

# Study Unit 7

# Water, Sanitation and Hygiene (WASH)

## Study Unit 7 Outline

WASH study unit covers the following topics.

- Introduction of WASH and approaches.
- Water Quality and Safety.
- DSR and outbreak response.
- Disease-associated with water
- Critical of Sanitation safety, solid and waste management.

## Study Unit 7 Duration

This Study Unit requires 2 hours of formal study time.

You may spend an additional 2-3 hours for revision

## Preamble

This chapter covers the main aspects of WASH in a humanitarian setting. It enables you to learn the meaning of WASH, approaches, water quality and safety, IDSR and outbreak response, & water-associated diseases.

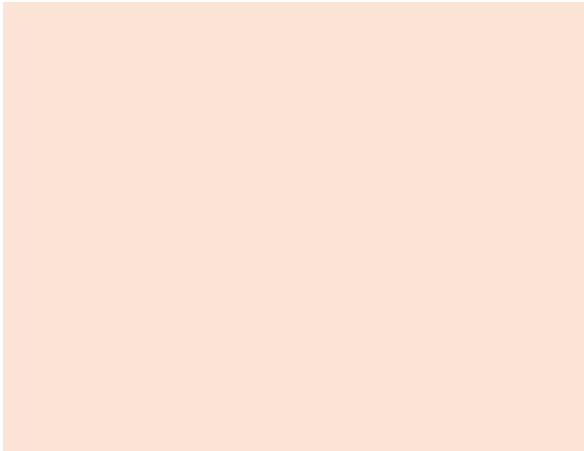
## Learning Outcomes of Study Unit 7

After completing this study unit, you should be able to:

- 7.1 Describe WASH and its main approaches
- 7.2 Implement water quality and safety measures.
- 7.3 Discuss Integrated Disease Surveillance and Response (IDSR) objectives
- 7.4 Enumerate Diseases associated with water, their causes and Treatment plans.
- 7.5 Implement and Ensure Sanitation, Safety and Waste Management procedures.

## Terminologies

WASH	Water Hygiene and Sanitation.
PHAST	Participatory Hygiene and Sanitation Transformation
CHAST	Child Hygiene and Sanitation Transformation.



CLTS	Community-Led Total Sanitation
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## **7.1 Introduction to Water, Sanitation and Hygiene (WASH)**

### **7.1.1 Safe water, toilets and good hygiene keep People alive and healthy.**

Is a healthy start to life possible if a person has access to clean water, proper sanitation, and basic hygiene? Having insufficient access to WASH services has a negative impact on the health, economic well-being, and overall well-being of a large number of people. According to the Joint Monitoring Programme for Water Supply, Sanitation, and Hygiene Report by the World Health Organization and UNICEF, 844 million households do not have access to water. Over 892 million people continue to defecate in public despite the fact that 2.3 billion people lack access to proper sanitation. (ALMAZAN, 2014)

The United Nations' Sustainable Development Goal (SDG6), which seeks to provide universal access to and environmental management of water and hygiene, highlights the importance of WASH improvements and their impact on achieving a healthy and sustainable world.

Students are taught the fundamental concepts for planning, creating, and implementing efforts to enhance sustainable and equitable use of securely managed water and sanitation systems and hygiene habits. (Kar, 2015)

### **7.1.2 The Approaches of WASH**

#### **(Participatory Hygiene and Sanitation Transformation) (PHAST)**

Individuals build confidence in themselves and their potential to act and improve their communities through this strategy. Personal empowerment and development are equally as vital as physical changes such as environmental cleanups or the installation of latrines.

This process has seven steps. A plan for preventing diarrhoeal infection via improved water supply, hygiene practices, and sanitation is developed in the first five stages. The seventh and

eighth stages are for monitoring and evaluation. (Kar, 2010)t.

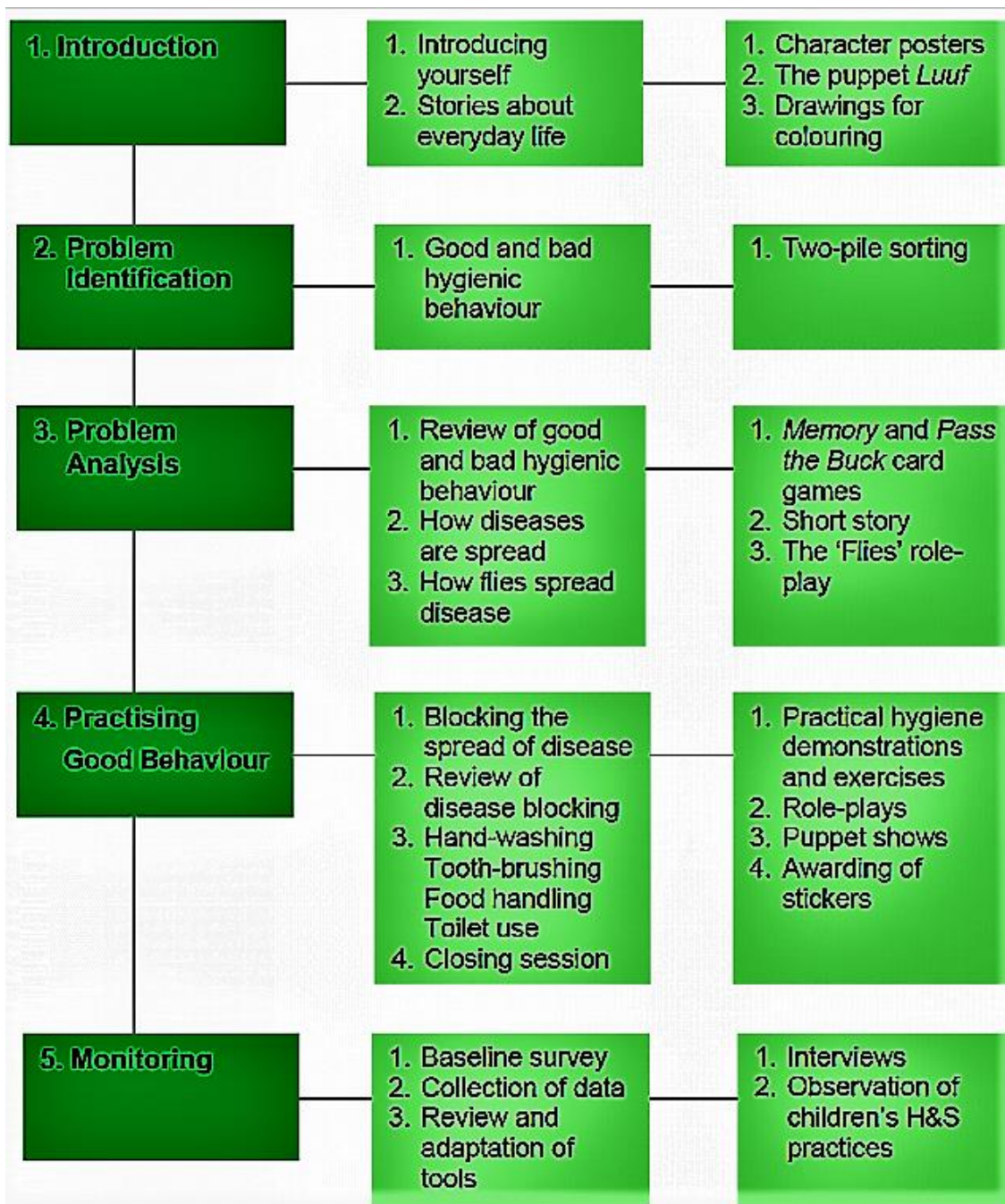


Fig 7.1.2: Steps in PHAST (Bockhorn, 2012)

### **Child Hygiene and Sanitation Transformation (CHAST)**

This is a rural Somalia strategy to educate children about proper hygiene. The PHAST approach is used. It's a community-based participatory learning technique that aims to decrease diarrhea and improve water and sanitation management in impoverished areas. As part of CHAST's efforts to teach children the importance of personal hygiene, the organization utilizes games and activities.

As a child's habits are easier to change than an adult's, CHAST was founded on this premise. Young children may benefit from the PHAST approach as much as adults. The CHAST technique emphasizes a child's natural curiosity and desire to learn. CHAST encourages students to debate and express their opinions. During CHAST activities and games, young people are encouraged to work in pairs or small groups before presenting to the larger group. Using games, exercises, and role-playing scenarios, the CHAST products encourage children to learn about personal cleanliness and hygiene in a pleasant way. **(Bockhorn, 2012)**



**Fig 7.1.3: Steps in Child Hygiene and Sanitation Transformation.**

Source: DE VREEDE (2004)

### Community-Led Total Sanitation (CLTS)

To improve sanitation and hygiene in developing countries, this strategy is most often used. Open defecation cessation is "triggered" in rural regions in an effort to alter rural behavior. When it comes to a community's behavior, it focuses on how it can change on its own. The phrase "trigger" is critical: Building basic toilets like pit latrines is a common way of preventing people from defecating in the open. Characteristics of the CLTS generate positive feelings of self-worth and a sense of belonging in the community. Disgust and embarrassment are also evoked by the presence of feces, which may be seen and touched. Working with communities, CLTS identifies the issue of open defecation and encourages them take collaborative action to clean up the mess. (Kar, 2010)

Kamal Kar proposed the idea for rural Bangladesh in the early 2000s. CLTS gained popularity in 2011. When CLTS was initially adopted in a country, NGOs were often at the forefront. Communities that are "open defecation free" may be recognized (ODF).

The CLTS first plan did not include toilet subsidies since doing so would have slowed down the process. A total of 53 countries make use of CLTS, or TS adapted for urban settings. Post-emergency and weak nations have also seen its use.

With CLTS, human rights violations, poor sanitation standards, and long-term use rates are all difficulties.. Human rights-based sanitation is congruent with CLTS, yet there are some harmful practices. Those who work in CLTS, as well as public health officials and municipal leaders, must do more to combat discrimination, social norms awareness, and pre-existing inequities. Everyone should benefit equally from CLTS efforts, including those who are less fortunate. (Kar, 2010)

### 7.1.3 Phases of **Community-Led Total Sanitation (CLTS)**

#### **Pre-triggering**

Pre-triggering is the process of determining whether or not a community is ready to participate in CLTS. A variety of characteristics, including visits, help identify populations most likely to benefit from triggering. Pre-triggering is a time when facilitators get to know the people in the community and build trust..

#### **Triggering**

No "one technique" to activate CLTS, says the 2008 "CLTS Handbook." This guide contains an approximate step-by-step procedure. Adapting activities to the local environment is recommended. The UNICEF CLTS guideline for Sierra Leone suggests the following trigger steps:

- Conduct a community tour, highlighting the critical nature of knowing about the sanitary status in the neighbourhood. Facilitate 'Kaka Mapping,' which comprises sketching the village's essential features and the main defecation sites.
- Try to make it seem like you're leaving the room. Assist the community in participating in the "Walk of Shame," which entails visiting sites where open defecation occurs. Place a little bit of faeces in a plastic bag and seal it shut. Flies travel between food and water sources, so distribute dung on the floor in front of the community and explain this. Ask the people whether they'd drink a half-full water bottle of faeces.
- Calculate the number of faeces generated each day and enquire about their disposal. Ignition Await the development of "Natural Leaders" with whom to collaborate to establish a strategy

This technique is designed to infuriate the locals by showing them how bad their hygiene is firsthand. A serious sanitation issue must be recognized and remedied during this phase, which is



known as the "ignite" phase. Involved individuals of the community who are seen as having the ability to influence the process are known as "Natural Leaders".

Community members are not found to be motivated by shame or disgust as a universal motive. Motivations like enhanced health, self-esteem, and self-confidence are much more common. (Bockhorn, 2012)

### **Post-triggering**

**On the basis of the evidence-based response to the ignition phase, non-governmental organizations (NGOs) aid communities by providing information and assistance tailored to their local context.**

**During the post-trigger period, there are several obstacles to overcome. As part of these efforts, toilet hardware and technical assistance for latrine structures will be provided. Toilet owners may request help in modernizing and improving sanitation and handwashing facilities using materials that are available in their area. (Kar, 2015)**

## **7.2 Water Quality and Safety**

- Water quality is what defines water's appropriateness for a particular purpose. Water quality testing will reveal the health of the watercourse. Water testing demonstrates variations in the water's quality throughout time. Numerous crucial parameters must be considered.
- Physicochemical parameters.
- Chemical constants
- Parameters biologiques. (Kar, 2015)

## Water Quality Parameters:

**Water has its own**

- **Physical properties**
- **Chemical composition and**
- **Biological Properties**

**Fig 7.2: Water Quality Systems**

Temperature, pH, turbidity, salinity, nitrates, and phosphates are all possible parameters to test. Additionally, an examination of aquatic macroinvertebrates might offer information about the water's quality. (Kar, 2015)

### **7.2.1 Temperature.**

Temperature impacts the quantity of dissolved oxygen in a waterway, therefore it's important to keep an eye on it. The amount of oxygen that can dissolve in water increases as the temperature drops. In the absence of heat, water can only store 7.6 mg/L of oxygen at 30oC, compared to water's room temperature capacity of 14.6 mg/L.L. (Kar, 2015)

Photosynthesis in plants and aquatic organisms is influenced by temperature as well as their ability to reproduce and their ability to resist toxins and parasites. Temperature also has an impact on species' mobility and migration patterns as well as their susceptibility to disease. Temperature swings are regularly found to be associated with the life cycles of aquatic organisms. The amount of dissolved oxygen in a body of water is directly proportional to its temperature. The quantity of oxygen dissolved in water increases as the temperature drops. At ambient temperature, water can hold up to 14.6 mg of oxygen per liter, but only 7.6 mg/liter at 30oC. (Bockhorn, 2012)

Photosynthesis in plants, aquatic creature metabolism, growth, reproduction, mobility, and migratory patterns, as well as their sensitivity to toxins and parasites, are all influenced by the temperature. Temperature variations are often a factor in the life cycles of aquatic species. (Kar, 2010)

### **7.2.2 Salinity.**

"Salinity" is a scientific word that describes the concentration of salts in water. In times of low flow, salinity levels tend to be most noticeable and diminish as water levels fall. Both TDS (Total Dissolved Solids) and EC are used to express salinity. TDS is the concentration of dissolved salts in water, while EC is the capacity of a material to operate as a conductor. More salty water conducts electricity more rapidly than less salty water does. It is possible to convert an EC value to TDS or the other way around. (ALMAZAN, 2014)

### 7.2.3 Turbidity

Turbidity is the capacity of light to travel through water or the water's murkiness. The quantity of suspended particulates in the water is determined by ambiguity. NTUs (Nephelometric Turbidity Units) measure turbidity.

Suspended Solids enter the water by soil erosion or wastewater intake from sewage facilities or industry. Suspended particles naturally occur in water due to bank and channel erosion, but human use has expedited the process. Turbidity measures the number of algae and plankton in the water. These contaminants can form complexes with floating materials and sink to the sedimentary bed to accumulate.

In low flows, suspended particles can smother aquatic plants and jam fish mouths and gills. Turbidity impacts submerged plants by limiting light for photosynthesis. High turbidity can also drastically boost the water temperature. Aquatic life needs consistent water temperature to live.

While excessive turbidity often indicates poor water quality and land management, clear water does not necessarily mean health. Clearwater shows strong acidity or salinity. **(Bockhorn, 2012)**

### 7.2.4 Faecal of Coliforms

These bacteria are present in the intestines of all animals and birds, including humans. Coliforms in feces are a sign of sewage contamination. Coliforms in feces provide a health danger. Their presence indicates the existence of harmful bacteria and viruses.

Septic systems, feedlot and dairy runoff, agricultural runoff, and animals defecating directly into streams and rivers are all potential sources of faecal coliforms. Excellent 0 Excellent >0 to 35 35 - 230 Secondary > 700 poor No contact

Swimming, for example, is a primary contact activity. Maximum 150/100 mL coliforms in faeces Secondary contact is when you are exposed to water but not entirely submerged. *C. elegans* should not exceed 1000/100 mL. (Kar, 2010)

## **7.3 Integrated Disease Surveillance and Response (IDSR) & Outbreak Response**

### **7.3.1 Public Health Surveillance**

Surveillance is the process of gathering, analyzing, and interpreting large amounts of health data over an extended period of time. The timely dissemination of the produced data to those who need it to take action is also a necessary component. The creation, implementation, and assessment of public health initiatives need constant monitoring. (ALMAZAN, 2014)

National programs may employ a variety of surveillance techniques. The surveillance's objective determines the method chosen.

Among the techniques are the following:

Surveillance in health facilities or the community: This is a concentrated effort on a single location. The systematic collecting, analysis, and interpretation of health data over a prolonged period is surveillance. Additionally, it requires the timely transmission of the generated data to those who need it to take action. The creation, execution, and assessment of public health initiatives need constant monitoring. (Kar, 2015)

Federal programs can use various surveillance tactics. The approach selected is dictated by the surveillance aim.

Several approaches include the following:

Surveillance in hospitals and the community: This is a targeted effort directed at a specific site.

### **Community-based surveillance.**

It is done at authorized or representative health care facilities or reporting locations where the surveillance is carried out. It collects data to provide early warning of diseases and pandemics.

1. Laboratory surveillance: This type of monitoring is undertaken in laboratories to spot occurrences or patterns that are not usually obvious in other areas.
2. Disease-specific surveillance: This refers to actions targeted at acquiring precise health data regarding a particular disease.

Whatever monitoring method is utilized, what is crucial is that health data be used to promote public health. (Kar, 2010)

### **7.3.2 Integrated Disease Surveillance and Response (IDSR)?**

It has been effective when resources were dedicated to recognizing certain diseases, getting laboratory confirmation and setting district-level action levels.

#### **Objectives of IDSR**

- IDSR's particular aims are to
- Develop and execute action plans, advocate for funding, and mobilize resources to help governments improve their surveillance capabilities.
- Integrate numerous surveillance systems to maximize the efficiency of equipment, persons, and resources
- Information technology may be improved so that public health events can be dealt with in an evidence-based manner; health policies can be designed and implemented in a way that is based on the most up-to-date information available.

- Improve the flow of surveillance data between and among the various levels of the health care system.. (Bockhorn, 2012)

### **International Health Regulations IHR**

- There are international health regulations in 2005, the International Health Regulations IHR (2005), aimed at preventing the spread of disease, protecting against it and controlling it, and providing the appropriate and limited public health responses to public health risks without interfering with international traffic and commerce.

It has been expanded to include all International Public Health Emergencies (IHR-2005) from cholera, plague, and yellow fever (PHEIC). Infectious diseases, chemical agents, radioactive materials, and contaminated food are just a few of the many sources of contamination. IDSR's objective is to improve the country's whole disease surveillance system, especially at the district level, and to guarantee the continuous and timely supply and use of information for public health decision-making:

- Surveillance, investigation, confirmation, reporting, and reaction infrastructure and resources
- Skilled staff.
- A well-defined procedure for implementation (sensitization, assessment, plan of action development, implementation, monitoring, and evaluation) • General assessment guides, plan-of-action development guides, technical guidelines, training materials, tools, and Standard Operating Procedures (SOP) (Kar, 2015)

Thus, IDSR can assure a uniform information flow to the national level to meet IHR obligations. The IHR (2005) presents a chance to address the danger posed by re-emerging and new infectious diseases and worldwide public health emergencies (PHEIC). They also provide an excellent opportunity to enhance monitoring and response systems and to adopt IDSR.

Notably, African Member States pushed for IHR (2005) and IDSR. IHR (2005) is a legal document. International public health emergency, worldwide partnerships and international

collaboration, and a focus on rights responsibilities processes and progress monitoring are critical issues emphasized in the report. (Kar, 2015)



### 7.3.3 The function surveillance as per the guidelines?

In order to recognize and react to priority diseases and conditions, these suggestions presume that all levels of the health care system are conducting surveillance (even though the different levels do not perform identical functions). Prioritize diseases, ailments, and events are among these functions.

Determine whether this is an epidemic-prone sickness, or a PHEIC or a disease that has to be eradicated or eliminated. Determine whether a Public Health Emergency of International Concern exists by using the decision tool (PHEIC).

- Gather and evaluate data to identify patterns. Finding and comparing information from the past
- Confirm the existence of events, epidemics, or other occurrences. If possible, do laboratory testing to confirm the case, pandemic, or occurrence. Investigate the source of the epidemic to determine the most effective control and prevention strategies.

In order to react quickly to epidemics or public health disasters, it is important to plan ahead.

For public health emergencies: • Respond, coordinate, and deploy resources and human resources.

- Make a contribution. Persuade others to join in the future by letting them know how successful the investigation was.

The system should be evaluated and improved. It's important to keep an eye on things like reaction times and quality of information while designing surveillance and response systems. Ask for help and improve your performance.. **(Kar, 2015)**

### 7.3.4 Surveillance Community based.

#### Introduction

It is the practice of keeping tabs on diseases in a community to locate instances and report them so that community-led action may be taken to prevent the spread of the disease, including early referral to a health center. (WHO, 2006)

The country has prioritized community disease monitoring to •

Guide community health actions through assisting in the diagnosis of infectious diseases.

In order to promote health and wellbeing, educate the public on the causes and patterns of illness.

• Make it easier to track the spread of infectious diseases in communities.

It was decided that the community strategy effort would serve as a vehicle for families and communities to take an active part in improving their own health via respectful, evidence-based conversation, and hence, community disease monitoring would be led by this initiative.

Health promotion and disease prevention messaging are the major health intervention in the community approach, which aims to encourage positive behavior change in the community members. Health professionals in the community are given a comprehensive kit (85% IEC materials) to help them in their duties. As part of community disease monitoring, they are also expected to keep track of the number of illnesses that occur in their area.

The goal of community-based disease surveillance is to improve the capacity of individuals' homes to monitor and control the spread of illness.

Improve the use of surveillance data in making health care decisions at the community level

Increasing the involvement of Community Health Workers (CHWs) in surveillance activities

Level 1 of the health care system should be bolstered in terms of the flow of surveillance data.

To optimize the utilization of resources, include community disease monitoring into CHS. (WHO, 2006)

## **Data Collection**

To gather statistics on the health of a community, Community Health Workers travel about, visit homes, and enquire about any health issues among the residents.

### **7.4 Diseases Associated with Water**

### 7.4.1 Diarrhoea

#### Key facts of diarrhoea

Diarrhea is the 2nd major cause of death in children. Both a preventative and curative measure may be found in this product.

· Every year, over 525,000 children under the age of 5 die from diarrhea. • A significant portion of diarrheal sickness may be prevented with clean drinking water, sanitation and hygiene.

Worldwide, about 1.7 billion children have diarrhea every year. Among children under the age of five, diarrhea is the most prevalent cause of malnutrition, according to the World Health Organization. (WHO, 2006)

Diarrhea is the second leading cause of mortality in children under five, accounting for approximately 525 000 deaths per year. Diarrhea can last for days, dehydrating the body and depleting it of critical fluids and minerals. Historically, diarrhea fatalities were attributed to acute dehydration and fluid loss. Additional reasons, such as septic bacterial infections, are increasingly being investigated expected to account for a greater proportion of diarrhea-related mortality. Malnourished infants, those with weakened immune systems, and HIV-positive individuals are particularly vulnerable to deadly diarrhea. (WHO, 2006)

To get diarrhea, you must pee three times a day (or more frequent passage than is normal for the individual). Diarrhea does not include frequent bowel movements or "pasty" stools.

Typically, diarrhea is a sign of an intestinal infection, such as bacterial, viral, or parasitic. Contaminated food and drink, as well as unsanitary living conditions, are the primary methods of illness dissemination.

Diarrhoea may be avoided by drinking clean water, maintaining excellent hygiene, and cleaning oneself with soap. Sugar and salt are added to filtered water in ORS to help patients stay hydrated. The use of dispersible 20 mg zinc tablets for a 10- to 14-day period also reduces the length of diarrhea and improves results.

There are three types of diarrhoea: acute watery diarrhoea, acute bloody diarrhoea, and pervasive diarrhoea, all of which may linger for many days or weeks. (WHO, 2006)

### **Interventions**

Prevention of viral diseases like hepatitis A and E remains the most effective means of control, including the following: Providing education on basic sanitation and hygiene, especially washing hands; Having appropriate and clean water sources and sufficient waste disposal; and Immunisation against hepatitis A for persons at risk, such as tourists visited zones where the disease is pervasive. (Bockhorn, 2012)

## **7.5 Sanitation, Safety, Solid and Liquid Waste Management**

### **7.5.1 Sanitation**

Sanitation is the process of safely discarding human urine and faeces. This involves the capture and containment of toilets, their emptying, transportation, treatment (on- or off-site), ultimate disposal, and end usage. (ALMAZAN, 2014)

### **Recommendations**

The following proposals are directed at equally local and national of government. Ensure widespread access to and use of safe restrooms.

Governments should place a premium on universal access to safe toilets and the abolition of open defecation while ensuring that development is equitable and consistent with the human right to water and hygiene.

Concurrently addressing sanitation demand and supply is necessary to guarantee toilet acceptability and use.

Every community should have access to safe toilets that collect excrement and remove technological and behavioural barriers to usage.

When private toilets are not feasible, shared and public toilets that securely retain excreta can be encouraged.

Everyone should have access to a secure toilet that preserves excreta in schools, hospitals, (**Kar, 2015**)companies, and public venues.

### **7.5.2 Implementing of Sanitation programs**

#### **Sanitation safety systems**

To ensure the safety of the sanitation service chain, sanitation systems must fulfill the following minimum standards.

##### Toilet

- The design, building, maintenance, and usage of toilets should ensure that people are kept safe from faeces.
- The toilet superstructure should be designed to keep out rainfall, stormwater runoff, animals, and insects.
- Toilets should be adequately maintained and cleaned regularly, with culturally and

contextually appropriate anal cleaning, hand-washing, and menstrual hygiene management facilities.

– preservation/treatment The risk assessment should verify that there is sufficient vertical and horizontal separation between the base of a porous container, soak pit, or leach field and the nearby water table or source allowing at least 15 m horizontal distance and 1.5 m vertical distance between permeable containers and drinking-water sources is suggested as a rule of thumb).

- All tanks and pits that discharge should be connected to a soak pit, leach field, or piped sewer.
- When products from on-site storage or treatment are handled for final use or disposal, risk assessments should safeguard the safety of personnel and downstream consumers.

#### Conveyance

Motorized emptying and transport should always be preferred.

It is imperative that workers be educated on the hazards of handling wastewater and feces, as well as the proper safety practices (SOPs).

Personal protection equipment should be worn by anybody who is doing manual sewage cleaning or manual emptying (PPE).

- Sewage and on-site sanitation faecal sludge must be treated before use or disposal, regardless of the source.

In order to identify, manage, and monitor risk across the whole system, the treatment facility should be developed and run particularly for that purpose.

As a safety precaution, employees who handle waste or feces should get training in hazardous materials handling methods and personal protection equipment.

- A multi-barrier strategy should be used (i.e., numerous control measures act as a pathogen barrier). (Bockhorn, 2012)



### 7.5.3 Sanitation Behavior Change

All sanitation initiatives place a premium on behaviour modification to increase acceptance and usage of safe sanitation.

- Governments should give leadership and sufficient funding for initiatives aimed at changing sanitation habits. (**Bockhorn, 2012**)
- An extensive sanitation promotion/behavior transformation (includes monitoring and assessment) should accompany all sanitation projects.

Understanding existing sanitation practices and their underlying variables is necessary to alter behaviour and create effective marketing programs.

The most successful interventions for behaviour transformation target the determinants of behaviour. Numerous models and frameworks exist to aid in the comprehension and targeting of behavioural factors.

- The delivery style of the intervention should be carefully evaluated (stand-alone behaviour modification vs integrated methods; targeted versus comprehensive strategies).
- Changing behaviour demands concentrated effort.

The toilet seat, latrine slab, pedestal, pan, and urinal are all part of the sanitation system.

Toilets may be pour- or cistern-flushed, dry, or urine-diverting. The toilet's superstructure might be standalone or part of a bigger construction (e.g., private house, a school, health care facility, workplace, or another public setting).

Safe toilet management is based on preventing active (e.g., filthy surfaces) and passive contact (e.g., via flies or other vectors).

Regular toilet cleaning removes trash and germs, reducing danger to users. Cleaning and maintaining toilets should be done safely and with the correct tools. Beyond pathogen exposure in excreta, accessibility, security, privacy, and menstrual hygiene management are all facets of user health. These considerations must be made to ensure that the facility is appropriate for its intended users and is operated and maintained safely (e.g., open defecation). (Kar, 2015)

### 7.5.2 Possible Determinant Outcome of Open Defecation

- Inadequate amenities

Inadequate quality/odorous

dirty facilities

- Accessibility

Habits

Absence of acquaintance with toilet

Inadequate knowledge of health repercussions

### 7.5.3 Excreta related Pathogens

Bacteria are unicellular creatures capable of self-replication in the absence of a host. The majority of enteric bacteria are responsible for gastroenteritis and are transmitted to the mouth via faeces. Certain types have significant health repercussions with long-term ramifications.

While it is conceivable for pathogenic gut bacteria to thrive in the environment, this is highly improbable. While many intestinal bacteria are zoonotic (transmitted between animals and humans), these standards do not mention proper animal waste management.

Bacteria can develop an uncultivable state, allowing them to survive in their environment for a lengthy period. (Kar, 2015)

## Viruses

They are made of genetic material (DNA or RNA) and protein shells. Often between 20 and 100 nanometers in diameter, they are the only intracellular species studied (i.e., they must be within a susceptible host cell to reproduce). Viruses may be carried by water in large numbers. Because viruses cannot metabolize, their life depends on the protein capsid's ability to withstand severe environments. The viruses addressed in this chapter are enteric and cause gastroenteritis, however some may cause hepatitis and viral meningitis.

### **Protozoa**

Parasitic protozoa are complex single-celled organisms that are incapable of reproducing in the absence of a suitable host. (Kar, 2015)

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