WHO: Guidelines on Sanitation and Health Guidelines

Introduction

The Significance of Sanitation for Human Health

- Safe sanitation is **essential for health,** from preventing infection to improving and maintaining mental and social well-being.
- The lack of safe sanitation systems leads to **infection and disease,** including Diarrhoea, tropical diseases such as soil-transmitted helminth infections, schistosomiasis and trachoma; Vector-borne diseases such as West Nile Virus, lymphatic filariasis and Japanese Encephalitis.
- Unsanitary conditions have been linked with **stunting,** which affects almost one quarter of children under-five globally through repeated diarrhoea and environmental enteric dysfunction.
- The lack of safe sanitation systems contribute to the emergence and spread of **antimicrobial resistance**.

Sanitation as a Human Development Issue

- Many people worldwide practice open defecation and do not have services that prevent faecal waste from contaminating the environment.
- In many low-and middle-income countries (LMICs), rural areas are underserved, while cities are struggling to cope with the scale of sanitation needs caused by rapid urbanization.
- Sanitation system maintenance is costly worldwide.
- Challenges caused by climate change require continued adaptation to ensure sanitation systems that safeguard public health.
- Sanitation has gained importance on the global development agenda, starting in 2008 with the **UN International Year of Sanitation,** followed by **the recognition of the human right to safe water and sanitation** in 2010 and the call for an end to open defecation by the UN Deputy Secretary- General in 2013.

- Safe management of sanitation, as well as treatment and reuse of wastewater, was given a central place under the **Sustainable Development Goals**.

Human right to sanitation (UN, 2010)

The human right to sanitation entitles everyone to sanitation services that provides privacy and ensures dignity, and that are physically accessible and affordable, safe, hygienic, secure, socially and culturally acceptable. Human rights principles must be applied in the context of realising all human rights, including the human right to sanitation:

1. **Non-discrimination and equality:** All people must be able to access adequate sanitation services, without discrimination, prioritizing the most vulnerable and disadvantaged individuals and groups.
2. **Participation:** Everyone must be able to participate in decisions relating to their access to sanitation without discrimination.
3. **The right to information:** Information relating to access to sanitation, including planned programmes and projects must be freely available to those who will be affected, in relevant languages and through appropriate media.
4. **Accountability (monitoring and access to justice):** States must be able to be held accountable for any failure to ensure access to sanitation, and access (and lack of access) must be monitored.
5. **Sustainability:** Access to sanitation must be financially and physically sustainable, including in the long-term.

The normative content of the human right to sanitation is defined by:

1. **Availability:** A sufficient number of sanitation facilities must be available for all individuals.
2. **Accessibility:** Sanitation services must be accessible to everyone within, or in the immediate vicinity, of household, health and educational institution, public institutions and places and workplace. Physical security must not be threatened when accessing facilities.
3. **Quality:** Sanitation facilities must be hygienically and technically safe to use. To ensure good hygiene, access to water for cleansing and hand washing at critical times is essential.
4. **Affordability:** The price of sanitation and services must be affordable for all without compromising the ability to pay for other essential necessities guaranteed by human rights such as water, food, housing and health care.
5. **Acceptability:** Services, in particular sanitation facilities, have to be culturally acceptable. This will often require gender-specific facilities, constructed to ensure privacy and dignity.

All human rights are interlinked and mutually reinforcing, and no human right takes precedence over another.

The Sustainable Development Goals (SDGs) and sanitation (UN, 2015)

- **Goal 6 on clean water and sanitation** (specifically targets 6.2 and 6.3 on sanitation and water quality respectively), and **Goal 3 on good health and well-being,** are particularly relevant to sanitation.
- Several other goals for which sanitation contributes or is necessary for achievement, including those on **poverty** (particularly 1.4 on access to basic services), **nutrition, education, gender equality, economic growth, reduction in inequalities and sustainable cities**.
- The SDGs also set out the principles of implementation for States to follow, including increasing financing, strengthening capacity of health workers, introduction of risk-reduction strategies, building on international cooperation and participation of local communities.
- Goal 1 states the need to improve the flow of information and increase monitoring capacities and disaggregation so that it is possible to identify which groups are being left behind.

Safe Sanitation

- A **safe sanitation system** is defined as a system that separates human excreta from human contact at all steps of the sanitation service chain from toilet capture and containment through emptying, transport, treatment and final disposal.
- Safe sanitation systems must meet requirements of safe sanitation system in a manner consistent with human rights.
- Safe sanitation systems should also address co-disposal of **greywater** (water generated from the household, but not from toilets), **associated hygiene practices** (e.g. managing anal cleansing materials) and essential **services required for the functioning of technologies** (e.g. flush water to move excreta through sewers).

Objectives

- The purpose of these guidelines is to promote safe sanitation systems and practices in order to promote health.
- They summarize the evidence on the links between sanitation and health, provide evidence-informed recommendations, and offer guidance for encouraging international, national and local sanitation policies and actions that protect public health.
- The guidelines also seek to articulate and support the role of health and other actors in sanitation policy to ensure that health risks are identified and managed effectively.

- The guidelines are designed to be adapted to local contexts taking social, economic, environmental and health aspects into consideration.

Recommendations and Good Practice Actions

Recommendations

Recommendation 1: Ensure universal access and use of toilets that safely contain excreta:

- This recommendation is in line with human rights principles and **reinforces SDG 6 and target 6.2**.
- Access to a toilet does not mean it is used or used consistently by everyone at all times. Poorly constructed and managed facilities may lead to households reverting to open defecation
- Toilets should be available, accessible and affordable to all, constantly, and at least separate excreta from human contact.
- In **urban areas,** achieving full coverage and safe containment is important and should be addressed through city-wide planning and implementation, as interlinkages can occur through waterways, groundwater, pipes and drains.
- **Shared and public toilet facilities** that safely contain excreta can be promoted for households as an incremental step when individual household facilities are not feasible.

The Sustainable Development Goals (SDGs)

- **SDG 6 – Ensure availability and sustainable management of water and sanitation for all and**
- **Target 6.2 – By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.**

Recommendation 2: Ensure universal access to safe systems along the entire sanitation service chain.

- There is need to ensure systems and services are selected to respond to the local context and that investment and system management are based on local level risk assessments.
- Sanitation systems should address containment, emptying, conveyance, treatment and end use or disposal of excreta, to achieve safe sanitation.
- Risk assessment should assess potential exposure and risks to all groups along the chain – users, local communities, workers and wider communities.

Recommendation 3: Sanitation should be addressed as part of locally delivered services and broader development programmes and policies.

- Sanitation services should be included in local planning processes to avert the higher cost and complexity of retrofitting sanitation services and infrastructure where there is insufficient space and where sanitation clashes with other local services and infrastructure.
- Sanitation interventions should be coordinated with water and other hygiene measures, as well as safe disposal of child faeces and management of domestic animals and their excreta to maximize the health benefits of sanitation.
- While sanitation is a primary barrier, secondary barriers such as safe water, hand washing with soap, animal waste management and fly control are needed.
- Interventions to address all above issues may be delivered together in a transformative water, sanitation and hygiene **(WASH) approach**.

WASH Approach

WASH is an acronym that stands for "water, sanitation and hygiene". Universal, affordable and sustainable access to WASH is a key public health issue within international development and is the focus of Sustainable Development Goal 6.

Recommendation 4: The health sector should fulfil core functions to ensure safe sanitation to protect public health

- Coordination is required to accommodate the multi-sectoral nature of sanitation and facilitate action by multiple stakeholders including overall health, education, housing, agriculture, development, public works and environment programmes.
- Health authorities must contribute to the development of sanitation norms and standards, this includes contribution to the development (or revision) and implementation of safety standards.
- Sanitation promotion and monitoring should be included within health services to maximize and sustain health impact.
- Sanitation promotion is an important function that should be embedded to the extent possible in community-based, school-based and population-wide initiatives and campaigns.

Good Practice Actions

1. Define government-led multi-sectoral sanitation policies, planning processes and coordination.

- Define sanitation as a basic service in national and sub-national plans, for which government is responsible and accountable.

- Review and update existing policies to identify impediments to improving sanitation along the whole service chain.

2. Ensure health risk management is properly reflected in sanitation legislation, regulations and standards.

- Review the public health effectiveness of existing national and local legislation, regulations and standards to identify and address impediments to improving sanitation.
- Explicitly recognize sewered and non-sewered sanitation system types in relevant legislation and regulations at national, state, municipal and local levels.
- Regulate service quality for all steps in the sanitation service chain, based on public health risk assessment and management.
- Protect sanitation workers from occupational hazards through health and safety standards and standard operating procedures.

3. Sustain the engagement of the health sector in sanitation through dedicated staffing and resourcing, and through action on sanitation within health services.

Build capacity of environmental health staff to fulfil health sector functions – contribution to sanitation coordination, health in sanitation policies, health protecting norms and standards, health surveillance and response, sanitation in health programme delivery, sanitation behaviour change and sanitation in Healthcare facilities.

4. Undertake local level health-based risk assessment to prioritize improvements and manage system performance

- Define sanitation at sub-national level as a basic service for which local government is responsible and accountable.
- Allocate sufficient financial and human resources for long-term implementation.

5. Enable marketing of sanitation services and develop sanitation services and business models.

- Establish a sustained marketing effort for safe sanitation services to eliminate open defecation and unimproved toilets.
- Promote private sector service provision for those parts of the sanitation service chain with high customer benefit and consider public-private partnership where appropriate.
- Acknowledge the informal sanitation service providers, recognizing that improved services will have to compete with them and that their experience is a valuable resource that should be utilized within the formal system.

Enabling Safe Sanitation Service Delivery

Safe sanitation systems require input from a range of stakeholders, but national and local government are central to their effective planning, delivery, maintenance, regulation and monitoring.

Components of an Implementation Framework

The services themselves can be broadly divided into **three categories,** according to how they are delivered:

- **Customer services,** such as toilet construction, hardware supplies, removal of faecal sludge or containers, and provision of public toilets. These provide direct benefits to users as well as improving public health at the community level.
- **Public services,** which include operation and maintenance of sewerage and drainage systems and faecal sludge treatment. These are delivered downstream of users, producing public health benefits to the community, and may not be possible or fair to finance entirely by direct user fees.
- Public services are usually delivered by local authorities, utility companies or subcontracted to the private sector and funded through local tax revenue, cross subsidy from water supply and government subsidies.
- **Infrastructure development,** comprising the design and construction of sewerage, drainage, faecal sludge transfer stations and faecal sludge and wastewater treatment plants, primary water supply systems or slum upgrading.
- Infrastructure development provides public health benefits to the community, but requires major investment.

Enforcement and Compliance

- Achievement of compliance with standards and regulations requires a broad approach that includes a mix of incentives, promotion and sanctions.
- Non-coercive means, such as information dissemination, technical assistance, promotion and awards should be used in the first instance.
- Sanitation standards need to be monitored and enforced. The capacity for inspection and prosecution needs to be assessed to determine whether it is sufficient to cope with the predicted demands.

Coordination and Roles

- It is necessary to establish a multi-sectoral platform for dialogue between the main stakeholders and to develop and oversee coordinated plans of action.
- Political leadership for the coordination and implementation of safe sanitation

systems and services is also needed to assume the challenge of driving progress on sanitation.

Environmental Health Authorities and Their Role in Sanitation

- Environmental health covers topics such as **drinking-water safety, sanitation, air pollution, occupational health and chemical safety**.
- It should be seen as part of a larger spectrum of activities that includes education and sanitation promotion, with punishment of offenders as a last resort.
- It must be feasible for people to adopt the desired behaviour so enforcement and promotion must be coordinated with services development and information campaign.
- To enable environmental health staff to play their role fully, they should receive training to equip them to manage specialists and contractors and to advocate internally for the allocation of sufficient resources for sanitation behaviour change.

Delivering Sanitation at Local Level

Sanitation as a basic service

- In all environments, maximum health benefits can only be obtained from sanitation when combined with adequate water supply and good hygiene behaviours.
- In a high density (urban) environment sanitation is closely linked to land-use patterns, housing occupancy patterns, level of water supply services, drainage and solid waste management and cannot be managed independently of them.
- Planning and implementing sanitation must therefore be coordinated with these other basic services.

Sanitation behaviour change

- Active user participation is needed to achieve sanitation and good hygiene. Multiple behaviours by different stakeholders require addressing along the sanitation service chain, and may require specific strategies.
- Behaviour change should be seen as an integral component of providing sanitation, as concentrating on infrastructure and services alone will not deliver the desired public health outcomes.

Local monitoring

- They might be formal or informal community leaders, or staff from health, agriculture or other sectors which have a community presence.
- Budgets should be programmed for the purpose, and a continuous training programme established.

Developing Sanitation Services and Business Models

Designing services

- Sanitation services must respond to the physical, social and economic conditions prevailing in each area, and these factors should be assessed prior to embarking on sanitation improvements.
- As cities grow, there is an increasing need for decentralized sanitation systems in urban areas, both small sewerage systems and faecal sludge transfer facilities and treatment sites.

Financing services

- People are prepared to pay for sanitation services at the toilet, containment and onsite treatment, and parts of conveyance that benefit them directly.
- In urban areas, sanitation fees can be combined within the water tariff, especially if all sanitation services are managed by a utility.
- They can also be included in local taxes.
- In low-density rural areas, where the principal activity is sanitation promotion and the safe and consistent use of self-built toilets, there is little alternative to that of using government budgets for these activities.

Management of Special Sanitation Risks

Sanitation in emergencies

- These guidelines focus on including sanitation in disaster preparedness planning as an immediate priority action.
- To facilitate this, sanitation and hygiene materials should be purchased and pre-positioned along with other emergency supplies (such as those for shelter, nutrition and health).
- Provision for people with disabilities, for children, and for women’s privacy, safety and menstrual hygiene needs are critical and need careful planning during emergencies, when women and girls are especially vulnerable.

Sanitation during enteric disease outbreaks and epidemics

- Special attention should be paid to sanitation during disease outbreaks and epidemics of enteric diseases with a faecal-oral transmission route including cholera etc.
- Preventive action to reduce faecal load in the environment especially in known hotspots with recurrent outbreaks, is more effective.

Sanitation in health care facilities

- Heath care facilities represent a particularly high sanitation risk, due to both infectious agents and toxic chemicals.
- Health care facility sanitation should be under the responsibility of the Ministry of Health, with responsibility for its management clearly specified in the job descriptions of health care facility managers and relevant staff.
- Recommended numbers of toilets are 1:20 for inpatients and at least two toilets for outpatient settings as per WHO 2008.

Sanitation Behaviour Change

Introduction

- Sanitation programmes have historically tried to influence practices through the direct provision of hardware and with various forms of health education or health promotion.
- People choose to use toilets and practice related hygienic behaviours for many reasons other than the desire to improve health.
- Behaviour change is now seen as an essential component of sanitation programmes to improve the uptake of sanitation solutions, hygienic practices in households and in the institutions responsible for sanitation programming.

Depending on the Specific Situation, Desired User Behaviours Include

- Abandoning open defecation and adopting safe sanitation facilities.
- Hand washing with soap at critical times.
- Building and using non-emptiable pit latrines, which are covered over when full and new facilities are constructed.
- Building and using permanent onsite facilities with access for emptying and accessibly situated for emptying equipment.
- Ensuring the regular desludging of such facilities and the infiltration of liquid effluents to the subsoil or other safe disposal route.
- Connecting to a sewerage system where available, and paying the service charges.
- Safe practices in handling wastewater and faecal sludge in food production and sale.

Institutional and Government Responsibilities for Sanitation Behaviour Change

- Sanitation behaviour change requires financial and human resources, failure to commit sufficient resources may lead to failure to achieve sustained adoption or use of household sanitation services.

- Health authorities should ensure that all sanitation interventions include a robust sanitation behaviour change strategy.
- Behaviour change work should be conducted in coordination with organisations providing infrastructure and services.
- This may involve engaging with organizations with technical and subject matter expertise, such as universities and social marketing and design agencies.

Sanitation Behaviours and Determinants

- To design successful activities to influence sanitation behaviours it is important to understand the range of existing sanitation behaviours and their determinants.
- For sanitation to be effective, a variety of inter-related behaviours are important. These include the sustained use of facilities and their maintenance and upkeep, good hand hygiene and the hygienic disposal of child and infant faeces.
- Having access to a toilet is essential for use to take place, but it does not guarantee consistent use. **There are multiple reasons why existing facilities may not be used, including:**
    - Facilities may not be adequately accessible to intended users, particularly women, older people or people with disabilities.
    - Facilities may not offer sufficient privacy to users given the intimate and often taboo nature of sanitation behaviours.
    - Facilities and the use of facilities may not provide a safe environment free from harassment, violence, or other physical and emotional forms of harm.
    - They may be broken, dirty or uncomfortable to use.
    - Individuals may prefer open defecation, particularly when sanitation options are unappealing or unhygienically maintained.
    - Facilities may not be available at the times users need them, such as when individuals are away from home (school, work place, public places) or may be locked at night.
    - Users may be concerned about the impact of long-term use on pit-filling and future maintenance, thus avoid using the facility.
    - Sharing facilities may discourage people from using facilities, even when sharing is limited to members of the same family.
    - Shared and public facilities may be located at a long distance; queues may also discourage use.
- The determinants of behaviours of interest may be positive i.e. they promote the behavioural outcome or negative i.e. where they act as a barrier to the behavioural outcome.
- Behavioural determinants are found at different levels e.g. society, community, individual, etc. and include factors which can be characterized as being related to context, technology and psychosocial experiences.
- Individual-level determinants of behaviour include knowledge around toilet

construction and use, costs and benefits, motivation and desire for sanitation, and the way in which the behaviour fits in with daily routines and habits.
- Determinants that operate at the household level could include roles and responsibilities and the division of labour within the household.
- Community-level determinants include societal norms of toilet use and capacity for the management and maintenance of facilities.
- Behavioural determinants are related to the context in which behaviours occur such as climate, geography and access to materials, economic determinants availability of subsidies or the enforcement of fines and/or penalties.
- Sanitation technologies can also determine behaviour through, for example, ease of use, location and cost.

Changing Behaviours

Main approaches

Different behaviour change approaches commonly used for sanitation and hygiene behaviour change.

- **Information, education and communication approaches (IEC)**
  - Messaging and awareness raising are the cornerstone of conventional information, education and communication (IEC) initiatives. IEC approaches are often used in public health behaviour change communication.
  - IEC can include mass media, group or interpersonal communication and participatory activities.
- **Community-based approaches**
  - The focus of community-based approaches to sanitation is the collective mobilization of groups of people.
  - Collective processes are used to develop a shared understanding of a local problem, reach a collective agreement on actions and to create new norms around a specific behaviour.
  - These norms help to create new social pressures to comply with the promoted behaviour.
  - **Community-Led Total Sanitation (CLTS)** initiatives are organized around series of community-based activities, led by trained facilitators, which focus on behaviour change and aim to ignite a sense of disgust and shame in a community related to open defecation and its impact on the community's health and well-being.
  - **CLTS programmes have been implemented number of countries and have evolved in multiple ways to improve outcomes on sustained sanitation use including:**
    - Targeting subsidies to marginalized households.

        - Tailoring initiatives to focus on the inclusion of marginalized groups and households.
        - Paying increased attention to supply-side interventions such as social and commercial-marketing based approaches discussed below, in order to stimulate progress from basic to safely managed sanitation.
        - Understanding reasons for slippage and reversion to open defecation.
- **Approaches incorporating psychological and social theories of behaviour**
    - In recent years, models and frameworks drawing on psychological and social theories have been developed and applied to sanitation and hygiene promotion and behaviour change.
    - Approaches include the use of **environmental "nudges"** to create or sustain new default behavioural patterns and cue desired behaviour, and strategies that focus explicitly on habit formation through repetition, fostering stable environments and reducing perceived barriers to behaviour.
    - Approaches based on psychological and social theory are often associated with specific behaviour change techniques (BCTs).
    - These are the smallest building blocks of a behaviour change intervention and refer to the mechanisms through which intervention or programme activities influence behavioural determinants to result in changes in behaviour.
    - Evidence suggests that the use of multiple BCTs is more effective than interventions that utilize a single or limited number of techniques.

Stages in Behaviour Change Strategy Design

Documenting existing behaviour

- In order to design sanitation behaviour change intervention, it is necessary to collate available information on the sanitation situation and behaviours within the target population.
- This involves reviewing published and grey literature and consulting global and local experts.

Understanding behavioural drivers

- Context specific research, which may include quantitative, qualitative and participatory methods, is useful in order to understand the behaviour within the actual population.
- This examination may suggest specific messaging strategies or specific determinants that have the potential to leverage the most change within the population.

Creating a sanitation behaviour change intervention

Information gathered as part of the previous two steps can be collated and organized

using a framework for understanding sanitation behavioural determinants.

Testing, adapting and delivering a sanitation behaviour change intervention

- The focus of behavioural trials results is to inform the development and modification of a potential programme before introduction to a wider audience.
- Regardless of the approach used, attention should be given to the frontline workers who are engaged in the direct delivery of sanitation behaviour change activities

Monitoring and learning for success

- Monitoring and oversight of sanitation behaviour change interventions should help to organize stakeholders around common objectives and provide systems for assessing progress.
- These efforts can inform the adaptation and improvement of future strategies through systematic learning.

Excreta-Related Pathogens

Introduction

- Sanitation interventions and the safe disposal of human excreta have the potential to impact on the transmission of a diverse range of microbial hazards.
- This chapter outlines the characteristics of the four main groups of pathogenic hazards (bacteria, viruses, protozoa and helminths) considered within these guidelines, and examines their transmission pathways and how infection relates to poor sanitation.

Bacteria

- Bacteria are small (typically 0.2-2 micrometres) single celled organisms, many of which are capable of multiplication outside a host under favourable conditions.
- Most bacteria considered here are enteric, transmitted by the faecal-oral route, and predominantly cause gastroenteritis. Some can cause severe health outcomes and may have long-term effects.
- Bacteria may develop antimicrobial resistance (AMR), where they become resistant to the effects of antibiotics, biocides and so on.
- While the development of AMR is a natural phenomenon, it can be accelerated by the selective pressure exerted by the use and misuse of antimicrobial agents in people and animals, and by their environmental release.

Viruses

- Viruses are simple infectious agents, consisting only of genetic material (DNA or RNA) encased in a protein capsid.
- They are the smallest (typically 20-100 nanometres) organisms considered here and they are obligate intracellular organisms (i.e. they must be within a susceptible host cell to reproduce).
- Viruses can be excreted in very high numbers and may be transported long distances in water.

Protozoa

Parasitic protozoa are complex and relatively large (typically 3-20 micrometers) single celled organisms that cannot replicate outside a suitable host.

Helminths

- Helminths (also known as parasitic worms) include tapeworms (cestodes), flukes (trematodes) and roundworms (nematodes).
- They are multi-cellular, complex organisms. Some helminths, referred to as soil-transmitted helminths (STH), can be transmitted by the faecal-oral route (after a period of maturation in the environment), with infection being caused by ingestion of fertile worm eggs or through skin penetration by infective larvae.

Microbial Aspects Linked to Sanitation

The role of poor sanitation and excreta in disease transmission depends on the individual pathogen. In the simplest categorization, there are three primary ways in which human excreta may increase the occurrence of human infections:

- As a source of enteric pathogens in the environment.
- By contributing to excreta dependent lifecycles.
- By facilitating vector breeding.

Excreta as a source of enteric pathogens in the environment

- Enteric pathogens colonize the intestine, multiply within infected individuals, and are subsequently excreted with faeces.
- Every excreted infectious pathogen has the potential to cause a new infection if ingested by another person. Potential exposure pathways include:
  - **Fingers:** Pathogens may be transferred to fingers through touching of faeces or faeces- contaminated surfaces or people and then, subsequently, cause infection as a result of putting fingers in the mouth or nose, or on food.
  - **Food:** Fresh produce can become contaminated through the use of wastewater for irrigation, faecal sludge for fertilizing or the use of contaminated wash water. When consumed raw (or lightly cooked) the produce can contain infectious

pathogens.
    - **Drinking-water:** Drinking-water from surface and groundwater sources can be contaminated with faecal pathogens.
    - **Hygiene and household water:** Faecally contaminated water used for washing and food preparation, while consumed in smaller quantities than drinking-water or unintentionally, can also lead to exposure to faecal pathogens.
    - **Surface water:** Playing or bathing in contaminated surface waters may lead to unintentional ingestion of water and subsequent infection. Similarly, occupational exposure (e.g. fishing, vehicle washing) can lead to ingestion of surface water.
- The focus and objective of a safe sanitation system is to interrupt all the exposure pathways.
- Sanitation intervention is expected to reduce exposure to microbial hazards, but the extent of that reduction will depend on the pathogen, setting and individual.

Pathogen persistence in the environment

- Assessing the survival time of pathogens in the environment is a key component of health risk assessment.
- Pathogens are, typically, adapted to the conditions of the human or animal gut and so persistence under unfavourable conditions is limited.
- Nevertheless, dark and cool conditions, neutral pH and sufficient moisture may lead to prolonged survival of pathogens.

Treatment and control

- Wastewater and sludge treatment processes are an essential barrier for protection of human health.
- Some treatment processes have been shown to have a relatively minimal impact on pathogen levels in sewage (with less than 90% reduction of any of the four pathogen groups).
- When microbial reductions are explicitly considered, they often rely on bacterial indicators with little focus on the other pathogen groups.
- The mechanism of pathogen inactivation needs to be defined and the critical limits of those mechanisms identified for the key pathogens of interest.

Common Pathogen Inactivation Mechanisms Include

- **Time:** Natural inactivation over time is a valuable treatment mechanism incorporated into many systems. The time needed to achieve inactivation will depend on temperature and specific conditions.
- **Sedimentation and partitioning to solids:** Sedimentation processes are typically designed for suspended solids removal. In waste stabilisation ponds, allowing time for

sedimentation can lead to removal of larger pathogens.

- **Solar radiation:** Many pathogens, particularly viruses, are susceptible to inactivation by solar radiation. The extent of removal will be driven by water depth, clarity and exposure time.
- **Thermal treatment:** When storage is combined with a thermal process pathogen reduction times can be drastically reduced. To ensure reductions are achieved, it is necessary to know the temperature profile of the waste.
- **Filtration:** Physical filtration processes from natural wetlands to filter beds can effectively remove pathogens. Removal depends upon the filter pore size and the biological activity of the filter matrix.
- **Chemical disinfection:** Addition of chemical disinfectants will enhance pathogen reduction however response will be pathogen-specific and depend on the dose, water matrix and the organic content. Using lime to raise the pH is a useful strategy in emergency settings.
- **Attenuation in the subsurface:** Many sanitation technologies rely on pathogen attenuation in the subsurface. The fate of pathogens in the subsurface is determined by their survival in soils and retention by soil particles and is mainly determined by local climatic conditions, the nature of the soil and features.