment for food business owners and grocery stocks, bags of rice and weighing scales for *sarisari* storeowners. In helping to jumpstart early recovery, people were provided with the opportunity to help themselves and regain their businesses. They also reported that another benefit of this early recovery activity was the stabilising of market prices for basic commodities and deterring opportunists that prey on the vulnerability of the community's situation.
- Two months after the Post Disaster Needs Assessment beneficiaries were able to group into clusters/sectors (dressmaking, eatery/*carinderia* operations, delicacy making, and food vending). Sub-sector members were able to gather, discuss updates on their businesses, identify potential markets, and update themselves with market trends (UNDRR, no date).

Risk managers reflecting on previous disruptions highlighted five priority strategies to improve control measures further: risk quantification, scenario planning, data sharing, trusted networks, and multi-stakeholder input to legislation (Doherty and Botwright, 2020).

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Coordination agency or organisation

Not Identified.

TL0011 / **TECHNOLOGICAL / Construction/ Structural Failure**

Critical Infrastructure Failure

Definition

Critical Infrastructure failure is defined as the failure in one or more of the physical structures, facilities, networks and other assets which provide services that are essential to the social and economic functioning of a community or society (UNGA, 2016).

Reference

UNGA, 2016. Report of the open-ended intergovernmental expert working group on indicators and terminology relating to disaster risk reduction A/71/644. United Nations General Assembly (UNGA). www.preventionweb.net/files/50683_oiewgreportenglish.pdf Accessed 8 November 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

Paragraph 18 of the Sendai Framework on Disaster Risk Reduction 2015-2030 calls for the global target of:

d. Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030 (UNDRR, 2015).

The Sendai Framework identified as priorities for action (Priority 4: Enhancing disaster preparedness for effective response and to 'Build Back Better' in recovery, rehabilitation and reconstruction) this example of reducing critical infrastructure hazards and failures:

c. To promote the resilience of new and existing critical infrastructure, including water, transportation and telecommunications infrastructure, educational facilities, hospitals and other health facilities, to ensure that they remain safe, effective and operational during and after disasters in order to provide live-saving and essential service (UNDRR, 2015).

The United Nations General Assembly report of the open-ended intergovernmental expert working group on indicators and terminology relating to disaster risk reduction, defines the following of relevance to critical infrastructure failure:

- "A sudden onset disaster is one triggered by a hazardous event that emerges quickly or unexpectedly. Sudden onset disasters could be associated with, e.g., earthquake, volcanic eruption, flash flood, chemical explosion, critical infrastructure failure, transport accident" in the Disaster impact definition (UNGA, 2016).
- "Corrective disaster risk management activities address and seek to remove or reduce disaster risks which are already present and which need to be managed and reduced now. Examples are the retrofitting of critical infrastructure or the relocation of exposed populations or assets" in the Disaster risk management definition (UNGA, 2016).
- "Examples of physical assets that are the basis for calculating direct economic loss include homes, schools, hospitals, commercial and governmental buildings, transport, energy, telecommunications infrastructures and other infrastructure; business assets and industrial plants; and production such as crops, livestock and production infrastructure. They may also encompass environmental assets and cultural heritage" in the Economic loss definition (UNGA, 2016).
- "Technological hazards originate from technological or industrial conditions, dangerous procedures, infrastructure failures or specific human activities. Examples include industrial pollution, nuclear radiation, toxic wastes, dam failures, transport accidents, factory explosions, fires and chemical spills. Technological hazards also may arise directly as a result of the impacts of a natural hazard event" in the Hazard Definition (UNGA, 2016).

- "The medium and long term rebuilding and sustainable restoration of resilient critical infrastructures, services, housing, facilities and livelihoods required for the full functioning of a community or a society affected by a disaster, aligning with the principles of sustainable development and 'build back better', to avoid or reduce future disaster risk" in the reconstruction definition (UNGA, 2016).

Critical infrastructure is essential for community, national, regional and global resilience. It includes water, transportation and telecommunications infrastructure, educational facilities, hospitals and other health facilities that ensure that all remain safe, effective and operational during and after disasters in order to provide lifesaving and essential services.

Metrics and numeric limits

The Sendai Framework Monitor calls for all UN member states to report on the agreed global targets. Of note is Global Target D: Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030 (UNDRR, 2017).

- D1 (compound) Damage to critical infrastructure attributed to disasters.
- D2 Number of destroyed or damaged health facilities attributed to disasters.
- D3 Number of destroyed or damaged educational facilities attributed to disasters.
- D4 Number of other destroyed or damaged critical infrastructure units and facilities attributed to disasters. The decision regarding those elements of critical infrastructure to be included in the calculation will be left to the Member States and described in the accompanying metadata. Protective infrastructure and green infrastructure should be included where relevant.
- D5 (compound) Number of disruptions to basic services attributed to disasters.
- D6 Number of disruptions to educational services attributed to disasters.
- D7 Number of disruptions to health services attributed to disasters.
- D8 Number of disruptions to other basic services attributed to disasters. The decision regarding those elements of basic services to be included in the calculation will be left to the Member States and described in the accompanying metadata.

WHO technical guidance notes on Sendai Framework Reporting by Ministries of Health (WHO, 2020).

Key relevant UN convention / multilateral treaty

Sendai Framework for Disaster Risk Reduction 2015–2030 (UNDRR, 2015).

Examples of drivers, outcomes and risk management

The Sendai Framework is the successor instrument to the Hyogo Framework for Action (HFA) 2005-2015: Building the Resilience of Nations and Communities to Disasters. The HFA was conceived to give further impetus to the global work under the International Framework for Action for the International Decade for Natural Disaster Reduction of 1989, and the Yokohama Strategy for a Safer World: Guidelines for Natural Disaster Prevention, Preparedness and Mitigation and its Plan of Action, adopted in 1994 and the International Strategy for Disaster Reduction of 1999 (UNDRR, 2015).

The Sendai Framework has most significantly a strong emphasis on disaster risk management as opposed to disaster management. The scope of disaster risk reduction has been broadened significantly to focus on both natural and man-made hazards and related environmental, technological and biological hazards and risks. Health resilience is strongly promoted throughout (UNDRR, 2015).

Two examples from the health domain are shared below to show how leadership at a UN level engages to deliver approaches to help at local and national levels to reduce critical infrastructure failures:

Making health facilities safe in emergencies

In emergencies, disasters and other crises, the lives and well-being of the affected population must always be protected, particularly in the minutes and hours immediately following impact or exposure as time is of the essence in saving lives. The ability of health services to be delivered by critical infrastructure such as health facilities without interruption in these situations is a matter of life and death. For a safe health facility to remain intact, accessible and functioning at maximum capacity before, during and immediately following an emergency or disaster, it relies on key factors: health infrastructure that can resist exposures and forces from all types of hazard (e.g., retrofitted towards disaster risk reduction); medicine and medical equipment that are essential, accessible and protected from damage from all hazards (including climate change impacts); community infrastructure and critical services (such as water, food, electricity and medical supplies) that are available to support the delivery of health services; and health personnel who can provide medical assistance in safe and secure settings where and when they are most needed (WHO, no date).

The World Health Organization (WHO)'s safe health facilities' programme supports Member States to: develop national policies and regulations on making health facilities safe from disasters; protect the lives of the occupants of a health facility; protect the economic investment as well as the functionality of both new and existing health facilities and those identified as priorities (e.g., hub hospital) within the health services network; compile, organise and monitor the implementation of policies as well as national and international regulations on safe health facilities; and make health facilities safe, energy-efficient and resilient to future risks, including climate change (WHO, no date).

The Hospital Safety Index, developed by the WHO is a tool used by health authorities and multidisciplinary partners to gauge the probability that a health facility will continue to be safe and operational in emergency situations. The tool includes evaluation forms, a guide for evaluators, and a safety index calculator (WHO, no date).

WHO Health Emergency and Disaster Risk Management Framework

Launched at the Global Platform for Disaster Risk Reduction in May 2019, the WHO Health Emergency and Disaster Risk Management Framework is designed to reduce the health risks and consequences of emergencies and is vital to local, national and global health security and for building the resilience of communities, countries and health systems. Sound risk management is essential to safeguard development and implementation of the Sustainable Development Goals (SDGs), including the pathway to universal health coverage (UHC), the Sendai Framework for Disaster Risk Reduction 2015–2030 (Sendai Framework), International Health Regulations (IHR) (2005), the Paris Agreement on Climate Change (Paris Agreement) and other related global, regional and national frameworks (WHO, 2019).

The WHO Health Emergency and Disaster Risk Management Framework provides a common language and a comprehensive approach that can be adapted and applied by all actors in health and other sectors who are working to reduce health risks and consequences of emergencies and disasters. The Framework also focuses on improving health outcomes and well-being for communities at risk in different contexts, including in fragile, low- and high-resource settings (WHO, 2019).

The WHO Health Emergency and Disaster Risk Management Framework emphasises assessing, communicating and reducing risks across the continuum of prevention, preparedness, readiness, response and recovery, and building the resilience of communities, countries and health systems (WHO, 2019).

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WHO, 2020. WHO Technical Guidance Notes on Sendai Framework Reporting by Ministries of Health. World Health Organization (WHO date). https://apps.who.int/iris/bitstream/handle/10665/336262/9789240003712-eng.pdf?sequence=1&isAllowed=y Accessed 8 November 2020.

Coordination agency or organisation

World Health Organization (WHO) and UNICEF in collaboration with the United Nations Educational, Scientific and Cultural Organization (UNESCO).

TL0012 / **TECHNOLOGICAL / Infrastructure Failure**

Nuclear Plant Failure

Definition

Nuclear plant failure occurs when the accidental melting of the core of a nuclear reactor results in either the core to have a complete or partial collapse (adapted from USNRC, 1975).

Reference

USNRC, 1975. Reactor Safety Study: An Assessment of Accident Risks in US Commercial Nuclear Power Plants (Vol 88). United States Nuclear Regulatory Commission (USNRC). www.nrc.gov/docs/ML0706/ML070610293.pdf

Annotations

Synonyms

Nuclear meltdown, Nuclear shutdown.

Additional scientific description

Nuclear reactors are used to heat water to produce enormous amounts of low-carbon electricity and can be powered by a variety of different fuels. The fissioning of atoms in the chain reaction releases a large amount of energy as heat. The generated heat is removed from the reactor by a circulating fluid, typically water. This heat is then used to generate steam which drives turbines for electricity production (World Nuclear Association, 2020).

Electricity is essential for modern life, however, almost one billion people live without access to electricity. Global challenges such as climate change, pollution and environmental degradation require nations to generate electricity renewably (World Nuclear Association, no date). During the 20th century, the main energy sources for generating electricity were fossil fuels, hydroelectricity and since the 1950s, nuclear energy. Despite the growth and demand for renewable energy, fossil fuels remain the dominant source globally. Nuclear power is an environmentally friendly form of electricity generation. Although proponents of nuclear energy claim this is a renewable and safe form of energy, when nuclear plant failures do occur, they can have significant human, environmental, and socio-economic impacts (World Nuclear Association, no date).

In 2018, nuclear power generated 10.5% of the world's electricity (World Nuclear Association, 2020).

Nuclear reactors are a reliable source of energy and are capable of running for 24 hours a day for many months and possibly up to years without interruption, providing large amounts of clean electricity. Most nuclear reactors can operate for many years, over 60 years in some cases (World Nuclear Association, 2020).

Reactors derived from designs originally developed for propelling submarines and large naval ships generate about 85% of the world's nuclear electricity. The most common power reactor types use water, with more than 90% of the world's reactors being water-based (World Nuclear Association, no date).

The nuclear plant failures in Chernobyl and Fukushima are notable examples of major disasters.

Chernobyl, Ukraine (former Soviet Union) 1986: Chernobyl, is considered the world's worst nuclear disaster to date. A sudden power surge resulted in explosions and nearly complete destruction of the reactor. Fires broke out in the building which contributed to the extensive radioactive releases. The initial steam explosion and fire killed two people with a further 28 dying from radiation poising within three months. Massive amounts of radiation spread across the Soviet Union and Europe, and displaced 220,000 people as well as contributing to significant health, environmental and socio-economic impacts (WHO, 2016; World Nuclear Association, 2019).

Fukushima, Japan 2011: The 2011 Great East Japan Earthquake and tsunami that struck Japan on 11 March 2011, destroyed four reactors at the Fukushima nuclear power plant due to the loss of cooling as a result of the tsunami. There were no deaths or serious injuries as a direct result of radioactivity.

Metrics and numerical limits

Design certification of reactors is the responsibility of national regulators. There is international collaboration among national regulators to varying degrees, and there are various sets of mechanical codes and standards related to quality and safety (World Nuclear Association, 2019).

Key relevant UN convention / multilateral treaty

The Convention on Nuclear Safety, adopted 1994, aims to commit Contracting Parties operating land-based civil nuclear power plants to maintain a high level of safety by establishing fundamental safety principles to which States would subscribe. The Convention is based on the Parties' common interest to achieve higher levels of safety that will be developed and promoted through regular meetings (IAEA, 1994).

Examples of drivers, outcomes and risk management

Despite recent nuclear disasters such as Chernobyl and the devastation that brought, there is very little risk of nuclear power plants releasing radioactive materials to nearby communities. There has been strong awareness of the potential hazard of both nuclear criticality and release of radioactive materials from generating electricity through nuclear power, which has led to increased safety measures, an increase in well-trained reactor operators, thorough testing and maintenance, and policy and regulations put in place by organizations such as the Nuclear Regulatory Commission (USNRC, 2011; World Nuclear Association, 2019). The design and operation of nuclear power plants to date, aims to minimise the likelihood of accidents, and avoid major human consequences through implementation of nuclear safety measures and risk-informed decision-making (USNRC, 2011).

The International Atomic Energy Agency (IAEA) reports that nuclear power plants are equipped with multiple safety systems able to deal with a wide range of abnormal operating conditions. They also have well-proven emergency operating procedures that help operators to achieve a stable and safe end state. However, the most severe circumstances can result in damage to the nuclear fuel and the containment structures, possibly leading to a release of radioactivity to the environment. Yet even in these events the consequences can still be mitigated using available and, in some cases, dedicated plant equipment (IAEA, no date).

To protect the public and the environment from the consequences of a nuclear power plant accident, each plant operator establishes a severe accident management programme, which is kept under constant review and development. The main objective of the guidelines used to design such programmes is to utilise any available equipment at the nuclear power plant to terminate core damage, maintain containment integrity and minimise the release of radioactivity from the site (IAEA, no date).

The severe accident management guidelines vary according to plant design, local regulations and site characteristics. The IAEA has developed a toolkit to help operators develop their own guidelines and offers its Member States modular training programmes (IAEA, no date).

Although they are unlikely to be needed, severe accident management programmes are a critical part of the Defence in Depth concept, which is a hierarchical deployment of different levels of equipment and procedures in a graded approach to protect against a wide variety of incidents, accidents, equipment failures, human errors and events initiated outside the plant. In general, severe accident management programmes are designed to: evaluate generically the capability of existing plants to tolerate a severe accident; identify events that can lead to severe accidents and formulate preventive and mitigation strategies; and identify short-term and long-term measures for handling severe accidents (IAEA, no date).

The IAEA provides extensive materials on nuclear power plant safety systems which are designed to mitigate a range of abnormal operating conditions. In the unlikely case of a severe accident, plant operators use guidelines developed specifically for the purpose. The IAEA has a toolkit to help operators develop these guidelines and offers training to its Member States (IAEA, no date).

In addition, the IAEA organises the International Conference on Radiation Safety: Improving Radiation Protection. In 2020 it was held virtually, from 9 to 20 November. The Conference was organised in cooperation with the European Commission, the Food and Agriculture Organization of the United Nations, the International Labour Organization, the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development, the Pan American Health Organization, the United Nations Environment Programme and the World Health Organization (IAEA, 2020).

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Coordinating agency or organisation

Not identified.

TL0013 / **TECHNOLOGICAL / Infrastructure Failure**

Power Outage/ or Blackout

Definition

In the electric power domain, especially in power transmission and distribution, a power outage usually refers to a partial or total loss of power supply to some end user (e.g., population, enterprises, critical systems). Triggering factors may include accidents, equipment breakdowns, failure of control mechanisms, targeted attacks (physical or cyber), organisational errors, and natural hazards (adapted from Pescaroli et al., 2017; UK Cabinet Office, 2017; EIS Council, 2019; and FEMA, 2018).

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Pescaroli, G., S. Turner, T. Gould, D.E. Alexander and R.T. Wicks, 2017. Cascading Effects and Escalations in Wide Area Power Failures: A Summary for Emergency Planners. www.ucl.ac.uk/risk-disaster-reduction/sites/risk-disaster-reduction/files/report_power_failures.pdf Accessed 9 October 2020.

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Annotations

Synonyms

Electricity failure, Electricity disruption, Power cut, Power loss, Brownout.

Additional scientific description

Power outage can manifest in various forms, including transient faults, brownouts, and blackouts. They may initiate from both the supply and demand side. In some cases, power outages also materialise as the result of a situational response, such as in order to prevent worse consequences (e.g., rolling blackouts).

Event severity of power outages may exceed the ordinary by far; for instance, the Electric Infrastructure Security Council defines a Black Sky Hazard as “a catastrophic event that severely disrupts the normal functioning of our critical infrastructures in multiple regions for long durations” (EIS Council, 2019). The process of full restoration of the electricity network after the total or partial shutdown of the grid is sometimes termed as black start (UK Cabinet Office, 2017).

Terminology and definitions may vary, even significantly, across operational contexts and agencies.

Metrics and numeric limits

Metrics are in place to capture the many facets of a power outage. Some of these metrics are derived from standards such as IEEE 1366-2012 (IEEE, 2012).

Duration/frequency/occurrence time. For electric power utilities, commonly used reliability indicators include the System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI). In power outages analysis and reporting, it is common to refer to short- to long-duration events as a function of the specific legislative and operational context. For instance, the US Department of Homeland Security (2017) refers to a "long-term (+72 hours) interruption", while in general customer interruptions are considered as power outages even if much briefer. Important figures are those related to occurrence times of the failure event chains.

Magnitude and size. Typical indicators assess the affected parts and quotas of the grid, the estimated electricity not provided, or the geographic extent of the event. Power outages are often described as local, regional, national, cross-national, up to global. However, geography-based reporting may depend on jurisdictions and generally it is not possible to find an official definition on the size of blackouts (Galbusera and Giannopoulos, 2018).

Number of users affected. Figures typically considered are the number of people or households affected, or similar indicators for industries and businesses, sometimes accompanied by spatio-temporal details (Galbusera and Giannopoulos, 2018).

Economic indices. Indices in use to evaluate supply interruption-related costs include, the Interruption Energy Assessment Rate (IEAR), Value of Lost Load (VOLL), and Willingness to Pay (WTP) (e.g., €/kWh). A comprehensive impact quantification should account for both direct and indirect costs (Galbusera and Giannopoulos, 2018).

Key relevant UN convention / multilateral treaty

The Sendai Framework for Disaster Risk Reduction 2015-2030 includes disaster risk reduction objectives related to critical infrastructures (UNISDR, 2015). Disaster reduction policies on power outages stand at the crossway of commercial and market-regulatory treaties, development strategies, and national/cross national security agreements in the field of critical infrastructure protection. At the EU level, relevant policy documents include: Council Directive 2008/114/EC (European Parliament Think Tank, 2021); Directive 2009/72/EC (European Commission, 2009); and Directive (EU) 2019/944 (European Commission, 2019). Multi-country agreements in place include, for instance, the 2015 International Energy Charter (Energy Charter, 2015).

Examples of drivers, outcomes and risk management

Power outages are associated with cascading and systemic risks rooted at the intersection between physical, societal, functional and organisational dynamics (Pescaroli and Alexander, 2016). Since the early 2000s, larger impacts of power outages have been associated with growing and varying demand, network size and complexity, as well as market deregulation (Helbing et al., 2006). Triggering events include failure of operation, failure of equipment or material damage, human errors, aging infrastructure, and damage caused by natural hazards on equipment, facilities and lines (Amin, 2002; Little, 2002; Petermann et al., 2011; Karagiannis et al., 2017). Directly and indirectly targeted malicious acts include cyberattacks, terrorist acts, or electromagnetic pulse attacks (Amin, 2002; Linkov et al., 2013). The impact of power outages can be amplified if the outage happens in concurrency with climate-related extreme events (e.g., cold waves, heatwaves) (Klinger et al., 2014).

Petermann et al. (2011) illustrated that power outages can heavily disrupt societal and economic functions both directly (due to the lack of energy they rely on) and indirectly (e.g., through interdependencies). According to Pescaroli et al. (2017), the effects of power outages are associated with direct threats to life (e.g., impacts on the health sector, water shortages, or disruption of heating and cooling); indirect threats to life (e.g., increased need of vulnerable population, loss of cash flow); and challenges for operational capacities (e.g., loss of efficiency of emergency services).

Risk management strategies include national and international risk assessments, development of policies and practices for continuity management, training and exercises for complex scenarios involving multiple interdependent failures, assessment of new technologies (e.g., microgrids, cashless transactions), and the improvement of crisis communication before, during and after power outage events (FEMA, 2018).

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Coordinating agency or organisation

Not identified.

TL0014 / **TECHNOLOGICAL / Infrastructure Failure**

Emergency Telecommunications Failure

Definition

Emergency telecommunications failure is an umbrella term for telecommunications of an 'extraordinary nature' under abnormal and potentially adverse network conditions (ITU, 2007).

Reference

ITU, 2007. Y.2172: Service restoration priority levels in Next Generation Networks. International Telecommunication Union (ITU). www.itu.int/rec/T-REC-Y.2172-200706-I/en Accessed 30 November 2019.

Annotations

Synonyms

Emergency communication systems, Communications capability, Emergency telecommunications, Network enabled capability, Emergency services.

Additional scientific description

Emergency telecommunications failure is closely linked to service restoration. Service restoration is described as a set of automated or manual methods, invoked after a network failure, to enhance the ability of successful communications reroute and completion around the failed network element(s) (ITU, 2007).

All forms of communications traffic are expected to be carried by next generation networks – control plane traffic (e.g., routing and signalling messages), emergency telecommunications, real-time voice and video services, data services, virtual private network (VPN) services, as well as traditional 'Best effort' traffic. In such an environment, it is important to assign priority classifications and establish rules for service restoration such that critical services (e.g., control plane traffic and emergency telecommunications) are recognised and restored over other services in case of network overloads or failures. As service flows can be expected to traverse multiple network domains, priority classification is an important step in the development of the necessary signalling protocol extensions as well as of the mechanisms for enabling preferential restoration of critical services (ITU, 2007).

The priority level classification is based on the following premise: "under reduced bandwidth conditions resulting from network failure, the critical issue for next generation network is the ability to recognize and restore higher priority traffic flows over others" (ITU, 2007).

The priority level recommendations proposed by the International Telecommunication Union (ITU) strictly relate to the relative importance of traffic classes from this perspective (ITU, 2007).

Metrics and numeric limits

The ITU is currently developing global guidelines for countries to develop National Emergency Telecommunications Plans (NETS) to be used for early warning and in times of emergency. The framework seeks to address a country's exposure to natural hazards and disasters prior to developing emergency data and communication systems (ITU, 2019).

Key relevant UN convention / multilateral treaty

The Tampere Convention on the Provision of Telecommunication Resources for Disaster Mitigation and Relief Operations was established in 2005. This international treaty allows countries to remove regulatory issues to immediately provide emergency telecommunications where a disaster has occurred (United Nations Treaty Collection, 1998).

Examples of drivers, outcomes and risk management

Emergency telecommunications are critical when a disaster occurs, to enable emergency and disaster response teams, government ministries, departments and agencies, as well as humanitarian agencies to coordinate and deliver disaster response and recovery efforts.

Drivers include natural hazards and disasters that can destroy telecommunications infrastructure and cause severe network disruptions. Electrical power is essential for these emergency communication systems to operate and power outages are directly linked to the drivers of this hazard (Townsend and Moss, 2005; Chang et al., 2007).

The ITU's NETS framework can be used across all stages of the disaster management cycle and provides guidelines for a country to establish robust Information and Communication Technologies (ICT) systems before, during and after a disaster (ITU, 2019).

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Coordinating agency or organisation

International Telecommunication Union (ITU), in partnership with World Food Programme (WFP), United Nations Office for the Coordination of Humanitarian Affairs (UN OCHA) and United Nations High Commissioner for Refugees (UNHCR).

TL0015 / **TECHNOLOGICAL / Infrastructure Failure**

Water Supply Failure

Definition

Water supply failure is the physical shortage or scarcity in access of water supply due to the failure of institutions to ensure a regular supply or due to a lack of adequate infrastructure (adapted from UN-Water, no date).

Alternative definition: Water supply systems are networks whose edges and nodes are pressure pipes and either pipe junctions, water sources or end-users. Water supply systems are designed to protect the customer from natural biological contamination, and the same systems have potential efficacy against deliberate biological and chemical contamination (adapted from Franchin and Cavalieri, 2013; and Jain et al., 2014).

References

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Annotations

Synonyms

Water network failure.

Additional scientific description

A water supply system loss of safety may result from: failure of its individual subsystem or elements such as water intakes, pumping stations, the water distribution network or its utilities; failure of other technical systems such as sewerage, energy, water structures; extreme natural hazards such as floods and droughts; poor organisational structures; and from incidental pollution of water sources (Pietrucha-Urbanik and Tchórzewska-Cieślak, 2018).

A water supply system failure generally results in a decreased amount of water supplied with inadequate parameters such as low pressure which could lead to water scarcity. Public water system bodies have the responsibility of maintaining physical and human infrastructure to supply water and are often bound by regulations. However, water use has been increasing globally at more than twice the rate of population growth over the past century. Some regions are reaching the limit at which services can be sustainably delivered. In the latter half of the twentieth century, there was an increase in major accidents and disasters relating to the functioning of public water supply systems in rural, urban and industrial areas (Pietrucha-Urbanik, 2015). Failures in water supply systems, treatment processes, and distribution networks can often lead to water contamination incidents, some of which result in disease outbreaks.

As the global population rises, there is a need to balance competing demands on water resources to provide basic necessities for operation and survival. In order to keep up with demand, water supply systems require periodic inspections, maintenance and repairs. Inspections allow for early detection of potential damage, with planning for repair to prevent negative and ongoing consequences associated with the lack of water supply (Pietrucha-Urbanik and Tchórzewska-Cieślak, 2018). Recent practice to reduce the number of emergency failures, has been the implementation of preventative renewal. This identifies the elements within the water supply systems that are most vulnerable to failure and ensures that they are replaced, thereby reducing the probability of failure (Pietrucha-Urbanik and Tchórzewska-Cieślak, 2018). This has largely been applied for aging infrastructure. Actions taken to reduce the number of water supply system failures include but are not limited to: technical renewal of pipelines (renovations, maintenance and diagnostics); replacement of pipes and fittings; improvements in detecting places of leaks; network pressure limitation to the lowest permissible value; and proper operation, design and execution of water supply systems.

Metrics and numeric limits

While significant progress has been made towards improving water supply infrastructure and achieving access to basic water, sanitation and hygiene, gaps remain in the quality of services provided. A recent report concluded that 1.8 billion people have gained access to basic drinking water services since 2000, but there remains vast inequalities in the accessibility, availability and quality of these services and more than 2 billion people around the world do not have safely-managed drinking water (UN-Water, no date a).

Key relevant UN convention / multilateral treaty

The United Nations Sustainable Development Goals (2015), specifically with regards to achieving universal and equitable access to safe and affordable drinking water for all (Goal 6: Ensure availability and sustainable management of water and sanitation for all) (United Nations, 2015).

Examples of drivers, outcomes and risk management

Water is essential for socio-economic development, energy and food production, healthy ecosystems and human survival. Access to safe drinking water is a major global health concern and water is also considered at the core of adaptation to climate change, providing the crucial link between society and the environment.

In recent decades, analyses and assessments of water system failures have been conducted in many countries, concluding that assessments have been used to improve programming, design, implementation and operation, and to inform and/or amend technical regulations, design standards, guidelines and instructions for the performance and acceptance of facilities of water supply systems (UN-Water, no date a).

Integrated water resources management, which has been accepted internationally, provides a broad framework for governments to align water use patterns with the needs and demands of different users (UN-Water, 2008).

In addition to Integrated Water Resources Management, a number of regulations and standards have been developed to address water supply security and safety, particularly from the World Health Organization in regards to the applications of water safety plans, some of which include:

- Water sanitation hygiene: Global water supply and sanitation assessment 2000 report (WHO, 2000a).
- Operation and maintenance of rural water supply and sanitation systems A training package for managers and planners (WHO, 2000b).
- Global costs of attaining the Millennium Development Goal for water supply and sanitation (WHO, 2008).
- Vision 2030: The resilience of water supply and sanitation in the face of climate change Summary and policy implications (WHO, 2009).
- Guidance on water supply and sanitation in extreme weather events (WHO Regional Office for Europe, 2012).

The United Nations (UN) seeks to support countries in monitoring water and sanitation related issues within the framework of the 2030 Agenda for Sustainable Development and in compiling country data to report in global progress toward Sustainable Development Goal 6 (SGD6). The aim of this initiative is to increase the availability of high quality data to inform evidence-based policymaking, regulations and planning investments at all levels.

UN-Water has developed a global data portal 'The SDG 6 Data Portal' which brings together all the UN's water and sanitation information to show the global status on Indicator 6.4.1: Change in water-use efficiency over time. The objective of the portal is to: track overall progress towards SDG6 at global, regional and national levels; enable assessment and analysis of the state of water resources and linkages to other sectors; raise awareness of water and sanitation issues to help catalyse action; and encourage and improve SDG6 monitoring and reporting at all levels (UN-Water, no date b).

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WHO Regional Office for Europe, 2012. Guidance on water supply and sanitation in extreme weather events. www.euro.who.int/en/publications/abstracts/guidance-on-water-supply-and-sanitation-in-extreme-weather-events-2012 Accessed 10 November 2020.

Coordination agency or organisation

World Health Organization (WHO) and United Nations International Children's Emergency Fund (UNICEF) in collaboration with United Nations UN-Water.

TL0016 / **TECHNOLOGICAL / Infrastructure Failure**

Radio and Other Telecommunication Failures

Definition

Radio and other telecommunication failures can be said to occur when there is internal or external interruption of communications by either party that results in difficult to transport the message as it was intended (adapted from Dainty et al., 2007).

Reference

Dainty, A., D. Moore and M. Murray, 2007. Communication in Construction: Theory and Practice. Routledge.

Annotations

Synonyms

Communication breakdown, Communication system failure.

Additional scientific description

Radio and communication technology is integrated into everyday life and has significantly advanced in recent decades. Communication channels such as radio, cellular networks, and satellites aim to broadcast or convey information and warnings to populations. In a disaster response event, the goal of any communication system is to maximise the number of people who act on and take appropriate and timely actions for protecting property and ensuring life safety (Khaled and Mcheick, 2019).

Efficient and effective communication linkages are critical prior to, during and following a disaster event, particularly among emergency personnel to assist with disaster response and recovery. However, failure of communication systems, whether complete or partial such as radio or satellites systems has caused inefficiency and delays in emergency relief efforts and response, which leads in turn to loss of life and preventable injuries. Failure of communication systems can cause catastrophic damage to human life and economic activities as people are unable to communicate with each other in a timely manner and with a good quality of service (Khaled and Mcheick, 2019).

A notable example of radio and communications failure was caused by the 2004 Indian Ocean earthquake and tsunami: A magnitude 9.0 earthquake struck the west coast of Sumatra, Indonesia, generating tsunami waves with maximum heights ranging from 2 to 30 m, inundating the coastal areas of many surrounding countries. Although this event was the first global natural disaster where practitioners and the public mediated their experience of it through the internet, communication technology was not used to its fullest extent during the immediate response, which resulted in a lower delivery of humanitarian aid. The main reasons for the communication failure were the destruction of technology infrastructure, accumulated debris, and extensive flooding that affected the power systems and cabins that contain the base transceiver station (BTS) equipment. There were also other telecommunications limitations such as limited network coverage, lack of early warning systems, and lack of rescue equipment (Khaled and Mcheick, 2019).

Key reasons for communications systems failure include: damage and/or destruction of communication system components; damage and/or disruption in supporting network infrastructure; and disruption due to congestion.

Damage and/or destruction of communication system components is considered the most common and well-documented cause of telecommunications failures in recent disasters. Because of the time and funding needed to repair and replace systems, disruption caused by physical damage tends to be more severe and time-consuming to restore as it may require maintenance or replacement of complex hardware, particularly essential components such as cell towers or cables. The fragility of communication systems is due to the lack of a high degree of redundancy (Townsend and Moss, 2005).

Communication outages caused by damage and/or disruption in supporting network infrastructure tend to be far more widespread and damaging during response and recovery efforts. Some communication systems are reliant on many other local and regional technical systems to ensure effective operation. Supporting infrastructure often lacks resiliency to physical damage (Townsend and Moss, 2005).

Disruption due to congestion is another type of major communication failure during disaster and is a direct result of network congestion or overload, and results in blocked calls and messages unsent. Historically, disasters are one of the most intense generators of communications traffic, and the resulting surge of demand can clog even the most well-managed networks. However, communication can be restored relatively rapidly (Khaled and Mcheick, 2019).

Lessons identified from previous disaster events, conclude that radio and satellite-based communications were most effective, while conventional communications outlets (i.e. wireless phones and landlines) were either damaged or overwhelmed in many disaster events hindering the efficient and timely transfer of information (Khaled and Mcheick, 2019).

Metrics and numeric limits

Not measured globally.

Key relevant UN convention / multilateral treaty

Sustainable Development Goals (SDGs) (UNDESA, 2021).

Examples of drivers, outcomes and risk management

Developing and implementing common technical characteristics and guidelines for radio communication systems for early warning and disaster response and relief, would promote a common technical basis in planning for and responding effectively to an emergency. A guide to Radio Communications Standards for Emergency Responders was developed and prepared under the United Nations Development Program and the European Commission Humanitarian Office through the Disaster Preparedness Programme. The aim of the manual is providing a standard of operation and a guide for training message handling techniques and net procedures for Radio Emergency Service operators for national and local radio networks (UNDP, 2010). In 2017, United Nations Children Fund (UNICEF), developed an Emergency Telecommunications Handbook which presents a set of guidelines and detailed instructions to support teams facilitating and delivery of effective emergency telecommunications in the field. The handbook captures the nature of integration of various telecommunication systems (UNICEF, 2017).

In addition, the International Telecommunication Union has developed numerous resources including:

- Radio Regulations Navigation Tool (regulations that govern the global use of the radio-frequency spectrum and satellite orbits) (ITU, no date).
- Space Networks Systems Database of the Radiocommunication Bureau of the International Telecommunication Union. The database contains AP4 data of geostationary satellite filings, non-geostationary satellite filings and earth station filings (ITU, no date).
- Definitions of world telecommunication/ICT Indicators (ITU, no date).

References

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UNICEF, 2017. Emergency Telecommunications Handbook. www.unicefinemergencies.com/downloads/eresource/docs/3.6%20ICT/Emergency%20Telecommunications%20Handbook.pdf Accessed 3 November 2020.

Coordination agency or organisation

Not identified.

TL0017 / **TECHNOLOGICAL / Cyber Hazard**

Misconfiguration of Software and Hardware

Definition

Misconfiguration of software and hardware is the incorrect or suboptimal configuration of an information system or system component that may lead to vulnerabilities (NIST, no date).

Reference

NIST, no date. Misconfiguration. Glossary: Computer Security Resource Center. National Institute of Standards and Technology (NIST) Information Technology Laboratory. https://csrc.nist.gov/glossary/term/misconfiguration Accessed 9 November 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

Security configuration includes security rules configured in the cloud platform, network, virtual machines and various application components. It is different to a high-level security policy, which sets out the organisation's approach to achieve its information security objectives (ITU, 2016). Misconfiguration implies an incorrect or suboptimal system component that may lead to vulnerabilities in the cloud platform, network, virtual machines and various application components (NIST, no date).

Cloud service providers (CSPs) should execute the integrated security configuration management to provide efficient implementation and fast deployment of the security configuration (ITU, 2016).

In security configuration management, it is suggested that CSPs set security policy configuration templates and security configuration policy baselines. Furthermore, CSPs should take measures to ensure the consistency and efficiency of security configuration when the cloud environment changes and to isolate the security configuration between Cloud service customers (CSCs) in a multi-tenancy environment (ITU, 2016).

Security configuration templates include the main templates of security configuration that the current cloud computing environment needs, such as account management, authentication, access control policies, audit policies, dynamic response policies, application and software update policies, and backup and recovery policies (ITU, 2016).

Security configuration baselines provide a criterion for the security configuration requirements of the entire cloud computing environment, which can help CSPs evaluate whether the current security configuration meets the fundamental security level or not, and further provide detailed guidance to reinforcement. The categories of security configuration baselines should include but are not limited to the following: operating system (OS) security configuration baselines, database security configuration baselines, firewall security configuration baselines, switch security configuration baselines, and router security configuration baselines, etc.

Security configuration management involves the following measures (ITU, 2016):

- *Security configuration template management:* CSPs should set the main security templates for the demands of the cloud environment to make security configuration deployment faster and more convenient. Security configuration template management should support customised templates, update and optimise templates continuously according to the changes of cloud platform, network status, service requirements, and so on. Furthermore, CSPs should provide CSCs with the capability to customise new security configuration templates according to their own requirements. CSCs should also be responsible for the effectiveness of the security configuration which they customised.

- *Security configuration process management:* CSPs should testify against the effectiveness of the security configuration. Security configuration can be configured according to CSC and cloud service requirements. The main process of security configuration management involves configuration request, configuration approval, testing and technical validation, implementing, configuration archiving and output report.
- *Security configuration baseline management:* CSPs should develop security configuration baseline by comprehensively considering the security requirements of the cloud computing platform, cloud service, CSCs, and the security clause of Service level agreement (SLA), etc. The main process of security configuration baseline management involves security configuration checking request and record, approval, checking implementing, checking report output, reinforcement implementing, and reinforcement report output. Security configuration checking should be executed periodically during daily operations and can be implemented through configuration collecting and baseline security analysis.
- *Security configuration conflict management:* In a resource sharing cloud environment, due to faults caused by either the security administrator or for other reasons, the security configuration might be compromised which may result in vulnerabilities in the cloud computing environment. CSPs should implement efficient measures to detect security configuration conflicts and establish a security configuration conflict handling process and retrieval mechanisms. The handling process of security configuration conflict should involve conflict alarm, conflict analysis (which includes reasons and influences analysis), conflict handling and output report.
- *Security configuration migration management:* When cloud computing resource or service changes (such as service capacity expansion, virtual machine [VM] migration, etc.), CSPs should provide dynamic security configuration adjustment means. For example, during VM migration, automatic security configuration policy migration can be implemented through migration status sensing, automatic matching and redeployment of the original security configuration policy, which could ensure security configuration policy consistency and fast deployment in the cloud environment and improve the efficiency of the security operation.
- *Security configuration isolation management:* In a multi-tenancy environment of cloud computing, CSPs should execute strict classification management of CSC security configuration, and take measures such as authentication, access control, etc. This is to ensure security configuration isolation between different CSCs.

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Challenges to the management mode of cloud computing: The characteristics of cloud computing, such as cross-regional services, huge computing power, separation of data management and ownership, distinguishes it from the traditional information technology (IT) services. These challenges require effective management and co-operation between branch nodes to solve security problems by CSPs. For CSPs, some necessary technical measures, such as security configuration management, etc., a reasonable distribution of management authority, and a set of effective management rules and processes will be needed to prevent the leakage of user data. For example, CSPs should take measures to prevent internal administrators from overstepping their authority so as to prevent users from abusing the cloud computing resources (ITU, 2016).

Health status monitoring of the cloud computing infrastructure: CSPs should provide the capability to collect and monitor the security event logs, vulnerability information, alteration of security device configuration, performance and operational status on all objects of the cloud computing infrastructure, which include VM resources, cloud computing management platform, security devices, database, etc. This monitoring can help CSPs to keep a perceptive awareness of the overall health status and operating status of the cloud infrastructure (ITU, 2016).

References

ITU, 2016. Series X: Data Networks, Open System Communications And Security. Cloud computing security best practices and guidelines. ITU-T Telecommunication Standardization Sector of ITU (03/2016) SERIE X.1642. International Telecommunication Union (ITU). www.itu.int/rec/dologin_pub.asp?lang=e&id=T-REC-X.1642-201603-I!!PDF-E&type=items Accessed 29 April 2021.

NIST, no date. Misconfiguration. Glossary: Computer Security Resource Center. National Institute of Standards and Technology (NIST) Information Technology Laboratory. https://csrc.nist.gov/glossary/term/misconfiguration Accessed 9 November 2020.

Coordinating agency or organisation

International Telecommunication Union (ITU).

TL0018 / **TECHNOLOGICAL** / **Cyber Hazard**

Non-Conformity and Interoperability

Definition

Conformity assessment: activity that provides demonstration that specified requirements relating to a product, process, system, person or body are fulfilled (NIST Information Technology Laboratory, no date).

For the purposes of this standard, interoperability allows any government facility or information system, regardless of the personal Identity verification (PIV) Issuer, to verify a cardholder's identity using the credentials on the PIV Card (NIST, no date).

Reference

NIST, no date. Misconfiguration. Glossary: Computer Security Resource Center. National Institute of Standards and Technology (NIST) Information Technology Laboratory. https://csrc.nist.gov/glossary/term/misconfiguration Accessed 9 November 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

Conformity assessment guarantees that ICT equipment implements a technical specification or standards. Compliance helps vendors and users of the equipment to evaluate how the equipment will perform in the network where it will integrate with other network devices to provide an offered network service. Interoperability testing measures if two or more products correctly implement the technical specifications necessary to ensure successful integration supporting particular communication protocols (ITU, 2020).

Conformance and interoperability testing is important to identify the possible non-compliance aspects of equipment to be part of an Information and Communications Technology (ICT) network, as defined by accepted standards in the industry, that may interfere in the quality of the network service being provided. High quality performing products available for commercial use contribute to the widespread deployment of the network technologies and their associated network services (ITU, 2020).

International Telecommunication Union relevant information and activities:

- ITU - C&I Portal (ITU, 2021a).
- Resolution 177, Dubai, PP-18 (ITU, 2021b).
- Resolution 47, Buenos Aires, WTDC-17 (ITU, 2017).
- Resolution 76, Hammamet, WTSA-16 (ITU, 2016).
- Resolution 62-2, Geneva, RA-19 (ITU, 2021b).
- ITU Council C&I related documents (ITU, 2021a).
- ITU-D Study Group Question 4/2: Terms of Reference - Final Report (ITU, 2018).
- Project - International Telecommunication Testing Center (ITU, 2009).
- Virtual Testing Pilot Project (ITU, 2021a).
- Training Activities on Conformance and Interoperability (ITU, 2021b).

- Conformity and Interoperability Assessment Studies on Regional Basis: Collaboration with Regional and Subregional Organizations for establishing a common C&I Regime and Mutual Recognition Agreements (ITU, 2015a).
- Collaboration agreements (ITU, 2021a).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Assistance in the establishment of Commercial and Industrial (C&I) programmes in developing countries: This activity is intended to facilitate the establishment of regional or sub-regional conformity and interoperability C&I Programmes, including regional or national test centres, and to encourage/assist with Mutual Recognition Agreements. Guidelines (see below) have been prepared by the ITU Telecommunication Development Bureau (BDT) in this aim and will provide basic elements to establish a strategy to establish test centres, including technical, human and instrumental resources, international standards and financial issues (ITU, 2020).

International Telecommunication Union Deliverables and Guidelines:

- ITU-D Study Group Q4/2 Report (2017): Assistance to developing countries for implementing conformance and interoperability programmes (ITU, 2018).
- Guidelines for Developing Countries on establishing conformity assessment test labs in different regions (ITU, 2021a).
- Guidelines for the development, implementation and management of Mutual Recognition Agreements (MRAs): (ITU, no date).
- Feasibility Study for a Conformance Testing Center: - Table B2 Rev. 1: Detailed cost estimation (ITU, 2013).
- Establishing Conformity and Interoperability Regimes: Basic Guidelines: (ITU, 2014).
- Establishing Conformity and Interoperability Regimes: Complete Guidelines: (ITU, 2015b).
- EUIPO-ITU Report: The Economic Cost of IPR Infringement in the Smartphones Sector (ITU, 2021c).

References

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ITU, 2013. Feasibility Study for a Conformance Testing Centre. www.itu.int/en/ITU-D/Technology/Documents/ConformanceInteroperability/FeasibilityStudy_ConformanceTestingCentre_FINAL.pdf#:~:text=This%20feasibility%20study%20for%20a%20conformance%20testing%20centre,as%20well%20as%20presenting%20best%20practice%20for%20all Accessed 20 May 2021.

ITU, 2014. Establishing Conformity and Interoperability Regimes Basic Guidelines. www.itu.int/en/ITU-D/Technology/Documents/ConformanceInteroperability/CI_BasicGuidelines_February2014_E.pdf#:~:text=Establishing%20conformity%20and%20interoperability%20regimes%3A%20Basic%20guidelines%201,standards%20and%20specifications%20for%20equipment%20and%20systems%20which Accessed 20 May 2021.

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ITU, 2021a. ITU Conformity and Interoperability Portal. www.itu.int/en/ITU-T/C-I/Pages/default.aspx Accessed 20 May 2021.

ITU, 2021b. Conformity and Interoperability. www.itu.int/en/ITU-D/Technology/Pages/ConformanceandInteroperability.aspx Accessed 20 May 2021.

ITU, 2021c. EUIPO-ITU Report: The Economic Cost of IPR Infringement in the Smartphones Sector. www.itu.int/en/ITU-D/Regulatory-Market/Pages/Counterfeiting/SmartphonesStudy.aspx Accessed 20 May 2021.

Coordinating agency or organisation

International Telecommunication Union (ITU).

TL0019 / **TECHNOLOGICAL / Cyber Hazard**

Malware

Definition

Malware is a summary term for different forms of malevolent software designed to infiltrate and infect computers, typically without the knowledge of the owner (ITU, 2008).

Reference

ITU, 2008. ITU Study on the Financial Aspects of Network Security: Malware and Spam. International Telecommunication Union (ITU). www.itu.int/ITU-D/cyb/cybersecurity/docs/itu-study-financial-aspects-of-malware-and-spam.pdf Accessed 3 October 2020.

Annotations

Synonyms

Malicious software, Viruses, Worms, Trojan horses.

Additional scientific description

In 2008, the International Telecommunication Union (ITU) reported that until a few years ago, the most common types of malware were viruses and worms. More recently other types have appeared and are widely distributed, including Trojan horses, backdoors, keystroke loggers, rootkits, and spyware. These terms correspond to the functionality and behaviour of the malware. For instance, a virus is self-propagating, and a worm is self-replicating (ITU, 2008a).

Malware is often categorised into 'families' (referring to a particular type of malware with unique characteristics) and 'variants' (usually a different version of code in a particular family). Malware is put in an information system to cause harm to that system or other systems, or to subvert them for use other than that intended by their owners (ITU, 2008a).

There are two principal ways by which malware can be inserted into information systems to carry out the malicious player's goal. One option is an automated installation, and the other is manual installation. Malware compromises the system and may download additional payload code to expand or update its functionality. Once installed, new features and capabilities are therefore easily added (ITU, 2008a).

Malware can be used to distribute spam and to support criminal activities including those based on spam. It can be used to infect systems to gain remote access for the purpose of sending data from that system to a third party without the owner's permission or knowledge. Malware can be instructed to hide that the information system has been compromised, to disable security measures, to damage the information system, or to otherwise affect the data and system integrity. Sometimes the malware uses encryption to avoid detection or conceal its means of operation (ITU, 2008a).

Metrics and numeric limits

None identified.

Key relevant UN convention / multilateral treaty

The Council of Europe (CoE) convention on cybercrime also known as the Budapest Convention is the only binding international treaty on this issue. At the time of writing the total number of countries that had ratified the convention was 64 and includes both members and non-members of the CoE (CoE, 2001).

Examples of drivers, outcomes and risk management

Malware attacks can originate in the cyber environment, such as via worms or other malware, by direct attack on critical infrastructure, such as telecommunications cables, or through the actions of a trusted insider. A combination of these attacks is also possible. Risks are often characterised as high, medium, or low. The level of risk varies among different components of the cyber environment (ITU, 2008a).

Cyber security threats and attacks are growing rapidly and a wide variety of types of malware exist, including computer viruses, worms, Trojan horses, spoofing attack identity theft, ransomware, spyware, adware, rogue software, and scareware. Some examples are summarised as follows (ITU, 2008b):

- *Worm:* a programme that reproduces by replicating itself from one system to another without the need of human involvement.
- *Viruses:* attach themselves to user files and can become active by replicating themselves into other files when an unsuspecting user performs an action such as opening an infected file.
- *Trojan horse:* conceals a harmful code that is unsuspected by a user.
- *Spoofing attack:* a complex attack that exploits trust relationships.
- *Identify theft:* involves capturing or copying personal identity details such that the legitimate owner or user may not even be aware of the theft.

Use of antivirus scanning technologies is therefore to ensure the security of a system is maintained (ITU, 2008b).

Risk management measures include the use of antivirus software to protect cyber environments against malicious code, worms and Trojan horse attacks. Internet Service Providers (ISP) can provide the software, or it can be installed via an electronic device of a user. Various techniques such as string signature, activity scanners and static heuristic scanners are used to identify malware, viruses, worms and Trojan horses (ITU, 2008b).

WannaCry is an example of Trojan horse malware that was used to extort money by holding files to ransom. In a report by the UK National Audit Office (2018), on Friday 12 May 2017 a global ransomware attack, known as WannaCry, affected more than 200,000 computers in at least 100 countries. In the UK, the attack particularly affected the National Health Service (NHS), although it was not the specific target. At 4 pm on 12 May, NHS England declared the cyber-attack a major incident and implemented its emergency arrangements to maintain health and patient care. On the evening of 12 May, a cybersecurity researcher activated a kill-switch so that WannaCry stopped locking devices. According to NHS England, the WannaCry ransomware affected at least 80 out of the 236 trusts across England, because they were either infected by the ransomware or had turned off their devices or systems as a precaution. A further 603 primary care and other NHS organisations were also infected, including 595 General Healthcare Practices. As an example of the impact of the cyber-attack on the health sector, it was reported that thousands of appointments and operations had been cancelled (UK National Audit Office, 2018).

Security is all about risk management. Many techniques can be used to manage risk. For example, the development of a defence strategy that specifies countermeasures to possible attacks may be used; detection, which includes identifying an attack in progress or afterward; formulating a response to an attack that specifies the collection of countermeasures to an attack to either stop it or reduce its impact; and formulating a recovery strategy that enables the network to resume operation from a known state (ITU, 2008a).

References

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ITU, 2008b. X.1205: Overview of cybersecurity. International Telecommunication Union (ITU). Accessed 21 November 2019.

UK National Audit Office, 2018. Investigation: WannaCry cyber attack and the NHS. HC 414 SESSION 2017–2019. www.nao.org.uk/wp-content/uploads/2017/10/Investigation-WannaCry-cyber-attack-and-the-NHS.pdf Accessed 3 October 2020.

Coordinating agency or organisation

International Telecommunication Union (ITU).

TL0020 / **TECHNOLOGICAL / Cyber Hazard**

Data Breach

Definition

A data breach is a compromise of security that leads to the accidental or unlawful destruction, loss, alteration, unauthorised disclosure of, or access to protected data transmitted, stored, or otherwise processed (ICO, no date).

Reference

ICO, no date. Personal Data Breaches. Information Commissioner's Office (ICO). https://ico.org.uk/for-organisations/guide-to-data-protection/guide-to-the-general-data-protection-regulation-gdpr/personal-data-breaches Accessed 30 April 2021.

Annotations

Synonyms

Data spill, Data leak, Security breach, Intellectual data breach.

Additional scientific description

The Ponemon Institute defined a data breach as an event in which an individual's name and a medical record and/or a financial record or debit card is potentially put at risk – either in electronic or paper format (Ponemon Institute, 2017). They identified three main causes of a data breach: malicious or criminal attack, system glitch or human error (Ponemon Institute, 2017). The costs of data breach vary according to the cause and the safeguards in place at the time of the data breach.

Metrics and numeric limits

Not available globally.

Key relevant UN convention / multilateral treaty

Convention for the Protection of Individuals with regard to Automatic Processing of Personal Data, Strasbourg 1981. The Council of Europe (CoE) convention on cybercrime also known as the Budapest Convention is the only binding international treaty on this issue. At the time of writing the total number of countries that had ratified the convention was 64 and includes both CoE members and non-members (CoE, 2001).

The Sustainable Development Goals International Telecommunications Union Global Cybersecurity Index (GCI) is a trusted reference that measures the commitment of countries to cybersecurity at a global level – to raise awareness of the importance and different dimensions of the issue. As cybersecurity has a broad field of application, cutting across many industries and various sectors, each country's level of development or engagement is assessed along five pillars – legal measures, technical measures, organisational measures, capacity building, and cooperation – and then aggregated into an overall score (ITU, 2020a).

Examples of drivers, outcomes and risk management

Cybersecurity threats and attacks are growing rapidly, these can be viruses, worms, Trojan horses, spoofing attack and identity theft (ITU, 2008). In 2017, the UN released its second Global Cybersecurity Index (GCI), and the International Telecommunication Union (ITU) reported that about 38% of countries have a published cybersecurity strategy and an additional 12% of governments are in the process of developing one (United Nations, 2017; ITU, 2020a).

The ITU reports that cybersecurity remains high on Sustainable Development Goal study group 17's (SG17) agenda (ITU, 2020b). In addition, SG17 is coordinating security standardisation work covering combating counterfeit and mobile device theft, IMT-2020, cloud based event data technology, e-health, open identity trust framework, Radio Frequency Identification (RFID), and Child Online Protection. ITU-T's Cybersecurity Information Exchange (CYBEX) offers tools to ensure rapid, internationally coordinated responses to cyber threats. The ITU-T X.1500 CYBEX ensemble of techniques is a collection of best-of-breed standards from government agencies and industry. It presents a standardised means to exchange the cybersecurity information demanded by Computer Incident Response Teams (CIRTS) and is an essential tool to prevent the contagion of cyberattacks and data breach from nation to nation (ITU, 2020b).

The US Ponemon Institute has been conducting an annual review of the cost of data breach over the past few years. In their 2017 Cost of Data Breach Study: Global Overview, they revealed that the average cost to companies of a data breach was USD 3.62 million (Ponemon Institute, 2017). Given that major sectors including healthcare, finance, retail, and e-commerce are among regular targets of data breaches, preventative and timely protection measures are vital.

An example of a data breach occurred in 2017 (Wang and Johnson, 2018). Equifax had a corporate data breach and the unauthorised personal information of 140 million customers including sensitive personal and financial information was disclosed, violating the confidentiality of protected data assets.

The components of data breach costs include: the unexpected and unplanned loss of customers following a data breach (churn rate); the size of the breach or the number of records lost or stolen; the time it takes to identify and contain a data breach; the detection and escalation of the data breach incident; post data breach costs, including the cost of notifying victims; and an attack by a malicious insider or criminal is costlier than system glitches and negligence (human factor) (Ponemon Institute, 2017).

The Ponemon Institute identified several notable points associated with the impact of data breach incidents, including: the more records lost, the higher the cost of the data breach; the faster the data breach can be identified and contained, the lower the costs; hackers and criminal insiders cause the most data breaches; incident response teams and extensive use of encryption reduce costs; and third-party involvement in a breach and extensive cloud migration at the time of the breach increases the cost.

Current thinking towards actions to reduce data breach hazards includes: having an incident response team; having extensive use of encryption; having employee training and their participation in threat sharing; developing processes for business continuity management; using cyber analytics; using systems for data loss prevention; and appointing professionals such as a Chief Privacy Officer Technology, Computer, Computer Security with Board level involvement for leadership in managing data breach reduction (Ponemon Institute, 2017).

The purchase of cyber and data breach insurance can help manage the financial consequences of the incident (Ponemon Institute, 2017).

In summary, cybersecurity is a collection of tools, policies, security concepts, security safeguards, guidelines, risk management approaches, actions, training, best practices, assurance and technologies that can be used to protect the cyber environment and organisation and user assets (ITU, 2019).

References

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Wang, P. and C. Johnson, 2018. Cybersecurity incident handling: a case study of the Equifax data breach. Issues in Information Systems, 19:150-159.

Coordinating agency or organisation

International Telecommunication Union (ITU).

TL0021 / **TECHNOLOGICAL / Cyber Hazard**

Data Security-Related Hazards

Definition

Data security is related to the preservation of data to guarantee availability, confidentiality and data integrity. Data security-related hazards include risks arising from increased system complexity because this provides opportunities for malicious cyberattacks and data loss in the case of serious incidents, including natural disasters (ITU, 2017).

References

ITU, 2017. X.1040 (10/17). Security reference architecture for lifecycle management of e-commerce business data: Information and network security – Network security. International Telecommunication Union (ITU). www.itu.int/rec/T-REC-X.1040-201710-I/en Accessed 20 November 2019.

Annotations

Synonyms

Security incidents, Security threats.

Additional scientific description

To guarantee service continuity and integrity, the information and communications technology (ICT) systems that oversee and control data security-related hazards and will need to consider, from the initial stages of inception and design, measures to ensure cybersecurity, robustness, reliability, privacy, information integrity, and crucially, resilience (ITU, 2015).

For example, the International Telecommunication Union (ITU) suggests that the resilience of ICT systems is linked to a series of attributes, which can be linked to security as follows (ITU, 2015):

- *Robustness* and ability to maintain performance and to continue operating, even under a cyber-attack or other incident (e.g., natural hazard related disaster).
- *Redundancy* of system components that allow the system to resume operations, within a defined delay of time, in the case of abrupt interruption, total or partial.
- *Flexibility and adaptability* to new circumstances, including the systems' ability to prepare for future threats by adjusting/ rectifying issues that allowed the incident to occur, or that took place during an incident.

Achieving resilience and cyber resilience in an ICT context will ensure service continuity.

Metrics and numeric limits

None identified.

Key relevant UN convention / multilateral treaty

The Convention for the Protection of Individuals with Regard to Automatic Processing of Personal Data, Strasbourg, Council of Europe 1981. The Council of Europe (CoE) convention on cybercrime also known as the Budapest Convention is the only binding international treaty on this issue. At the time of writing the total number of countries that had ratified the convention was 64 and includes both members and non-members of the CoE (CoE, 2001).

Examples of drivers, outcomes and risk management

Cybersecurity risks are growing and becoming more frequent year by year, these drivers can be viruses, worms, Trojan horses, spoofing attacks and identity theft (ITU, 2008a). Additional intentional or accidental threats include: illegal disclosure of stolen data; data that have been altered by illegal means or malware; unexpected loss of data; data contamination; and denial of access to data (ITU, 2017).

An example of a data security-related hazard occurred in 2017. Equifax had a corporate data breach and the unauthorised personal information of 140 million customers was disclosed, indicating serious issues in their data security (Wang and Johnson, 2018).

The ITU states that the purpose of cybersecurity is to ensure and maintain the levels of security for a user or organisation to prevent security risks in the cyber environment (ITU, 2003, 2008a,b).

References

CoE, 1981. Convention for the Protection of Individuals with Regard to Automatic Processing of Personal Data (Strasbourg Convention). European Treaty Series - No. 108. Council of Europe (CoE). rm.coe.int/1680078b37 Accessed 20 November 2019.

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ITU, 2008a. X.1205: Overview of cybersecurity. Series X: Data Networks and Open System Communication: Telecommuncation security. International Telecommunication Union (ITU). www.itu.int/rec/T-REC-X.1205-200804-I Accessed 20 November 2019.

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ITU, 2017. X.1040 (10/17). Security reference architecture for lifecycle management of e-commerce business data. Data Networks, Open system, communications and Security. International Telecommunication Union (ITU). www.itu.int/rec/T-REC-X.1040-201710-I/en Accessed 20 November 2019.

Wang, P. and C. Johnson, 2018. Cybersecurity incident handling: a case study of the Equifax data breach. Issues in Information Systems, 19:150-159.

Coordinating agency or organisation

International Telecommunications Union (ITU).

TL0022 / **TECHNOLOGICAL / Cyber hazard**

Disrupt

Definition

A service procedure is disrupted by another service if the second service results in service primitives of the first service not being used as specified for the procedure of the first service (ITU, 2012).

Reference

ITU, 2012. X.216: Information technology – open systems interconnection – presentation service definition (1994 E). International Telecommunication Union (ITU). www.itu.int/rec/T-REC-X.216-199407-I/en Accessed 20 December 2019.

Annotations

Synonyms

Internet resilience, Disruption tolerance, Network security.

Additional scientific description

Disruption of cyber networks is a complex issue (Seattle Office of Emergency Management, 2019) and may occur through:

- Power outages which can create cyber disruptions and if fuel delivery to generator sites is impaired, can cause extensive disruption.
- Hazards such as earthquakes, floods, and fires which can destroy computer and network equipment.
- High-powered sprinkler systems which may also cause water damage.
- Accidental damage to cables during construction or repaving projects, causing temporary internet and phone outages for thousands of customers.
- An electromagnetic pulse is an intense burst of electromagnetic energy resulting from natural (e.g., solar storms) or man-made (e.g., nuclear and pulse-power device) sources that can destroy or damage unshielded electrical and electronic equipment.
- Cyber-attack to gain unauthorised access to system services, resources, or information, or an attempt to compromise system integrity.
- Human error.

Metrics and numeric limits

The ISO/ IEC 27000 series are internationally accepted standards and guidance on the security of information and communication technology networks (ISO, 2015).

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

The internet and communication networks are critical for society today and are dependent on many digital and mobile services. These networks are exposed to a range of challenges in attempting to provide normal levels of operation, including non-performance of components, wireless communication connectivity issues, malware, attacks (interruption, interception, modification and fabrication), misconfiguration due to human error and malicious behaviour, power failure, natural hazards and disasters. These can be expanded further to include network links and nodes in a geographical area (Çetinkaya et al., 2013).

The drivers of any disruption in data and communication networks can severely affect the performance of these networks at different layers of the Open Systems Interconnect (OSI) model.

The examples in the table are of different services for network security standards to reduce the disruption of data and communication networks (Kizza, 2017):

Area of application	Service	Security standard
Internet security	Network authentication	Kerberos
	Secure Transmission Control Protocolm/ Internet Protocol (TCP/IP) communications over the Internet	IPsec
	Privacy-enhanced electronic mail	S/MIME, PGP
	Public Key Cryptography Standards	3DES, DSA, RSA, MD5, SHA-1, PKCS
	Secure Hypertext Transfer Protocol	S-HTTP
	Authentication of directory users	SSL, TLS, SET
Digital signature and encryption	Advanced encryption standard/ Public Key Infrastructure (PKI)/ digital certificates, Extensible Markup Language (XML) digital signatures	X.509, RSA BSAFE SecurXML-C, DES, AES, DSS/ DSA, EESSI, ISO 9xxx, ISO, SHA/SHS, XML digital signatures (XML-DSIG), XML Encryption (XMLENC), XML Key Management Specification (XKMS)
Login and authentication	Authentication of user's right to use system or network resources	SAML, Liberty Alliance, FIPS 112
Firewall and system security	Security of local, wide, and metropolitan area networks	Secure Data Exchange (SDE) protocol for IEEE 802, ISO/IEC 10164

References

Çetinkaya, E.K., D. Broyles, A. Dandekar, S. Srinivasan and J.P.G. Sterbenz, 2013. Modelling communication network challenges for Future Internet resilience, survivability, and disruption tolerance: A simulation-based approach. Telecommunication Systems, 52:751-766. 10.1007/s11235-011-9575-4

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Seattle Office of Emergency Management, 2019. Seattle Hazard Identification and Vulnerability Analysis. www.seattle.gov/Documents/Departments/Emergency/PlansOEM/SHIVA/SHIVAv7.0.pdf Accessed 25 October 2020.

Coordinating agency or organisation

International Telecommunication Union (ITU).

TL0023 / **TECHNOLOGICAL / Cyber Hazard**

Outage

Definition

A cyber outage is the unavailability of a service or resource (ITU, 1996).

Reference

ITU, 1996. X.791: Profile for trouble management function for ITU-T applications. Series X: Data Networks and Open system Communication. International Telecommunication Union (ITU). www.itu.int/rec/T-REC-X.791-199610-I/en Accessed 30 November 2019.

Annotations

Synonyms

Internet outage, Service outage, Network service disruption, Cyber disruption.

Additional scientific description

Cybersecurity is crucial to ensuring universal, trustworthy, and equitable access to connectivity (ITU, 2019a). Cyber outages or disruptions of service or operations are critical issues for maintaining cybersecurity.

In their summary on the role of the International Telecommunication Union (ITU) in building confidence and trust in the use of information and communication technology (ICT), the ITU stated that "Enhancing cybersecurity and protecting critical information infrastructures are essential to every nation's social and economic development. Cybersecurity-related incidents can compromise the availability, integrity and confidentiality of information transiting on networks and disrupt the operations and functioning of critical infrastructure, digital and physical. They can also compromise the security of people and whole countries where a cyberthreat is a potential malicious act that seeks to damage data, steal data, or disrupt digital life in general, irrespective of whether it actually occurs or succeeds" (ITU, 2019a). In particular, ITU noted that cyber disruptions are a cyber threat.

Metrics and numeric limits

Not found.

Key relevant UN convention / multilateral treaty

Sustainable Development Goals: The ITU Global Cybersecurity Index (GCI) is a trusted reference that measures the commitment of countries to cybersecurity at a global level – to raise awareness of the importance and different dimensions of the issue. As cybersecurity has a broad field of application, cutting across many industries and various sectors, each country's level of development or engagement is assessed along five pillars – legal measures, technical measures, organisational measures, capacity building, and cooperation – and then aggregated into an overall score (ITU, 2020b).

Convention for the protection of individuals with regard to automatic processing of personal data, Strasbourg 1981. The Council of Europe (CoE) convention on cybercrime also known as the Budapest Convention is the only binding international treaty on this issue. At the time of writing the total number of countries that had ratified the convention was 64 and includes both members and non-members of the CoE (CoE, 1981).

Examples of drivers, outcomes and risk management

Modern society expects high levels of data and communication performance, driven by the increase in use of mobile phones, computers and digital services. Network architectures are growing in scale and complexity and are exposed to a number of challenges in meeting expected levels of operational performance and reliability (Liu and Ji, 2009; Hasegawa and Uchida, 2019). The drivers of outages include non-performance of components, wireless communication connectivity issues, malware, attacks (interruption, interception, modification and fabrication), misconfiguration due to human error, power failure, and natural hazards and disasters (Erjongmanee and Ji, 2011; Djatmiko et al., 2013; Arif and Wang, 2018).

To minimise outages in data and communication networks there needs to be effective monitoring to predict network outages and ensure network resilience (Hasegawa and Uchida, 2019).

The ITU improves cybersecurity readiness, protection, and incident response capabilities of Member States by conducting CyberDrills at the regional and international level (ITU, 2020b). A CyberDrill is an annual event during which cyber-attacks, information security incidents, or other types of disruption are simulated in order to test an organisation's cyber capabilities; from being able to detect a security incident to the ability to respond appropriately and minimise any related impact. Through a CyberDrill, participants are able to validate policies, plans, procedures, processes, and capabilities that enable the preparation, prevention, response, recovery, and continuity of operations. As of 2020, the ITU has organised more than 29 CyberDrill events around the world to enhance cybersecurity capacity and capabilities through regional collaboration and cooperation (ITU, 2020a).

At the ITU/ Telecommunication Development Bureau (BDT) Cyber Security Programme on GCI, one question asked of member states is that when they conduct regular cyber security exercises such as CyberDrills, do they have a "planned event during which an organization simulates a cyber disruption to develop or test capabilities such as preventing, detecting, mitigating, responding to, or recovering from the disruption. Are the exercises organized periodically or repeatedly" (ITU, 2019b).

References

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ITU, 2020a. The ITU 2020 Global CyberDrill, September-November 2020. International Telecommunication Union (ITU). www.itu.int/en/ITU-D/Cybersecurity/Pages/Cybedrills-2020.aspx Accessed 5 October 2020.

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Coordinating agency or organisation

International Telecommunication Union (ITU).

TL0024 / **TECHNOLOGICAL / Cyber Hazard**

Personally Identifiable Information (PII) Breach

Definition

A personally identifiable information (PII) breach is a situation where PII is processed in violation of one or more relevant PII protection requirements (ITU, 2018).

Reference

ITU, 2018. Security framework for the Internet of things based on the gateway model ITU-X 1361 (09/18). Series X: Data Networks, Open System Communications and Security: Secure applications and services (2) – Internet of things (IoT) security. International Telecommunication Union (ITU). www.itu.int/rec/T-REC-X.1361-201809-I/en Accessed 4 October 2020.

Annotations

Synonyms

General Data Protection Regulation (GDPR), Information risk management, Personal data breach, Privacy breach, Identity theft, Personal information breach.

Additional scientific description

The International Telecommunication Union (ITU) 2018 Security framework for the Internet of things based on the gateway model ITU-X 1361 (09/18) includes additional agreed information for a personally identifiable information (PII) breach as follows:

Any information that (i) can be used to identify the PII principal to whom such information relates, or (ii) is or might be directly or indirectly linked to a PII principal (ITU, 2018).

To determine whether a PII principal is identifiable, account should be taken of all means which can reasonably be used by the privacy stakeholder holding the data, or by any other party, to identify that natural person.

It also addresses malicious code execution and defines this as any part of a software system or script, which is intended to cause undesired effects, security or PII breaches, or damage to a system. Typical examples includes viruses, worms, and Trojan horses (ITU, 2018).

Metrics and numeric limits

The ITU established ITU-T X. 1058 (ITU, 2017), a code of practice for PII protection. This document establishes control objectives, controls and guidelines for implementing controls, to meet the requirements identified by a risk and impact assessment related to the protection of PII. The document specifies guidelines based on ISO/IEC 27002 taking into consideration the requirements for processing PII which may be applicable within the context of an organisation's information security risk environments (ISO, 2013).

Key relevant UN convention / multilateral treaty

Convention for the protection of individuals with regard to automatic processing of personal data, Strasbourg 1981. The Council of Europe (CoE) convention on cybercrime also known as the Budapest Convention is the only binding international treaty on this issue. At the time of writing, the total number of countries that had ratified the convention was 64 and includes both members and non-members of the CoE (CoE, 1981).

Examples of drivers, outcomes and risk management

The number of organisations and amount of online personal information being processed is increasing. In turn, users expect higher levels of security relating to PII and individual data (ITU, 2017). PII can include birth dates, names of under-age individuals, addresses, passport numbers, health care information, social security numbers, driving licence numbers and bank account numbers (Zeiger and Rojas, 2016). Government ministries, departments and agencies are also exposed to PII breaches (McCallister et al., 2010).

Examples of a PII breach include: data breaches (unauthorised disclosure of personal information); security incidents (malicious attacks directed at a company); privacy violations (alleged violation of consumer privacy); and phishing/skimming incidents (individual financial crimes) (Ramanosky, 2016).

An example of a PII breach occurred in 2017. Equifax had a corporate data breach and the unauthorised personal information of 140 million customers including sensitive personal and financial information was disclosed, violating the confidentiality of protected data assets thus breaching PII (Wang and Johnson, 2018).

The International Organization for Standardization / International Electrotechnical Commission (ISO/IEC) has developed a high high-level framework for the protection of PII within information and communication technology (ICT) systems, initially agreed in 2011 and since reviewed and retained in 2017 (ISO/IEC, 2017). The privacy framework is intended to help organisations define their privacy safeguarding requirements related to PII within an ICT environment by: specifying a common privacy terminology; defining the actors and their roles in processing PII; describing privacy safeguarding requirements; and referencing known privacy principles (ISO/IEC, 2017).

The privacy framework provided within this International Standard can serve as a basis for additional privacy standardisation initiatives, such as for: a technical reference architecture; the implementation and use of specific privacy technologies and overall privacy management; privacy controls for outsourced data processes; privacy risk assessments; or specific engineering specifications (ISO/IEC, 2017).

Some jurisdictions might require compliance with one or more of the documents referenced in ISO/IEC JTC 1/SC 27 WG 5 Standing Document 2 (WG 5 SD2) — Official Privacy Documents references with other applicable laws and regulations, but this International Standard is not intended to be a global model policy, nor a legislative framework (ISO/IEC, 2017; ISO, 2020).

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Coordinating agency or organisation

International Telecommunication Union (ITU).

TL0025 / **TECHNOLOGICAL / Cyber Hazard**

Internet of Things (IOT)-Related Hazards

Definition

The Internet of Things (IoT) is a global infrastructure for the information society, enabling advanced services by interconnecting (physical and virtual) things based on existing and evolving interoperable information and communication technologies (ITU, 2012).

NOTE 1: Through the exploitation of identification, data capture, processing and communication capabilities, the IoT makes full use of things to offer services to all types of applications, while ensuring that security and privacy requirements are fulfilled.

NOTE 2: From a broader perspective, the IoT can be perceived as a vision with technological and societal implications.

The IoT is a relatively new technology that is a hazard if a data security or breach occurs.

Reference

ITU, 2012. Recommendation Y.4000/Y.2060 (06/12). Series Y: Global Information Infrastructure, Internet Protocol Aspects and Next-Generation Networks: Next Generation Networks – Frameworks and functional architecture models. International Telecommunication Union (ITU). www.itu.int/rec/T-REC-Y.2060-201206-I Accessed 3 October 2020.

Annotations

Synonyms

Industrial Internet (II), Internet of Everything (IoE), Web of Things (WoT), Industrial Internet of Things (IIoT), Ambient intelligence, Smart dust.

Additional scientific description

Device: With regard to the Internet of Things (IoT), a device is a piece of equipment with the mandatory capabilities of communication and the optional capabilities of sensing, actuation, data capture, data storage and data processing (ITU, 2012).

Thing: With regard to the IoT, a 'thing' is an object of the physical world (physical things) or the information world (virtual things), which is capable of being identified and integrated into communication networks (ITU, 2012).

Security: In the IoT, every 'thing' is connected which results in significant security threats, such as threats towards confidentiality, authenticity and integrity of both data and services. A critical example of security requirements is the need to integrate different security policies and techniques related to the variety of devices and user networks in the IoT (ITU, 2012).

Privacy protection: Privacy protection needs to be supported in the IoT. Many things have owners and users. Sensed data of things may contain private information concerning their owners or users. The IoT needs to support privacy protection during data transmission, aggregation, storage, mining and processing. Privacy protection should not set a barrier to data source authentication (ITU, 2012).

Metrics and numeric limits

Not found.

Key relevant UN convention / multilateral treaty

Not found.

Examples of drivers, outcomes and risk management

Growth of the IoT and connected smart devices will continue to increase in numbers significantly and is forecast to reach into the billions over the next few years (Gartner, 2017). There is also an increasing dependency on information and communication technology infrastructures such as the IoT to support critical infrastructure operations such as health, banking, transportation, energy and many other systems including smart cities, businesses and homes (Pacheco and Hariri, 2016).

Attacks on IoT devices can cause data breaches or disrupt functioning services (Atac and Akleylek, 2019), for example:

A cyber attack is an attack on a computer and network system that compromises security (Chi et al., 2001). This can include (Raiyn, 2014): (i) a denial of service (DoS): this is performed by a single host by flooding the information and communication technology (ICT) networks with internet traffic requests and overloading the capability of the system to deny users resources such as computers, networks or websites; (ii) a distributed denial of service (DDoS): this is a DoS performed by multiple hosts, in this particular case IoT devices under a control of a malicious user; and malware: software that is created to harm computer networks, servers, IoT devices etc.

Insufficient authentication/ authorisation processes to confirm and verify the identity of an IoT entity i.e., embedded sensors, actuators, end points that needs access to the IoT infrastructure, as well as provide permission trusts (Li and Xu, 2017).

Lack of cryptographic techniques that ensure confidentiality, integrity, authenticity, non-repudiation in data transmission and storage. Cryptography ensures the confidentiality of the data exchanged and authentication of interacting devices (Hodgson, 2019).

Software/firmware related issues include regular security updates of both software and firmware for millions of IoT devices; firmware is a type of software programmed for an IoT device that allows it to communicate and function with other devices (Zanderg et al., 2019; Huichen and Bergmann, 2016).

References

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Coordinating agency or organisation

International Telecommunications Union (ITU).

TL0026 / **TECHNOLOGICAL / Cyber Hazard**

Cyberbullying

Definition

Cyberbullying is bullying that takes place using digital devices such as cell/mobile phones, computers, and tablets. Cyberbullying can occur through SMS, e-mail, apps, social media, forums, or gaming when people view, participate in, or share content. Cyberbullying includes the deliberate sending, posting, or sharing of negative, harmful, false, or mean content about someone else. It can include sharing personal or private information about someone else causing embarrassment or humiliation. Some cyberbullying may also be unlawful or criminal behaviour (US Government, 2020).

Reference

US Government, 2020. What is Cyberbullying: Stopbullying.gov. www.stopbullying.gov/cyberbullying/what-is-it Accessed 8 November 2020.

Annotations

Synonyms

Cyber harassment, Harassment online, Online bullying, Online harassment.

Additional scientific description

The United Nations Children's Fund (UNICEF) describes cyberbullying as bullying with the use of digital technologies. It is repeated behaviour, aimed at scaring, angering or shaming those who are targeted. Examples include: spreading lies about or posting embarrassing photos of someone on social media; sending hurtful messages or threats via messaging platforms; and impersonating someone and sending mean messages to others on their behalf (UNICEF, no date).

Face-to-face bullying and cyberbullying can often happen alongside each other. But cyberbullying leaves a digital footprint – a record that can prove useful and provide evidence to help stop the abuse (UNICEF, no date).

The International Telecommunication Union (ITU) and UNICEF define cyberbullying as wilful and repeated harm inflicted through the use of computers, cell phones, and other electronic devices (ITU and UNICEF, 2015). It may involve direct (such as chat or text messaging), semi-public (such as posting a harassing message on an e-mail list) or public communications (such as creating a website devoted to making fun of the victim).

Online harassment is harassment taking place via the internet (on a social network, a forum, a multiplayer video game, blogs).

Other cyberbullying activities include: dissemination of photos or video ridiculing the person; grooming; radicalisation; non-consensual diffusion of intimate photos or personal information; dissemination of false rumours; identity theft from social media accounts; impersonating another person online; sharing private messages; creating hate websites/social media pages; excluding people from online groups; flaming, or using purposeful extreme or offensive language in order to get into online arguments and fights; and cyber stalking (PHE, 2014; Broadband Commission for Sustainable Development, 2019; Public Service France, 2020; Family Lives, no date).

Metrics and numeric limits

Not found.

Key relevant UN convention / multilateral treaty

United Nations Convention on the Rights of the Child (1990) (United Nations, 1990).

United Nations Sustainable Development Goals (United Nations, 2015).

Examples of drivers, outcomes and risk management

Research has demonstrated the causal relationship between experiencing bullying and poorer health and wellbeing outcomes in children and adolescents, with potentially long-term impacts into adulthood. The negative effect of bullying has also been demonstrated among the perpetrators of bullying and not just the victims. Moreover, there is often an interaction between being bullied and bullying others; those who are both bullies and victims (bully/victims) are likely to display the worst health and social outcomes. In summary: 20% of children and young people indicate fear of cyber-bullies made them reluctant to go to school; 5% reported self-harm; 3% reported an attempt of suicide as a direct result of cyberbullying; young people are found to be twice as likely to be bullied on Facebook as any other social networking site; and 28% of young people have reported incidents of cyberbullying on Twitter (PHE, 2014).

Socio-economic or educational disadvantage, disability, minority ethnic origin (some groups) and LGBT status are also indicators of a high risk for cyberbullying (Cross et al., 2012).

Research conducted in 28 countries, including the USA, China, India, Russia, and Brazil found that, on average, 17% of parents said their children had been a victim of cyberbullying. In India, that figure was as high as 37% (Comparitech, 2020).

References

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Coordinating agency or organisation

International Telecommunications Union (ITU).

TL0027 / **TECHNOLOGICAL / Industrial Failure**

Natech

Definition

Natural hazard triggered technological accident (Showalter et al., 1994).

Reference

Showalter, P.S. and M.F. Myers, 1994. Natural disasters in the United States as release agents of oil, chemical, or radiological materials between 1980-1989: analysis and recommendations. Risk Analysis, 14:169-182.

Annotations

Synonyms

Natech accident, Secondary technological hazard.

Additional scientific description

Natural hazards can trigger fires, explosions, and toxic or radioactive releases at hazardous installations and other infrastructures that process, store, or transport dangerous substances (Krausmann et al., 2017). These technological 'secondary effects' caused by natural hazards are also called 'Natech' accidents. They are a returning but often overlooked feature in many natural-disaster situations and have repeatedly had significant and long-term social, environmental, and economic impacts. In the immediate aftermath of a natural disaster, Natech accidents add significantly to the burden of the population already struggling to cope with the effects of the triggering natural event (Krausmann et al., 2019).

Metrics and numeric limits

In addition to country initiatives to address Natech hazards, several international bodies have started to address Natech hazards and risks. For example, the Organisation for Economic Co-operation and Development (OECD) issued a Natech addendum to its Guiding Principles for Chemical Accident Prevention, Preparedness and Response (OECD, 2021). The addendum consists of a number of modifications to the Guiding Principles and the addition of a new chapter providing more detailed guidance on Natech prevention, preparedness and response. Recognising the potential for severe acute and chronic health impacts from Natech accidents, the World Health Organization has issued information for public health authorities in the wake of chemical releases caused by natural events, focusing on earthquakes, floods and cyclones. It aims to provide brief information to planners in the health sector and to public health authorities that wish to learn more about chemical releases resulting from natural events. The United Nations Office for Disaster Risk Reduction (UNDRR) has gathered a team of experts who prepared Words into Action Guidelines for National Disaster Risk Assessment and for Man-made/Technological Hazards, both of which contain chapters that discuss actions and guidance for Natech risk reduction (UNDRR, 2020).

Recently, work on developing metrics to measure the performance of Natech risk management has been launched by the European Commission's Joint Research Centre, and a framework for a performance rating system has been proposed by researchers at Kyoto University in Japan (Suarez-Paba, 2019).

Relevant UN convention / multilateral treaty

UNECE Convention on the Transboundary Effects of Industrial Accidents (UNECE, 2017).

Examples of drivers, outcomes and risk management

Natural hazards can cause multiple and simultaneous releases of hazardous materials over extended areas, damage or destroy safety barriers and systems, and disrupt lifelines needed for accident prevention and consequence mitigation. These are also the ingredients of cascading disasters. Emergency responders are usually not prepared for or do not have the necessary resources to combat multiple release events at the same time (Feng and Li, 2018).

The risk management of an industrial installation is usually viewed in isolation from its surroundings and does not take account of the potential interactions with other industry, lifelines and nearby communities to capture the potential for cascading events and the impact on industry resilience and recovery (Krausmann et al., 2017). A call for integrated risk governance of Natech hazards has been made, which requires bringing together industry, government agencies overseeing regulatory frameworks, public health and environment authorities, city planners, emergency responders and natural hazard experts, together with potentially affected communities, in order to promote resilient territories (UNDRR, 2017).

Community encroachment on natural-hazard areas, climate change, rapid demographic changes and urbanisation all increase the exposure (and vulnerability) of the population to Natech hazards (Krausmann et al., 2017). Identification of Natech hazards is not always easy as information on technological hazards is often considered confidential and is closely held by industry unless notification and reporting obligations exist.

References

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UNDRR, 2017. Words into Action guidelines: National disaster risk assessment. United Nations Office for Disaster Risk Reduction (UNDRR). www.unisdr.org/we/inform/publications/52828 Accessed 16 September 2020.

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Coordinating agency or organisation

European Commission Joint Research Centre.

TL0028 / **TECHNOLOGICAL / Industrial Failure**

Pollution

Definition

Pollution is defined as the presence of substances and/or heat in environmental media (air, water, land) whose nature, location, or quantity produces undesirable environmental effects (UN data, no date).

Alternative definition: Pollution is defined as activity that generates pollutants (UN data, no date).

Reference

UN data, no date. Pollution. Environment Glossary / United Nations Statistics Division. http://data.un.org/Glossary.aspx?q=pollution Accessed 23 October 2020.

Annotations

Synonyms

Contamination, Poisoning.

Additional scientific description

Our food, air and water expose us to a complex mixture of chemicals and materials (UNEP, no date a).

These chemicals have a wide range of effects on health. In 2012, the World Health Organization (WHO) estimated that 23% of all deaths worldwide, amounting to 12.6 million people, were due to environmental causes; with 90% occurring in low- to middle-income countries (UNEP, 2021). In the same year, the burden of disease from environmental factors related directly to pollution in terms of death, illness and disability was estimated at 345 million Disability Adjusted Life Years (UNEP, no date a). More recently, a study indicated that pollution is currently the largest environmental cause of disease and death, responsible for an estimated 9 million premature deaths globally in 2015 (Landrigan et al., 2017). With world population growing, the numbers of vulnerable groups exposed to pollutants will increase unless urgent pollution abatement policies are implemented, and actions taken at the local level (UNEP, no date a).

Pollution can have a disproportionate and negative effect on the poor, the disadvantaged and the vulnerable. Pollution constitutes a significant impediment to achieving health, well-being, prosperity and the sustainable development goal of 'leaving no one behind' (UNEP, no date a).

There is a critical need for system-wide transformations to prevent, reduce and control pollution, toward greater resource efficiency and equity, circularity and sustainable consumption and production, and improved ecosystem resilience to support cleaner and more sustainable development (UNEP, no date a).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty includes:

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989). At the time of writing, there were 187 parties to the Basel Convention. At its 14th meeting, the Conference of the Parties to the Basel Convention adopted decision BC-14/12 by which it amended Annexes II, VIII and IX to the Convention with the aim of enhancing the control of transboundary movements of plastic waste and clarifying the scope of the Convention as it applies to such waste.

The Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (1998). The Convention promotes shared responsibility between exporting and importing countries in protecting human health and the environment from the harmful effects of such chemicals and provides for the exchange of information about potentially hazardous chemicals that may be exported and imported.

The Stockholm Convention on Persistent Organic Pollutants (2001). The Convention is a global treaty to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have harmful impacts on human health or on the environment.

Examples of drivers, outcomes and risk management

Pollution is one of the great existential challenges of the Anthropocene epoch (Landrigan et al., 2017). Pollution, especially pollution caused by industrial emissions, vehicle exhausts, and toxic chemicals, has increased sharply in the past 500 years, and the greatest increases today are seen in low-income and middle-income countries (Landrigan et al., 2017). Many organisations including the United Nations Environment Programme (UNEP), in partnership with other United Nations organisations, member states, scientists and communities at all levels has developed programmes addressing air pollution, water contamination, marine pollution, chemicals, plastics and waste and space debris. Brief summaries follow.

Air pollution: Killing an estimated 7 million people per year, air pollution is currently the biggest environmental health risk. Airborne pollutants are responsible for about one third of deaths from stroke, chronic respiratory disease, and lung cancer, as well as one quarter of deaths from heart attack. Air pollution is also strongly influencing climate and is generated from various sources, from cookstoves and kerosene lamps to coal-fired power plants, vehicle emissions, industrial furnaces, wildfires, and sand and dust storms. The problem is most acute in urban areas, particularly in Africa and Asia. In low- and middle-income countries, 98% of cities with more than 100,000 inhabitants fail to meet the WHO air quality guidelines. Addressing air pollution can bring significant benefits for economies, human health, and the climate. This underlies global efforts by UNEP to tackle air pollution by supporting cleaner fuels and vehicles, inspiring individuals and city leaders to act, strengthening laws and institutions, and developing affordable technologies to monitor air quality (UNEP, no date b).

Water contamination: UNEP reports that once water is contaminated, it is difficult, costly, and often impossible to remove the pollutants (UNEP, no date c). Currently, 80% of global wastewater goes untreated, and is contaminated by a wide range substances, from human waste to highly toxic industrial discharges. The type and amount of pollutants in freshwater determines its suitability for human uses such as drinking, bathing, and agriculture. Pollution of freshwater ecosystems can also impact the habitat and quality of life of fish and other wildlife. This can include pathogens (largely from human and animal waste), organic matter (including nutrients from agricultural run-off such as nitrogen or phosphorus), chemical pollution (from irrigation, domestic wastewater and runoff of mines into rivers) and salinity. Plastics, and chemicals of emerging concern such as certain pharmaceutical products, are issues for which their extent and impacts on freshwater are largely unknown. A 2016 preliminary assessment of water quality in rivers in Latin America, Africa and Asia, A Snapshot of the World's Water Quality (Ringler, et al., 2016), estimated that severe pathogenic pollution affects around one third of all rivers, severe organic pollution around one seventh of all rivers, and severe and moderate salinity pollution around one-tenth of all rivers in these regions (UNEP, no date c).

Marine pollution: Municipal, industrial and agricultural wastes and run-off account for as much as 80% of all marine pollution (UNEP, no date e). Sewage and waste water, persistent organic pollutants (including pesticides), heavy metals, oils, nutrients and sediments - whether from rivers or discharged directly into coastal waters – can have significant impacts on human health and coastal ecosystems. The result is more carcinogens in seafood, more closed beaches, more red tides, and more beached carcasses of seabirds, fish and even marine mammals. One billion people in developing countries depend on fish for their primary source of protein, making them vulnerable to the chemicals they carry. The first regional steps to address this widespread issue were taken in the Mediterranean, with the adoption of the Protocol on Land-Based Sources of Pollution in May 1980 (UNEP, 1980). Over the next two decades, this landmark agreement led to similar regional agreements in other Regional Seas (UNEP, no date d).

Chemicals, plastics and waste: As the world's population approaches 8 billion, the need for sound management of chemicals and waste is increasing. UNEP promotes joint approaches to the environment and health that demonstrate the economic, environmental and health advantages of sound chemical management for all concerned to stimulate policies and investment to reduce chemical risks to health and environment (UNEP, no date e). By 2025, the world's cities are forecast produce 2.2 billion tonnes of waste per year, more than three times the amount produced in 2009 (UNEP, no date e). An important chemical-generating pollution is plastic. The presence of plastic in the environment and in particular in marine sediments can be seen as a stratigraphic indicator of the Anthropocene era (Zalasiewicz et al., 2016). Plastic pollution has mostly been studied in marine ecosystems (e.g., Eriksen et al., 2014; Haward, 2018), including seabirds (Wilcox et al., 2015), but freshwater ecosystems (Blettler et al., 2018) and soil ecosystems (Chae and An, 2018) are also affected. The accumulation of plastic, especially micro- and nano-plastics is a threat to human health (e.g., Revel et al., 2018).

Space debris: Pollution also extends to the Lower Earth Orbit (LEO) where millions of pieces of debris are found. These are mostly of anthropogenic origin, such as pieces of space craft, flecks of paint from a spacecraft, parts of rockets, or satellites that are no longer working. These objects fly at high speed (up to 18,000 miles per hour) and together with the amount of debris present puts astronauts and equipment in space at risk. Some of the equipment at risk is essential to global communication and earth monitoring networks, including weather and hazard forecast and early warning systems (NASA, 2019). There are no international space laws to clean up debris in the LEO, from where it is expensive to remove space debris because there are almost 6000 tons of material in LEO. The NASA Orbital Debris Program began in 1979 in the Space Sciences Branch at the Johnson Space Center in Houston, Texas. The programme looks for ways to create less orbital debris, and designs equipment to track and remove debris already in space (NASA, 2019).

Risk management mechanisms for pollution/contamination prevention and control are essential and may include: local, national and global policies, strategies and legislation; planning and coordination (at all levels – national, subnational, local, including regional and transboundary); financial and human resources with a trained multidisciplinary workforce capacity; information and knowledge management for risk assessments, early warning and surveillance and technical guidance and support; mechanisms for risk communication; infrastructure support to include environmental and health services; and facilities for monitoring and evaluating drivers, impacts, outcomes and controls and reporting to local, national and international partners and organisations.

The WHO works closely with countries and partners to monitor and report on their emergency preparedness capacities for all hazards, including for chemical incidents relating to pollution and contamination. Surveillance of diseases of possible chemical etiology is a daily element in the WHO's outbreak alert and response activities (WHO, 2020). Other health-related resources include the WHO Health Emergency and Disaster Risk Management Framework (WHO, 2019). This has been designed to help manage the recovery phase of a pollution incident where contamination has affected food production systems, inhabited areas and water environments, further information can be found in the UK Recovery Handbook for Chemical Incidents (PHE, 2020).

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Coordinating agency or organisation

Not identified.

TL0029 / **TECHNOLOGICAL / Industrial Failure**

Explosion

Definition

Explosion-related technological incidents can be defined as accidental or intentional events that result in the actual or potential exposure of responders and/or members of the public to a chemical hazard (adapted from WHO, no date).

References

WHO, no date. Technical Hazard Sheet -Technological Disaster Profiles. World Health Organization (WHO). www.who.int/hac/techguidance/ems/chemical_insidents/en Accessed 23 October 2020.

Annotations

Synonyms

Not applicable.

Additional scientific description

The effects of explosions can be devastating in terms of lives lost, injuries, damage to property and the environment, and to business continuity. Working with flammable liquids, dusts, gases and solids is hazardous because of the risk of explosion and potentially a subsequent fire (HSE, no date).

Explosions include accidents at hazardous installations (such as chemical plants) and accidents while hazardous substances are in transport (such as by tankers or lorries). Notable examples of chemical plant explosions include those at the Piper Alpha oil platform in the North Sea in 1986 (Cullen, 1990), the AZF fertiliser factory in Toulouse, France in 2001 (French Ministry of Sustainable Development, 2013) and the Buncefield oil storage depot in 2005 (HSE, 2011). Fires and explosions are frequently grouped together but an explosion can happen without a fire.

Explosion-related technological incidents can be sudden and acute, when hazardous chemicals are 'overtly' released into the environment. The factors leading up to an incident include poor maintenance of manufacturing and storage equipment, lack of regulation and/or poor enforcement of safety regulations, road traffic accidents, human error, natural events such as heavy rain, earthquakes, hurricanes, floods, and terrorism (WHO, no date).

Most explosion-related technological incidents occur at the interfaces between transport, storage, processing, use, and disposal of hazardous chemicals, where these systems are more vulnerable to failure, error or manipulation. Exposure levels generally differ for the different people involved in a chemical incident (WHO, no date):

- *Employees and other on-site persons:* usually more than one exposure pathway, often inhalation (breathing) of smoke and vapours and skin contact from splashing and clean-up of chemicals.
- *Emergency services:* usually close to the emergency and involved in rescue, containment of chemicals, managing the impact of the explosion and extinguishing fires; primary and secondary contamination of fire officers, ambulance officers, other emergency staff; secondary contamination of medical staff and other hospital patients of incomplete decontamination of causalities.
- *Public:* exposure via air, water, food, soil etc.

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

No globally agreed treaty identified.

Regional Directive: Europe example: Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC Text with EEA relevance, Applies to European Commission Member States (European Parliament and Council, 2012). In Europe, the catastrophic accident in the Italian town of Seveso in 1976 prompted the adoption of legislation on the prevention and control of such accidents. The so-called Seveso-Directive (Directive 82/501/EEC) was later amended in view of the lessons learned from later accidents such as Bhopal, Toulouse or Enschede resulting in Seveso-II (Directive 96/82/EC). In 2012, Seveso-III (Directive 2012/18/EU) was adopted taking into account, among others, the changes in the European Union legislation on the classification of chemicals and increased rights for citizens to access information and justice. The Directive applies to more than 12,000 industrial establishments in the European Union where dangerous substances are used or stored in large quantities, mainly in the chemical and petrochemical industry, as well as in fuel wholesale and storage (including the liquefied petroleum gas and liquefied natural gas) sectors (European Commission, 2020).

Examples of drivers, outcomes and risk management

Factors that affect the vulnerability of responders and the general public to an explosion include the nature of the hazard, the level of exposure, availability and quality of shelter, availability of personal protective equipment (PPE), access into and out of the site, the degree to which employees and responders (and possibly the general public) are prepared and trained to deal with a chemical release and the amount of training provided. Vulnerability can be reduced by ensuring that information is available on: the incident; measures being taken to contain the release; who is currently under threat; what the health effects might be from exposure; what the public can actually do to protect themselves; and how to get further information; when, where and how it will be available (WHO, no date).

Some individuals and sub-populations are at increased risk because they are more susceptible to the adverse effects of a given exposure. Among the potential causes of enhanced susceptibility are inherent genetic variability; age; gender; pre-existing disease (e.g., diabetes, asthma, chronic obstructive pulmonary disease); inadequate diet; occupational, environmental or lifestyle factors (e.g., smoking); and stress and inadequate access to health care (WHO, no date).

In most cases the mechanisms and health outcomes of exposure are unknown. Symptoms may present differently depending upon the explosion and any products of combustion and chemicals and other material involved in the explosion. In general, adverse health outcomes to toxic chemical exposure include:

- Effects that are local or arise at the site of contact with the products of combustion and chemicals, such as bronchoconstriction from respiratory irritants, or irritation of the skin and eyes by gases, liquids and solids.
- Effects that are systemic or affect organ systems remote from the site of absorption, such as depression of the central nervous system from inhalation of solvents, or necrosis of the liver from the inhalation of carbon tetrachloride.
- Effects on mental health arising from real or perceived releases, which depend on the psychosocial stress associated with an incident.

The time elapsing between exposure and the onset of symptoms can vary. Some effects, for example eye and respiratory irritation or central nervous system depression, can occur rapidly, within minutes or hours of exposure (acute effects). Other effects, for example congenital malformations or cancers, may take months or years to appear (delayed effects). The duration of the symptoms can also vary, from short term, to long term or chronic. Chemical incidents (especially acts of terrorism) may also cause fear and anxiety in populations (WHO, no date).

Risk management measures can be grouped under the categories prevention and control, preparedness and response (WHO, no date).

Prevention and control

Being aware of explosive related hazards: locating chemical sites away from centres of population; registration of all chemicals in commercial establishments with a hazard inventory to ensure rapid identification of the released chemical; regular evaluation of plans and their implementation; inspection/monitoring and enforcement of safety measures; reducing the amounts of chemicals stored; appropriate labelling of all chemicals; rapid notification of the chemical incident emergency services in the event of a chemical release; regular surveillance and standardized reporting of incidents, including the small, commonly occurring incidents; measures to decontaminate land or water already contaminated by waste disposal; measures to prevent or contain any fire-fighting water run-off; and construction of drainage ditches or holding tanks to contain liquid chemicals.

In any chemical incident, there are a number of essential steps to go through as part of the chemical incident plan. In approximate chronological order these are: alerting the health care services; best outcome assessment of actions and management options; environmental monitoring; public information and public warnings; advice on protection; sheltering or evacuation; other interventions to protect public health; and organising registers and samples.

Preparedness

Careful planning and thorough preparedness are prerequisites for an effective response to chemical incidents. Public authorities, at all levels, and the management staff of installations where hazardous chemicals are produced, stored etc. should establish emergency preparedness plans. All responsible parties should ensure that manpower equipment, and financial and other resources necessary to carry out emergency plans are readily available for immediate activation in the event, or imminent threat of an accident. In addition, all personnel involved in the emergency response process should be adequately educated and trained.

Response

Depending on the level of potential exposure, risk zones are usually established around an incident:

- The hot zone, is the area where first responders must use protective equipment to prevent primary contamination.
- The warm zone, which surrounds the hot zone, is the area where appropriate PPE must be worn to prevent secondary contamination.
- The cold zone is the uncontaminated area between the inner cordon and the outer cordon where it has been assessed that there is no immediate threat to life.
- The decontamination line separates the warm zone from the cold zone.
- A vulnerable zone (in effect a potential hot zone) can be declared, which is the area likely to be contaminated if the emergency response action is not successful. The population within the vulnerable zone includes the resident population as well as the working population (in the plant and in the area), and other populations in the area at certain times, such as motorist, tourists and visitors to entertainment facilities.

Consider contacting the nearest Poisons Centre in the case advice on diagnoses and treatment of chemical poisonings is needed. Also consider setting-up a public health team which, in the case of an explosion related chemical incident, will provide accident and emergency departments with information about the nature of the chemicals(s), any precautions to be taken, and information about secondary contamination and how to decontaminate casualties, staff and equipment. Further details and guidance can be found in WHO manual on the public health management of chemical incidents (WHO, 2009).

Designed to help manage the recovery phase of a chemical incident where contamination has affected food production systems, inhabited areas and water environments, further information can be found in the UK recovery handbook for chemical incidents (PHE, 2020).

The WHO works closely with countries and partners to monitor and report on their emergency preparedness capacities for all hazards, including for chemical incidents. Surveillance of diseases of possible chemical etiology is a daily element in the WHO outbreak alert and response activities (WHO, 2020).

The WHO also convenes regional meetings to strengthen the global network of poison centres and thus facilitate emergency responses to chemical incidents. Guidance and training materials to strengthen preparedness for chemical incidents and emergencies have been developed in collaboration with the Organisation for Economic Co-operation and Development, the Inter-Organization Programme for the Sound Management of Chemicals, and relevant organizations in the United Nations system (WHO, 2020).

Additional resources include the WHO human health risk assessment toolkit for chemical hazards (WHO, ILO and UNEP, 2011) and the guidance document on evaluating and expressing uncertainty in hazard characterization (WHO and IPCS, 2018).

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Coordinating agency or organisation

World Health Organization (WHO) with partners including the International Labour Organization and the United Nations Environment Programme.

TL0030 / **TECHNOLOGICAL / Industrial Failure**

Leaks and Spills

Definition

A leak or a spill is an incident involving the uncontrolled release of a toxic substance, potentially resulting in harm to public health and the environment. Chemical incidents can occur as a result of natural events, or as a result of accidental or intentional events. These incidents can be sudden and acute or have a slow onset when there is a 'silent' release of a chemical. Chemical leaks and spills can range from small releases to full-scale major emergencies (adapted from WHO, 2020).

Reference

WHO, 2020. Chemical incidents. World Health Organization (WHO). www.who.int/health-topics/chemical-incidents/#tab=tab_1 Accessed 23 October 2020.

Annotations

Synonyms

Not applicable.

Additional scientific description

Three notable examples of technological incidents involving a chemical leak and/or spill are the Seveso chemical leak, the Bhopal chemical leak and the Exxon Valdez oil spill.

Seveso chemical leak: At approximately 12:37 on Saturday 10 July 1976, a bursting disc on a chemical reactor ruptured at the Icmesa chemical company, Seveso, Italy. Maintenance staff heard a whistling sound and a cloud of vapour was seen to issue from a vent on the roof. A dense white cloud, of considerable altitude drifted offsite. Among the substances in the white cloud was a small deposit of 2,3,7,8-tetrachlorodibenzo-p-dioxin ('TCDD' or 'dioxin'), a highly toxic material. The release lasted for twenty minutes. Over the next few days there was confusion due to the lack of communication between the company and the authorities in dealing with this type of situation. The nearby town of Seveso, located 15 miles from Milan, had 17,000 inhabitants. No human deaths were attributed to TCDD but many people fell ill. Thousands of animals in the contaminated area died and many thousands more were slaughtered to prevent TCDD entering the food chain (HSE, no date).

Bhopal chemical leak: On 3 December 1984, more than 40 tons of methyl isocyanate gas leaked from a pesticide plant in Bhopal, India. The gas drifted over the densely populated neighbourhoods around the plant killing thousands of people immediately. The leak also had long-term effects on health, with estimates of over 15,000 people killed in the years following the leak. This event highlighted the need for enforceable international standards for environmental safety, preventative strategies to avoid similar accidents and industrial disaster preparedness (Broughton, 2005).

Exxon Valdez oil spill: On 24 March 1989, the oil tanker Exxon Valdez ran aground on a charted rock, Bligh Reef, in Alaska's northern Prince William Sound. More than 11 million litres of crude oil spilled, eventually polluting over 30,000 km2 of coastal and offshore waters (Peterson et al., 2003).

Technological incidents such as chemical spills and leaks can be sudden and acute, when hazardous chemicals are 'overtly' released into the environment. Some chemical leaks and spillages may also result in fires, explosions and contamination of land. The factors leading up to an incident include poor maintenance of manufacturing and storage equipment, lack of regulation and/or poor enforcement of safety regulations, road traffic accidents, human error, natural events such as heavy rain, earthquakes, hurricanes, floods, and terrorism (WHO, no date).

Chemical spills and leaks are one of the issues addressed by the Food and Agriculture Organization of the United Nations (FAO). They report that spills and leaks from containers are a major problem in the storage and transport of pesticides. The main cause of these spills and leaks is rough handling which dents drums, weakens or splits seams and weakens closures (lids, caps, stoppers). Leaks also result from corrosion of the container, which may be accelerated by mechanical damage (dents may rupture drum linings). Corrosion may start internally, with the pesticide itself or its breakdown products being the primary cause. Alternatively, corrosion may begin externally, due to rusting in damp storage conditions or contamination from chemicals leaking from nearby containers. Rodents may damage paper, board or fibre containers. Termites may attack paper and card. Pesticides should be repacked in containers made of the same materials as the original containers because some chemicals are not compatible with different materials (FAO, no date).

Most chemical spill-related technological incidents occur at the interfaces between transport, storage, processing, use, and disposal of hazardous chemicals, where these systems are more vulnerable to failure, error or manipulation. Exposure levels will in general be quite different for different people involved in a chemical incident (WHO, no date):

- *Employees and other on-site persons:* usually more than one exposure pathway, often inhalation (breathing) of smoke and vapours and skin contact from splashing and clean-up of chemicals.
- *Emergency services:* usually close to the emergency and involved in rescue, containment of chemicals, managing the impact of chemical spills; primary and secondary contamination of fire officers, ambulance officers, other emergency staff; secondary contamination of medical staff and other hospital patients of incomplete decontamination of casualties.
- *Public:* exposure via air, water, food, soil etc.

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

No globally agreed treaty identified.

Regional Directive: Europe example: Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC Text with EEA relevance, Applies to European Commission Member States (European Parliament and Council, 2012). In Europe, the catastrophic accident in the Italian town of Seveso in 1976 prompted the adoption of legislation on the prevention and control of such accidents. The so-called Seveso-Directive (Directive 82/501/EEC) was later amended in view of the lessons learned from later accidents such as Bhopal, Toulouse or Enschede resulting in Seveso-II (Directive 96/82/EC). In 2012, Seveso-III (Directive 2012/18/EU) was adopted taking into account, among others, the changes in the European Union legislation on the classification of chemicals and increased rights for citizens to access information and justice. The Directive applies to more than 12,000 industrial establishments in the European Union where dangerous substances are used or stored in large quantities, mainly in the chemical and petrochemical industry, as well as in fuel wholesale and storage (including the liquefied petroleum gas and liquefied natural gas) sectors (European Commission, 2020).

Examples of drivers, outcomes and risk management

Factors that affect the vulnerability of responders and the general public to a leak or spill include the nature of the hazard, the level of exposure, availability and quality of shelter, availability of personal protective equipment (PPE), access into and out of the site, the degree to which employees and responders (and possibly the general public) are prepared and trained to deal with a chemical release and the amount of training provided. Vulnerability can be reduced by ensuring that information is available on: the incident; measures being taken to contain the release; who is currently under threat; what the health effects might be from exposure; what the public can actually do to protect themselves; and how to get further information; when, where and how it will be available (WHO, no date).

Risk management measures can be grouped under the categories prevention and control, preparedness and response.

Prevention and control

Being aware of chemical incident related hazards: locating chemical sites away from centres of population; registration of all chemicals in commercial establishments with a hazard inventory to ensure rapid identification of the released chemical; regular evaluation of plans and their implementation; inspection/monitoring and enforcement of safety measures; reducing the amounts of chemicals stored; appropriate labelling of all chemicals; rapid notification of the chemical incident emergency services in the event of a chemical release; regular surveillance and standardised reporting of incidents, including the small, commonly occurring incidents; measures to decontaminate land or water already contaminated by waste disposal; measures to prevent or contain any fire-fighting water run-off; and construction of drainage ditches or holding tanks to contain liquid chemicals (WHO, no date).

In any chemical incident, there are a number of essential steps to go through as part of the chemical incident plan. These steps include alerting the emergency services; assessment of actions and management options; environmental monitoring; public information and public warnings; advice on protection; sheltering or evacuation; other interventions to protect public health; and organising registers and samples as required (WHO, no date; National CBRN Centre, 2016).

Preparedness

Careful planning and thorough preparedness are prerequisites for an effective response to chemical incidents. Public authorities, at all levels, and the management staff of installations where hazardous chemicals are produced, stored etc. should establish emergency preparedness plans. All responsible parties should ensure that manpower, equipment, and financial and other resources necessary to carry out emergency plans are readily available for immediate activation in the event, or imminent threat of an accident. In addition, all personnel involved in the emergency response process should be adequately educated and trained (WHO, no date; National CBRN Centre, 2016).

Response

Depending on the level of potential exposure from chemical leaks and spills consider, if appropriate, setting up, risk zones. These are usually established around an incident:

- The hot zone, is the area where first responders must use protective equipment to prevent primary contamination and is the area with actual or potential contamination and the highest potential for exposure.
- The warm zone, which surrounds the hot zone, is the area where appropriate personal protective equipment must be worn to prevent secondary contamination. The warm zone is an area uncontaminated by the initial release of a substance, which becomes contaminated by the movement of people or vehicles. The warm zone will be extended to include the area of decontamination activity. These areas cannot be guaranteed as free from contamination.
- The cold zone is the uncontaminated area between the inner cordon and the outer cordon where it has been assessed that there is no immediate threat to life.
- The decontamination line separates the warm zone from the cold zone, which is the area free from contamination (National CBRN Centre, 2016).

Consider contacting the nearest Poisons Centre in the case advice on diagnoses and treatment of chemical poisonings is needed. Also consider setting-up a public health team which, in the case of a spill related chemical incident, will provide accident and emergency departments with information about the nature of the chemicals(s), any precautions to be taken, and information about secondary contamination and how to decontaminate casualties, staff and equipment. Further details and guidance can be found in the WHO manual on the public health management of chemical incidents (WHO, 2009).

Designed to help manage the recovery phase of a chemical incident where contamination has affected food production systems, inhabited areas and water environments, further information can be found in the UK recovery handbook for chemical incidents (PHE, 2020).

The World Health Organization (WHO) works closely with countries and partners to monitor and report on their emergency preparedness capacities for all hazards, including for chemical incidents. Surveillance of diseases of possible chemical etiology is a daily element in the WHO outbreak alert and response activities (WHO, 2020).

The WHO also convenes regional meetings to strengthen the global network of poison centres and thus facilitate emergency responses to chemical incidents. Guidance and training materials to strengthen preparedness for chemical incidents and emergencies have been developed in collaboration with the Organisation for Economic Co-operation and Development, the Inter-Organization Programme for the Sound Management of Chemicals, and relevant organizations in the United Nations system (WHO, 2020).

Additional resources include the WHO human health risk assessment toolkit for chemical hazards (WHO, ILO and UNEP, 2011) and the guidance document on evaluating and expressing uncertainty in hazard characterization (WHO and IPCS, 2018).

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Coordinating agency or organisation

Not identified.

TL0031 / **TECHNOLOGICAL / Industrial Failure**

Soil Pollution

Definition

Soil pollution refers to the presence of a chemical or substance out of place and/or present in a soil at higher than normal concentration that has adverse effects on any non-targeted organism (Rodríguez-Eugenio et al., 2018).

Reference

Rodríguez-Eugenio, N., M. McLaughlin and D. Pennock, 2018. Soil Pollution: A Hidden Reality. Food and Agriculture Organization of the United Nations. www.fao.org/3/i9183en/i9183en.pdf

Annotations

Synonyms

Contaminated Land, Special sites, 'Brownfield' sites, Soil contamination.

Additional scientific description

Human activities over thousands of years have left a legacy of polluted soils worldwide. Much of it is local soil contamination which occurs commonly in connection to past and present mineral extraction, industrial activities, waste management and disposal, and includes remnants of hazardous materials such as obsolete pesticides. Countless chemical agents, some of them highly persistent, are found at various levels in the ground and can enter groundwater and surface water, locally produced food, and can even become airborne (gases, vapours, dusts, particulates). Soil pollution and its adverse health effects have been documented in many cases, but the magnitude of the overall impact on human health is not known. This is in contrast to air or water pollution, for which reliable estimates of their impacts have been available for two decades (FAO, 2018).

Soil pollution has been identified as one of the main soil threats affecting global soils and the ecosystem services that they provide (FAO and ITPS, 2015). Soil pollution poses a serious risk to human health through direct contact (dermal exposure, inhalation of polluted soil particles, intentional ingestion of polluted soil) or indirectly, by consuming plants or animals that have accumulated significant amounts of soil contaminants (FAO, 2018). For example, in an area of Japan where soil has been contaminated with cadmium from zinc/lead mines, Itai-itai disease used to be widespread and is still seen in women over 50 years of age. Itai-itai disease is characterised by osteomalacia, osteoporosis, painful bone fractures and kidney dysfunction (WHO, 2019). Health risks associated with the widespread soil pollution by radionuclides released during the Chernobyl disaster in 1986 are an enduring memory for many people (Rodríguez-Eugenio et al., 2018).

Despite efforts in many regions of the world to estimate the extent of soil pollution, the lack of harmonised and comprehensive data at national, regional and global level limits the mobilisation of economic resources to minimise soil pollution and to achieve public and private commitment to combating soil pollution. There is a need to translate sound scientific evidence into concrete actions to prevent, control and remediate soil pollution (FAO, 2018).

Remediation of polluted soils is essential, and research continues to develop novel, science-based remediation methods. Increasingly, expensive physical remediation methods such as chemical inactivation or sequestration in landfills are being replaced by science-based biological methods such as enhanced microbial degradation or phytoremediation (Rodríguez-Eugenio et al., 2018). The maintenance of soil health and the prevention and reduction of soil pollution are possible through promoting sustainable soil management practices, environmentally friendly industrial processes, reduction of waste generation, recycling and reuse of goods, and sustainable waste storage (FAO, 2018).

The risks to human health posed by contaminated soils is assessed by comparing a representative soil concentration with chemical specific assessment criteria indicative of 'safe' levels of exposure. There is no international standard for deriving these criteria. For example, Jennings (2013) compared the range of American standards with standards used elsewhere around the world. A total of 5949 guidance values for 57 elements were identified across the US regulatory authorities and assessment criteria values were seen to have been published in at least 71 other United Nations member states.

Metrics and numeric limits

No globally agreed metrics have been identified.

Key relevant UN convention / multilateral treaty

United Nations (2015) Sustainable Development Goals (United Nations, 2015). The prevention of soil pollution could reduce soil degradation, increase food security, contribute substantially to the adaptation and mitigation of climate change, and contribute to the avoidance of conflict and migration. Therefore, by taking immediate actions against soil pollution, contributions to the achievement of almost all the Sustainable Development Goals (SDGs) are possible, with a significant impact on SDGs 1, 2, 3, 6, 9, 11, 12, 13, 14, 15 and 17 (FAO, 2018).

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989). At the time of writing, there were 187 parties to the Basel Convention (Basel Convention, 2011). At its fourteenth meeting, the Conference of the Parties to the Basel Convention adopted decision BC-14/12 by which it amended Annexes II, VIII and IX to the Convention with the objectives of enhancing the control of the transboundary movements of plastic waste and clarifying the scope of the Convention as it applies to such waste.

Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (1998). The Convention promotes shared responsibility between exporting and importing countries in protecting human health and the environment from the harmful effects of such chemicals and provides for the exchange of information about potentially hazardous chemicals that may be exported and imported.

Stockholm Convention on Persistent Organic Pollutants (2001). The Convention is a global treaty to protect human health and the environment from chemicals that remain intact in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and have harmful impacts on human health or on the environment.

Minamata Convention on Mercury (UNEP, 2013). The Convention is a global treaty to protect human health and the environment from the adverse effects of mercury, which includes a ban on new mercury mines, the phase-out of existing ones, the phase out and phase down of mercury use in a number of products and processes, control measures on emissions to air and on releases to land and water, and the regulation of the informal sector of artisanal and small-scale gold mining. The Convention also addresses interim storage of mercury and its disposal once it becomes waste, sites contaminated by mercury, and health issues.

Examples of drivers, outcomes and risk management

Soil plays a key role in food production and food quality, in climate regulation and in the provision of raw materials and other resources. Notwithstanding the enormous scientific progress made to date, protection and monitoring of soil condition at national and global levels still face complicated challenges impeding effective on-the-ground policy design and decision making (FAO, 2018).

Key drivers for the assessment of contaminated land in the UK, primarily in the context of urban development, include remediation of contamination identified as impacting on groundwater quality or ecology and remediating brownfield sites for a change of land use and in particular development for housing. To this local management, using soil guidance values and land quality management is essential (European Commission, no date). As examples of local risk assessment and management the sites of the 2000 Olympic Games in Sydney and the 2012 Olympic Games in London (Mead et al., 2013) were successfully remediated contaminated land sites. However, further remediation could be required for any future land-use change involving more sensitive end-use, such as redevelopment for domestic gardens.

A number of assessment models and tools are available via CLARINET, the Concerted Action of the European Commission's Environment and Climate Research and Development Programme, which provides access to technical recommendations based on the concept of Risk Based Land Management for decision-making (EUGRIS, 2008). Also, in the European context, NICOLE is a European forum for the dissemination and exchange of good practice, practical and scientific knowledge and ideas to manage contaminated land in a sustainable and collaborative way.

The outcome document of the Global Symposium on Soil Pollution 'Be the Solution to Soil Pollution' (FAO, 2018) recommends an active and effective implementation of the Voluntary Guidelines for Sustainable Soil Management, which were developed through an inclusive process and endorsed by the 155th session of the FAO Council (Rome, 5 December 2016) (FAO, 2017). Their implementation is important in order to progress with the accomplishment of several of the sustainable soil management objectives, such as: to ensure that the availability and flows of nutrients are appropriate to maintain or improve soil fertility and productivity, and to reduce their losses to the environment; to reduce soil salinisation, sodification and alkalinisation; to ensure that water is efficiently infiltrated and stored to meet the requirements of plants and ensure the drainage of any excess; to ensure that contaminants are below toxic levels, i.e., those which would cause harm to plants, animals, humans and the environment; to guarantee that soil biodiversity provides a full range of biological functions; and to undertake soil management (FAO, 2018).

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Coordinating agency or organisation

Food and Agriculture Organization of the United Nations in partnership with Global Soil Partnership (GSP), Intergovernmental Technical Panel on Soils (ITPS), Basel, Rotterdam and Stockholm Conventions Secretariat (BRS Conventions); United Nations Environment Programme (UN Environment) and the World Health Organization (WHO).

TL0032 / **TECHNOLOGICAL / Industrial Failure**

Fire

Definition

Fire related technological incidents can be defined as accidental or intentional events that result in the actual or potential exposure of responders and/or members of the public to a chemical hazard (adapted from WHO, no date)

References

WHO, no date. Technical Hazard Sheet - Technological Disaster Profiles. World Health Organization (WHO). www.who.int/hac/techguidance/ems/chemical_insidents/en Accessed 23 October 2020.

Annotations

Synonyms

Not applicable.

Additional scientific description

The effects of fires or explosions can be devastating in terms of lives lost, injuries, damage to property and the environment, and to business continuity. Working with flammable liquids, dusts, gases and solids is hazardous because of the risk of fire and explosion (HSE, no date).

Fire-related chemical incidents may also include explosion, spills, leaks and contamination.

Notable examples of fire-related technological incidents include the Piper Alpha oil platform disaster, UK, 1986 (Cullen, 1990), the Kuwaiti oil fires in 1991 (Al-Damkhi et al., 2009), the World Trade Centre fires in New York, USA in 2001 (Klitzman and Freudenberg, 2003), and the explosion and fire at the Buncefield oil storage depot, UK, in 2005 (HSE, 2011).

Fire-related technological incidents can be sudden and acute, when hazardous chemicals are 'overtly' released into the environment. The factors leading up to an incident include poor maintenance of manufacturing and storage equipment, lack of regulation and/or poor enforcement of safety regulations, road traffic accidents, human error, natural events such as heavy rain, earthquakes, hurricanes, and floods, and terrorism (WHO, no date).

Most fire-related technological incidents occur at the interfaces between transport, storage, processing, use, and disposal of hazardous chemicals, where these systems are more vulnerable to failure, error or manipulation. Exposure levels will in general be quite different for different people involved in a chemical incident (WHO, no date):

- *Employees and other on-site persons*: usually more than one exposure pathway, often inhalation of smoke, vapour and skin contact from splashing and clean-up of chemicals
- *Emergency services*: usually close to the emergency and involved in rescue, containment of chemicals, managing the impact of fires; primary and secondary contamination of fire officers, ambulance officers, other emergency staff; secondary contamination of medical staff and other hospital patients of incomplete decontamination of causalities.
- *Public*: exposure via air, water, food, soil etc.

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

A globally agreed treaty was not identified.

Regional Directive: Europe example: Directive 2012/18/EU of the European Parliament and of the Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC Text with EEA relevance, Applies to European Commission Member States (European Parliament and Council, 2012). In Europe, the catastrophic accident in the Italian town of Seveso in 1976 prompted the adoption of legislation on the prevention and control of such accidents. The so-called Seveso-Directive (Directive 82/501/EEC) was later amended in view of the lessons learned from later accidents such as Bhopal, Toulouse or Enschede resulting into Seveso-II (Directive 96/82/EC). In 2012 Seveso-III (Directive 2012/18/EU) was adopted taking into account, among others, the changes in the European Union legislation on the classification of chemicals and increased rights for citizens to access information and justice. The Directive applies to more than 12 000 industrial establishments in the European Union where dangerous substances are used or stored in large quantities, mainly in the chemical and petrochemical industry, as well as in fuel wholesale and storage (including liquefied petroleum gas and liquefied natural gas) sectors (European Commission, 2020).

Examples of drivers, outcomes and risk management

Factors that affect the vulnerability of responders and the public include the nature of the hazard, the level of exposure, availability and quality of shelter, availability of Personal Protection Equipment (PPE), access into and out of the site, the degree to which employees and responders (and possibly the public) are prepared and trained to deal with a chemical release and the amount of training provided. Vulnerability can be reduced by ensuring that information is available on: the incident; measures being taken to contain the release; who is currently under threat; what the health effects might be from exposure; what the public can actually do to protect themselves; and how to get further information; when, where and how it will be available (WHO, no date).

Some individuals and sub-populations can also be at increased risk because they are more susceptible to the adverse effects of a given exposure. Among the potential causes of enhanced susceptibility are inherent genetic variability, age, gender, pre-existing disease (e.g., diabetes, asthma, chronic obstructive pulmonary disease), inadequate diet, occupational, environmental or lifestyle factors (e.g., smoking), stress and inadequate access to health care (WHO, no date).

In most cases the mechanisms and health outcomes of exposure are unknown. Symptoms may present differently depending upon the products of combustion and chemicals and other material involved in the fire. In general, the adverse health outcomes to toxic chemical exposure may be:

- Effects that are local or arise at the site of contact with the products of combustion and chemicals, such as bronchoconstriction from respiratory irritants, or irritation of the skin and eyes by gases, liquids and solids.
- Effects that are systemic or affect organ systems remote from the site of absorption, such as depression of the central nervous system from inhalation of solvents, or necrosis of the liver from the inhalation of carbon tetrachloride.
- Effects on mental health arising from real or perceived releases, which depend on the psychosocial stress associated with an incident.
- The time elapsing between exposure and the onset of symptoms can vary:
- Some effects, for example eye and respiratory irritation or central nervous system depression, can occur rapidly, within minutes or hours of exposure (acute effects).
- Other effects, for example congenital malformations or cancers, may take months or years to appear (delayed effects).

The duration of the symptoms can also vary, from short-term, to long-term or chronic. Chemical incidents (especially acts of terrorism) may also cause fear and anxiety in populations (WHO, no date).

The World Health Organization (WHO) recommends that risk management measures include: being aware of explosive related hazards; locating chemical sites away from centres of population; registration of all chemicals in commercial establishments with a hazard inventory to ensure rapid identification of the released chemical; regular evaluation of plans and their implementation; inspection/monitoring and enforcement of safety measures; reducing the amounts of chemicals stored; appropriate labelling of all chemicals; rapid notification of the chemical incident emergency services in the event of a chemical release; regular surveillance and standardized reporting of incidents, including the small, commonly occurring incidents ones; measures to decontaminate land or water already contaminated by waste disposal; measures to prevent or contain any fire-fighting water run-off; and construction of drainage ditches or holding tanks to contain liquid chemicals (WHO, no date).

In any chemical incident, there are a number of essential steps to go through as part of the fire related chemical incident plan. These are in an approximate chronological order: alerting the health care services; best outcome assessment of actions and management options; environmental monitoring; public information and public warnings; advice on protection; sheltering or evacuation; other interventions to protect public health; and organising registers and samples.

Preparedness

That careful planning and thorough preparedness are prerequisites for an effective response to chemical incidents. That public authorities, at all levels, and the management staff of installations where hazardous chemicals are produced, stored etc. should establish emergency preparedness plans.

That all responsible parties should ensure that manpower equipment, and financial and other resources necessary to carry out emergency plans are readily available for immediate activation in the event, or imminent threat of an accident.

That all personnel involved in the emergency response process should be adequately educated and trained.

Response

That depending on the level of potential exposure, risk zones are usually established around an incident:

- The hot zone, is the area where first responders must use protective equipment to prevent primary contamination.
- The warm zone, which surrounds the hot zone, is the area where appropriate personal protective equipment must be worn to prevent secondary contamination.
- The cold zone is the uncontaminated area between the inner cordon and the outer cordon where it has been assessed that there is no immediate threat to life.
- The decontamination line separates the warm from the cold zone.

That a vulnerable zone (in effect a potential hot zone) can be declared, which is the area likely to be contaminated if the emergency response action is not successful. The population within the vulnerable zone includes the resident population as well as the working population (in the plant and in the area), and other populations in the area at certain times, such as motorist, tourists and visitors to entertainment facilities.

To contact the nearest Poisons Centre in case advice on diagnoses and treatment of chemical poisonings is needed.

To set-up a public health team which, in case of an fire related chemical incident, will provide accident and emergency departments with information about the nature of the chemicals(s), any precautions to be taken, and information about secondary contamination and how to decontaminate causalities, staff and equipment. Further details and guidance can be found at WHO Manual: The Public Health Management of Chemical Incidents (WHO, 2009).

Designed to help manage the recovery phase of a chemical incident where contamination has affected food production systems, inhabited areas and water environments, further information can be found in the UK Recovery Handbook for Chemical Incidents (PHE, 2020).

The WHO works closely with countries and partners to monitor and report on their emergency preparedness capacities for all hazards, including for chemical incidents. Surveillance of diseases of possible chemical etiology is a daily element in WHO's outbreak alert and response activities (WHO, 2020).

The WHO also convenes regional meetings to strengthen the global network of poison centres and thus facilitate emergency responses to chemical incidents. Guidance and training materials to strengthen preparedness for chemical incidents and emergencies have been developed in collaboration with the Organisation for Economic Co-operation and Development, the Inter-Organization Programme for the Sound Management of Chemicals, and relevant organizations in the United Nations system (WHO, 2020).

Additional resources include the WHO human health risk assessment toolkit for chemical hazards (WHO, ILO and UNEP, 2011) and the guidance document on evaluating and expressing uncertainty in hazard characterization (WHO and IPCS, 2018).

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WHO, ILO and UNEP, 2011. World Health Organization Human Health Risk Assessment Toolkit: Chemical Hazards. Harmonization Project Document No. 8. www.who.int/publications/i/item/9789241548076 Accessed 23 October 2020.

Coordinating agency or organisation

Not identified.

TL0033 / **TECHNOLOGICAL / Industrial Failure**

Mining Hazards

Definition

Mining hazards can be defined as having major environmental impacts including the production of waste, release of toxic and hazardous waste, air pollution and emissions, water pollution and depletion, and the loss of productive land and ecosystems (adapted from UNDP and UN Environment, 2018).

Reference

UNDP and UN Environment, 2018. Managing Mining for Sustainable Development: A sourcebook. United Nations Development Programme (UNDP). www.undp.org/content/undp/en/home/librarypage/poverty-reduction/Managing-Mining-for-SD.html Accessed 12 October 2020.

Annotations

Synonyms

Mining catastrophes, Mining disasters.

Additional scientific description

Over recent decades, mining has generated considerable wealth, reduced poverty in developing countries, and improved quality of life through the provision of natural resources. Although mining has considerable benefits, this industry can have harmful impacts on people, society, and the environment (Donelly, 2018). The most common mining hazards include but are not limited to ground collapse, subsidence, fault reactivation and fissures, mine water rebound, acid mine water drainage, mine gas emissions, and combustion. Other notable hazards are mining-induced landslides, mining-induced seismicity, waste, dereliction, and contamination. Although potentially foreseeable, mining hazards cannot necessarily be forecast or predicted in terms of their timing, location, duration, magnitude, and extent. Mining hazards can occur in isolation or as groups of hazards occurring simultaneously (Donelly, 2018).

To prevent mining hazards occurring, monitoring and site inspections are recommended prior to, during, immediately after and long after mineral production ceases and a mine is abandoned (Donelly, 2018).

Artisanal and small-scale mining (ASM) has experienced substantial growth in recent years, largely due to the increasing value of mineral prices and additional sources of income, particularly in Africa and Latin America. Despite being low in productivity, ASM is an important source of minerals and metals and accounts for approximately 20% of the global gold supply and 20% of the global diamond supply. In 2017, 40.5 million people are estimated to have been involved within this sector. The most recent estimates are for about 9 million ASM operators in Africa and about 54 million people whose livelihoods depend on the sector (IGF, 2017). However, The Africa Minerals Development Centre considers this a 'conservative estimate', citing an important lack of data on ASM, as the activity is often informal and mostly operates illegally in several African countries. The Latin America ASM sector has strict regulations on informal operators and the use of certain substances but has limited capacity to implement these regulations. It is particularly difficult to control informal mining where there are large numbers of miners; such as in Colombia, where about 87% of 4134 Colombian gold mining operations are illegal and 95% of all the gold mines have no environmental permit (IGF, 2017).

Perceptions of ASM activity vary from country to country. Stakeholders often tend to vilify artisanal and small-scale mining because of its informal nature and hazardous characteristics, with significant health and safety risks as well as susceptibility to social conflict and human rights violations (Barreto, 2011).

The use of hazardous substances in mining puts the health of miners and their communities at risk – they are exposed, for example, to mercury, zinc vapour, cyanide, or other acids. This is a particular concern in artisanal gold mining, where mercury is frequently deployed and cyanide use is growing. Other health concerns include inhaling dust and fine particles from blasting and drilling processes causing respiratory diseases such as silicosis or pneumoconiosis in men and women, and in the children who often accompany their parents a lack of ear protection to filter noise from equipment such as drills or crushers can cause temporary or permanent hearing loss and speech interference (ILO, 2014).

Concrete actions started in 2018 with a focus on formalisation, establishing gold-buying schemes, capacity building at the national level on mercury-free technologies, awareness raising and knowledge sharing. Governments need to adopt a progressive approach to eliminating the use of hazardous chemicals.

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Occupational safety and health in the mining (coal and other mining) sector (ILO, 2014).

Adoption of the Hours of Work (Coal Mines) Convention (No. 31) in 1931 to the Safety and Health in Mines Convention (No. 176), which was adopted in 1995 (ILO, 2014).

The ILO's International Classification of Radiographs of Pneumoconioses and Guidelines (OSH 22) is an internationally recognised tool for recording systematically radiographic abnormalities in the chest provoked by the inhalation of dusts (ILO, 2014).

The ILO has created the following labour standards and codes of practice relevant to mining hazards:

ILO International labour standards

- C155 - Occupational Safety and Health Convention, 1981 (No. 155)
- R164 - Occupational Safety and Health Recommendation, 1981 (No. 164)
- C187 - Promotional Framework for Occupational Safety and Health Convention, 2006 (No. 187)
- R197 - Promotional Framework for Occupational Safety and Health Recommendation, 2006 (No. 197)
- C161 - Occupational Health Services Convention, 1985 (No. 161)
- R171 - Occupational Health Services Recommendation, 1985 (No. 171)
- C176 - Safety and Health in Mines Convention, 1995 (No. 176)
- R183 - Safety and Health in Mines Recommendation, 1995 (No. 183)
- C124 - Medical Examination of Young Persons (Underground Work) Convention, 1965
- R125 - Conditions of Employment of Young Persons (Underground Work) Recommendation, 1965 (No. 125)

ILO Codes of practice

- 2006 - Safety and health in underground coal mines
- 1991 - Safety and health in opencast mines
- 1986 - Safety and health in coal mines
- 1974 - Prevention of accidents due to explosions underground in coal mines
- 1965 - Guide to the prevention and suppression of dust in mining, tunnelling and quarrying
- 1959 - Prevention of accidents due to electricity underground in coal mines
- 1959 - Prevention of accidents due to fires underground in coal mines
- 1949 - Model code of safety regulations for underground work in coal mines
- 2001 - HIV/AIDS and the world of work

Examples of drivers, outcomes and risk management

Mineworkers face a constantly changing combination of workplace circumstances. Some work in an atmosphere without natural light or ventilation, creating voids in the earth by removing material and trying to ensure that there will be no immediate reaction from the surrounding strata. Despite the efforts in many countries, the toll of death, injury and disease among the world's mineworkers means that, in most countries, mining remains the most hazardous occupation when the number of people exposed to risk is taken into account (ILO, 2015).

Although only accounting for 1% of the global workforce, mining is responsible for about 8% of fatal accidents at work. No reliable data exist on injuries, but they are significant, as is the number of workers affected by such disabling occupational diseases as pneumoconiosis, hearing loss and the effects of vibration (ILO, 2015).

In some countries, many more people are employed in small-scale, often informal, mining than in the formal mining sector. Many of these jobs are precarious and are far from conforming with international and national labour standards. Accident rates in small-scale mines are routinely six or seven times higher than in larger operations, even in industrialised countries. A special problem is the employment of children (IGF, 2017).

The Global Environment Facility has developed the Global Opportunities for Long-term Development of ASGM Sector (GEF GOLD) which is an important funding body for projects on ASM and hazardous substances. In 2016, the Global Opportunities for Long-term Development (GEF GOLD) was launched to support the phasing out of mercury use in artisanal and small-scale gold mining and reduce environmental health and safety risks in the sector. The United Nations Industrial Development Organization (UNIDO) is one of the main organisations in charge of implementing the project. Eight countries will benefit: Burkina Faso, Colombia, Guyana, Indonesia, Kenya, Mongolia, Peru and the Philippines (GEF, 2017).

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ILO, 2014. Occupational safety and health in the mining (coal and other mining) sector. International Labour Organization (ILO). www.ilo.org/global/topics/safety-and-health-at-work/industries-sectors/WCMS_219026/lang--en/index.htm Accessed 12 October 2020.

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Coordinating agency or organisation

Not identified.

TL0034 / **TECHNOLOGICAL / Industrial Failure**

Safety Hazards Associated with Oil and Gas Extraction Activities

Definition

Oil and gas extraction, and associated servicing activities involve many types of equipment and materials. Identifying and controlling hazards is critical to preventing injuries and deaths (US Department of Labor, no date).

Alternative definition: For the purpose of the C155 - Occupational Safety and Health Convention, 1981 (No. 155) (ILO, 1981):

a) the term branches of economic activity covers all branches in which workers are employed, including the public service.

b) the term workers covers all employed persons, including public employees.

c) the term workplace covers all places where workers need to be or to go by reason of their work and which are under the direct or indirect control of the employer.

d) the term regulations covers all provisions given force of law by the competent authority or authorities.

e) the term health, in relation to work, indicates not merely the absence of disease or infirmity; it also includes the physical and mental elements affecting health which are directly related to safety and hygiene at work.

References

ILO, 1981. C155 - Occupational Safety and Health Convention (No. 155). International Labour Organisation (ILO). www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:12100:0::NO::P12100_ILO_CODE:C155 Accessed 8 November 2020.

US Department of Labor, no date. Occupational Safety and Health Administration Oil and Gas Extraction: Safety hazards associated with oil and gas extraction activities. www.osha.gov/SLTC/oilgaswelldrilling/safetyhazards.html Accessed 8 November 2020.

Annotations

Synonyms

Not identified.

Additional scientific description

The oil and gas industry will retain an important role as affordable, reliable and versatile energy products for a growing global population. According to the International Energy Agency, in 2019, oil and gas combined, accounted for more than 50% of global energy demand and it is expected in the long term that energy demand will still grow by 25% by 2040. The challenge is to address climate change through emission reduction while also meeting global energy demand and supporting economic development in the long term (IAEA, 2019).

Oil and gas extraction activities include exploration, drilling, production, construction, transport and catering to refineries, which they also help to plan, build, equip and maintain, and delivery of energy products (ILO, 2010).

Oil and gas extraction activities have the potential to cause damage to or destruction of property and the environment and could even lead to injury and loss of life, particularly if the activity is not controlled, monitored, or regulated appropriately (Rodhi et al., 2018). Safety hazards associated with oil and gas extraction activities include but are not limited to (US Department of Labor, no date):

- *Vehicle collision:* workers and equipment are required to be transported to and from sites, which are often located in remote areas. Highway vehicle crashes are the leading cause of oil and gas extraction worker fatalities. In the United States, roughly four out of every ten workers on the job in this industry are killed as a result of a highway vehicle incident.
- *Struck-by/ caught-in/caught-between:* workers might be exposed to struck-by/caught-in/caught-between hazards from multiple sources such as moving vehicles or equipment, falling equipment, and high pressure lines. In the United States, this hazard is responsible for three in five on-site fatalities in the oil and gas industry.
- *Explosions and fires*: flammable gases such as well gases, vapours, and hydrogen sulphide, can be released from wells, trucks, production equipment or surface equipment. Ignition sources can include static, electrical energy sources, open flames, lightning, cutting and welding tools, hot surfaces, and frictional heat. Workers in the oil and gas industry face these risks, particularly the risk of fire and explosion due to ignition of flammable vapours or gases.
- *Falls:* can be a direct result of workers being required to access platforms located high above ground.
- *Confined spaces: w*orkers are often required to enter confined spaces such as petroleum and storage tanks, mud pits, reserve pits and other excavated areas. Safety hazards associated with confined space include ignition of flammable vapours or gases. Health hazards include asphyxiation and exposure to harmful chemicals. Confined spaces that contain or have the potential to contain a serious atmospheric hazard must be classified as permit-required confined spaces, tested prior to entry, and continuously monitored.
- *Ergonomic hazards:* oil and gas workers might be exposed to ergonomics-related injury risks such as lifting heavy items, bending, reaching overhead, pushing and pulling heavy workloads and performing the same tasks repetitively. Risk factors can be minimised or eliminated through interventions such as pre-task planning, using the right tools and education and awareness of potential hazards.
- *High pressure line and equipment:* workers in this industry may be exposed to hazards from compressed gases or from high-pressure lines. This can be as a result of internal erosion of lines which might result in leaks or line bursts.
- *Electrical and other hazardous energy*: industry workers may be exposed to uncontrolled electrical, mechanical, hydraulic, or other sources of hazardous energy if equipment is not designed, installed, and maintained properly.
- *Machine hazards:* oil and gas extraction workers may be exposed to a wide variety of rotating wellhead equipment including top drives and kelly drives, pumps, compressors, catheads, hoist blocks, belt wheels and conveyors, and might be injured if they are struck by or caught between unguarded machines.
- *Planning and prevention:* many countries within the industry use a job safety analysis processes to identify hazards and find solutions to reduce incidents that could lead to injury or fatalities.

Metrics and numeric limits

The International Association of Oil & Gas Producers (IOGP) recent 'Safety Data Report' concluded thatfewer fatalities and injuries occurred in 2019 compared to the year prior (IOGP, 2020). In 2019, the industry experienced 25 fatalities in 22 separate incidents across 3 billion work hours. The largest proportion of fatalities was attributed to 'caught in, under or between' incidents, which excludes those involving dropped objects. Data reported by IOGP members also recorded a decline in the number of injuries. In 2019, there were 0.92 injuries per million hours worked. Overall, participating companies reported 21,899 days of work lost through injuries (IOGP, 2020).

Key relevant UN convention / multilateral treaty

C155 - Occupational Safety and Health Convention (No. 155) (ILO, 1981).

Occupational safety and health in the oil and gas production and oil refining sector (ILO, no date).

ILO International labour standards

- C155 - Occupational Safety and Health Convention, 1981 (No. 155)
- R164 - Occupational Safety and Health Recommendation, 1981 (No. 164)
- C187 - Promotional Framework for Occupational Safety and Health Convention, 2006 (No. 187)
- R197 - Promotional Framework for Occupational Safety and Health Recommendation, 2006 (No. 197)
- C161 - Occupational Health Services Convention, 1985 (No. 161)
- R171 - Occupational Health Services Recommendation, 1985 (No. 171)

ILO Codes of practice

- Safety and health in the construction of fixed offshore installations in the petroleum industry

Global Political Commitments: Initiatives, Declarations, Action Plans, Programmes as listed by the Global Marine Oil Pollution Information Gateway (no date)

Global Political Commitments: Initiatives, Declarations, Action Plans, Programmes

- Agenda 21. World Summit on Sustainable Development (WSSD 2002).
- Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA).

International Conventions

- Convention on the Law of the Sea (UNCLOS).
- MARPOL 73/78: International Convention for the Prevention of Pollution from Shipping. Pollution Casualties. have been amended twice in 1991 and 1996. The IMO provides the secretariat for the Convention.
- London Convention: Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter.

Examples of drivers, outcomes and risk management

The IOGP serves as the industry's regulator and as a global partner for improving safety, and environmental and social performance. The IOGP also acts as a global forum within which members can identify and share best practices to achieve improvements in health, safety, the environment, security, social responsibility, engineering and operations within the sector. The IOGP works to improve the industry and make a positive contribution to society through a number of external projects (IOGP, no date):

- Standards Solution: a forum for developing ISO standards with interested parties.
- Reports, guidelines, publications on a range of oil and gas topics including recommended practices, safety, and management.
- The IOGP Data Portal, through which it collects safety and environmental data from its member companies annually.

Leading oil and gas companies have increased efforts towards adopting a risk-based approach, through enhancing risk management capability such as the management of health, safety, and environment (HSE) risks by implementing the risk management framework 130 31000:2009 to achieve sustainable development (Rodhi et al., 2018).

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US Department of Labor, no date. Occupational Safety and Health Administration Oil and Gas Extraction: Safety hazards associated with oil and gas extraction activities. www.osha.gov/SLTC/oilgaswelldrilling/safetyhazards.html Accessed 8 November 2020.

Coordination agency or organisation

Not identified.

TL0035 / **TECHNOLOGICAL / Waste**

Disaster Waste

Definition

Disaster waste is the waste generated by the impact of a disaster, both as a direct effect of the disaster as well as in the post-disaster phase as a result of poor waste management (UNEP/OCHA, 2011).

Reference

UNEP/OCHA, 2011. Disaster Waste Management Guidelines. Annex X: Terminology. United Nations Environment Programme (UNEP) / United Nations Office for the Coordination of Humanitarian Affairs (OCHA). www.unocha.org/sites/unocha/files/DWMG.pdf Accessed 19 November 2019.

Annotations

Synonyms

None identified.

Additional scientific description

Disaster waste includes: concrete, wood, steel, spillage of tailings, industrial toxic and hazardous waste from dumps/stacks/ landfills, clay and tar elements from damaged buildings and infrastructures; household furnishings; parts from the power and telephone grids such as electrical poles, wire, electronic equipment, transformers; parts from water and sewage distribution systems; natural debris such as clay, mud, trees, branches, bushes, palm tree leaves; chemicals, dyes and other raw materials from industries and workshops; waste from relief operations; damaged boats, cars, buses, bicycles; unexploded ordnance (e.g., landmines); waste from disaster settlements and camps including food waste, packaging materials, excreta and other wastes from relief supplies; pesticides and fertilisers; household cleaners; paint, varnish and solvents; and healthcare waste (Joint UNEP/OCHA Environment Unit, 2011; UNDP, 2016).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Not relevant.

Examples of drivers, outcomes and risk management

Waste is an important factor to consider in preparedness, response, recovery, remediation and environmental decontamination preceding or following a disaster.

Response and recovery may generate various amounts of waste (e.g., irretrievably damaged or contaminated objects and structures) or waste by-products such as water run-off from disinfection procedures. For large-scale incidents, normal waste disposal routes may be inadequate. Laboratory analysis may be required prior to disposal to identify such properties as ignitability, corrosiveness, reactivity and toxicity, which would inform the treatment and waste disposal options (HPA, 2012).

In addressing these issues, various criteria need to be examined such as type and amount of waste (e.g., hazardous, non-hazardous), legislation concerning disposal routes for waste, capacity of disposal facilities, agricultural impact following disposal, environmental impact following disposal, potential impact of biological agents, chemical agents and radioactive materials during and after disposal, and societal/ethical issues (PHE, 2016).

In post-conflict/disaster settings, hazardous wastes that are frequently encountered during debris and municipal solid waste management activities include Unexploded Ordnance (UXOs), asbestos (as part of building rubble), infectious health care waste and other hazardous wastes such as expired and obsolete hazardous pesticides, equipment containing polychlorinated biphenyls (PCBs) and oils (e.g., electrical transformers) and other types of hazardous wastes (UNDP, 2016).

A temporary disposal site, a place where disaster waste is safely placed, stored and processed for a predefined period after a disaster, should be selected following a rapid environmental assessment, and emissions should be minimised in relation to appropriate and available technology (UNDP, 2016).

References

HPA, 2012. UK Recovery Handbook for Chemical Incidents. Health Protection Agency (HPA). assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/201024/UKRHCI_publication_31st_May_2012_web2.pdf Accessed 19 November 2019.

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UNDP, 2016. Guidance Note: Municipal solid waste management in crisis and post-crisis settings. United Nations Development Programme (UNDP). www.undp.org/content/undp/en/home/librarypage/poverty-reduction/municipal-solid-waste-management-in-crisis-and-post-crisis-setti.html Accessed 19 November 2019.

Coordinating agency or organisation

Not identified.

TL0036 / **TECHNOLOGICAL / Waste**

Solid Waste

Definition

Solid waste covers discarded materials that are no longer required by the owner or user. Solid waste includes materials that are in a solid or liquid state but excludes wastewater and small particulate matter released into the atmosphere (United Nations, 2014).

Reference

United Nations, 2014. System of Environmental-Economic Accounting 2012—Central Framework. unstats.un.org/unsd/envaccounting/seeaRev/SEEA_CF_Final_en.pdf Accessed 19 November 2019.

Annotations

Synonyms

Not available.

Additional scientific description

Solid waste may include such materials as: general domestic garbage such as food waste, ash and packaging materials; human faeces disposed of in garbage; hazardous waste; healthcare waste; and disaster waste. Examples of disaster waste include plastic water bottles, packaging from other emergency supplies and other waste from relief operations, rubble resulting from the disaster, mud and slurry deposited by the disaster, fallen trees and rocks obstructing transport and communications (WHO, 2019).

Conceptual and methodological problems of statistics on solid waste have long been identified. They have been discussed by a range of international organisations, such as the United Nations Statistics Division (UNSD), the Organisation for Economic Co-operation and Development (OECD), Eurostat, the United Nations Economic Commission for Europe (UNECE), and the Basel Convention, but due to the complexity of the subject the issues cannot be addressed by individual organisations separately (UNECE, 2016).

Methodological work related to statistics on solid waste is mainly carried out by Eurostat and the UNSD, and by the OECD. It takes into consideration the work of the Secretariat of the Basel Convention on the control of transboundary movements of hazardous wastes and their disposal (Basel Convention) and the European Commission (Commission Decision 2014/955/EU on the list of waste, Commission Regulation 1357/2014/EU on the hazardousness properties of waste) for hazardous waste, and where necessary of the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade (Rotterdam Convention) (UNECE, 2016).

Metrics and numeric limits

Not available

Key relevant UN convention / multilateral treaty

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989). At the time of writing, there were 187 parties to the Basel Convention (UN Treaty Collection 2019).

Examples of drivers, outcomes and risk management

Poor waste management (including ineffective collection and disposal) causes air, soil and water pollution (UN Environment, no date). The safe disposal of solid waste is critical for public health (WHO, 2019; UN Environment, no date) and presents a serious risk to ecosystems (UN Environment, no date).

Solid waste poses a hazard in emergencies (WHO, 2019). The Sphere Handbook (Sphere Association, 2018) is the internationally recognised tool (but non-legally binding) in the field of humanitarian standards, including for solid waste management. The Sphere standards state that people should be able to live in an environment that is uncontaminated by solid waste and suggests respective standards in disaster response and humanitarian assistance.

Solid waste creates favourable habitats for insects, rodents and other disease vectors and thereby increases the risk of disease such as dengue, malaria and yellow fever (WHO, 2013; Sphere Association, 2018). In addition, communities may scavenge among solid waste, leading to increased cases of disease such as dysentery and exposure to other noxious or toxic substances. Meanwhile, indiscriminate dumping of waste can also block water courses causing flooding (WHO, 2013). Breathing difficulties can arise from the fungi that develop on solid waste. People passing through solid waste containing areas are exposed to risk of injuries from broken glass, needles, etc. Waste has a demoralising impact on communities and may lower morale (WHO, 2013).

References

Sphere Association, 2018. The Sphere Handbook: Humanitarian Charter and Minimum Standards in Humanitarian Response. 4th Edition. spherestandards.org/wp-content/uploads/Sphere-Handbook-2018-EN.pdf Accessed 19 November 2019.

UN Environment, no date. Solid Waste Management. www.unenvironment.org/explore-topics/resource-efficiency/what-we-do/cities/solid-waste-management Accessed 19 November 2019.

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UNECE, 2016. Problems with waste statistics and a proposal for action, ECE/CES/BUR/2016/OCT/7. United Nations Economic Commission for Europe (UNECE). www.unece.org/fileadmin/DAM/stats/documents/ece/ces/bur/2016/October/07-Waste_statistics_final.pdf Accessed 19 November 2019.

WHO, 2013. Technical notes on drinking-water, sanitation and hygiene in emergencies: Solid waste management in emergencies. World Health Organization (WHO). www.who.int/water_sanitation_health/emergencies/WHO_TN_07_Solid_waste_management_in_emergencies.pdf?ua=1 Accessed 19 November 2019.

WHO, 2019. Solid Waste Management in Emergencies. World Health Organization (WHO). www.who.int/water_sanitation_health/publications/tech_note7/en Accessed 19 November 2019.

Coordinating agency or organisation

Not identified.

TL0037 / **TECHNOLOGICAL / Waste**

Wastewater

Definition

Wastewater is regarded as a combination of one or more of the following materials: domestic effluent consisting of 'blackwater' (excreta, urine and faecal sludge, contaminants from pharmaceutical and personal care products) and 'greywater' (used water from washing and bathing); water from commercial establishments and institutions, including hospitals; industrial effluent, stormwater and other urban runoff; and agricultural, horticultural and aquaculture runoff (UN Water, 2017).

Reference

UN Water, 2017. Wastewater: The Untapped Resource. www.preventionweb.net/publications/view/52444 Accessed 13 November 2019.

Annotations

Synonyms

Used water, Effluent.

Additional scientific description

Insufficient treatment of wastewater and faecal sludge spreads disease and is a driver of antimicrobial resistance (WHO, 2019). Wastewater is also considered to contain increasing amounts and types of unregulated contaminants and organic compounds of emerging concern, such as human and veterinary antibiotics, and prescription and non-prescription drugs (USGS, 2051).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Convention on the Protection and Use of Transboundary Watercourses and International Lakes also referred as the Water Convention (1992). Although initially intended for the United Nations Economic Commission for Europe (UNECE) region, in 2016 the Water Convention allowed accession of all United Nations Member States worldwide. At the time of writing, there were 43 parties to the Water Convention. Almost all countries sharing transboundary waters in the UNECE region are Parties to the Convention (UNECE, 2019).

Examples of drivers, outcomes and risk management

Industrialisation without adherence to environmental standards and lack of wastewater management systems is a driver of contaminated wastewater. Globally, approximately 80% of all wastewater is discharged without adequate treatment (UNESCO, 2017). As of 2014, most cities were missing the appropriate infrastructure and resources to address wastewater management in an efficient and sustainable way (UNDESA 2014, cited in UN Water, no date). Urban areas with high population densities in low-income and lower-middle income countries are considered particularly at risk (UNEP, 2016). Discharge of wastewater without adequate water treatment may have serious implications for health and well-being (UN Environment, 2017).

In parallel, wastewater treatment plant operatives are exposed to a variety of hazardous chemical agents, within the effluents and the reagents used in water processing, or generated during water treatment. These chemical agents may cause acute poisoning, chemical accidents (skin burns, injury to the eyes, etc.), damage to the respiratory system, allergies, dermatitis, and chronic diseases (ILO, 2012).

Demand for wastewater as a reliable source of water and nutrients for agriculture is growing under the pressures of population growth, urbanisation, increasing water scarcity and the effects of climate change (WHO, 2019).

References

ILO, 2012. Operator, Wastewater Treatment Plant: International Hazard Datasheets on Occupation. International Labour Organization (ILO). www.ilo.org/safework/cis/WCMS_192394/lang--en/index.htm Accessed 13 November 2019.

UN Environment, 2017. Untreated Wastewater - A Growing Danger. www.unenvironment.org/news-and-stories/story/untreated-wastewater-growing-danger Accessed 13 November 2019.

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UNESCO, 2017. Wastewater: An Untapped Resource. United Nations Educational, Scientific and Cultural Organization (UNESCO). https://reliefweb.int/report/world/2017-un-world-water-development-report-wastewater-untapped-resource Accessed 28 April 2021.

USGS, 2015. National Reconnaissance of Emerging Contaminants in the Nation's Stream Waters. United States Geological Survey (USGS). https://toxics.usgs.gov/regional/contaminants.html Accessed 30 September 2020.

WHO, 2019. Wastewater. World Health Organization (WHO). www.who.int/water_sanitation_health/sanitation-waste/wastewater/en Accessed 13 November 2019.

Coordinating agency or organisation

Not identified.

TL0038 / **TECHNOLOGICAL / Waste**

Hazardous Waste

Definition

Hazardous waste is waste that has physical, chemical, or biological characteristics such that it requires special handling and disposal procedures to avoid negative health effects, adverse environmental effects or both (Joint UNEP/OCHA Environment Unit, 2011).

Reference

Joint UNEP/OCHA Environment Unit, 2011. Disaster Waste Management Guidelines. Annex X: Terminology. Joint United Nations Environment Programme (UNEP) / United Nations Office for the Coordination of Humanitarian Affairs (OCHA) Environment Unit. www.unocha.org/sites/unocha/files/DWMG.pdf Accessed 8 November 2019.

Annotations

Synonyms

Not identified.

Additional scientific description

Typical characteristics of hazardous waste include oxidising, explosive, flammable, irritant, corrosive, toxic, ecotoxic, carcinogenic, infectious, and toxic for reproduction and/or mutagenic properties. Toxic wastes may produce toxic gases when in contact with water, air or acid which can result in the generation of additional hazardous substances following disposal. The term ‘hazardous’ relates to the situation and circumstances as well as to the properties of waste materials (Joint UNEP/OCHA Environment Unit, 2011).

Metrics and numeric limits

The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989) has extensive definitions to inform metrics in its annexes, among others: a description of categories of waste requiring control (Annex I); hazardous characteristics (Annex III); the extensive list of wastes characterised as hazardous under the Convention (Annex VIII); other Wastes (Annex II); and wastes presumed to be non-hazardous (Annex IX) (UN Treaty Collection, 2019).

Basel Convention codes are necessary for any transboundary movements of hazardous and other wastes in the scope of the Convention, movements which require a prior consent procedure from all states involved. For more information, it is necessary to contact the Basel Convention Competent authority of the states concerned with the movement. A list of Basel Convention Competent authorities is available on the Basel Convention website (European Commission, 2020). Other codes are applicable to hazardous wastes, in Harmonized System codes issued by the World Customs Organisation, ADR codes for road transport, IMDG codes for maritime transport and ICAO/IATA codes for air transport, GHS codes and UN numbers (World Customs Organisation, no date).

Key relevant UN convention / multilateral treaty

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989). At the time of writing, there were 187 parties to the Basel Convention (UN Treaty Collection, 2019).

International Conventions related to Harmonised System, Accord relatif au transport international des marchandises Dangereuses par Route (ADR), International Maritime Dangerous Goods, International Civil Aviation Organisation/International Air Transport Association and Globally Harmonised Systems codes.

Examples of drivers, outcomes and risk management

Hazardous waste is waste that owing to its properties poses an actual or potential hazard to the health of humans, other living organisms, or the environment (United Nations, 2016).

According to Agenda 21, the Rio Declaration on Environment and Development, adopted by more than 178 governments at the United Nations Conference on Environment and Development held in Rio de Janeiro, Brazil, 3-14 June 1992, it was recognised that to address effective control of the generation, storage, treatment, recycling and reuse, transport, recovery and disposal of hazardous wastes is "of paramount importance for proper health, environmental protection and natural resource management, and sustainable development" (United Nations, 1992: Chapter 20).

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Coordinating agency or organisation

Not identified.

TL0039 / **TECHNOLOGICAL / Waste**

Plastic Waste

Definition

Plastic is a generic term used in the case of polymeric material that may contain other substances to improve performance and/or reduce costs, with plastic waste almost exclusively comprising one non-halogenated polymer and waste substances or objects which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law (adapted from Basel Convention, 1989; and Basel Convention Secretariat, 2019).

References

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Basel Convention Secretariat, 2019. Basel Convention. Plastic Waste. Overview. www.basel.int/implementation/plasticwastes/overview/tabid/6068/default.aspx Accessed 5 October 2020.

Annotations

Synonyms

Plastic pollution, Plastic debris, Plastic litter, Plastic marine litter, Plastic trash.

Additional scientific description

Plastic is a lightweight, hygienic and resistant material which can be moulded in a variety of ways and used in a wide range of applications. Unlike metals, plastics do not rust or corrode. Most plastics do not biodegrade, but instead photodegrade, meaning that they slowly break down into small fragments known as microplastics. (UNEP, 2018).

The 14th Meeting of the Conference of the Parties to the Basel Convention defined categories of wastes requiring special consideration (European Commission, 2019). This includes plastic wastes:

- Plastic waste, including mixtures of such waste, with the exception of the following: plastic waste that is hazardous waste pursuant to paragraph 1 (a) of Article 18; plastic waste listed below, provided it is destined for recycling in an environmentally sound manner and almost free from contamination and other types of wastes; and plastic waste almost exclusively consisting of one non-halogenated polymer, including but not limited to the following polymers: polyethylene (PE), polypropylene (PP), polystyrene (PS), acrylonitrile butadiene styrene (ABS), polyethylene terephthalate (PET), polycarbonates (PC), and polyethers.
- Plastic waste almost exclusively consisting of one cured resin or condensation product, including but not limited to the following resins: urea formaldehyde resins; phenol formaldehyde resins; melamine formaldehyde resins; epoxy resins; and alkyd resins.
- Plastic waste almost exclusively consisting of one of the following fluorinated polymers: perfluoroethylene/ propylene (FEP); perfluoroalkoxy alkanes; tetrafluoroethylene/ perfluoroalkyl vinyl ether (PFA); tetrafluoroethylene/ perfluoromethyl vinyl ether (MFA); polyvinylfluoride (PVF); polyvinylidenefluoride (PVDF); and mixtures of plastic waste, consisting of polyethylene (PE), polypropylene (PP) and/or polyethylene terephthalate (PET), provided they are destined for separate recycling of each material and in an environmentally sound manner and almost free from contamination and other types of wastes.

Most plastics are usually a blend of polymers and additives (e.g., stabilisers such as lead stabilisers and cadmium stabilisers; plasticisers such as phthalates; flame retardants such as antimony oxides, phosphatases, brominated flame retardants and medium-chain chlorinated paraffins). The elements most commonly found in plastics are carbon, hydrogen, nitrogen, oxygen, chlorine, fluorine and bromine. Some of these elements are hazardous when uncombined but become inert when incorporated into an organic polymer (UNEP, 2002).

The composition of plastic waste does not only depend on the intrinsic composition of the different plastics included, but also on impurities or contaminants. These may depend on the type of application of the plastic, the waste-generation process or the waste-collection process. For instance, plastic food packaging may contain food residues, films used in agriculture may contain high percentages of soil, and plastic waste from cables may contain residual metal (UNEP, 2002).

Key relevant UN convention / multilateral treaty

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989). At the time of writing, there were 187 parties to the Basel Convention (UN Treaty Collection, 2019). At its 14th meeting, the Conference of the Parties to the Basel Convention adopted decision BC-14/12 by which it amended Annexes II, VIII and IX to the Convention with the objectives of enhancing the control of the transboundary movements of plastic waste and clarifying the scope of the Convention as it applies to such waste (European Commission, 2019).

The following new entries to the Basel Convention Plastic Waste Amendment became effective on 1 January 2021:

- Annex II, new entry Y48: covers plastic waste, including mixtures of with various exceptions listed thereunder, making them subject to the prior informed consent (PIC) procedure.
- Annex VIII, new entry A3210: clarifies the scope of plastic waste presumed to be hazardous and therefore subject to the PIC procedure.
- Annex IX, new entry B3011 replacing existing entry B3010: clarifies the types of plastic waste that are presumed not to be hazardous and, as such, not subject to the PIC procedure. The waste listed in entry B3011 includes: a group of cured resins, non-halogenated and fluorinated polymers, provided the waste is destined for recycling in an environmentally sound manner and almost free from contamination and other types of wastes; mixtures of plastic wastes consisting of PE, PP and PET provided they are destined for separate recycling of each material and in an environmentally sound manner, and almost free from contamination and other types of waste.

Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 (IMO, 2020), or 'London Convention' for short. This is one of the first global conventions to protect the marine environment from human activities and has been in force since 1975. Its objective is to promote the effective control of all sources of marine pollution and to take all practicable steps to prevent pollution of the sea by dumping of wastes and other matter. Currently, 87 States are Parties to this Convention.

Examples of drivers, outcomes and risk management

Plastic waste harms wildlife and damages ecosystems (UNEP, no date) and is responsible for vast economic losses in the tourism, fishing and shipping industries. Worldwide, the total damage to the world's marine ecosystem due to plastic waste is estimated to total at least USD 13 billion per year (United Nations, 2019). As well as harm to wildlife and ecosystems, many plastics may be chemically harmful in other contexts because they are themselves potentially toxic, contain additives or because they absorb other pollutants (Rochman et al., 2013).

Plastics account for a large proportion of current solid waste production (United Nations, 2019) and many countries classify plastics as a solid waste. Nearly 50% of the plastic waste generated globally in 2015 was plastic packaging and other single-use plastics, and approximately 16% of plastic produced globally is thought to be used in building and construction globally (UNEP, 2018).

Treating plastic waste requires a consideration of both the intrinsic composition of plastic and potential contamination. The presence of impurities and contaminants in the plastics may influence the options for managing the waste in an environmentally sound manner and should be addressed appropriately. Contaminated plastic wastes may be a major or minor hazard depending on the contaminant (UNEP, 2002).

Plastic waste recycling faces technical, economic and structural issues that are still to be overcome globally (UNEP, 2002). Recycling of plastic waste can be supported with legal and economic instruments (UNEP, 2002). To reduce plastic pollution, it is of critical importance to improve the state of solid waste collection services, strengthen the recycling industry and ensure safe disposal of waste to controlled landfills (UNEP, 2018). Through BC-14/13, the Conference of the Parties to the Basel Convention (COP-14, 29 April - 10 May 2019) decided to update the technical guidelines for the identification and environmentally sound management of plastic waste and for their disposal (European Commission, 2019).

In their report on microplastics in drinking-water, the World Health Organization concluded that routine monitoring of microplastics in drinking-water is not recommended at this time, as there is no evidence to indicate a human health concern. They considered that concerns over microplastics in drinking-water should not divert resources of water suppliers and regulators from removing microbial pathogens, which remain the most significant risk to human health from drinking-water along with other chemical priorities (WHO, 2019). As part of water safety planning, water suppliers should ensure that control measures are effective and should optimise water treatment processes for particle removal and microbial safety, which will incidentally improve the removal of microplastic particles. The report also stated that measures should be taken to better manage plastics and reduce the use of plastics where possible, to minimise plastic and microplastic pollution despite the low human health risk posed by exposure to microplastics in drinking-water, as such actions can confer other benefits to the environment and human well-being (WHO, 2019).

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Coordinating agency or organisation

Not identified.

TL0040 / **TECHNOLOGICAL / Marine**

Marine Debris

Definition

Marine debris is any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment. Marine litter consists of items that have been made or used by people and deliberately discarded into the sea or rivers or on beaches; brought indirectly to the sea with rivers, sewage, storm water or winds; or accidentally lost, including material lost at sea in bad weather (adapted from UN Environment, no date; and NOAA, no date).

References

UN Environment, no date. Marine Litter. www.unenvironment.org/explore-topics/oceans-seas/what-we-do/working-regional-seas/marine-litter Accessed 14 October 2020.

NOAA, no date. National Ocean Service. What are microplastics? National Oceanic and Atmospheric Administration (NOAA). https://oceanservice.noaa.gov/facts/microplastics.html Accessed 14 October 2020.

Annotations

Synonyms

Microplastics, Nanoparticles.

Additional scientific description

Marine debris originates from many sources and causes a wide spectrum of environmental, economic, safety, health and cultural impacts. The very slow rate of degradation of most marine litter items, mainly plastics, together with the ever growing quantity of debris disposed of, is leading to a gradual increase in marine litter found at sea and on the shores (United Nations, 2017).

Marine debris is present in all marine habitats, from densely populated regions to remote areas far from human activities, from beaches and shallow waters to deep ocean trenches (Wang et al., 2016). The average density of marine debris is estimated to vary from 13,000 to 18,000 pieces per square kilometre (UNEP, 2017). However, data on plastic accumulation in the North Atlantic and Caribbean from 1986 to 2008 showed that the highest concentrations (more than 200,000 pieces per square kilometre) occurred in the convergence zones between two or more ocean currents (Law et al., 2010). Computer model simulations, based on data from about 12,000 satellite-tracked floats deployed since the early 1990s as part of the Global Ocean Drifter Program, confirm that debris will be transported by ocean currents and will tend to accumulate in a limited number of subtropical convergence zones or gyres (Wang et al., 2016).

Plastics are by far the most prevalent debris item recorded, contributing an estimated 60% to 80% of all marine debris. Plastic debris continues to accumulate in the marine environment. The density of microplastics within the North Pacific Central Gyre has increased by two orders of magnitude in the past four decades. Marine debris commonly stems from shoreline and recreational activities, commercial shipping and fishing, and dumping at sea. The majority of marine debris (approximately 80%) entering the sea is considered to originate from land-based sources.

Nanoparticles are a form of marine debris, the significance of which is only now emerging. They are minuscule particles with dimensions of 1 to 100 nanometres (a nanometre is one millionth of a millimetre). A large proportion of the nanoparticles found in the ocean are of natural origin. It is the anthropogenic nanoparticles that are of concern. Those originate from two sources: from nanoparticles deliberately created for use in various industrial processes and cosmetics and from the breakdown of plastics in marine debris, fragments of artificial fabrics discharged in urban wastewater, and leaching from land-based waste sites. Recent research has highlighted the potential environmental impacts of plastic nanoparticles: they appear to reduce primary production and uptake of food by zooplankton and filter-feeders (United Nations, 2017).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (IMO, 2019).

Examples of drivers, outcomes and risk management

Marine debris takes many forms, including derelict fishing gear and vessels, abandoned recreational equipment, and discarded consumer plastics, metals, rubber, paper, and textiles.

Marine debris can result in economic losses, habitat damage (including to fragile coral reefs), hazards to shipping resulting in costly vessel damage and loss, transport of potentially invasive species that may have devastating impacts on ecosystems, and wildlife injury, illness, and death (NOAA, no date).

Marine debris can affect a wide range of marine life, from small microorganisms to humpback whales. Animals may inadvertently eat debris or become entangled in it. For instance, plastic bags are a common threat to sea turtles, which often mistake them for jellyfish; a common food item. Marine debris also affects other species, such as the endangered Hawaiian monk seal, where one death caused by marine debris is a huge loss (NOAA, no date).

References

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Coordinating agency or organisation

Not identified.

TL0041 / **TECHNOLOGICAL / Waste**

Electronic Waste (E-Waste)

Definition

Electrical and electronic waste, or E-waste, refers to electrical or electronic equipment that is waste, including all components, sub-assemblies and consumables that are part of the equipment at the time the equipment becomes waste (UNEP, 2019).

Reference

UNEP, 2019. Technical guidelines on transboundary movements of electrical and electronic waste and used electrical and electronic equipment, in particular regarding the distinction between waste and non-waste under the Basel Convention. (Version of 10 May 2019). United Nations Environment Programme (UNEP). www.basel.int/Implementation/TechnicalMatters/DevelopmentofTechnicalGuidelines/TechnicalGuidelines/tabid/8025/Default.aspx Accessed 6 October 2020.

Annotations

Synonyms

Waste Electrical and Electronic Equipment (WEEE), E-scrap.

Additional scientific description

Electrical and electronic waste is classified both as hazardous waste and non-hazardous waste, according to the Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (UNEP, no date a). It is categorised as hazardous waste when it belongs to any category in Annex I of the Basel Convention unless it does not possess any of the hazardous characteristics included in Annex III to the Convention. For example, e-waste is classified as hazardous waste when it contains toxic substances such as mercury, lead and brominated flame retardants (Basel Convention, 2020).

Besides containing recyclable and recoverable metals and materials such as gold, copper, nickel, silver, rare-earths and materials of strategic importance such as indium and palladium, e-waste can contain up to 60 different elements from the period table, including hazardous chemicals, of which some are persistent organic pollutants (POPs) listed under the Stockholm Convention on Persistent Organic Pollutants (PACE, 2019).

Metrics and numeric limits

Classification of e-waste that can inform the metrics is provided in Annex I, (Y codes e.g., Y29) Annex VIII (List A of waste presumed to be hazardous e.g., A1180) and Annex IX (List B of waste presumed to be non-hazardous e.g., B1110) under the Basel Convention (UN Treaty Collection, 2019). For an exhaustive list of codes that can be used for transboundary movements of e-waste under the Basel Convention, it is possible to consult the E-waste Technical Guidelines (Basel Convention, 2011).

Key relevant UN convention / multilateral treaty

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989) (UNEP, no date a,b, 2019). At the time of writing, there were 187 parties to the Basel Convention (UN Collection, 2019).

Examples of drivers, outcomes and risk management

While e-waste is one of the fastest growing hazardous waste streams globally (PACE, 2019), the findings from the Global E-Waste Monitor 2017 highlighted the low rate of electronic waste recycled globally (Baldé et al., 2017). By 2016, the world generated 44.7 million metric tonnes of e-waste and only around 20% was recycled through appropriate channels (Baldé et al., 2017). The World Health Organization reported in 2020 that global e-waste is surging and is up 21% in 5 years with a record 53.6 million tonnes of e-waste produced globally in 2019 – the weight of 350 cruise ships the size of the Queen Mary 2; USD 57 billion in gold and other components discarded – mostly dumped or burned (WHO, 2020).

E-waste dumping and open burning is driven and exacerbated by such factors as lack of a formal infrastructure ensuring proper decontamination, dismantling, recycling, recovery of items of economic value, disposal of electronic waste fractions, such as through open burning, poor incineration and use of acid baths for metals extraction, landfilling; lack of environmental protection measures and treatment standards; lack of policies, legislation or insufficient implementation and enforcement of relevant legislation; and illegal export and dumping (Baldé et al., 2017).

Electrical and E-waste can cause severe damage to human health through exposure to hazardous elements and informal recycling and the environment (Forti et al., 2018), through direct and indirect human exposure and through contamination of soil, groundwater and air.

Several health studies suggest effects from exposure to electrical and electronic waste, including adverse perinatal and neonatal outcomes and changes in behavioural and mental health disturbances (Grant et al., 2013; UNEP, 2018, cited in United Nations, 2019; PACE, 2019). Many POPs in electronic waste are also considered to be endocrine-disrupting chemicals (Grant et al., 2013).

References

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Coordinating agency or organisation

Not identified.

TL0042 / **TECHNOLOGICAL / Waste**

Healthcare Risk Waste

Definition

Healthcare waste includes waste generated within healthcare facilities, research centres and laboratories related to medical procedures and medical equipment. It also includes waste originating from minor and scattered healthcare sources, including waste produced in the course of emergency medical treatment or health care undertaken in the home (e.g., home dialysis, self-administration of insulin, recuperative care) (WHO, 2014).

Reference

WHO, 2014. Safe management of wastes from health-care activities, 2nd Edition. World Health Organization (WHO). apps.who.int/iris/bitstream/handle/10665/85349/9789241548564_eng.pdf?sequence=1 Accessed 15 November 2019.

Annotations

Synonyms

Terminology varies across stakeholders: medical waste, clinical waste, regulated medical waste, hospital waste (Rutala and Mayhall, 1992).

Additional scientific description

The main sources of medical waste are hospitals, clinics, laboratories, blood banks and mortuaries. Whereas physician's offices, dental clinics, pharmacies, home-based health care and so on, generate healthcare waste but in smaller amounts (UNGA, 2011).

Metrics and numeric limits

Classification of healthcare waste (HCW) that can inform the metrics is shown below (Basel Convention and WHO, 2005):

Healthcare waste for the purpose of transboundary movements under the Basel Convention can be classified with the codes Y1 (Clinical wastes from medical care in hospitals, medical centres and clinics) or Y2 (Wastes from the production and preparation of pharmaceutical products, or Y3 (Wastes pharmaceuticals, drugs and medicines), among others.

Approximately 15% of healthcare waste is estimated to be hazardous and has a potential to cause disease or injury. About 85% of healthcare waste is general waste, and is non-hazardous and includes items such as paper, glass, plastic packaging material, and food that have not been in contact with patients. It is similar to domestic/household waste (WHO, 2018).

Key relevant UN convention / multilateral treaty

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989). At the time of writing, there were 187 parties to the Basel Convention (UN Treaty Collection, 2019).

Examples of drivers, outcomes and risk management

Drivers of this hazard include lack of awareness about the health hazards related to healthcare waste; inadequate training in proper waste management; absence of waste management and disposal systems; insufficient financial and human resources; and the low priority given to healthcare waste. Many countries either do not have appropriate regulations, or do not enforce them (WHO, 2018).

Healthcare waste may result in the following outcomes (WHO, 2018):

- Potentially harmful microorganisms can infect hospital patients, health workers and the general public.
- Release of drug-resistant microorganisms from healthcare facilities into the environment.
- Needle stick injury (e.g., a person who experiences one needle stick injury from a needle used on an infected source patient has risks of 30%, 1.8%, and 0.3% respectively of becoming infected with HBV, HCV and HIV).
- Radiation burns.
- Toxic exposure to pharmaceutical products, especially antibiotics and cytotoxic drugs released into the surrounding environment, and to substances such as mercury or dioxins, during the handling or incineration of healthcare wastes.
- Chemical burns arising in the context of disinfection, sterilisation or waste treatment activities.
- Air pollution arising from the release of particulate matter during medical waste incineration.
- Thermal injuries occurring in conjunction with open burning and the operation of medical waste incinerators.
- Indirect health risks (environmental impact) due to the release of pathogens and toxic pollutants into the environment.
- Inadequate incineration or the incineration of unsuitable health waste materials can result in the release of pollutants into the air and in the generation of ash residue. Incinerated materials containing or treated with chlorine can generate dioxins and furans, which are human carcinogens and have been associated with a range of adverse health effects. Incineration of heavy metals or materials with high metal content (especially lead, mercury and cadmium) can lead to the spread of toxic metals in the environment.
- Treatment of healthcare wastes with chemical disinfectants can result in the release of chemical substances into the environment if those substances are not handled, stored and disposed of in an environmentally sound manner.
- Disposal of untreated healthcare wastes in landfills can lead to the contamination of drinking water, surface waters, and groundwaters if the landfills are not properly constructed.

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Coordinating agency or organisation

World Health Organization.

TL0043 / **TECHNOLOGICAL / Waste**

Landfilling

Definition

Landfilling is the final placement of waste into or onto the land in a controlled way. The definition covers both landfilling at internal sites (i.e., where a generator of waste is carrying out its own waste disposal at the place of generation) and at external sites (United Nations, 2016).

Reference

United Nations, 2016. Environmental Indicators: Waste. United Nations Statistics Division. unstats.un.org/unsd/environment/wastetreatment.htm Accessed 19 November 2019.

Annotations

Synonyms

Dumping ground, Waste disposal site, Dumpsite (including engineered dumpsite), Garbage tip, Rubbish pile, Dump waste (including fly-tip).

Additional scientific description

The following distinction between landfill and dumpsite is provided by the Joint United Nations Environment Programme / United Nations Office for the Coordination of Humanitarian Affairs Environment Unit (Joint UNEP/OCHA Environment Unit, 2011):

- *Landfill:* A scientifically designed and constructed site where waste is disposed of systematically where all emissions of gases, liquids and solid materials are controlled and not allowed to contaminate the surrounding environment.
- *Dumpsite*: A non-scientifically designed and constructed site where waste is disposed of unsystematically, and where gas emissions, liquid leakage and solids contamination of the surrounding environment is not controlled or managed and where scavenging by waste pickers often takes place.

Other mechanisms for defining landfilling exist. The Basel Convention assists in defining these. Waste deposits into or onto land are used for the disposal of waste in most countries. If these deposits are not designed and operated in an environmentally sound manner, they can present risks to human health and the environment (Basel Convention Secretariat, 2019). Specially engineered landfill (e.g., placement into lined discrete cells which are capped and isolated from one another and the environment, etc) allows for the final disposal of hazardous wastes and other wastes in an environmentally sound manner with limited impact to water, air, soil, plants or animals, and for control over noise or odours without adverse effects on the landscape, places of special interest and the environment (Basel Convention Secretariat, 2019).

The Basel Convention Technical Guidelines on Specially Engineered Landfill (Basel Convention Secretariat, 2002) also identify the following types of landfill: historic, closed sites; historic, still operating; green field sites; specific operational types of landfill (containment sites and landfills providing for attenuated release); specially engineered landfill.

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (1989). At the time of writing, there were 187 parties to the Basel Convention (UN Treaty Collection, 2019).

Examples of drivers, outcomes and risk management

A report by the International Solid Waste Association noted that as of 2015, dumpsites received about 40% of the world's waste (including municipal solid waste, sewage sludge, hazardous waste, e-waste, healthcare risk waste etc.) (ISWA, 2015). The report went on to suggest that the 50 biggest dumpsites in 2015 were daily affecting the lives of at least 64 million people. A series of studies documented that dumpsites can have serious effects on the health and wellbeing of the population and environment (ISWA, 2015).

A wide range of toxic substances for human health can be released into the environment from uncontrolled waste disposal, such as methane, carbon dioxide, benzene and cadmium. Hazardous compounds from industrial production such as asbestos and lead are also likely to be found at dumpsites.

The health and environmental impacts of landfills and dumpsites are particularly associated with the emissions from waste decomposition, namely leachate and biogas. Leachate if not properly controlled, may pass through the underlying soil and contaminate sources of drinking water, as well as surface water. The decomposition of waste also brings about the generation of gases, mainly a mixture of methane and carbon dioxide (about 50–50% in anaerobic conditions), known as 'biogas'. Methane is lighter than air and highly flammable. If it enters a closed building and the concentration increases to about 5–15% in the air, a spark or a flame is likely to cause a serious explosion. In addition, if open burning of solid waste occurs (a normal practice to reduce volume), it could result in the emission of toxic substances to the air from the burning of plastics and other materials (ISWA, 2015:11).

Landfills and dumpsites can also cause soil pollution. Leachate from the waste matrix carries different metals, which are then transferred to plants in the soil by different pathways and eventually end up either in water held in the soil or leached to the underground water table or aquifers (ISWA, 2015). Waste in open dumps may become a breeding ground for insects, rodents and other disease vectors (WHO, 2013).

Epidemiological studies demonstrate that from the human health perspective, cancer and congenital malformation are potential health outcomes associated with exposure to dumpsites (ISWA, 2015). Collapse of sites has become more frequent at solid waste final disposal sites in urban areas in low- and lower-middle income countries, causing casualties. Uncontrolled dumpsites are often heavily scavenged by waste pickers exacerbating potential exposure contact. Health risks can be decreased through implementation of on-site measures (ISWA, 2015).

Guidelines for National Waste Management Strategies: Moving from Challenges to Opportunities – a joint effort of the United Nations Environment Programme and the United Nations Institute for Training and Research – provides a conceptual and methodological framework for national planning that countries may adapt to their particular circumstances. It also establishes a clear rationale for making waste management a national priority (UNEP and UNITAR, 2013).

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Coordinating agency or organisation

Not identified.

TL0044 / **TECHNOLOGICAL / Waste**

Tailings

Definition

Tailings are a common by-product of the mineral recovery process. They usually take the form of a liquid slurry made of fine mineral particles (created when mined ore is crushed, ground and processed) and water (ICMM, 2019).

Reference

ICMM, 2019. Tailings management. International Council on Mining and Minerals (ICMM). www.icmm.com/en-gb/environment/tailings Accessed 21 November 2019.

Annotations

Synonyms

Mining waste, Mine waste, Extractive waste.

Additional scientific description

Tailings are the fine-grained waste material remaining after the metals and minerals recoverable with the technical processes applied have been extracted. The material is rejected at the 'tail end' of the process with a particle size normally ranging from 10 µm to 1.0 mm (UNECE, 2014:3). Tailings are mixtures of crushed rock and processing fluids from mills, washeries or concentrators that remain after the extraction of economic metals, minerals, mineral fuels or coal from the mine (Kossoff et al., 2014).

Tailings are the by-product of several extractive industries, including those for aluminium, coal, oil sands, uranium and precious and base metals (Kossoff et al., 2014). The chemical composition of tailings depends on the mineralogy of the ore body, the nature of the processing fluids used to extract the economic metals, the efficiency of the extraction process and the degree of weathering during storage in the dammed impoundment. Major components usually include such elements as silica also known as silicon dioxide ($SiO2$), iron (Fe), oxygen (O), aluminium (Al), calcium (Ca), potassium (K), magnesium (Mg), manganese (Mn), sodium (Na), phosphorus (P), titanium (Ti) and sulphur (S) (Kossoff et al., 2014). Tailings may also contain toxic elements such as arsenic (As) or chemical reagents such as cyanide (CN^-) which can be toxic in sufficient concentrations (Jewell, 1998).

As an example, uranium tailings are radioactive and can retain the majority of the radioactivity of the ore from which they are derived. In parallel, their radioactivity is very long-lived; they contain a range of biotoxic heavy metals and other compounds; they may contain sulphidic minerals and so generate acid mine drainage; their granular to slime constituency makes them readily leachable, erodible or collapsible under different conditions; the common method of surface disposal exposes a large surface area to the natural elements and thus increases the risk releasing radiation flux, radioactive and geochemically toxic dusts, and interaction with surface water systems; and the large surface area of these generally thin tailings deposits (or 'piles') adversely affects large areas of land and renders potentially valuable land unfit for other uses (IAEA, 2004:6).

Tailings are also of concern due to the danger of tailing dam failures (one of the most common tailings storage methods). Failure of mining dams and the release of toxic waves of material can claim thousands of lives, affect water and sediment quality, fish, terrestrial animal life and plant life, cause irreversible environmental damage, and negatively impact biodiversity and the reputation of the mining industry.

Metrics and numeric limits

For every tonne of ore, the extraction of metal concentrates results in about 850 kg of residual solid waste and an equal amount of water containing slightly less than 1 kg of residual chemicals (Jewell, 1998). The total global volume is unknown (UNEP, 2017) and environmentally acceptable storage constitutes a significant challenge.

At the time of writing, the International Council on Mining and Metals (ICMM), the United Nations Environment (UN Environment) and the Principles for Responsible Investment (PRI) were co-convening a global tailings review to establish an international standard (Global Tailings Review, 2019).

Key relevant UN convention / multilateral treaty

Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (1972), also referred as the 'London Convention' prevents dumping of waste at sea. At the time of writing, there were 87 parties to the London Convention (IMO, 2019).

UNECE Convention on the Transboundary Effects of Industrial Accidents (1992) at the time of writing had 41 Parties (UN Treaty Collection, 1992a).

Convention on the Protection and Use of Transboundary Watercourses and International Lakes (1992) also referred as the 'Water Convention', applies as industrial accidents at tailings management facilities may lead to water pollution (UNECE, 2014). Serviced by the United Nations Economic Commission for Europe (UNECE), it started as a regional convention but was opened up to countries outside the UNECE region in 2016. At the time of writing it had 43 parties (UN Treaty Collection, 1992b).

Directive 2006/21/EC on the management of waste from the extractive industries also referred as the Extractive Waste Directive (2006) (European Commission, 2019).

Directive 2012/18/EU on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC Text with EEA relevance also referred as the Seveso III Directive includes in its scope operational tailings disposal facilities, including tailing ponds or dams, containing dangerous substances (European Commission, 2019).

Examples of drivers, outcomes and risk management

Approaches to the handling and storage of tailings can include riverine disposal, submarine disposal, wetland retention, backfilling, dry stacking, and most commonly used – storage behind dammed impoundments – 'tailing ponds' or 'tailing dams' (Kossoff et al., 2014).

Tailings are usually stored under water to prevent the formation of surface dusts and acid mine drainage (by forestalling oxidation), especially when large amounts of acid-generating pyrite and pyrrhotite are present (Kossoff et al., 2014).

Mine wastes and their storage facilities require particularly careful management for preventing and minimising air, water, and soil contamination. The rate of failure is one in 700 to one in 1750 with a significantly higher failure rate for water-retaining dams – one in 10,000 (David, 2003). Causes of failure include overtopping, poor maintenance, breach following heavy rain, breach following earthquake, foundation failure, and retention wall failure (Kossoff et al., 2014). Furthermore, abandoned mining sites and mining waste storage facilities may contain chemicals and other elements which may be dangerous to human and animal health and to the wider environment.

Effective legal and institutional frameworks for dam safety and environmental protection, implementation and enforcement of relevant laws and safety standards, adequate tailing dam designs based on accurate risk assessments, regular inspections and special monitoring systems are of critical importance for sound tailings management (Centre for Economic Development, Transport and the Environment, 2012).

Application of technology-driven solutions such as remote sensing methods has shown significant development for tailing dam monitoring and early warning systems to prevent their failure. More attention needs to be given to monitoring of the leachate coming out of the ponds/dams.

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Coordinating agency or organisation

Not identified.

TL0045 / **TECHNOLOGICAL / Waste**

Waste Treatment Lagoons

Definition

Waste [treatment] lagoons can be defined as impoundments made by excavation or earth fill for biological treatment of animal and other agricultural waste (Spellman and Bieber, 2012).

Reference

Spellman, F.R. and R.M. Bieber, 2012. Environmental Health and Science Desk Reference. Government Institutes, 807.

Annotations

Synonyms

Not applicable.

Additional scientific description

Effluents from livestock industrial production are commonly discharged into the environment or stored in 'lagoons', from which waste may spill or leak into nearby streams and groundwater supplies. Noxious gases escape into the atmosphere, subjecting downwind neighbours to sickening odours and contributing to atmospheric aerosol formation, build-up of greenhouse gases and acid rain (FAO, 2007).

The term 'lagoon' is often misused, mistakenly including manure storage basins as lagoons (Hamilton et al., 2006). Manure storage basins are not meant to provide significant biological treatment or long storage periods (Livestock and Poultry Environmental Learning Community, 2019).

'Lagoons' can be anaerobic, aerobic, naturally-aerobic, mechanically aerated and facultative, depending on their loading and design (Miller et al., 2011). Lagoons rely on physical, chemical, and biological processes to degrade manure (Hamilton et al., 2006; Miller et al., 2011).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

In recent decades, livestock production (e.g., pig farms, dairies, poultry industry) has increased rapidly. Increased production comes from industrial farms clustered around major urban centres (FAO, 2007). The livestock waste is a major source of greenhouse gases, air pollutants, harmful pathogens and odour (Sorathiya et al., 2014). Concentrations of animals (including intensive farming) and animal wastes close to dense human populations can cause large-scale environmental problems including soil, water, air pollution, and biodiversity loss and may negatively impact human health. It is potentially more dangerous if such concentrated production is conducted in areas near water sources (FAO, 2007).

The environmental and public health risks of industrial feedlots and effluent lagoons can be limited by ensuring that they are not located too close to each other, to streams and aquifers and to densely populated communities. Environmental damage can be reduced further by encouraging and enforcing standards for the design and construction of buildings and lagoons to conform with approved manure management system (FAO, 2007). Meat processing plants produce large amounts of slaughterhouse wastewater, treatment and final disposal (Bustillo-Lecompte and Mehrvar, 2017).

Livestock waste lagoons and manure storage basins may spill or leak into nearby streams and groundwater supplies. Furthermore, cracks, improper construction, increased rainfall, storm or stronger than normal winds can cause lagoon overflow. Ponds or lagoons used to store effluents should be lined to reduce leaching and be big enough to allow for manure storage at times when application on crops is not suitable, such as during the rainy season (FAO, 2007). Overflow can spread harmful bacteria, pesticides, animal antibiotics, additional oestrogens, heavy metals, and protozoa into the groundwater supply and contaminate surrounding areas and these could be identified as socio-economically generated sediments (Sharma and Singh, 2015).

Pollution associated with animal waste management in intensive livestock production include (FAO, 207):

- Leaching of nitrates into groundwater, threatening drinking water supplies.
- Eutrophication of surface water, as nitrogen, phosphorus and other nutrients are discharged or run off into streams, damaging wetlands and fragile coastal ecosystems, and fuelling algae ‘blooms’ that use up oxygen in the water, killing fish and other aquatic life.
- Build-ups of excess nutrients and heavy metals in the soil, damaging soil fertility and shrinking arable land resources.
- Contamination of soil and water resources with pathogens, heavy metals or drug residues.
- Release of ammonia, hydrogen sulphide, methane, carbon dioxide and other gases into the air, some of which can negatively impact health hazards, damage crops and ecosystems.

Effective policies and legislation to regulate intensive livestock operations and support environmentally and economically sustainable approaches, the use of adequate practices and technologies are of high importance for addressing these challenges and mitigating production of the pollutants. Livestock waste is a major source of nutrients and energy which contributes to improving the circular bioeconomy. Proper management and use of livestock waste as a fertiliser or for conversion into biogas, compost and vermicompost is a useful means to increase crop yield, sustainability, and income (Sorathiya et al., 2014).

References

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Coordinating agency or organisation

Food and Agriculture Organization of the United Nations.

TL0046 / **TECHNOLOGICAL / Flood**

Drain and Sewer Flooding

Definition

Drain and sewer flooding is said to occur when sewage or foul water leaks from the sewerage system (through pipes, drains or manholes) or floods up through toilets, sinks or showers inside a building (Priestly, 2016).

Reference

Priestly, S., 2016. Sewer flooding. House of Commons Library. London. https://commonslibrary.parliament.uk/research-briefings/cbp-7839 Accessed 30 October 2020.

Annotations

Synonyms

Urban flooding, Drainage floods, Pluvial flood.

Additional scientific description

Drain and/or sewer flooding is a condition where wastewater and/or surface water escapes from or cannot enter a drain or sewer system and either remains on the surface or enters buildings. Drains and/or sewers can also undergo surcharge which is a condition in which wastewater and/or surface water is held under pressure within a gravity drain or sewer system but does not escape to the surface to cause flooding (Document Center, 1995).

The United Nations Educational, Scientific and Cultural Organization (UNESCO) Intergovernmental Hydrological Programme (IHP) Urban Water Series, comprising a set of books on urban water management, addresses fundamental issues related to the role of water in cities and the effects of urbanisation on the hydrological cycle and water resources. Focusing on integrated approaches to sustainable urban water management, the Series provides valuable scientific and practical information for urban water practitioners, policymakers and educators throughout the world (UNESCO, 2011).

Water governance is usually highly decentralised, with overall responsibility held at the level of local government. However, there are still countries where the federal level or the state plays a key role in day-to-day operations (UNESCO / ARCEAI IdF, 2016).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

The European Committee for Standardization (CEN) provides hydraulic performance criteria in the European Standard EN 752 (CEN, 1996 & 1997).

Examples of drivers, outcomes and risk management

Urban flooding caused by severe pluvial rainstorms has been reported for an increasing number of locations throughout the world (Grüning and Grimm, 2015; Schmitt and Scheid, 2020). For many years the design of urban drainage systems had been based upon concepts of design storm frequencies. Surface runoff and sewer flow values have been computed for site-specific rainfall intensities provided by national weather services or databases (IDF curves) and required sewer pipe slope and diameters have been selected. Little consideration had been given to the possible occurrence of sewer flooding and resulting damage, in general and in terms of site-specific factors of flood hazards (Schmitt and Scheid, 2020).

In 1970, the United Nations identified three megacities. This number rose to 10 in 1990 and 28 in 2014. According to projections, there will be 41 megacities by 2030, many located in the world's least developed countries. Throughout history, these cities have often lacked both the time and the means to develop their urban services, including those relating to access to water, sanitation and rainwater drainage. This situation creates profound vulnerabilities and complex challenges. It is crucial that megacities share their experiences, to develop services capable of meeting the expectations of their inhabitants (UNESCO / ARCEAI IdF, 2016).

The study of hydrological extremes should consider that humans are part of the hydrologic system, both as agents of change and as beneficiaries of ecosystem services. While there have been significant advances in coupling hydrological and biogeophysical models over the past decade, these advances remain inaccessible to resource management decision-makers and other water sector professionals. With most river basins being no longer 'natural' as humans live and interact with the continuously changing hydrological system, there remains a need for better understanding of the coupled human-ecosystems (UNESCO IHP, 2019).

Sewage contains harmful microorganisms such as bacteria, viruses and protozoa. This contributes significantly to the spread of diseases such as typhoid and cholera and may increase the likelihood of contracting worm infections from soil contaminated by faeces. Flooding itself may displace populations and lead to further health problems (Howard et al., 2002). The greatest danger is not the risk of disease, but the risk of electrocution or explosion. People need to avoid entering a flooded basement or lighting matches until the utility companies have shut off the gas and electric service.

Flooding in urban drainage systems as may occur at different stages of hydraulic surcharge depending on the drainage system (separate or combined sewers), general drainage design characteristics, as well as specific local constraints. When private sewage drains are directly connected to the public sewer system without backwater valves, the possible effects of hydraulic surcharge depend on the levels of the lowest sewage inlet inside the house (basement), the sewer line, and the water level during surcharge, respectively. Whenever the water level in the public sewer exceeds the level of gravity inlets in the house below street level, flooding inside the house will occur due to backwater effects. In such a case flooding is possible, as well as surface flooding. In the same way, hydraulic surcharge in the sewer system might produce flooding on private properties via storm drains, when their inlet level is below the water level of the surcharged storm or combined sewer. In both cases, the occurrence of flooding, being linked directly to the level of inlets versus water level (pressure height) in the sewer can be easily predicted by hydrodynamic sewer flow simulations, assuming the availability of physical data for the private drains and public sewer system (Schmitt et al., 2002).

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Coordinating agency or organisation

Not Identified.

TL0047 / **TECHNOLOGICAL / Flood**

Reservoir Flooding

Definition

A reservoir is an artificial lake where water is stored (National Geographic, 2020). Reservoir flooding occurs when excess rainfall causes the lake level to rise or flood water to spill downstream.

Reference

National Geographic, 2020. Reservoir. National Geographic Encyclopaedia. www.nationalgeographic.org/encyclopedia/reservoir Accessed 30 October 2020.

Annotations

Synonyms

Reservoir overtopping.

Additional scientific description

Reservoirs are artificially created lakes that are usually formed by building a dam across a river. When a dam fails, a large volume of water is suddenly released from the reservoir, resulting in downstream land or properties being flooded (Cheshire East Council, 2020).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

UN Convention on the Law of the Non-navigational Uses of International Watercourses (UN Convention), adopted in 1997 (UNGA, 1997).

Examples of drivers, outcomes and risk management

Reservoir operation is an effective tool for water supply, hydropower generation, flood control and environmental or ecological enhancement. Dams are designed to safely pass floodwater, however floods exceeding the design capacity of the dam spillways cause uncontrolled release of water over the dam crest, which is accompanied by a high risk of failure. Uncontrolled water passing over a dam crest can compromise the structural integrity of the dam, such as through erosion or cavitation, which can rapidly escalate to complete failure (US Department of the Interior Bureau of Reclamation, 2014).

As climate change causes increasing rainfall, larger flood peaks may result, which may increase the risk of overtopping (Qiu et al., 2021).

Reservoir flooding can cause economic losses, environmental impacts, loss of cultural resources and loss of life. Consequences of flooding are dependent on the exposed population and assets downstream, warning times, severity of flood and flood severity understanding (U.S. Department of the Interior Bureau of Reclamation, 2014).

The effects of flooding on health are extensive and significant, ranging from mortality and injuries resulting from trauma and drowning to infectious diseases and mental health problems (acute and long-term). While some of these outcomes are relatively easy to track, understanding of the human impact of floods is still weak. For example, it has been reported that two-thirds of deaths associated with flooding are from drowning, with the other third due to physical trauma, heart attacks, electrocution, carbon monoxide poisoning and fire. Often, only immediate traumatic deaths from flooding are recorded (WHO, 2013).

Morbidity associated with floods is usually due to injuries, infections, chemical hazards and mental health effects (acute as well as delayed) (WHO, 2013). Hypothermia may also be an issue, particularly in children, if trapped in floodwaters for lengthy periods (WHO, 2021). There may also be an increased risk of respiratory tract infections due to exposure (loss of shelter, exposure to flood waters and rain). Power cuts related to floods may disrupt water treatment and supply plants thereby increasing the risk of water-borne diseases and may also affect proper functioning of health facilities, including cold chain (WHO, 2021). Floods can potentially increase the transmission of communicable diseases, including water-borne diseases (such as typhoid fever, cholera, leptospirosis and hepatitis A) and vector-borne diseases (such as malaria, dengue and dengue haemorrhagic fever, yellow fever, and West Nile Fever) (WHO, 2021).

The longer-term health effects associated with a flood are less easily identified. They include effects due to displacement, destruction of homes, delayed recovery, and water shortages (WHO, 2013).

Provided a reservoir is properly maintained the likelihood of it failing and causing flooding is low. However, in the very unlikely event of a dam collapse, a large volume of water could be released, quickly flooding a large area and possibly causing significant property damage or loss of life. Cheshire East Council in the UK provides guidance on its website for access by all on reservoir flooding. This includes finding out where a reservoir is in your area; showing how you can prepare for reservoir flooding; information about evacuation when seeking refuge from floodwaters upstairs would be unsafe and you may need to evacuate the area; and guidance on evacuation centres, routes and road closures (Cheshire East Council, 2020).

References

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WHO, 2021. Flooding and Communicable Diseases Fact Sheet. World Health Organization (WHO). www.who.int/hac/techguidance/ems/flood_cds/en Accessed 28 February 2021.

Coordinating agency or organisation

Not identified.

TL0048 / **TECHNOLOGICAL / Transportation**

Air Transportation Accident

Definition

An air transportation accident is defined as an occurrence associated with the operation of an aircraft which takes place between the time any person boards the aircraft with the intention of flight until such time as all such persons have disembarked, in which one of the following applies: a person is fatally or seriously injured, the aircraft sustains damage or structural failure, and the aircraft is missing or is completely inaccessible (United Nations, European Union and the International Transport Forum at the OECD, 2019:119).

Reference

United Nations, European Union and the International Transport Forum at the OECD (2019). Glossary for transport statistics. 5th Edition. www.unece.org/fileadmin/DAM/trans/main/wp6/pdfdocs/Glossary_for_Transport_Statistics_EN.pdf Accessed 8 November 2019.

Annotations

Synonyms

Not available.

Additional scientific description

Additional information on air transportation accidents from the Glossary for Transport Statistics (United Nations, European Union and the International Transport Forum at the OECD, 2019) is as follows:

- A person is fatally or seriously injured where this is as a result of being in the aircraft, or direct contact with any part of the aircraft, including parts which have become detached from the aircraft, or direct exposure to jet blast, except when the injuries are from natural causes, self-inflicted or inflicted by other persons, or when the injuries are to stowaways hiding outside the areas normally available to the passengers and crew.
- The aircraft sustains damage or structural failure where this adversely affects the structural strength, performance or flight characteristics of the aircraft, and would normally require major repair or replacement of the affected component (except for engine failure or damage, when the damage is limited to the engine, its cowlings or accessories; or for damage limited to propellers, wing tips, antennas, tyres, brakes, fairings, small dents or puncture holes in the aircraft skin).
- The aircraft is missing or is completely inaccessible - an aircraft is considered to be missing when the official search has been terminated and the wreckage has not been located.

Metrics and numeric limits

The International Civil Aviation Organization (ICAO) is a UN agency, established in 1944 to manage the administration and governance of the Convention on International Civil Aviation (Chicago Convention). ICAO hosts an application which provides occurrence data as well as accident and fatality statistics to 2019 (ICAO, 2020).

Statistically agreed metrics for air transportation accidents (United Nations, European Union and the International Transport Forum at the OECD, 2019) are as follows:

- Fatal injury: an injury resulting in death within 30 days of the date of the accident.
- Non-fatal injury: an injury, other than a fatal injury, which is sustained by a person in an accident.

- Serious injury: a non-fatal injury which is sustained by a person in an accident and which requires hospitalisation for more than 48 hours, commencing within seven days from the date the injury was received; or results in a fracture of any bone (except simple fractures of fingers, toes, or nose); or involves lacerations which cause severe haemorrhage, nerve, muscle or tendon damage; or involves injury to any internal organ; or involves second or third-degree burns, or any burns affecting more than 5% of the body surface; or Involves verified exposure to infectious substances or injurious radiation.
- Slight injury: a non-fatal injury, other than a serious injury, which is sustained by a person in an accident.

Key relevant UN convention / multilateral treaty

Convention for the Unification of Certain Rules for International Carriage by Air, also known as the Montreal Convention, adopted in 1999 by ICAO member states (IATA, 1999; UN Treaty Collection, 1999).

Examples of drivers, outcomes and risk management

The ICAO lists the drivers of air accidents as being runway safety-related events, loss of control in flight, controlled flight into terrain, and malicious events (ICAO, 2019).

The ICAO describes the overall purpose of their Global Aviation Safety Plan (GASP) as being to guide the harmonized development of regional and state safety planning, supported by regional safety activities coordinated by the regional aviation safety groups (ICAO, 2016).

The ICAO is coordinating an international effort to bring together expertise from such organizations as the World health Organization (WHO), the International Air Transport Association (IATA), the Airports Council International (ACI) and other partners to assist in preparedness planning, not only for pandemic influenza but for other communicable diseases or other types of public health event that might cause a public health emergency (ICAO, no date). The ICAO has published guidelines for states concerning the management of communicable disease posing a serious public health risk (ICAO, 2009). These guidelines are generic, in that they are applicable to many communicable diseases, not only influenza, and can form the basis for management of other types of public health event, such as a nuclear power plant explosion that may emit a radioactive plume that impinges on aircraft routes. They will continue to be modified as more information is gained on preparedness planning. They are based on the WHO International Health Regulations (WHO, 2016).

References

IATA, 1999. Montreal Convention 1999. International Air Transportation Association (IATA). www.iata.org/policy/documents/mc99_en.pdf Accessed 20 November 2019.

ICAO, no date. Public Health and Aviation. International Civil Aviation Organisation (ICAO). www.icao.int/safety/aviation-medicine/pages/guidelines.aspx Accessed 3 October 2020.

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United Nations, European Union and the International Transport Forum at the OECD, 2019. Glossary for Transport Statistics. 5th Edition. www.unece.org/fileadmin/DAM/trans/main/wp6/pdfdocs/Glossary_for_Transport_Statistics_EN.pdf Accessed 3 October 2020.

WHO, 2016. International Health Regulations, 2005. 3rd Edition. World Health Organization (WHO). www.who.int/ihr/publications/9789241596664/en Accessed 26 September 2020.

Coordinating agency or organisation

United Nations Economic Commission for Europe (UNECE) in collaboration with the International Civil Aviation Organisation (ICAO).

TL0049 / **TECHNOLOGICAL / Transportation**

Inland Water Ways

Definition

An inland waterway transportation accident is an unwanted or unintended sudden event or a specific chain of such events occurring in connection with inland water vessel operations, which have harmful consequences (United Nations, European Union and the International Transport Forum at the OECD, 2019).

Reference

United Nations, European Union and the International Transport Forum at the OECD (2019). Glossary for transport statistics. 5th Edition. www.unece.org/fileadmin/DAM/trans/main/wp6/pdfdocs/Glossary_for_Transport_Statistics_EN.pdf Accessed 30 November 2019.

Annotations

Synonyms

Not identified.

Additional scientific description

The Glossary for Transport Statistics prepared by the United Nations, the European Union and the International Transport Forum at the Organisation for Economic Co-operation and Development (2019) gives additional information for Inland Waterways Transportation Accidents, and describes these as an event that has resulted in any of the following: the death of, or serious injury to, a person that is caused by, or in connection with, the operations of an Inland Waterway Transport (IWT) vessel; or the loss of a person from an IWT vessel that is caused by, or in connection with, the operations of an IWT vessel; or the loss, presumed loss or abandonment of an IWT vessel; or material damage to an IWT vessel; or the stranding or disabling of an IWT vessel, or the involvement of an IWT vessel in a collision; or material damage to the inland waterways' infrastructures external to a vessel that could seriously endanger the safety of the vessel or another vessel or an individual; or damage to the environment brought about by the damage of an IWT vessel or IWT vessels being caused by, or in connection with, the operations of an IWT vessel or IWT vessels.

Any accident in connection with the normal operation of the vessel, including when it is in port or at anchor is covered.

Terrorism, other criminal acts and acts of war are excluded. By definition suicides are excluded as they are a deliberate act. Illness not related to operation of the ship is excluded.

Metrics and numeric limits

Statistically agreed metrics for an Inland Waterway Accident are as follows (European Union and the International Transport Forum at the Organisation for Economic Co-operation and Development, 2019):

- *Fatal accident:* any injury resulting in a person killed.
- *Non-fatal accident:* any injury incident other than a fatal accident.
- *Person killed:* any person killed immediately or dying within 30 days as a result of an injury accident excluding suicides.
- *Person injured:* any person who as a result of an injury accident was not killed immediately or not dying within 30 days but sustained an injury, normally needing medical treatment, excluding attempted suicides.

A suicide or an attempted suicide is a deliberate act to injure oneself fatally and is therefore not considered as an accident. However, if a suicide or an attempted suicide causes injury to another person on an IWT vessel, then this is regarded as an injury accident (United Nations, European Union and the International Transport Forum at the Organisation for Economic Co-operation and Development, 2019).

Key relevant UN convention / multilateral treaty

The multilateral convention relating to the limitation of the liability of owners of inland navigation vessels (CLN) (UN Treaty Collection, 1973).

Examples of drivers, outcomes and risk management

United Nations, European Union and the International Transport Forum at the Organisation for Economic Co-operation and Development (2019) details drivers of this hazard as collision, storm, overloading, stability failure, excessive current, and bottom damage. For malicious acts refer to societal hazards.

The UK Inland Waterways Association Safety Policy (2012) presents information on the roles and responsibilities of those involved in their association and subsidiaries to prevent and reduce the risk of accidents occurring.

References

UK Inland Waterways Association, 2012. Safety policy: Roles and responsibilities. Accessed 30 November 2019.

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United Nations, European Union and the International Transport Forum at the OECD (2019). Glossary for transport statistics. 5th Edition. www.unece.org/fileadmin/DAM/trans/main/wp6/pdfdocs/Glossary_for_Transport_Statistics_EN.pdf Accessed 30 November 2019.

Coordinating agency or organisation

United Nations Economic Commission for Europe (UNECE).

TL0050 / **TECHNOLOGICAL / Transportation**

Marine Accident

Definition

A marine accident is an event, or a sequence of events, that has resulted in any of the following occurring directly in connection with the normal operation of a marine vessel: the death of, or serious injury to, a person; the loss of a person from a ship; the loss, presumed loss or abandonment of a marine vessel; material damage to a marine vessel; the stranding or disabling of a marine vessel, or the involvement of a marine vessel in a collision; material damage to the marine infrastructures external to a vessel, that could seriously endanger the safety of the vessel or another vessel or an individual; and severe damage to the environment, or the potential for severe damage to the environment, brought about by the damage of a marine vessel (United Nations, European Union and the International Transport Forum at the OECD, 2019).

Reference

United Nations, European Union and the International Transport Forum at the OECD (2019). Glossary for transport statistics. 5th Edition. www.unece.org/fileadmin/DAM/trans/main/wp6/pdfdocs/Glossary_for_Transport_Statistics_EN.pdf Accessed 3 October 2020.

Annotations

Synonyms

Not available.

Additional scientific description

Statistically agreed definitions for Marine Accident (United Nations, European Union and the International Transport Forum at the OECD, 2019) as follows:

- *Fatal accident:* any injury resulting in a person killed.
- *Non-fatal accident:* any injury incident other than a fatal accident.
- *Person killed:* Any person killed immediately or dying within 30 days as a result of an injury accident. *For countries that do not apply the threshold of 30 days, conversion coefficients are estimated so that comparisons on the basis of the 30 day-definition can be made.*
- *Person lost at sea:* A person missing at sea, being presumed to have gone overboard.
- *Person Injured:* Any person who as result of an injury accident was not killed but sustained an injury.
- *Serious injury:* An injury which is sustained by a person in a casualty resulting in incapacitation for more than 72 hours commencing within seven days from the date of injury.
- *Person seriously injured:* Any person who as result of an injury accident was seriously injured.
- *Person slightly injured:* Any person who as result on an injury accident was not seriously injured.

- *Very serious marine casualty:* A casualty to a marine vessel which involves the total loss of the marine vessel, loss of life or severe damage to the environment.
- *Serious marine casualty:* A casualty which does not qualify as a very serious casualty and which involves a fire, explosion, grounding, contact, heavy weather damage, ice damage, hull cracking or suspected hull defect, etc., resulting in: structural damage rendering the marine vessel not navigable, such as penetration of the hull underwater, immobilisation of the main engines, extensive accommodation damage etc.; or pollution (regardless of quantity); and/or a breakdown necessitating towage or shore assistance.
- *Marine incident:* An occurrence or event being caused by, or in connection with, the operations of a marine vessel in motion at sea, other than a marine casualty that endangered, or, if not corrected, would endanger the safety of the vessel, its occupants or any other person or the environment.

Metrics and numeric limits

The International Maritime Organization (IMO) is the United Nations agency with responsibility for the safety and security of shipping and the prevention of marine and atmospheric pollution by ships. The IMO's work supports the United Nations Sustainable Development Goals (IMO, 2019). Reporting to IMO of marine safety investigations and marine casualties and incidents are based on the following IMO instruments (IMO, no date):

- Code of International Standards and Recommended Practices for a Safety Investigation into a Marine Casualty or Marine Incident (Casualty Investigation Code), 2008 edition (resolution MSC.255(84)).
- Safety of fishermen at sea, resolution A.646(16), paragraph 3.
- Reports on casualty statistics concerning fishing vessels and fishermen at sea, MSC/Circ.539/Add.2.
- Report on fishing vessels and fishermen statistics, MSC/Circ.753.
- Provision of preliminary information on serious and very serious casualties by rescue co-ordination centres, MSC/Circ.802.
- Guidance on near-miss reporting, MSC-MEPC.7/Circ.7, paragraph 4.
- Casualty-related matters, Reports on marine casualties and incidents, MSC-MEPC.3/Circ.4/Rev.1.
- Guide on the process of Reporting a marine casualty and incident to IMO; and Reviewing the analysis of a marine safety investigation report submitted to IMO, which is a user guidance for the Global Integrated Shipping Information System (GISIS) module on marine casualties and incidents.
- Guide on the process to Associate interest to a Marine Safety Investigation report, which is regarding how Member States can be associated to a Marine Safety Investigation report previously uploaded into GISIS-MCI.

Key relevant UN convention / multilateral treaty

United Nations Convention on the Law of the Sea (United Nations, 1982).

Examples of drivers, outcomes and risk management

The causes of marine accidents include collision, close quarters and contact accidents; grounding; fire; explosion; lifeboat (lack of training and/or maintenance); inadequate risk management; third party deficiency; technical failure and weather and other environmental factors (Acejo et al., 2018).

The IMO has established an International Safety Management (ISM) Code that seeks to establish systems for safe operation and management of ships and for pollution prevention (IMO, 1993). The Code's origins go back to the late 1980s, when there was mounting concern about poor management standards in shipping. Investigations into accidents revealed major errors on the part of management, and in 1987 the IMO Assembly adopted resolution A.596(15), which called upon the Maritime Safety Committee to develop guidelines concerning shore-based management to ensure the safe operation of ro-ro passenger ferries. The procedures required by the Code should be documented and compiled in a Safety Management Manual, a copy of which should be kept on board (IMO, 1998).

References

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United Nations, European Union and the International Transport Forum at the OECD (2019). Glossary for transport statistics. 5th Edition. www.unece.org/fileadmin/DAM/trans/main/wp6/pdfdocs/Glossary_for_Transport_Statistics_EN.pdf Accessed 30 November 2019.

Coordinating agency or organisation

United Nations Economic Commission for Europe.

TL0051 / **TECHNOLOGICAL / Transportation**

Rail Accident

Definition

A rail accident is an unwanted or unintended sudden event or a specific chain of such events (occurring during train operation) which has harmful consequences (United Nations, European Union and the International Transport Forum at the OECD, 2019).

Reference

United Nations, European Union and the International Transport Forum at the OECD (2019). Glossary for transport statistics. 5th Edition. www.unece.org/fileadmin/DAM/trans/main/wp6/pdfdocs/Glossary_for_Transport_Statistics_EN.pdf Accessed on 3 October 2020

Annotations

Synonyms

Train crash, Train wreck, Railroad accident.

Additional scientific description

United Nations, European Union and the International Transport Forum at the Organisation for Economic Co-operation and Development Glossary (2019) states that the statistically agreed definitions for Rail Accident are as follows (United Nations, European Union and the International Transport Forum at the OECD, 2019):

- *Accident:* An unwanted or unintended sudden event or a specific chain of such events (occurring during train operation) which has harmful consequences.
- *Incident:* Any occurrence, other than an accident, highlighting a potential safety issue in railway operations. (*Sometimes also referred to as accident precursor, or near-miss.)*
- *Significant accident:* Any accident involving at least one rail vehicle in motion, resulting in at least one killed or seriously injured person, or significant damage to stock, track, other installations or environment, or extensive disruption to traffic. Accidents in workshops, warehouses and depots are excluded. *This definition is used by the UIC (Union Internationale des Chemins de Fer).*
- *Significant damage to stock, track, other installations or environment:* Damage that exceeds an internationally agreed threshold. (*The threshold for significant damage, adopted by the UIC, was set at EUR 150,000 in 2007.)*
- *Extensive disruption to traffic:* Extensive disruption to traffic occurs when train services on at least one main railway line are suspended for more than six hours.
- *Injury accident:* Any accident involving at least one rail vehicle in motion, resulting in at least one killed or injured person. Accidents in workshops, warehouses and depots are excluded. (*This definition includes accidents with slightly injured persons and is similar to that used in road accident statistics.)*
- *Serious injury accident:* Any accident involving at least one rail vehicle in motion, resulting in at least one killed or seriously injured person. Accidents in workshops, warehouses and depots are excluded. (*This definition is normally used by the UIC for railway accidents and excludes the accidents with slightly injured persons. Figures collected under this definition cannot be compared directly to the number of road accidents which includes accidents with slightly injured persons.)*
- *Casualty:* Any person killed or injured as a result of an injury accident, excluding attempted suicides.
- *Person killed:* Any person dying immediately or within 30 days as a result of an injury accident, excluding suicide. (*It includes passengers, employees and other specified or unspecified persons involved in a rail injury accident. A killed person is excluded if the competent authority declares the cause of death to be suicide, i.e., a deliberate act to injure oneself resulting in death. For countries that do not apply the threshold of 30 days, conversion coefficients are estimated so that comparisons on the basis of the 30 day-definition can be made.)*

- *Person injured:* Any person who as a result of an accident was not killed immediately or not dying within 30 days, but sustained an injury, normally needing medical treatment, excluding attempted suicide. (*Injuries include cases such as, but not limited to, a cut, fracture, sprain, or amputation. Persons with lesser wounds, such as minor cuts and bruises are not normally recorded as injured. An injured person is excluded if the competent authority declares the cause of the injury to be attempted suicide by that person, i.e., a deliberate act to injure oneself resulting in injury, but not in death.)*
- *Person seriously injured:* Any person injured who was hospitalised for more than 24 hours as a result of an accident, excluding attempted suicide.
- *Person slightly injured:* Any person injured normally needing medical treatment, excluding attempted suicide, not classified as seriously injured. (*Persons with lesser wounds, such as minor cuts and bruises are not normally recorded as injured.)*
- *Collision:*
  - Collision of two or more rail vehicles (*Any front to front, front to end or a side impact between a part of a train and a part of another train or rail vehicle, or with shunting rolling stock).*
  - Collision of rail vehicle with an obstacle within the clearance gauge (*An impact between a part of a train and objects fixed or temporarily present on or near the track (except at level crossings if lost by a crossing vehicle or user), including impacts with overhead contact lines).*
- *Derailment:* Any case in which at least one wheel of a train leaves the rails. (*Derailments as a result of collisions are excluded. These are classified as collisions.)*
- *Level crossing accidents:* Any accident at a level crossing involving at least one railway vehicle and one or more crossing vehicles, other users of the road such as pedestrians or other objects temporarily present at or near the track (*Sometimes also referred to as grade crossing accident.)*
- *Accidents to persons caused by rolling stock in motion:* Accidents to one or more persons that are either hit by a railway vehicle or part of it or hit by an object attached to it or that has become detached from the vehicle. Persons that fall from railway vehicles are included, as well as persons that fall or are hit by loose objects when travelling on-board vehicles.
- *Fires in rolling stock:* Fires and explosions that occur in railway vehicles (including their load) when they are running between the departure station and the destination, including when stopped at the departure station, the destination station or intermediate stops, as well as during re-marshalling operations.
- *Accident involving the transport of dangerous goods:* Any accident or incident that is subject to reporting in accordance with the Regulation concerning the International Carriage of Dangerous Goods by Rail (OTIF, 2021).
- *Suicide:* An act to deliberately injure oneself resulting in death, as recorded and classified by the competent national authority.
- *Attempted suicide:* An act to deliberately injure oneself resulting in serious injury, but not in death, as recorded and classified by the competent national authority.

Category of person in railway accident statistics:

- *Rail passenger:* Any person, excluding members of the train crew, who makes a trip by rail. For accident statistics, passengers trying to embark/disembark onto/from a moving train are included.
- *Employees or contractor:* Any person whose employment is in connection with a railway and is at work on duty at the time of the accident. It includes the crew of the train and persons handling rolling stock and infrastructure installations.
- *Level crossing user:* Persons using a level crossing to cross the railway line by any means of transportation or by foot.
- *Trespasser (unauthorised persons on railway premises):* Any persons present in railway premises where such presence is forbidden, with the exception of level crossing users.
- *Others:*
  - *Other person at platform:* means any person at a railway platform who is not defined as 'passenger', 'employee or contractor', 'level crossing user', 'other person not at a platform' or 'trespasser'.
  - *Other person not at platform:* means any person not at a railway platform who is not defined as 'passenger', 'employee or contractor', 'level crossing user', 'other person at a platform' or 'trespasser'.

Metrics and numeric limits

Not reported globally.

Key relevant UN convention / multilateral treaty

Not identified.

Examples of drivers, outcomes and risk management

Drivers of this hazard include collisions, derailments, level crossing accidents, accidents to persons caused by rolling stock in motion, and fires in rolling stock (United Nations, European Union and the International Transport Forum at the OECD, 2019).

The Railway Safety Directive was published with the purpose of establishing and improving rail safety and security standards across the European Union (ORR, 2004). This framework also includes Common Safety Targets (CST) to develop and improve safety performance (European Union Agency for Railways, 2017).

It should be noted that, in contrast to other modes of transport, a large majority of rail accident fatalities occur to level crossing users or trespassers on rail tracks, as opposed to railway passengers (European Union Agency for Railways, 2018). This thus presents different hazard management challenges than for other modes of transport.

References

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Coordinating agency or organisation

United Nations Economic Commission for Europe (UNECE).

TL0052 / **TECHNOLOGICAL / Transportation**

Road Traffic Accident

Definition

A road traffic accident is any accident involving at least one road vehicle in motion on a public road or private road to which the public has right of access, resulting in at least one injured or killed person (United Nations, European Union and the International Transport Forum at the OECD, 2019).

Reference

United Nations, European Union and the International Transport Forum at the OECD (2019). Glossary for transport statistics. 5th Edition. www.unece.org/fileadmin/DAM/trans/main/wp6/pdfdocs/Glossary_for_Transport_Statistics_EN.pdf Accessed 15 November 2019.

Annotations

Synonyms

Traffic accident, Motor vehicle collision, Motor vehicle accident, Car accident, Automobile accident, Road traffic collision, Car crash.

Additional scientific description

Statistically agreed definitions for road transport accident (United Nations, European Union and the International Transport Forum at the OECD (2019) are as follows:

- *Injury accident:* Any accident involving at least one road vehicle in motion on a public road or private road to which the public has right of access, resulting in at least one injured or killed *person. (A suicide or an attempted suicide is not an accident, but an incident caused by a deliberate act to injure oneself fatally. However, if a suicide or an attempted suicide causes injury to another road user, then the incident is regarded as an injury accident.)*

Injury accidents include collisions between road vehicles; between road vehicles and pedestrians; between road vehicles and animals or fixed obstacles and with one road vehicle alone. Included are collisions between road and rail vehicles. Multivehicle collisions are counted as only one accident provided that any successive collisions happen within a very short period. Injury accidents exclude accidents incurring only material damage.

Injury accidents exclude terrorist acts.

- *Fatal accident:* Any injury accident resulting in a person killed.
- *Non-fatal accident:* Any injury accident other than a fatal accident.
- *Casualty:* Any person killed or injured as a result of an injury accident.
- *Person killed:* Any person killed immediately or dying within 30 days as a result of an injury accident, excluding suicides. (*A killed person is excluded if the competent authority declares the cause of death to be suicide, i.e., a deliberate act to injure oneself resulting in death. For countries that do not apply the threshold of 30 days, conversion coefficients are estimated so that comparisons on the basis of the 30 day-definition can be made.)*
- *Person injured:* Any person who as result of an accident was not killed immediately or not dying within 30 days, but sustained an injury, normally needing medical treatment, excluding attempted suicides. (*Persons with lesser wounds, such as minor cuts and bruises are not normally recorded as injured. An injured person is excluded if the competent authority declares the cause of the injury to be attempted suicide by that person, i.e., a deliberate act to injure oneself resulting in injury, but not in death.)*
- *Person seriously injured:* Any person injured who was hospitalised for a period of more than 24 hours.

- *Person slightly injured:* Any person injured excluding persons killed or seriously injured. (*Persons with lesser wounds, such as minor cuts and bruises are not normally recorded as injured.)*
- *Maximum abbreviated injury scale (MAIS):* The Maximum Abbreviated Injury Scale is a medical classification on the severity of injuries. MAIS 1-2 is regarded as slight injuries and 3-6 as serious injuries. *(Other classifications can be used if they can be transcoded to MAIS.)*
- *Driver involved in an injury accident:* Any person involved in an injury accident who was driving a road vehicle at the time of the accident.
- *Passenger involved in an injury accident:* Any person involved in an injury accident, other than a driver, who was in or on a road vehicle, or in the process of getting in or out of a road vehicle.
- *Pedestrian Involved in an injury accident:* Any person involved in an injury accident other than a passenger or driver as defined above. *(Included are occupants or persons pushing or pulling a child's carriage, an invalid chair, or any other small vehicle without an engine. Also included are persons pushing a cycle, moped, roller-skating, skateboarding, skiing or using similar devices.)*
- *Accident between road vehicle and pedestrian:* Any injury accident involving one or more road vehicles and one or more pedestrians. *(Included are accidents irrespective of whether a pedestrian was involved in the first or a later phase of the accident and whether a pedestrian was injured or killed on or off the road.)*
- *Single-vehicle road accident:* Any injury accident in which only one road vehicle is involved. *(Included are accidents of vehicles trying to avoid collision and veering off the road, or accidents caused by collision with obstruction or animals on the road. Excluded are collisions with pedestrians and parked vehicles.)*
- *Multi-vehicle road accident:* Any injury accident involving two or more road vehicles. The following types of injury accidents involving two or more road vehicles are:
  - Rear-end collision: collision with another vehicle using the same lane of a carriageway and moving in the same direction, slowing or temporarily halted. *(Excluded are collisions with parked vehicles.)*
  - Head-on collision: collision with another vehicle using the same lane of a carriageway and moving in the opposite direction, slowing or temporarily halted. *(Excluded are collisions with parked vehicles.)*
  - Collision due to crossing or turning: collision with another vehicle moving in a lateral direction due to crossing, leaving or entering a road. *(Excluded are collisions with vehicles halted and waiting to turn which should be classified under (a) or (b).)*
  - Other collisions, including collisions with parked vehicles: collision occurring when driving side by side, overtaking or when changing lanes; or collision with a vehicle which has parked or stopped at the edge of a carriageway, on shoulders, marked parking spaces, footpaths or parking sites, etc. *Included in B.VI-15 (d) are all collisions not covered by (a), (b) and (c). The constituent element for classification of accidents between vehicles is the first collision on the carriageway, or the first mechanical impact on the vehicle.)*
- *Accident with drivers reported to be under the influence of alcohol, drugs or medication:* Any injury accident where at least one driver is reported to be under the influence of alcohol, drugs or medication impairing driving ability, according to national regulations.
- *Suicide:* An act to deliberately injure oneself resulting in death, as recorded and classified by the competent national authority. (Designation of individual suicide must be determined by a coroner, public police officer or other public authority. *(Attempted suicide as an act of deliberately injuring oneself (not leading to the death) is excluded. Only the death of the individual(s) who committed suicide is to be reported as suicide. Therefore, a fatality caused to a person by another person who committed suicide or who attempted to commit suicide is not to be reported as a suicide.)*
- *Attempted suicide:* Act to deliberately injure oneself resulting in serious injury, but not in death, as recorded and classified by the competent national authority.

Metrics and numeric limits

Not globally reported.

Key relevant UN convention / multilateral treaty

Hague Conference on Private International Law (1971).

Examples of drivers, outcomes and risk management

In 2018, the more than one quarter of those killed and injured are pedestrians and cyclists. Road traffic injuries are now the leading cause of death for children and young adults aged 5 to 29 years. Given the enormous human suffering and major economic losses for families and societies, road traffic deaths remain an unacceptable price to pay for mobility.

The WHO's Global Status Report on Road Safety 2018, presents information on road safety from 175 countries (WHO, 2018b). This report is the fourth in a series and provides an overview of the road safety situation globally. The global status reports are the official tool for monitoring the Decade of Action. The World Health Organization (WHO) reported that approximately 1.35 million people lose their lives on the world's roads every year, and up to 50 million are injured (Association for Safe International Road Travel, no date).

The WHO has identified that road traffic crashes cost most countries 3% of their gross domestic product; more than half of all road traffic deaths are among vulnerable road users: pedestrians, cyclists, and motorcyclists; and 93% of the world's deaths on the roads occur in low- and middle-income countries, even though these countries have approximately 60% of the world's vehicles (WHO, 2018a).

The 2030 Agenda for Sustainable Development has set an ambitious target of halving the global number of deaths and injuries from road traffic accidents by 2020 (United Nations, no date).

The WHO is the lead agency for Coordinating the Decade of Action for Road Safety by working in collaboration with the United Nations regional commissions for road safety within the UN system (WHO Regional Office for Africa, 2020). WHO chairs the United Nations Road Safety Collaboration (United Nations Road Safety Collaboration, 2019) and serves as the secretariat for the Decade of Action for Road Safety 2011– 2020. Proclaimed through a UN General Assembly resolution in 2010, the Decade of Action was launched in May 2011 in over 110 countries, with the aim of saving millions of lives by implementing the Global Plan for the Decade of Acton (WHO, 2018b). WHO also plays a key role in guiding global efforts by continuing to advocate for road safety at the highest political levels; compiling and disseminating good practices in prevention, data collection and trauma care; sharing information with the public on risks and how to reduce these risks; and drawing attention to the need for increased funding.

Road traffic injuries can be prevented. Governments need to take action to address road safety in a holistic manner. This requires involvement from multiple sectors such as transport, police, health, education, and actions that address the safety of roads, vehicles, and road users (WHO, 2018a). Effective interventions include designing safer infrastructure and incorporating road safety features into land-use and transport planning, improving the safety features of vehicles, improving post-crash care for victims of road crashes, setting and enforcing laws relating to key risks, and raising public awareness (WHO, 2018a).

The 3rd Global Ministerial Conference on Road Safety was held in Sweden in February 2020. Hosted at the request of the UN General Assembly by the Government of Sweden in collaboration with WHO, the theme was Achieving Global Goals 2030, highlighting the connections between road safety and achievement of other Sustainable Development Goal targets. The Ministerial Conference culminated in the forward-looking Stockholm Declaration, which calls for a new global target to reduce road traffic deaths and injuries by 50% by 2030. In addition, it invites strengthened efforts on activities in all five pillars of the Global Plan for the Decade of Action: better road safety management; safer roads, vehicles and people; and enhanced post-crash care. It also calls for speeding up the shift to safe, affordable, accessible and sustainable modes of transport like walking, cycling and public transport. WHO is asked to continue to produce the series of global status reports, as a means of monitoring progress towards achievement of the 12 Global Road Safety Performance Targets (WHO, 2020).

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United Nations Road Safety Collaboration, 2019. Decade of Action for Road Safety 2011-2020. www.who.int/groups/united-nations-road-safety-collaboration Accessed 15 November 2019.

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Coordinating agency or organisation

United Nations Economic Commission for Europe (UNECE) and World Health Organization (WHO).

TL0053 / **TECHNOLOGICAL / CBRNE (Chemical, Biological, Radiological, Nuclear and Explosive)**

Explosive agents

Definition

Explosive agents include improvised explosive devices (IEDs) which can be made anywhere from a wide range of materials – from everyday tools, to conventional explosives, to commercial explosives used in construction and mining. They are cheap and relatively easy to construct (UNODA, 2014).

Reference

UNODA, 2014. Improvised Explosive Devices (IEDs) Publication. United Nations Office for Disarmament Affairs (UNODA). www.un.org/disarmament/convarms/ieds2 Accessed 1 December 2019.

Annotations

Synonyms

Not available.

Additional scientific description

The threat of improvised explosive device (IED) attacks is a global problem. Cheap and relatively easy to construct, IEDs can be made anywhere from a wide range of materials. Categorisation of the harm from the explosive device can be determined through its velocity (high/low). The lack of proper stockpile security of military and commercial explosives – making them susceptible to diversion into illicit hands – also presents a significant security risk (UNODA, 2014).

Metrics and numeric limits

Improvised explosive devices kill thousands of people every year, inflicting grievous physical injuries, causing dire psychological harm and spreading fear and disruption across affected communities. Their impact on the security and stability of affected States is profound: IED attacks not only hinder the political, social and economic development of a country, but also block life-saving humanitarian aid (UNODA, 2014).

Owing to their specific nature as a tool of asymmetric warfare, IEDs are produced entirely outside government oversight. Combating their covert, rough-and-ready manufacture is a particular challenge. A full and comprehensive approach to addressing IEDs has been lacking. There is only piecemeal international cooperation against the rapid and widespread transfer of knowledge on IED design, little work on controlling commercial components, and an absence of sustained attention to victim assistance.

Some relevant initiatives to address IEDs have been put in place by governments and international and regional organisations. Under the Convention on Certain Conventional Weapons, an expert group has compiled a list of existing guidelines and best practices aimed at addressing the diversion or illicit use of materials which can be used for IEDs (UNODA, 2014).

Key relevant UN convention /multilateral treaty

Convention on Certain Conventional Weapons, Amended Protocol II (United Nations, 2008).

In 2015, Afghanistan took the lead within the United Nations General Assembly to develop a resolution focused on the need for an effective global, comprehensive, coordinated approach to counter the proliferation of IEDs in settings of violent extremism and instability. The resolution (70/46), adopted by consensus, included a call for the consistent collection of data, awareness raising, options for the regulation of components, international technical assistance and cooperation, and victim assistance (UNODA, 2014).

Examples of drivers, outcomes and risk management

Strengthening vigilance and national controls: IEDs are often made with military- or commercially-sourced explosives. The General Assembly resolution calls for measures to be put in place to establish tighter controls over materials or components used for making IEDs. These controls could encompass national ammunition stockpiles and industrially produced detonators, detonating cords and industrially produced explosives, such as for mining. Relevant industry and corporations could also be encouraged to engage in the regulation of pre-cursor and prefabricated components (UNODA, 2014).

Enhancing information sharing: owing to the ad-hoc design of IEDs, there is an overriding need for States to share information on the composition and production methods of captured IEDs, including after IED attacks. The resolution underlines this necessity. Effective information sharing on IED designs and components between Member States has the potential to shorten the learning curve that military and security forces have to go through in order to identify and develop effective counter measures. Also, civilians will be protected better when effective information sharing on new IED designs leads to quicker neutralisation (UNODA, 2014).

References

UNODA, 2014. Improvised Explosive Devices (IEDs) Publication. United Nations Office for Disarmament Affairs (UNODA). www.un.org/disarmament/convarms/ieds2 Accessed 4 March 2021.

United Nations, 2008. Convention on Certain Conventional Weapons. Amended Protocol II. Group of Experts. www.unog.ch/80256EE600585943/(httpPages)/39340DE9A9659E5CC1257CF400344B35?OpenDocument Accessed 1 December 2019.

Coordinating agency or organisation

Not identified.

SOCIETAL

SO0001 / **SOCIETAL / Conflict**

International Armed Conflict (IAC)

Definition

International armed conflict covers all cases of declared war and other de facto armed conflict between two or more States, even if the state of war is not recognised by one of them and/or the use of armed force is unilateral (ICRC, 2016).

Reference

ICRC, 2016. Commentary on the First Geneva Convention. International Committee of the Red Cross (ICRC). https://ihl-databases.icrc.org/applic/ihl/ihl.nsf/Comment.xsp?action=open Document&documentId=BE2D518CF5DE54EAC1257F7D0036B518#44 Accessed 14 January 2020.

Annotations

Synonyms

Interstate armed conflict, State-based armed conflict.

Additional scientific description

Common Article 2 of the Geneva Conventions of 1949 defined International Armed Conflict (IAC) as, "all cases of declared war or of any other armed conflict which may arise between two or more of the High Contracting Parties, even if the state of war is not recognized by one of them." IAC "exists whenever there is a resort to armed force between States" (ICTY, 1995) and "can always be assumed when parts of the armed forces of two States clash with each other" (Schindler, 1979). (The Geneva Conventions refer to States that are party to the Conventions as 'High Contracting Parties'.)

International armed conflict is conceptually broader and more flexible than the notion of war between States, because IAC is based on objective and factual criteria and does not rely on the formal declaration of war (ICRC, 2016). By extension, the termination of IAC is based on evidence on the ground and not a ceasefire or peace agreement (ICRC, 2016). Article 6(2) of the Fourth Convention stipulates that the Convention ceases to apply when there is objective evidence of "the general close of military operations," and the International Criminal Tribunal for the former Yugoslavia (ICTY) ruled that International Humanitarian Law "extends beyond the cessation of hostilities until a general conclusion of peace is reached" (ICTY, 1995: para. 70).

The category of IAC encompasses a broad range of international hostilities, including, but not limited to:

- "All cases of partial or total occupation of the territory of a High Contracting Party, even if the said occupation meets with no armed resistance" (ICRC, 1949, Article 2[2]).
- "An unconsented-to invasion or deployment of a State's armed forces on the territory of another State – even if it does not meet with armed resistance" (ICRC, 2016, para. 223).
- "Armed conflicts in which peoples are fighting against colonial domination, alien occupation or racist regimes" (ICRC, 1977, Additional Protocol I, Article 1[4], para. 1).
- "Minor skirmishes between the armed forces, be they land, air or naval forces" (ICRC, 2016, para. 237).

Armed forces and non-military agencies acting on behalf of the State may be involved in the means and methods of IAC, and the use of armed force may be directed against a State's armed forces, territory, population, or military or civilian infrastructure (ICRC, 2016).

Metrics and numeric limits

The identification and classification of IAC is not conducted by a central authority, and there is no minimum threshold of intensity or duration for a confrontation to be considered a situation of IAC (ICRC, 2016).

There are numerous academic conflict datasets available that provide their own operational thresholds for the minimum number of annual fatalities for IAC events and trends to be included. For example, two of the most influential academic conflict datasets, the Uppsala Conflict Data Program (Uppsala Universitet, no date) and the Correlates of War (The Correlates of War Project, no date) apply annual conflict-related fatality thresholds of 25 and 1000, respectively.

Key relevant UN convention / multilateral treaty

Article 2 Common to the Geneva Conventions

Geneva Convention Relative to the Protection of Civilian Persons in Time of War (Fourth Geneva Convention) (ICRC, 1949).

Protocol additional to the Geneva Conventions of 12 August 1949 and relating to the Protection of Victims of International Armed Conflicts (Protocol I) (ICRC, 1977).

Examples of drivers, outcomes and risk management

Armed conflict carries immediate and severe impacts on human lives, health, and dignity: "Increasing numbers of civilians have been killed, wounded, treated without dignity, arbitrarily detained and/or separated from their families. They have been targeted on purpose, forced to leave their homes, and deprived of their basic rights as human beings, such as the right to supplies essential to their survival" (ICRC, 1999).

In situations of armed conflict, international humanitarian law aims to protect people, the environment (e.g., Article 55 of ICRC 1977), livelihoods, infrastructure, education systems, health systems, and cultural objects and property, to name a few (ICRC, 1999).

References

ICRC, 1949. Geneva Convention Relative to the Protection of Civilian Persons in Time of War (Fourth Geneva Convention). International Committee of the Red Cross (ICRC). www.refworld.org/docid/3ae6b36d2.html Accessed 14 January 2020.

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Schindler, D., 1979. The different types of armed conflicts according to the Geneva Conventions and Protocols. RCADI, Vol. 163, 1979-II, p. 131.

The Correlates of War Project, no date. About the Correlates of War Project. https://correlatesofwar.org Accessed 6 November 2020.

Uppsala Universitet, no date. Uppsala Conflict Data Program. Department of Peace and Conflict Research. https://ucdp.uu.se Accessed 6 November 2020.

Coordinating agency or organisation

Not identified.

SO0002 / **SOCIETAL / Conflict**

Non-International Armed Conflict (NIAC)

Definition

Non-international armed conflict is defined as protracted armed confrontations occurring between governmental armed forces and the forces of one or more armed groups, or between such groups arising on the territory of a State. The armed confrontation must reach a minimum level of intensity, and the parties involved in the conflict must show a minimum of organisation (ICRC, 2008).

Reference

ICRC, 2008. How is the term 'Armed Conflict' defined in International Humanitarian Law? Opinion Paper. International Committee of the Red Cross (ICRC). www.icrc.org/en/doc/assets/files/other/opinion-paper-armed-conflict.pdf Accessed 15 January 2020.

Annotations

Synonyms

Armed conflict not of an international character, Internal armed conflict.

Additional scientific description

Article 3 of the Geneva Conventions provides for "the case of armed conflict not of an international character," and the definition of Non-International Armed Conflict (NIAC) offered herein reflects the International Committee of the Red Cross (ICRC)'s understanding based on practice and international case-law (ICRC, 2016). The category of NIAC includes:

- Armed conflicts between a State Party and one or more organised non-State Parties (ICRC, 2016).
- Armed conflicts which do not include a State Party but are between two or more organised non-State Parties (UNGA, 1998).

Confrontations must occur between organised Parties possessing organised armed forces (ICRC, 2016). While NIAC occurs predominantly within a State, NIAC may feature extraterritorial aspects (ICRC, 2016) and/or become internationalised with the involvement of foreign States in support of one or more Parties (ICRC, 2016).

Armed violence must meet a minimum threshold of intensity that distinguishes it from situations not considered NIAC, including the following:

- "Internal disturbances and tensions, such as riots, isolated and sporadic acts of violence and other acts of a similar nature" (UN, no date; Article 1 of Additional Protocol II).
- "Banditry, unorganized and short-lived insurrections, or terrorist activities" (ICRC, 2016).

The intensity of violence is assessed on a case-by-case basis based on cumulative evidence relating to objective criteria, and the International Criminal Tribunal for the former Yugoslavia (ICTY) developed a non-exhaustive set of 'indicative factors' that can be used as examples to determine 'the seriousness of attacks' (ICTY, 2008).

The termination of NIAC is also based on objective criteria and not the declaration of a ceasefire, armistice, or peace agreement. International humanitarian law "extends beyond the cessation of hostilities until…a peaceful settlement is achieved" (ICTY, 1995: para. 70). The termination of NIAC may be initiated when one of the Parties is summarily defeated and ceases to exist or otherwise dissolves, or when there is a lasting absence of armed confrontations between the original Parties.

Metrics and numeric limits

The identification and classification of NIAC is not conducted by a central authority, and the minimum threshold of intensity and duration for an armed confrontation to be considered a situation of NIAC is determined on a case-by-case basis (ICRC, 2016).

There are numerous academic conflict datasets available that provide their own operational thresholds for the minimum number of annual fatalities for NIAC events and trends to be included. For example, two of the most influential academic conflict datasets, the Uppsala Conflict Data Program (Uppsala Universitet, no date) and the Correlates of War (The Correlates of War Project, no date) apply annual conflict-related fatality thresholds of 25 and 1000, respectively.

Key relevant UN convention / multilateral treaty

Article 3 Common to the Geneva Conventions

- Geneva Convention Relative to the Protection of Civilian Persons in Time of War (Fourth Geneva Convention) (ICRC, 1949).
- Rome Statute of the International Criminal Court (ICC) (last amended 2010) (UNGA, 1998).

Examples of drivers, outcomes and risk management

Armed conflict carries immediate and severe impacts on human lives, health, and dignity: "Increasing numbers of civilians have been killed, wounded, treated without dignity, arbitrarily detained and/or separated from their families. They have been targeted on purpose, forced to leave their homes, and deprived of their basic rights as human beings, such as the right to supplies essential to their survival" (ICRC, 1999).

In situations of armed conflict, international humanitarian law aims to protect people, the environment, livelihoods, infrastructure, education systems, health systems, and cultural objects and property, to name a few (ICRC, 1999).

References

ICRC, 1949. Geneva Convention Relative to the Protection of Civilian Persons in Time of War (Fourth Geneva Convention). International Committee of the Red Cross (ICRC). www.refworld.org/docid/3ae6b36d2.html Accessed 14 January 2020.

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Coordinating agency or organisation

Not identified.

SO0003 / **SOCIETAL / Conflict**

Civil Unrest

Definition

'Civil unrest' is an umbrella term for a wide spectrum of phenomena, and although there is no commonly agreed United Nations definition the term is used widely among United Nations agencies, funds and programmes, particularly to describe violent and non-violent group acts.

A suggested definition for 'civil unrest' is as follows: a term that includes limited political violence (such as acts of 'terrorism', individual assassinations, etc.), sporadic violent collective action (such as riots), or nonviolent and mildly violent collective action (such as protests, demonstrations, etc.) – all of which tend to take place in times of peace (Kalyvas, 2000:3).

Reference

Kalyvas, S., 2000. The logic of violence in civil war: theory and preliminary results. Estudio/Working Paper 2000/151. June 2000.

Annotations

Synonyms

Terms often used as synonyms include social unrest, civil disorder, civil disobedience, violent disorder and civil disturbance, although this is not uniform as definitions and meanings vary depending on user group.

Additional scientific description

Despite wide use, there is no commonly used definition for 'civil unrest'. The term does not feature in the Rome Statute of the International Criminal Court, although related terms, such as riot, terrorism, protest and violent disorder are defined in some national legislation. The United Kingdom's (1986) Public Order Act (United Kingdom Government, 1986), for example, defines riot and violent disorder. Academic and non-legal definitions are available, as outlined below. Some authors emphasise the explicit non-state affiliation in their definition of 'civil' unrest, while others are less clear about the state and non-state contribution. An important distinction is that civil unrest is largely understood to take place in times of peace (Kalyvas, 2000), although not exclusively as noted below by the International Committee of the Red Cross (ICRC). Instances of civil unrest can take place over short or long timeframes, and are widely although not exclusively, understood to be urban acts (Kalyvas, 2000).

While acts such as peaceful protests can have no or relatively minimal disturbance, violent riots can result in deaths, destruction of property and infrastructure (Evans, 1993; Braha, 2012). In the case of civil unrest in Los Angeles in 1992, for example, violence resulted in 53 deaths, 2325 reported injuries and more than USD 735 million in damage to buildings (Evans, 1993).

Civil unrest is generally understood to include violent and non-violent group acts such as riots, protest, isolated and sporadic acts of violence (Braha, 2012; Lawand, 2012; Basedau et al., 2018). The perceived or actual motivation for the act is often emphasised when describing collective action as civil unrest, alongside a clash with authority (Ramakrishnan et al., 2014). Frequently cited explanations include tension or dissatisfaction over political, economic or social changes/conditions (Kalyvas, 2000). According to Basedau et al. (2018:5) 'One can conceptualize civil unrest as a special form of collective action and people need to be motivated and able to exert it.' Braha (2012) defined civil unrest as a 'form of collective human dynamics, which has led to major transitions of societies in modern history', while Oncevay et al. (2020) defined it as 'public manifestations, where people demonstrate their position for different causes'.

Kalyvas (2000:3) defined civil unrest as "a term that includes limited political violence (such as acts of 'terrorism', individual assassinations, etc.), sporadic violent collective action (such as riots), or nonviolent and mildly violent collective action (such as protests, demonstrations, etc.) – all of which tend to take place in times of peace." In contrast, according to Melzer (2009), as part of guidance from the International Committee of the Red Cross (ICRC) on International Humanitarian Law, civil unrest can also take place in times of armed conflict, and can be contextualised as follows:

"During armed conflict, political demonstrations, riots, and other forms of civil unrest are often marked by high levels of violence and are sometimes responded to with military force. In fact, civil unrest may well result in death, injury and destruction and, ultimately, may even benefit the general war effort of a party to the conflict by undermining the territorial authority and control of another party through political pressure, economic insecurity, destruction and disorder. It is therefore important to distinguish direct participation in hostilities – which is specifically designed to support a party to an armed conflict against another – from violent forms of civil unrest, the primary purpose of which is to express dissatisfaction with the territorial or detaining authorities."

Metrics and numeric limits

Given the lack of a single definition, it is unsurprising that there are no commonly agreed metrics or numerical limits for the term. Attempts have been made to forecast civil unrest using open source indicators (such as Ramakrishnan et al., 2014), although the most commonly used conflict data sets do not define civil unrest. For example, the term is not commonly defined or used by the Armed Conflict Location & Event Data Project (ACLED, 2019) or the Peace Research Institute Oslo (PRIO). ACLED does however offer definitions for different forms of violent and non-violent action which could all fall under the definition of civil unrest, such as protest and riot. Similarly, the Social Conflict Database (SCAD, 2017) does not provide a single definition for civil unrest but offers several definitions which may be classed as forms of civil unrest. These are: organised demonstration; spontaneous demonstration; organised violent riot; spontaneous violent riot; general strike; and limited strike.

Of the numerous challenges in defining and measuring civil unrest, a particular challenge is translation into standard equivalents in other languages, and the inclusion/exclusion of the 'civil' aspect. For example, in Spanish it can be translated as 'guerra' while others translate it is as 'revueltas civiles', 'disturbios civiles' or as 'descontento social' only. French offers a range of similar translations. The transnational aspects of civil unrest also seem to be lacking.

Key relevant UN convention / multilateral treaty

Not available.

Examples of drivers, outcomes and risk management

Documented operational risk management for civil unrest includes preparedness and response by the US Fire Administration, and Emergency Medical Services, in response to their understanding that: "…Civil unrest may occur as a period of social upheaval during heightened community tension or at mass gatherings such as sporting events, concerts and political conventions" (USFA, 2020). The public health sector also offers frameworks for violence prevention interventions as well as responses, as documented by the World Health Organization (Krug et al., 2002).

Successful outcomes are generally regarded as cessation of physical violence and restoration of civic order.

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Coordinating agency or organisation

Not identified.

SO0004 / **SOCIETAL / Post-Conflict**

Explosive Remnants of War

Definition

Explosive remnants of war are unexploded ordnance and abandoned explosive ordnance that are left by a party to an armed conflict following the cessation of warfare. Explosive ordnance is defined as conventional munitions containing explosives (United Nations, 2004:2).

Reference

United Nations, 2004. Protocol on Explosive Remnants of War to the Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons which may be deemed to be Excessively Injurious or to have Indiscriminate Effects (Protocol V). https://treaties.un.org/doc/Treaties/2003/11/20031128%2001-19%20AM/Ch_XXVI_02_dp.pdf Accessed 13 October 2020.

Annotations

Synonyms

Unexploded ordnance, Abandoned explosive ordnance.

Additional scientific description

The United Nations (2004) definition provided above is from Protocol V of the Convention on Certain Conventional Weapons but does not include any reference to explosive remnants of war (ERW) in the form of improvised explosive devices.

'Explosive remnants of war' is a catchall term for any explosive ordnance that remains unexploded and abandoned following the cessation of conflict. An explosive ordnance may be considered 'unexploded' or 'abandoned' if it has been "primed, fused, armed, or otherwise prepared for use […] in an armed conflict" prior to being "left behind or dumped by a party to an armed conflict" (United Nations, 2004:2).

Cluster munitions are an example of ERW and have a long history of conventional use by state actors during warfare (UNODA, 2020a). They are "designed to cover an area with explosive force" and have been used in warfare since the Second World War (Bolton and Nash, 2010:175). A cluster munition produces damage by exploding a single projectile, which fragments into a number of smaller explosive ordnance, which then detonate over a large area (Bolton and Nash, 2010:175). Cluster munitions are of particular concern when discussing the impact of ERW, as the impact of unexploded cluster munitions when detonated is significantly higher than other conventional munitions. A study of the comparative impact on civilian populations found that "ten unitary projectiles with a 10 per cent failure rate will leave one unexploded item whereas ten cluster munitions with 100 submunitions each and a 10 per cent failure rate will leave 100 unexploded items – ten times as many" casualties or fatalities (Bolton and Nash, 2010:175). The clearance of cluster munitions has proved extremely challenging in many contexts – for example in Kosovo, where civilians who went in search of provisions such as firewood accidentally detonated the munitions, causing many casualties and fatalities (ICRC, 2001:18).

Explosive remnants of war frequently have adverse effects on populations owing to the shedding of chemicals or chemically active compounds into areas where they are abandoned. This can have long-term effects when a population is exposed to the chemicals through contamination of water, soil, food sources, and general living environment. One such example is the presence of depleted uranium, which has had significant impacts on the health of conflict affected populations and their environment since it was introduced into conventional warfare (UNODA, 2020b). Depleted uranium has a high density, which makes it a useful component of kinetic energy weapons such as anti-tank weaponry (Murray et al., 2002). In areas with high radioactive contamination, there is a risk of wildfires burning terrain leading to an uncontrolled re-distribution of radioactive particles – which has a profound negative impact on population health. This has resulted in depleted uranium weapons being used widely with the exploded particle remnants being inhaled by those working and living in the vicinity of the conflict (Murray et al., 2002). The long-term effects of exposure to the remnants of depleted uranium from a health perspective are still unclear, but the environmental impact is profound – with an increase in uranium in water supplies, contaminated soil, and potentially unexploded remnants of depleted uranium munitions (Murray et al., 2002).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaties

The Convention on Cluster Munitions (2008) (Daj Hammarskjold Library, 2020); the Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on their Destruction (1997) (Daj Hammarskjold Library, 2020); and the Convention on Certain Conventional Weapons (CCW) (1980) (Daj Hammarskjold Library, 2020).

Examples of drivers, outcomes and risk management

Explosive remnants of war have a profound impact on civilian populations and their environment well after the end of a conflict. Civilians in areas with ERW embedded in their environment are at risk of becoming casualties of explosive ordnance, potentially losing limbs or their lives (UNODA, 2020c). The presence of ERW restricts the movement of populations, resulting in potentially limited access to arable land, water, care or trade (UNODA, 2020c).

Explosive remnants of war have an impact on the quality of water sources and arable land, as particulate matter from these remnants may infiltrate the environment – as in the case of depleted uranium weaponry (Murray et al., 2002). Explosive remnants of war pose a threat to people's health and human rights in more than 60 lower- and middle-income countries (Frost et al., 2017). Annual casualty numbers fell from 9220 reported casualties in 1999 to 6461 in 2015, with many casualties being maimed rather than killed. Although the exact number of survivors is unknown, many develop subsequent long-term psychological and physical sequelae (Frost et al., 2017). The wider long-term effects of ERW are a social and economic burden to victims, their families, the wider at-risk community, and health systems (Frost et al., 2017).

Protocol V of the Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons outlines the following control measures to mitigate the impact of ERW: survey and assess the threat posed by ERW in a post-conflict situation; assess and prioritise needs for the marking and removal/clearance of ERW; and clear/remove the ERW where possible and safe (United Nations, 2004:3).

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Coordinating agency or organisation

Not identified.

SO0005 / **SOCIETAL / Post-Conflict**

Environmental Degradation from Conflict

Definition

Environmental degradation from conflict is defined as the reduction of the capacity of the environment to meet social and ecological objectives and needs (UNISDR, 2009:6).

Reference

UNISDR, 2009. UNISDR Terminology on Disaster Risk Reduction. United Nations International Strategy for Disaster Reduction (UNISDR). www.undrr.org/publication/2009-unisdr-terminology-disaster-risk-reduction Accessed 25 November 2019.

Annotations

Synonyms

Ecological degradation, Environmental damage.

Additional scientific description

The types of human-induced degradation are varied and include land misuse, soil erosion and loss, desertification, wildland fires, loss of biodiversity, deforestation, mangrove destruction, land, water and air pollution, climate change, sea-level rise and ozone depletion (UNISDR, 2009:6).

Environmental degradation occurs during peace time but can be particularly exacerbated by an armed conflict. The level of environmental damage from conflict depends on several factors: the weapons as well as the tactics used; location of the military operations (e.g. rural vs urban, proximity to industrial sites), the duration of the military conflict (Jensen, 2019) and the pre-war environmental conditions (Biswas, 2000). In parallel, countries might enter the vicious cycle between environmental degradation and conflict as pollution and environmental hazards can on the other hand undermine security and lead to political instability, disasters and regional tensions (Conca and Wallace, 2009).

Metrics and numeric limits

Not identified.

Key relevant UN convention / multilateral treaty

International Humanitarian Law, International Criminal Law, International Environmental Law, and International Human Rights Law, including provisions protecting the environment in conflicts. In 2019, the International Law Commission Drafting Committee provisionally endorsed 28 legal principles intended to mitigate environmental degradation before, during and after conflicts (International Law Commission, 2019).

Examples of drivers, outcomes and risk management

The impact of conflicts on the environment is three-fold: direct impact, secondary impact, and environmental governance impact.

Direct impact includes intentional targeting of the environment, physical destruction, or the use of natural resources by militant groups to finance conflict, environmental contamination from bombing of industrial sites, and military debris and demolition waste from targeted infrastructure (Solomon et al., 2018; Jensen, 2019). Modern military confrontation may involve exposure to toxic substances and substances of uncertain toxicity, such as depleted uranium used in munition. Large amounts of depleted uranium may remain deposited in soil after the end of the military operations. It represents a significant hazard due to potential contamination of air, soil and water (Murray et al., 2002). Furthermore, conflict can impact the environment regionally (Hopke, 2009).

Secondary impact results from the coping strategies used by the population to survive in conflict, such as overuse of natural resources, environmental damage due to population displacements, growth of a black market for natural resources during conflict, and implementation of large-scale humanitarian and peacekeeping operations without due consideration to environmental impact (Jensen, 2019).

Third, military conflicts frequently weaken environmental governance structures, and hinder policy coordination, investment and the enforcement of law (UNEP, 2009; Bruch, 2019; Jensen 2019). The financial resources and technical equipment usually utilised for environmental law enforcement can be redirected to war needs (Bruch, 2019). The breakdown of environmental governance is potentially the most challenging impact to address (Bruch et al., 2016; Jensen, 2019). The consequences are long-term, persistent and affect larger territories than from direct impact (Jensen, 2019). For instance, conflicts are generally known to have negative direct and secondary impacts on biodiversity (Solomon et al., 2018). However, a study at UC Berkley suggested that during armed conflicts, institutional collapse kills even more wildlife than military tactics (Gaynor et al., 2016).

Nevertheless, the impact of environmental damage in conflicts on human lives and health is still poorly documented and addressed in conflict resolution and humanitarian assistance (Toxic Remnants of War Network, 2015).

Protection of the environment during a military conflict has the potential to facilitate peacebuilding (Conca and Wallace, 2009), or in case of failure to respond, can hinder further peacebuilding efforts (Jensen and Lonergan, 2012). Assurance of implementation of international law, training of military personnel (including revision of military training manuals regarding protection of environment in conflict), integration of environmental considerations including biodiversity conservation into military, reconstructions and humanitarian programmes in conflict areas, are some of the measures than can help mitigate environmental damage from conflict.

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Coordinating agency or organisation

Not identified.

SO0006 / **SOCIETAL / Behavioural**

Violence

Definition

Violence refers to the intentional or unintentional use of force whether physical or psychological, threatened or actual, against an individual, oneself, or against a group of people, a community, or a government. Violence can either be targeted or indiscriminate, motivated by certain aims, including political, religious, social, economic, ethnic, racial, or gender-based, or unintentional and can be initiated with the aim to directly or indirectly inflict harm, injury or death (Krug et al., 2002). Armed as well as non-armed forms of violence can occur both in conflict and non-conflict settings. Violence has been explicitly identified as a significant public health problem (Rutherford et al., 2007).

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Rutherford, A., A.B. Zwi, N.J. Grove and A. Butchart, 2007. Violence: a glossary. Journal of Epidemiology & Community Health, 61:676-680.

Annotations

Synonyms

Not identified.

Additional scientific description

The World Health Organization categorises violence as: self-directed, interpersonal and collective. All three categories of violence can have a societal impact whether directly or indirectly (WHO, 2002). According to Galtung (1969, 1996), violence can also be direct, structural, and cultural. There are several forms and typologies of violence. These are characterised here on the basis of the motives, target groups and tactics of violence:

Motives:

Political violence is defined as hostile, aggressive or violent acts motivated by political objectives or a desire to directly or indirectly affect political change or change in governance. As a phenomenon, political violence includes a range of political acts from mass protest, riots, coups, rebellions, uprisings and terrorism to violent acts committed by state and non-state actors, including pogroms, ethnic cleansing, and genocide (Kalyvas, 2013; Balcells, 2015).

Radicalisation, radicalism and violent extremism are generally used in the discourse of terrorism but remain poorly defined and understood. While violent extremism is generally equated with terrorism, radicalisation is often perceived as a prelude and a pre-condition to violence. While radicalisation, by definition, does not involve the use of violence, it refers to a process, often a multidimensional, complex and long-term process, by which individuals are introduced to extremist ideologies that motivate them to defy and challenge the status quo. This often leads to the eventual adoption of violence. Violent extremism refers to the "the willingness to use or support the use of violence" or terror as appropriate means to achieve ideological, social or political objectives (Elshimi, 2018; Mansour-Ille, 2019).

Religious violence refers to violent acts committed by either state or non-state actors and motivated by religious convictions, ideologies or belief systems. Religious violence is closely associated with radicalism and religious extremism and refers to acts ranging from inciting violence against particular religious groups, discrimination or segregating certain religious groups, persecution, genocide, random physical aggression, gang or mob violence and defaming or injuring verbal abuse or violence (Clarke, 2011).

Ethnic or racial violence refers to violence between different groups of people on the basis of ethnic or racial differences or differences in culture, religion or language motivated by ethnic or racial diversity. Violent acts motivated by ethnic or racial differences take many forms, ranging from segregation and institutionalised discrimination to genocide, ethnic cleansing, pogroms, civil wars and violent separatist movements (Bergmann and Crutchfield, 2009; Rutherford and Bar-Yam, 2010).

Social violence (also referred to as societal violence) refers to any type of violence employing physical or emotional acts of aggression committed by individuals or a community of individuals with the aim to have a social or societal impact or cause serious physical and emotional harm to a group of people or to society as a whole. These acts can be direct or indirect and can take various forms across countries varying from targeted social discrimination, segregation, terrorism, physical aggression to gang violence. The Convention on the Elimination of All Forms of Discrimination against Women (CEDAW) (1979) refers to various forms of discriminatory acts on the basis of gender, which may impair or nullify "the recognition, enjoyment or exercise by women" of their basic human rights and fundamental freedoms equal to men "in the political, economic, social, cultural, civil or any other field" (Art. 1). Social violence can also be politically motivated (Kelly, 2014).

Target groups:

Gender-based violence is defined as acts or threats of acts intended to cause harm, injury, physical, sexual or psychological suffering to women on the basis of their gender or acts affecting women disproportionally (Krantz and Garcia-Moreno, 2005). It is defined by the UN Declaration on the Elimination of Violence against Women (1993) as "any act of gender-based violence that results in, or is likely to result in physical, sexual or psychological harm or suffering to women, including threats of such acts, coercion or arbitrary deprivation of liberty, whether occurring in public or in private life" (Art. 1). Gender-based violence is also used in the context of domestic violence or intimate partner violence and can result in various forms of abuse and exploitation, including economic exploitation. A form of gender-based violence is sexual violence and exploitation, which refers to any form of abuse or exploitation that is sexually motivated targeting vulnerable groups, particularly women and children. Convention C190 of the ILO (2019) defines gender-based violence as violence and harassment "directed at persons because of their sex or gender or affecting persons of a particular sex or gender disproportionately and includes sexual harassment" (Art. 1b).

Child abuse, violence and exploitation refer to acts of violence, cruel or harmful treatment of a minor for profit, labour, sexual gratification, vengeance or other personal or financial gains (Legal Dictionary, 2015). The Convention on the Rights of the Child (CRC) (1989) explicitly prohibits "all forms of physical or mental violence, injury or abuse, neglect or negligent treatment, maltreatment or exploitation, including sexual abuse, while in the care of parent(s), legal guardian(s) or any other person who has the care of the child" (Art. 19.1).

Tactics:

Terrorism refers to acts – either politically or religiously motivated – that aim to instil fear and/or the intimidation of fear in society (i.e. mass terror). Terrorism includes acts of aggression or violence that causes either directly or indirectly physical or psychological harm or injury to a group of people. Terrorism can both be perpetrated by as well as against the state (Teichman, 1989). One of the most widely used definitions of terrorism is that of the US Department of State, which in 1983 defined terrorism as "premeditated, politically motivated violence perpetrated against non-combatant targets by subnational groups or clandestine agents, usually intended to influence an audience" (Sinai, 2008). 'Non-combatants' refer to both civilian and military personnel, who neither armed nor on duty. The definition, however, excludes state terrorism (Sinai, 2008).

Psychological violence refers to any intentional or unintentional conduct that aims to cause serious emotional or psychological harm to another person (European Institute for Gender Equality, 2017). The Istanbul Convention (2011) outlines examples of such acts to include verbal aggression, coercive threats and intimidation, control, harassment or stalking, insults, humiliating and defaming conducts as well as acts that render another person isolated from family, friends and any sort of support. Such acts mainly occur in interpersonal relationships, such as familial, parental or intimate partner relationships (Chapter V).

Torture is defined in the Convention against Torture (CAT) (1984) as "any act by which severe pain or suffering, whether physical or mental, is intentionally inflicted on a person for such purposes as obtaining from him or a third person information or a confession, punishing him for an act he or a third person has committed or is suspected of having committed, or intimidating or coercing him or a third person, or for any reason based on discrimination of any kind, when such pain or suffering is inflicted by or at the instigation of or with the consent or acquiescence of a public official or other person acting in an official capacity" (Art. 1.1). The Convention, however, excludes pain or suffering arising from the enforcement of lawful sanctions.

The prohibition against torture and other forms of ill-treatment are embodied in several international human rights treaties and declarations, including: the Universal Declaration of Human Rights (UDHR) (Art. 5, 1948), the International Covenant on Civil and Political Rights (ICCPR) (Art. 7, 1966), and the Convention against Torture and Other Cruel, Inhuman or Degrading Treatment or Punishment (1984). Several regional human rights treaties also uphold and reaffirm the prohibition against torture and other forms of ill-treatment, including: The European Convention for the Protection of Human Rights and Fundamental Freedoms (ECHR) (Art. 3, 1950), the American Convention on Human Rights (ACHR) (Art. 5, 1969), the African Charter on Human and Peoples' Rights (ACHPR) (Art. 5, 1981), the Inter-American Convention to Prevent and Punish Torture (1985), and the European Convention for the Prevention of Torture and Inhuman and Degrading Treatment or Punishment (1987).

Cruel, inhumane and degrading treatment refers to ill-treatment, which is premediated and applied for prolonged periods of time that amounts to be cruel, inhumane and violating human dignity aimed at causing bodily injury, harm or intense physical and mental suffering (European Court of Human Rights, 2000).

Gang-related violence refers to violence that is perpetrated by a group of people who associate themselves to what can be referred to as a 'gang' – a relatively well-defined, durable and predominately street-based group of young people dominating a particular territory and known to the wider community (UK Government, 2016). Organised crime, on the other hand, refers to violent crimes or criminal activities committed by a group of people in an organised manner for profit using coercion, retaliation and extortion (UK Department of Justice, 2020). Organised crimes are not confined to particular territories or borders.

Metrics and numeric limits

Not applicable.

Key relevant UN convention / multilateral treaty

Several conventions are of relevance and include the UN Declaration on the Elimination of Violence against Women; the Convention on the Elimination of All Forms of Discrimination against Women; the Convention against Torture and Other Cruel, Inhuman or Degrading Treatment or Punishment; the Convention on the Rights of the Child; the Istanbul Convention; and Convention C190 (ILO Violence and Harassment Convention).

Examples of drivers, outcomes and risk management

Globally, some 470,000 homicides occur each year and millions of people suffer violence-related injuries. Beyond death and injury, exposure to violence can increase the risk of smoking, alcohol and drug abuse; mental illness and suicidality; chronic diseases like heart disease, diabetes and cancer; infectious diseases, such as HIV, and social problems, such as crime, and further violence. Yet, violence can be prevented. Interventions to address violence are delivered as part of a four-step public health approach that includes: defining the problem; identifying causes and risk factors; designing and testing interventions; and increasing the scale of effective interventions (WHO, no date).

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Coordinating agency or organisation

Not identified.

SO0007 / **SOCIETAL / Behavioural**

Stampede or Crushing (Human)

Definition

Stampede or crushing is the surge of individuals in a crowd, in response to a perceived danger or loss of physical space. It often disrupts the orderly movement of crowds resulting in irrational and dangerous movement for self-protection leading to injuries and fatalities (Illiyas et al., 2013).

Reference

Illiyas, F., S. Mani, A. Pradeepkumar and K. Mohan, 2013. Human stampedes during religious festivals: a comparative review of mass gathering emergencies in India. International Journal of Disaster Risk Reduction, 5:10-18.

Annotations

Synonyms

Crush, Mass panic, Crowd disaster.

Additional scientific description

With population growth and a constant increase in human travels, mass gatherings are becoming more frequent and attract increasing numbers of participants (Johansson et al., 2012). Mass gatherings can be defined as a concentration of people at a specific location for a specific purpose over a set period of time, and which has the potential to strain the planning and response resources of the country or the community (WHO, 2015).

Mass gatherings are either spontaneous, such as at train stations during rush hour (Johansson et al., 2012) or are planned, such as at sport, cultural, religious, or political events (WHO, 2015). The Hajj pilgrimage in Saudi Arabia and the Kumbh Mela in India are the biggest regular mass gatherings globally, bringing millions of pilgrims together (Ahmed et al., 2006; Illiyas et al., 2013). Mass gatherings may affect health in different ways and crowd disasters may occur, including the collapse of infrastructure, fire incidents, terrorist attacks, violence riots, and human stampedes (Soomaroo and Murray, 2012; WHO, 2015; Still, 2019).

Stampedes are often described as the "disruption of the orderly movement of crowds…leading to injuries and fatalities" (Illiyas et al., 2013), often "in response to a perceived danger, loss of physical space", or "a will to attain something seen as gratifying" (Ngai et al., 2009; Burkle et al., 2011; Illiyas et al., 2013). They carry high mortality rates and are, besides heat-related illnesses, the most common cause of mortality in mass gatherings (Steffen et al., 2012; Still, 2019).

Most human stampede casualties result from traumatic asphyxia caused by external compression of the thorax and/or upper abdomen, resulting in complete or partial cessation of respiration. It has been reported that significant compression forces can be present with even moderate crowds; forces of up to 4500 N (1000 lb) can be generated by just six to seven people pushing in a single direction with forces large enough to bend steel railings (Ngai et al., 2009).

Although survivors of human stampedes and autopsy reports suggest traumatic asphyxia as the primary cause of death, other mechanisms have been considered, including myocardial infarction, direct crushing injury to intrathoracic or intraabdominal organs, head injury, and neck compression. All these mechanisms are possible; however, little actual supportive evidence exists. It has been concluded from autopsy findings that "people who succumb in these scenarios typically die (standing up) in a vertical position" due to compression force and "do not collapse to the floor until after the crowd density and pressure have been relieved. Compressive forces applied front to back or vice versa resulted in ventilatory failure, whereas those experiencing compressive forces from side to side were spared, presumably because chest expansion was not compromised to the same extent" (Ngai et al., 2009).

The full spectrum of injuries – including fractures, dislocations, and other mechanical injuries – may be expected. Among survivors, many may suffer from posttraumatic stress, grief, or survivor guilt and require psychological counselling or intervention (Ngai et al., 2009).

Metrics and numeric limits

Not available.

Key relevant UN convention / multilateral treaty

International Health Regulations (2005) (WHO, 2016).

Examples of drivers, outcomes and risk management

Much of what is known about human stampedes is derived from anecdotal news reports and observations. In recent decades, the toll from human stampedes has been increasingly well documented. Although there appears to be an uptick in the occurrence of deadly stampedes mirroring risks of increasing overall population densities, especially in low and middle-income countries, the number of reports may in reality reflect greater sharing of information via mass media. Numerous other events before the 1990s, particularly in less developed countries, may have resulted in sizeable stampedes that were unreported. In general, injuries are estimated or are not recorded, whereas direct deaths (not including deaths following injuries) are more precisely reported and readily obtained (Ngai et al., 2009; Still, 2019). Often stampede and crushing events occur due to the systematic failure of organisations to provide a safe environment for places of public assembly (Still, 2019).

Between 1980 and 2007, the Ngai method identified 215 stampede events worldwide, and 350 events between 1980 and 2012. Between 1980 and 2007, 7069 deaths and 14,078 injuries were caused by stampedes (Hsieh et al., 2009) increasing to 10,243 deaths and 22,445 injuries between 1980 and 2012 (Ngai et al., 2009). Most stampedes occur indoors, during daytime hours, and in sports events (Hsieh et al., 2009). Uni-directional mechanism increased the fatality rate 3.46-fold, believed to be due to the confluence of forces in the same direction (Hsieh et al., 2009). Women, children, and older people were reportedly more affected because they were less able to defend themselves from external weight pressure (De Almeida and Von Schreeb, 2019).

Risk management: Stampede or crushing (human) hazards are associated with mass gatherings. A mass gathering is an organised or unplanned event where the number of people attending is sufficient to strain the planning and response resources of the community, state or nation hosting the event. Sporting events, music festivals, political demonstrations and religious pilgrimages can be mass gathering events. A safe and healthy mass gathering requires early multi-sectoral preparation involving event organisers, health emergency managers, public health authority representatives, local hospital emergency departments, first-aid personnel and other sectoral partners, including police and emergency services (WHO and PHE, 2017).

A risk assessment for any event where a stampede or crushing hazard is a risk, informs the selection and implementation of risk reduction measures, response planning, and capacity development for health functions, including: mass casualty management; on-site trauma care and local hospitals; disease surveillance and outbreak response; environmental health and food safety; public information and health promotion; leadership, coordination and communication; and emergency preparedness and response to natural hazards, transport crashes, stampedes, and security incidents (WHO and PHE, 2017).

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Coordination agency or organisation

World Health Organization.

SO0008 / **SOCIETAL / Economic**

Financial shock

Definition

A financial shock is an unexpected disturbance which originates from the financial sector and has a significant effect on an economy (e.g. national, regional, or global). The term is largely used to refer to events which have negative impacts (ECB, 2013).

Reference

ECB, 2013. Financial Shocks and the Macroeconomy: Heterogeneity and Non-Linearities. European Central Bank (ECB), Occasional Paper Series No. 143. www.esm.europa.eu/sites/default/files/financialshocksandthemacroeconomy.pdf Accessed 12 September 2020.

Annotations

Synonyms

Financial crisis, Bank run, Banking crisis, Currency crisis, Debt crisis, Liquidity crisis.

Additional scientific description

The term 'financial shock' generally refers to a disruptive event in the financial system, which manifests in the sudden re-pricing of assets (often in combination with a severe deterioration of economic conditions). Financial shocks are difficult to predict but tend to be more likely when borrowers are vulnerable, such as when they have taken on excessive risk relative to their repayment capacity (e.g. highly-leveraged firms that have both uncertain future profits and low liquidity) (Peersman, 2015).

Financial shocks may be triggered by different sources of risk, that can be either inside or outside the financial system, and are often amplified by adverse macro-financial feedback effects, such as when a deterioration in economic conditions weakens the solvency of financial institutions and markets, which in turn results in tighter financial conditions for firms and households (Ong and Jobst, 2013). A significant economic slowdown could lead to rising business insolvencies, higher unemployment, and constrained public investment. They can morph into financial crises if a sharp decline in asset prices causes consumers and businesses to default on their loans, and financial institutions become unable to access liquidity – either in terms of cash or assets which are easily convertible into cash (Moretti et al., 2020).

For example, the collapse of the U.S. sub-prime mortgage market, prior to the 2007–2009 Global Financial Crisis, was largely driven by excessive leverage of borrowers, an overheated housing market, and insufficient transparency when banks re-packed and combined mortgage loans into new financial instruments, through what is referred to as 'securitization' (Jobst, 2008). Recent currency and/or sovereign debt crises also illustrate that unsustainable external imbalances, such as a deteriorating current account (which reflects cross-border economic activities) and rising foreign currency borrowing by public or private sector organisations (if suddenly unwound), can amplify and/or cause fragilities in the financial system. Examples include the cases of the 1997 Asian financial crisis and the 2007–2009 Global Financial Crisis (Claessens et al., 2014).

Metrics and numeric limits

Measures linked to financial shocks typically focus on aspects of financial stability, due to the inherent difficulty in predicting the occurrence of financial shocks (IMF, 2020a). Examples of these measures include:

Financial sector: financial soundness indicators (solvency, liquidity, asset quality) of banks and non-bank financial institutions (insurance companies, investment funds, and other asset managers), default risk (via credit ratings or credit default swap spreads).

Financial markets: equity prices, corporate bond spreads (as measure of default risk), market liquidity/volatility, house prices (indicate bubbles/crashes).

Other sectors: measures of corporate financial risk (e.g. corporate debt), households (e.g. household debt), and governments (e.g. public debt), as well as real economic activity (e.g. GDP growth, interest rates, inflation) and external ratios (e.g. balance of payments, exchange rates).

Key relevant UN convention / multilateral treaty

Articles of Agreement of the International Monetary Fund (IMF, 2020b); and Basel III: A Global Regulatory Framework for More Resilient Banks and Banking Systems (Bank of International Settlements, 2020).

Examples of drivers, outcomes and risk management

The health and functioning of a country's financial sector has far-reaching implications for its own and other economies. Prudential regulators and supervisors play a central role in safeguarding the capacity of the financial system – its intermediaries, markets and infrastructures – to provide deposit, credit, and other financial services to households, firms, and governments (OECD, 2010).

Designing policies that align private incentives with the public interest to facilitate market discipline and limit excessive risk-taking is challenging. In some cases, a financial institution and/or market might be considered too-big-to-fail (TBTF), because their insolvency and failure could cause massive disruptions to the functioning of the financial system, resulting in a significant tightening of financial conditions and a contraction of economic activity. This situation creates an expectation that they would be bailed out by the government, via direct financial support measures, during times of stress. Safety nets, such as deposit insurance (guaranteeing bank depositors access to their money even if a bank fails), play an important role as shock absorbers, helping to maintain the functioning of the financial system during times of stress.

At the national level, regulated financial institutions are subject to both microprudential and macroprudential oversight:

Microprudential supervision focuses on the safety and soundness of individual financial institutions, such as banks, insurance companies, and investment funds. Supervisors complete regular on- and off-site inspections and reviews to ensure that these financial institutions are well-managed and have enough capital to absorb the impact of adverse shocks (such as a recession).

Macroprudential surveillance elevates this concept of financial supervision to a system-wide perspective, by focusing common vulnerabilities across all or several institutions. Macroprudential measures to mitigate risk, such as additional capital requirements, are not specific to individual firms but apply uniformly across all relevant institutions.

International institutions facilitate cross-border coordination across supervisors and regulators through agreements on common standards and peer reviews (e.g. Bank for International Settlements, Financial Stability Board) while others focus on multilateral surveillance and direct engagement with countries, often via capacity building and technical assistance (e.g. International Monetary Fund, World Bank) (IMF, 2020a; World Bank, 2020). The Financial Sector Assessment Program (FSAP) represents a comprehensive and in-depth analysis of a country's financial sector. FSAP assessments are the joint responsibility of the IMF and World Bank in "developing economies and emerging markets", and of the International Monetary Fund alone in "advanced economies" (IMF, 2019).

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Coordinating agency or organisation

International Monetary Fund.

ANNEX

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