Federal Democratic Republic of Ethiopia
Ministry of Health

Hygiene and Environmental Health, Part 2

Blended Learning Module for the Health Extension Programme

HEAT
Health Education and Training
HEAT in Africa

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AMREF Better Health for Africa

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Contents

Study Session

Study Session 13 Provision of Safe Drinking Water

Introduction

Water is essential for life. An adequate, safe and accessible water supply must be available to all people, and improving access to safe drinking water can result in tangible benefits to health. Water is one of the factors which contribute to the transmission of many diseases. In this study session, you will learn and understand about the public health importance of water, the water (hydrological) cycle, the basic requirements for a safe, adequate and accessible drinking water supply, and the obstacles to safe water provision. You will also learn about different indicators for safe, adequate and accessible water supply. This study session will help you to recognise the basic requirements for safe water supply and to understand the transmission of waterborne diseases.

Learning Outcomes for Study Session 13

When you have studied this session, you should be able to:

13.1 Define and use correctly all of the key words printed in **bold**. (SAQs 13.1 and 13.3)

13.2 Describe the various types of disease associated with water. (SAQ 13.2)

13 3 Describe the hydrological cycle. (SAQ 13.3)

13.4 List and describe the basic requirements for safe, adequate and accessible drinking water. (SAQ 13.4)

13.5 Identify the groups of people who are particularly vulnerable to the lack of provision of safe water. (SAQ 13.5)

13.6 Describe the barriers to the provision of safe water. (SAQ 13.6)

13.1 The public health importance of water

We begin this study session by describing the public health significance of water. A satisfactory water supply must be available to all humans. By 'satisfactory' we mean water must be available in adequate quantity, be safe to drink and be accessible. Improving access to safe drinking water can result in tangible benefits to health so every effort should be made to achieve drinking water quality that is as safe as is practicably possible.

The great majority of water-related health problems are the result of microbial (bacteriological, viral, protozoan or other biological) contamination. Infectious waterborne diseases such as diarrhoea, typhoid and cholera are leading causes of death and illness in the developing world. There are many diseases associated with water, which can be classified as waterborne, water-washed, water-based and water-related (Box 13.1).

Box 13.1 Diseases associated with water

Several terms are used to describe the types of disease associated with water. These are:

- **Waterborne diseases** are those caused by ingestion of water that is contaminated by human or animal excrement and contains pathogenic microorganisms. Transmission occurs by drinking contaminated water. Waterborne diseases include most of the enteric and diarrhoeal diseases caused by bacteria and viruses, including cholera, typhoid and bacillary dysentery. They also include diseases caused by protozoa (single-celled microorganisms) such as giardiasis, amoebic dysentery and cryptosporidiosis.
- **Water-washed diseases** are caused by poor personal hygiene, and skin and eye contact with contaminated water. They are also sometimes known as water-scarce diseases because they occur when there is not enough water available for adequate personal washing. They include scabies, trachoma, typhus, and other flea, lice and tick-borne diseases.
- **Water-based diseases** are caused by parasites that spend part of their lifecycle in water. For example, schistosomiasis and dracunculiasis are both water-based diseases caused by helminths (parasitic worms). Schistosomiasis (also known as bilharzia) is caused by a worm that spends part of its lifecycle in the body of a particular species of water snail. People can become infected from swimming or wading in infected water. Dracunculiasis or guinea worm is transmitted by drinking water that is contaminated with copepods (very small crustaceans) that contain the larvae of the worm.
- **Water-related diseases** are caused by insect vectors, especially mosquitoes, that breed or feed near water. They are not typically associated with lack of access to clean drinking water or sanitation services. Water-related diseases include dengue fever, filariasis, malaria, onchocerciasis, trypanosomiasis and yellow fever.

Note that, rather confusingly, the term 'water-related' is sometimes used to mean all the above, i.e. all diseases associated with water.

Chemical contamination of water is another potential cause of health problems. In some places, water may contain naturally occurring toxic chemicals such as arsenic and fluoride. Other chemicals may get into the water supply because of pollution. Lead poisoning, for example, can result from water contaminated with lead. These diseases are also classified as waterborne diseases.

Safe water is water which is free from disease-causing agents and does not have any significant risk to health over a lifetime of consumption. The term **potable water** is also sometimes used; 'potable' means safe to drink. A related but different term is **palatable water**, which means water that is pleasant to drink. Palatable water is at a desirable temperature, completely transparent and free from tastes, odours and colours, but is not necessarily free from disease-causing agents. Safe drinking water is suitable for all usual domestic purposes, including personal hygiene. Access to safe and affordable water is considered to be a basic human right.

Many million individuals in Ethiopia have to get their water from unsafe sources and this makes them vulnerable to waterborne disease. Figure 13.1 shows the relative proportions of people in Ethiopia with access to improved and unimproved sources (see also Box 13.2).

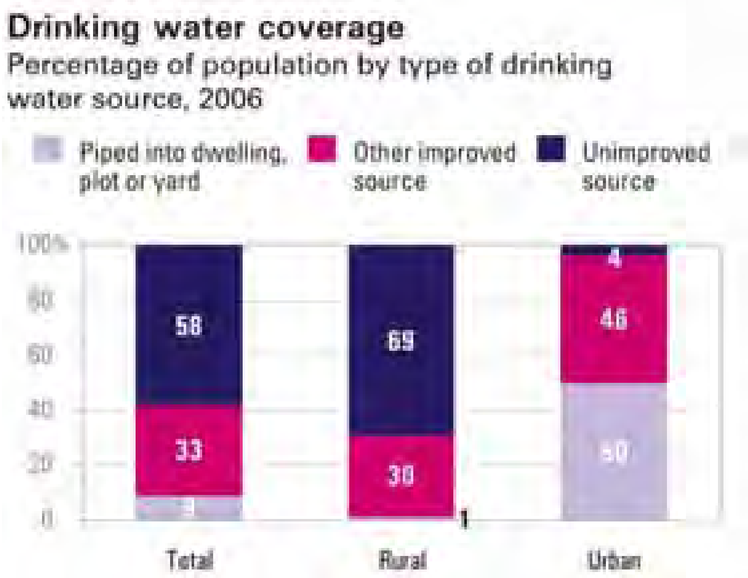


Figure 13.1 Drinking water sources for the population of Ethiopia. (Source: WHO/UNICEF JMP, 2008)

- ■ Look at the bar graph in Figure 13.1. What proportion of the rural population in Ethiopia obtains their water from unimproved sources? And what proportion of the urban population?
- □ 69% of the rural population and 4% of the urban population get their water from unimproved sources.

Box 13.2 Water sources

Water source simply means water in its natural environment that is used by people to meet their need for water. Common water sources are groundwater, surface water such as rivers and lakes, spring water, and rainwater.

Water sources can be described as protected or unprotected. **Unprotected sources** are those where there is no barrier or other structure to protect the water from contamination. **Protected sources**, on the other hand, are covered by stonework, cement or other material that prevents the entry of any physical, chemical or biological contaminant. Water from a protected source is likely to be safe to drink but water from unprotected sources cannot be considered safe.

The terms *improved* and *unimproved* sources may also be used, as in Figure 13.1. These terms are broadly equivalent to *protected* and *unprotected*. Improved drinking water sources include household connections, public standpipes and water points, boreholes, protected dug wells, protected springs and rainwater collections. Unimproved water sources include rivers, lakes, unprotected wells and unprotected springs.

- Using the data in Figure 13.1, in general terms, what *fraction* of the rural Ethiopian population uses an unimproved water source?

- 69% of rural people use an unimproved water source. This is roughly equivalent to two-thirds of the population (two-thirds equals 66.7%).

The provision of safe water and sanitation is not only essential for disease prevention, it is also a key mechanism required to break the cycle of poverty, particularly for women and girls. Lack of access to water may limit the use of latrines because the need for handwashing creates an additional water requirement and therefore an additional burden on the person responsible for collecting water. With improved access to safe water, women and girls have more time to tend to crops and livestock, more time and resources to spend on improved food preparation, more time to attend school, and an opportunity to participate in the local economy. These are all mechanisms for breaking the cycle of poverty.

13.2 The uses of safe water

13.2.1 For drinking

All individuals need water for drinking every day. Inadequate consumption of water, either by drinking or through food, can lead to dehydration of the body and ultimately to death. The water requirement of individuals for drinking and food preparation will vary according to diet, climate and the type of work they do. Pregnant women and breastfeeding mothers need more water than other people. The minimum amount of water needed for survival ranges from about 2 litres **per capita** per day in temperate climates to about 4.5 litres for people in hot climates who have to carry out manual work.

Per capita means per person or per head of population

13.2.2 For food preparation and cooking

Water is an ingredient of many foodstuffs and is also needed for food hygiene to make certain that food is safe to eat. Most people need at least 2 litres of safe water per day for food preparation.

13.2.3 For hygiene

Providing safe water and encouraging people to practise good hygiene will achieve massive health benefits. For example, the *Shigella* bacterium causes dysentery or bloody diarrhoea and it is a major contributor to the millions of water-related deaths each year. However, the simple step of washing hands with soap and water will significantly reduce shigellosis and other diarrhoeal diseases. Moreover, providing clean water for washing can prevent trachoma, which is the leading cause of preventable blindness.

- Why is hand hygiene so important for reducing communicable diseases?

- Our hands can be soiled by many different contaminants, for example, while visiting a toilet, during farming activities, cleaning children's bottoms and so on; hence washing hands with soap and water is very important.

13.3 The hydrological cycle

Water is in plentiful supply on our planet but most of it is not available for human use. Over 97% of the world's water is in the oceans and is salty. Fresh water, found in rivers, lakes and within the ground, accounts for less than 1% of the total (Figure 13.2). It is not distributed evenly around the world. There is a surplus in some places and scarcity in others.

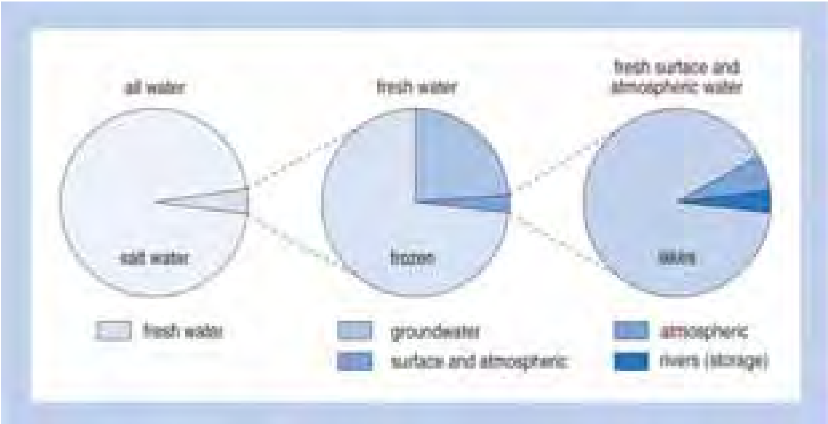


Figure 13.2 Components of world water storage. The sizes of the segments in the circles represent the relative volumes of water in each category.
(Source: The Open University)

Water is in continuous motion in a series of processes called the **hydrological cycle** or **water cycle** that governs the health of the planet. (Hydrology is the study of water, hence the alternative name for the water cycle.) Figure 13.3 shows a diagram of the water cycle. Without continuous evaporation from the oceans, precipitation on land and runoff back to the oceans, there would be no recharge (replacement) of surface and groundwater.

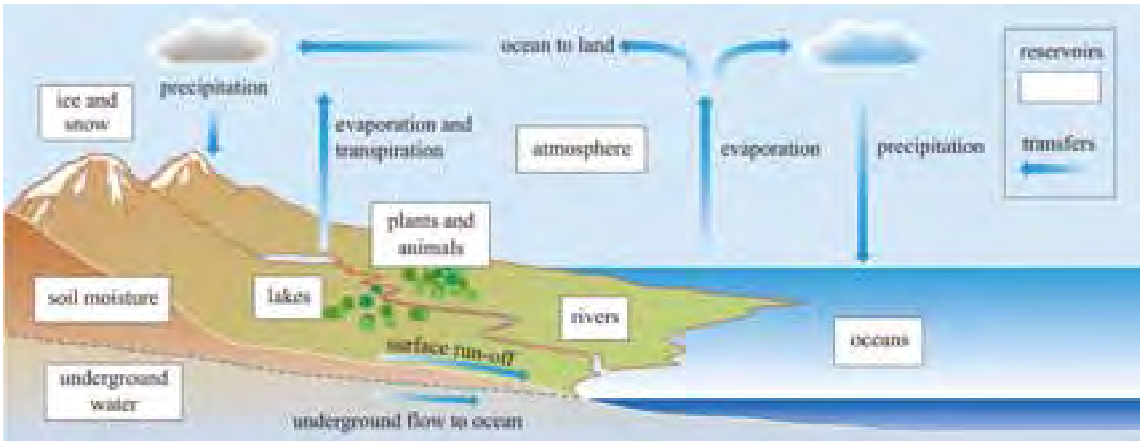


Figure 13.3 The hydrological cycle. (Source: The Open University)

There are several important terms here that need explanation. **Evaporation** is the change from a liquid to a gas. When the sun shines on the surface of water, water molecules evaporate from the water body into the atmosphere above. **Precipitation** simply means water falling from the atmosphere to the Earth's surface; mostly this means rain, although it also includes snow. **Runoff** includes all water that flows, under the force of gravity, across land in streams and rivers and across the surface, for example, of a field. **Groundwater** includes all water that is found underground within the rocks; some groundwater may be near the surface and some may be deep underground.

In Figure 13.3, the transfers (the movements or flows) of water are shown as arrows and the reservoirs (stores) as boxes. Note that the word 'reservoirs', in general speech, refers to artificial lakes that have been constructed to store water at the surface. In the context of the water cycle and hydrology, **reservoir** means all stores of water. Another term included in Figure 13.3 is **transpiration**, which is the release of water vapour (water as a gas) from plants and soils into the atmosphere. Evaporation and transpiration are sometimes referred to together as *evapotranspiration*.

13.4 Criteria for satisfactory water

■ What are the three main criteria for 'satisfactory' water supply?

□ Satisfactory water means water that is available in adequate quantity, is safe to drink and is accessible.

Human beings have a right to have clean, safe water. Several criteria need to be satisfied to ensure that the people in your community have satisfactory access to water. These are discussed below.

13.4.1 Sufficient quantity

According to international and national guidelines, the quantity of water available in each household should be 50–100 litres per person per day, or an absolute minimum of 20 litres. In practice, the amount of water collected every day by households is considerably less than this and is largely determined by the distance of the source of water from the home. If the water source is outside the home, but within around 1 kilometre (or 30 minutes total collection time), about 20 litres per person per day will typically be collected.

Where water is supplied through a single tap within the confines of the household's living area, the water used is typically about 50 litres per person per day. At this level it is much easier to ensure good hygiene. For example, households may use 30 times more water for child hygiene compared with those who have to collect water from a communal source. Households that do not have to travel to collect water have more time for economic activity, food preparation, child care and education. Having access to a greater volume of water potentially encourages handwashing, general physical cleanliness and improved living conditions.

13.4.2 Safe and acceptable

Water must be safe for drinking and other household uses. Drinking water must be free from microbes and parasites, and free from chemical and physical contaminants that constitute a danger to a person's health. It must also be acceptable in terms of colour and odour.

■ The two photos in Figure 13.4 were taken at the same place. Do you think that water from the river in Figure 13.4 would be safe to drink? Is this an example of a protected or unprotected source?

□ This river is likely to be contaminated with animal dung, urine and possibly other pollutants. It is not advisable to use this water for drinking and cooking without any treatment. The river is an unprotected source; there is nothing to protect the water from contamination.

Figure 13.4 Animals come to the river to drink at the same place as the women collect the water. (Photos: Nancy Platt, Pam Furniss)

13.4.3 Physically accessible

Water must be within safe physical reach, in or near the house, school or health facility. Accessibility to safe water can be classified as follows:

No access. You would say people do not have access to safe water when:

- The distance to the water source is more than one kilometre or more than a 30-minute round trip.
- The amount of water collected is very low (often below 5 litres per capita per day).

Basic access (see Figure 13.5). You would say people have a basic level of access to safe water when:

- The water source is within one kilometre/30-minute round trip.
- The amount of water to be collected on average is unlikely to exceed 20 litres per capita per day.

Figure 13.5 Public water point – an example of basic access, assuming the user lives within one kilometre distance. (Photo: Pam Furniss)

Intermediate access (see Figure 13.6). You would say people have an intermediate level of access to safe water when:

- Water is provided onsite through at least one tap (at yard level).
- Average volume of water collected is approximately 50 litres per capita per day.

Figure 13.6 Provision of safe water for a household with a single tap – an example of intermediate access. (Photo: Richard Adam)

Optimal access. You would say people have optimal access to safe water when:

- Supply of water is through multiple taps within the house.
- Approximately 100–200 litres per capita per day or more is available.

■ Earlier in this session it was said that the daily minimum water requirement was between 2 and 4.5 litres per person per day according to climate conditions. Why does this differ from any of the average consumption figures quoted above?

□ Because the average consumption refers to water used for all household purposes including washing, cooking and cleaning as well as drinking and eating. The requirement of 2 to 4.5 litres per person per day is the volume of water that must be *consumed* by a person to survive.

13.4.4 Affordable

As well as being physically accessible, water should also be reasonably priced and affordable for everyone. Buying water should not reduce a person's capacity to buy other essential goods. This means that essential amounts of water must sometimes be provided free according to the socioeconomic strength of the communities. Ensuring the affordability of water requires that services match what people can pay. For example, in most rural communities of Ethiopia protected water sources are freely provided by the government and other organisations.

13.5 Vulnerability due to lack of satisfactory water provision

As you know, the poor are among those most directly affected by unsafe water. They are not only less likely to have access to safe water and sanitation, but they are also less likely to have the financial and human resources to manage the impact of this deficiency. The majority of those who have no access to improved sources of drinking water are the rural poor. This lack of access is reflected in the day-to-day investment of time to collect water which means that women, in particular, do not have time for productive activity, for household tasks, for childcare or for education.

As well as the dangers arising from using water from unprotected sources, women's health may also be affected by the heavy burden of carrying water because carrying heavy loads may cause spinal injuries. Furthermore, women who collect water may be physically attacked while performing this task. Women also suffer from the lack of appropriate sanitation facilities. When there is little privacy or security for them, women and girls have to go into an inappropriate location where they may risk being attacked. Water facilities and services must be culturally appropriate and sensitive to gender, and privacy requirements.

Infants and children are particularly vulnerable to the lack of safe water provision. Lack of accessible safe water increases their vulnerability to diseases. Their immune systems are not fully developed and may not be able to respond to a water-related infection. They also have less body mass than adults, which means that a waterborne chemical may be dangerous for a child at a concentration that is relatively harmless for an adult. Children often share with women the responsibility for fetching water. This means they may miss school and it can affect their health and put them, especially girls, at risk of harassment. Other groups who may be more vulnerable to a lack of safe water include people who are ill or debilitated in some way because their immune system may already be weakened. The elderly may also be at greater risk.

13.6 Future impacts on provision of water

13.6.1 Population dynamics

Rapid population growth puts increasing pressure on our limited resources. The percentage of young children is increasing within the Ethiopian population. In 2007, a Central Statistics Agency report estimated the Ethiopian population as 73 million, of whom about half are under 15 years of age. This means an increase in the proportion of the total population at highest risk from infectious waterborne diseases (gastrointestinal illnesses disproportionately affect the health of the very young and very old).

The general increase in population means that more and more land is brought into use to support the growing number of people. This can have a serious impact on the environment and also on water resources. There is a close relationship between land use, and water quality and quantity. If land is cleared of natural vegetation, water will run off the surface more quickly and will not soak into the soil. This not only reduces the amount of soil water available for plant growth it also reduces replenishment of groundwater reservoirs. The water flows off into rivers before it has penetrated into the ground. The increased runoff resulting from loss of vegetation also causes soil erosion, especially in the rainy season, because the soil is washed away into the rivers. Erosion is especially likely on slopes and where the ground is ploughed, which loosens the surface layers. The eroded soil particles run off into the rivers and make the water very turbid (muddy). The loss of natural vegetation, especially forest, also means a loss of biodiversity, i.e. a reduction in the number of different types of living organisms of all types that exist in an area.

13.6.2 Poverty

Poverty is a major cause of public health problems in Ethiopia. Although we hope this will change, in reality it is likely that poverty will be a problem in the future as well. Poverty makes it difficult for people to access safe water and find solutions for the sanitation problems in the country. Lack of resources, lack of education and limited political, social and economic influence all have a significant impact on the provision of safe water.

13.6.3 Climate change

Climate change is the name given to the long-term change in global weather patterns caused by human activities. It is a global problem and its effects may not be easy to see at a local level. However, it may have an increasingly important impact on the future provision of safe water and therefore on human health and safety. The effects of climate change could include more frequent and intense rainfall events that can mobilise disease-causing organisms and other contaminants. It could also mean increased frequency and magnitude of flood events which would affect the availability of clean water. On the other hand, it could also mean reduced rainfall. Climate change could have profound impacts on the burden of illness associated with waterborne diseases. Increasing water shortage will lead to an increase in sickness and death amongst the populations of developing countries. In Ethiopia, although it is difficult to make exact estimates of the impacts of climate change, declining rainfall could lead to reduced water sources and depleted groundwater, climate sensitive disease could increase, and food insecurity could become an increasing problem.

13.6.4 Globalisation

Today’s world is becoming a big village in which people are increasingly mobile and goods and materials are transported further and faster. Globalisation has both advantages and disadvantages. Infectious and vector-borne diseases associated with water are moving from place to place in a shorter time, and pathogens and vectors can also travel around the globe.

13.7 Major barriers to the provision of safe water

Capacity and finance are the main factors that prevent the effective provision of water. *Capacity*, in this context, means having the ability to do something. It can be described in terms of the human, technological, infrastructural, institutional and managerial resources required at all levels from the individual through to national governance. Capacities have to be built within each of these levels and they should be institutionalised, meaning formal organisational structures will be needed to bring about effective change. Individuals and groups of people can act together informally but this is less likely to succeed. Local communities need to be empowered to build their capacity and use infrastructure effectively, or the provision of safe water will be difficult.

13.7.1 Lack of community capacity and engagement

Engagement of local people is essential for finding sustainable solutions and increasing the chances of long-term success. People need to be made aware of the possibilities and have the autonomy to create their own favourable conditions within the community. For example, they need to identify their own problems, prioritise them and put forward their own solutions. Considering cultural and societal norms of the community, the involvement of influential people, and the collaboration of local institutions and organisations are important. The participation of women is especially important to improve the success of project outcomes.

13.7.2 Lack of technological capacity

Technological capacity includes both existing and new technologies. The provision of water and sanitation could be significantly improved with the wider application of existing technologies, if other constraints could be overcome. These benefits could be extended even further with the development and application of new technologies that help specifically with the provision of safe water at household and community level. These technologies need to be user-friendly and designed so it is easy to understand how they should be effectively constructed, operated and managed.

13.7.3 Lack of institutional capacity

Collaboration between different sectors of the population is required to plan and implement actions in a coordinated way. For example, the health sector, agricultural sector and local administrators should all work together. This collaboration is the basis for multi-sectoral approaches to ensure that planned goals are achieved to solve environmental, water and health problems.

13.7.4 Insufficient financing

A lack of global investment in water and sanitation has limited the attainment of the Millennium Development Goals (MDGs). The United Nations MDGs, set in 2000, consist of eight goals for international development. Goal 7 is to 'ensure environmental sustainability' and within that, target 7c is to 'halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation'.

Good progress has already been made towards meeting this goal in some parts of the world but there is still a long way to go, especially in sub-Saharan Africa. Water and sanitation continue to suffer from severe underfunding. At a local level, the potential sources of finance are government, non-governmental organisations and others. You can try to make a difference firstly by understanding who these different potential sources of funds are and then working with your colleagues and others in the community to seek financial support.

Summary of Study Session 13

In Study Session 13, you have learned that:

1. Water is essential to sustain life and a satisfactory (adequate, safe and accessible) water supply must be available to all human beings.
2. Waterborne, water-washed, water-based and water-related diseases are the four main types of disease associated with water.
3. Water is in continuous motion by the processes of the hydrological cycle.
4. Improved access to clean water can reduce diarrhoea and waterborne diseases. The provision of safe water and sanitation is a key mechanism required to break the cycle of poverty, particularly for women and girls.
5. Sufficient, physically accessible, affordable and safe water are the main criteria for measuring whether your locality has satisfactory water provision or not.
6. Your local community's access to water can be assessed as no access to water, basic access, intermediate access or optimal access.
7. The poor, women and children, and people who are sick or elderly are more vulnerable to lack of safe, adequate and accessible water.
8. Rapid population growth, poverty, climate change and globalisation are likely to have negative impacts on the provision of safe, adequate and accessible water.
9. Capacity and finance are the major barriers that inhibit the enhancement of provision of safe, adequate, affordable and accessible water supply.

Self-Assessment Questions (SAQs) for Study Session 13

Now that you have completed this study session, you can assess how well you have achieved its Learning Outcomes by answering these questions. Write your answers in your Study Diary and discuss them with your Tutor at the next Study Support Meeting. You can check your answers with the Notes on the Self-Assessment Questions at the end of this Module.

SAQ 13.1 (tests Learning Outcome 13.1)

Match the words in list A with the definitions in list B by drawing an arrow between them.

A	**B**
Accessible	Provision of water without payment or at a low price
Safe	Water free from disease-causing organisms or contaminants
Affordable	A minimum of 20 litres per person per day
Adequate	The source of water is near to one's house

SAQ 13.2 (tests Learning Outcome 13.2)

Which of the following statements is *false*? In each case, explain why it is incorrect.

A Water-washed diseases are caused by drinking water that has been contaminated with pathogens.
B Diarrhoea and typhoid fever are diseases that occur when water is scarce.
C Children may become infected with bilharzia if they swim and play in lakes where there are many snails.
D Malaria is an example of a waterborne disease.

SAQ 13.3 (tests Learning Outcomes 13.1 and 13.3)

Rewrite the paragraph below using terms from the list provided to fill the gaps.

The terms to use are: atmosphere; evaporation; hydrological cycle; ocean; precipitation; surface runoff; transpiration.

Water on the Earth's surface moves in an unceasing cycle through rivers, oceans, clouds and rain called the _______________. The heat from the Sun causes ______________ of water, principally from the ____________ and also from lakes and wetlands on land. Plants also lose water through their leaves by the process of _____________. Water vapour in the _____________ forms into clouds which are moved around by wind. Rain and snow, collectively known as ___________, fall from the clouds. Some water that falls on land soaks into the ground and some collects into streams and rivers which form _______________ that flows back to the ocean to complete the cycle.

SAQ 13.4 (tests Learning Outcome13.4)

Suppose you are working in a village and you want to assess whether the village has satisfactory access to water. Name three things you would need to find out about.

SAQ 13.5 (tests Learning Outcome 13.5)

Suppose you are working in a village where sources of water are inaccessible and people walk a long distance to fetch water. This means that clean water is in short supply in the village. As a Health Extension Practitioner you need to identify the most vulnerable individuals in order to ensure they have sufficient clean water. Which members of the community would you include in your list?

SAQ 13.6 (tests Learning Outcome 13.6)

Which of the following statements is *false*? In each case, explain why it is incorrect.

A Community empowerment has no input in provision of safe water.

B New technologies can help to overcome the barriers to the provision of safe water.

C Local government should not be involved in finding sustainable solutions for provision of safe water.

D Provision of safe water improves the lives of infants and children.

Study Session 14 Treatment of Drinking Water at Household and Community Level

Introduction

Water has always played a prominent role in human civilisation. Water was, and continues to be, needed for drinking, preparing food, bathing, cleaning, irrigating crops and a variety of other tasks. Having ready access to water, therefore, has always been important. However, the water sources used for supplying water were not always clean. Treating drinking water to improve smell and taste and to remove disease-causing organisms has been necessary throughout human history.

Water must look and taste clean, i.e. have eye appeal and taste appeal, if we are going to want to drink it, and it must also be safe to drink. Water is the breeding ground for an unbelievably large variety of organisms that get into water through a variety of routes. Microbial contamination is the most common and widespread health risk associated with drinking water; therefore treatment of water to eliminate pathogenic microbes is of vital importance. In this study session, you will learn about the public health significance of water treatment, the characteristics of raw (untreated) water that determine the treatment methods, types of household/community–based water treatment and a selection of treatment processes.

Learning Outcomes for Study Session 14

When you have studied this session, you should be able to:

14.1 Define and use correctly all of the key words printed in **bold**. (SAQs 14.1 and 14.5)

14.2 Explain the purpose of water treatment at household, community and municipality levels. (SAQ 14.2)

14.3 Describe the methods of water treatment at household and community levels. (SAQs 14.3 and 14.4)

14.4 List the stages of large-scale (municipal) water treatment. (SAQ 14.5)

14.1 Waterborne diseases

Diarrhoea, infectious hepatitis, typhoid and paratyphoid enteric fever are all examples of waterborne diseases that are common problems in our country. These are all caused by microbial contamination. Lead poisoning and fluorosis, caused by chemical contamination, are also classified as waterborne diseases.

- ■ What distinguishes waterborne diseases from other types of disease associated with water?
- □ Waterborne diseases are caused by *consumption* of water that has been contaminated by human or animal wastes, or chemicals. Other types of disease may be caused by external contact (water-based), or infection by an insect vector (water-related), or by limited availability of water for washing (water-washed).

Waterborne diseases can also be classified in a different way as either acute (short-lived) or chronic (long-lasting). **Acute health effects** occur when the levels of some contaminants in drinking water are high enough to cause acute (immediate) health effects within hours or days of consumption, for example, vomiting. **Chronic health effects** occur after long-term exposure to a contaminant that may be present only in small amounts. Examples of chronic health effects are liver and kidney damage.

14.1.1 Causes of waterborne disease outbreaks

There are a lot of possible causes for an outbreak of waterborne disease. The use of untreated spring water and surface water, and inadequately or interrupted disinfection of surface water, spring water and well water may all be responsible. These are all causes associated with the source of water but other problems can arise at points in the system after the source. For example, cross-connections of pipework, contamination of water in the household, contamination during the construction of water source protection, contamination of storage facilities including private storage tanks are all contributors. Consumption of water that was not intended for drinking, contaminated bottled water and ingestion of water while swimming are also possible causes.

14.2 Water treatment

The purpose of **water treatment** is to reduce or remove all contaminants that are present in the water and to improve water quality so that it is completely safe to drink. Water is unlikely to be completely free of contaminants at the original source. The types of water treatment processes depend on the characteristics of the **raw water** (untreated water direct from its source) and required water quality standards. Suspended solids, bacteria, algae, viruses, fungi, minerals such as iron and manganese, and fertilisers are among the substances that are removed during water treatment. (**Suspended solids** are tiny particles of solid material that are carried along or suspended in the water.) Effective treatment should ensure the removal of all disease-causing agents and so reduce the possibility of the outbreak of waterborne disease.

Water treatment systems can be categorised as small-scale water treatment, which includes community and household treatment methods, or large-scale water treatment that might be found in towns and cities.

14.3 Small-scale water treatment systems

Household- and community-level treatment systems are the methods most likely to be used in rural areas.

Household-level water treatment is appropriate when:

- A relatively small amount of water is obtained from a well or spring and is collected and transported by hand.
- The source is contaminated and simple protective measures can neither improve water quality nor stop the contamination.
- Community resources are inadequate to meet the cost of a simple community treatment system and make it difficult to develop a centralised treatment system.

- An emergency situation causes disruption of the service and contamination of the water supply so that a long-term rapid solution is needed.

Community-level water treatment is appropriate when:

- A water source serves a larger population than can be served by household level or individual treatment systems.
- A community water source is contaminated and simple protective measures can neither improve water quality nor stop the contamination.
- Community resources are adequate to cover the cost of construction, operation and maintenance of a simple community-level treatment system.

There are several different methods of small-scale water treatment that can be employed at the household and community level. Broadly speaking these can be grouped either as **filtration** methods, in which water passes through a porous barrier (filter) that traps tiny particles including pathogenic microorganisms and other impurities, and **disinfection** methods, in which contaminants are removed by the use of various chemicals or by energy from the sun.

14.3.1 Household sand filter

Household filters are an attractive option for household treatment because these filters can usually be made from locally available and inexpensive materials like clay pots or barrels. They are simple and easy to use. The upper pot contains layers of sand and gravel. Water is poured in at the top and, as it passes through the layers of sand, any particles within it are filtered out. The thickness of the layers should be approximately 5 cm of gravel, 5 cm of coarse sand and 10 cm of fine sand. The bottom of the upper pot should be perforated (have tiny holes in it) so the clean water can drip into the lower pot. The lower pot should have a tap (faucet) to draw off the clean water easily (see Figure 14.1). The sand and gravel should be changed when the rate of filtration starts to slow; at minimum it should be changed every two or three months.

Figure 14.1 Household water filter using two clay pots placed on top of each other.

14.3.2 Cloth filtration

Cloth filtration is a common water treatment technique that is easy to use and inexpensive (Figure 14.2). Cloth filtration can be very effective against cholera, guinea worm (dracunculiasis) and other disease-causing agents. By following the procedures and practice yourself, you can demonstrate this for communities you are working with. The steps in cloth filtration are:

- Use a large cloth, preferably made of finely-woven cotton. The cloth must be big enough to easily cover the opening of the container once it has been folded.

Figure 14.2 Cloth filtration. (Source: International Federation of Red Cross and Red Crescent Societies, 2008, *Household water treatment and safe storage in emergencies*)

- Fold the cloth at least four times so there are multiple layers of fabric and place this over the opening of the storage vessel.
- Fasten the cloth securely around the rim of the opening and tighten the string. If reusing the cloth, always use the same side up each time.
- Filter all water immediately at source as it is being collected.
- Always keep filtered water separated from non-filtered water.
- Rinse the filter cloth after each use, with a final rinse using cloth-filtered water, and then leave the cloth in the sun until it is dry.
- Clean the cloth regularly using soap and replace it as soon as there are any visible tears or holes.

14.3.3 Other filtration methods

There are other filtration methods such as ceramic filters and biosand filters that are not currently widely used in Ethiopia but are also appropriate for household and community use.

Micron is another name for the micrometre–which is one millionth of a metre, i.e. a thousandth of a millimetre.

Ceramic filters of various types have been used for water treatment throughout the world. The majority of bacteria are removed mechanically through the filter's very small (0.6–3.0 microns) pores. Ceramic filters are easy to use, relatively low cost and have a long life if the filter remains unbroken. They are good for reduction of bacteria and protozoa but lack residual protection so recontamination is possible.

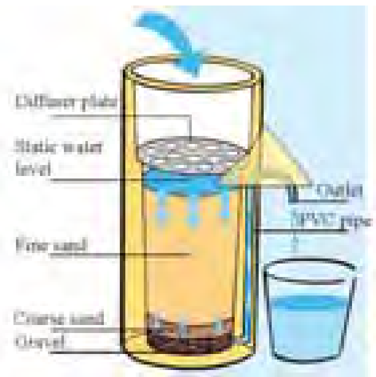


Figure 14.3 Biosand filter. (Source: as Figure 14.2)

Biosand filters differ from the other types of filter described above in that they make use of biological activity as well the mechanical filtering of particles. The most widely used version of the biosand filter is a concrete container about one metre in height and filled with sand (Figure 14.3). The container is filled with water so the water level is above the sand layer. The water allows a 'bioactive' layer to grow on top of the sand. This bioactive layer consists of algae, plankton and other microscopic plant life that helps reduce disease-causing organisms, particularly protozoa and bacteria. The biosand filter is fairly easy to use, can be produced from locally available materials, needs little maintenance and has a long life but it has a high initial cost and is difficult to transport. It will improve the look and taste of the water and is good for removing protozoa but has a low rate of virus inactivation and does not remove 100% of bacteria so recontamination is possible.

14.3.4 Solar disinfection

Solar disinfection, also known as SODIS, relies on energy from the sun to kill pathogenic organisms, especially bacteria. Ultraviolet light from the sun is an effective bactericide for water.

Turbidity is a measure of the cloudiness of water. It is caused by very small particles (suspended solids) that are individually too small to see with the naked eye.

This simple technique requires only a few plastic bottles and sunlight. Firstly, collect several bottles (0.3 to 2.0 litre) made of clear plastic, remove all labels and wash them thoroughly. Fill the bottles with water of low **turbidity** and shake for about 20 seconds to aerate the water. Expose the bottles to the sun by placing them on a roof or rack for at least six hours (if sunny) or two days (if cloudy) (see Figures 14.4 and 14.5). The water is now ready to drink.

Figure 14.4 Solar disinfection. (Photo: Eawag)

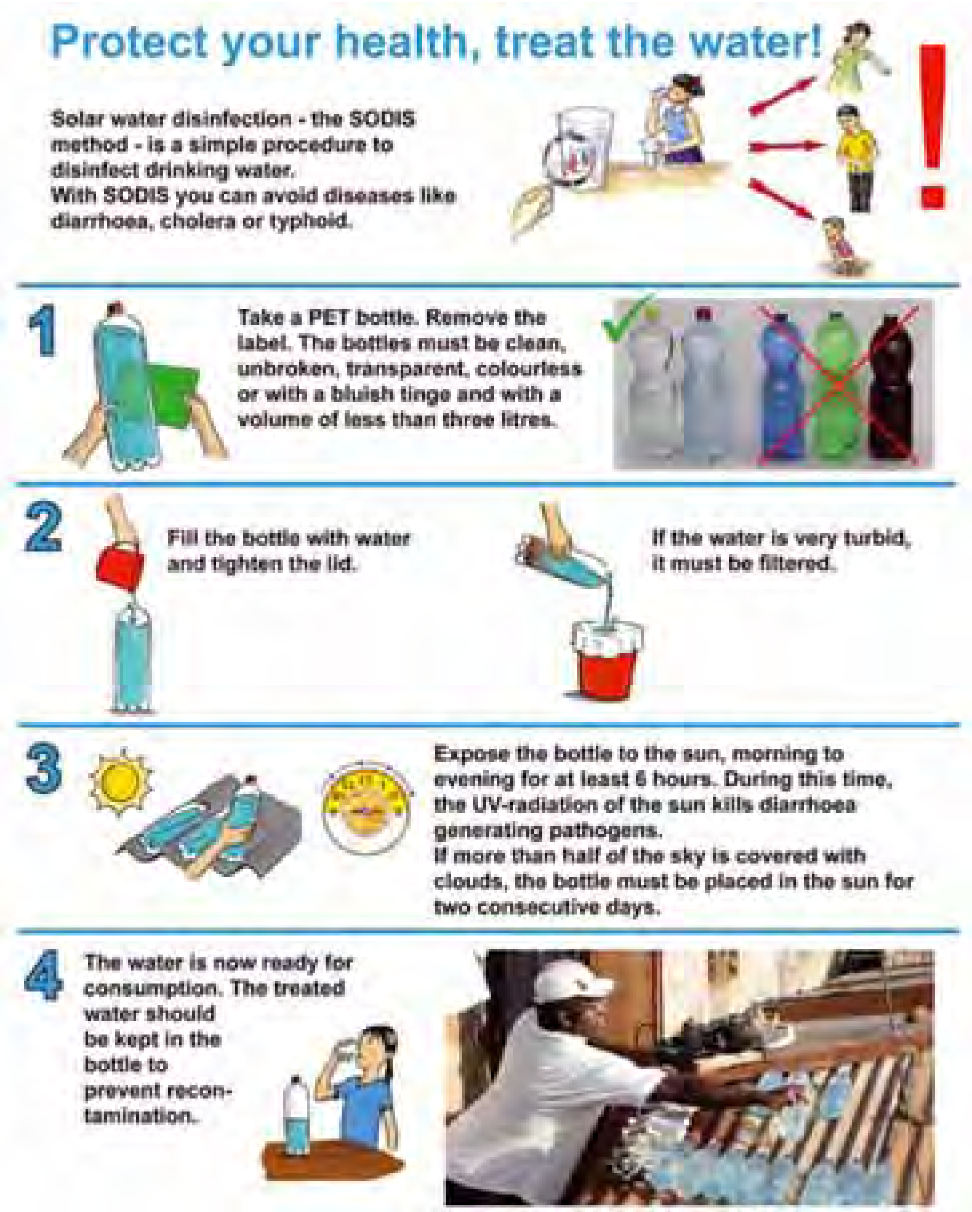


Figure 14.5 The SODIS method of water treatment. (Source: Eawag)

The *benefits* of solar disinfection include:

- proven reduction of bacteria, viruses and protozoa
- acceptability to users because of the minimal cost to treat water, ease of use and minimal change in water taste
- unlikely recontamination because water is consumed directly from the small, narrow-necked bottles (with caps) in which it is treated.

The *drawbacks* include:

- requires relatively clear water (if the water is too cloudy it has to be filtered first)
- only a limited volume of water can be treated at one time
- the length of time required to treat it.

14.3.5 Chemical disinfection methods

There are several commercially available products designed for treating water at household level.

Chlorine solution

Contact time is the amount of time that elapses when two substances are mixed. Chlorine contact time means the time between the introduction of chlorine and using the water.

Chlorine solution, also known as sodium hypochlorite solution or bleach, is the most affordable, easiest to produce, and most widely available chemical for household water treatment. It is supplied in bottles and has easily interpretable instructions for use on the side of the bottle. Typically, the procedure is to add a capful of chlorine solution to a 25 litre water storage container, then shake and wait for 30 minutes **chlorine contact time** before drinking. Double dosing is advisable if the water is visibly dirty.

Aquatabs

Aquatabs are a specifically formulated and branded solid form of sodium dichloroisocyanurate (NaDCC) (see Figure 14.6). NaDCC is stable in Aquatabs form as a solid which gives it a longer shelf life and makes storage, handling and transport much easier than with liquid bleach. One Aquatab contains 67 mg of NaDCC and treats 20 litres of clear water. For visibly turbid water, two tablets per 20 litres are needed. It is very important to mix well and leave for 30 minutes contact time before consumption.

PUR

'PUR Purifier of Water' is the brand name of a combined *flocculant* and disinfectant product produced by Procter and Gamble (Figure 14.7). It is now on the market in Ethiopia although it may not be widely available across the country. PUR can be used to treat raw source waters with a wide range of turbidity and pathogen load. This water treatment chemical allows flocculation to take place and helps to remove *Giardia* and *Cryptosporidium* cysts that are resistant to chlorine disinfection. (A *cyst* is a dormant stage in the life cycle of some protozoa and bacteria that is resistant to adverse environmental conditions and therefore difficult to destroy.) PUR comes in sachets with one sachet needed to treat 10 litres of water.

Flocculation is a process in which suspended solids are removed from water and turbidity is reduced. The solid particles lump together to form 'flocs' which slowly settle to the bottom of the container. A flocculant is a substance that can be added to water to encourage this process.

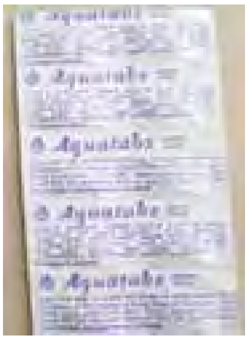


Figure 14.6 Aquatabs tablets for household water treatment. (Photo: Abera Kumie)

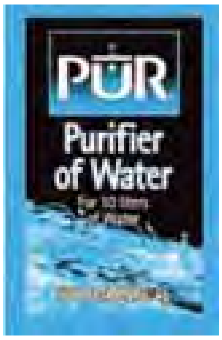


Figure 14.7 PUR Purifier of water. (Source: as Figure 14.2)

Wuha Agar

Wuha Agar is a chlorine-based water treatment solution that is used in Ethiopia (Figure 14.8). The procedure is very similar to other chemical treatment methods. For a 20 litre jerrycan, add one capful of Wuha Agar, cover and shake. After 30 minutes contact time you can use it.

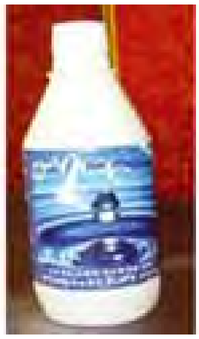


Figure 14.8 Wuha Agar for household water treatment. (Photo: Abera Kumie)

14.3.6 Boiling

Boiling is also an optional water treatment at household level. Boiling is a simple way of killing any ova (eggs), cysts, bacteria and viruses present in contaminated water. Water should be heated until large bubbles are continuously coming to the surface of the water. The disadvantage of boiling as a treatment method is that it requires large amounts of fuel, so cost may prevent people from using this method. Also, boiling may give an unpleasant taste to the water, which may be unacceptable, and very hot water can cause accidents in the home. Boiled water can become recontaminated once it has cooled.

14.4 Safe storage

Whatever type of treatment method is used, it is essential that water is stored safely and hygienically. Even if water has come from an improved source, this will not guarantee that it is safe because contamination can occur in the household due to poor storage and handling practices. The principal health risk associated with household water storage is the ease of recontamination, particularly where the members of a family or community do not all follow good hygiene practice. Safe storage is especially designed to eliminate sources of recontamination by keeping objects, including hands, out of the system.

Figure 14.9 Safe storage containers.

- ■ What is it about the two containers shown in Figure 14.9 that make them safe for storing water?
- □ They both have lids which prevent dust and insects from falling in the water and they both have taps so people can take water without removing the lid or dipping their hands or a smaller container, which may be dirty, into the water.

It is important to recognise that unsafe water is not made safe just by using safe storage methods. Safe storage helps to ensure that post-treatment recontamination does not occur within the household.

14.5 Large-scale water treatment

Large-scale or municipal water treatment is not common in rural communities but you may find it in larger towns and cities where there is a network of pipes and pumps to distribute water from the treatment works. There are several steps in municipal water treatment intended to remove solids, kill pathogenic organisms and make water safe to drink. The main stages are usually aeration, sedimentation, coagulation, filtration and disinfection.

Aeration simply means to mix air with the water. It is used to remove volatile (easily evaporated) substances from drinking water. Air and water are put into contact with each other, i.e. air is bubbled through the water, so that the volatile substances are evaporated into the airstream and removed from the water. Aeration can be carried out in towers or aeration basins to provide the necessary contact time between air and water. **Sedimentation** is the settling out of comparatively heavy suspended material (suspended solids) in water because of gravity. The settling takes place in a quiet pond or a specially constructed tank (Figure 14.10). A minimum 24-hour retention time is necessary to have a significant reduction in suspended matter. (**Retention time** means the length of time the water is kept (retained) in the tank.) Sedimentation can be used alone or in combination with coagulation.

Figure 14.10 Sedimentation tank at a municipal water treatment works. (Photo: Pam Furniss)

Coagulation is the formation of particles in a liquid by adding chemicals. Its meaning is similar to flocculation. The flocculant used in large-scale treatment plants is usually alum (hydrated aluminum sulphate). This chemical is mixed with turbid water and then allowed to remain still in a sedimentation tank or basin so that the larger particles, or floc, settle to the bottom.

Filtration is the removal of suspended material from water as it passes through beds of porous material. This is exactly the same principle as filtration methods at household level. Filters can be made of layers of sand, gravel or charcoal. Filtration cannot completely remove all bacteria.

Disinfection kills most harmful organisms including pathogenic bacteria. Without disinfection, the risk from waterborne disease will remain. Disinfecting agents include chlorine, ultraviolet light, ozone, iodine and others but, of these, chlorine is the most frequent treatment agent. The process is called chlorination.

14.6 Chlorination

Chlorination, used at both household and large-scale levels, is one of the most effective and widely used methods for disinfecting water and making it safe to drink. Whatever the level, it is important that the correct quantity of chlorine is added to remove all impurities.

- ■ Which of the water treatment methods described earlier for household use involve chlorination?
- □ Three of the four chemical disinfection methods described are chlorination methods. Chlorine solution, PUR and Wuha Agar all use chlorine as the disinfecting agent.

At municipal level, various terms are used to describe aspects of the chlorination process. **Chlorine dosage** is the amount of chlorine added to the water system in milligrams per litre (mg/l). **Chlorine demand** is the amount of chlorine that combines with the impurities and therefore is no longer available as a disinfecting agent. The chlorine that remains in the water after the chlorine demand has been satisfied is called free **chlorine residual**. A certain amount of residual chlorine is a good idea because it protects against future recontamination.

The **orthotolidine-arsenite test** (OTA) is used to determine the amount of free chlorine residual. When orthotolidine reagent is added to water containing chlorine, a greenish-yellow colour will appear. The intensity of the colour is measured against a chart to determine the amount of free available residual chlorine in the water. The amount of residual chlorine needs to be in the range of 0.2–0.5 mg/l if it is to prevent recontamination with bacteria. The OTA test requires a special test kit. If required, this should be available from your district environmental health office.

The *benefits* of point-of-use chlorination include:

- Chlorine is proven to be effective in the reduction of bacteria and most viruses.
- The residual chlorine is effective in protection against recontamination.
- It is easy to use.
- Chlorine is easily available at low cost.

The *drawbacks* of chlorine treatment include:

- It provides relatively low protection against some viruses and parasites.
- Lower effectiveness in water contaminated with organic and certain inorganic compounds.
- Potential objections to taste and odour.
- Some people have concerns about the potential long-term carcinogenic effects of chlorination byproducts.

Summary of Study Session 14

In Study Session 14, you have learned that:

1 Drinking water is treated to improve smell, taste, clarity and to remove disease-causing pathogens.

2 If water from an unprotected source is not treated before it is used for drinking, this may cause an outbreak of waterborne disease. Disease outbreaks may also occur because of contamination at some point after collection from the source.

3 The main objectives of water treatment are to:

   - reduce or remove all contaminants that are present in the water
   - raise water quality to the highest possible level for long-term use
   - meet water quality standards
   - reduce waterborne diseases.

4 Household water treatment technologies include dilute bleach solution, Aquatabs, solar disinfection (SODIS), cloth filters, ceramic filters, the biosand filter, PUR and Wuhu Agar. Safe storage is also essential.

5 Conventional large-scale water treatment is feasible for urban areas where the population is dense. There are several steps in the treatment process at this level.

Self-Assessment Questions (SAQs) for Study Session 14

Now that you have completed this study session, you can assess how well you have achieved its Learning Outcomes by answering the following questions. Write your answers in your Study Diary and discuss them with your Tutor at the next Study Support Meeting. You can check your answers with the Notes on the Self-Assessment Questions at the end of this Module.

SAQ 14.1 (tests Learning Outcome 14.1)

Match the words in list A with the corresponding phrases in list B, by drawing an arrow between them.

A	B
Chlorination	Free residual available chlorine in treated water
Chlorine contact time	Water not yet treated
Raw water	Time required to wait to drink after chlorination
Chlorine residual	Process of treating with chlorine

SAQ 14.2 (tests Learning Outcome 14.2)

Suppose you went to a village to promote household water treatment. Mr. Abebe, a local farmer, asks you why he needs to treat the water for drinking. What would you say to him as an explanation?

SAQ 14.3 (tests Learning Outcome 14.3)

Suppose you have a group of women in your area who want to know about household water treatment by chlorine solution, particularly Wuha Agar. What are the key points you would explain to them?

SAQ 14.4 (tests Learning Outcome 14.3)

A man comes to see you and explains that his family obtains water from a protected water source and that it has been treated with chlorine. He asks you how he can find out whether the chlorine still protects his family or not. How could you find out if his water was still safe to drink?

SAQ 14.5 (tests Learning Outcomes 14.1 and 14.4)

Filtration and disinfection are important water treatment processes. Briefly describe each of these processes and explain their role in making water safe to drink.

Study Session 15 Community Drinking Water Source Protection

Introduction

Every public drinking water source should be protected from possible contamination. In this study session, you will learn about different sources of water, the basic techniques of developing small-scale drinking water schemes (i.e. springs, hand-dug wells, rainwater harvesting and surface water). You will also learn how to identify water sources that need protection and how they can be protected from potential contaminants through community mobilisation, regular inspection, proper maintenance, hygiene promotion and periodic treatment of water to prevent waterborne diseases from affecting the community.

Learning Outcomes for Study Session 15

When you have studied this session, you should be able to:

15.1 Define and use correctly all of the key words printed in **bold**. (SAQ 15.1)

15.2 List the different sources of drinking water. (SAQ 15.2)

15.3 Describe the main activities when planning and developing water source protection. (SAQ 15.2)

15.4 Describe the methods of preventing contamination of well and spring water. (SAQs 15.3 and 15.4)

15.1 Sources of drinking water

The sources of drinking water that are practicable for public and domestic purposes are classified as:

- rainwater
- surface water such as lakes, rivers and ponds
- groundwater from springs, wells and boreholes.

15.1.1 Rainwater

Rainwater can be used for domestic purposes in areas where there are no alternative sources of water such as springs, rivers and lakes, or where these sources of water are contaminated. The term **rainwater harvesting** is sometimes used. It simply means collecting, or harvesting, rainwater as it runs off from hard surfaces such as rooftops and storing it in a tank or cistern (Figure 15.1).

The main advantage of rainwater is that it is free. It is fairly reliable though obviously dependent on the amount of rain that falls. It does not usually require pumps or pipes and is available at the doorstep. Using rainwater can reduce the burden on women and children who typically are the water carriers in Ethiopia and walk long distances to fetch inadequate supplies.

Figure 15.1 Rainwater is collected from the roof of this health centre and stored in a covered, watertight cistern. (Photo: Pam Furniss)

15.1.2 Surface water

Surface water supplies are taken from rivers, lakes or ponds. Surface water can provide a consistent and manageable source of water. However, it is subject to greater risk of contamination than groundwater and therefore usually requires treatment. Contamination is most likely to be with microbiological pathogens from human and animal excreta. There is also the possibility of accidental or deliberate pollution by industries or the agricultural community.

Figure 15.2 A surface water source that is likely to be polluted. (Photo: Richard Adam)

- ■ What are the likely sources of contamination in the river in Figure 15.2?
- □ Excreta from the cattle will be washed into the river water. Their hooves have disturbed the ground so soil is also likely to be washed in. The road passing over the bridge in the background could be a source of pollution from cars and lorries.

15.1.3 Groundwater

Groundwater is water found beneath the ground surface held in the spaces within porous soil and rock. Groundwater can be obtained from springs, boreholes or wells. A borehole is a particular type of well with a narrow shaft. Usually a drilling rig is needed to drill (bore) the hole into the rock.

The depth that water is taken from and the types of rock it has passed through are important factors that affect the quality of the groundwater. Groundwater, particularly from deep sources, may provide water of good microbiological quality. This is because bacteria, protozoa, viruses and helminths are filtered from the water as it passes through the layers of soil and rock into the groundwater. Groundwater sources are therefore preferable to surface water sources. However, groundwater can contain chemical contaminants, such as arsenic, fluorides and nitrates.

Springs

A spring occurs at the point where the boundary between a **permeable layer** of underground rock and an **impermeable layer** reaches the ground surface. Rainwater percolates (trickles down) through the soil into permeable layers of subsoil or underground rock. The downward **percolation** will be stopped if this layer sits on top of an impermeable layer and the water can go no further. Depending on the slope of the layers, the water will run along the top of the impermeable layer to a point where it reaches the surface and emerges as a spring (see Figure 15.3). A spring may vary in volume and contamination levels according to the amount of rainfall.

Permeable rocks have tiny spaces between the solid rock particles that allow water and other fluids to pass through and be held within the rock structure. Impermeable rocks do not have these spaces and water cannot pass through them.

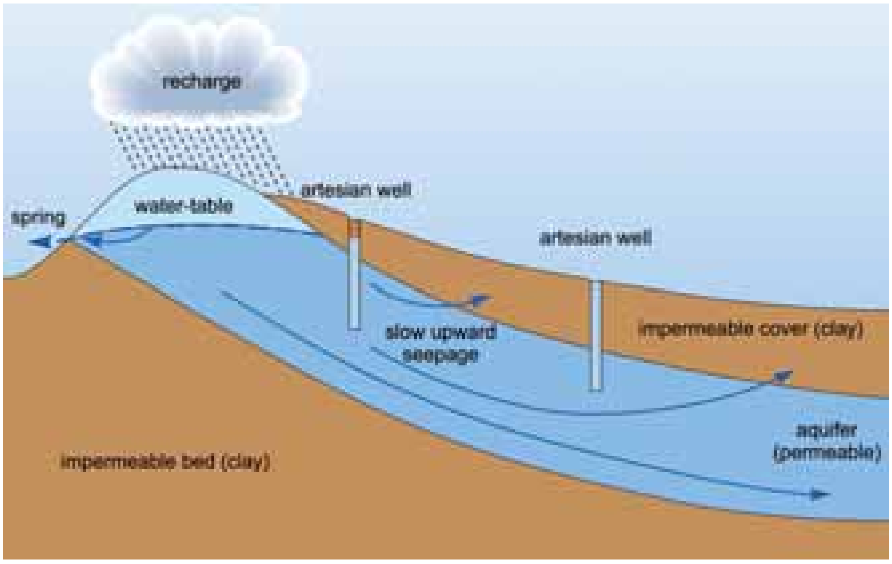


Figure 15.3 Diagram of groundwater formation with spring and artesian wells. (Source: The Open University)

Springs are likely to be polluted by direct contamination through the topsoil unless the surrounding land area is protected. A spring supply issuing from a deep, water-bearing layer, rather than a permeable layer near the surface, can produce both a consistent volume and a better quality supply. Whether the spring originates from shallow or deep rock layers, animals should be excluded from the surrounding area by a stock-proof fence, and any water running off the land after rain should be diverted to a suitable ditch away from the spring.

Wells

The practice of obtaining water from wells is common and well water is an important source of supply in many developing countries like Ethiopia. A well should be located uphill from any possible sources of pollution. Wells are classified based on the depths of the water-bearing layers as follows:

- *Shallow wells* tap into water held in **aquifers** (layers of water-bearing rock) above the first impermeable layer. 'Shallow' is not a definite depth, but an indication of the layer of rock from which it is abstracted.
- *Deep wells* obtain water from aquifers below at least one impermeable layer. A deep well must be constructed so as to exclude subsoil water and contamination from above. It should be watertight down to a point slightly below the level of the deep supply.
- *Artesian supply*. Water in aquifers is sometimes under pressure because of the surrounding impermeable layers and this can cause the water to flow upwards to the surface. In Figure 15.3, the water level in the two artesian wells is determined by the level of the water table. In the well on the right, water rises to the land surface but in the well on the left it does not.

15.2 Planning the development and protection of sources of water

As you learned in Study Session 13, nearly 70% of the rural population of Ethiopia get their water from unimproved sources. There is, therefore, a widespread need to develop new sources of water and to ensure they are adequately protected. Several issues need to be taken into consideration when planning the protection and development of water sources.

15.2.1 Assessing needs

Water source protection should be based on needs identified by the community themselves. The community should identify its own water and sanitation needs through a process of internal discussion and external negotiation. The internal discussion would involve you, other health experts, community leaders and other members of the community. Local people have local knowledge and it is important to draw on this knowledge when planning new developments. The external negotiations may involve local government offices, NGOs and other partners who can assist with the assessment of the communities' needs with information and technical guidance.

15.2.2 Water source identification

All potential water sources should be considered and checked. Issues to consider are the sources of possible contaminants, the amount of water available to users annually and the consistency of the supply. Other important issues are social acceptance, cost effectiveness and community health. All potential water sources need to be assessed in order to identify the best solution.

For instance, whenever rivers and streams are considered for use and development, the communities immediately upstream and downstream should be consulted and involved in the decision-making process prior to implementation. This is because both quality and quantity of surface water can be affected by the activities of the people living upstream (toward the source of the stream or river). If the upstream users abstract large volumes or pollute the water, this will have a damaging effect on the downstream users (Figure 15.4). All communities have an interest in having good quality and adequate quantities of water; therefore, it is important that proposed surface water developments should be discussed with and agreed by both the upstream and downstream communities.

Figure 15.4 Upstream and downstream: the upstream users usually have the upper hand in terms of both (a) quantity and (b) quality. (Source: the Open University)

15.2.3 Water quantity

Whenever a new protected water source is proposed it should have the capability of supplying at least 20 litres of water per person per day to the target population. The protected water source should provide sufficient quantities of water to meet essential health-related household and personal needs, including drinking, cooking, personal hygiene, clothes washing and cleaning for all community members.

15.2.4 Sanitary surveys

Before any new water source protection is developed or maintenance is planned on an existing source, it is important to conduct a **sanitary survey**. A sanitary survey is an evaluation of the physical environment to identify possible health hazards and sources of environmental contamination. It will reveal the potential risks to the health of people that may arise from the proposed water source. The risks may be negligible or they may need to be controlled with specific correction activities. This sanitary survey will be part of the baseline information for the water source development and should include the nature of the water-bearing layer, the **hydraulic gradient** (i.e. the variations in underground water pressure that affect the natural flow of water), topography, vegetation, potential sources of contamination, and the adequacy of the yield particularly for dry seasons. (You will learn more about sanitary surveys in Study Session 16.)

15.2.5 Health and hygiene education

Before developing any water protection, the health benefits of an improved water supply and sanitation need to be accepted by the local community. You can provide hygiene education for the people in order to promote their behavioural change.

- ■ What good hygiene practices would you encourage so that the local community get the full benefit of an improved water supply?

- □ The most important aspects of good hygiene education would be:
  - Washing their hands after using the latrine and before preparing meals or feeding babies and eating their food.
  - Protecting water supplies at the source and in the home.
  - Using an appropriate latrine rather than the open fields.

Water and sanitation activities should be integrated with community health developments if it is possible. Individual and community health are the major beneficiaries of improved water supplies and sanitation.

15.2.6 Water quality

Water quality should be a primary concern in all water projects. Water quality is a description of the chemical, physical and biological characteristics of water, usually with respect to its suitability for drinking. The quality of drinking water must be uppermost in the planning and implementation of water and sanitation activities. Water source development projects should draw water from the best available sources. Water quality assessment is discussed in more detail in Study Session 16.

15.3 Protection of wells

15.3.1 Types of well

There are several different ways of constructing a well in order to access groundwater sources. These include dug wells, bored wells (also known as boreholes), and driven and jetted wells.

Dug well

A dug well is usually excavated by hand, but may be dug by mechanical equipment. They are usually 90–180 cm in diameter and 4.5–10.5 m deep, depending on where the water-bearing layer or groundwater is encountered. Wider and deeper dug wells are less common. Dug wells have a relatively large diameter and therefore have large storage capacity, but the water level will be lower at times of drought and the well may go dry. On the other hand, during heavy rain, dug wells are susceptible to contamination by pathogens which may be deposited on the surface or naturally present in the soil and are washed in to the well, particularly if it is improperly constructed. Handpumps placed over the well need to be built so the surrounding ground is covered and protected (Figure 15.5). Any pipework associated with pumps that enters the well needs to have watertight connections so there can be no contamination from surrounding soil.

Figure 15.5 Protected handpump over a dug well. Note the concrete surround and the fence to keep out animals. (Photo: Pam Furniss)

Bored well

Bored wells or boreholes are constructed with a hand- or machine-driven auger and tend to be used in relatively soft soils and rocks. An auger is a device with a rotating blade that is used to drill holes and draw out the loosened rock and soil. Bored wells vary in diameter from 5–75 cm and in depth from
7.5–18 m. A lining, known as a *casing*, of concrete, metal, or plastic pipe is necessary to line the hole and prevent the soil and rock from caving into the well. Bored wells have characteristics similar to dug wells in that they have small yields, may be easily polluted, and are affected by droughts.

Driven and jetted wells

These types of well consist of a metal pipe with a screen attached at the bottom end. A well screen is a device that allows water to pass in to the pipe but keeps out soil particles. The pipe is *driven* or *jetted* into a water-bearing rock layer found at a comparatively shallow depth. For a driven well, the end of the pipe is shaped into a point and it is hammered into the ground. The jetted well is constructed by directing a high velocity stream of water through the bottom of the pipe, thereby loosening and flushing out the soil which is forced back up to the surface as the pipe is lowered. Driven wells are commonly 2.5–5 cm in diameter and less than 15 m in depth. Jetted wells may be 5–30 cm in diameter and up to 30 m deep. Larger and deeper jetted wells can be constructed. Following development, the well should be tested to determine the dependable well yield (i.e. the volume of water reliably produced). The well is then disinfected and the project completed.

15.3.2 Protection of well water from pollution and contamination

Before and during water source development, care should be taken to minimise possible risks. The well should be located on a higher level than possible sources of contaminants such as latrines and cesspits (a pit for collection of waste matter and water especially sewage). This is because the liquid from the pit may seep into the surrounding ground and into the groundwater. If the latrine is higher up a slope than the well then the contaminated groundwater is likely to flow downwards and into the well. The natural flow of the groundwater (the hydraulic gradient) should be away from the well and towards the sources of contaminants, and not the other way round. In normal soils, the minimum distance between the well and the source of contaminants should never be less than 15 metres and a distance of 30–50 m is recommended. However for limestone and some other soil formations this distance needs to be greater because groundwater can pass very easily through some rocks and soils.

The inside wall of the well should be made waterproof by constructing a well casing. As noted above, in small diameter bored wells the casing can be a pipe, but in larger wells the casing needs to be constructed by cementing from the top of the well down to a minimum depth of 3 metres. The casing of the well should also be extended for a minimum of 60 cm above the surrounding ground level to prevent the entrance of surface runoff. A concrete cover should be fitted over the casing to prevent dust, insects, small animals and any other contaminants from falling in (Figure 15.6).

Figure 15.6 Two wells with concrete protection. Note the removable covers. (Photos: Pam Furniss)

A pump should be installed, but if a pump is not available then a sanitary bucket and rope system may be used. The immediate area of the well should preferably be fenced to keep animals away (see Figure 15.5). The area surrounding the well should be graded off (i.e. should slope away from the well) in order to prevent the flow of storm water into the well.

15.3.3 Contamination of well water

The causes of bacterial contamination in a well are usually due to:

- Lack of, or improper, disinfection of a well following repair or construction.
- Failure to seal the space between the drill hole and the outside of the casing.
- Failure to provide a tight sanitary seal at the place where the pump line(s) passes through the casing.
- Wastewater pollution caused by contaminated water percolating through surrounding soil and rocks into the well.

At the time when a new well is constructed or repairs are made to a well, pump or piping, contamination from the work is possible. Therefore, it is important that the well, pump, piping and associated structures should be regularly disinfected using chlorine solution.

Tracing the source of contamination

There are different methods which help to identify a possible source of groundwater contamination. One method is sodium or potassium **fluorescein.** This is a brightly-coloured, fluorescent, water-soluble dye and can be used as a tracer when a sewage disposal system is suspected of contaminating groundwater. A solution flushed into the disposal system or suspected source may appear in the well water within 12–24 hours. It can be detected by sight, taste or analysis.

15.4 Spring source protection

There may not be many opportunities to develop new spring sources but, if the opportunity does arise, there are certain procedures to follow to ensure the spring water is protected and safe to drink. You would be working with others if a new spring source was to be developed but the same principles will apply to existing spring sources because the protection needs to continue to work into the future.

Before using a spring a thorough sanitary survey needs to be carried out at the site to assess the quantity and quality of water, and the possible contamination. (Sanitary surveys are described in Study Session 16.) If the results of the sanitary survey are satisfactory, the eye of the spring (the point where the water emerges from the ground) should be located by digging out the area around the spring down to the impermeable layer.

Different types of spring protection can be constructed but in general they are as follows:

- A concrete waterproof protection box, also known as a spring box, should be constructed over the spring to prevent all actual and potential sources of contamination.
- A retention wall in the front part of the protection box should be constructed to keep water flowing to the delivery pipe. In Figure 15.7 (on the next page) you can see the retention wall of this spring with the delivery pipe emerging from it.
- In some situations, if the flow is not constant, a collection box may also be constructed in order to ensure adequate water storage.

- The intake and overflow pipes should be screened to prevent the entrance of small animals. The spring and collection box, if there is one, should have a watertight top, preferably concrete. Water will move by gravity flow or by means of a properly-installed mechanical pump. An inspection hole should be tightly covered and kept locked.

Springs should be protected from flooding and surface water pollution by constructing a deep *diversion ditch* above and around the spring. The ditch should be constructed so it collects surface water running towards the spring and carries, or diverts, it away. It needs to be deep enough to carry all surface water away, even in a heavy rainstorm. The surrounding area should be fenced to protect it from animals (see Figure 15.7).

Figure 15.7 A protected spring. Note the concrete retention wall with two delivery pipes and the surrounding fence. (Photo: WaterAid in Ethiopia)

15.5 Rainwater source protection

A lot of care must be taken to ensure rainwater that is used for water supply is not contaminated by improper methods of storage or by bird droppings and leaves from the roof the water is collected from. Rainwater may be also be contaminated by pollutants in the air, dust, dirt, paint and other material on the roof or in roofing materials. All of these contaminants can be washed into the storage tank or cistern.

To protect the water, various precautions are needed. The tank must be completely covered and well maintained. The roof and gutters should be cleaned regularly, especially before the start of the wet season. It may be necessary to divert the first rainwater away from the tank so the dust and dirt is washed away. Leaves and other larger debris can be prevented from entering the tank by placing a mesh screen between the guttering and the pipe that leads to the tank; the mesh screen will need to be cleaned regularly.

15.6 Surface water sources

All surface water sources are subject to continuous or intermittent pollution and must be treated to make them safe to drink. One never knows when the organisms causing diseases such as typhoid fever, gastroenteritis, giardiasis or infectious hepatitis A will contaminate surface water sources. The extent of the treatment required will depend on the results of a sanitary survey made by an experienced professional, including physical, chemical and microbiological analyses. Protecting surface water from pollution is difficult because, as noted earlier, the activities of upstream users of the river water will affect the quality of the water for downstream users and the land use in the surrounding area will also have an impact. Surface waters are, by definition, unprotected sources.

Summary of Study Session 15

In Study Session 15, you have learned that:

1. Rainwater, surface water (from lakes, rivers, ponds) and groundwater (from springs, wells and boreholes) are the sources of water for public and domestic purposes.
2. Groundwater sources are generally preferable to surface water sources. They tend to be safer and less in need of costly water treatment.
3. There are number of issues to be considered before the development of a new water source, including assessment of the quantity and quality of the available water, and consideration of the needs and involvement of the community. A thorough sanitary survey is an important part of this process.
4. Dug wells, deep wells, bored wells, and driven and jetted wells are some of the methods of groundwater source development.
5. Protection of well water and spring water from contaminants and pollutants is very important.
6. After construction, or when repairs are made, the spring, well, pump or piping should be disinfected with chlorine solution.
7. Sodium or potassium fluorescein is a water-soluble dye that can be used as a tracer when a sewage disposal system is suspected of contamination of groundwater.
8. Rainwater harvesting is very important when the quantity or quality of other water sources is inadequate. Rainwater must be stored in a closed tank and kept free of contaminants.

Self-Assessment Questions (SAQs) for Study Session 15

Now that you have completed this study session, you can assess how well you have achieved its Learning Outcomes by answering these questions. Write your answers in your Study Diary and discuss them with your Tutor at the next Study Support Meeting. You can check your answers with the Notes on the Self-Assessment Questions at the end of this Module.

SAQ 15.1 (tests Learning Outcome 15.1)

Match the following words in list A with the corresponding phrases in list B by drawing an arrow between them.

A	B
Surface water	Water trickling down through soil
Groundwater	Underground water-bearing rock layer
Aquifer	Freshwater supply beneath the Earth's surface
Percolation	Rivers and lakes

SAQ 15.2 (tests Learning Outcome 15.2 and 15.3)

A community leader in a village comes to your office claiming the villagers use water from an unprotected source. He asks if you can help in the development of a new water source. What steps need to be taken to investigate if a new water source was possible for this village?

SAQ 15.3 (tests Learning Outcome 15.4)

Suppose inhabitants of a village obtain water from a spring. What advice do you give to the users about the prevention of contaminants?

SAQ 15.4 (tests Learning Outcome 15.4)

Look at Figure 15.8 which shows a handpump over a well. What are the potential sources of contamination of the water in this well? What would you recommend should be done to improve protection?

Figure 15.8 For use with SAQ 15.4. (Photo: Janet Haresnape)

Study Session 16 Sanitary Survey of Drinking Water

Introduction

Diseases related to contamination of drinking water constitute a major burden on human health. The great majority of water-related health problems are the result of microbial (bacteriological, viral, protozoan or other biological) contamination. Sanitary surveying of drinking water is an important tool for reducing the risks of water contamination and waterborne illness. In Study Session 15 you learned that undertaking a sanitary survey is an important part of the process to develop a new water source. Sanitary surveys are also essential for monitoring the condition of existing water sources to ensure they continue to be safe to use.

Learning Outcomes for Study Session 16

When you have studied this session, you should be able to:

16.1 Define and use correctly all of the key words printed in **bold**. (SAQ 16.1)

16.2 Describe the purpose and benefits of a sanitary survey. (SAQ 16.2)

16.3 Describe the purpose and benefits of water quality analysis. (SAQs 16.3 and 16.4)

16.4 Explain the methods of conducting a sanitary survey at different water sources. (SAQ 16.5)

16.1 Rationale for a sanitary survey

In Study Session 15 you learned that a sanitary survey is an evaluation of the physical environment to identify possible health hazards and sources of environmental contamination. The survey should include an inspection of the entire water system, including the water source, facilities, equipment, operation and maintenance. It can be a complex technical task if carried out at a detailed level and may require expert help but you can conduct an onsite survey of the key elements, which are the water source itself, sources of contaminants and water handling by household members. There are many different aspects to a sanitary survey and different questions to be answered, so having a checklist of the necessary items is a useful aid. Some example checklists are included later in this session.

There are several reasons for conducting sanitary surveys of drinking water. Sanitary surveys are a comprehensive inspection of the entire water delivery system from the source to the mouth and are, therefore, the best means of identifying potential problems and changes in the quality of drinking water. They play a fundamental role in ensuring that consistent and safe drinking water supply is provided to the community by identifying and correcting any deficiencies in the system, and helping to identify public health risks related to drinking water.

The benefits of a sanitary survey, therefore, are that they can:

- Assure the long-term quality and safety of drinking water.
- Help to protect public health.
- Reduce the risk of waterborne disease outbreaks.
- Help source protection.

After conducting a sanitary survey you will be able to describe the extent of problems and consider possible solutions, which will vary depending on the circumstances. You can discuss these with the community leaders, religious leaders and local administrators, and perhaps find a rapid solution, if it is controllable by you. If the problems are more difficult to handle, you can report to the experts who are working at the district level.

A sanitary survey or inspection is a relatively simple technique that depends on gathering information, principally by observation and also by making enquiries. A more detailed assessment of water quality would require chemical and microbiological analysis, which would need specialised equipment and qualified staff, and would be more expensive than a sanitary survey. Some analytical equipment is portable and can be taken to the site but other tests can only be done in a laboratory. The recommended tools for field use are a portable pH meter with digital readout, a hand-held colorimeter, portable spectrophotometer and residual chlorine test kit.

16.2 Elements of a sanitary survey

One of the most important functions of the onsite sanitary survey is to determine whether the existing facilities are adequate to meet the needs of the users at all times. This is one of several elements that are considered essential in the proper conduct of a thorough sanitary survey. The two key elements that you should focus on are the *water source* (its physical components, protection and condition of any associated structures) and the *use of water at home*.

16.2.1 Water source (components, protection and condition)

As you know, the water supply source is the beginning of the drinking water system. Preventing source water contamination is the most effective means of preventing contaminants from reaching consumers. Source water protection also helps you to ensure the least expensive method is used for treatment of water. Hence, a sanitary survey should be designed to assess the control of contaminants and determine the reliability, quality, quantity and vulnerability of the source of water.

During a sanitary survey, you need to consider the terrain (the slope of the land), soil types, land cover, rainfall and runoff, and animals, which can all affect the water quality. In particular the potential sources of contamination by pathogens need to be assessed.

■ What pathogens might be a problem for water quality and what are the sources of those pathogens?

□ The pathogens are bacteria, protozoa, viruses and helminths. The primary source is human waste which gets into the water because of open defecation, discharge of sewage to water bodies, poorly sited latrines, etc.

In addition to contamination by pathogens from human body waste, there are many other human activities that can affect water quality. Runoff from barnyards and other areas where animals are kept will contain animal wastes and can cause significant problems. Farming activities can also lead to contamination from pesticides that may percolate into groundwater or wash off from fields into surface waters. Construction activities can result in large amounts of sediment being washed into rivers and streams.

Flooding is a natural event that may also be a source of contamination to sources of water supply. Surface runoff, which is a major contributor to flooding, can carry dirt, oil, pesticides, fertilisers and other contaminants that might be washed off from surrounding land.

16.2.2 The use of water at home

As you know, water is said to be safe to drink when it is free from pathogens, physical contaminants and chemical contaminants. This needs to apply right up to the point when water goes in the mouth**.** Identifying and assessing the potential risks associated with the collection and use of water is therefore a very important part of the survey (Figures 16.1 and 16.2). You need to ask users, or observe their practice, on:

- How they collect the water and the types of vessel they use (e.g. whether jerrycan, buckets or pots).
- How the vessels are handled and stored when not in use.
- Whether the vessels are used for purposes other than water collection that may contaminate them.
- Whether users know how to collect safe water and keep it safe.
- Whether the water is treated or disinfected after collection and assess the hygiene practices of users, especially young children.

Figure 16.1 Collecting water in jerrycans and traditional pots. (Photo: Richard Adam)

Figure 16.2 Water storage at home. (Photo: Nancy Platt)

16.3 Vulnerability assessment at a water source

A vulnerability assessment is used to determine the likelihood that potential contaminant sources in the drinking water protection area will degrade the source water quality. A vulnerability determination will include consideration of several factors including hydrological sensitivity, the source of contaminants, how these sources can be managed, and the condition of any water source protection.

Hydrological sensitivity means assessing how sensitive a water source is to contamination. Higher sensitivity ratings apply if geological conditions allow contamination to move quickly from its place of origin through the rocks and soil to water sources. Lower ratings apply when contamination moves more slowly.

Another factor is vegetation and surrounding land use. If the land around a water source has no vegetation it is more susceptible to contamination than a water source surrounded by land with thick vegetation. This is because plants and trees can act as a physical and biological barrier to pollutants.

You also need to look at the condition of source water structures. For example, at a well you need to check the well casing, joints, delivery structures and equipment to move water from the well and assess their integrity. 'Integrity' means the quality of design, construction, maintenance and state of repair of the structure.

Factors affecting vulnerability to contamination include:

- Drinking water wells located close to potential sources of contamination have more risk than wells located further away.
- Whether the potential source of contamination is from a single identifiable point which would be easier to manage but could have greater potential for major contamination than diffuse contamination spread over a wider area.

■ Can you think of an example of a possible source of contamination of a water well?

□ Contamination could be caused by a pit latrine or other waste disposal pit if it is sited at a higher level than the well and/or is too close. The wastewater from the pit could slowly seep through the rocks into the groundwater.

16.4 Source water quantity

The quantity of water for users is also an important part of a sanitary survey. An adequate quantity of source water should be available to meet the community's needs. The quantity must be sufficient to meet the anticipated demand of the community. The location of source water supply facilities is also an important factor in determining the ability of the water system to meet the community's needs at all times. The source should be within 1 km or a 30-minute round trip.

■ What is the recommended minimum volume of water needed per person per day?

□ The minimum volume is 20 litres per person per day.

16.5 Sanitary survey of wells

Wells should have a well casing (a liner pipe or tube or stone wall), protective devices such as good fences, and warning signs to discourage human and animal activities that might disturb the well area. Figure 16.3 shows what you should be looking for when you are doing a sanitary survey of a well, and Box 16.1 (on the next page) has a list of questions to be asked. The numbers in the diagram demonstrate particular points and correspond to the questions in the checklist. Answering 'yes' to any of the questions would be a cause for concern.

Note that the minimum safe distance (MSD) between the well and potential sources of pollution will vary depending on the local conditions, particularly the soil type, geology, hydraulic gradient and slope of the land. It should never be less than 15 metres but 30–50 metres is recommended.

In addition to the observations of the physical condition of the well and its surroundings, you should also find out and make a note of the maintenance programme for the well, for example, the frequency of cleaning and disinfection.

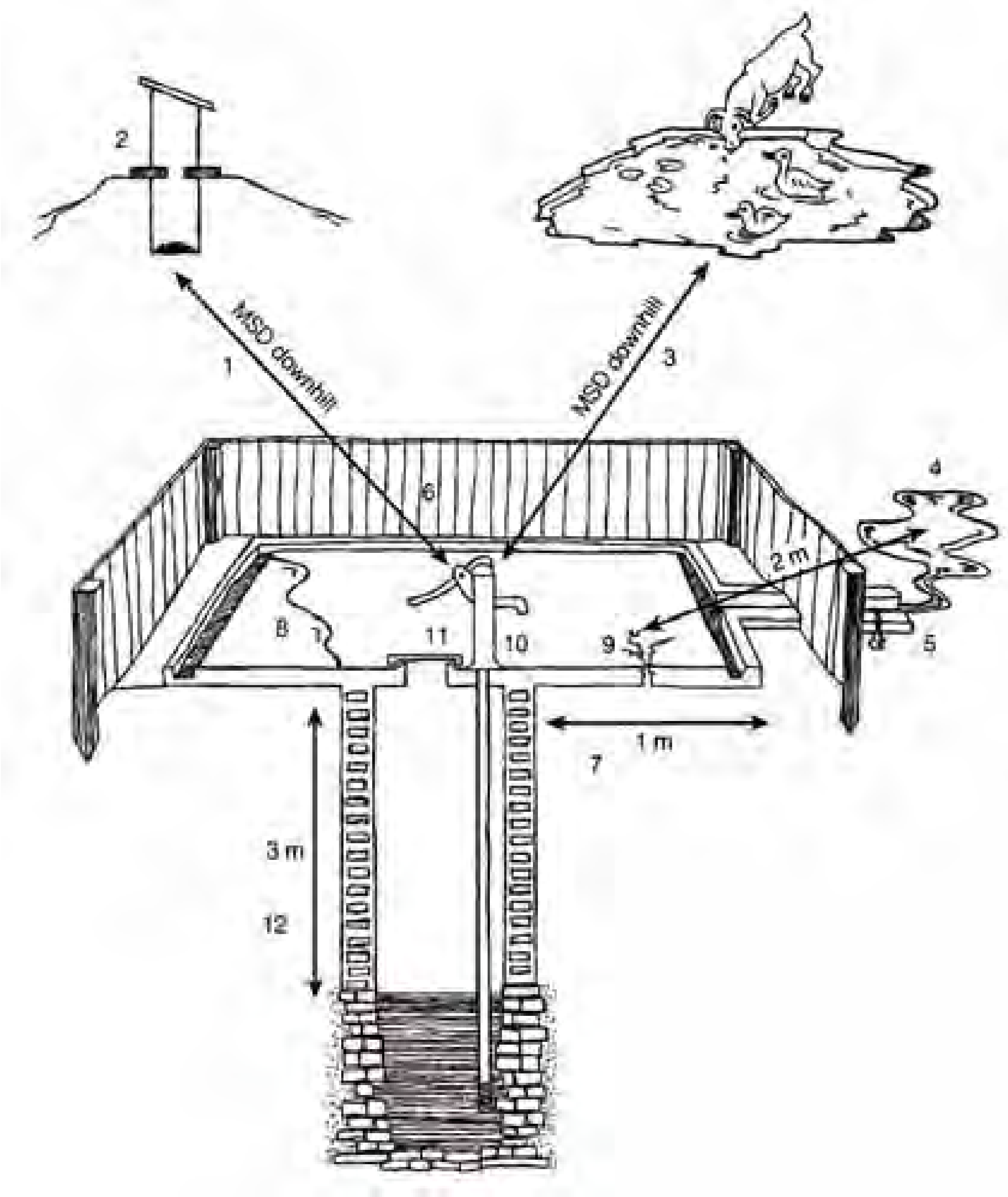


Figure 16.3 Sanitary inspection of a well with handpump. The numbers refer to the questions in Box 16.1. Note: MSD means 'minimum safe distance'. MSD will vary depending on local conditions but should not normally be less than 15 m. (Source: World Health Organization, 1997, *Guidelines for drinking water quality*, Volume 3)

Box 16.1 Sample checklist for well water sanitary inspection

Name of Health Post ______________________

Village name and location of well/handpump

____

Questions to be asked during survey:

1 Is there a latrine within 15 m of the well and handpump?

2 Is the nearest latrine on higher ground than the handpump?

3 Are there any animal excreta or rubbish within 15 m of the handpump?

4 Does the drainage channel contain stagnant water within 2 m of the handpump?

5 Is the drainage channel broken allowing a pool of water to form?

6 Does the wall or fencing around the handpump have any breaks that would allow animals in?

7 Is the concrete floor less than 1 m wide all around the handpump?

8 Are there any pools of water on the concrete floor around the handpump?

9 Does the concrete floor around the handpump have any cracks that could let water in?

10 Is the handpump loose at the point of attachment to the base which could let water enter the casing?

11 Is the cover of the well unhygienic (unclean)?

12 Are the walls of the well poorly sealed at any point for 3 m below ground level?

Name ______________________

Signature ______________________

Date ______________________

16.6 Sanitary survey of springs

When a spring is chosen for a water supply, the sanitary survey should determine that the water quality is acceptable, the quantity of water available is adequate to meet the needs of the community and the spring is protected from contamination. The quantity of water available from a spring can vary significantly due to changes in groundwater storage.

Like wells, springs should have protective devices such as good fences and warning signs to discourage human and animal activities that might disturb the spring area. The spring box or storage tank and cover need to be watertight to prevent undesirable water from entering. Since most springs never stop producing water, an overflow is needed to ensure that water pressure does not build up and damage the spring box. The end of the overflow drain should have a screen to prevent the entrance of animals. Springs should have a diversion ditch located at the uphill end of the site which keeps rainwater from flowing over the spring area. A good impervious barrier, such as clay or a plastic liner, can help ensure high quality water by preventing potential contaminants from entering the collection facilities. Figure 16.4 shows what you should be looking for when you are doing a sanitary survey of a spring and Box 16.2 has a list of questions to be asked. The numbers in the diagram demonstrate particular points and correspond to the questions in the checklist.

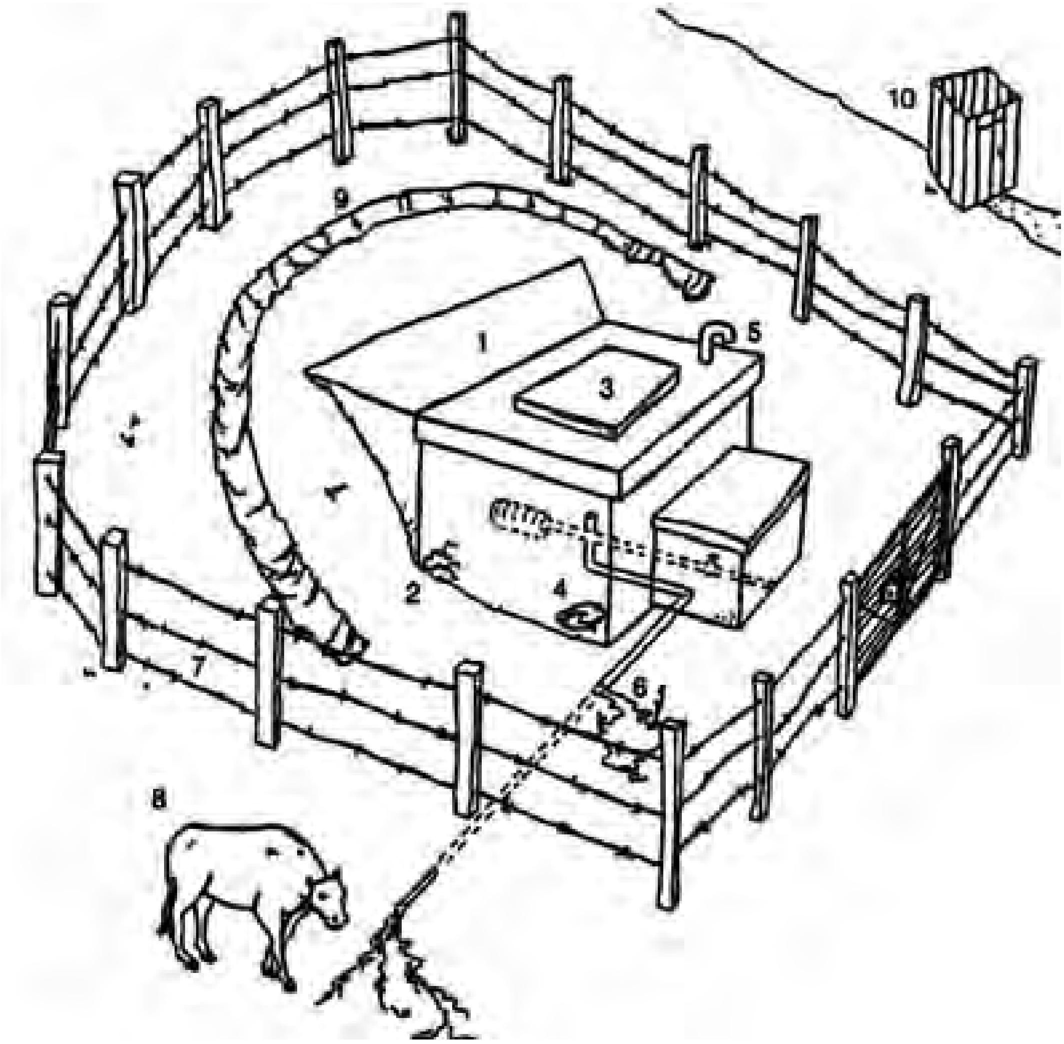


Figure 16.4 Sanitary inspection of a protected spring. The numbers refer to the questions in Box 16.2. (Source: as Figure 16.3)

Box 16.2 Sample checklist for protected spring source inspection

Name of Health Post ____________________

Village name ____________________

Questions to be asked during survey:

1 Is the spring source open to any contamination?
2 Is the stonework protecting the spring broken anywhere?
3 Could contaminants get into the box through the inspection hole?
4 Does the spring box have any contaminating silt?
5 If the spring box has an air vent, could it let in any contaminants?
6 If the spring box has an overflow, is it unsanitary (unclean)?
7 Is the area around the spring unfenced?
8 Do animals have access to within 15 m of the spring source?
9 Is a diversion ditch above the spring absent or non-functional?
10 Are there any latrines uphill of the spring?

Name ____________________

Signature ____________________

Date ____________________

16.7 Sanitary survey of rainwater collection and storage

As you learned in Study Session 15, rainwater harvesting is applicable for areas that have a shortage of other water sources. The roof from which rain is collected should be free from contaminants. There also needs to be a clean and well-constructed tank with no cracks in the walls and a properly covered inspection hole. Figure 16.5 shows what you should be looking for when you are doing a sanitary survey of rainwater collection and Box 16.3 has a list of questions to be asked. As before the numbers in the diagram demonstrate particular points and correspond to the checklist of questions. Any 'yes' answers would be a cause for concern.

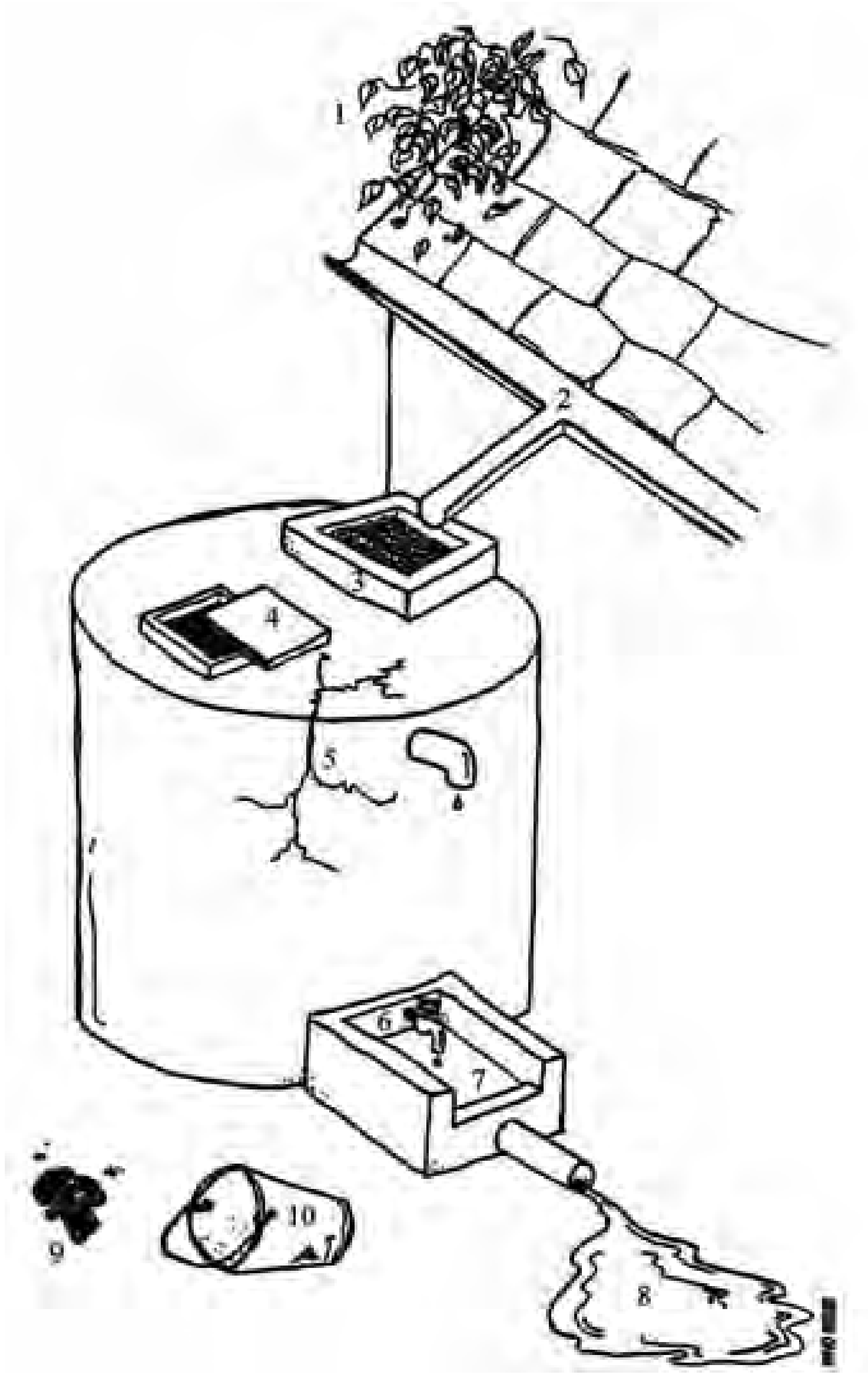


Figure 16.5 Rainwater collection and storage. The numbers refer to the questions in Box 16.3. (Source: as Figure 16.3)

Box 16.3 Sample checklist for rainwater collection and storage inspection

Name of Health Post ____________________

Village name ____________________

Questions to be asked during survey:

1 Does the roof have any visible contaminants (plants, dirt or excreta)?
2 Are the guttering channels that collect the water dirty?
3 Does the filter box at the tank inlet have any defects that could let in fine dusts?
4 Does the tank have any other point of entry which is not properly covered?
5 Do the walls or top of the tank have cracks or holes that could let water in?
6 Does the tap leak or have any defects?
7 Does the concrete floor under the tap have any defects?
8 Does the water collection area drain inadequately?
9 Does the area around the tank or water container have any source of pollution like faeces?
10 If a bucket is in use and left in place, is it exposed to contamination?

Name ____________________

Signature ____________________

Date ____________________

16.8 Water quality assessment

As you know, water can be polluted by chemical or biological contaminants and the water may be harmful to humans when consumed. There are many analytical methods used to test for the presence and concentration of possible pollutants. You are not expected to carry out microbiological and chemical tests of drinking water but it will help you if you understand the principles.

If at all possible, drinking water should not contain any pathogenic microorganisms. It would be very difficult and time-consuming to test for all the possible pathogens. The source of the pathogens is usually human faeces; therefore, tests have been devised that detect the presence of faecal contamination. If faecal contamination is found, this indicates that pathogenic organisms may be present.

The most widely used tests for faecal contamination are total coliforms, faecal coliforms and *Escherichia* coli (*E.coli*). Coliforms are a group of bacteria found in human and animal faeces and also in soils and some other natural environments. '**Total coliforms**' includes all bacteria in this group. The presence of 'total coliforms' indicates contamination of some sort but, because of their relatively wide distribution, cannot be used to confirm if the contamination is from faeces.

Faecal coliforms are a sub-set of total coliforms and, as the name suggests, are typically found in faeces. However, even this group includes some species that are not necessarily faecal in origin. ***E.coli*** is a type of faecal coliform bacterium that is found only in faeces of humans and other warm-blooded animals. If *E.coli* is present in a water sample, this indicates faecal pollution and the possible presence of pathogenic types that often occur in the intestines as well; the absence of *E.coli* from a sample shows that the chances of faecal contamination of the water, and therefore of pathogens being present, are negligible. Thus the presence or absence of *E.coli* in a water sample provides an important indicator of pollution and public health. However, it is important to realise that *E.coli* is only an indicator and its absence cannot give complete assurance that water is safe. Some pathogens such as *Giardia, Entamoeba histolytica* and some viruses are more resistant to disinfection than *E.coli;* therefore, the absence of *E.coli* will not necessarily mean that water is totally free from other organisms.

Although the great majority of health-related water quality problems are the result of bacteriological contamination, chemical contamination of water sources can also cause serious health problems. For example, the presence of nitrate and nitrite in water may result from the excessive application of fertilisers or from seepage of wastewater into surface water and groundwater. Fluorosis is a common problem in children living in the Rift Valley region of Ethiopia caused by exposure to high levels of naturally occurring fluoride in the water which can lead to mottling of children's teeth (Figure 16.6), skeletal fluorosis and crippling.

Figure 16.6 Fluorosis causes mottling of children's teeth (Photo: Basiro Davey)

Some health effects may occur as a result of specific chemical deficiencies in the diet, of which water forms a part, for example, goitre caused by iodine deficiency and dental caries resulting from low fluoride intake.

Turbidity, colour, taste and odour (smell), whether of natural or other origin, affect people's perceptions of water. As you know water should be free of tastes and odours that would be unpleasant to the majority of people. In extreme cases, people may avoid water that does not look or taste good – even if it is otherwise safe – in favour of more pleasant looking and tasting water that may actually be contaminated. Colour in drinking water occurs due to the presence of organic matter and metals such as iron and manganese. Odour in water is due mainly to the presence of organic substances. Taste is the combined perception of substances detected by the senses of taste and smell. Changes in the normal taste of a municipal water supply can be important as they may signal changes in the quality of the raw water source or deficiencies in the treatment process. Onsite testing is essential for the determination of turbidity and residual chlorine, which change rapidly during transport and storage.

Summary of Study Session 16

In Study Session 16, you have learned that:

1. Sanitary surveys play a major role in prevention and correction of water system deficiencies.
2. Sanitary surveys begin at the source of the water. Preventing source water contamination is the most effective means of preventing contaminants from reaching consumers.
3. Source water quality, quantity, location of water source and condition of the water source facilities are the key elements of a sanitary survey.
4. Sanitary surveys also include assessment of water use in the home and ensuring that household practices do not allow recontamination.
5. Wells, springs and rainwater cisterns are important sources of water to which you need to pay attention when you are doing sanitary surveys.
6. Faecal coliform bacteria and *E.coli* are used to test for the presence of faecal contamination and to indicate the likelihood of the presence of pathogenic organisms in drinking water.

Self-Assessment Questions (SAQs) for Study Session 16

Now that you have completed this study session, you can assess how well you have achieved its Learning Outcomes by answering the following questions. Write your answers in your Study Diary and discuss them with your Tutor at the next Study Support Meeting. You can check your answers with the Notes on the Self-Assessment Questions at the end of this Module.

SAQ 16.1 (tests Learning Outcome 16.1)

Which of the following statements is *false*? In each case explain why it is false.

A *E.coli* is a type of virus found in faeces.
B Faecal coliforms are typically found in human and animal faeces.
C The presence of *E.coli* in a water sample means the water is safe to drink.
D The absence of *E.coli* in a water sample means the water is safe to drink.

SAQ 16.2 (tests Learning Outcome 16.2)

In a village there is a protected dug well. The water is treated frequently by chlorine and contamination is avoided. However, you hear that there are several cases of diarrhoea in children. Where would you suspect the water could possibly be recontaminated and what would you do?

SAQ 16.3 (tests Learning Outcome 16.3)

Suppose you have a joint plan with environmental health experts to assess the quality of water from a well. What tests would you do?

SAQ 16.4 (tests Learning Outcome 16.3)

The people in Agita village have two possible water sources available to them – a protected well and a river. Water quality surveys were undertaken by you and environmental health experts. The results indicate that the river water is highly contaminated with pathogenic microorganisms, but it has a good taste. The well water is tasteless but is not contaminated with pathogenic microorganisms. How would you explain to the villagers that they should use water from the well?

SAQ 16.5 (tests Learning Outcome 16.4)

You are about to set off from your Health Post for a neighbouring village to conduct a sanitary survey of a protected spring. What would you take with you? Name four things you will be looking for during your survey.

Study Session 17 Water Pollution and its Control

Introduction

In the previous study sessions you have learnt about the importance of protecting water from contamination and the techniques for undertaking a sanitary survey of drinking water. In this study session, you will learn about the sources and types of water pollution, the public health impacts and indicators of water pollution and approaches to the control of pollution.

Learning Outcomes for Study Session 17

When you have studied this session, you should be able to:

17.1 Define and use correctly all of the key words printed in **bold**. (SAQ 17.1)

17.2 Describe the sources and types of water pollution. (SAQ 17.2)

17.3 Explain some techniques for the control of water pollution. (SAQ 17.3)

17.4 Describe techniques for taking samples from drinking water sources. (SAQ 17.4)

17.1 Sources of water pollution

Water is a good solvent. This is the reason why many different chemical substances are found dissolved in water. Gases in the atmosphere will dissolve in rainwater as it passes through the air. By the time water reaches a stream or river, it will contain a variety of chemical compounds dissolved within it from the air and from the rocks and soil through which it has percolated. These compounds may be completely harmless, naturally occurring substances, but they may also include pollutants.

Pollution can be defined as the introduction into the natural environment (air, water or land) of substances (**pollutants**) that are liable to cause harm to human health or to animals, plants and the wider environment. **Water pollution** occurs when a river, lake or other body of water is adversely affected due to the addition of pollutants (Figure 17.1).

Water quality can be affected by pollution from point sources and non-point sources. **Point sources** are identifiable points or places, such as a pipe or channel, which discharge directly into a body of water. This might be from wastewater treatment plants, factories and industrial plants, latrines, septic tanks or piped discharge from barnyards and other places where livestock are confined. **Non-point sources** are those where pollution arises over a wider area and it is often difficult to locate the exact place of origin. For example, fertiliser or pesticide washed from a field by rain may seep into a river or stream at many places both on the surface and through the soil. Pollution from non-point sources, also known as *diffuse pollution*, contributes most of the contaminants in rivers and lakes. Other non-point sources are pollution from construction sites and other land disturbances. The problems in identifying the exact point of origin make non-point sources much more difficult to control.

Figure 17.1 Washing lorries and cars in rivers is a source of water pollution. (Photo: Nicholas Watson)

- ■ Look at Figure 17.1. What pollutants are likely to be washed into the river from the lorry? Is this a point source or non-point source of pollution?
- □ Dust and dirt from the lorry will be washed into the river. Some oil and fuel may also be washed from the underside. The lorry is the single source of pollution so this is an example of a point source.

17.2 Types of water pollutants

17.2.1 Sediments and suspended solids

Sediments consist of fine particles of mostly inorganic material such as mud and silt washed into a stream as a result of land cultivation and construction. They may also arise from demolition and mining operations where these activities take place. The presence of solid particulate material suspended in the flowing water is the reason why many rivers look brown in colour, especially in the rainy season. The particles are called suspended solids while they are carried (suspended) in flowing water. When they settle to the bottom, they are called sediments.

Organic matter means anything that is derived from living organisms, i.e. all plants and animals. Inorganic matter has a mineral, rather than biological, origin meaning it comes from rocks and other non-living sources.

Large quantities of **inorganic matter**, in the form of suspended solids, may reduce light penetration into the water which can affect the growth of plants. Sediments may even suffocate organisms on the river bed. River water may also contain **organic matter**, such as human and animal wastes, which can deplete (reduce) the oxygen in the water if the river is slow-flowing (see Box 17.1). This can lead to anaerobic conditions which may create unsightly conditions and cause unpleasant odours.

Box 17.1 Oxygen in water

Many aquatic (water living) organisms depend on oxygen dissolved in the water to survive. Aquatic animals include fish, amphibians and many invertebrate species such as insect larvae, snails and worms. Their supply of oxygen in the water is maintained from atmospheric oxygen in the air above the water and from oxygen produced by green aquatic plants by the process of *photosynthesis*. Fast-flowing, turbulent water will be aerated (gain oxygen) more than still water because the boundary between air and water is more active.

If organic pollutants such as human and animal wastes are released into a water body, bacteria will use the waste as food and break it down into simpler, less harmful substances. As they do this, the bacteria will use up the dissolved oxygen from the water. This is called **deoxygenation**. If the quantity of organic pollution is high, then all the oxygen from the water may be used up leading to anaerobic (without oxygen) conditions. This is unlikely in a river where the water is moving but can happen in lakes or slow-flowing channels.

Inorganic solids, such as mud and silt, do not have this effect because they are inert (stable and inactive) and cannot be used as food by bacteria.

17.2.2 Nutrients

Phosphorus and nitrogen are common pollutants generated from residential areas and agricultural runoff, and are usually associated with human and animal wastes or fertiliser. Nitrogen and phosphorus are plant nutrients required by plants to grow. They are spread on farmland in the form of fertilisers. Rain washes these nutrients into rivers, streams and lakes. If the nutrients are present in large quantities, they can encourage excess plant growth in the water causing the phenomenon known as an *algal bloom*, which means a sudden increase in the population of microscopic algae. If a water body has high nutrient levels it is said to be eutrophic; the process is called **eutrophication**. The main problem of eutrophication is that the suddenly increased population of aquatic plants can die off equally quickly. The decay of the plant material by bacteria can cause deoxygenation of the water.

- ■ Can you think of a reason why eutrophication is more likely to be a problem in lakes than in rivers?
- □ Because flowing water in a river will disperse the nutrients; in the still water of a lake, the nutrients will accumulate.

17.2.3 Biological pollutants

Biological pollutants are microorganisms (bacteria, viruses, protozoa and helminths) that are harmful to humans and other forms of life. Infectious diseases caused by biological pollutants, such as typhoid and cholera, are the most common and widespread public health risks associated with drinking water.

Microorganisms may get into water with dust from the air as rain falls, and when water passes through soil which is polluted with human and animal wastes. The contamination of water supplies with raw sewage (human and domestic wastes generated from residential areas) is the most common route for biological pollutants to enter water.

When contaminated river water moves downstream it is possible that any pollutant will be diluted as more water flows in and so increases the total volume of water in the river. This dilution may be enough to reduce the contaminants sufficiently to minimise the possible health effects but this process may not work for all pathogens.

Bacteria

Many different types of bacteria are found in fresh water. They are not all pollutants because many are not harmful in any way and play a valuable role in the natural breakdown of organic matter and the cycling of nutrients. Other bacteria, however, as you have learnt in other sessions, are pathogens, and are the cause of many waterborne diseases. The presence of faecal coliform bacteria in drinking water, and *E.coli* in particular, can indicate a possible presence of harmful, disease-causing organisms.

Viruses

Enteric (intestinal) viruses are produced by infected persons and excreted in faeces. Viral contamination may come from sewage effluent discharged into a river or from open defecation by an infected person which may be washed by rainwater to a river or stream. Some enteric viruses are resistant to chlorination. The common waterborne viruses are polio, hepatitis A and rotavirus. The presence of any enteric virus in water bodies can be taken as an indication of the possible presence of other harmful viruses.

Protozoa

There are several protozoa that can be discharged into water bodies from infected persons. For example, *Cryptosporidium* and *Giardia* are common problems in rural parts of Ethiopia.

■ What type of household water treatment is appropriate for removing protozoa from drinking water?

□ A home sand filter is appropriate for removing protozoa from drinking water. The layers of sand and gravel will trap the protozoa.

Helminths

Helminths or parasitic worms can also cause ill health in humans. Infection occurs through ingestion of the helminth eggs which may be present in food. For example, helminth eggs may be present in the meat of cattle grazing on land contaminated by faeces.

■ Can you think of an example of a helminth infection that is transmitted by polluted water?

□ Guinea worm (dracunculiasis) is transmitted by drinking water that contains copepods infected by the larvae of the worm.

17.2.4 Chemical pollutants

Heavy metals

Arsenic, copper, lead, mercury and cadmium are chemical pollutants that may be found in lakes, rivers and groundwater. Fortunately these are not common problems in rural Ethiopia. These heavy metals can harm aquatic organisms and humans. Farmers who use river water polluted by urban wastes for irrigation of fruits and vegetables may find their crops affected by the accumulation of these chemicals.

Pesticides

Pesticides include insecticides, herbicides and fungicides. There are several thousand different types in use and almost all of them are possible causes of water pollution. For example, DDT, malathion, parathion, delthametrine and others have been sprayed in the environment for long periods of time for the control of disease vectors such as mosquitoes, and to control the growth of weeds and other pests.

17.2.5 Types of pollutant defined by their source

Pollutants from certain sources may be a mixture of the types described above and therefore need a separate category because they combine several possible impacts. Municipal wastewater and agricultural wastes are in this category.

Municipal wastewater is generated from residential areas and often contains high concentrations of organic matter, phosphorus and nitrogen, pesticides, toxic chemicals, salts, inorganic solids such as silt, as well as pathogenic bacteria and viruses.

Agricultural wastes are generated from livestock and poultry farming and from growing crops. They can be the source of many organic and inorganic pollutants in surface waters and groundwater. Agricultural wastes include sediment from erosion of cropland, and phosphorus and nitrogen compounds that originate in animal wastes and commercial fertilisers. Animal wastes require oxygen to be broken down in water bodies and can also harbour pathogenic organisms. The extensive use of fertilisers and pesticides in agricultural regions means that both surface and groundwater are affected by these pollutants.

■ What is likely to happen when fertiliser is washed off agricultural fields into a lake?

□ Fertiliser contains nitrate and phosphate, which are plant nutrients. If these are washed into a lake the water will become eutrophic (high concentrations of nutrients).

17.3 Public health impacts of water pollution

Waterborne infectious diseases are transmitted primarily through contamination of the water sources with excreta of humans and animals who are either active cases or carriers of disease. Carriers do not show any signs of disease although they have disease-causing agents in their body that can be transferred to others; active cases are people who are displaying visible signs of disease. Use of contaminated water for drinking or cooking, or contact with contaminated water during washing or bathing, may result in infection.

The dose or amount ingested that is necessary to cause illness depends on the type of pathogen. Exposure to a single pathogenic organism does not always result in infection and disease. Sometimes many pathogens, perhaps several hundred, must be ingested to cause infection. The minimum infectious dose also varies with the age, health, nutritional and immunological status of the exposed individual. Infants and young children, people who are debilitated, people who are living in unsanitary conditions, people who are sick and the elderly are at greatest risk of waterborne diseases.

17.4 Indicators of water pollution

The physical, chemical and biological characteristics of water are changed when the water is contaminated with different pollutants. Water is colourless, odourless and tasteless, as you know, but when it is polluted with physical and chemical pollutants the water may have colour, odour and taste.

- ■ If water is completely clear and has no colour or odour, is it safe to drink?
- □ Not necessarily, because it may contain microorganisms or dissolved chemicals that cannot be seen.

To know whether water is polluted with specific bacterial contaminants, samples should be taken and sent to a laboratory for analysis. As noted in Study Session 16, *E.coli* is the standard indicator organism for faecal contamination of water and for the possible presence of faecal pathogens. For water intended for drinking, the World Health Organization (WHO) recommends that *E.coli* must not be detectable in any 100 ml sample. In most developing countries like Ethiopia the priority is to get from 'bad' quality (more than 1,000 faecal coliforms per 100 ml) to 'moderate' quality (less than 10 faecal coliforms per 100 ml). 'Good' quality is classed as zero faecal coliforms per 100ml.

17.5 Effects of pollution on water sources

17.5.1 Streams and rivers

Streams and rivers are not only potential water sources for humans, they are also important aquatic habitats for many plants and animals. Pollution can have a damaging effect on aquatic ecosystems (see Box 17.1) as well as potentially on human health.

Box 17.1 Aquatic ecosystems

Ecosystem was defined in Study Session 2. It means a community of living organisms that interact with each other, plus the environment in which they live and with which they also interact. An ecosystem therefore includes plants, animals and microorganisms and their physical environment which may be land, trees, soil, ocean, freshwater, etc., and also includes the relationships between all these components. Aquatic ecosystems can be categorised as marine ecosystems in the ocean, and freshwater ecosystems in rivers, lakes and other surface water bodies (Figure 17.2).

Figure 17.2 Lakes and rivers are important aquatic ecosystems supporting many forms of life in and around the water. (Photos: Pam Furniss)

The effect of pollution on streams and rivers depends on the type of pollutant. Some substances are acutely toxic to aquatic plants and animals and will cause dead zones downstream from the pollutant source in which no living organism is found. Other pollutants are health concerns to humans, but have little impact on aquatic communities.

One of the most common types of freshwater pollutant is biodegradable organic material. When a high concentration of organic material such as raw sewage (human excreta) is discharged into a stream, the levels of dissolved oxygen in the water may fall so low that the water is completely deoxygenated.

■ Why does the dissolved oxygen level fall if organic material pollutes a river?

□ Bacteria that break down the organic material require oxygen to survive. They use the oxygen dissolved in the water causing the level to fall.

17.5.2 Lakes

The effect of pollution on lakes differs in several respects from the effect on rivers. Water movement in lakes is slower than in rivers so re-aeration is slower. The reduction in flow rate as a stream enters a lake also causes sediments to settle out of the water and slowly accumulate on the bottom of the lake. Some pollutants are bound to the solid particles and will therefore also accumulate in the sediment.

17.5.3 Groundwater

Water that moves through the soil will, to some extent, be purified naturally. However, this is not always true because soil cannot remove all pollutants. Many soils have the ability to remove certain types of pollutants, including phosphorus, heavy metals, bacteria and suspended solids. However, pollutants that dissolve in water, like nitrate and ammonia from fertilisers and animal wastes, can pass through soils into the groundwater. This may cause high concentrations of pollutants in local drinking water wells. Leaking from underground storage tanks, solid waste landfills, improperly stored hazardous waste, careless disposal of solvents and hazardous chemicals on ground surfaces are other potential sources of groundwater pollution.

- ■ Why is it important for pit latrines to be located at least 15 metres from the nearest well and at a lower level?
- □ Because, depending on the local geology, liquid from the pit could flow through rock and soil into the groundwater and to the well. If the latrine is at a lower level than the well, the effect of gravity will make groundwater contaminated from the pit flow away from the well.

17.6 Problems of using polluted water

The impacts of using contaminated water for drinking have been discussed in other study sessions. However, we use water for other purposes that can also be affected by water pollution such as irrigation, for livestock and for recreation.

Contaminants in irrigation water (Figure 17.3) may accumulate in the soil and, after a period of years, render the soil unfit for agriculture. Even when the presence of pesticides or pathogenic organisms in irrigation water does not directly affect plant growth, it may potentially affect the acceptability of the agricultural product for sale or consumption.

Figure 17.3 An irrigation channel carries water from the river to the fields. (Photo: Pam Furniss)

Poor quality water can affect livestock by causing death, sickness or impaired growth. Some substances, or their degradation products, present in water used for livestock may occasionally be transmitted to humans. The purpose of good quality water used for livestock watering is, therefore, to help protect both the livestock and the consumer.

Contaminated water also has health problems for those who swim in it. They may become ill if the water is contaminated with faecal material or with microorganisms that could cause gastrointestinal illness or ear, eye or skin infections. For example, schistosomiasis is contracted simply by swimming or standing in water that is contaminated with the *Schistosoma* worm.

17.7 Control of water pollution

The control of pollution should ideally take place at the point of generation, or, in other words, it should be prevented at source. As you have learned from the sanitary survey, you should look out for possible sources of pollutants in your locality.

The control of excess nutrients is an important issue both from a public health perspective and to keep natural waters free from eutrophication. An increasing proportion of water pollution originates from diffuse (non-point) sources, such as agricultural use of fertilisers. Farmers may need guidance on good agricultural practices that will help reduce water pollution from agriculture. For example, the amount of fertiliser used and the timing of its application can make a significant difference.

■ Imagine you are a farmer thinking about the best time to apply fertiliser to your field. Would it be better to spread the fertiliser before or after heavy rain?

□ It would be better after the rain because if the fertiliser was spread beforehand then much of it would probably be washed away. This would not only pollute the nearest river but would, of course, also reduce the effectiveness on the crop.

Pollution prevention is best achieved by ensuring that each potential point source is properly sited, designed, constructed and managed; the aim being to contain the pollutants and prevent their uncontrolled release to the environment. Sources of pollution should be sited as far from watercourses as possible (at least 15 m away) and below any water sources on the site. Appropriate use of excreta disposal, solid waste disposal and animal waste disposal will help prevent contamination of both surface and groundwater. (You will learn more about this in the waste management study sessions that follow.)

Springs usually become contaminated when latrines, animal yards, sewers, septic tanks, cesspools or other sources of pollution are located on higher land nearby. In areas with limestone rocks, contaminated material can enter the water-bearing channels in the rock and descend through cracks and holes or other large openings and may be carried along with groundwater for long distances. Other rock types can have a similar effect so it is important to have knowledge of the local geology to assess the probability of groundwater contamination.

■ What are the key preventive measures that will help to ensure that spring water is of a consistently high quality?

□ The key measures are:

- Dig a diversion ditch above the spring that will take surface water away from it.
- Build a fence to keep animals away from the spring.
- Design and build a protection box for the spring that will prevent contamination.
- Monitor the condition of the spring and the quality of the water regularly.

Monitoring of the quality of spring water and other sources would be done by you and environmental health experts.

For rainwater harvesting, pollution control means proper maintenance of the roof and gutters and careful cleaning at the beginning of every wet season. Some form of mesh should be placed between the guttering and the pipe that leads to the storage tank to prevent the entry of coarse debris; it then becomes important to clean the screen regularly to prevent blockage. The worst fouling of roofs occurs when they are situated under trees in which birds roost. A rainwater storage tank should be completely covered and well maintained.

The *catchment area* of the water source is the total area of surrounding land that slopes towards the source. Water can become polluted from sources in the catchment even though they may be some distance away. Ideally, the whole catchment area should be protected to avoid pollution and erosion. Preserving the vegetation in the surrounding area can help protect the spring from pollution and from siltation caused by soil erosion.

17.8 Sampling methods for bacteriological testing

During the course of an investigation into a disease outbreak or as part of routine monitoring, you may be required to take water samples to be sent for microbiological or chemical analysis. It is important that samples are taken carefully and correctly to ensure they can be used for an accurate assessment of the condition of the source. When water samples are collected for analysis, you should take care to ensure that there is no external contamination of the samples. Glass bottles, rather than plastic, are best used for sampling. Both bottles and stoppers (caps) must be sterilised. Bottles should be clearly labelled with the place where the sample was taken and the date. You should be able to obtain sample bottles from your regional public health microbiology laboratory or your local environmental health office.

You may need to take water samples from a tap, river, lake, water tank or dug well, and each has a slightly different procedure to follow.

17.8.1 Sampling procedure from a tap or pump outlet

To obtain a representative sample of water, you should carefully follow the sampling procedure described below and illustrated in Figure 17.4. The steps are:

- Clean the tap/outlet using a clean cloth to remove any dirt.
- Open the tap and turn on at maximum flow and let the water run for 1 to 2 minutes; then turn it off.
- Sterilise the tap for a minute with the flame from a cigarette lighter, or an ignited alcohol-soaked cotton-wool swab.
- Open the tap again and allow the water to flow for 1 to 2 minutes at a medium flow rate.
- Open a sterilised bottle by carefully unscrewing the cap or pulling out the stopper.
- Immediately hold the bottle under the water jet and fill.
- While filling the bottle, hold the cap face downwards to prevent entry of dust, which may contaminate the sample.
- Place the stopper in the bottle or screw on the cap. A small air space should be left to make shaking before analysis easier.

Figure 17.4 Procedures for sampling water from a tap. (Source: WHO, 1997, *Guidelines for drinking water quality*, Volume 3)

17.8.2 Sampling procedure from a watercourse or reservoir

The steps are:

- Open the sterilised bottle as described above.
- Fill the bottle by holding it by the lower part and submerging it to a depth of about 20 cm, with the mouth facing slightly upwards. If there is a current, the bottle mouth should face towards the current (Figure 17.5).
- The bottle should then be capped or stoppered.

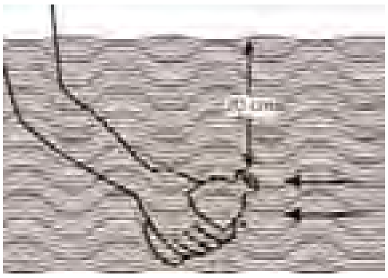


Figure 17.5 Sampling of water from surface water (rivers, ponds etc.). (Source: as Figure 17.4)

17.8.3 Sampling procedure from dug wells and similar sources

The steps are:

- Prepare the bottle with a piece of string and attach a clean weight to the sampling bottle. (Figure 17.6)
- Take a 20 m length of clean string rolled around a stick and tie it to the bottle string.
- Open the bottle as described above.

- Lower the bottle, weighed down by the weight, into the well, unwinding the string slowly. Do not allow the bottle to touch the sides of the well.
- Immerse the bottle completely in the water and lower it well below the surface but without hitting the bottom or disturbing any sediment.
- Raise the bottle when it is judged to be filled, rewind the string on the stick to bring up the bottle. If the bottle is completely full, discard some water to provide an air space.
- Stopper or cap the bottle as described previously.

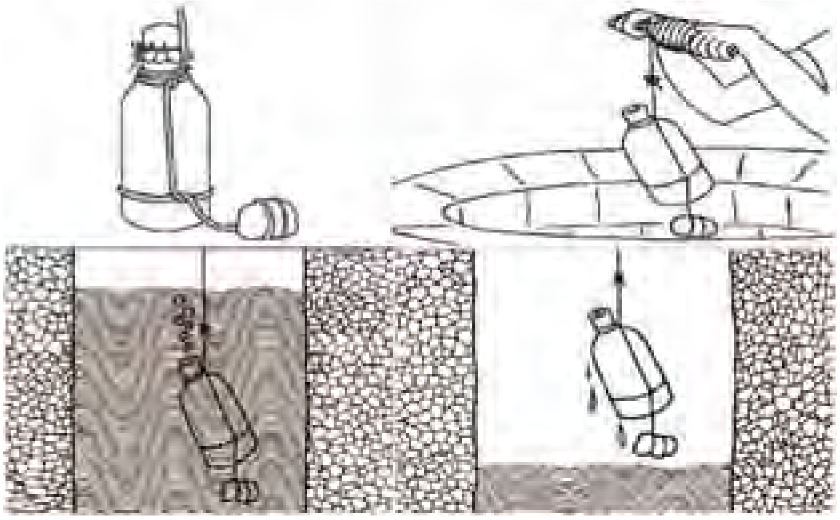


Figure 17.6 Procedure for sampling water from a well. (Source: as Figure 17.4)

Summary of Study Session 17

In Study Session 17, you have learned that:

1. Water pollution is any contamination of water with substances that are detrimental to human, plant or animal health.
2. Water pollutants can be of point or non-point source depending on whether substances are discharged directly into a body of water or indirectly from diffuse sources.
3. There are various types of water pollution including organic and inorganic sediments, nutrients, biological and chemical pollutants.
4. Biological pollutants include bacteria, viruses, protozoa and helminths. They enter the water from human faeces from infected people and are the cause of many water-related diseases.
5. The effects of water pollution on an aquatic ecosystem depend on the type of pollutant and the type of water body.
6. Ideally pollution control should take place at the point of origin, i.e. pollution should be prevented at source.
7. There are specified procedures to follow when taking a water sample for analysis to ensure the sample is representative.

Self-Assessment Questions (SAQs) for Study Session 17

Now that you have completed this study session, you can assess how well you have achieved its Learning Outcomes by answering the following questions. Write your answers in your Study Diary and discuss them with your Tutor at the next Study Support Meeting. You can check your answers with the Notes on the Self-Assessment Questions at the end of this Module.

SAQ 17.1 (tests Learning Outcome 17.1)

Match the words in list A with the corresponding phrases in list B, by drawing an arrow between them.

A	B
Contaminant	Diffuse source of pollution
Eutrophication	The source of pollutants is visible at time of discharge
Point source pollution	A foreign component in a substance
Non-point source pollution	High levels of plant nutrients in water

SAQ 17.2 (tests Learning Outcome 17.2)

In the village of Felashit, there are two dug wells. Some villagers fetch water from the eastern well and another group fetches water from the well dug on the western part of the village. The residents in the eastern part of the village are suffering from an outbreak of diarrhoea. What might be the possible reasons for this?

SAQ 17.3 (tests Learning Outcome 17.3)

Suppose you are working in a village and the community members want to know how they should protect their water source from pollution. What pollution control techniques would you tell them about?

SAQ 17.4 (tests Learning Outcome 17.4)

Imagine that you have been asked to take water samples from the two wells in Felashit village for chemical and microbiological analysis. What would you do to ensure that accurate samples were taken?

Study Session 18 Introduction to the Principles and Concepts of Waste Management

Introduction

In this study session you will learn about the basic concepts and principles of waste management. The definition of common terms and discussion of the concepts, principles and classification of wastes will help you understand the subject of waste management. You will also learn about the public health importance of solid waste and liquid waste management, and be introduced to the basic principles and process of waste decomposition. This is relevant for you to understand how waste is decomposed and can be treated or made safe from pathogenic organisms.

Learning Outcomes for Study Session 18

When you have studied this session, you should be able to:

18.1 Define and use correctly all of the key words printed in **bold**. (SAQ 18.1)

18.2 Outline the basic concepts and principles in waste management. (SAQs 18.2 and 18.3)

18.3 Describe the public health importance of solid and liquid waste management. (SAQ 18.4)

18.4 Identify the main types of waste and their sources. (SAQ 18.5)

18.1 Basic principles and concepts of waste management

Waste is introduced into the environment due to the day-to-day activities of humans. **Waste management** refers to the many methods and processes of dealing with waste at every stage from generation and collection through to final disposal.

Waste needs to be managed in order to prevent contact with humans or their immediate environment. Therefore, the main purpose of waste management is to isolate waste from humans and the environment, and consequently, safeguard individual, family and community health. In addition, the aesthetic value of a better outlook and a clean physical environment is important for our emotional wellbeing.

The waste we produce can be categorised as **liquid waste** or **solid waste** depending on its physical state. It can also be categorised as hazardous or non-hazardous (see Box 18.1).

Box 18.1 Hazardous and non-hazardous waste

Hazardous wastes are not classified by their physical state (solid, liquid or gas) but by their properties and potential to cause harm. Hazardous wastes are defined as wastes that have one or more of the following properties. They may be:

- corrosive (substances that cause damage on contact, e.g. acids)
- ignitable (materials that can catch fire easily like benzene)
- toxic (materials that can be poisonous to humans when inhaled or ingested, or come in contact with skin or mucous membranes)
- reactive (substances that can yield a harmful chemical if they react with other substances)
- infectious (substances that are capable of causing or communicating infection).

Potential sources of hazardous waste in rural households include obsolete pesticides, herbicides or rodenticides.

Non-hazardous wastes include all other types of waste.

18.1.1 Liquid waste

Liquid waste includes human waste, runoff (storm water or flood water), sullage, industrial wastewater and other forms of **wastewater** from different sources. Human waste is mainly composed of faeces and urine, which together are known as **excreta**. All human body waste is classed as liquid waste. The mixture of human waste with wastewater is known as **sewage** and also sometimes known as **blackwater. Runoff** is simply rainwater that collects on the ground and runs off into channels, ditches and rivers. **Sullage**, also known as **greywater,** is water that has been used for washing in bathrooms and kitchens; it does not include human waste.

Human waste is **biodegradable** (see Box 18.2) and when contained in a waste containment facility (for example, a pit latrine or septic tank) it undergoes a biological digestion process by which microorganisms, particularly bacteria, decompose the organic matter. The decomposing bacteria found in pit latrines and septic tanks do not require oxygen and are called *anaerobic* bacteria. The digestion process may take from several days to a few months, depending on the atmospheric temperature and other local conditions, before it is completely decomposed or degraded. The digested waste matter is called **sludge.**

Box 18.2 Biodegradable and non-biodegradable wastes

Biodegradable wastes are those that can be broken down (decomposed) into their constituent elements by bacteria and other microorganisms. The term can be applied to both liquid and solid waste. Human and animal wastes, food waste, paper, and agricultural wastes are all biodegradable. This natural biological decomposition process ensures that, under the right conditions, these wastes do not accumulate in the environment.

Many plastics are not biodegradable and these create environmental problems because they remain unchanged for many years (Figure 18.1). The bacteria responsible for biodegradation may be **aerobic**, meaning they require oxygen, or **anaerobic**, meaning they do not need oxygen to survive. Decomposition of biodegradable wastes by anaerobic bacteria is sometimes called digestion.

Figure 18.1 Non-biodegradable plastics are a problem because they persist in the environment and do not decompose. (Photo: Pam Furniss)

- ■ Do you think human waste is a danger to health?
- □ Yes it is. Human waste must be considered as potentially infectious matter because it may contain pathogenic organisms.

Although human waste is a potential source of disease, the amount of human faeces disposed of indiscriminately in open fields and under bushes, mostly in rural settings of Ethiopia, is a major problem. In rural areas, a large proportion of households do not have pit latrines and although this situation is changing, open defecation continues to be widely practised. Open defecation can spread disease, contaminate the soil and pollute drinking water sources, as discussed in previous study sessions. To avert these risks, households and communities should work towards community goals to be 'open defecation free'. This can be achieved through the building, and consistent use of, onsite communal or human waste disposal facilities. You will learn more about this in later sessions of this Module. Onsite facilities are, for example, pit latrines built in the compound of households; communal or public facilities are latrines built in streets or in market places. These public latrines are also referred to as municipal facilities.

18.1.2 Solid waste

Solid waste is defined as any waste that is dry in form and is discarded by people as unwanted. You can describe the solid waste from general housekeeping as residential waste, refuse, household waste or domestic waste. Waste produced in other areas is defined as industrial, commercial, institutional or agricultural waste, or street sweepings, depending on its source. In urban settings, municipal waste refers to the solid waste that is collected by local government (the municipality) and may include household, commercial, industrial waste and street sweepings. The solid waste that is produced as a result of food preparation, or any foodstuff leftover after eating, is called kitchen waste or garbage.

Understanding the appropriate methods for the management of solid waste is closely related to the characteristics of the waste and therefore to its source. Considering the sources one by one:

(a) Residential waste or domestic waste is generated from households. It is mostly characterised as non-hazardous wastes, especially in rural households. It may include rubbish, such as packaging materials, kitchen wastes, ash, etc.

(b) Agricultural solid wastes could include food residues, animal dung, crop residues, grass and leaves. Such wastes are mostly non-hazardous and biodegradable in nature. However, containers for used or obsolete pesticides, herbicides and rodenticides could be a health hazard to families and sprayers. Therefore, these items should be safely removed in collaboration with the agricultural development extension agents in your *kebele*.

(c) Commercial wastes are those generated from business establishments, food and drink service establishments, shops, or open market places. These vary a great deal but may include packaging paper, cardboard, electronics, timber, wire, metals, plastic bags (*festal*), tin cans, garbage and other wastes that are generally of non-hazardous nature.

(d) Industrial waste can be produced from small, medium or large-scale industries. The type of waste produced may vary depending on the raw material used and the product of the industrial process. These wastes may be hazardous or non-hazardous, depending on the process. The solid waste produced could contain chemicals, wood, metal, ceramic or other components.

(e) Institutional solid waste is produced from public or government institutions, offices, schools, universities, religious institutions, sporting fields, etc. It can be very mixed in its components.

(f) Healthcare waste is produced from healthcare facilities such as Health Posts, health centres and hospitals. This category of waste is composed of both hazardous (infectious) and non-hazardous wastes (also referred to as general waste). The management of healthcare waste needs special attention and is discussed in Study Session 23.

The rate of production and characteristics of residential or domestic solid waste depends on cultural habits, urbanisation, season of the year and the agro-ecological zone of the area.

- ■ Can you think of some differences in the kitchen waste produced in the dry and wet seasons?
- □ Your answer will depend on where you live and the type of foodstuff that is ripe during that particular season but you may have answered leaves of maize and maize husk, peelings of potatoes or sweet potatoes during the wet seasons and pods of chick peas (*shimbra tirtir*) during the dry season.

Urban and affluent societies tend to produce greater quantities of solid waste than rural communities. Rural waste comes from households and agricultural activities and is mostly organic and biodegradable in nature. This makes it suitable for making **compost**. Compost is a mixture of decomposed organic matter, mostly of plant origin, that can be used to improve soil structure and to return nutrients to the land.

Solid waste generated from households in your community will consist mostly of organic decomposable matter that will be broken down through bacterial action. In urban areas, where there is a large amount of solid waste, it is usually taken to a **landfill site** for disposal. Landfill sites, also known as dumps or rubbish dump sites, are sometimes located in places such as former quarries where the waste can be used to fill in a hole in the ground, hence the name 'land fill'. In landfill sites and some community waste disposal sites, the solid waste decomposition process will produce **leachate**. Leachate is formed when the liquid fraction from a mixed solid waste is separated by gravity from the solid component. Unless controlled, the leachate will seep out from the bottom of the waste tip and can pollute surface and groundwater. It may contain toxic chemicals in addition to pathogenic microorganisms. The **biosolid**s (the solid fraction) as well as the leachate formed in this process need to be disposed of safely in a way that will not affect the environment or human living conditions.

18.2 Public health importance of waste management

How does waste management affect public health and the environment? Improper disposal of wastes, such as solid waste, human excreta and sewage, is one of the major risk factors that affect the health and comfort of individuals in rural Ethiopia where municipal or onsite facilities do not exist, or are not functional.

- ■ Name three diseases or pathogens that are transmitted in human waste.
- □ There are many possible answers. You could have said diarrhoea, trachoma, amoebic dysentery, giardiasis, rotavirus, cholera, salmonellosis, shigellosis and other diarrhoeal diseases. In addition, you may have mentioned hookworm, roundworm, whipworm, tapeworms, schistosomiasis, filariasis, leptospirosis and many more. A very long list!

Poor waste handling and disposal can lead to environmental pollution, encourage the breeding of disease-vector insects, animal scavengers and rodents, and result in a range of diseases through different routes of exposure such as faeco-oral and soil transmitted mechanisms.

Figure 18.2 shows these routes of exposure diagrammatically; you may remember this diagram from Study Session 1. In this figure, you can see that faeces are the common source of contamination to the other 'Fs' – fluids, fingers, fomites and flies. These then contaminate our food and, consequently, a new susceptible human host.

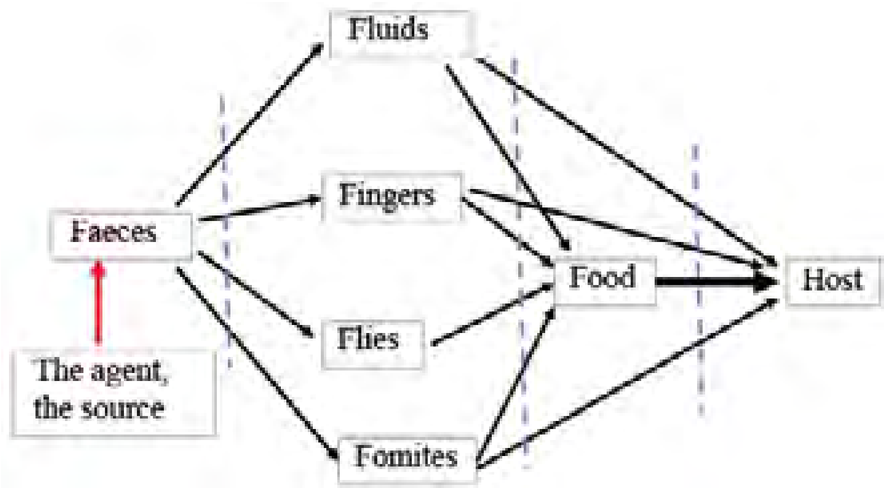


Figure 18.2 The 'F-diagram' showing the faeco-oral disease transmission pathways.

Survey studies conducted in different parts of Ethiopia indicate that there are many highly prevalent faeco-orally transmitted intestinal parasites and other infectious agents (bacteria and viruses) in our environment. To break the transmission route of these disease agents, there needs to be **total sanitation**, which means prevention of any human contact with waste, i.e. no open defecation and the proper handling of solid waste. The broken lines in Figure 18.2 show the points at which a barrier or intervention can be made to prevent transmission. The first line of defence is to contain the faeces. The second is to protect the food from contamination and the third is to protect the potential host, the person who may become infected, from contaminated food, fingers, drinking water or other objects. To achieve total sanitation, the community needs to be involved in any plan to clean the local environment and must initiate its own waste disposal methods. You will learn some of the techniques that are used to encourage this sort of behavioural change in Study Session 21.

In addition to the dangers of disease transmission, health hazards associated with improper solid or liquid waste disposal include:

- Public or community nuisance due to foul odour and unsightliness of open defecation faecal matter and openly dumped solid wastes.
- Obstruction of drainage systems leading to creation of favourable conditions for disease vector breeding sites.
- Fire hazards.
- Psychological health hazards.

18.3 Main components of waste management

In any waste management process, there is a stage when waste will be temporarily stored or contained onsite (i.e. in the place where the waste is produced). This may be temporary or be a final disposal site. If storage is temporary, then subsequent stages will be the transfer or transport to a treatment facility or technology, followed by final disposal offsite (i.e. away from the waste generation site).

18.3.1 Liquid waste management

Liquid waste management will include both onsite sanitation and offsite treatment and disposal methods. The most usual method of onsite liquid waste containment in rural Ethiopia is the pit latrine. Pit latrines are simple drop-and-store systems in which the liquid waste collects in a pit below. There are many different designs of pit latrine (Figure 18.3 and Figure 18.4), which are described in more detail in Study Session 20.

Figure 18.3 A traditional pit latrine. (Photo: Worku Tefera)

Figure 18.4 Ventilated improved pit (VIP) latrine. (Note the vent pipe emerging through the roof). (Photo: Worku Tefera)

In places where water is more easily available, typical methods are drop-flush-and-discharge systems, also known as water carriage systems, such as the pour-flush latrine (Figure 18.5) or a water closet (WC) (Figure 18.6).

Figure 18.5 Pour-flush latrine. (Photo: Eawag)

Figure 18.6 Water closet (WC) toilet. (Photo: Worku Tefera)

Wastewater from water carriage systems may be piped into a septic tank or into a community or municipal treatment system, if one exists. The various types of latrine and methods of liquid waste management are discussed in more detail in Study Sessions 19 and 20.

18.3.2 Solid waste management

Solid waste management can be classified into five main stages. These stages are also referred to as the *functional elements* of solid waste management. These are:

- onsite handling, storage and processing
- collection
- transfer and transport
- resource recovery and processing
- disposal.

Onsite handling, storage and processing methods are undertaken at household level. This includes compacting waste by squashing it and changing its size and shape for easy handling. It also includes sorting the waste in order to separate the items that can be reused or recycled. For example, organic wastes should be separated out for composting as part of onsite handling. Bottles and cans can be reused. Collection and transfer or transport activities are not common in rural areas because the waste is usually disposed of immediately onsite in a prepared waste disposal or composting pit. (The five functional elements of solid waste management are discussed in more detail in Study Session 22.)

Ideally, waste management should go beyond pollution prevention and disease prevention for humans and should benefit society by providing economic gain for families and communities. The preferred approach for dealing with solid waste is **integrated solid waste management** (ISWM). ISWM means considering not only the appropriate disposal of solid waste but integrating this with other management options such as minimising waste production, recycling, composting and other waste recovery options. The advantages of ISWM are that it considers all options and aims to manage waste in ways that are most effective in protecting human health and the environment. ISWM can also have many economic and social benefits for your community. For example, you could consider composting of human waste and animal manure to produce natural fertiliser for gardening and for cultivating vegetables and crops. Some solid wastes can be recycled or reused. You could also consider helping your community in the development of a **biomass** waste digestion plant that will produce **biogas** to be used for cooking and lighting energy. Biomass is any biological material from living or recently living plants that is used to generate energy, usually in the form of biogas.

18.4 Compare the different waste management methods

There are a range of **sanitation technologies** currently in practice that you may want to recommend to institutions, communities and households in your area. ‘Sanitation technologies’ is a general term used to describe any kind of waste treatment and disposal. It can refer to specific infrastructure, methods or services that are designed to contain, transform or transport waste. It therefore includes the facility used by the person, such as pit latrines, WCs, etc. and also the storage/treatment processes such as septic tanks, biogas reactors etc.

The effectiveness and efficiency of waste management facilities varies greatly because of the advantages and disadvantages each one of them has in terms of capacity to remove pathogenic organisms, cost of the technology, acceptability of the sanitation technology by the end users such as families and individuals, and the skill level needed for proper operation and maintenance of the scheme. If you have a good understanding of the different sanitation technologies then you will be able to identify those that are appropriate for your community. An appropriate sanitation technology is one that is economically affordable, socially acceptable and environmentally sustainable. You will then be in a good position to offer advice to household heads, community leaders, *kebele* leaders, sectoral government officers, local institutions such as schools and private firms about their choice of technology.

In later sessions we will discuss the advantages and disadvantages of different solid and liquid waste disposal methods that can be used at communal and individual household level so that you can apply your knowledge to your local situation.

Summary of Study Session 18

In Study Session 18, you have learned that:

1 Waste can be categorised as solid or liquid waste based on its physical state. It can also be categorised as hazardous and non-hazardous waste.

2 Liquid waste includes human waste, runoff (flooding), sullage (or greywater) and other forms of wastewater from different sources.

3 Solid waste is any dry waste that is discarded by people because they no longer need it. It can arise from households, industrial, commercial or agricultural activities, or from streets.

4 Human waste is biodegradable, meaning it will decompose by a biological process due to microorganisms, particularly bacteria.

5 The type, generation rate and characteristics of solid waste depend on the source of the waste and on cultural habits, urbanisation, season of the year and the agro-ecological zone of the area.

6 Poor waste management could result in various diseases, accidental fire or nuisance conditions for the environment and families.

7 Properly managed waste could benefit your community socially and economically by recycling and reusing waste, where possible.

8 The main components of solid waste management include onsite handling, storage and processing; waste collection; transfer and transport of solid waste; and waste recovery and final disposal.

Self-Assessment Questions (SAQs) for Study Session 18

Now that you have completed this study session, you can assess how well you have achieved its Learning Outcomes by answering these questions. Write your answers in your Study Diary and discuss them with your Tutor at the next Study Support Meeting. You can check your answers with the Notes on the Self-Assessment Questions at the end of this Module.

SAQ 18.1 (tests Learning Outcome 18.1)

The Glossary Game: Write down each of the key words printed in **bold** in this study session. Cut the paper into strips, with one word on each strip; fold them and put them into a bowl. Take a strip, read the word and write a definition in your Study Diary. Then check your definition with those in the study session.

SAQ 18.2 (tests Learning Outcome 18.2)

Waste can be categorised as solid or liquid, and as hazardous or non-hazardous. Give an example of a:

1 solid non-hazardous waste
2 liquid non-hazardous waste
3 solid hazardous waste
4 liquid hazardous waste.

SAQ 18.3 (tests Learning Outcome 18.2)

What is the main purpose of waste management?

SAQ 18.4 (tests Learning Outcome 18.3)

Outline three benefits for public health that can be provided by proper waste management.

SAQ 18.5 (tests Learning Outcome 18.4)

Match the types of solid waste in list B with the sources in list A by drawing an arrow between them.

A	B
Agricultural	Coffee bean shells
Commercial	Needles and other sharps
Healthcare	Manures
Coffee processing	Packaging materials, plastics

Study Session 19 Liquid Waste Management

Introduction

In general, in Ethiopia the management of liquid waste is poor. In the previous study session, you were introduced to the concepts and principles of waste management. In this session, you will learn the definitions of key terms in liquid waste management. You will also identify the types and sources of liquid waste and learn about the different liquid waste disposal methods. We will also consider the issues to be taken into account when choosing sanitation technologies.

- ■ Do you remember the definition of sanitation used in Study Session 1?
- □ Sanitation was defined as the prevention of contact between humans and waste.

According to the World Health Organization, sanitation generally refers to the provision of facilities and services for the safe disposal of human urine and faeces. It therefore means much the same as liquid waste management. Sanitation methods aim to decrease the spread of disease by ensuring that wastewater, excreta and other wastes are adequately treated. This session will help you to respond to the sanitation needs of families and institutions.

Learning Outcomes for Study Session 19

When you have studied this session, you should be able to:

19.1 Define and correctly use the key words printed in **bold**. (SAQ 19.1)

19.2 Identify the types and sources of liquid waste. (SAQ 19.1)

19.3 Describe some different methods of liquid waste disposal. (SAQ 19.1)

19.4 Identify issues to be considered when choosing sanitation technologies. (SAQ 19.2)

19.1 Types and sources of liquid waste

In Study Session 18 you learned that liquid waste includes human waste, sullage, industrial waste and runoff (also referred as storm water or flood water).

- ■ What is the difference between sewage and sullage?
- □ Sewage includes human wastes (i.e. faeces and urine), as well as wastewater from various sources. Sullage is the wastewater that arises from domestic activities such as washing in bathrooms and kitchens, including water from food preparation and dishwashing; it does not contain human excreta.

Human waste and sullage can arise from public institutions such as schools, as well as from individual households. Industrial waste arises from different industries as a result of processes to produce goods and services. The content of industrial waste may vary depending on the type of industry, the raw materials (inputs) used and the processes undertaken. Industrial waste may be toxic and thus hazardous in nature, or it could contain non-hazardous substances. Therefore, unlike the other types of liquid waste, some industrial wastes may require special treatment before discharge from the industry.

Runoff is simply flood water that arises from rain or the release of collected water from a pond or dam. It can carry many types of wastes along with it, including human waste. Therefore, it is potentially harmful to the health of the community. Liquid waste is also produced in healthcare facilities but this will be dealt with in detail in Study Session 23.

19.2 Management of liquid waste

Management of liquid waste focuses on finding a way to dispose of the waste in a way that is safe for humans and the environment. For this reason, the word 'disposal' is often used to mean the same as management in this context.

19.2.1 Human waste management

The basic requirements expected from a human waste (excreta) disposal method are:

- Surface water must not be contaminated.
- There should be no contamination of groundwater that may, in turn, contaminate springs or wells.
- Excreta should not be accessible to flies or other animals.
- There should be no handling of excreta; where this is unavoidable, it should be kept to a minimum.
- There should be no odours or unsightly conditions.
- The method used should be simple and inexpensive in construction and operation.
- The method should last for at least five years to be cost-effective.

In Study Session 18 you were introduced to some of the sanitation technologies that are used for human waste management. You may recall that WCs and pour-flush facilities were classed as wet or water carriage systems, also called drop-flush-and-discharge systems. The **aqua privy** or water privy is another in this group. Aqua privies consist of a latrine constructed above a watertight tank containing human waste and water. The wastewater from these systems is usually discharged to a septic tank or to sewers which carry it to a liquid waste treatment plant. The presence of adequate water is essential for all wet systems. For this reason, and also because of the cost involved, they are not recommended in most rural places where there is inadequate running water. For such areas, the recommended methods of sanitation are dry or non-water carried systems where there is no water needed to carry the waste offsite. In Study Session 20 you will learn more about the construction of pit latrines and other dry systems. Pit latrines are the most common type of latrine in Ethiopia.

Sanitation facilities have been classified in a different way by the WHO/UNICEF Joint Monitoring Programme (JMP), as ‘improved’ or ‘unimproved’.

Improved sanitation services or methods include:

These improved sanitation methods are described in Study Session 20.

- WC or flush toilet to piped sewer system or septic tank
- pour-flush latrine
- pit latrine with slab
- ventilated improved pit (VIP) latrine
- ecological sanitation (a type of latrine that converts human waste into useful material without damaging the environment or endangering human health).

Unimproved sanitation methods are all those that do not ensure there is no human contact with human excreta (see Figure 19.1). They include:

- service or bucket latrines (where excreta are manually removed)
- pit latrine without slab
- open latrines
- excretion in the environment (or simply, open field defecation).

Figure 19.1 An open latrine with no privacy for the user and an insecure cover of logs – an example of unimproved sanitation. (Photo: Pam Furniss)

■ Pit latrines may be classed as either improved or unimproved depending on the presence of a slab. Why does the presence of a slab make this important difference?

□ The slab that covers the pit is essential for ensuring there is no contact between the waste in the pit and the person using the latrine. This defines the difference between improved and unimproved sanitation.

Figure 19.2 shows the sanitation data for Ethiopia and indicates the relative proportions of the population with access to improved and unimproved facilities. In this graph, open defecation is classified separately from unimproved methods. A fourth category, shared facilities, means sanitation that is otherwise acceptable but is shared between two or more households.

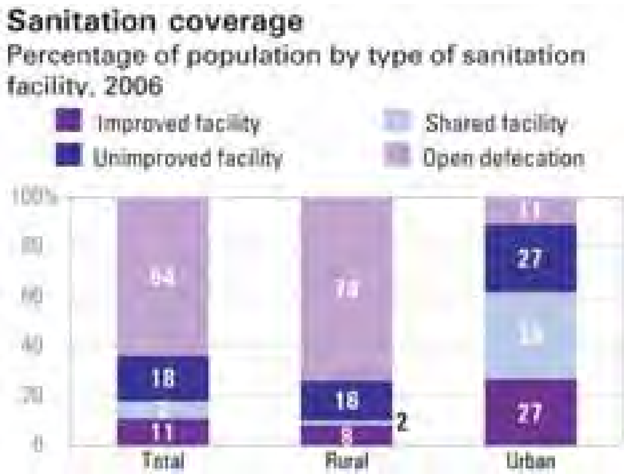


Figure 19.2 Sanitation coverage in Ethiopia. (Source: WHO/UNICEF JMP, 2008)

■ From Figure 19.2, what percentage of the rural population does not have access to improved facilities? How does this compare to the urban population?

□ 74% of rural people use open defecation and a further 16% only have access to unimproved facilities. Therefore, a total of 90% of people in rural areas of Ethiopia do not have access to improved sanitation facilities. In urban areas, 38% of people (11% + 27%) do not have access to improved facilities.

19.2.2 Sullage management

Some people may think they can simply throw used cooking and washing water away but it should not be disposed of indiscriminately because of its negative health effects on families and community members. Proper collection and disposal of sullage is advised. Some of the disadvantages of improper disposal of sullage include the potential to contaminate the soil, pollute water sources and create favourable breeding conditions for disease vectors.

■ Which vectors do you think might be encouraged by sullage collecting on the ground?

□ Mosquitoes are likely to be attracted as they use stagnant water as breeding sites. Flies and rats might also appear as the sullage would be a source of drinking water.

Unsightliness and bad odour affect the aesthetic value of our environment, therefore proper handling and disposal of sullage is required. Sullage can be discharged to sewers or septic tanks in areas where they exist. However, in many rural areas there is no sewer system so it is necessary to construct a pit near the household to dispose of sullage properly. The pit should be filled with gravel or sand and the sullage can be allowed to percolate into the ground. A sullage pit keeps the wastewater in one place and encourages it to soak quickly into the ground. It also avoids bad odour and unsightliness in the environment.

19.2.3 Industrial wastewater management

Effluent produced by an industry should meet the national guideline values of wastewater quality before it is released into rivers, streams or even municipal sewer systems. However, it is beyond your mandate to check on this. If you have any concerns, you should request inspection by experts such as occupational and environmental health officers in the district or higher administrative bodies. Given the expansion of agricultural-led industrialisation in rural Ethiopia, the challenge of industrial pollution is likely to increase in the future. In accordance with the law vested with the Ethiopian Environmental Protection Authority (EPA), industrialists have to undertake an Environmental Impact Assessment (EIA) and produce an Environmental Impact Statement (EIS) before they commence the construction of any new industrial development (see Box 19.1). In your role as a community healthworker, you can assist a relevant expert by providing the necessary information to your immediate supervisor to facilitate the enforcement of environmental law in your locality. You are not expected to take actions by yourself. Public health complaints by community members should also be communicated to the relevant officers for timely action.

Effluent means wastewater of any type that is discharged (flows out) from a pipe or other structure.

Box 19.1 Environmental Impact Assessment

Environmental Impact Assessment (EIA) is a preliminary step in in the planning phase of major development projects. It is a systematic process of assessing the possible impacts that a proposed project may have on the environment. The process usually requires the preparation of an Environmental Impact Statement (EIS) that should report on the findings of the EIA and recommend ways of reducing or mitigating any negative environmental impacts, including possible alternative actions.

In Ethiopia, the Environmental Protection Authority (EPA) is responsible for ensuring EIAs are undertaken for major projects. Established in 2002, the EPA’s mission statement is to enhance good environmental governance through ‘removing the constraints faced by public agents, individuals, civil society and the private sector to know, explore and utilize fully their own potentials to enlarge their choices for understanding their respective functions in an environmentally sound manner’.

19.2.4 Runoff management

Runoff or storm water needs to be properly managed to ensure it does not have a damaging impact on property or health. In some areas, mostly in towns and cities, runoff is directed into stormwater canals; these need to be used properly and kept clear of debris. In rural areas, stormwater canals are rarely present; therefore, there needs to be pre-planning to effectively prevent runoff from entering households and public buildings, and running over the roads, as is frequently the case. Improperly managed flood water could cause a physical hazard to the community and can also cause outbreaks of waterborne diseases due to contamination of drinking water sources and food stocks.

To prevent the damaging effects of stormwater in your community, the likely routes of stormwater should first be identified, i.e. the location and direction of channels that tend to form in heavy rain. Once the scope of the problem is identified, then development agents, in consultation with the community leaders, can design and implement a solution. Where the community lives near dams or river banks that frequently burst during the rainy season, it is advisable to devise an early warning system at village level. This should be based on a study of past experiences and use relevant information from the local Meteorology Office and/or Agricultural Office.

19.3 Collection, storage and treatment of liquid waste

There are different sanitation technologies used to collect and store liquid waste. Some of them also treat the waste and produce useful byproducts. The various different systems are used in different circumstances depending on the location, available resources and type of waste. In this section, we will describe septic tanks and anaerobic biogas reactors. We will also briefly describe the type of centralised treatment system that may be found in larger towns and cities.

19.3.1 Septic tanks

Septic tanks are used with water carriage sanitation systems. The human waste is washed into the tank, where it is stored and partially treated. A septic tank is a watertight chamber, usually made of concrete, and is mostly under the surface of the ground (Figure 19.3). They have inlet and outlet pipes. Fibreglass, PVC or plastic tanks can also be used. The retention time of the wastewater in septic tanks should be a minimum of 19 hours but can be a great deal longer.

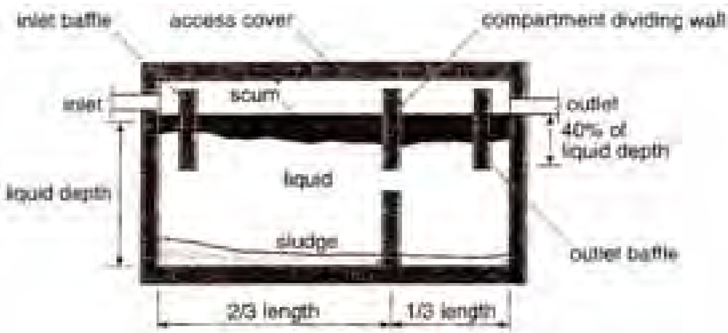


Figure 19.3 Diagram showing the typical internal structure of a septic tank. (Source: The Open University)

The purpose of septic tanks is for the solids to settle out of the wastewater and for anaerobic decomposition of organic solids to take place. However, the treatment in a septic tank is only partial. The solids will be broken down in the tank and diluted in the wastewater but this will still contain high levels of organic pollutants. Septic tanks should only be used in places where water is plentiful and where vacuum trucks are available to remove sludge periodically from the chamber (Figure 19.4). The process of removing sludge from the septic tanks is called **desludging**.

Figure 19.4 A tanker pumping out sludge from a septic tank or latrine. (Photo: Nicholas Watson)

Septic tanks are a storage and treatment unit to complement such facilities as WCs (cistern flush toilets), pour-flush toilets and aqua privies. The effluent from septic tanks is usually piped into a soak pit, also known as a **seepage pit** (Figure 19.5). A seepage pit is lined with open-jointed or porous material such as bricks or stone without mortar, which allows the wastewater to seep out slowly into the soil. Alternatively the wastewater may be spread across a drainage field using an array of pipes buried below the surface.

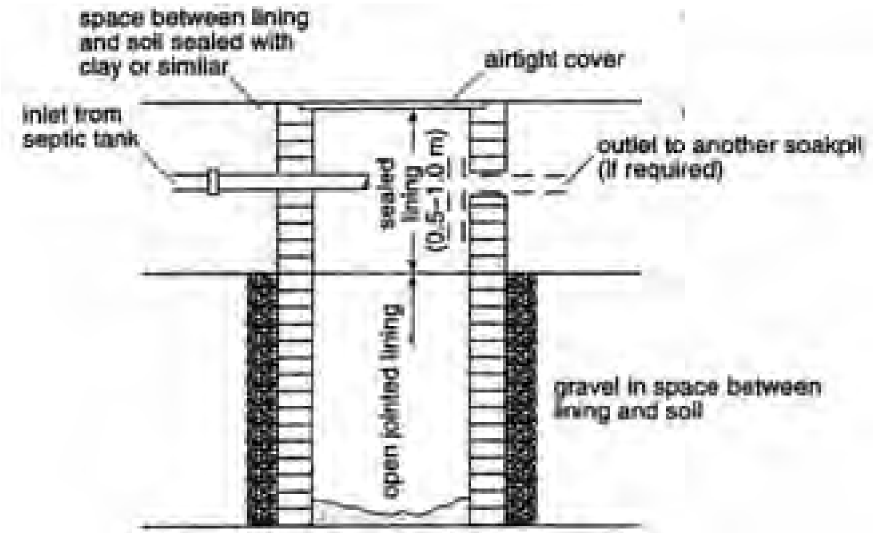


Figure 19.5 Diagram of a seepage pit. (Source: The Open University)

A septic tank has the following advantages:

- can be built and repaired with locally-available materials
- has a long service life
- presents no problem of flies and odour, if properly used
- has a relatively low capital cost (though it may not be affordable by rural households), and moderate operating costs
- does not require electrical energy because it uses gravity flow.

However, the constraints of a septic tank include the following:

- only applicable for water carriage sanitation systems
- treatment is only partial and the effluent may still contain pathogens
- sludge must be removed periodically.

19.3.2 Anaerobic biogas reactor

An anaerobic biogas reactor, also known as an anaerobic digester, uses **anaerobic digestion** to convert liquid wastes and other organic matter into sludge and biogas. The sludge can be used as a soil fertiliser and the biogas can be used for energy to produce heat (for use in cooking) or electricity. This affordable technology can easily be adapted by rural families and communities if appropriate training is given to local artisans and masons in the design and construction of the reactor (Figure 19.6).

The reactor consists of a chamber usually below the ground. It has an inlet for inputs (mainly human excreta) and two outlets (one at the centre for biogas, and the other on one of the sides for outlet of sludge). Addition of animal manure and vegetation will improve the efficiency of the reactor.

Figure 19.6 An anaerobic digester under construction. (Photo: WaterAid in Ethiopia)

Neighbourhoods can join together to share a digester. However, if sufficient wastes are generated, individual households can each have one and get the benefit of biogas production. You should explore if local loaning enterprises could help households install an anaerobic biogas reactor.

19.3.3 Centralised wastewater treatment systems

In larger towns and cities, liquid waste may be conveyed via a sewerage network to a centralised wastewater treatment plant; for example, Addis Ababa's waste is treated at the Kality Wastewater Treatment Facility. Simple small-diameter sewers convey sullage and sewage from individual households to larger main sewers and then to the treatment plant. (Note that the word 'sewerage' refers to the network of pipes and 'sewage' refers to the liquid waste that flows through the sewers.) This method is not likely to be used in rural and peri-urban areas of Ethiopia. In addition to sewage, industrial waste may be discharged into the sewerage network – although it may have to have special treatment (technically called pre-treatment) onsite beforehand.

19.4 Choosing appropriate sanitation technologies

By now you will have realised there are many different sanitation technologies that can be used for liquid waste management. Part of your role, in collaboration with others, is to encourage the installation of sanitation systems and help people in your community decide on the appropriate technology to use. The Federal Government's role is limited to issuing regulations, setting standards, providing technical assistance and financing public facilities. It is solely the responsibility of the district or *kebeles* to mobilise the community and coordinate the activities of sanitation at grassroots level. In this process, you should understand that sanitation should be driven by informed household demand. This means that apart from technically helping households to achieve sanitation, your role is to encourage them to *demand* sanitation.

There are many factors to consider in the choice of technologies but before we describe these, there are some general principles to bear in mind as well.

19.4.1 General principles

Involve the users in decision making

As you now know, in its broad definition, sanitation doesn't mean simply latrines; it involves hygiene and environmental behaviour as well. In the past, sanitation interventions used to focus on 'hardware' (the construction of latrines and other waste disposal facilities) instead of integrating 'software' (hygiene promotion and health behavioural change) components of the programme. This approach has been heavily criticised because it prescribes a single or limited technological option for the user community without involving them in the decision. People who will use the facility need to participate in the planning process, because technological choices that are imposed on them are unlikely to succeed.

Your local community

As a member of your local community, you should consider ways to stimulate and encourage local innovation and enterprise. Technologies that are accepted by people will not only meet their preferences and be affordable but also use the possible mix of local and external materials and skills, ideally emphasising the use of local resources first. Locally sourced technologies are more likely to involve local people in your village in their development, construction, marketing and use.

Sustainability

An important principle of sanitation is that it protects the environment. A *sustainable* sanitation system will safeguard the environment and be durable, affordable and socially acceptable. When you facilitate the implementation of human waste management, you must make sure that provision of sanitation avoids unacceptable impacts on the environment, especially surface and groundwater resources.

Finding the resources

Installing a sanitation system will require funding and human resources. The sanitation strategy of the Federal Ministry of Health of Ethiopia basically suggests 'no subsidy' for household sanitation.

Users or households will need to pay for the installation, operation and maintenance of latrines. However, some organisations such as The World Bank and some NGOs recognise that some people might require some form of support to achieve total sanitation. Targeted subsidies that consider, for example, people with disabilities or old people may be appropriate.

Integration with water supply and hygiene

Sanitation improvement cannot be achieved in isolation; it needs to be integrated with improvements to water supply and hygiene promotion. You should try to make a coordinated effort to combine hygiene and water supply promotion along with that of sanitation, in order to influence the behaviour of individuals and families in your community. You should work together with your local water supply and other related services to achieve better sanitation in your community.

19.4.2 Questions to consider

Now, let's discuss factors that are important for households to consider in the selection of liquid waste disposal facilities. When families are selecting a sanitation technology with your help, there are many interrelated and variable factors that they should take into consideration. Some of these factors are decided by the geographical location you are working in and you will not be able to influence these, although it is important that you take them into account. Others are determined by the people involved and by the local situation.

What is your location?

Your geographical location will influence factors such as:

- Climatic conditions: for example, in highland areas with heavy annual rain, latrines should be constructed in such a way that prevents flooding.
- Topography and geological formations: the depth of the water table, type of rock and the permeability of the soil; sandy soils, for example, are more permeable than clay soils.
- Abundance or scarcity of water: WCs and other water carriage systems are not appropriate in areas where there is no piped water.

Who will use the facility?

The number of people, their characteristics and attitudes will all need to be considered. For example:

- Cultural acceptability: social and cultural beliefs, and the values and practices of a community, are important considerations for households when selecting a sanitation technology.
- Affordability: the choice of technology will depend on the ability and willingness to pay; the cost should be fairly low for most people to be able to afford it.
- Safety to users: a latrine should not be constructed in ways that endanger the safety of children, women or other family members who use the facility.
- Accessibility: children, elderly people and people with disabilities may need special consideration to ensure the chosen facility is easily accessible to them without discomfort or inconvenience.

What local resources are available?

It's important to consider the local context and whether local resources can be used. This includes:

- Availability of resources and infrastructure: the presence of human skills, construction materials and other resources may make one technology more appropriate than another. In general, sanitation technologies that need less skill are important for rural households.
- Energy source and pit emptying requirements: in rural areas where a pit emptying service is not available, households will need to depend on traditional latrines.
- Demand for reuse of the waste: facilities that ultimately help households to recycle and use waste, such as composting and biogas reactors, are important considerations as well.

These are the main factors that determine the appropriateness of the sanitation technology that households choose and use. In general, the technology we choose must give a complete barrier to the liquid waste in order to protect the family's health, while being acceptable in terms of cost (i.e. installation, operation and maintenance costs) and be socially and culturally sound.

Summary of Study Session 19

In Study Session 19, you have learned that:

1. Sanitation can be defined as the means by which human excreta, as well as community wastewaters, are collected and disposed of so that they do not cause any harm to the community. It involves protection both of human health and the environment.
2. Liquid waste can be classified as human waste, sullage, industrial waste or runoff. Different methods of waste management apply to these different categories.
3. Human waste can be contained using wet or dry sanitation systems. Wet or water-carriage methods require easy access to a water supply and are not usually appropriate in rural areas. Sanitation systems can also be classified as improved or unimproved.
4. Septic tanks offer partial, anaerobic treatment of liquid waste. The sludge has to be removed periodically and the effluent has to be disposed of via a soak pit.
5. Anaerobic biogas reactors convert liquid wastes into a sludge and biogas through anaerobic processes. The sludge can be used as a fertiliser and the biogas as a source of energy.
6. In urban areas, wastewater may be conveyed via sewers to centralised wastewater treatment plants.
7. Choosing appropriate sanitation technologies requires consideration of many factors including the needs and wishes of the local community, local environmental conditions, costs and the availability of resources.

Self-Assessment Questions (SAQs) for Study Session 19

Now that you have completed this study session, you can assess how well you have achieved its Learning Outcomes by answering these questions. Write your answers in your Study Diary and discuss them with your Tutor at the next Study Support Meeting. You can check your answers with the Notes on the Self-Assessment Questions at the end of this Module.

SAQ 19.1 (tests Learning Outcomes 19.1, 19.2 and 19.3)

Which of the following statements is *false*? In each case, explain why it is incorrect.

A The decomposition of human waste in a septic tank is an aerobic process.

B A seepage pit is a watertight underground pit for containing liquid waste.

C Anaerobic digestion is a method of waste treatment that converts waste into useful products.

D Runoff does not cause environmental problems because it is only rainwater that runs off the land surface.

E Protection of groundwater from contamination is an essential requirement of human waste management.

SAQ 19.2 (tests Learning Outcome 19.4)

Explain why the following factors are important when choosing a sanitation technology.

(a) local geology
(b) local climate
(c) the age range of people using the facilities.

Study Session 20 Latrine Construction

Introduction

In Study Session 19, we described the various methods of liquid waste management and discussed the issues that need to be considered when choosing appropriate sanitation technologies. In most rural situations, a dry latrine of some sort will probably be the most appropriate technology to choose. This study session will provide some practical details about the different types of latrine and how they should be constructed.

It should be noted that we do not have space here to include all the technical construction details. This is not a construction manual. Although the techniques described are not complicated, the latrines need to be designed and built in the correct way and you may need to seek out further details or expert advice if you wish to promote the installation of some of these different types of latrine. *Latrine Technology Options*, published by the Federal Ministry of Health, is a useful reference.

Learning Outcomes for Study Session 20

When you have studied this session, you should be able to:

20.1 Define and correctly use the key words printed in **bold**. (SAQ 20.1)

20.2 Describe the main features of simple pit latrines and VIP latrines. (SAQs 20.2 and 20.3)

20.3 Describe ecological sanitation systems. (SAQ 20.1)

20.4 Describe standard construction techniques for latrines with handwashing facilities. (SAQs 20.2 and 20.4)

20.5 Help families select appropriate sanitation technologies. (SAQ 20.5)

20.1 Types of latrine

In Study Session 19, sanitation facilities were classified as improved or unimproved, and alternatively as wet or dry systems.

- ■ Three types of dry sanitation technology were included in the list of improved facilities in Study Session 19. What were they?
- □ Pit latrine with slab, ventilated improved pit (VIP) latrine and ecological sanitation.

Pit latrines are basic structures that can be adapted easily into different types of latrines such as VIP latrines and ecological sanitation systems. These other latrines share many common features of simple pit latrines; therefore, focusing first on pit latrines will help you to understand the other sanitation technologies as well.

20.2 Pit latrine with slab

Pit latrines are the simplest form of dry latrine. They consist of a pit dug in the ground and a cover slab or floor above the hole (Figure 20.1). Pit latrines must have a cleanable cover slab in order to be considered as improved sanitation systems. The excreta (both faeces and urine) drop through the hole to enter the dry pit. Pit latrines should be constructed on a slight mound so they are higher than the surrounding ground and water at the surface will flow away from the hole. They should also have a lid that can be placed over the hole to reduce problems with flies and odours. They may have a squat pan or a raised footrest to make using the latrine more convenient. The pit is often lined but the bottom remains open, allowing the liquid to drain into the soil and leaving the solids behind.

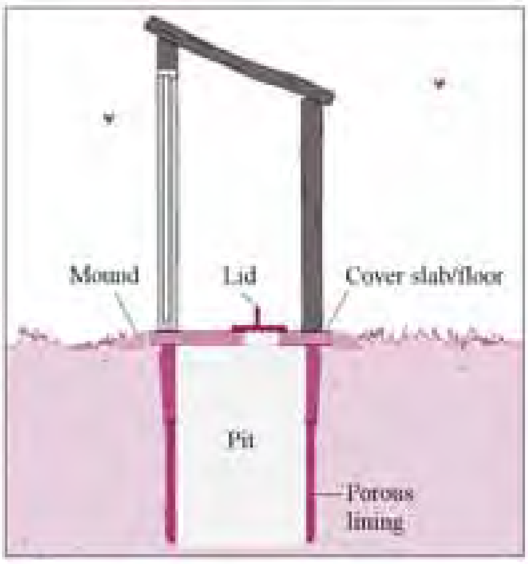


Figure 20.1 Diagram of a simple pit latrine. (Source: WHO and IRC, 2003, *Linking technology choice with operation and maintenance in the context of community water supply and sanitation: A reference document for planners and project staff*)

Pit latrines should also have an upper part, called the **superstructure**, to provide protection from the rain and sun, and privacy and comfort for the user (Figure 20.2).

Figure 20.2 Pit latrine superstructures can be built of different materials as long as they provide privacy and protection from the weather. (Photos: Pam Furniss, Abera Kumie, Worku Tefera)

Pit latrines can have a single pit or double pit. In double pits, while one is filling with excreta, the second pit remains out of service. When the first pit is filled with excreta up to about 50 cm below the slab, it is taken out of use and the remaining space is filled with grass and vegetation materials that can be composted. You then use the second pit until that is full. Meanwhile, the first pit will stay sealed for a period of 6–9 months, during which time the waste will decompose and any pathogenic microorganisms will die. After this period, the material (humus soil) in the first pit can be taken out manually. (Humus or humic is used to describe organic matter that has been stabilised by decomposition processes.) It is safe to handle and readily used as fertiliser in agriculture or can be disposed of safely. This is the principle of ecological sanitation that is described further in Section 20.4.

20.2.1 Advantages and disadvantages of pit latrines

In general, pit latrines with a slab are effective sanitation systems because they isolate human excreta from the surrounding environment and prevent the transmission of faeco-orally transmitted diseases. They also have other advantages:

- They do not require water so are appropriate in areas where there is no adequate water supply.
- Squatting is normal to many people and thus is acceptable to users.
- Alternating double pits will allow the excreta to drain, degrade and transform into a nutrient-rich, safe humic material that can be used to improve soils.
- They avoid contamination of surface water and top soil if properly installed and maintained.
- They can be constructed with minimum cost using local material and local skills.
- The presence of properly constructed slabs will allow easy cleaning and avoid flies and unsightliness.

However, pit latrines are not without limitations. There may be a foul odour from the pit and they can be a favourable place for the breeding of flies and mosquitoes. With single pits, a new pit needs to be dug every time one gets full. They can be susceptible to failure/overflowing during floods. Other disadvantages can be overcome by proper design, construction and usage. For example, if the superstructure is not properly constructed, it may discourage use of the latrine by family members. Children may be discouraged from using the latrine if the slab is not designed with them in mind and is too big for them. Use of excess water or less compostable materials for anal cleansing should be avoided because it may affect the decomposition rate of human excreta.

20.2.2 Siting, designing and constructing a pit latrine

The site of a latrine should preferably be in the backyard of the house and away from an alley in the village. It should not be nearer than 6 m or farther than 50 m from the house. The direction of the wind should be away from the main house. If there is a well in the compound, the latrine should be located as far away from it as possible on the downhill side to avoid possible seeping and contamination of groundwater. The faecal microorganisms may migrate from the pit through the soil, however, the degree that this happens varies with the type of soil, moisture levels and other environmental factors. It is, therefore, difficult to estimate the necessary distance between a pit and a water source, but 30–50 m is the recommended minimum, with an absolute minimum of 15 m.

The size of the pit depends on the number of people using it and the design period, i.e. the length of time before it is full. Typically, the pit should be at least 3 m deep for a family of five for a design period of three to five years. The diameter should be at least 1 m; up to 1.2 m diameter will make it easier to dig but if it exceeds 1.5 m there is an increased risk of collapse, especially in sandy soils.

As you may remember from Study Session 19, you need to consider the geology, soil type and topography (the slope of the land) when considering sanitation technologies. In flood-prone areas, it is advisable to raise the mound of the latrine and prepare diversion ditches around it. When the soil condition is rocky and it is impossible to dig a deep pit, the depth of the pit can be extended by building upwards with concrete rings or blocks. However, care must be taken to ensure the structure remains watertight. The level of the water table must also be taken into consideration. The pit must be entirely above the water table at all times of the year. If the water table is near the surface of the ground, the waste in the pit may contaminate the groundwater.

Lining the pit prevents it from collapsing and provides support to the superstructure. The pit lining material can be brick, rot-resistant timber, concrete, stones, or mortar plastered on to the soil. If the soil is stable (i.e. no sand or gravel deposits or loose organic materials), the whole pit need not be lined. The bottom of the pit should remain unlined to allow the percolation of liquids out of the pit.

The superstructure should be built using locally available materials. These may include a masonry wall made of cement blocks, bricks, or stone with cement or mud bindings; or a wooden structure covered with timber, bamboo, grass/thatch, sticks, leaves of banana or *enset* trees, or canvas made of sacks. However, the type of superstructure depends on several factors such as a household’s financial capacity, the availability of construction material locally, local customs and traditions, and the availability of skilled artisans.

■ Look again at Figure 20.2. What materials have been used for the different superstructures in these four pictures?

□ The latrine in the picture at top left has sticks with leaves for the walls and a plastic roof. The latrine at top right is made of sticks and grasses. At lower left, the latrine has walls of mud with a corrugated plastic or metal roof. The latrine at lower right is made of corrugated metal.

The cover slab needs to be strong and have a smooth surface so it can be cleaned easily. It may be made of concrete or termite- or rot-resistant timber, with or without stones and mud covering. Various designs of slab are used (Figure 20.3).

Figure 20.3 (a) Slab with raised footrest in a pit latrine. (b) Round cement slab with keyhole-shaped squat hole and footrests. Note also the vent pipe and lid. (Photos: Pam Furniss)

20.2.3 Maintenance of pit latrines

Pit latrines must be properly maintained to function properly. You should advise families to keep the squatting or standing surface clean and dry. This will help to prevent pathogen/disease transmission and limit odours.

If the pit has been dug to an appropriate size for the number of users, then it may never become full. The liquid will drain into the soil and the solid waste will slowly decompose so the volume remains stable.

20.3 Ventilated improved pit (VIP) latrine

The VIP latrine is an improvement over the simple dry pit latrine. The distinctive feature that gives the VIP latrine its name is the vent pipe installed into the pit, which is used to exhaust the foul odour from the pit and control flies (Figure 20.4). If you look back at the photos in this study session, you can see vent pipes in several of the latrines.

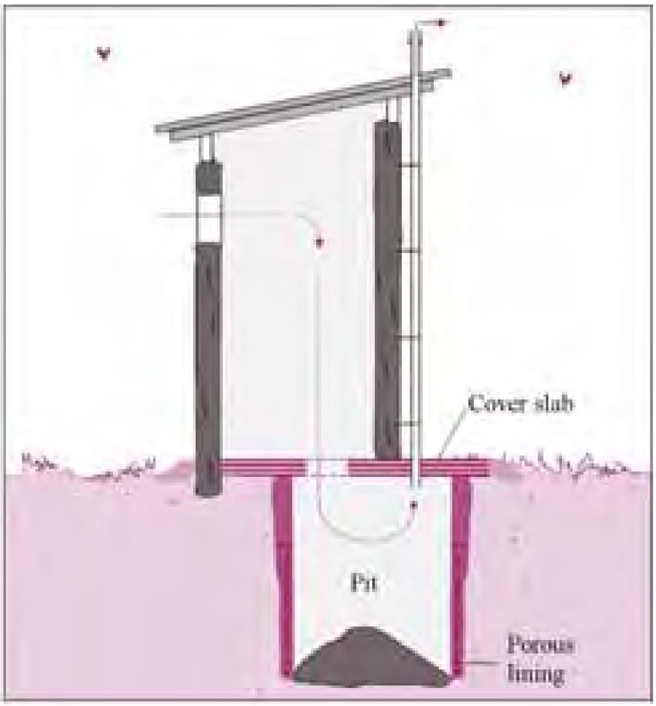


Figure 20.4 Diagram of VIP latrine (Source: as Figure 20.1)

The principle is that a continuous flow of air comes in through the superstructure and enters the pit through the hole. This cold air will go down into the pit displacing (pushing up) the hot smelly air upward through the vent pipe. The other advantage of the vent is controlling flies. As we discussed earlier, dry pit latrines potentially serve as breeding places for flies. Newly-emerging adult flies will try to escape through the vent pipe because the pipe allows sunlight to enter into the pit and flies are photopositive (meaning they move towards light) by nature. A mesh screen tied at the top of the vent pipe will prevent flies from escaping to the outside of the latrine.

VIP latrines can have a single pit or double pit. They share the advantages of simple pit latrines with slabs described above but they also have unique advantages that improve on the limitations, namely, that flies and odours are significantly reduced. It should be noted, however, that the health risks from flies are not completely removed by ventilation.

20.3.1 Constructing a VIP latrine

As it is based on a simple pit latrine, we will discuss only the improved features of VIP latrines. The vent pipe should have an internal diameter of 110–150 mm and reach more than 300 mm above the highest point of the superstructure. The vent works better in windy areas but where there is not much wind its effectiveness can be improved by painting the pipe black. This makes the vent pipe warmer and the heat difference between the pit (cool) and the vent (warm) creates an updraft that pulls the air and odours up and out of the pit. To test the efficacy of the ventilation, a small, smoky fire can be lit in the pit; the smoke should be pulled up and out of the vent pipe and not remain in the pit or the superstructure. The mesh size of the fly screen must be large enough to prevent clogging with dust and allow air to circulate freely. Aluminum screens with a holesize of 1.2–1.5 mm have proved to be the most effective.

20.3.2 Maintenance of VIP latrines

The maintenance requirements are similar to simple latrines. In addition, dead flies, spider webs, dust and debris should be removed from the ventilation screen to ensure a good flow of air.

20.4 Ecological sanitation

Ecological sanitation, also known as ecosan, describes an approach to human waste management rather than a single method. In ecosan systems, human excreta is considered to be a resource, not waste. The principle is to make use of excreta by transforming it into an end product that can be used as a soil improver and fertiliser for agriculture. Ecological sanitation aims to decrease contamination of the environment caused by human excretion and to prevent faeco-orally transmitted diseases. An additional benefit of using waste in this way is that the amount of artificial fertiliser used in cultivation of fields is decreased. This saves money for the farmer and protects lakes and other water bodies from eutrophication caused by runoff of these additional fertilisers.

There are, however, some constraints for communities to consider before adopting the ecosan approach. Ecosan systems require a little more space than conventional latrines. At the end of the process the decomposed waste, known as compost or ecohumus, has to be dug out before it can be spread on the land. There may be a cultural taboo against handling of excreta, even though it should be more like soil than waste by this stage. Some people may be unwilling to use the crops and foods produced. Nonetheless, ecological sanitation is a more sustainable approach to waste management than other systems and should therefore be promoted as the preferred option. You may need to convince families that it is safe and has no negative health effects. Model families may be able to help if they demonstrate to others that the compost produced is safe and acceptable to use.

20.4.1 Arborloo – a single pit method

A simple form of ecological sanitation is the **Arborloo** (Figure 20.5). This consists of a single, unlined shallow pit with a portable ring beam (circular support), slab and superstructure. It is used like a normal latrine but with the regular addition of soil, wood ash and leaves. When it is full, it is covered with leaves and soil and a small tree is planted on top to grow in the compost. (The tree gives the system its name; 'arbor' is Latin for 'tree'.) Another pit is dug nearby and the whole structure is relocated over the new pit. No handling of the waste is required. If a fruit tree or other useful variety is grown there is the added benefit of food or income.

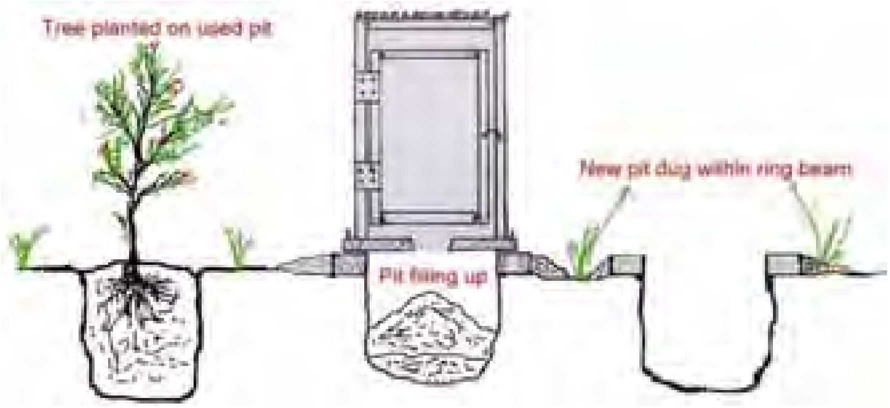


Figure 20.5 Arborloo – a single pit ecosan system. (Source: Stockholm Environment Institute, 2007, *Toilets that make compost: Low-cost, sanitary toilets that produce valuable compost for crops in an African context*)

20.4.2 Fossa Alterna – a double pit method

The double pit latrine system described in Section 20.2 can be constructed to be an ecosan system. The alternating waterless double pit is also known as **Fossa Alterna**, which means alternate ditch. The physical structure is constructed in a similar way to a single pit latrine except that it has two pits and they are shallower than a normal pit with a maximum depth of 1.5 m. The slab and superstructure may be movable between the two pits (Figure 20.6) or may be a larger permanent structure that covers both pits.

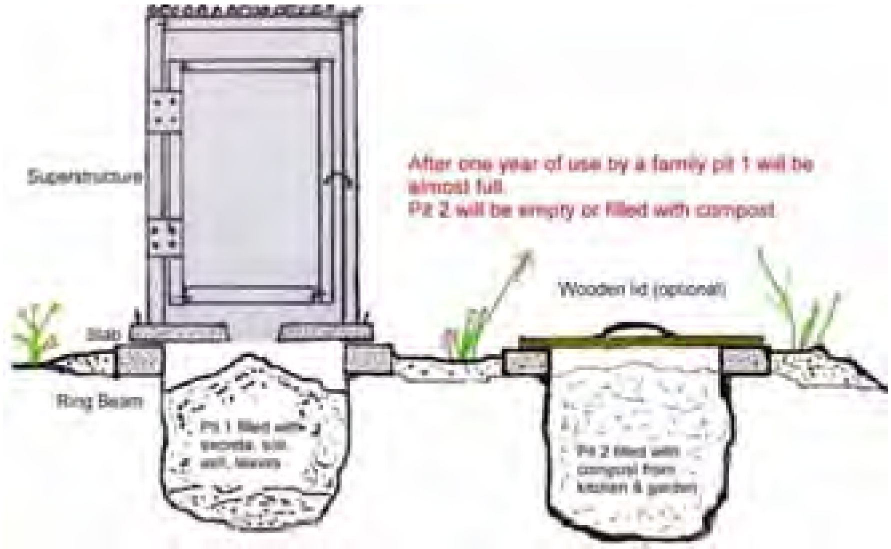


Figure 20.6 Fossa alterna – double alternating compost pit toilet. (Source: as Figure 20.5)

Like the Arborloo, soil, wood ash, vegetable kitchen waste and leaves are added regularly. A small amount should be added after each defecation (not urination). This introduces necessary plant material to mix with the human waste and also adds a variety of organisms like worms, fungi and bacteria that help in the degradation process.

When the first pit is full, after about 12–24 months depending on the size of the pit and the number of users, everyone starts using the second pit instead. The first pit is covered and the material in it will degrade into a dry, earth-like mixture. This takes about 6–12 months. After this time, the composted mixture is dug out manually and can be used to spread on soil. It is important in the construction to make sure the slab is movable or has a manhole large enough to allow access to the pit for digging out. The health risk for the people who empty the compost is minimal if the pit has been left for over one year. However, good personal hygiene should always be promoted in activities related to sanitation.

20.5 Water carriage systems of human waste disposal

20.5.1 Cistern flush toilet

Figure 20.7 Cistern flush toilet: in this example, the cistern or tank is behind the raised lid. (Photo: Worku Tefera)

The cistern flush toilet, also known as a water closet or WC, is usually made of ceramic material (Figure 20.7). The flush toilet consists of two parts: a tank (cistern) that supplies flushwater for carrying away the excreta and a bowl into which the excreta are deposited. It also needs connection to constant running water and a discharge pipe to take the wastewater away to a sewer or septic tank. WCs are rarely found in rural households but are quite common in government offices, some schools and health facilities.

The attractive feature of the flush toilet is that it has a water seal to prevent odours from coming back up through the plumbing. A skilled plumber is needed to install a flush toilet. From the users' perspective, it is a safe and comfortable toilet to use provided that it is kept clean, but the high capital cost for installation and the need for skilled personnel makes it not affordable by every family, especially those living in rural areas.

20.5.2 Pour-flush toilets

A pour-flush toilet is like a cistern flush toilet except that instead of the water coming from the cistern above, it is poured in by the user. When the water supply is not continuous, any cistern flush toilet can become a pour-flush toilet. Water is simply poured into the bowl manually from a bucket or a jug to flush the excreta; approximately 2–3 litres of water is usually sufficient. Pour-flush toilets share all the advantages of cistern flush toilets but use a lot less water. The wastewater should be disposed of to a septic tank or seepage pit, also known as a leach pit (Figure 20.8).

The pit will contain excreta, cleansing water and flush water. As this leaches from the pit and migrates through the soil, faecal organisms are removed. In some geological conditions, there is a risk of groundwater pollution; therefore, this method is not always recommended.

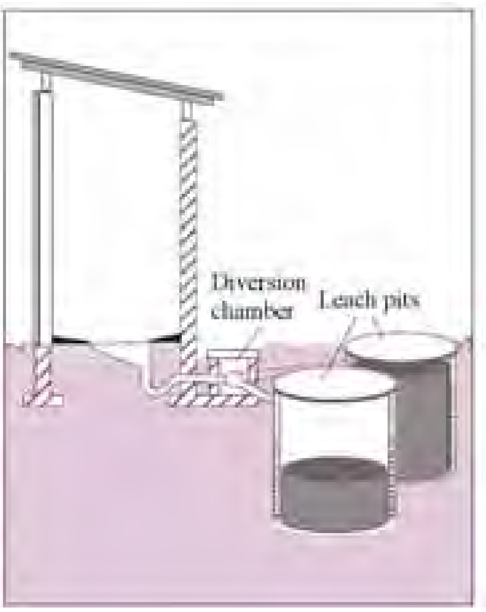


Figure 20.8 Pour-flush latrine design. (Source: as Figure 20.1)

20.5.3 Aqua privy

The aqua privy is a single pit latrine which has a watertight pit filled with water. Excreta drops into the pit and wastewater is displaced into a storage chamber, a seepage pit or a sewer line. It needs to be topped up regularly, so a nearby water supply is required.

20.5.4 Urinals

Urinals, used by men and boys, are only used for collecting urine. Urinals are either wall-mounted units or a drainage channel constructed on the floor in connection with the wall. Most urinals use water to flush although waterless urinals are now becoming popular. In public places and schools, urinals for men and boys help to keep toilets cleaner and decrease the demand for more toilet-seats.

20.6 Handwashing facilities

Every latrine or toilet must have handwashing facilities. As you know, hygiene is an essential component of health promotion and one of the critical times for handwashing is after visiting the toilet. A latrine without a proper handwashing facility will not serve its ultimate objective of disease prevention.

If there is no running water, handwashing stations can be made using jerrycans (Figure 20.9), tin cans, wooden bowls, or pottery depending on the local culture and custom of your community. Simple devices can be made using very basic materials (Figure 20.10).

Figure 20.9 Handwashing facility outside the latrine at a Health Post. (Photo: Pam Furniss)

Figure 20.10 Simple handwashing facility placed conveniently outside a household latrine. (Photo: Pam Furniss)

To make a handwashing station similar to the one in Figure 20.10, follow these easy steps: (Source: adapted from USAID/HIP, 2007)

1 Find a plastic container of approximately 5 litres capacity. A jerrycan or gourd can also be used.

2 You will also need a hollow tube to make the spout. You can use a pen casing (as shown in Figure 20.10), a pawpaw stem or anything that is hollow. You will also need a sharp knife, nail or screwdriver.

3 Decide on the design of your handwashing station before you begin working. Will your container sit on a platform or hang and tip?

4 Wash the container and tube so they are free from visible dirt.

5 Heat the knife, nail or screwdriver to make piercing a hole for the tube easier.
6 Make a small hole for inserting the tube. Make it as low on the container as you can, about 2 cm (two finger widths) from the bottom. Be careful to make it smaller than the tube.
7 Slowly and carefully push the tube into the hole. Be very careful not to push the hole so big that it leaks.
8 Test the water flow:

When using a plastic bottle: water is delivered when the bottle cap is unscrewed and stops flowing when the cap is tightly shut.

When using a jerrycan or gourd: water comes out when the cap on the pen or plug in the container is removed. If you don't have the original pen cap, find an old stick to 'plug' the flow.

Finally, set up the station right by the latrine by hanging it from a string around the neck, or setting it on a stable platform. You should also provide soap or ash for washing.

20.7 Your role in latrine construction

Your role is to promote latrine construction by giving advice and encouragement to people in your community to install or improve sanitation systems. In Section 19.4 of Study Session 19 we discussed some of the general principles to be considered when choosing sanitation technologies. This study session has provided further details about the different types of latrine. Figure 20.11 is a decision tree that has been designed to help you answer questions from households such as 'what type of latrine/toilet can I construct?' Start with the question at the top left corner and follow the arrows according to the answers. Be aware this is only an outline guide that summarises the key points.

As part of the process of latrine construction, you can help develop skills in your local area. With the help of district health offices, you should be encouraging local artisans and entrepreneurs to create a sanitary service chain of, for example, prefabricated slabs. You can also promote training of local people on proper latrine construction techniques, especially for improved types of latrine. You can also assist with training of model family household members in your community. Although they may not be common in rural Ethiopia, you should also be familiar with the concepts in higher level sanitation facilities such as water carried systems because you may be involved in advising households that want to upgrade their facilities up the sanitation ladder, step by step. Whichever type of latrine is used, your role is to promote good sanitation and hygiene wherever possible.

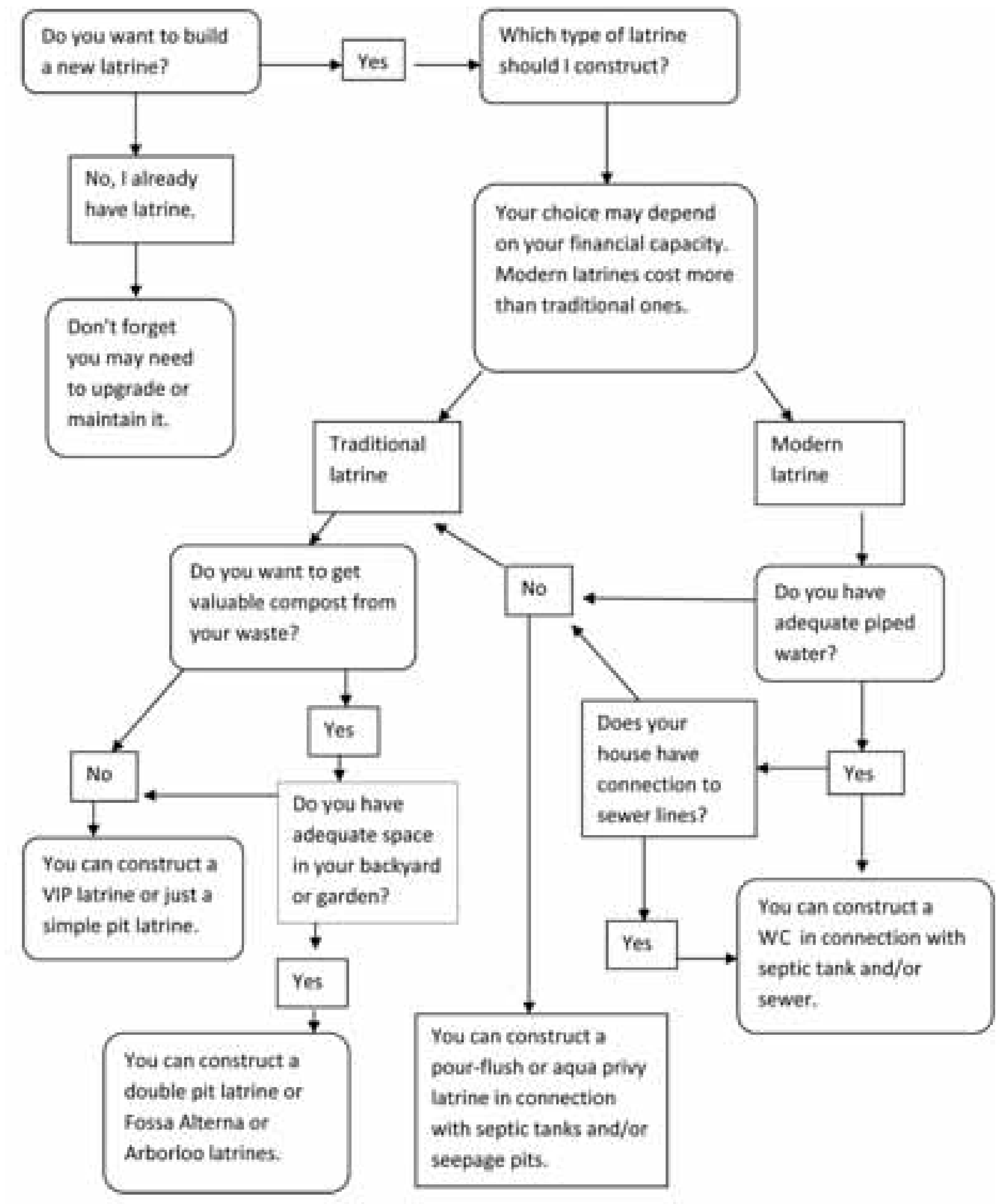


Figure 20.11 Decision tree for latrine options.

Summary of Study Session 20

In Study Session 20, you have learned that:

1. Pit latrines with slab, VIP latrines and ecological sanitation systems are all types of improved sanitation facility.
2. Pit latrines consist of a pit, slab and superstructure. The slab is essential to separate waste from the people using it. The superstructure ensures privacy; it can be constructed of many different locally available materials.
3. Latrines must be sited with due consideration of the type of rock/soil, the location of water sources, the location of houses and the wind direction.
4. VIP latrines are better than simple pit latrines because the vent pipe reduces smells and flies.

5 Ecological sanitation systems, also known as ecosan systems, have the added benefit of producing useful compost material that can be spread on fields as fertiliser.
6 Arborloo, with one pit, and Fossa Alterna, with two pits, are two types of ecosan system.
7 Water carriage systems such as WCs, pour-flush latrines and aqua privies have some advantages over dry systems but they require a regular water supply and are more expensive.
8 Handwashing facilities are essential for use with all types of latrine. They can be easily constructed from simple materials.
9 You can help families and others by providing advice on siting and choice of latrine.

Self-Assessment Questions (SAQs) for Study Session 20

Now that you have completed this study session, you can assess how well you have achieved its Learning Outcomes by answering these questions. Write your answers in your Study Diary and discuss them with your Tutor at the next Study Support Meeting. You can check your answers with the Notes on the Self-Assessment Questions at the end of this Module.

SAQ 20.1 (tests Learning Outcomes 20.1 and 20.3)

Explain the difference between an ecosan latrine and a standard pit latrine.

SAQ 20.2 (tests Learning Outcomes 20.2 and 20.4)

Figure 20.12 For use with SAQ 20.2.

What improvements would you suggest to the latrine shown in Figure 20.12?

SAQ 20.3 (tests Learning Outcome 20.2)

What are the potential risks posed to the environment in using dry pit latrines?

SAQ 20.4 (tests Learning Outcome 20.4)

List the materials you would need to make a simple device for handwashing.

SAQ 20.5 (tests Learning Outcome 20.5)

Ato Tedila, a local farmer, consults you about building a latrine in the compound of his house. He is an open-minded man who is keen to improve life for his family. He has a wife and three young children and his elderly mother also lives with them. They get their water from a well in the compound. The area has a heavy soil and the rock below is impermeable.

(a) Which types of latrine are possible choices for him?
(b) Which types of latrine would you recommend, and why?
(c) What other advice would you give him about the location, design and construction of the latrine?

Study Session 21 Latrine Utilisation – Changing Attitudes and Behaviour

Introduction

There is poor utilisation of latrines among individuals and families in some communities in Ethiopia. In the previous study session, you have learned about the alternative types and construction of latrines. In this study session, you will learn how to encourage latrine utilisation. You will be able to identify and take into account the factors that may influence people against using latrines. Involving model families to share their experiences and participate in regular inspections will help households to properly use their latrines, to seek technical advice when they need it and to solve any problems they encounter. The purpose of this study session is to teach you about approaches that are currently being used to achieve behavioural changes of individuals, families and communities towards good practice of hygiene and sanitation.

Learning Outcomes for Study Session 21

When you have studied this session, you should be able to:

21.1 Define and use correctly all of the key words printed in **bold**. (SAQ 21.1)

21.2 Identify various factors that affect the utilisation of latrines and handwashing facilities. (SAQ 21.2)

21.3 Describe ways of motivation used to enhance latrine utilisation. (SAQ 21.2)

21.4 Explain to selected model families, how to share their experiences of latrine utilisation to others. (SAQ 21.3)

21.5 Describe some approaches to community behaviour change. (SAQ 21.4)

21.6 List the tools used to conduct baseline surveys and regular inspections of latrine utilisation. (SAQ 21.5)

21.1 Benefits of hygiene and sanitation behaviour change

In the previous sessions of this Module you have learned that proper hygiene, adequate sanitation and safe drinking water have significant benefits for human health. You have also learned about the need to practise positive behaviours. Any change from bad habits to good practice is described as **behaviour change**.

■ When are the critical times for a person to wash his/her hands?

□ Critical times for handwashing are after visiting the latrine, after cleaning a child's bottom, before preparing food and before eating meals or feeding children.

Did you know? A gram of human faeces can contain 10 million viruses and 1 million bacteria.

Promotion of hygiene and proper sanitation is the single most important way to improve the health of your community (Figure 21.1). However, the right approaches need to be used to change behaviour and get people to take better care of themselves, their family's health and their environment. As health is an asset to a community, its improvement enhances economic development and brings wealth to a society.

Figure 21.1 Adults and children should always wash their hands after using the latrine. (Photos: WaterAid in Ethiopia)

21.2 Factors affecting the use of latrines and handwashing facilities

21.2.1 Latrines

The possession of an improved latrine, on its own, will not halt the transmission of faeco-orally transmitted diseases among the people of your community. For this to have an impact on health, the people have to use their latrines and handwashing facilities effectively.

■ What factors do you think affect the utilisation of latrines in your community?

□ There are several possible answers including the bad smell of a latrine, lack of privacy if the shelter is inadequate, childhood habits that are hard to break and many more.

The factors will vary from place to place depending on the local context. Behavioural, demographic, geographic, climatic, social, cultural and economic reasons can deter families from using latrines. For example, elderly or uneducated people in rural areas may find it difficult to get used to new technologies and may resist the adoption of new behaviours. In some local cultures, people may not want to share latrines with others; for example, women may not want to share the same facility as their father-in-law and there are some cultural practices that inhibit the use of one latrine by both the husband and wife. Children's faeces are often mistakenly considered not to be a potential health hazard and it may be considered unimportant for children to use the latrine. Household members may be discouraged from using the latrine at night because of the fear that 'evil' or 'devils' inhabit the latrine during that time. Another factor is the misconception that prevails among some farmers that using the 'cat-system' (i.e. burying excreta or leaving it open in a field) will improve the soil condition.

There are other more practical reasons such as the use of inappropriate materials for latrine construction, the collapse of latrines due to termites, flooding problems or loose soil conditions, and the need for frequent maintenance.

You need to identify the factors affecting the use of latrines that are relevant in your community. Once these are defined, then you can discuss them in a transparent way. Open discussion of these issues within the community will ease the construction and use of latrines.

21.2.2 Handwashing facilities

Despite the health benefits, some family members in rural households may not practise proper handwashing.

- ■ Why do you think that some people in your village don't wash their hands properly?
- □ Possible reasons include they can't afford to buy soap, they have a poor attitude to handwashing and can't be bothered to do it, they lack the utensils and equipment, the inappropriate placement of the handwashing facility or lack of water, but other reasons are also possible.

You should focus on individual and communal communication to change the attitude of people towards the direct (health) and the indirect (economic) benefits of handwashing. You can recommend the use of locally available materials such as ash for detergent purposes, and tin cans or jerrycans as handwashing devices (as described in Study Session 20). You can check that the handwashing facility is conveniently placed near latrines and that the water is clean to avoid further contamination.

21.3 Motivating people to change their behaviour

Health education is frequently delivered by someone lecturing about hygiene and sanitation in health facilities and community gatherings. However, such an approach is not recommended as the sole means to achieve individual behaviour change. Because human behaviour is influenced by the surrounding environment and social context, *specific* messages instead of *universal* messages of hygiene and sanitation are more important. Hygiene messages must be contextually and culturally suitable, and comfortable, for your community.

If you are trying to change behaviour by targeting individuals, you need to consider not only their prior experience but also their learned behaviours. These are the habits gained by **social learning** channels, i.e. from parents, friends and opinion leaders in their community. Each individual has their own beliefs, values and knowledge about health practices. People may ask themselves, before adopting a new behaviour, if the new practices are going to fit with their ideas and way of life. They need to be convinced that there will be important benefits from changing their behaviour.

Different motivational techniques can be used to good effect (see Box 21.1).

Box 21.1 Case study: Reasons for building latrines

In villages of Achefer *woreda*, different promotional techniques were used to encourage households to build pit latrines. Community members were asked which of these techniques was most effective. They were asked to choose the three most important reasons out of seven techniques that had been used. Table 21.1 shows the responses from 300 people.

Table 21.1 Reasons for building latrines in Achefer *woreda*.

Rank	Motivator/Reason	Points	%
1	House-to-house promotion of latrine building	92	31.3
2	Coffee ceremony to bring people together for discussion	73	24.8
3	Rewarding good practice with a coloured flag to be publicly displayed	39	13.3
4	Government enforcement	36	12.2
5	Influence of friends and neighbours (peer pressure)	27	9.2
6	Video show that demonstrated positive behaviour by others	23	7.8
7	Fear of being publicly shamed	4	1.4

House-to-house promotion by Health Extension Practitioners and health promoters, and holding coffee ceremonies specifically for hygiene promotion, were more effective than other methods in Achefer. Health promoters, including you, should use all possible ways of hygiene promotion in order to bring positive behaviour at community level.

(Source: adapted from WaterAid in Ethiopia, 2007, *The colour of change*)

In order to have an impact on health, any change in health practice needs to be adopted by many individuals in your community. Shared behaviour is only achieved when the community members themselves feel there is a problem, and are motivated to solve the problem by jointly taking actions that would permanently improve health conditions.

21.3.1 Using model households

Model households and families, also known as household models or role models, provide a valuable opportunity for you for to improve the exchange of learned behaviours to others. These households are often early adopters of new behaviours. You can select and recruit these families on the basis of their expressed interest and willingness to be involved in the promotion of hygiene and sanitation.

Your role would be to ensure they have the necessary knowledge and skill, and develop the right attitude, to help other households in learning about hygiene and sanitation. It is also important that model households are recognised and rewarded by the community leaders, both traditional and formal, and acknowledged by community members, friends and neighbours in order to sustain the existing achievements and encourage others to progress well.

21.3.2 Community motivation

UNICEF uses the term **Community Approaches to Total Sanitation** (CATS) to encompass a range of different community-based sanitation programmes. The aim of these approaches is **total sanitation** which means the complete separation of wastes from humans, i.e. no open defecation and 100% of excreta to be hygienically contained. An important goal for villages and other communities is to achieve **open defecation free** (ODF) status. Box 21.2 summarises the key elements of CATS.

Box 21.2 Essential elements of Community Approaches to Total Sanitation (CATS)

- CATS aim to achieve 100% open defecation free (ODF) communities through affordable, appropriate, acceptable technology and behaviour change.
- CATS depend on broad engagement with diverse members of the community, including households, schools, health centres and traditional leadership structures.
- Communities lead the change process and use their own capacities to attain their objectives.
- Subsidies – whether funds, hardware or other forms – should not be given directly to households.
- CATS support communities to determine for themselves what design and materials work best for sanitation infrastructure rather than imposing standards.
- CATS focus on building local capacities to enable sustainability.
- Government participation from the outset – at the local and national levels – ensures the effectiveness of CATS and the potential for scaling up.
- CATS have the greatest impact when they integrate hygiene promotion into programme design.
- CATS are an entry point for social change and a potential catalyst for wider community mobilisation.

(Source: UNICEF, 2009, *Community Approaches to Total Sanitation*)

The next section describes two particular approaches to community motivation that are becoming increasingly popular throughout the developing world.

21.4 Two approaches to communal behaviour change

Participatory Hygiene and Sanitation Transformation (PHAST) and **Community-Led Total Sanitation (CLTS)** are among the CATS techniques used to achieve total sanitation. These methods introduce community mobilisation and behaviour change as their core principles to improve sanitation and integrate hygienic practices.

Traditional methods of sanitation and hygiene promotion were teacher-driven, i.e. the educator taught by lecture and the community listened passively. CATS approaches are demand-driven, community-led and emphasise the sustainable use of user-friendly, affordable and safe sanitation. The following sections outline the basic principles of PHAST and CLTS but to be a facilitator of these techniques requires further study and training to develop the skills required. Such training might be sought from NGOs involved in water and sanitation (also known as WASH) projects.

21.4.1 Participatory Hygiene and Sanitation Transformation (PHAST)

PHAST is a widely used community approach to hygiene promotion. It uses participatory techniques to promote good hygiene behaviours, sanitation improvements and community management of water supply and sanitation facilities. It is derived from a *community appraisal* method of health practice that, in the process, empowers community members (participants) to be able to identify their community problems. Community appraisal is a process for analysing the existing community health problems by mapping water and sanitation, and identifying good and bad hygiene behaviour in relation to community hygiene practices and the spread of diseases. Figure 21.2 shows PHAST participants involved in group discussion and Figure 21.3 represents a group using a map they have drawn to identify the sanitation problems.

Figure 21.2 PHAST Community conversation. (Source: Addis Continental Institute of Public Health Students presentation, 2010)

Figure 21.3 PHAST participants looking at WASH mapping.

The next step in the process is for participants to make plans for solutions. During this planning process, they will look at the ways of blocking the paths for the spread of disease. Men and women share the tasks and select options for sanitation improvements and improved hygiene behaviour. This is followed by identifying who does what and noting what might go wrong. They also put in place the monitoring and evaluation process. Monitoring is meant to check the progress of the implementation of WASH activities, while evaluation looks at what improvements (health, social or economic) were brought about at community level. In all these steps, the facilitator's role is to guide the participants as they work through the PHAST process.

Box 21.3 describes a case study of the PHAST process.

Box 21.3 Case study: PHAST in Amba *kebele*

Tsehaye is a Health Extension Practitioner in Amba *kebele*. The *kebele* does not have adequate access to improved drinking water. A baseline survey of giardiasis prevalence was conducted and was found to be 25% among children under 10 years old.

Tsehaye had received training in the PHAST approach so that she could train others. She decided to put this training to good use and trained nine village volunteers in hygiene promotion specifically aimed at the prevention of giardiasis. These volunteers then mobilised 2,500 community members, both adults and children, in the *kebele*. During the training, the community members identified the bad behaviour they were aware of (such as open field defecation, disposal of child faeces in open spaces, not washing hands after visiting latrines and after cleaning a child's bottom). The community members, with the help of the nine village volunteers, planned to avoid those bad practices and in contrast, adopt and sustain good behaviour. The training and community mobilisation continued for one year. People started to change their behaviour as a result of increased awareness and a positive attitude towards healthy behaviour. Consequently, the prevalence of giardiasis among children in the Amba community was reduced to 10%.

Amba *kebele* is now planning to achieve open defecation free status within the coming 3–6 months. The achievement of Tsehaye and the volunteers was recognised and they took the best practitioner prize of the year from the *kebele* leader. They are highly motivated to work more to overcome the public health challenges in Amba *kebele*.

(Source: adapted from WHO, 1996, *Participatory hygiene and sanitation transformation*: *A new approach to working with communities*)

This case study demonstrates the use of PHAST as a tool for identifying the community WASH problems, planning the solutions and finally monitoring and evaluating the WASH performance. You should notice that the focus of PHAST is always on the involvement of the community to determine and solve its problems.

21.4.2 Community-Led Total Sanitation (CLTS)

CLTS aims to bring community-wide elimination of open defecation by raising awareness and promoting affordable technology options. NGOs, multinational organisations and government health programmes in many countries in developing regions of the world (including Ethiopia) are adopting this approach. It has become the most successful community approach to total sanitation.

Like PHAST, the core principle of CLTS is that it is a community-driven approach. The role of outsiders, possibly including you as a Health Extension Practitioner, is to guide the community to assess its sanitation situation, determine a strategy for improvement, implement the solution and develop a way to measure success.

CLTS relies on the skill of the facilitators using a set of activities and demonstrations to communities to study their situation (Figure 21.4). This includes open defecation patterns in their village and faeco-oral contamination that occurs in their community.

Figure 21.4 Sanitation profile mapping using a participatory approach. (Photo: WaterAid in Ethiopia)

CLTS encourages community members to change by going through an 'ignition' moment when they are 'triggered' into action, for example, the moment when they collectively realise that open defecation amounts to eating each others' faeces. In the 'ignition' process, the facilitator talks to a gathering of all community members (including men, women, children, youth and elderly) in direct language about sanitation in a way that is normally taboo in the community. By engaging them in frank and transparent discussions, for example asking them to assess the amount of faeces they produce, you will 'trigger' them by creating a sense of shame and disgust, which in turn mobilises the community to take immediate action to end open defecation. The facilitator will guide (not prescribe!) the participants in developing their own low-cost latrine designs and a sanitation plan of action for their villages. Hopefully, with the help of locally available expertise and resources, the participants can immediately start constructing latrines.

As part of the CLTS process, activists and enthusiastic members of the community called 'natural leaders' should emerge and take the lead. Natural leaders will play a vital role in encouraging communities to adopt and go through with the planned activities. These natural leaders could subsequently become 'consultants', triggering and providing engagement and support to communities other than their own.

School-Led Total Sanitation (SLTS) is a related form of community approach to total sanitation. You can engage school teachers and students in similar sanitation activities with the aim to clean up the school environment and promote hygiene among school children and staff. School sanitation clubs can be actively engaged in SLTS. Though the targets are slightly different, the techniques are similar to the CLTS approach.

In CLTS, it is very important for you to consider and understand the cultural and contextual differences between communities. There might be incidences when the community members may be angry or sensitive to discussions at times of triggering and when they are ignited. You must know how to handle these events in order to get back on track. So instead of adopting the whole practice of CLTS applied elsewhere, you may need to adapt it to fit your community's cultural and social conditions.

Box 21.4 Case Study: CLTS in Fura *kebele*

Fura *kebele* declared Open Defecation Free (ODF) status in September 2, 2007.

Fura is in Shebedino Woreda in the Southern Nations Nationalities People's Region of Ethiopia. Like other areas of Ethiopia, Shebedino suffered with open defecation in the fields, around the home, on footpaths and in the bush. Plan Ethiopia Shebedino Programme, an NGO, technically facilitated the implementation of CLTS in this *kebele* in February 2007. Local leaders and the Health Extension Workers and health promoters were first trained in CLTS approaches and then community members were involved. With CLTS training, the participants were overwhelmed with shame and disgust because of their open defecation practices. They promised to end open defecation and they achieved this within four months. CLTS mobilised community residents to identify their problems and design their own solutions to improve hygiene and sanitation behaviour. CLTS also facilitated development of local rules, such as 'any person caught defecating in the open, will be forced to shovel and carry his faeces to the nearest latrine'. All households, 1265 of them, had latrines and 7 communal latrines were constructed along the main road to the market place to be used by passers-by. About one third of household latrines were constructed after CLTS was introduced.

The progress towards total sanitation and the year when 100% coverage was achieved is shown on a chart on the wall of Fura Health Post (Figure 21.5).

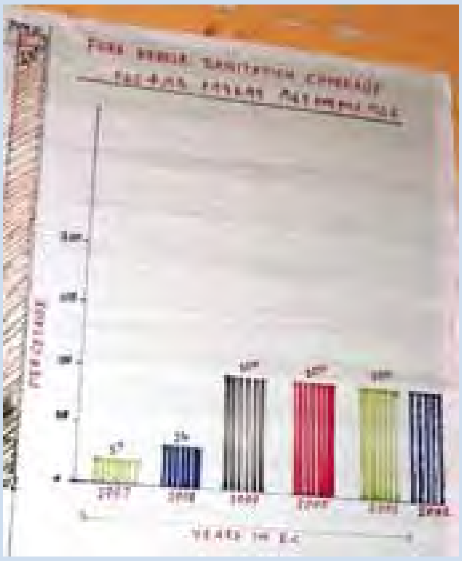


Figure 21.5 Wallchart at Fura Health Post showing the rapid increase in sanitation coverage in the *kebele.* 100% coverage was achieved in 1999 in the Ethiopian calendar, 2007 in the European calendar. (Photo: Pam Furniss)

Box 21.4 continues on the next page

Open Defecation Free was declared and celebrated on September 2, 2007. Project personnel, local leaders and the *kebele* residents, in total about 500 people, participated in the celebration which was organised in the compound of Fura School. Poems, drama, songs and posters that condemn open defecation were presented. One of the dramas (Figure 21.6) focused on the need to punish anyone who defecates in the open air.

Figure 21.6 Community members demonstrating in drama how they punish open defecators.

Slogans and sign boards that strongly promote the importance of hygiene and sanitation adorned the school compound. One slogan read: 'Fura: the *kebele* where all households constructed pit latrines on their own initiative, and where all use latrine, saying no to open defecation'. Other slogans read: 'Bury faeces not people'; 'Fura enters the New Ethiopian Millennium open defecation free'. Community members were very happy about the recognition they had for being Open Defecation Free. They were highly committed and promised to keep their *kebele* ODF in the future. Neighbouring *kebele* leaders and Health Extension Workers were invited to share the experience of the Fura ODF event. This resulted in the establishment of school clubs, advocating CLTS in churches and mosques, and establishment of CLTS Committees in other communities.

(Source: adapted from SuSanA, 2007, *Fura kebele declared open defecation free environment*)

21.5 Latrine utilisation monitoring and evaluation

Any programme that is promoting behaviour change needs to have a process for assessing how effective it is – in other words, a monitoring and evaluation process. Latrine utilisation promotion and other WASH projects therefore need to include monitoring and evaluation activities. This means setting specific, measurable and achievable objectives, and clearly stating the monitoring activities and indicators to be used.

There is an important preliminary step which is to gather baseline data of the situation *before* the intervention for comparison with the data gathered by the monitoring activities. The same indicators should be used both before and after so you can compare like with like. Important measurable indicators for latrine use and handwashing include:

- no visible human excreta in likely sites
- percentage of households that have a latrine and which is seen to be in use

- percentage of latrines with no faeces and urine soiling on walls and floors
- presence of handwashing facility and water near the latrine
- presence of soap, ash or other cleaning agent near latrine
- percentage of communities/villages certified as ODF
- percentage of households that have upgraded their latrine to an improved system
- percentage of households with clean compounds without any excreta.

A sample checklist for these indicators is shown in Box 21.5.

Box 21.5 Sample checklist for latrine utilisation

Name of *kebele*	
Name of village	
Questions to asked	**Response (yes/no)**
Is there a latrine?	
Is the latrine functioning?	
Is there faeces and urine around the latrine?	
Is there faeces and urine around the house?	
Is there a handwashing facility near the latrine?	
Do the family members wash their hands after latrine use? (observe)	
Is there water available for handwashing at the time of your visit?	
Is there soap or ash in the handwashing facility for handwashing?	
Do you observe fresh faeces inside the latrine?	
Is the footpath to the latrine free from any barrier?	
Name of data collector	
Date	
Signature	

Summary of Study Session 21

In Study Session 21, you have learned that:

1 Proper community hygiene and sanitation programmes have useful health and socio-economic benefits.

2 Identifying the possible reasons for not using latrines and handwashing facilities properly is important in order to promote and sustain positive hygiene behaviours.

3 Latrine utilisation and handwashing practices are affected by behavioural, cultural, social, custom, demographic and economic factors.

4 Motivating individuals, families and community members using various stimulating techniques will help to bring and sustain hygiene behavioural changes.

5 There are different behaviour change models and practical approaches that are applicable for hygiene and sanitation practice.

6 CLTS and PHAST approaches are community-driven, facilitator-guided methods for promoting total sanitation and good hygiene practices.

7 Monitoring and evaluating the performance of changed behaviour is always important in order to sustain established healthy behaviours.

Self-Assessment Questions (SAQs) for Study Session 21

Now that you have completed this study session, you can assess how well you have achieved its Learning Outcomes by answering these questions. Write your answers in your Study Diary and discuss them with your Tutor at the next Study Support Meeting. You can check your answers with the Notes on the Self-Assessment Questions at the end of this Module.

SAQ 21.1 (tests Learning Outcome SAQ 21.1)

Rewrite the paragraph below using terms from the list provided to fill the gaps.

The terms to use are: PHAST; behaviour change; CLTS; CATS; total sanitation; ODF status.

Improving latrine utilisation requires ________ by the people in the community. Some people may need to be persuaded that ________ and _______ are valuable aims that will help prevent the spread of disease. There are various approaches that can be used to try to achieve _________. Two examples of these approaches are _______ and _________. Both these methods depend on involving the whole community in the process and they are grouped together as _______.

SAQ 21.2 (tests Learning Outcomes 21.2 and 21.3)

Imagine a small village of about 20 households where open defecation is the normal practice. You have visited the village and, from discussions with the people there, you know that most of them are ignorant of the importance of sanitation. They say to you that they have always lived in this way and so did their parents and grandparents before them. They are reluctant to change their habits. What methods would you consider to motivate change in their behaviour?

SAQ 21.3 (tests Learning Outcome 21.4)

In the same village as SAQ 21.2, imagine there was one family that had their own latrine. You think they might be willing to be a model household to demonstrate good hygiene and sanitation to the others. What would you say to them to encourage them to volunteer as a model household?

SAQ 21.4 (tests Learning Outcome 21.5)

Identify one similarity and one difference between PHAST and CLTS approaches.

SAQ 21.5 (tests Learning Outcome 21.6)

Assume you have successfully implemented a CLTS programme. How do you really know if you have been successful?

Study Session 22 Solid Waste Management

Introduction

The common practice for household refuse disposal in rural areas is to dump solid wastes openly in backyard gardens or in an open space. Such indiscriminate disposal is an environmental hazard and can threaten human health and safety. Solid waste that is improperly disposed of can result in a number of problems. It can create a breeding ground for pathogenic microorganisms and vectors of disease, and cause a public nuisance due to unsightliness and bad smell. It can cause contamination of surrounding soil, groundwater and surface water, and it can also create fire hazards, physical hazards and have poisoning effects (from pesticides and insecticides). However, these problems can be avoided by using appropriate management techniques. For all waste management issues, your role should be to engage community members and families in awareness of the solid waste problems in their area and try to change their behaviour. In doing so, it should be possible to have a clean, attractive and sustainable environment.

In this study session, you will learn about the different types of solid waste and their common sources. You will also learn about the stages in solid waste management and appropriate disposal methods. Proper management of solid waste will help your community prevent communicable diseases and safeguard the environment in a sustainable manner.

Learning Outcomes for Study Session 22

When you have studied this session, you should be able to:

22.1 Define and use correctly all of the key words printed in **bold**. (SAQ 22.1)

22.2 Describe the different sources and characteristics of solid waste. (SAQ 22.2)

22.3 Describe the functional elements of solid waste management. (SAQ 22.3)

22.4 Describe the different methods of solid waste management. (SAQs 22.3 and 22.4)

22.5 Survey solid waste management practices. (SAQ 22.5)

22.1 Sources and classification of solid waste

Solid wastes include household refuse, agricultural remnants, food leftovers, plastic bags, tin cans, ash and packaging, such as cartons and used *jonya* sacks. They become waste once they have been discarded because they are no longer needed in their present form. Refuse, garbage, litter and street sweepings are all terms used to describe solid wastes in various situations.

In rural parts of Ethiopia, the type of solid waste generated will vary depending on the particular location and the socioeconomic and cultural conditions of the area.

In general, rural households produce wastes that are mostly *organic* in nature and result from agricultural production and processing activities. They include crop residues, food remnants, leaves and grass from clearing of sites, animal manures and dung, ashes, dead animal carcasses, etc. Other solid wastes could include glass, plastic containers, metal scraps, tin cans, plastic bags, condoms and obsolete agricultural pesticides and insecticides. These solid wastes need to be managed properly in a way that avoids the potential risks to the environment and to human health.

The type of waste will determine the choice of possible disposal methods. Therefore, it is important to be able to classify solid waste according to its characteristics (Table 22.1).

As you may remember from Study Session 18, solid waste can be classified based on its source as residential, agricultural, commercial, industrial, institutional or healthcare waste. You were also introduced to the classification of waste as hazardous or non-hazardous and also as biodegradable or non-biodegradable. Another word used in the context of biodegradable solid waste is *putrescible,* which means the waste decomposes (rots down) quite quickly. Waste can also be described as combustible or non-combustible depending on whether it will burn or not. Table 22.1 classifies waste using these different properties.

Table 22.1 Classification of solid waste.

Main classification	**Type**	**Short description**	**Examples**
Hazardous waste	Solid or semi-solid	Substances that are either ignitable, corrosive, reactive, infectious or explosive	Some obsolete pesticides such as DDT, dieldrin, etc.
Non-hazardous waste	Putrescible	Easily decomposable/ biodegradable solid waste	Food wastes
	Non-putrescible	Non-biodegradable solid waste, it includes combustible and non-combustible waste	Plastic bags, bottled water containers, tin cans, etc.

Putrescible wastes are generated by growing, handling, preparation, cooking and consumption of food. These kinds of wastes tend to be more abundant during the summer (rainy) seasons. Non-putrescible wastes do not decompose easily; they may or may not be combustible. Because they do not break down, they persist in the environment and are often the cause of nuisance and aesthetic problems.

■ Can you think of any non-putrescible wastes that cause environmental problems in your community?

□ We don’t know exactly what the waste problems are in your area but a probable answer is plastic bags because they are a widespread problem in Ethiopia.

Plastic bags are commonly known as *festal*. They are widely used to carry goods from market to home in all areas because they are convenient, cheap and easy to use. Plastic bags are usually non-biodegradable and persist in the environment for a very long time. Moreover, when discarded indiscriminately, they pollute the land surface of your community, prevent rainwater from percolating into the soil, can easily be blown all over the place by wind, and create unsightly and nuisance conditions. The bags can also be easily swallowed by animals, which may block their digestive system and kill them (Figure 22.1). In malaria-prone areas, there is also a potential to create breeding places for mosquitoes because the bags may trap small pools of water.

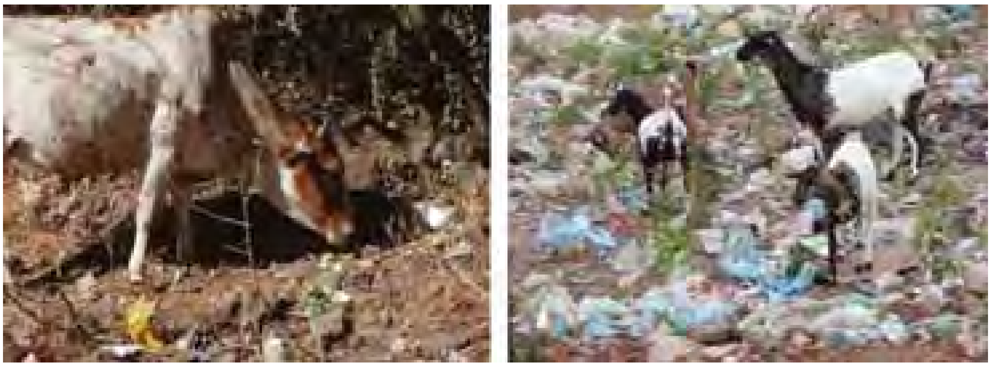


Figure 22.1 Discarded plastic bags are a health hazard for grazing animals. (Photos: Pam Furniss)

22.1.2 Hazardous waste

Hazardous wastes are treated as a separate category of waste because special management and disposal methods are required. The main sources of hazardous substances are agricultural offices/stores, health offices/stores and possibly also private firms, homes and retail shops. The toxic, corrosive, ignitable, explosive and/or infectious characteristics of these wastes require careful and stringently controlled methods of handling, storing and transportation. Hazardous wastes, because of their particular environmental health hazard, should be identified, quantified and reported to a higher level for further action.

- ■ What is an environmental health hazard?
- □ An environmental health hazard is any environmental factor or situation that can cause injury, disease or death.

In Study Session 2 you learned about the causes and types of environmental health hazards. The immediate health effects from hazardous wastes range from bad smells and simple irritation of eyes, skin, throat and breathing (lungs), to serious health conditions that affect the nervous system and could cause paralysis of the functional body parts. Some hazardous solid wastes have teratogenic (birth defects) and carcinogenic (cancer causing) effects.

The long-term effects of hazardous wastes can be devastating to community health and wellbeing. However, it is difficult to quantify the exposure level and predict the health consequences as a result of exposure because the types of hazardous waste are so variable. If you observe or get reports from others about the presence of any hazardous waste, you should report this to the environmental health office and/or the agricultural development agent in your locality.

If you know there are stores of hazardous materials in your community, you should monitor them regularly using observation checklists and by asking for information, and then report your findings if you have any concerns. You should not attempt to bury, burn or dispose of hazardous wastes. Hazardous solid wastes require specialised methods of handling, collection, transportation and disposal. Some wastes, such as obsolete pesticides or radioactive material, may need to be transported out of the country for final disposal. (Hazardous solid wastes from health institutions will be dealt with separately in the next study session.)

22.2 Functional elements of solid waste management

In Study Session 18 you were introduced to the functional elements (stages) of solid waste management which are:

- onsite handling, storage and processing
- collection
- transfer and transport
- resource recovery and processing
- disposal.

The complete set of functional elements will apply in urban centres managed by municipal authorities but not all of them will be relevant in rural areas.

22.2.1 Onsite handling, storage and processing

Figure 22.2 Waste basket provided by the local Guides Association at a Lake Tana monastery. (Photo: Pam Furniss)

Onsite means these functions are concerned with solid waste at the place where the waste is generated. For residential waste this means at home in the household. Onsite handling is the very first step in waste management. It involves individual family members, households and communities, all of whom need to know how to handle waste properly at this level. ‘Handling’ means the separation of wastes into their different types so they can be dealt with in the most appropriate way, for example, separating putrescible waste for composting. The benefits of appropriate onsite handling include reducing the volume of waste for final disposal and recovering usable materials.

Onsite storage means the temporary collection of waste at the household level. It is important that waste is stored in proper containers. These could be baskets, preferably made from locally available materials, plastic buckets or metal containers (Figure 22.2). Larger containers or dustbins, especially those used for food waste, should be leakproof, have tight lids and be long-lasting. The size of the container should be sufficient to hold at least the amount of solid waste that is generated per day at household level. Institutions and businesses should consider having onsite storage facilities with greater capacity. The proper location of storage containers and the frequency and time of emptying are important factors to be considered for efficient onsite storage.

Some wastes will need some sort of onsite processing before the next steps, for example, in areas where false banana (*enset*) is used as a staple crop, the byproducts should be chopped into pieces before composting to speed up the rate of decomposition.

22.2.2 Collection, transfer and transport of solid waste

In urban centres, collection is a function that has its own process and services. Waste is collected and held at central transfer stations where waste is stored before it is transported to a final disposal site. In rural areas, waste is not normally collected in this way and disposal is limited to onsite processing options, although sometimes there may be communal collection of solid waste using animal carts.

22.2.3 Resource recovery and processing

Resource recovery means finding a way to use the waste so it becomes a valuable resource, rather than just a disposal problem. This is a very important part of waste management. Resource recovery includes a range of processes for recycling materials or recovering resources from the waste, including composting and energy recovery. Converting the waste into a new product may require energy and equipment; therefore, there needs to be a careful assessment of inputs and outputs in case it is not economically sensible to do it. Resource recovery options are discussed further in the following sections of this study session.

22.2.4 Disposal of solid waste

Even after recycling and resource recovery there will almost certainly be some residual waste that needs final disposal. Methods of disposal can be sanitary or unsanitary. Open field dumping is the most unsanitary method of refuse disposal and is most likely to cause a health hazard. Sanitary methods – including controlled tipping or controlled burial, incineration and sanitary landfill – are discussed later in this study session.

22.3 Integrated solid waste management

The concept of **integrated solid waste management (ISWM)** mostly applies to municipal solid waste management in urban centres. The principles can, however, be applied to some extent in rural and peri-urban solid waste management.

In Study Session 18, it was explained that an ISWM approach means considering not only the appropriate disposal of solid waste but integrating this with other management options such as minimising waste production, recycling, composting and other waste recovery options. These different options can be ranked in order of their desirability as management options. This is often represented in a diagram known as the waste management hierarchy (Figure 22.3) that you first met in Study Session 2.

Figure 22.3 The waste hierarchy. Waste management options are listed in order of desirability from most desirable at the top to least desirable at the bottom.

At the top of the hierarchy is **reduction**, which means keeping the production of waste to a minimum. Next comes **reuse**, which simply means using something more than once. The third option in the hierarchy is **recovery,** which includes several separate processes that enable material or energy resources to be recovered from the waste. These include recycling, composting and energy from waste. Finally, the least desirable waste management option is **disposal,** which includes landfill, tipping and incineration (burning) without energy recovery.

We will now look at the options for waste management in the hierarchy in a little more detail.

22.3.1 Reduction strategies

Reduction strategies are the ways that a household or community may use to try to reduce or minimise the amount of solid waste they produce. This approach is generally more relevant in affluent homes and societies with a wasteful lifestyle. For example, people with more money may not worry about throwing household items away when they can afford to buy replacements. In a business context, using two-sided photocopying of a document reduces the paper used and also therefore the waste produced.

22.3.2 Reuse strategies

Reuse refers to the act of using an item more than once, either for the same or similar purpose. Figure 22.4 shows used plastic bottles and other containers for sale to be reused. Unlike recycling and other recovery options, reuse does not require reprocessing and therefore requires less energy.

Figure 22.4 Plastic containers are frequently reused. (Photos: Pam Furniss, Janet Haresnape)

- ■ What sort of materials or products are reused for the same or different purposes in your community?
- □ Using plastic bottles or glass containers for water, oil or gasoline are possible answers though there are a number of others from household utensils to personal uses.

22.3.3 Recovery strategies: recycling, composting and energy

Recycling

Recycling is a process by which waste is processed in some way to be reformed into new or similar products. The principle is to make a usable product from the waste. Plastic bottles, newspapers, cardboard and tin cans can all be reprocessed and made into new items. Plastic bags can also be recycled and used to make mats, carpets and other products. Waste metal has a number of possible uses because it is relatively easy to reshape (Figure 22.5). Careful separation of the waste into its different types is important for the efficiency of recycling processes. Recycling not only reduces the quantity of waste but also saves money, so there is an economic, as well as an environmental, incentive to recycle.

Figure 22.5 Waste metal can be recycled by using it to make new and different products. (Photos: Janet Haresnape, Basiro Davey)

Composting of organic solid wastes

Non-hazardous, putrescible solid wastes such as crop residues, leaves, grass and animal manures can be managed onsite by **composting**. Composting is a controlled process in which this type of waste is collected in an open pit or heap and is decomposed by natural biological processes. The waste is broken down by the action of a variety of microscopic and other small organisms. The waste is converted into a stabilised material that can be used as fertiliser. Composting is an environmentally friendly way of recovering value from organic waste.

As we discussed in previous sessions, both human waste and organic household waste can be composted. However, the process is different. Human waste can be composted in alternating double pit latrines and in ecological sanitation systems. This process of composting is anaerobic. In the case of organic household waste composting, it is an aerobic process.

■ What is the difference between aerobic and anaerobic processes?

□ Aerobic processes require oxygen or air to be present. Anaerobic processes take place without oxygen.

The pit for composting should be dug about 50 m away from a dwelling. The pit needs to be about 1 m deep and at least 1 m breadth and 1 m length. However, the size can vary with the amount of waste generated. The pit depth should be slightly less on one side, about 90 cm, to make a slope so that water does not collect at the bottom. To make the compost, organic matter such as grass, leaves and kitchen/food waste should be thrown into the pit in a shallow layer. It is very important that only biodegradable material is added, so care is needed to sort the waste beforehand. No plastic should be included and bones should be avoided. The waste should then be covered with a thin layer of soil. Covering with soil encourages the composting process and prevents the breeding of flies and other vermin. Air must be allowed to mix with the compost so the contents of the pit need to be turned frequently by digging. The compost needs a small amount of water to keep it moist. The time for the compost to be ready will vary depending on the temperature and the mix of waste among other factors but it should be ready within a few months.

Composting is mostly practised in rural communities. In Ethiopia, it is becoming customary for households to prepare compost from their household organic wastes and you should encourage this practice.

Energy from incineration

To incinerate something is to burn it. In waste management terms, however, **incineration** means burning in a controlled and managed process – usually at high temperature. Incineration cannot be implemented at household level; it is mostly used for institutional waste management purposes.

Different types of incinerator are used for burning waste. They differ by the temperature at which they operate, the cost of construction, the method of operation and the maintenance requirement. Incinerators can be used for disposal of wastes in health institutions/Health Posts and government and private institutions/offices/industries. Incineration can reduce the volume of refuse by up to 90%; the only remaining residual waste is ash. This significantly reduces the volume of material needing final disposal. Incineration is only classed as 'recovery' in waste management if the energy (heat) that is produced is used in some way.

22.3.4 Final disposal: landfill, controlled tipping and burning

Sanitary landfill means the *controlled* filling of compacted layers of solid waste and soil into pre-prepared land. Large-scale landfill sites for municipal waste need to be designed to protect surface and groundwater from contamination by **leachate**, the liquid waste that may seep out into the ground underneath the layers of waste. Sanitary landfill sites are not just rubbish dumps for open field dumping. To be classed as sanitary the site must be managed to minimise any negative environmental impact.

Controlled tipping or controlled burial is similar in principle to sanitary landfill but at a smaller scale that is appropriate in rural areas. In controlled tipping/burial, solid waste is disposed of into a dug pit and is regularly covered with soil to avoid attracting disease vectors such as flies and rodents. Covering the waste also stops it from being blown by the wind and avoids bad smells – hence 'controlled'.

Note that various similar terms may be used to describe different types of waste disposal pit. A refuse pit is a simple pit used to dispose of household refuse, which may or may not be used for controlled tipping (with soil). Some wastes will need to be buried under soil as soon as they are disposed of, in which case the pit may be referred to as a burial pit.

When there is a need for preparing a refuse pit for households, you should advise them that sites for controlled tipping should be 10 m away from the house (preferably at the back of the house), at least 15 m and preferably 30–50 m away from water wells and at a lower ground level. At community level, a communal refuse pit should be 100 m away from houses and they will also need to consider the direction of wind. The site should be easily accessible, with adequate space, and should be fenced so that it is not accessible to children and domestic animals (Figure 22.6).

Figure 22.6 Refuse pit with a fence to prevent people or animals from accidentally falling in. (Photo: Pam Furniss)

Care must be taken to avoid creating places that could harbour rats or encourage the breeding of flies and other insects. Waste from individual households should be taken to the site in suitable containers such as sacks, plastic bags or buckets. For a community waste disposal pit, it should be a collective responsibility to keep communal areas clean.

Animal carcasses need to be disposed of carefully because they can encourage the breeding of flies and rodents, and attract scavenger animals. They can be disposed of in a common burial pit for the community.

Burning of waste is another possible, though less desirable, method of final disposal. A burning site should be sited downwind and well away from houses. Non-combustible materials such as broken bottles, bones, etc. should be separated and buried at a safe location, not used by farming. Ashes that remain after burning can be used as fertiliser or, if mixed with mud, can be used for plastering of earth walls or floors.

22.4 Surveying solid waste management

The management of solid waste can have a significant impact on human and environmental health. You need to be able to survey the ways that solid waste is managed in your area so that you can assess the situation and identify possible areas for improvement. The list of questions below indicates some of the issues that should be covered in your survey; you may think of other questions to include.

How many of the households in your *kebele* have a compost pit?

Do households without compost pits have adequate space to make one?

Are there other opportunities for recycling or reuse of waste material?

Does the community have a communal refuse disposal pit?

How many people use each refuse pit?

Is there a need for another communal pit?

Are the refuse pits fenced and properly managed?

Is there adequate equipment in your *kebele* for managing solid waste?

Is there any open dumping of waste in your *kebele*?

Answering these questions will provide you with the baseline data you will need for planning improvements to the solid waste disposal facilities. If households do not manage their waste properly you may want to try to find out the reasons for this. It may be lack of resources such as money, space or labour, or there may be behavioural reasons that make people unwilling to use compost pits, for example. Understanding the reasons for the behaviour will help you to give advice to the family and indicate the most effective ways to promote good waste management practices.

After analysing your survey results, you may want to prepare an action plan. There are several possible measures that you could consider including in your plan to lessen the problems. You may want to promote general good practice by ensuring all households have adequate waste containers at home. You may need to ensure all pits are fenced and properly managed. You may need to mobilise the community to dig a new refuse pit, if your survey suggests that one is needed. You may want to focus on a specific problem like plastic bags. You could advise people to collect their plastic bags in one place for recycling and it may also be possible to encourage individuals and enterprises to undertake this profitable activity. You could encourage more reuse of plastic bags by suggesting that people take bags with them to the market or shop to be used again. You could promote other types of bag such as paper bags because they are made of biodegradable materials or permanent bags like cloth bags. You could get the local school involved and initiate a campaign among the children to collect waste bags to clean up the local environment.

Keep in mind that any action plan should be drawn up with the involvement of your community because it will not succeed without their full cooperation. You should include regular monitoring in your plan so you can assess if progress is being made.

Summary of Study Session 22

In Study Session 22, you have learned that:

1 In rural communities of Ethiopia, the type of waste produced is mainly agricultural and household waste, which is organic and compostable in nature.

2 There are several different ways of classifying waste, including putrescible or non-putrescible, hazardous or non-hazardous, and combustible or non-combustible.

3 Hazardous chemicals such as obsolete pesticides are concerns in rural communities.

4 The functional elements of solid waste management are onsite storage, processing and handling, collection, transfer and transport, resource recovery, and final disposal.

5 Landfill as a means of disposal of solid waste is used in urban situations but may not apply in rural settings. Controlled tipping/burial and composting methods are preferred.

6 Disposal of plastic bag wastes (*festal*) is a cause of concern and needs special attention to be managed sustainably.

7 Care should be given in selection of disposal sites at residential or communal level.

8 Surveying and community involvement is needed in order to prepare viable action plans to improve solid waste management practices.

Self-Assessment Questions (SAQs) for Study Session 22

Now that you have completed this study session, you can assess how well you have achieved its Learning Outcomes by answering these questions. Write your answers in your Study Diary and discuss them with your Tutor at the next Study Support Meeting. You can check your answers with the Notes on the Self-Assessment Questions at the end of this Module.

SAQ 22.1 (tests Learning Outcome 22.1)

Which of the following statements is *false*? In each case, say why it is incorrect.

A Recycling is the best approach to solid waste management.
B Composting is an aerobic decomposition process for converting organic solid waste into useful compost.
C Reusing plastic water bottles is an example of waste recovery.
D Controlled tipping is so called because only a limited quantity of waste can be tipped at any one time.

SAQ 22.2 (tests Learning Outcome 22.2)

Categorise the different kinds of waste listed below as hazardous or non-hazardous, and as compostable or non-compostable.

Tin cans, manure, grass, obsolete herbicides, paper bags, plastic *festal*, expired drugs, potato peelings.

SAQ 22.3 (tests Learning Outcomes 22.3 and 22.4)

List the functional elements of solid waste management. Which of these are relevant to rural settings? Explain why these are relevant but the others are not.

SAQ 22.4 (tests Learning Outcome 22.4)

Briefly describe the preparation of compost.

SAQ 22.5 (tests Learning Outcome 22.5)

Identify two important indicators used to monitor solid waste management in a community. Describe how you would assess them.

Session 23 Healthcare Waste Management

Introduction

Improper handling and disposal of healthcare wastes (also sometimes called medical waste) puts the health worker, the patient and the community at large at risk through transmission of pathogens via blood or body fluids, contaminated medical equipment, or sharp instruments. In this study session, you will learn to identify the types and sources of healthcare waste. The session also describes the components of waste management and the disposal methods for these wastes. Recognising the health risks involved in poor healthcare waste management and practising proper medical waste disposal will help protect everyone from the hazards of healthcare waste.

Learning Outcomes for Study Session 23

When you have studied this session, you should be able to:

23.1 Define and use correctly all of the key words printed in **bold**. (SAQ 23.1)

23.2 Distinguish between the types, and identify the risks, of medical waste. (SAQ 23.2)

23.3 Describe the handling and disposal requirements for healthcare waste. (SAQs 23.3 and 23.4)

23.4 Describe the health risks to health workers or patients related to sharps injuries. (SAQ 23.4)

23.1 Sources and classification of healthcare waste

Healthcare waste can be defined as any waste produced by healthcare activities. It may also be known as medical waste, hospital waste or infectious waste. The major sources include hospitals, Health Posts, emergency medical care services, healthcare centres and dispensaries, obstetric and maternity clinics, outpatient clinics, and the like. Other sources are dental clinics, psychiatric hospitals, cosmetic ear-piercing and tattoo parlours, and illegal drug users. Healthcare waste can be put into one of two broad categories; non-hazardous 'general waste' and hazardous 'healthcare risk waste'.

Between 75% and 90% of the waste produced in healthcare establishments is general waste. This includes papers, packaging materials, dust and the like. This can be disposed of in the same way as other non-hazardous wastes, but only if is not contaminated by contact with hazardous wastes. The remaining 10–25% of waste is hazardous and could be composed of sharps (needles, lancets, etc.), syringes, blood or body fluid, contaminated surgical instruments, delivery bowls, used gauzes and gloves, plasters, etc. It may also contain expired drugs, lab reagents and other chemicals. Your main concern here should be on managing the hazardous wastes in a safe way. However, you should not ignore non-hazardous wastes, because poor handling and segregation can lead to them being contaminated with hazardous materials.

You can categorise hazardous healthcare waste into:

- Infectious waste: waste that may contain pathogens. This includes used dressings, swabs and other materials or equipment that have been in contact with infected patients or excreta. It also includes liquid waste such as faeces, urine, blood and other body secretions.
- Pathological waste: human tissues including placentas, body parts, blood and fetuses. Anatomical waste is a sub-group of pathological waste and consists of recognisable body parts.
- Sharps: needles, infusion sets, scalpels, blades and broken glass.
- Pharmaceutical waste: expired or no longer needed pharmaceuticals; items contaminated by or containing pharmaceuticals (bottles, boxes).
- Genotoxic waste: substances with genotoxic properties (meaning they can cause genetic damage) such as certain drugs and genotoxic chemicals.
- Chemical waste: wastes containing chemical substances such as laboratory reagents, film developer, disinfectants that are expired or no longer needed, and solvents.
- Waste with high content of heavy metals: includes batteries, broken thermometers, blood-pressure gauges, etc.
- Pressurised containers: gas cylinders, gas cartridges and aerosol cans.
- Radioactive waste: containing radioactive substances from radiotherapy or laboratory research.

You should note that the last five on the list may not necessarily apply at Health Post level; however, you should be aware of these hazards in case you encounter them elsewhere.

Note also that infectious waste and pathological waste are overlapping categories. Blood, for example, is in both categories. All pathological waste should be considered as potentially infectious. Following the precautionary principle, pathological waste must be handled and disposed of as if it were infectious.

■ What is the precautionary principle?

□ In Study Session 2, you learned that if you follow the precautionary principle, this means you take precautions to avoid environmental damage, even if you are not certain that damage will result.

23.2 Public health importance of healthcare waste

Healthcare waste is varied in type and the amount produced is increasing each year. Moreover, if there is little or no segregation of non-hazardous and hazardous waste, it is inevitable that the general waste component will become contaminated and must then be regarded as hazardous.

Everyone in the community is potentially at risk from exposure to healthcare waste, including people within the healthcare establishment and those who may be exposed to it as a result of poor management of the waste.

- List all the people who could be at risk from healthcare waste produced at a village Health Post.

- Your answer will depend on where your Health Post is and on the local conditions, but your list might include yourself as the Health Extension Practitioner; your patients and people accompanying them; anyone who takes the waste away for disposal; anyone who lives or works close to the disposal place; children who may play in the area and pick up contaminated items.

23.2.1 Hazards from infectious waste

Infectious wastes may contain a variety of pathogenic microorganisms. The route of entry into the body for microorganisms may be through a puncture, abrasion or cut in the skin, possibly caused by sharps contaminated with pathogens. Entry may also be through the mucous membranes (such as eye, mouth or nose), by inhalation, or by ingestion.

There is a particular concern about infection with human immunodeficiency virus (HIV) and hepatitis viruses B (HBV) and C via healthcare waste. These viruses are generally transmitted through needlestick injuries contaminated by human blood. Needlestick injuries are piercing wounds usually caused by the point of a needle but also by other sharp objects. To avoid the risk of HBV, it is recommended that all personnel handling healthcare waste should be immunized. Unfortunately, no vaccine is yet available against hepatitis C.

23.3 Management of hazardous healthcare waste

The aim of healthcare waste management is to contain infectious waste and reduce risks to public health. The steps to achieve this goal include waste minimisation, identification and segregation, recycling, adequate packaging, handling and storage, and proper treatment and disposal.

22.3.1 Waste handling

There are a number of basic guidelines for waste handling. All healthcare waste should be segregated and placed into waste bins by the person generating the waste at the point where waste is generated. All specific healthcare waste segregation, packaging and labelling needs to be explained to the medical and supporting staff. Information should be displayed in charts on the walls of each room. Carts and recyclable containers used for transport of healthcare waste should be disinfected after each use. Sanitary staff and sweepers must wear proper protective clothing at all times when handling infectious waste including face masks, aprons, boots, and heavy duty gloves, as required.

23.3.2 Waste minimisation

Waste minimisation is the first and most important step in any waste management plan. Minimising the amount of waste produced will help the environment by reducing the amount of waste to be disposed of or burned in incinerators, and consequently reduces air pollution. For effective waste minimisation, you should always bear in mind that the materials and supplies purchased should create no or minimal waste. However, it is important to note that minimising waste should never be carried out if it compromises patient care or creates any other risk of infection.

23.3.3 Segregation of healthcare waste

Segregation is the process of separating different categories of waste. Healthcare waste is usually segregated into colour-coded waste bags or bins. This should take place at the source (when the waste is created). You should follow the guidelines for segregation of waste so that the different types of waste are kept separate and each can be handled safely and economically.

Healthcare facilities should provide coloured waste receptacles specifically for each category of waste. The colour-coding system aims to ensure immediate, easy and unambiguous (clear) identification and segregation of the waste which you are handling or going to treat. Based on the type of hazards involved, a different colour code and type of container is assigned and should be used as follows:

- Black: all bins or bags containing non-hazardous healthcare waste.
- Yellow: any kind of container filled with any type of infectious healthcare waste, including yellow safety boxes for sharps.
- Red: any kind of container filled with heavy metal or effluent.
- White: any container or bin filled with drug vials, ampoules or glass bottles for glass recycling or reuse.

You should also note that in a resource-limited Health Post, red containers can be omitted and heavy metals and other effluents can be handled as any other infectious waste using yellow containers. However, please don't forget that heavy metals and other effluents should *not* be incinerated (burned) in final disposal sites. The Ethiopian Food, Medicine, Health Professionals Control and Regulatory Authority guidelines should be referred to about the disposal of pharmaceutical wastes. You should be able to obtain these guidelines from your supervisor or district health office.

23.3.4 Recycling and reuse of healthcare waste

■ What is the difference between reuse and recycling of waste?

□ Reuse means using the same item again and again without changing its physical form or appearance. Recycling of waste requires processing of some sort, usually in another location, to create a new and different product.

Reuse of some healthcare waste such as glassware is possible but only after cleaning and disinfection. Items should be immersed in a 0.5% chlorine solution for 10 minutes and carefully washed with a brush and soap, rinsed and dried before use. During the disinfection process, you should always protect your hands with appropriate gloves. It is also recommended that you autoclave the glassware at 121^{o}C for at least 30 minutes after washing to ensure complete sterilisation/disinfection (see Section 23.4.1). Only unbroken glassware should be reused; if it is broken it will be sharp waste and must be disposed of.

Materials such as non-contaminated glass and plastic items can be recycled. Recycling may increase the segregation criteria and require more effort on your part because separate containers are needed for materials to be recycled.

23.3.5 Use of safety boxes

You should always collect sharp wastes immediately after use in a safety box. This helps you avoid injuries.

A safety box is used only for sharps (Figure 23.1). It is designed as a puncture- and leak-resistant container for their collection and disposal. The advantage is it confines all sharps in one place and helps prevent reuse. The correct use of safety boxes can prevent needlestick injuries to you and the community. The role of health workers (you) and waste handlers in proper use of safety boxes, starting from assembly through to final disposal, is critical. You should follow these guidelines for effective use of safety boxes:

- Follow the instructions printed on the box.
- Keep safety boxes within your reach at each place where you give injections.
- Dispose of the used syringes into the safety box *immediately* after use.
- Do not recap and do not collect syringes for future disposal.
- Never place fingers inside the box.
- Stop using the box and close the flap (cover) when it reaches three-quarters full; do not overfill.
- When handling the safety box, always wear gloves.
- Once a safety box contains any sharps, it should be stored in a locked room or cupboard to prevent the public from coming into contact with it.
- Finally, do not forget to wash your hands using antiseptic or hand rub and dry them after using the safety box.
- When the safety box is three-quarters full it should be incinerated (see Section 23.4.2 for further details) and the remains disposed of in a sharps pit (see Section 23.4.4).

Figure 23.1 Safety box in use at a Health Post. (Photo: Pam Furniss)

23.3.6 Packing healthcare wastes before disposal

Some healthcare wastes need to be placed into special containers or packed up in a particular way before they are transported or disposed of. A safety box for sharps is one example. Liquid infectious wastes need to be placed in capped or tightly stoppered bottles or flasks; large quantities would need a containment tank. Solid or semi-solid wastes should be packed in durable, tear-resistant plastic bags. Special packaging is required for items to be incinerated. These need to be put in combustible containers. Similarly items to be sterilised by steam need containers that allow the passage of steam and air. Clean clothes can be used to wrap items that need to be autoclaved or sterilised.

23.3.7 Waste storage

Some waste may need to be stored carefully onsite until such time as it can be disposed of appropriately. The guidelines for healthcare waste storage that you should follow are:

- A specified place in each room where waste is generated for placing bags, bins or containers.
- Separate central storage facilities for yellow bags should be provided with clear indication that no other materials be stored there.
- No waste shall be stored for more than two days before being treated or disposed of. (This does not include safety boxes, where filled boxes can be kept locked up for up to one week if no onsite incinerator is available.)
- The universal biological hazard symbol (Figure 23.2) should be posted on the storage door and on waste containers.

Figure 23.2 Biological hazard symbol.

23.4 Methods of healthcare waste treatment and disposal

23.4.1 Steam sterilisation (autoclaving)

kPa is the abbreviation of kiloPascal, a unit of pressure.

Steam sterilisation is one of the most common methods of treatment of waste. It uses saturated steam within a pressurised vessel called an **autoclave** (see Figure 23.3) at a temperature that is high enough to kill pathogenic microorganisms. Contaminated items or waste should be sterilised for 30 minutes at 121°C at a pressure of 106 kPa. You should note carefully that the timing should start only after it has reached the necessary temperature and pressure.

Figure 23.3 Autoclave in a Health Post. (Photo: Pam Furniss)

23.4.2 Incineration

Incinerators convert combustible materials into ashes or residues. Gases are ventilated through the chimney stack into the outer air. If the incinerator is properly designed, maintained and operated, it serves the purpose of destroying infectious microorganisms in the waste.

You may remember from Study Session 22 that, in the context of waste management, incineration means more than just burning. It means controlled and managed burning, usually at high temperature. A waste incinerator needs to reach very high temperatures in order to completely destroy needles and syringes. This type of high temperature incinerator is unlikely to be available to you but other options for burning can be used at Health Post level. With the help of others in your community, you may be able to build a low temperature incinerator, also known as a *protected hearth*, like the one shown in Figure 23.4.

Figure 23.4 An incinerator used for healthcare waste. (Photo: Muluken Azage)

If a brick-built incinerator is not available, you may be able to burn the waste in a converted metal drum or barrel. To do this, you will need a metal drum with both ends removed to make a cylindrical container. You will also need four bricks and two rigid metal screens that are large enough to cover the open ends of the drum. You will need to place the drum in a fenced area away from the Health Post buildings. Place the bricks on the ground, with spaces between them and a metal screen or grate on top. Place the open base of the drum on the metal screen and put another screen on top. The metal screens are to allow air to flow around the burning waste so the fire gets hotter, and to reduce the amount of ashes flying out of the top. Put the safety box or other waste with some paper, dry leaves, or small sticks into the drum and sprinkle them with a small amount of kerosene (if available). Put paper under the drum, between the bricks, and set light to it so the flames rise through the metal screen.

If there are no incinerators, then open pit burning is also possible, and frequently used in rural Health Posts (Figure 23.5). The pit must be protected with a fence to prevent people or animals from gaining access to it. It is advisable to watch the fire until everything is burned to be sure that no waste is blown around by the wind or left unburned. The ash or residue must be buried for final disposal.

Figure 23.5 Open pit burning of healthcare waste. (Photo: Muluken Azage)

23.4.3 Chemical or high-level disinfection (HLD)

Chemical disinfection, also known as high-level disinfection (HLD), is the preferred treatment for liquid infectious wastes. It can also be used for solid infectious waste treatment. The chemical disinfectants are hazardous to skin and mucous membranes, and it should not be applied without wearing gloves and goggles. Chlorine and glutaraldehyde are the best chemical disinfectants; the most appropriate being 0.5% chlorine solution for 10 minutes. The ultimate disposal of chemical waste must safeguard users, the community and the environment. It should be disposed of into a seepage pit and the bottom of the pit should be not less than 3 m from the water table in order to prevent contamination of the groundwater.

Training on handling techniques of chemical disinfection should be provided for persons involved in healthcare waste treatment to minimise personal exposure of hazards and handling of sterilised materials.

23.4.4 Final disposal: burial pits

Burial pits are acceptable for some wastes but ideally, there should be separate pits for general healthcare wastes and for hazardous healthcare waste. The general waste could be transported to community refuse pits, if there are any. Burial pits for hazardous waste should be properly fenced to prevent access by people or animals. They should not be used, however, in areas with a high groundwater table. The bottom of the pit should be at least 1.5 m higher than the groundwater table for disposal of solid waste. You should make sure that the final disposal of hazardous waste by reputable waste handlers is performed according to applicable federal and local regulations.

Sharps pit

A sharps pit is a particular type of burial pit that should be used only for the final disposal of needles and other sharps. Safety boxes should be incinerated to sterilise the contents before carefully collecting the residue for disposal in the sharps pit. A properly constructed sharps pit should have a cover at the surface and be lined with cement to make it watertight in order to avoid contamination of groundwater and soil. It must have a fence around it. For a Health Post, the pit need not be large and can take many years to fill.

23.4.5 Anatomical waste and placentas

The visual impact of anatomical wastes (especially for observable body parts) is very sensitive and may alarm the general public. The wastes are also a health hazard. Therefore, it is mandatory to properly contain anatomical wastes based on the local custom or cultures of your society. Special care and sensitivity is needed when considering the appropriate disposal of fetuses from stillbirths. You should make sure, while considering the local contexts, that the method you choose should not contaminate the environment.

Anatomical waste and placentas need a special placenta pit. The placenta pit should also be used for blood, vomit and other bodily secretions. This burial pit should be sited inside the Health Post compound and dug down to at least 1 m deep. The pit should be fenced and locked. The waste should be collected in a plastic or galvanised metal container with a tight-fitting cover and immediately transported to the pit using dedicated trolleys or carts. The waste should be covered with a layer of soil immediately after disposal into the pit.

Due to cultural conditions, and the low temperature incinerators present in Health Posts, you should avoid using incinerators for anatomical waste. You should wear heavy-duty gloves while handling and transporting the waste. Wash and dry the gloves after use.

23.5 Prevention and control of risks to healthcare workers

All healthcare workers, including the waste handlers and maintenance workers, should be instructed to use personal protective equipment (PPE) such as gloves while working in contaminated areas and with contaminated materials, and to wash their hands thoroughly after removing the gloves. The workers should be aware of the fact that other people may not have followed the correct procedures while disposing of gloves, blades or needles; therefore, they need to be careful when handling all healthcare waste bags and containers.

People working in healthcare facilities may get accidental injuries because they are in a hurry to help their patients, or in an emergency, or simply due to ignorance or not being able to practise what they know. The following guidelines should be followed for the prevention and control of risks to healthcare workers:

- Keep desks and countertops free from sharps.
- Discard needles and other sharps into safety boxes, never into waste bins or plastic bags.
- Never try to recap needles (i.e. use once and dispose of immediately).
- Regularly review the rules for safe disposal and collection of sharps or other hazardous materials.
- You (or any healthcare worker) should always examine and handle soiled linens and similar items *as if* they were hazardous.
- Workers should receive periodic instruction at least once a year to keep them aware of the specific hazards of healthcare waste.
- Workers should take appropriate measures to limit further contagion from waste by practising universal precautions of self-protection from exposure to infectious wastes.

23.6 Planning and monitoring healthcare waste management

Managing the safe and proper disposal of healthcare waste is an essential part of infection protection and control for you (the healthcare worker), your clients/patients and the general public. In addition to meeting national and local guidelines on infection prevention, it helps you prevent **nosocomial** infections (i.e. healthcare facility/hospital acquired diseases).

Planning and preparation for proper waste disposal will help you ensure the availability and correct functioning of infection control facilities in the Health Post, including sanitising materials and hazardous healthcare waste management and disposal equipment. Forward planning can also help reduce the likelihood of accidents; for example, the chance of needlestick injury will be reduced if you always think ahead and have the sharps box close to you when you give an injection.

Table 23.1 is a template for waste management planning in the Health Post. It lists various waste management activities and indicates how often they should be done, the materials and equipment needed and who is responsible. You may wish to adapt this for your own Health Post and draw up your own management plan. Having a plan similar to this will help to ensure that waste is managed correctly.

Table 23.1 Example template for a Health Post waste management plan.
Key: R = routinely (at a specific time, if possible); BP = before procedure; AP = after procedure; O = occasionally.

Activity	**When?**	**Equipment/materials needed**	**Who?**	**Comments**
Handwashing	R, BP and AP	Water, soap, disinfectant/alcohol	Health Extension Practitioner	Sullage should be disposed of into a seepage pit
Disposing of sharps	R (when the safety box gets ¾ filled), AP	Safety box, incinerator, sharps pit	Health Extension Practitioner	Avoid needle recapping
Disposing general waste and solid infectious waste	R	Waste bin, incinerator, gloves, matches, burial pit	Health Extension Practitioner and others	Incinerate in a brick incinerator, or metal drum or burn in an open pit
Inspecting waste disposal facilities	O	Heavy-duty gloves, protective clothes	Health Extension Practitioner	
Sterilisation of instruments/materials	AP	Autoclave, indicator	Health Extension Practitioner	An indicator is a strip or tape that changes colour when the material/equipment reaches sterilising temperature
Disposal of liquid/ semi-liquid infectious waste	AP	Placenta pit	Health Extension Practitioner	Pit should be fenced and locked
Disposal of expired drugs	O	List of drugs expired, reporting, disposal pit	Committee from district office, *kebele* and Health Extension Practitioner	You need to notify the committee if you have drugs that need to be disposed of
Cleaning the Health Post	R	Water, detergents, disinfectants, gloves, protective clothing, broom, mops, dustbin, etc.	Health Extension Practitioner and others	

You can monitor the management of healthcare waste at your Health Post and identify possible improvements that you could make by checking your current practices. For example:

- Could you reduce the amount of waste produced in your Health Post (waste minimisation)?
- Do you separate infectious from non-infectious waste?
- Is infectious waste packaged before disposal to reduce contact and exposure?
- Do you have adequate supplies of gloves, colour-coded bins and other waste management supplies?

- Is everyone at the Health Post properly trained in correct healthcare waste management procedures?

There may be other questions you can think of to include on your checklist.

Concluding note

We have now reached the end of the *Hygiene and Environmental Health* Module. In these 23 study sessions, you have been learning about personal and environmental hygiene, how to keep food hygienic, about the provision, use and treatment of safe water, and how to manage wastes in the household, community and healthcare facility.

As you know, poor hygienic and environmental health conditions are the major cause of illness and death in Ethiopia and other developing countries. It is our sincere hope that this Module, along with other Modules in this curriculum, will enable you to understand the concepts and principles of hygiene and environmental health. By putting these concepts and principles into practice, your community disease profile will improve significantly to a level that common infectious diseases that arise due to poor hygiene and environmental health, such as diarrhoea, intestinal parasites, malaria, pneumonia and TB, will not be major causes of morbidity or mortality in your area. Moreover, as well as learning about the protection of human health, you have also learned how to keep our environment safe.

Summary of Study Session 23

In Study Session 23, you have learned that:

1 Healthcare waste is any waste produced in a healthcare facilty and is also known as medical waste, hospital waste or infectious waste. It includes hazardous and non-hazardous waste.

2 Health hazards from pathogens are the major concern in waste from Health Posts.

3 Waste minimisation is the first and most important step in healthcare waste management.

4 Healthcare waste must be segregated into different categories and colour-coded containers used for storage.

5 Safety boxes are important devices for safe collection of sharps. A sharps pit is also required for final disposal.

6 Personnel involved in handling and storage of healthcare waste should be trained in correct procedures and provided with the necessary PPE to protect their health.

7 Autoclaving, incineration, placenta/burial pit and HLD using chemicals are the most commonly used final disposal methods.

Self-Assessment Questions (SAQs) for Study Session 23

Now that you have completed this study session, you can assess how well you have achieved its Learning Outcomes by answering these questions. Write your answers in your Study Diary and discuss them with your Tutor at the next Study Support Meeting. You can check your answers with the Notes on the Self-Assessment Questions at the end of this Module.

SAQ 23.1 (tests Learning Outcome 23.1)

Which of the following statements is *false*? In each case, explain why it is incorrect.

A Healthcare waste contains hazardous and non-hazardous waste.

B Infectious healthcare waste is kept in red containers.

C Chemical disinfection involves treating waste with 0.5% chlorine solution for 10 minutes by immersing in an autoclave.

SAQ 23.2 (tests Learning Outcome 23.2)

Which items in the list below are classed as pathological waste?

Syringes, used swab, placenta, used gauze, expired drugs, body parts, paper packaging, blood.

SAQ 23.3 (tests Learning Outcomes 23.3)

Gadissa, a local farmer, had an accident last week while working in his fields and cut his leg. He came to the Health Post immediately afterwards and you treated the wound with a dressing and bandage. Today he is returning to the Health Post to have the dressing changed. What should you do before examining his wound? What should you do with the used dressing?

SAQ 23.4 (tests Learning Outcome 23.3 and 23.4)

Read Case Study 23.1 and then answer the questions that follow it.

Case Study 23.1 A story of a busy rural Health Post

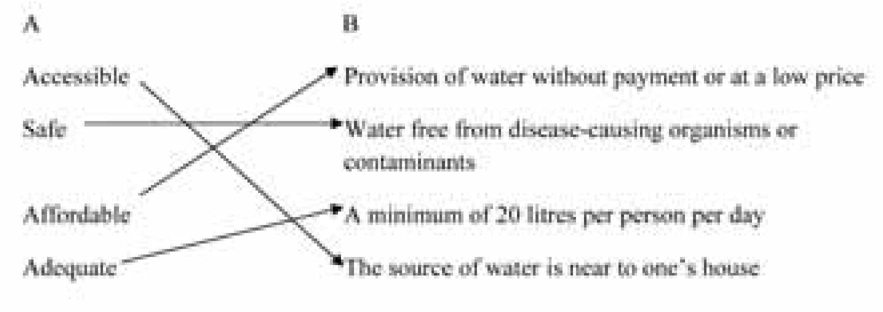
Hirut, a Health Extension Practitioner in Robit rural *kebele*, is working in a Health Post. One busy day, the Health Post was full of clients for family planning, children who need immunization, and children having diarrhoeal problems. Hirut started her day by giving health education for mothers on the importance of family planning, hygiene and environmental sanitation. Her workmate, Almaz, was preparing the schedule for their subsequent activities. Because of the workload, the Health Extension Practitioners could not go home for lunch on time. They were too exhausted. At this time, Hirut was giving an injection of Dipo Provera to a woman. She accidentally pricked her finger with the used needle while trying to recap it.

What did Hirut do that was procedurally wrong? What should she have done?

Notes on the Self-Assessment Questions for *Hygiene and Environmental Health*, Part 2

Study Session 13

SAQ 13.1



SAQ 13.2

A is *false*. Water-washed diseases are caused by poor hygiene when there is insufficient water for thorough washing, and not by drinking contaminated water.

B is *false*. Diarrhoea and typhoid fever are examples of waterborne disease and are caused by consumption of water or food contaminated with pathogens.

C is true. Bilharzia is transmitted via water snails.

D is *false*. Malaria is an example of a water-related disease.

SAQ 13.3

Water on the Earth's surface moves in an unceasing cycle through rivers, oceans, clouds and rain called the *hydrological cycle*. The heat from the Sun causes *evaporation* of water, principally from the *ocean* and also from lakes and wetlands on land. Plants also lose water through their leaves by the process of *transpiration*. Water vapour in the *atmosphere* forms into clouds which are moved around by wind. Rain and snow, collectively known as *precipitation*, fall from the clouds. Some water that falls on land soaks into the ground and some collects into streams and rivers which form *surface runoff* that flows back to the ocean to complete the cycle.

SAQ 13.4

Satisfactory water supply is water that is safe, adequate and accessible.

Your answer could include any three of the following:

- You need to know where the source of the water for the village is.
- You need to know if the source of the water is protected.
- You need to estimate the average distance the residents travel to fetch water or estimate the time taken for a round trip for fetching water.
- You need to know the amount of water collected per person per day.
- Finally you can assess whether the status of village is classed as no access, basic access, intermediate access or optimal access.

SAQ 13.5

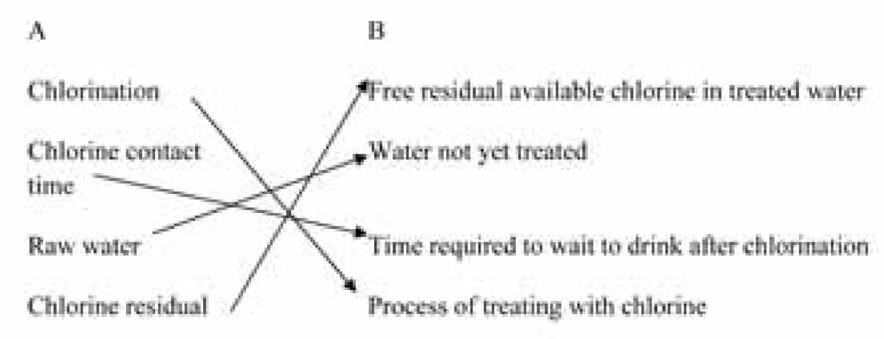
Vulnerable groups include children and infants, the elderly, and people who are ill or debilitated.

SAQ 13.6

A is *false*. Local communities' empowerment will increase the provision of safe water.
B is true. New technologies can help with the provision of safe water.
C is *false*. Local government involvement is important for the success of safe water provision projects.
D is true. Safe water improves the lives of infants and children.

Study Session 14

SAQ 14.1



SAQ 14.2

Nearly all river and stream water may be contaminated with at least one of the three types of potentially disease-causing microorganisms, namely protozoa, bacteria and viruses. These can be removed by treating the water.

If Mr. Abebe used one of the methods of household water treatment he would be protecting his family and himself from many unpleasant, debilitating and possibly life-threatening diseases.

SAQ 14.3

Wuha Agar is a type of chlorine solution that is commonly available. To use it you add one capful of Wuha Agar to a 20 litre jerrycan of water, replace the lid and shake. After 30 minutes of contact time you can use the water for drinking and other domestic purposes. This will kill bacteria and help to reduce diarrhoeal diseases.

SAQ 14.4

You should do the orthotolidine-arsenite test (OTA) to measure the residual chlorine. The residual chlorine helps to prevent recontamination of pathogenic bacteria if it is between 0.2–0.5 mg/l.

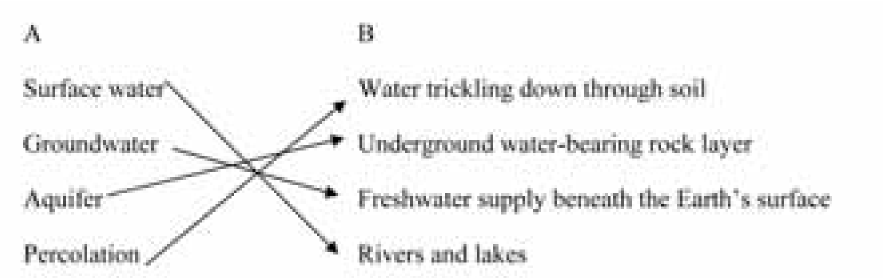
SAQ 14.5

Filtration means passing water through a layer of sand, gravel, cloth or other barrier that allows the water to pass through, but holds back any small particles. The particles may be dirt, soil and other contaminants including many pathogenic microorganisms that make the water unsafe to drink. However, some bacteria can pass through filters, so filtered water is not completely safe to drink.

Disinfection is a process for removing contaminants from water and killing most of the harmful microorganisms that may be present. It usually involves treatment with chlorine or other chemicals.

Study Session 15

SAQ 15.1



SAQ 15.2

A plan for the new water source would need to be prepared. This would involve the community, the community leaders and the local administration. The following steps would be needed:

- Identify the community's water and sanitation needs.
- Identify possible sources of water, which could include groundwater from springs or wells, and rainwater.
- Identify potential sources of pollutants of the proposed water source.
- Identify the amount of water that would satisfy the needs of all community members.

SAQ 15.3

The users of the spring should be advised to:

- Avoid open defecation around the spring.
- Not construct latrines above the spring because of the danger of contaminated groundwater.
- Use latrines properly.
- Keep animals away from the spring.

SAQ 15.4

The wall and fence has been broken down so animals could get in and contaminate the area around the pump. The stone wall and wooden fence should be repaired and a gate fitted so that people can gain access but animals cannot.

Study Session 16

SAQ 16.1

A is *false*. *E.coli* is a type of bacteria, not a type of virus.

B is true. Faecal coliforms are found in faeces.

C is *false*. If a water sample is positive for *E.coli* this indicates faecal contamination, which means it is likely that pathogens are present in the water.

D is also *false*. The absence of *E.coli* indicates the water is not contaminated with bacteria of faecal origin but it does not mean it is safe to drink because the water may contain other pathogens.

SAQ 16.2

You would have to do a sanitary survey to check the possible reasons for the childhood diarrhoea. This would include checking how the water is handled because it may be exposed to recontamination after it is collected from the protected well. Pots and buckets used for collection and storage should be checked to see if they are left open or not. If they are open, and people dip smaller containers into them, there is greater chance of recontamination. A jerrycan is preferable because it has a small opening that cannot be used for dipping. The cleanliness of the containers may be poor because of improper washing or the container may be used to collect both unclean and clean water. You may need to educate the families concerned about good hygiene and the proper handling of water.

SAQ 16.3

Together with the environmental health experts you would conduct tests to measure the colour, taste and odour. You may test pH and for certain chemicals such as nitrate, fluoride and chloride, using portable water field test kits where available. You might also test turbidity (suspended solids). Water analysis would include microbiological tests as well as chemical tests. To do this a water sample would need to be taken and sent to a central laboratory for *E.coli* assessment and other microbiological tests.

SAQ 16.4

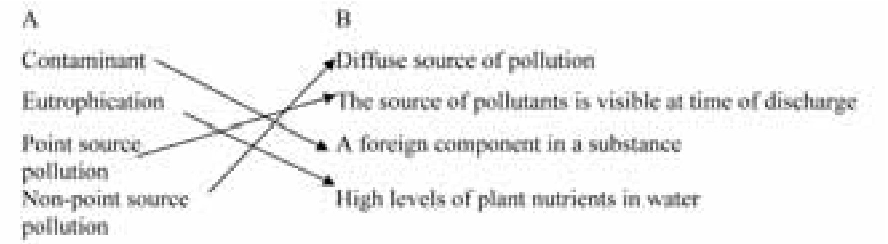
You should tell the villagers that the river water is contaminated with pathogens and will cause waterborne diseases. Without any treatment, the surface water should not be used for drinking and domestic purposes. The water from the well may not taste so nice but it is safer to drink and use for domestic purposes. You will need to advise them that the tests reveal more about water quality than taste does.

SAQ 16.5

You would need to take an appropriate checklist of questions to ensure that you survey thoroughly and don't forget anything. You will also need a notebook and pen or pencil to record all the information you collect. Important things to look for include the location of any latrines or other possible sources of contamination relative to the spring, a sound fence, the condition of the concrete/stone box that protects the spring, the presence of a diversion ditch and any other defect in its construction that could affect the water quality. Your answer could include any four of these or related issues.

Study Session 17

SAQ 17.1



SAQ 17.2

Assuming there were no other differences to consider than their respective sources of water, it would seem likely that the eastern well has become contaminated. The possible sources may be point sources from a latrine, if there is one located above the dug well or from an overflow of the latrine into the dug well. Possible non-point sources might be open defecation around the village causing contamination of the well after rain. Further investigation would be needed to identify the cause for certain.

SAQ 17.3

It would be important to ensure there was no contamination of the samples during or after sampling and that they were a representative sample of the water in the wells. The sampling bottles and their stoppers must be sterilised. The sample bottles for the two wells would need to be clearly labelled so that there was no danger of confusion between them. The sample should be taken by weighting the bottle and lowering it on a string into the well, lowering it below the surface of the water but not hitting the bottom, waiting until it is filled, then raising the bottle and capping it immediately.

SAQ 17.4

Your answer will depend on the local situation but the same general rules will apply anywhere. You should advise them to be aware of the importance of proper disposal of human excreta, which means avoiding open defecation and constructing latrines that are at least 15 m away from water sources and at a lower level; appropriate disposal of animal wastes; appropriate disposal of solid waste; and the possibility of pollution from agricultural activities such as spreading fertiliser. In some locations there may also be potential hazards from industry, roads and other sources of pollution.

Study Session 18

SAQ 18.1

This game is intended to familiarise you with the technical terms you will meet again in subsequent study sessions. To find the right answer, you can check the definition written in your own words with that in the study session.

SAQ 18.2

You may have come up with different suggestions but we thought of these examples:

1 vegetable peelings and waste from food preparation
2 water that has been used to wash clothes
3 used dressings and bandages from the Health Post
4 diesel fuel leaking from a damaged can.

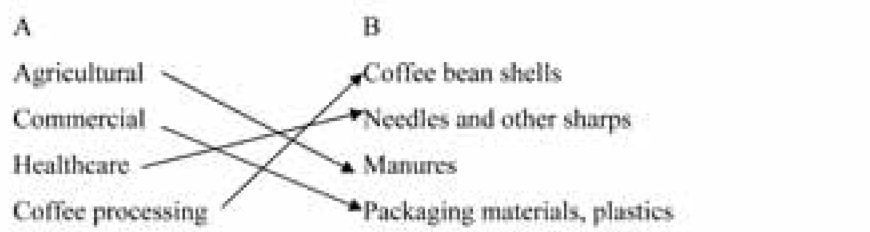
SAQ 18.3

The main purpose of waste management is to isolate waste from humans and the environment, and protect human health.

SAQ 18.4

There are many public health benefits including prevention of faeco-orally transmitted diseases, reduction in public nuisance from wastes in the environment, creation of a more aesthetically pleasant environment, and the possibilities of generating income from creating economically valuable products from the treatment, recycling and reuse of waste.

SAQ 18.5



Study Session 19

SAQ 19.1

A is *false*. Decomposition in a septic tank is an anaerobic, not aerobic, process.

B is *false*. A seepage pit must not be watertight. Liquid must be able to seep slowly out of the pit into the surrounding ground.

C is true. Anaerobic digestion of waste produces biogas and digested sludge that can be used as a fertiliser.

D is *false*. Runoff is rainwater running off the land but it may contain human and other types of waste that have been washed off the land surface. It can also cause flooding problems.

E is true. Human waste management must ensure the protection of groundwater from contamination.

SAQ 19.2

(a) Local geology is important because the type of rock will need to be considered for any technology that relies on liquid waste percolating into the ground. For example, a pit latrine must be sited further away from a water source if the rock is permeable.

(b) Climate can make a difference if the usual rainfall pattern causes frequent flooding. This will need to taken into consideration when locating and building the chosen latrine.

(c) The sanitation technology must be comfortable and convenient for all the people who are going to use it. Small children may need special arrangements that allow them to use the latrine without danger. Elderly people may not be fully mobile and may also need special consideration to ensure the latrine is accessible for them.

Study Session 20

SAQ 20.1

In an ecosan latrine, human waste is mixed with plant material, ash and vegetable waste so that when it has decomposed it produces a useful product. It converts the waste into a resource. The compost can be used for growing a tree in the Arborloo system or it can be dug out to be used to spread on fields as a fertiliser. This does not happen in a standard pit latrine, which simply contains the waste.

SAQ 20.2

This latrine is very basic. It would be improved by the proper installation of a concrete slab over the pit. The slab should have a lid over the squat hole. It could also be improved by installing a vent pipe in the proper way to convert it into a VIP latrine. There should be a handwashing facility just outside the door.

SAQ 20.3

The liquid waste seeps out of pit latrines into the ground beneath. This could cause pollution of groundwater and surface water.

SAQ 20.4

The materials needed to make a handwashing device are a water container that can hold about 5 litres with a lid, a hollow tube of some sort for the spout, something sharp to make the hole with and something to stand or hang the container on. You will also need soap or ash for effective handwashing.

SAQ 20.5

(a) Ato Tedila cannot install a water carriage system because he does not have a piped water supply; therefore, he has to install a pit latrine of some sort. The possible choices are a single pit latrine, a pit latrine with slab, a VIP latrine with slab, a double pit latrine or one of the ecosan systems, namely an Arborloo or a Fossa Alterna.

(b) You should not recommend a pit latrine without a slab because this does not provide adequate sanitation. The VIP latrine is preferable to a simple latrine, but an ecosan system would be better because this would produce a useful product as well as protecting the health of the family and the environment. You would need to ask Tedila about his attitude to using an ecological sanitation system and whether he would be willing to make use of the composted waste material. He is a farmer so he may be able to use it on his fields and he is open-minded so this system may be attractive to him. If he was reluctant to dig out the compost you could recommend the Arborloo system because that does not require handling; the tree is planted on top of the filled pit.

(c) You should advise him to consider the location of the pit. It must be at least 15 m away from his well and preferably a greater distance. It must also be at a lower level according to the slope of the land. He should also consider the wind direction and place the latrine downwind and at a convenient distance from the house. He would need to consider the design of the squat hole to ensure it is safe for his children and comfortable for his elderly mother. You could advise him about possible materials to be used for the superstructure and recommend what is available locally. You should also advise him to install a handwashing facility next to the latrine.

Study Session 21

SAQ 21.1

Improving latrine utilisation requires *behaviour change* by the people in the community. Some people may need to be persuaded that *total sanitation* and *ODF status* are valuable aims that will help prevent the spread of disease. There are various approaches that can be used to try to achieve *behaviour change*. Two examples of these approaches are *PHAST* and *CLTS*. Both these methods depend on involving the whole community in the process and they are grouped together as *CATS*.

SAQ 21.2

The people in this village are not aware of the importance of sanitation so you would need to find ways to educate them about the connection between hygiene and sanitation, and their health. You could ask to speak to a community meeting but this approach may not be successful if you simply stand and talk to the villagers. You could suggest a coffee ceremony or other social gathering as a means to initiate discussion about the issue and to encourage people to attend. You could consider individual house-to-house visits to have more private conversations with individuals and families about hygiene and sanitation. Individual visits may help you identify potential model households that you could also use in your campaign. With the cooperation of the community, and if you had had the appropriate training or could call on the support of others who had, you may also consider using a CLTS approach. You may have to adopt several of these approaches and be flexible according to the responses you get from the community. You should also recognise that it may take time to convince the people of the benefit of change.

SAQ 21.3

To encourage the family to become a model household you will need to explain to them the purpose and benefits of the role. You should discuss the importance of correct latrine construction and use, and the importance of handwashing with them to check they have a complete understanding. You should check the condition of their latrine and that they have handwashing facilities and use them routinely. You could explain that being a model household will bring respect and admiration from others and they can be proud of their position and achievements. You should also explain that their attitude to others needs to be supportive and encouraging, not bossy and dictatorial.

SAQ 21.4

PHAST and CLTS are both community-based approaches to achieving total sanitation. They aim to promote behaviour change in the community.

PHAST uses techniques such as mapping and community discussions to promote change. CLTS uses similar techniques but also depends on confronting the community members with questions that make them realise the impact of open defecation. By bringing these questions out into the open, the community is ‘triggered’ into action to change their behaviour.

SAQ 21.5

To assess the success of the programme you would need to survey latrine use in the community. You would also need to have done a baseline survey before the CLTS programme so that you had the data of latrine utilisation beforehand to compare with. The data you would need to collect would include the number of households with a latrine and handwashing facility, how many of them use their latrine, and whether there were any signs of open defecation anywhere in the area such as faeces visible in fields, paths, compounds, etc.

Study Session 22

SAQ 22.1

A is *false*. Recycling is a good method of waste management but reducing the amount of waste produced in the first place or reusing the waste without reprocessing is preferred.
B is true. Composting of solid waste is an aerobic decomposition process that produces compost.
C is *false*. Waste recovery means that something useful is recovered from the waste; reuse of waste simply means using the item again in the same way it was used in the first place.
D is *false*. Controlled tipping is called 'controlled' because the waste is regularly covered with soil rather than just left in the open.

SAQ 22.2

	Hazardous	*Non-hazardous*
Compostable		Manure, grass, paper bags, potato peelings
Non-compostable	Obsolete herbicides, expired drugs	Tin cans, plastic *festal*

SAQ 22.3

The functional elements of waste management are: onsite handling, storage and processing; collection; transfer and transport; resource recovery and processing; and disposal. In rural areas, waste is not normally collected or transported, so the second and third elements are not relevant. Most waste in rural areas is organic and there is plenty of space. Onsite handling, resource recovery in the form of recycling or composting and final disposal are found in rural areas.

SAQ 22.4

Compost can be made from household kitchen food waste, leaves, grass, kitchen waste, and any other organic biodegradable material. The compostable waste must be separated out so it contains no plastic or metal. The waste is put in a pit or heap at least 1 m × 1 m × 1 m. It needs a little water and it should be turned over regularly to provide air for the composting organisms. The resulting compost should be like soil and have a good earthy smell.

SAQ 22.5

There are several possible indicators that can be used to assess waste management practices. These include the number of households with a compost pit, whether there is a communal refuse pit, the number of people using a communal pit, if there is one, whether the refuse pits are fenced and managed, and others. You would assess these indicators by visiting the community, observing people's practice and discussing with them what they did with their solid waste.

Study Session 23

SAQ 23.1

A is true. Healthcare waste does contain both hazardous and non-hazardous waste,

B is *false*. Infectious waste should be stored in a yellow container.

C is *false*. Chemical disinfection does involve treatment with chlorine solution of 0.5% concentration for 10 minutes but an autoclave is a steam sterilising device that relies on temperature to disinfect.

SAQ 23.2

Placenta, body parts and blood are all pathological wastes.

SAQ 23.3

You should wash your hands thoroughly before removing the old bandage. You may also want to put on gloves. Pick up a sterilised set of instruments, such as scissors, to remove the dressing. You may find the used dressing is blood-stained. It should be handled in the same way as infectious waste because, although Gadissa may be perfectly healthy, all waste that has been in contact with body fluids should be considered to be potentially infectious. You should immediately place the used dressing in a yellow waste container or bag. Keep the container tightly closed. At the end of the day, you should dispose of the container in an incinerator, if available, or burn it in the refuse pit before you leave the Health Post.

SAQ 23.4

Hirut should not have tried to recap the needle. She should have put it in to the safety box immediately.