Chapter 6

Sanitation

Sanitation is everything associated with excreta* in relation to people. It includes the structures used to deal with excreta (e.g. latrines), the materials needed to use these correctly (e.g. water), and people's behaviours and attitudes in relation to both excreta and the sanitary structures (e.g. acceptance of open defecation, washing hands after defecation).

This chapter looks at how excreta and excreta-related infections are linked, and how these infections can be prevented by improved sanitation. Several sanitation-related issues are considered in some detail, and we look at issues which are important to the planning, design, and construction of sanitary structures.

In addition to health benefits, the installation of adequate sanitation may bring people increased convenience and privacy. Improving sanitation can eliminate the unpleasant or unsightly living or working conditions which often result from poor sanitation. Where excreta is reused, people acquire a potential resource. And although this will not be the development worker's motivation, nice sanitary structures often increase the prestige of the owner.

The uncontrolled discharge of excreta, sewage, or effluent into surface water may result in environmental problems. The organic matter in excreta-related waste will use oxygen to oxidise, and it will draw its oxygen from the water. The amount of oxygen used is called the Biochemical Oxygen Demand (BOD) of the excreta. If the waste is discharged into surface water without being adequately treated, the natural aquatic life in the water may die from lack of oxygen.

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* Excreta can be faeces and urine, and can be human as well as animal

6.1 The transmission of excreta-related infections

Infections are related to excreta in two ways: the pathogens leave the original host's body through excreta, or one of the vectors of the disease benefits from the lack of adequate sanitary structures or from accessible excreta.
Several disease-groups leave the body through excreta.

Faecal-oral infections are transmitted directly through faecally contaminated hands, food, water, or soil. The pathogen must be ingested to cause infection (see Section 2.4.1.1, Figure 2.2).

Schistosomiasis needs to develop in a freshwater snail before it can infect people. The pathogen infects people by penetrating skin which is in contact with infected surface water (see Section 2.4.2.2, Figure 2.4).

Water-based helminths with two intermediate hosts (e.g. fasciolopsiasis, clonorchiasis) need to develop in two freshwater intermediate hosts before they become infectious to people. Transmission occurs when the second intermediate host is eaten without being properly cooked (see Section 2.4.2.2 Figure 2.4).

Soil-transmitted helminths (e.g. hookworm disease and roundworm infection) have to develop in soil before they can infect people. Some of these helminths infect people by penetrating their skin when they are in contact with contaminated soil, others infect people when ingested (see Section 2.4.2.1, Figure 2.3).

Beef tapeworm and pork tapeworm have to be ingested by cattle or pigs and development in them. People are infected by eating poorly cooked beef or pork.

Cysticercosis, a complication of pork tapeworm, is transmitted like a faecal-oral infection from person to person (see Section 2.4.2.3).

Leptospirosis is mainly transmitted through direct skin contact with water or material contaminated with the urine of infected rats (see Section 2.4.1.2).

Vectors which benefit from inadequate sanitation include domestic flies, cockroaches, and *Culex* mosquitoes.

Domestic flies, which can transmit several faecal-oral infections including conjunctivitis, trachoma, and yaws, can breed in, and feed on, excreta [67].

Cockroaches, which have the potential to transmit several faecal-oral infections, can feed on excreta and hide in sanitary structures.

The mosquito *Culex quinquefasciatus*, a vector of filariasis and several arboviral infections, can breed in the polluted liquids in latrines and cesspits or septic tanks(61).

As there are many disease-groups related to excreta and sanitation, the following concept should help to assess when these infections could pose a risk.

If pathogen transmission is to succeed, the excreta has to come in contact with certain elements. For example, schistosomiasis can only be transmitted if the pathogen infects a freshwater snail, so transmission can only occur if the excreta is released into fresh surface water.

Table 6.1 shows the different elements that the pathogens have to come in direct contact with to be transmitted.

Table 6.1. Disease groups and the elements that play a role in disease transmission (adapted from 60)

The element excreta must come in direct contact with:	Faecal-oral infections	Schistosomiasis	Water-based with two intermediate hosts	Soil-transmitted helminths	Beef and pork tapeworm	Leptospirosis	Guinea-worm infection	Spread by direct contact	Vector-borne infections
People	H/A				H[a]	A			
Animals	H/A				H	A			
Insects	H/A							(b)	(c)
Crops, food, vegetation	H/A				H	A			
Soil	H/A			H		A			
Surface water	H/A	H/A	H/A		H	A			(c)
Ground water	H/A								

H: Human excreta
A: Animal excreta
(a): Only cysticercosis, a complication of pork tapeworm
(b): Domestic flies can breed in excreta and can transmit conjunctivitis, trachoma, and yaws
(c): The mosquito *Culex quinquefasciatus*, vector of filariasis and several arboviral infections, can breed in sanitary structures or surface water polluted by excreta

Faecal and urinary transmission of infections

Most excreta-related infections are only transmitted by faeces. The exceptions are urinary schistosomiasis, which is common in Africa and which has no animal host; leptospirosis, which is transmitted mainly through animal urine; and (para-) typhoid fever, which is occasionally transmitted through urine [16].

The risk of children's excreta

As many excreta-related infections occur mainly in children, it is more likely that children's excreta will contain pathogens than adult's excreta, so special care must be taken in disposing their faeces. Health and hygiene promotion to mothers will usually be needed to improve the children's behaviour and reduce the risks of open defecation by children. Sanitary structures will have to be adapted and acceptable to children.

The risk of animal excreta

Many excreta-related pathogens can infect animals as well as people, and animals can be important reservoirs of disease. Cattle, pigs, dogs and rats are all potential hosts for several diarrhoeal infections, several water-based helminths, and leptospirosis. Chickens and wild birds can be the reservoir of pathogens that cause diarrhoea. More information on the potential animal reservoirs of specific diseases can be found in Annexe 1. Where animals are believed to be playing a role in the transmission of infections they will have to be controlled.

6.1.1 Risk-factors relating to excreta and sanitation

There are five major problems relating to excreta and sanitation which can result in a health risk:

- There is open defecation as people do not use sanitary structures.
- People do not wash their hands (properly) after defecation.
- Sanitary structures are not used correctly, are poorly designed, or are poorly maintained.
- Excreta is re-used as a fertiliser, fish food, building material, or for fuel.
- People come in contact with excreta of infected animals.

Several of these problems can be broken down further into specific risk-factors. These specific risk-factors with their associated disease-groups are presented in Table 6.2.

Several of these risk-factors will be looked at in more detail in Section 6.2.

Table 6.2. Specific sanitation-related risk-factors

Risk-factors relating to:
i Open defecation
ii Poor personal hygiene
iii Poor functioning or design of structure
iv Excreta used as a resource
v Animal contact

	Risk-factor	Faecal-oral infections	Schistosomiasis	Water-based with two intermediate hosts	Soil-transmitted helminths	Beef and pork tapeworm	Leptospirosis	Guinea-worm infection	Spread by direct contact	Vector-borne infections
i	Sanitary structures are not used (by all)	■	■	■	■	■	(a)		(b)	
ii	Poor handwashing after defecation	■				(c)				
iii	Poor hygiene of sanitary structure	■			■	(c)			(b)	
	Openings or cracks in sanitary structure	■							(b)	(d)
	Collapse of sanitary structure or pit	■				■			(b)	(d)
	Overflowing of sanitary structure	■	■	■	■	■			(b)	
	Excreta discharged in surface water	■	■	■	■	■			(b)	(d)
	Sanitary structure pollutes groundwater	■								
	Excreta is handled in O&M	■	■	■	■	■			(b)	
iv	Excreta is re-used	■	■	■	■	■			(b)	(d)
v	Access of animals to living quarters	■					■			
	Close contact between people and animals (work, play)	■					■			
	Animal faeces on domestic plot	■					■		(b)	
	Animals have access to well, spring, etc.	■								
	Animals have access to stored water or food	■					■			
	Animals have access to surface water	■	■	■			■			

Sanitary structure: latrine, sewage system
O&M: Operation and maintenance (of the sanitary structure)

[a]: Leptospirosis, if transmitted by excreta, is usually transmitted by animal urine and therefore almost impossible to confine through improved sanitation
[b]: A potential for breeding and feeding of domestic flies
[c]: A risk of cysticercosis, a complication of pork tapeworm; all other 'positives' in this column can result in both cysticercosis and in infection of cattle or pork
[d]: A potential for breeding of the mosquito *Culex quinquefasciatus*

Table 6.3. Reduction in occurrence of disease associated with improved sanitation

Disease (group)	*Reduction in occurrence*	*Remarks*
Diarrhoea	36% [26]	improved sanitation
	42% [70]	sanitary facilities are well maintained (clean)
	44% [40]	hygiene improved in existing toilets in schools
	30% [70]	elimination of excreta from around the house
Infant diarrhoea	negligible [70]	improved neighbourhood sanitation but poor water quality
	25% [70]	improved neighbourhood sanitation with good water quality
Hookworm	4% [26]	improved sanitation only; reduction when improved sanitation and medical treatment were combined: 69%
Roundworm	29% [26]	improved sanitation and water supply; reduction when improved sanitation and medical treatment were combined: 80%
Tapeworms	important [73]	improved sanitation

6.1.2 The health impact of improving sanitation

Table 6.3 shows how different excreta-related infections can be reduced with improved sanitation.

6.1.3 The survival of excreta-related pathogens in the environment

Outside the host, excreta-related pathogens will usually die off over time. Most pathogens can remain viable in the environment for some time, however, and Table 6.4 shows the maximum time of survival of some. As a general rule, pathogens survive longer when they are in lower temperatures, in a moist environment, and protected from direct sunlight [28,31]. Again as a general rule, helminths and viruses will survive longer then bacteria and protozoa.

Except for roundworm, all the infections in Table 6.4 are faecal-oral. It is less useful to look at the survival times of pathogens which need intermediate hosts, as these usually remain viable for as long as the intermediate host survives.

Table 6.4. Maximum survival times (in days) of pathogens in different media (from 28)								
Media in which pathogens survive (at 20 to 30°C)	**Bacterial enteritis (by E.coli)**	**Salmonellosis**	**Shigellosis (bacillary dysentery)**	**Cholera**	**Amoebiasis**	**Faecal-oral viruses (e.g polio)**	**Roundworm**	
Fresh water and sewage	60	60	30	30	30	120	many months	
Faeces, nightsoil, and sludge	90	60	30	30	30	100	many months	
Soil	70	70	-	20	20	100	many months	
On the surface of crops	30	30	10	5	10	60	60	

The health risk of contaminated material (water, food, other objects) will usually decrease over time if no multiplication or recontamination occurs. As the number of pathogens discharged is often very large, the potential for transmission can remain high, even if most pathogens die off or if the excreta is diluted in surface water. A person with cholera can defecate up to $1x10^{12}$ bacteria per litre of diarrhoea, for example, a person with urinary schistosomiasis can discharge 50,000 eggs per litre of urine, and people infected with hookworm disease can shed $1x10^{6}$ eggs per day [(73)].

Several bacteria and helminths can multiply outside the host. The bacteria *Salmonella* spp. (causing salmonellosis and (para-)typhoid), *Shigella* spp. (causing bacillary dysentery) [(3)] and *E.coli* (causing bacterial enteritis) [(28)] can all multiply in food. The food can be contaminated through faeces, hands, utensils, domestic flies, or cockroaches. Meat and dairy products pose the greatest risk. Thus food which is not initially harmful because it contains too little bacteria can become infectious over time because the bacteria have multiplied.

Several water-based helminths (schistosomiasis, fasciolopsiasis, fascioliasis, clonorchiasis, and opisthorchiasis) can multiply in freshwater snails, and strongyloidiasis can multiply in soil. Here again, a light contamination of water or soil can can become very infectious because the pathogen has multiplied outside the host.

Excreta poses a large and prolonged health risk because of its potentially high load of pathogens, the persistence of pathogens in the environment, and the potential for multiplication outside the host, so excreta-related wastes must be dealt with carefully.

6.2 Practical issues on sanitation

This section looks at several of the risk factors mentioned in Table 6.2. It also presents several aspects important to the planning, design, and construction of sanitary structures.

6.2.1 Open defecation

Open defecation allows the transmission of all excreta-related infections and is therefore a serious health threat. Open defecation is not acceptable close to the household plot, or in urban communities or other areas with high or medium population densities.

Each infected person usually has great potential to spread pathogens, so sanitary structures will only be effective in preventing disease if they are used by everyone, all the time. Even if only some people in the population (e.g. children) defecate in the open, the health benefits of sanitary structures will be limited. Some examples to illustrate this problem [adapted from 2,3,16,73]:

- A person with bacillary dysentery excretes $1x10^9$ bacteria in a small stream. Ingesting 10 to 100 bacteria can cause infection. The number of pathogens excreted in the water could in theory pollute $10,000m^3$ of water with 100 bacteria per litre.
- A person with a hookworm infection can easily release 1,000,000 eggs per day. If this person does not always use a latrine, and we assume that 1 per cent of the eggs end up in favourable soil, become infectious, and remain viable for six weeks, then this person will be responsible for over 400,000 infectious larvae in the soil at any time for as long as the infection lasts.

Even though open defecation is a serious health threat, it should not be condemned categorically in areas with low population densities. Open defecation might be preferable to using poorly maintained latrines [57] which can become foci for the transmission of diarrhoea [40] and hookworm [9].

6.2.2 Poor hygiene of sanitary structures

Sanitary structures can play an important role in disease transmission if they are not kept clean [28]. Faecal-oral infections can be spread through direct contact with faeces, contaminated material, or through flies or cockroaches. Latrines with floors contaminated with faeces can transmit hookworm.

Sanitary structures must be kept clean to reduce health risks and to make them acceptable to users. Installing a SanPlat, which is a smooth concrete latrine slab,

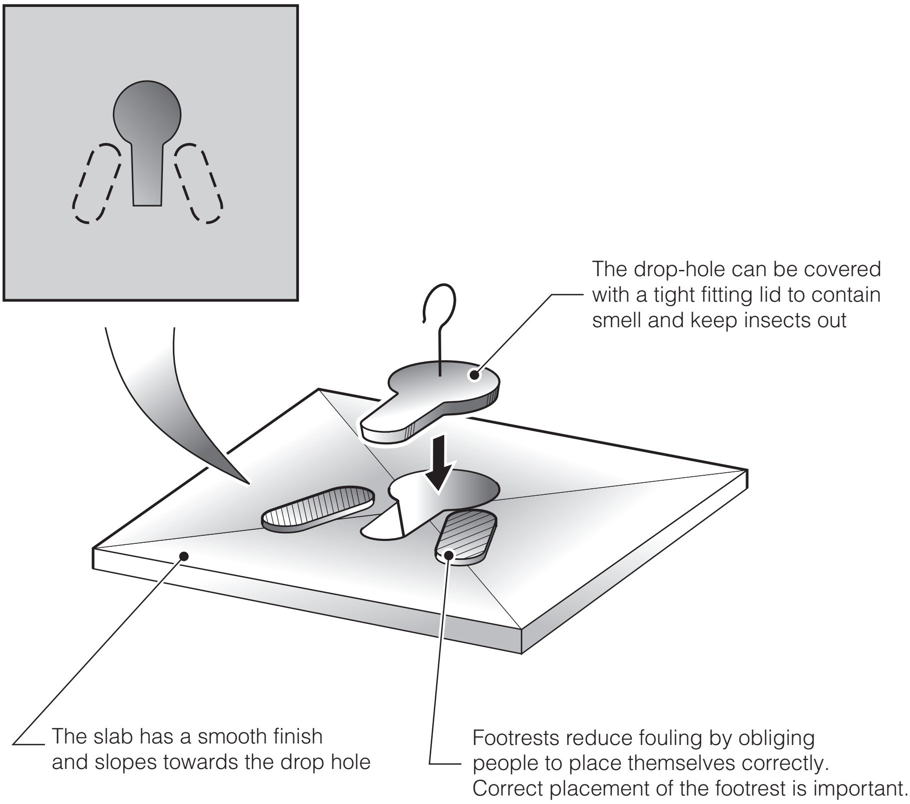

Figure 6.1. The SanPlat (9)

makes it easier to clean the latrine. A SanPlat can be built into a new latrine or an existing latrine can be upgraded (9). The slab should slope towards the drop-hole so that spilled water, or water used for cleaning, flows into the hole. Figure 6.1 shows an example of a SanPlat.

6.2.3 Water supply and the sanitary structure

There should be a reliable source of water near the sanitary structure. Water is used for handwashing and cleaning the structure, and possibly for flushing or anal cleansing. The water does not have to be high quality as it is not used for drinking.

Table 6.5. Water demands of a sanitary structure [66]	
Water use	***Quantity needed***
Handwashing	1-2 litres per person per day
Cleaning structure	2-8 litres per cubicle per day
Flushing (pour-flush)	3-5 litres per person per day
Flushing (sewerage)	20-40 litres per person per day
Anal cleansing	1-2 litres per person per day

Table 6.5 gives approximate quantities of water needed. A communal pour-flush latrine used by 20 people who use water for anal cleansing may need around 200 litres of water per day to work – and be used – correctly.

6.2.4 Discharge of excreta or effluent in surface water

Discharging excreta-related waste into freshwater causes different risks than discharging into seawater.

Discharging excreta in freshwater

Discharging excreta, nightsoil, or sewage into fresh surface water creates a serious health risk. Faecal-oral infections can be transmitted to people who drink the contaminated water, and water-based helminths (e.g. schistosomiasis, clonorchiasis) can infect their intermediate hosts. If cattle and pigs drink contaminated water, they can be infected with beef and pork tapeworm. Domestic flies, which transmit conjunctivitis and trachoma, and *Culex* mosquitoes, which transmit filariasis and several arboviral infections, can breed in surface water polluted with faeces.

The discharge of excreta, nightsoil, or raw sewage into fresh surface water should be limited as much as possible. The practise would only be acceptable where the waste was diluted in a large volume of moving water, where people are not in contact with the water (including people downstream), and where the risk from food taken from the river is very small. This combination is unlikely to occur in developing countries.

As conventional sewage treatment plants do not usually reduce the number of pathogens to a safe level (their main aim is generally to reduce the BOD to acceptable levels), their effluent is normally still very polluted. Exceptions to this are properly designed and functioning waste stabilisation ponds, plants with maturation ponds, and adequate filtration systems (see Section 6.2.6) [28].

Discharging excreta into seawater

Only faecal-oral infections pose a health risk if excreta, nightsoil or sewage are discharged into seawater. The cysts of protozoa and the eggs of helminths will settle out rapidly, so only viruses and bacteria will normally be a threat. It is unlikely that pathogens will travel more than a few kilometres from a sewage outfall.

As seawater is not used for drinking, the main health risk comes from handling or eating contaminated fish and shellfish. Fish can harbour pathogens in their body for weeks and can therefore be a risk if they are caught close to a sewage outfall. As shellfish can accumulate pathogens in their bodies, they are a larger health risk than fish. Fish and shellfish should always be properly cooked before eating.

The additional health risks from contaminated seawater will normally be limited if people already live in an environment with poor sanitation (28).

6.2.5 Groundwater pollution by sanitary structures

Polluted liquid seeping out of sanitary structures can sometimes percolate through the soil into the groundwater. The groundwater can thus be polluted with pathogens and chemicals from the excreta. Both types of pollution will be covered here, with the emphasis on pollution by pathogens.

Only faecal-oral pathogens will be transmitted by polluted groundwater, and unless the soil consists of fissured rock or coarse sands, only viruses and bacteria will pose a risk. Because of their large size, the cysts of protozoa and eggs of helminths will easily be blocked by the soil and will not seep down (42).

Groundwater pollution will only be a problem if the groundwater is used for drinking, or if water mains with intermittent supply are piped through polluted soil (see Section 5.2.3).

It is important to remember that the health risks from open defecation or from using inadequate sanitary structures are usually greater than the health risk of polluting the groundwater by sanitation.

If groundwater pollution is a serious risk, it is usually more appropriate to change to a piped water supply than to install off-site sanitation (e.g. a sewerage system).

Although groundwater pollution is often used as an argument against on-site sanitation (e.g. pit latrines), poorly constructed or maintained sewerage systems are just as likely to pollute the groundwater (62).

Pollution in the unsaturated zone

In the zone above the water table, polluted liquid from the sanitary structure will percolate downwards under the influence of gravity. The removal of pathogens in the unsaturated zone is very effective [31], and where groundwater pollution could be a problem, this distance should be maximised (e.g. by raising the latrine, using a shallow pit) [42]. If there is at least 2m of fine sand or loam between the source of pollution (e.g. the base of the pit of the latrine) and the groundwater table, most pathogens will be removed from the liquid [57]. Within months of a latrine being used an organic mat will form naturally in the soil. This mat is very effective in removing pathogens [42].

Pollution in the saturated zone

To understand the principles of pollution below the water table, the movement of groundwater in the saturated zone must be understood.

Shallow groundwater tables usually follow roughly the form of the terrain [34]. As water flows from high to low areas, groundwater will normally move in the same direction that water on the surface would flow. As a rough rule, the steeper the terrain and the coarser the soil particles (if there are no small particles like silt and clay), the faster the groundwater will flow [24].

When the polluted liquid meets the groundwater, the liquid will be carried with the groundwater flow. The liquid forms a ‘tongue’ which follows the flow of the groundwater, but the liquid and the groundwater do not really mix [30]. This is shown in Figure 6.2.

Bacteria will not normally travel further than the distance the groundwater flows in 10 days [42]. Predicting the exact distance that pathogens will travel from a sanitary structure is difficult, as this will depend strongly on the local situation. In terrain with a low gradient and medium to fine sands, bacteria will probably not travel further than 10 metres. Viruses can travel further, as can bacteria in coarse sands or fissured rocks [42]. In fine soils a safety distance of 15 metres will usually be adequate [57].

These values can be used for sanitary structures which have to deal with up to 50 litres of liquid per horizontal m^2 per day [30], and family structures will usually not exceed this.

Even though pathogens are removed from the flow, they are not necessarily killed, and if large volumes of liquid are suddenly discharged, viable pathogens which were ‘stuck’ may be flushed out. Pathogens will not travel as far if the same amount of liquid is discharged continuously than if it is discharged in gushes.

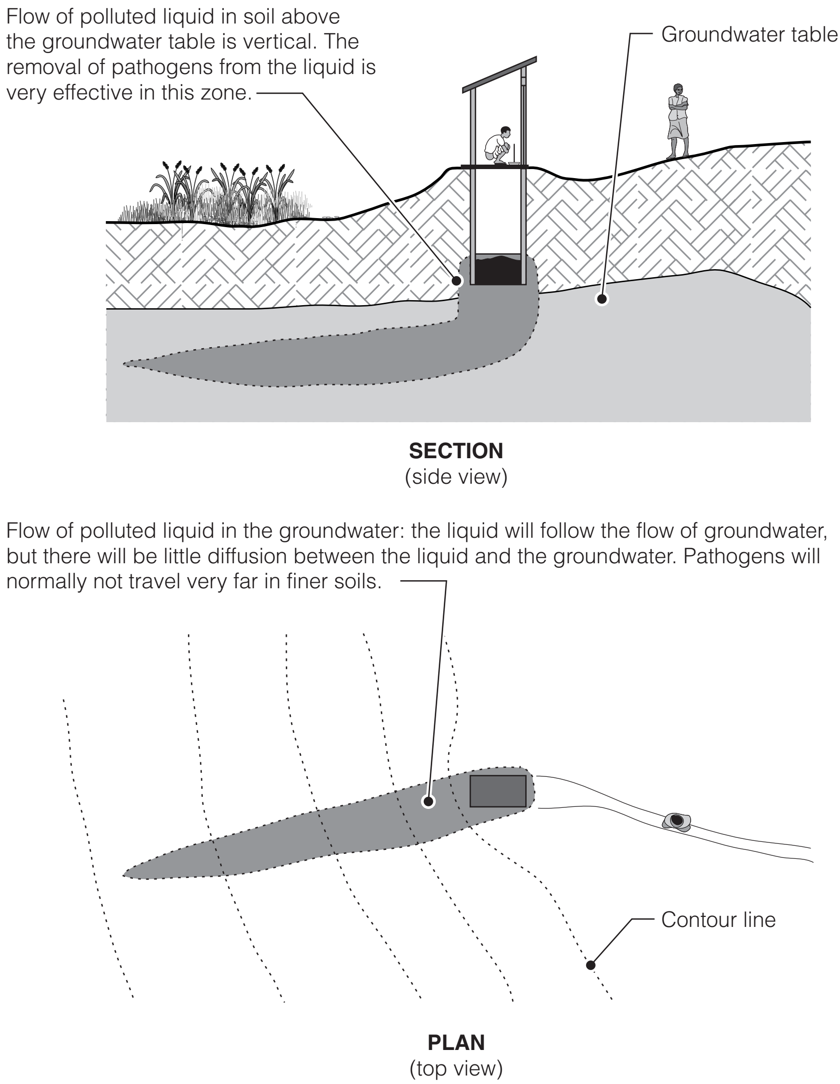

Figure 6.2. Groundwater pollution by a pit latrine (30,42)

If groundwater is abstracted through a properly sealed borehole well below the polluted layer, the water from the pump will be safe. This only works if water is abstracted in low volumes (e.g. with a handpump). Mechanised pumping can draw down the water table to such an extent that the pollution of deeper groundwater is possible (24,57). A properly sealed borehole that pierces an impermeable layer would be even safer. It might sometimes be possible to install latrines and properly constructed tube-wells close together, but it is always better to have a minimum safe distance between the two.

Chemical pollution of groundwater through sanitation

The chemical pollution of groundwater is caused mainly by nitrogen (nitrate) and chloride [43]. The health risk of chloride in groundwater is limited [46] (chloride is a component of kitchen salt), but a high chloride content could make the water taste unacceptably salty. Nitrate can cause blue-baby syndrome in infants, but this risk seems to be limited [62,68]. Nitrate is possibly linked to gastric cancer and congenital deformities, but here again, the risks seem to be limited [62].

Unless there is a high population density, or some other cause of chemical pollution (e.g. using sanitary structures to discharge chemically polluted waste water), the health risk of chemical polluting groundwater by sanitary structures will usually be small.

6.2.6 Re-use of excreta

Excreta can be a valuable resource. Excreta-related wastes can be used for:

- fertilising or irrigating crops: nightsoil, sludge, sewage or composted wastes can be used to fertilise plants, and sewage or effluent can be used for irrigation (and fertilisation).
- Aquaculture: nightsoil, sludge or sewage can be used to feed fish in ponds.
- Gas production: nightsoil is used to produce biogas, a useful source of energy.

Fresh excreta, nightsoil, sludge, sewage, or effluent can all contain large quantities of pathogens, and thus pose a serious health risk to the people who handle the waste and those around them. People who work directly with waste or who live or work close to where excreta-related wastes can all be at risk from excreta-related infections. But excreta, effluents, and sludge can be treated to make them relatively safe to handle and re-use.

Treatment of excreta-related wastes

There are several ways to make excreta-related wastes safer. The waste may not be totally free of pathogens, but if one of the following techniques are used correctly, the risk of handling the treated waste will normally be negligible.

- Pass the waste through properly designed and working waste stabilisation ponds [15].
- Let the effluent from a sewage treatment plant sit for enough time in maturation ponds.

- Filter sewage treatment plant's effluent through a sand bed.
- Compost excreta, nightsoil or sludge under aerobic conditions, at temperatures of at least 62°C for over one hour, 50°C for over one day, or 46°C for over one week.
- Treat nightsoil or sludge with heat; temperatures and duration should be at least equivalent to those mentioned above [(28)]. The high financial and environmental costs of fuel will usually make this method inappropriate.
- Bury excreta, nightsoil, or sludge for two years [(30)] (e.g. use twin-pit latrines, bury nightsoil or sludge in trenches, or top with earth full latrines). In tropical climates most pathogens, except for roundworm, will not survive longer than one year when buried.
- Dry nightsoil or excreta for at least one year [(28)].

Fresh excreta, nightsoil, and any type of excreta-related sludge or effluent that has not been treated adequately can contain pathogens and should therefore be isolated as much as possible from people, animals, insects, food, crops, vegetables, soil, and water. Conventional sewage treatment plants usually do not reduce the number of pathogens to safe levels, and their effluent can still contain high levels of pathogens.

Use of excreta-related waste for fertilisation and irrigation

The main health risks of workers (and often of their families) who use excreta-related waste for fertilisation or irrigation are faecal-oral infections and soil-transmitted helminths (e.g. roundworm and hookworm). Where workers come in contact with contaminated surface water schistosomiasis could also be a problem.

Consumers of the crops are at risk of faecal-oral infections and ingested soil-transmitted helminths (e.g. roundworm and whipworm).

The health risks of using excreta-related waste for fertiliser should be reduced by minimising the contact between crops and pollution as much as possible (e.g. through subsurface irrigation). Excreta-related wastes should only be applied before the crops are planted or up to one month before the crops are harvested. This will reduce, though not eliminate, the risks of faecal-oral pathogens. The health risks of soil-transmitted helminths will not be reduced significantly.

The health threat to people can be reduced by feeding these crops to animals, though several infections (e.g. salmonellosis and beef and pig tapeworm) will remain a health threat to people through infections in the animals [(28)].

Use of excreta-related waste for aquaculture

Using excreta-related waste to feed fish ponds creates several health risks. People who handle, prepare, or eat undercooked fish from these ponds are at risk from the faecal-oral pathogens that are on the fish's body or in its intestines [(28)].

In addition to faecal-oral infections, consumers are at risk from water-based helminths which use fish as an intermediate host (e.g. clonorchiasis and opisthorchiasis). These pathogens can be transmitted to people or animals if the fish is not properly cooked. Other pathogens which have to reach surface water to develop (e.g. schistosomiasis) could also potentially be transmitted.

Keeping the live fish in unpolluted water for two to three weeks before eating them will reduce the health risks.

As the eggs of water-based helminths with two intermediate hosts settle out easily in water, the risk of these pathogens can be reduced by putting ponds in series, and only harvesting fish from ponds which have not been fed with excreta-related wastes [(6)].

Production of biogas

Handling excreta and the sludge that has to be removed regularly from a biogas plant could be a health risk. The sludge could be heavily contaminated with pathogens and should be handled and disposed of with the same care as fresh excreta.

6.2.7 Some practical issues on the planning and construction of sanitation

While not all practical sanitation issues can be considered here, some important issues need to be highlighted.

Assessment

To maximise the impact of improved sanitation, everyone must have access to adequate structures, and these structures must be used correctly.

The structures have to be adapted to local behaviour, traditional beliefs, and the population's needs. In addition, sanitation has to be affordable to the users, and appropriate for local institutional capabilities and restrictions. The structures also have to be adapted to the physical situation in which they will have to operate. A thorough assessment will be needed, and it is likely that different groups will identify different issues, needs, and preferences, and these must be identified and considered. It is especially important to address the problems of marginalised people to ensure that everyone has access to sanitation.

Household versus communal latrines

Each household should normally have its own sanitary structure so that responsibility for maintenance and cleanliness lies with the family.

In a stable situation, communal latrines should only be considered if it is impossible to install structures at household level (e.g. because there is no space or installation is unaffordable), or in public structures like schools or hospitals.

Where communal structures have to be installed, the issues of management, cleaning, maintenance, and operation must be worked out before construction begins. Usually people have to be employed to keep communal structures clean [56]. The facilities for men and women should be separated, and issues of privacy and safety for women using the structures, or walking to the structures, have to be addressed in the planning phase.

Numbers and location of latrines

People will only use sanitary structures if they do not lose too much time at them. This is achieved by having enough latrines available and siting them close to the users.

There should be no more than six cubicles per communical latrine [21], with not more than 20 [66] or at most 25 users per cubicle [21]. Structures should be sited less than 50 metres [66] from people's houses, and at most 250 metres [21].

If groundwater is the community's drinking-water source, latrines must be located and constructed so that the risk of contaminating groundwater is minimal. As a general rule, if the latrine is constructed in fine soils, there should be at least 15 metres between the water source and the latrine. If possible, the water source should be installed on higher ground than the latrine. Where the soil is coarse, or waste water is discharged in the structure, the distances between water source and latrine may have to be more. (The problem of groundwater pollution has been addressed in more detail in Section 6.2.5.) Latrines should be located so that the risk of flooding by stormwater or floodwater is minimised. The top of the latrine slab should be raised a minimum of 0.15 metres above surface level to prevent surface water or rainwater from entering the structure [30]. Pits should be dug some metres away from the foundations of buildings as this could weaken the foundation or cause collapse; and pits must not be dug against a road carrying heavy traffic as this can also collapse the pit.

Sanitation in emergencies

In the early stages of an emergency it is not usually feasible to provide household latrines or even enough communal latrines. It may be necessary to construct structures with 50 to 100 users per cubicle or metre of trench (if trench latrines are used) to begin with. This must be upgraded as soon as possible to communal latrines with 20 users per cubicle, or household latrines [(47)]. As it is not normally possible to provide adequate structures from the beginning, and the aim should be to decrease the health risks and increase the convenience to the users as quickly as possible.

Start by discouraging people from defecating near any water source used by people and animals, or in fields where crops for consumption are grown. As soon as possible defecation should be confined to specific areas: open defecation fields or trench defecation fields. The next step could be to install trench latrines, or communal borehole or pit latrines. Following that latrines could be installed at household level if feasible [(64)]. Provision should progress through these steps as soon as possible, to use the best feasible structures at all times.

If communal latrines are installed people have to be employed to maintain and clean them. Anal cleansing material, water and soap for handwashing, and soil to cover the excreta may have to be provided [(66)].

If insects can access the contents of the latrines, the excreta should be covered with 0.1 metre of soil every two to three days [(21)].

Some issues concerning construction

Structures are designed to last a certain period (the 'design life'). In a stable situation the pit of a latrine may be expected to last for up to 30 years [(30)]. The expected number of users at the end of the design life should be used when designing structures. Annexe 5 has information on the accumulation rates of solids in pit latrines, and how to estimate the infiltration capacity of the soil.

Where soil stability, soil erosion, or rats could become a problem, the top 0.5 metres of a pit should be protected with a closed lining. If the soil cannot carry much weight the superstructure should be light. It may be necessary to make a foundation in the form of a concrete ring beam to make the latrine structurally sound [(30)]. The more complex a latrine becomes, the more expensive and demanding its construction will be.

Latrines should be built so that insects cannot enter the pit. This can be achieved by installing a tight-fitting lid (this is difficult in a communal structure), a water seal (this will only be adequate if water or soft paper is used for anal cleansing), or a VIP-latrine (this type of latrine is probably less adapted to use at household level as they are expensive and rather complex; in addition, VIP latrines usually do not stop mosquito breeding). If the latrine is ‘wet’, polystyrene beads can be used to create a floating layer which will prevent mosquitoes from breeding in the pit [61]. All other openings which give access to the pit containing excreta should either be sealed or closed with flyproof netting.

Vandalism and theft must be prevented by sealing the lids of access-holes with mortar or locking them and by making structures as solid as possible; this is especially important in communal structures.

This example of a pit latrine (Figure 6.3) shows some of most important points for proper use.

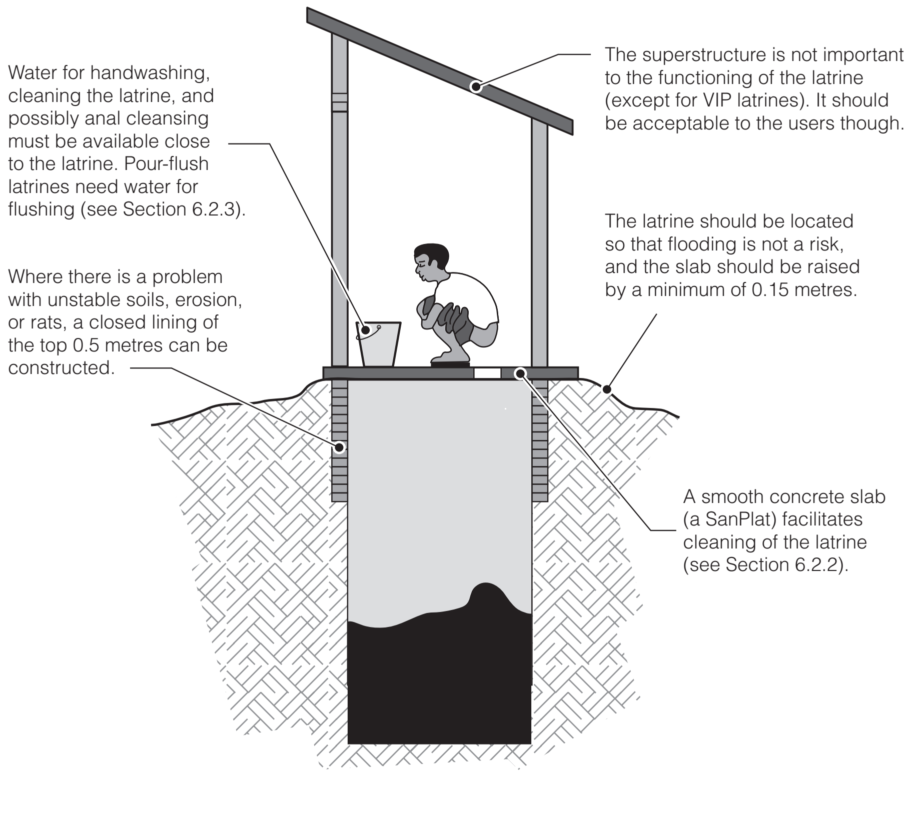

Figure 6.3. Example of a pit latrine (adapted from 30)