WEDC Water Engineering and Development Centre

UNIT 2

HOUSEHOLD AND COMMUNAL SANITATION MANAGEMENT (HCSM)

On-site rural sanitation

What this unit is about

This unit considers how the context of rural settings influences the way in which sanitation services are provided.

It also presents a range of sanitation facilities and services that are considered to be appropriate in rural settings, with a view to ensuring safely managed services.

What you will learn

On completion of this unit you will be able to:

- describe ways in which rural settings influence sanitation approaches and service options;
- discuss the main types of onsite sanitation facilities appropriate for rural settings; and
- explain key designs and innovations that support safer in-situ emptying and disposal of excreta.

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2.1 Nature of rural settings

Rural settings and the communities that live in them cannot be viewed as homogenous. A rural area may be defined as any area that is located outside of a town or city, or it may be defined on the basis of the population within a given settlement. In the UK for example, areas are considered rural if they have a resident population of less than 10,000. In Mexico, that number drops to 2,500 people. Definitions will be set by a government office, such as the national census bureau or office of statistics.

Rural areas can be divided up into three main categories. They may consist of:

- dispersed settlements that have plenty of space and land between the houses (see Photo 2.1 above);
- semi-compact settlements consisting of clusters of houses (sometimes called hamlets) with a clear grouping or boundary; and
- compact settlements with houses close together in a defined pattern, such as a village (see Photo 2.1 below).

Photo 2.1 A dispersed settlement (above) and compact settlement (below)

Depending on the nature and size of a rural settlement, the sanitation practices, facilities and services are likely to vary. They will be influenced by the advantages and disadvantages of rural living (Table 2.1) – although these will vary in their degree of influence, depending on the nature of the settlement.

Table 2.1 Aspects of rural living

Advantages of rural living	Disadvantages of rural living
Increased access to space and nature	Limited access to markets, materials and services
Better social networks and support	Limited transport routes and connections
Less distinct class structures – increased "cohesion"	Slower social and political progress
Less stressful environment	Limited employment opportunities

2.1.1 Rural opportunities and constraints

Types of sanitation infrastructure (in the form of toilets) and services (that help to maintain the functionality of toilets), present in rural areas will be influenced by the opportunities and constraints resulting from the nature and settlement of the community.

2.1.1.1 Opportunities

Increased access to **space** enables households to build and own individual family toilets within the boundary of their housing plot. Where they own the land they live on, they also have increased decision-making powers and rights to choose what they build and how.

Increased access to **nature** can provide a source of local materials for constructing a toilet (wood, bamboo, cow-dung, grass, sand) at relatively low cost. While they may not provide long-term durability to the structure, it is possible they can be more easily replaced than materials bought from a remote supplier. If **handling and reusing excreta** is culturally and socially appropriate, there are more opportunities for the removed contents from pits and tanks to be applied to land in gardens or neighbouring fields without involving significant transport time and costs.

Where the community provides increased levels of **social cohesion and support**, community-based approaches intended to raise demand for improved sanitation are more likely to work and result in appropriate and sustainable sanitation facilities, as well as changes in hygiene behaviours. These approaches often include support being extended to those less able to provide for themselves, identified and managed by members of the community.

Such community-based approaches can be those intended to create a quick response within a community (such as used in Community Led Total Sanitation, CLTS) or those that adopt a longer-term approach (such as used in Community Health / Hygiene Clubs, CHCs).

Community Led Total Sanitation (CLTS) is an approach designed to trigger collective action within a community. It uses participatory methods to provoke a sense of 'disgust' amongst the community, on realisation of the extent of open defecation practices and its implications. It is the most widely used community-based sanitation approach, operating in over 50 countries around the world. Having started in Bangladesh, it's popularity quickly spread throughout South and Southeast Asia, before it was introduced and adopted across Sub-Saharan Africa, as well as a few countries in Latin America and the Caribbean. CLTS will be explored in more detail in later units of this module.

In contrast, **Community Health / Hygiene Clubs (CHCs)** consist of community-based groups that form to promote family sanitation and health. Weekly meetings are held to discuss a range of health and hygiene topics, with peer or social pressure and competition used to encourage behaviour change by the participating households. The CHC approach started in Zimbabwe and is used mainly in southern African countries, including Rwanda, as well as the Dominican Republic.

Both approaches view participants as agents of change within their community, while also being beneficiaries of the interventions intended to change behaviours.

Source: Venkataramanan (2017)

Further information about Community Health Clubs **ONLINE**

2.1.1.2 Constraints

In the recent past, sanitation projects adopted supply-driven approaches, where toilets were subsidized – in part or fully – for the households. Although this resulted in significant numbers of toilets being built, many were later abandoned or used for non-sanitation purposes (such as storing valuable items or keeping small animals). The emphasis of these projects was too heavily focused on getting the technology right, without accounting for people's needs, opinions, or means to maintain their sanitation facility.

Since the move away from supply-driven, subsidized approaches, the challenge has been to enable communities to end open defecation and move towards use of improved sanitation facilities, as the means to improve both health and other non-health outcomes in the community.

Where rural communities are remote from markets, they face challenges in having limited access to different building materials suited to construct a range of appropriate, affordable and sustainable toilets, as well as technical advice and skills for constructing them (Box 2.1). Their remoteness also affects access to a range of design options and the costs associated with the sanitation services – such as manual workers or suction tankers to empty pits and tanks when full, or builders who can carry out maintenance work, repairs and upgrading.

Box 2.1 Remoteness of villages in East Timor and toilet durability

A study of a number of NGO-supported CLTS projects in rural villages in East Timor found that the remoteness of some villages affected the quality of toilets being constructed following the CLTS triggering event and their subsequent sustainability.

In response, the NGO found that providing indirect support to households in these remote villages helped with construction of more durable toilets. This support was provided in the form of training up local champions in how to construct durable toilet slabs, loaning toilet moulds for households to construct the slabs, and providing help with the transport of manufactured materials (such as cement, reinforcing bar and plastic ventilation pipes) from the nearest town.

Source: Dwan (2012)

Rural communities also face a range of constraints that influence the existing nature of sanitation practices and chances of improving them. In many low- and middle-income countries, rural communities are widely affected by extensive and growing rural poverty. This can be exacerbated by increasing migration from rural to urban areas which reduces the number of working adults available to offer labour, or the potential for household income.

Alongside a CLTS or CHC approach (see under section 2.1.1.1), financing approaches might also be adopted. These make use of financing mechanisms to help increase the uptake, or sustainability, of sanitation facilities and services among the unserved or the most vulnerable members of society. Examples include the provision of micro-financing (in the form of small loans to households) or targeted hardware subsidies (provided to families to help them purchase materials).

Discussions continue around the appropriateness of using subsidies, targeted to those most in need, through either direct or indirect support for capital or maintenance costs (Box 2.2).

Box 2.2 Examples of hardware subsidies for rural sanitation

- Infrastructure subsidies, including use of public funds to construct new infrastructure, part or all the cost of a household toilet in rural areas
- Direct subsidies to household to access a range of sanitation services
- Operational subsidies, by paying the service provider to offset some or all the costs of supplying a service
- Cross-subsidies, such as one group of users contributing part or all the cost of providing services to another group.

Source: WSSCC (2009)

2.1.2 Safely managed rural sanitation

The opportunities and constraints present in a given rural area will influence the forms of sanitation that are most prevalent. They will also be strongly influenced by cultural practice and taboos around sanitation practices, as well as the natural topography, soil and groundwater conditions, access to water (for flushing excreta, anal cleansing and associated hygiene practices), and environmental factors such as climate change and population movement.

Typically, people living in rural areas with low population density in low-income settings either continue to practice open defecation or make use of low-cost toilets that dispose of excreta on the plot occupied by the family dwelling (see Table 2.2). The sanitation options that manage the excreta on-site can provide a limited, basic or even safely managed sanitation service. For rural toilets to achieve the definition for safely managed sanitation services, they are more likely to rely on the safe disposal of excreta in-situ, rather than needing excreta to be transported to an offsite treatment facility. The costs associated with safe emptying and transport of faecal sludge from pits and tanks, particularly if treatment facilities are some distance away, is likely to be unaffordable to the majority of rural households.

When designed, constructed, operated and maintained correctly and safely, and used by all members of the family in combination with good hygiene practices, simple latrines that have in situ disposal can support improved health outcomes.

Table 2.2 Access to different rural sanitation options (excluding shared) in 2015

Region	Latrines	Septic tanks	Sewer connections
Sub-Saharan Africa	18%	2%	1%
Central and Southern Asia	21%	17%	2%
East and South-eastern Asia	40%	16%	8%
Latin America and the Caribbean	22%	32%	14%
World	26%	16%	9%

Source: JMP, 2017: p.107

2.1.2.1 Enabling sustained sanitation outcomes for all

The construction and use of toilets in rural settings do not in themselves guarantee the achievement of the desired sanitation outcomes of *sustained use and maintenance of facilities*, towards ensuring safely managed sanitation *for all*. Ending open defecation practices is a significant achievement, but there is increasing evidence that sustaining this, together with other sanitation outcomes (such as use of a clean and hygienic toilet by all family members, handwashing with soap at critical times and safe management of liquid waste) is fragile in many rural settings. This is particularly true for the most vulnerable households, including the poorest families, those living in flood-prone or drought-prone areas, female-headed households, families with a disabled child or dependent elderly relatives. Such families are more likely to revert back to open defecation when their toilet becomes damaged or the pit becomes full and requires investment in new materials or emptying services to function correctly.

Collective action is required to both secure the initial outcome of an open defecation free (ODF) community, as well as to enable the community to progress beyond this together, to ensure sustained use of toilets and the broader sanitation outcomes. These will be considered in greater depth in the later unit looking at sustainable outcomes from CLTS programmes. The desired outcomes are likely to require ongoing support to encourage and enable behaviour change, with targeted support provided to the poorest and most vulnerable households who would otherwise be unable to find the resources to achieve improved sanitation and hygiene (Robinson and Gnilo, 2016). Such support, if provided by external finance, must be sure to reach the intended target group(s), align with national policy objectives for sanitation, be delivered in an open and transparent way and be financially sustainable (Evans et al, 2009).

Now read: Venkatarmanan et al (2018) for a summary of key elements recommended by WaterAid, UNICEF and Plan International, for developing context-responsive rural sanitation programmes.

ONLINE **USB**

2.1.3 Appropriate on-site toilet options

In rural areas of many low- and middle-income countries, sewerage services are not available or practical. In such settings, the disposal of excreta and often sullage takes place on or near the site of generation – such as a housing plot or school toilet block. These on-site methods of excreta disposal can involve a range of technical options, including simple pit latrines or septic tanks with soakage system, which come under the category of on-site systems.

The different forms of on-site toilets described in this unit have the important advantage that they can more readily be constructed and maintained at the household level. There is no need for the construction of expensive off-site facilities such as sewerage and sewage treatment. In addition, householders can take more responsibility for carrying out and paying for the necessary operation and maintenance tasks. A well-maintained on-site system can provide sanitation that is as hygienic as the more expensive option of sewered sanitation.

Some of the most common on-site sanitation options appropriate in rural contexts are described in the following sections. They are divided into two groups, depending on whether they are considered dry latrines, or water-based (pour-flush) latrines.

2.2 Dry latrines

Where people use dry materials for anal cleansing (common examples include toilet paper, newspaper, leaves, sticks, stones and mud-balls), they may be referred to as "wipers". To accept such cleansing material, a latrine that has the pit directly below the defecation hole is preferable. This reduces the chance of blockages that dry materials would cause in any pans, u-bends or connecting pipework that is common in water-based latrines.

2.2.1 Pit latrines

Any discussion of on-site sanitation should start with pit latrines. This is because they are one of the oldest forms of formal sanitation in the world and for many, they are still the best option (Box 2.3). Pit latrines are probably the most common form of sanitation facilities in rural areas of low-income countries. They consist of a hole dug in the ground, where faeces and urine are deposited, usually covered by a slab or platform.

Box 2.3 Pit latrines have a number of advantages

When well-designed, built and maintained, pit latrines:

- are simple to build,
- are easy and safe to use, operate and maintain,
- can be built using local materials and technologies,
- are versatile and can be constructed to suit a wide range of physical and human environments,
- have designs that are easy to copy,
- are the cheapest technology for the safe disposal of human excreta, and
- can be improved incrementally over time.

Simple, single pits are appropriate where this is sufficient space to either dig a new pit when the one in use is full, or there is an appropriate place close by to safely empty, treat and/or dispose of the faecal sludge generated in the pit. They are therefore ideally suited to rural areas where the soil can be easily dug and can absorb the leachate generated in the pit.

There are various types of pit latrine technologies suitable for rural settings. These include:

Shallow pit latrine: Also known as the 'cat' method (as it is similar to what cats typically do when they defecate), this is where people dig shallow holes and bury their faeces (Figure 2.1). It is usually practised in rural areas when people are out working on their farms away from home, or at home to manage the faeces of young children. The practice can be considered the first step on the sanitation ladder towards improving sanitation practices. While covering the faeces will reduce smells and flies, it can still lead to the transmission of hookworm as the faeces are not buried very deeply. As the faeces decompose, this adds nutrients to the soil.

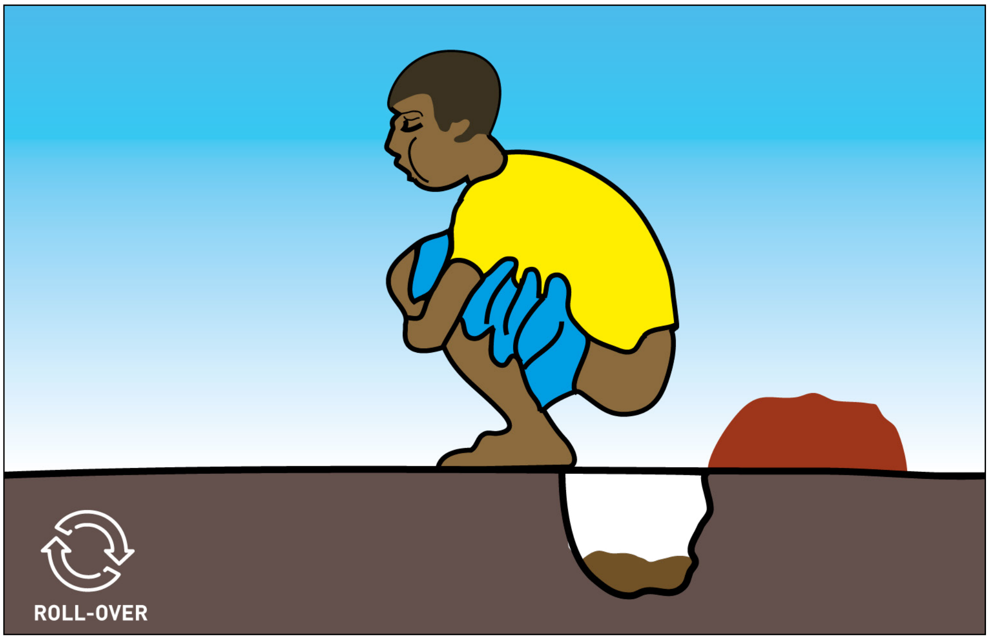
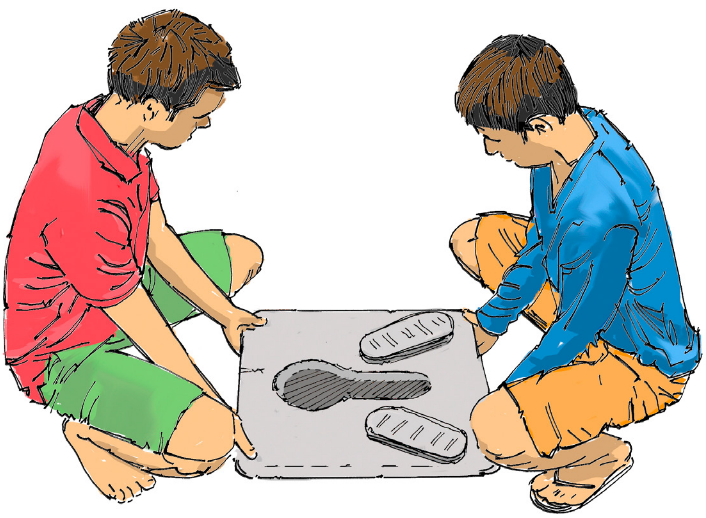


Figure 2.1 The 'cat' method

Simple pit latrine: This is also often referred to as a traditional pit latrine and consists of a pit of about 2m deep, or more. The user squats (or sits on a pedestal) directly over a hole in a platform that covers the pit. This platform may be made of wooden logs covered with compacted earth, or more robust materials. The latrine may or may not have a shelter (superstructure) to provide privacy and cover to the user, depending on social and cultural norms. Shelters are usually made of locally available materials including mud bricks, timber and thatch. Such latrines often have problems with odours and flies, particularly if the area around the hole in the platform is not kept clean. (Figure 2.2.)

Improved pit latrines: This is a pit latrine with an improved slab, platform and/or a superstructure. The slab is often made of more robust materials such as treated wood, plastic or concrete, that is durable and can be easily cleaned. A concrete slab may be reinforced and can be square (e.g. such as a SanPlat – see below) or round (e.g. a domed slab).



Laying a SanPlat

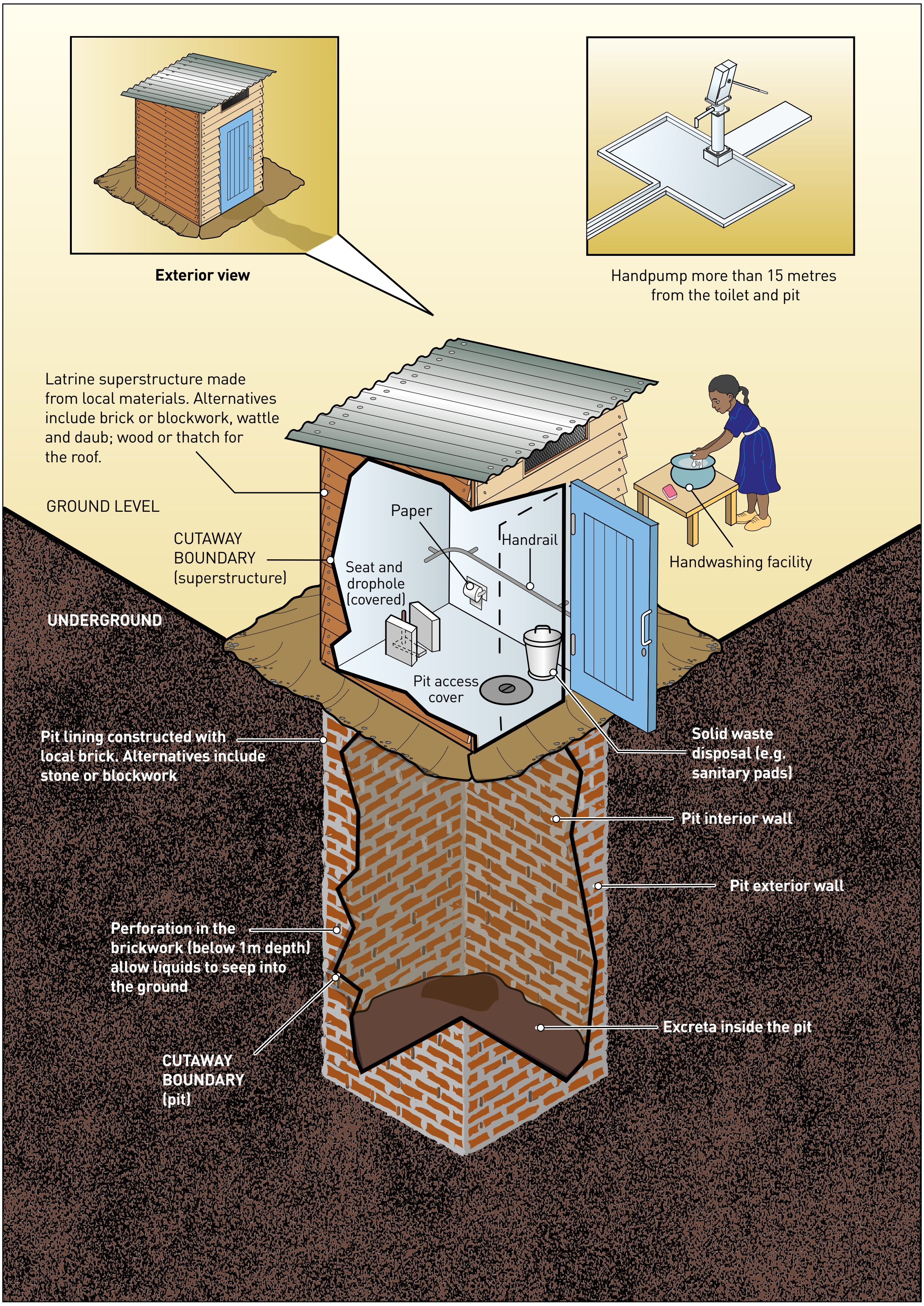


Figure 2.2 A simple pit latrine (with covered drophole)

Source: WEDC for WHO

Ventilated improved pit (VIP) latrine: This is perhaps the best-known type of improved latrine. Like the simple pit latrine, it has an open squatting hole (which can have a seat if the users prefer). It also has a darkened interior to the superstructure and a tall vertical vent pipe directly above the pit (Figure 2.3).

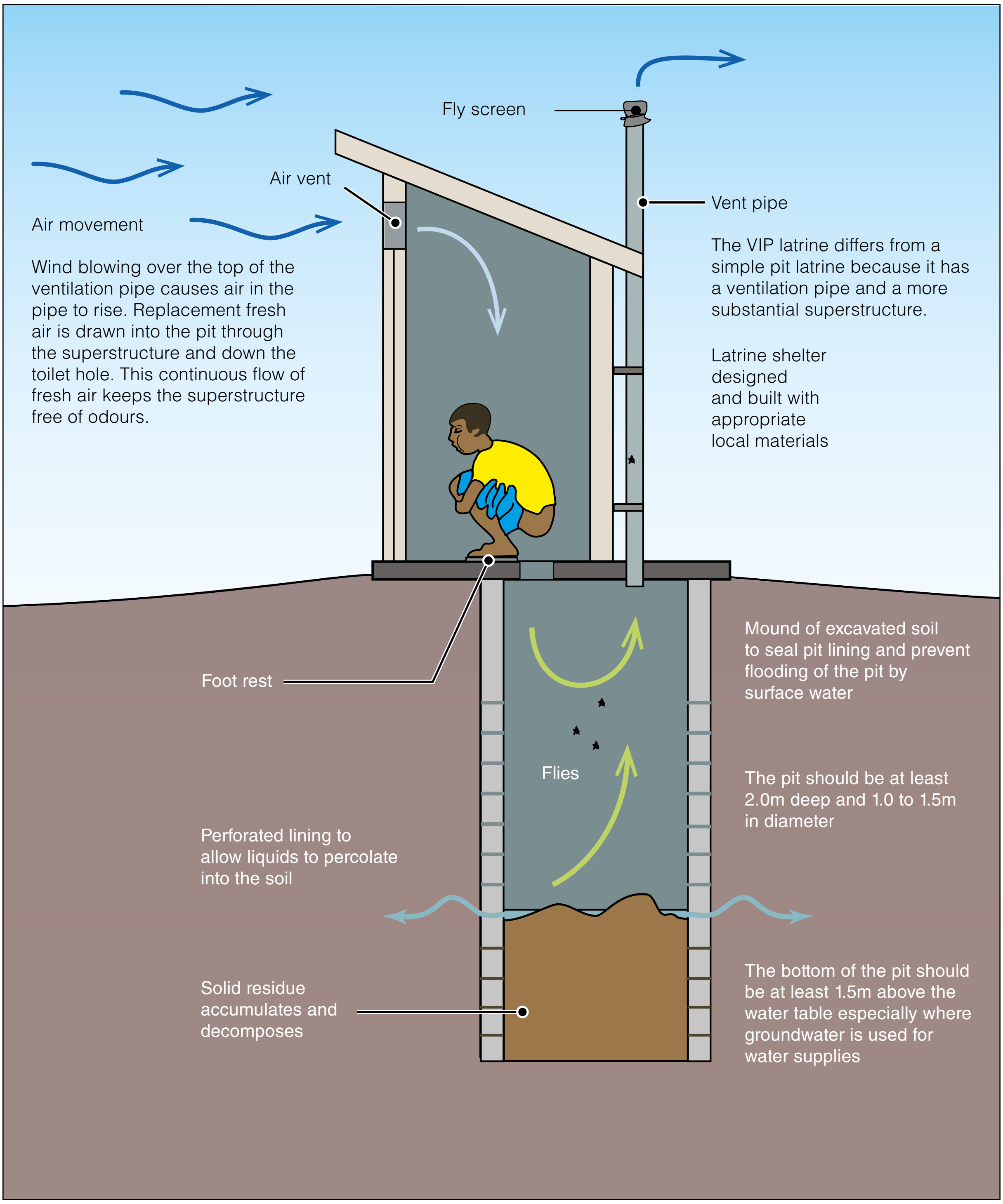


Figure 2.3 VIP latrine

Source: WEDC

The top of the pipe is fitted with a corrosion-resistant fly screen. A well-constructed and maintained vent (at least 150mm diameter plastic pipe, or 225mm square if made from brick) considerably reduces the problems of odours and flies. It should project at least 0.5m above the highest point of the roof. Wind blowing over the top of the vent pipe creates an up draft through the pipe, drawing air down through the hole in the cover slab and through the pit. To allow this air flow, the squatting hole must not be tightly sealed.

If the door to the superstructure faces the direction of the wind this also pressurizes the air in the superstructure to promote the same direction of airflow just mentioned.

A small ventilation hole can be provided above the door to facilitate entry of air movement when the door is closed. Hence, odours pass up and out of the vent pipe, rather than through the squatting hole and into the superstructure.

Flies outside are attracted to the top of the vent pipe, but cannot enter because of the fly screen, made of fine mesh, that is fixed flat across the top of the pipe.

Liquids seep into the soil through the base and perforated lining of the pit.

The inside of the superstructure is kept relatively dark, so that any flies that enter through the squatting hole into the pit are then attracted to sunlight shining into the pit from the top of the vent pipe. The fly screen prevents these flies from escaping via the vent and they eventually die and fall into the pit.

2.2.2 Pit with a sealed hole

- **Replaceable stopper**: These are like simple pits, but a stopper/cover is placed in/over the hole when the pit is not in use to control the problem of flies and odours.

  An example is the Mozambican arched (domed) slab when it is used with a stopper that fits tightly in the squat hole, as shown in Figure 2.4.

- **Hinged flap with water seal**: In recent years, using a hinged flap at the outlet to a squatting pan has been introduced as a means of providing a seal between the user and the pit. This counterweighted flap is used with the SATO Toilet Pan (the name is from Safe Toilet). SATO pans are patented plastic pans that have a sealing mechanism built into them to provide a mechanical seal and a shallow water seal (Figure 2.5). The original model has a 'trap-door' flap that covers the hole, held closed when the toilet is not in use by a counterweight.

  When in use, urine and faeces are deposited on to the flap, causing it to open. After defecation, a small amount of water is poured onto the flap to rinse it (suppliers say that as little as 200ml of water is needed). This causes the flap to open fully to allow any remaining waste to fall through to the pit below. The flap then returns to the closed position, creating a physical seal. A small amount of additional water can then be poured onto the flap, providing a shallow water seal (about 10mm) which is held within the raised edge of the flap. The combination of flap and water seal is proving to give an excellent barrier to odours and flies. Developments to the pan have resulted in other designs and attachments becoming available and used. These include a connection box to divert the excreta and flushing water to an off-set pit. Further details can be found in Araya (2017) and LIXIL Corporation (2017).

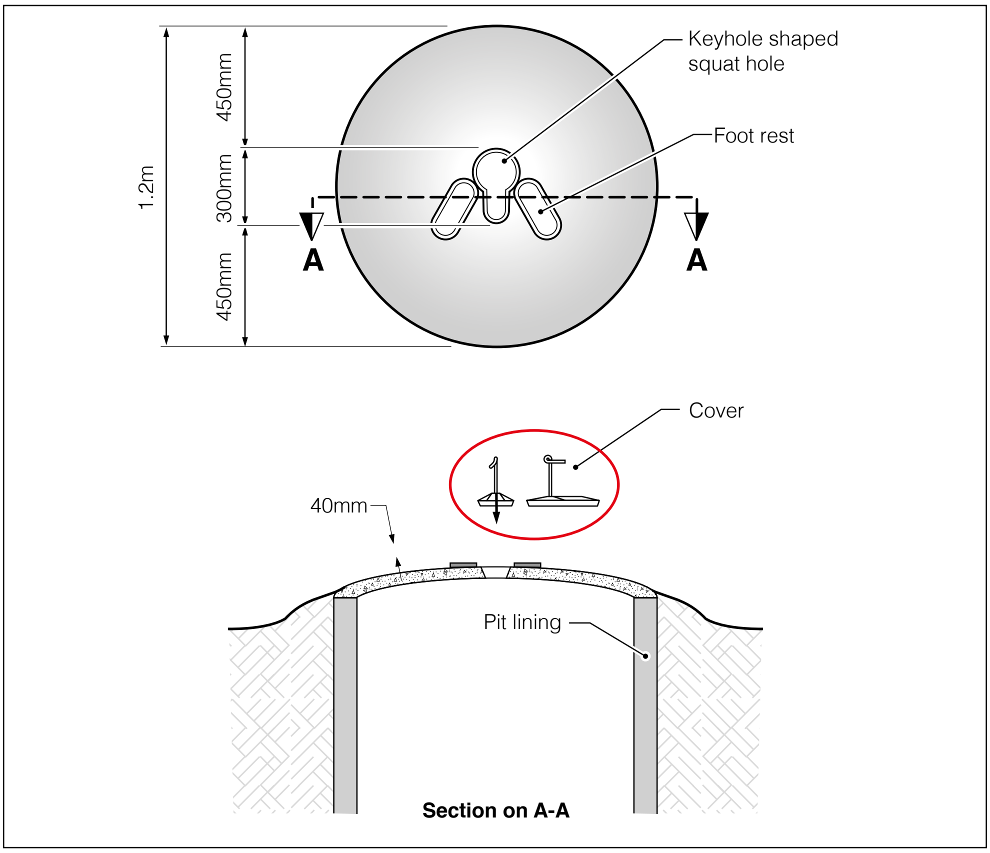


Figure 2.4 Mozambique slab with cover

Source: WEDC

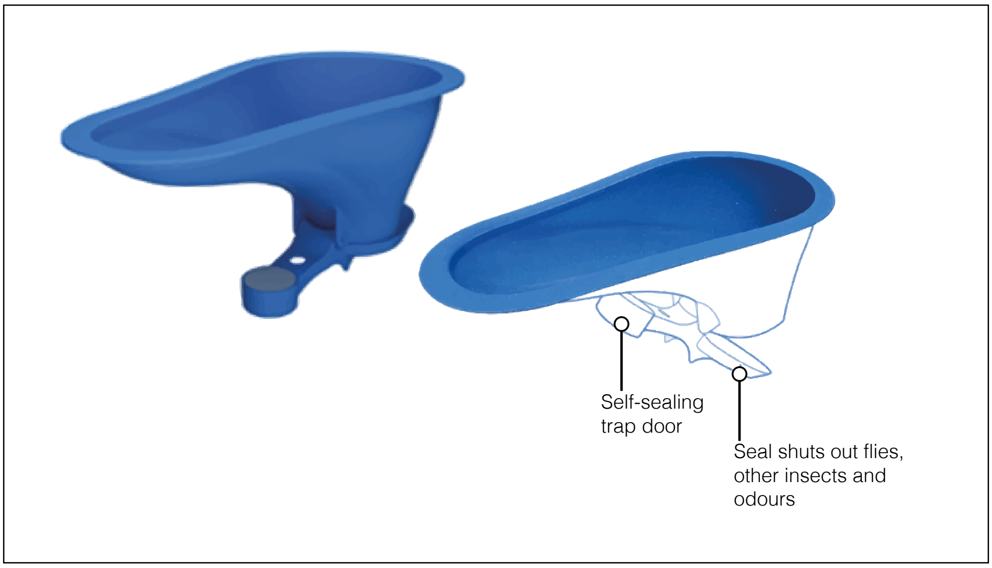


Figure 2.5 SATO Pans

Source: WEDC

2.2.3 Other types of dry latrine

- **Composting latrine**: This is a latrine that is built to store faeces while it decomposes to form compost that can then be used in agriculture. The latrine consists of a sealed vault(s) instead of pit, with access usually provided at the back to allow decomposed excreta to be collected. For proper composting to take place, the moisture content needs to be between 50-60 per cent, which requires a good air supply into the vault. This air supply is also needed so aerobic conditions are maintained. The carbon:nitrogen ratio of the contents should be between 15:1 and 30:1. To support this, wood ash or vegetable matter is added to the vault after defecation to encourage decomposition. The pathogens present in the faeces typically die due to the adverse conditions in the vault. Some pathogens however, such as the eggs of Ascaris (roundworm) may persist for a long time, so care needs to be taken to ensure that the eggs are deactivated by an adequate period of storage (at least one year and ideally more than two years) before the compost is handled. A double-vault system should be used, as using just a single chamber will mean that material being removed is likely to contain recently deposited faeces. (Figure 2.6.)

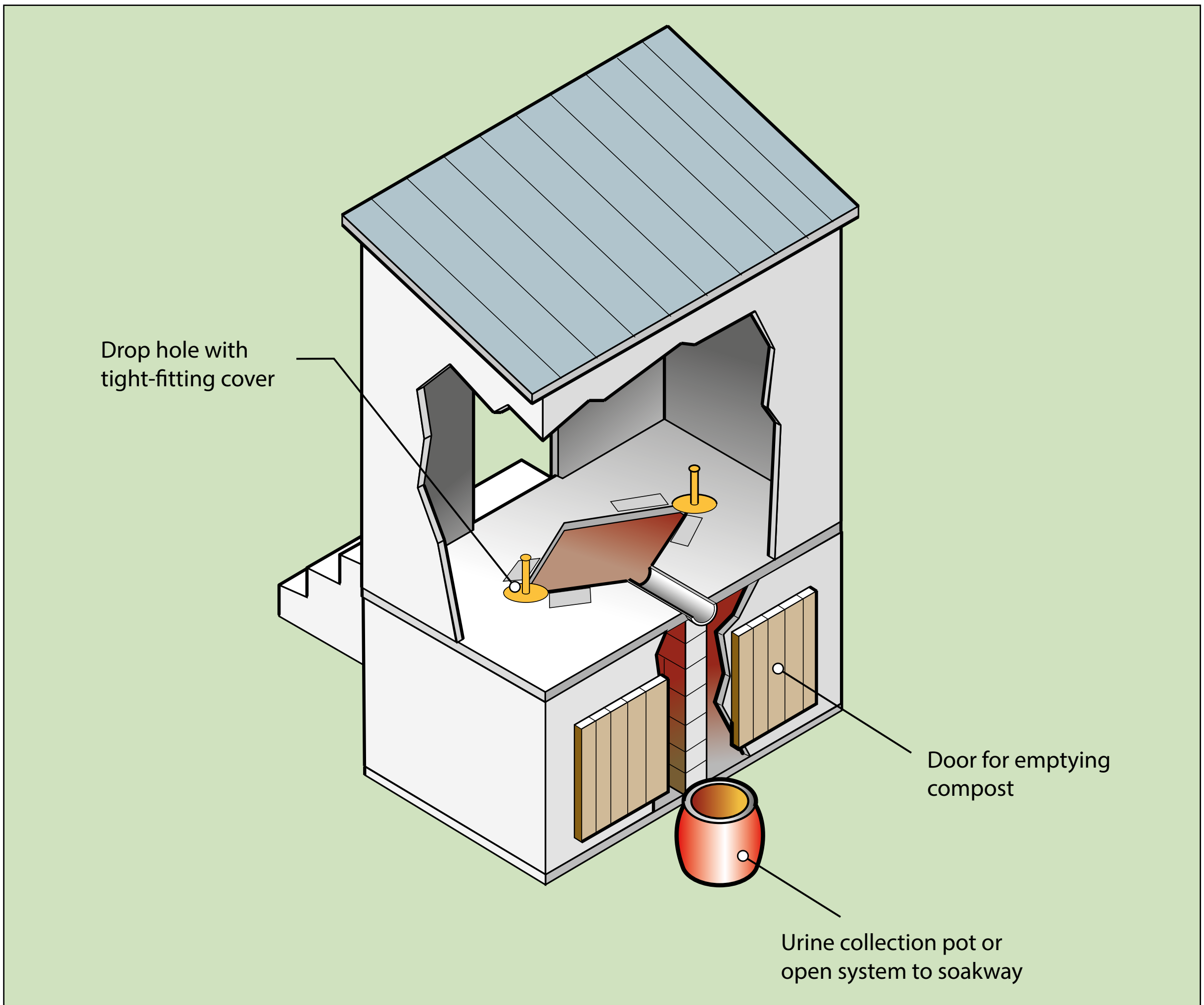


Figure 2.6 Composting latrine

Source: WEDC

- **Dehydrating latrine**: Dehydrating latrines reduce the moisture content in the vault to less than 20 per cent, often by the addition of dry organic material such as lime, wood ash or sawdust and sometimes by the flow of air across the faeces. In a few cases, solar heating of an exposed cover on the vault is used to encourage evaporation of water from the faeces. In dehydrating latrines, the pathogens are destroyed by depriving them of water and by increasing the pH above tolerable levels (e.g. by the addition of ash or lime). The low moisture level reduces odours and breeding of flies. There is little decomposition of organic material, so toilet paper, etc. is best disposed of separately. The product of dehydration, particularly where the urine is separated out from the faeces, is not as good a soil conditioner as that produced by composting latrines, as most of the nutrients (in the form of nitrogen, phosphorous and potassium) are contained in the urine. These latrines function best for the user however if the urine is diverted directly to a separate collection system.
- **Borehole latrines**: This consists of a borehole excavated using an auger. They have a diameter of 300-500mm and a depth typically of 5-10m. The storage volume is relatively small, but they can be constructed quickly, especially if an engine-powered auger is used. They are therefore more appropriate as a temporary solution for short-term use, particularly in emergencies. (Figure 2.7.)

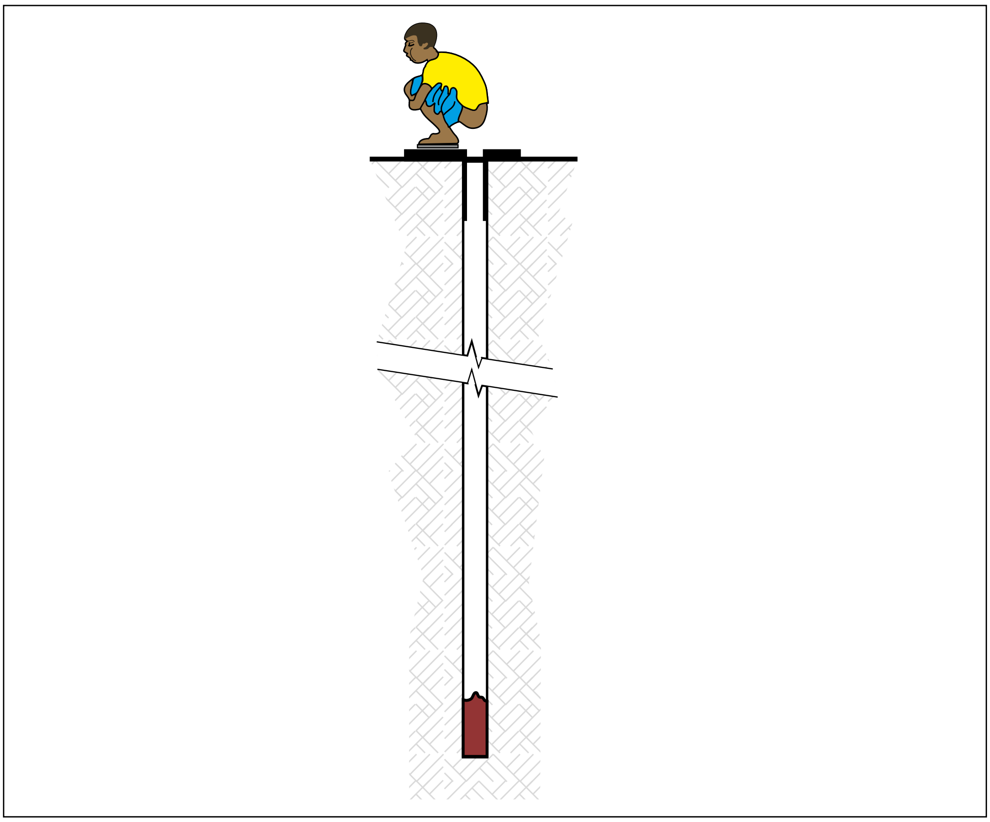


Figure 2.7 A borehole latrine

Now read: WEDC Guide 25: *Simple pit latrines*. Loughborough: WEDC, Loughborough University. ONLINE USB

 Last updated: 27 January 2020 RS

2.3 Water-based latrines

In settings where people are "washers" – i.e. they use water for anal cleansing – the defecation point can be improved by adding a pan and possibly a water trap (sometimes called a water seal, or u-bend). The pan may also be connected to a pipe that diverts the excreta and anal cleansing water to a pit or tank that is off-set (i.e. a distance away) from the defecation point.

The latrine will only function where water or soft toilet tissue is used for anal cleansing. Other than in the case of the SATO pan design (see section 2.2), hard material can block the water trap and attempts to remove the blockage usually causes damage. So long as users do not use hard materials for anal cleansing there is little, if any, risk of blocking.

The options for water-based latrines range from relatively simple pit-based latrines to those involving a fully engineered septic tank and a soakage (or infiltration) system.

2.3.1 Pour-flush latrines

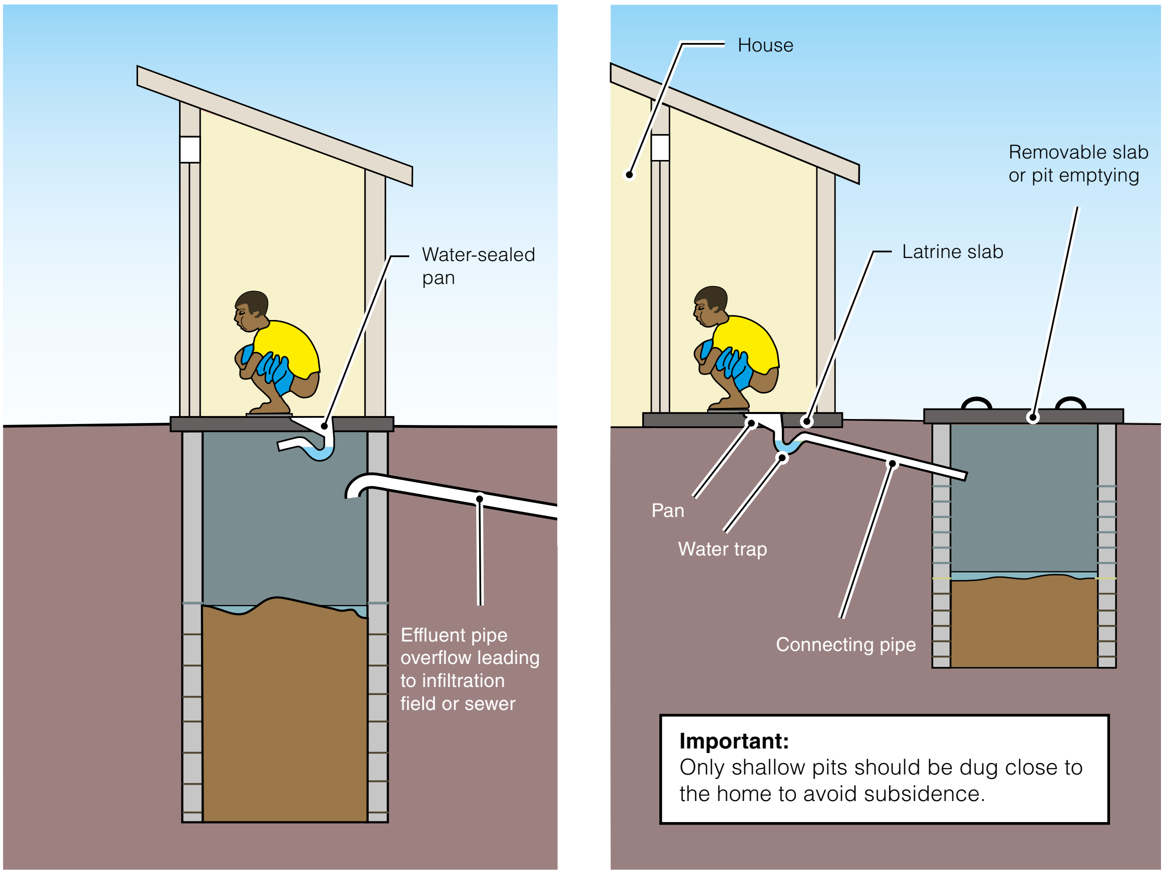
Pour-flush latrines are a cross between a pit latrine and a septic tank or sewer. A small amount of water is used to flush excreta out of a collection pan, down a short pipe and into a pit. A water trap, if fitted, fills with water to form a seal and isolates the pit from the user – an effective way of controlling smells and flies (Figure 2.8).

The flushing action means that:

- access to the pit is concealed, making users (particularly children and older people), feel more secure when using the latrine;
- users cannot see into the pit, making using the latrine more pleasant; and
- a large pan can be used for defecation (dry pit latrines have smaller drop holes which are harder to defecate into, so the slab can be fouled more frequently).

Simple pour-flush latrine (Figure 2.8a): This is a simple adaptation to a pit latrine, in which a pour-flush pan is set directly into the cover slab of a pit. This is sometimes called a direct pour-flush or an overhung pour-flush latrine. Faeces drop into the pan and water is poured into the pan to flush away faeces into the pit. The pipe from the pan should be arranged so that the discharge does not come into contact with the walls of the pit, as over time this could damage the lining. The pan is often designed so that it can be removed from the surrounding slab, leaving a hole large enough to allow the pit to be emptied.

The collection pan may be fitted with a water trap. If fitted, it should be filled with about 0.5 litres of water before use. After use, a litre of water as a minimum is thrown into the pan. This flushes the excreta and urine out of the pan, through the water trap and into the pit. A small amount of water is retained in the trap to provide a physical water seal between the pit and the latrine shelter.



(a) Direct pour-flush **(b) Offset pour-flush**

Figure 2.8 Pour-flush latrine and pans with/without a water trap: (a) direct (b) offset

Adding a water trap ensures that:

- odours produced in the pit cannot escape into the latrine shelter so there is no problem with smell – the gases seep into the surrounding soil; and
- flies and mosquitoes cannot get into or out of the pit.

With the water trap controlling smells and flies, the shelter of pour-flush latrines can be well lit.

The main disadvantage of including a water trap is that it takes more water to flush the excreta through each time. This may place an additional burden on the users (particularly women and children) to fetch water, if there is no piped supply into the shelter. It can also add operating costs to the daily functioning of the latrine. However, if the pan is not kept clean then flies and odours are likely be of a problem and may discourage some people from using the latrine. Also, as the contents of the pit are not visible, users may not be aware when a pit needs emptying.

Off-set pour-flush latrine (Figure 2.8b): In this case, the pit is located to one side of the pan rather than being directly underneath it. Off-setting the pit means the toilet can be located inside the house or in a shelter connected to it , rather than away from the house because of the smell and difficulties with emptying the pit. The off-set pit can be more easily accessed for emptying, without having to interfere with the latrine slab and pan.

Offset latrines can also be upgraded at a later stage, to discharge into a septic tank or a sewer.

Now read: WEDC Guide 26: *Pour-flush latrines*. Loughborough: WEDC, Loughborough University

ONLINE USB

2.3.2 Watertight tanks with outlets to disposal systems

This group of latrines are on-site systems that use watertight tanks for the settlement and digestion of solids, and soakage systems for the disposal of liquid effluent. No system in this classification should be installed until a proper method for the removal and disposal of sludge formed in the tank has been planned. If the tank is not de-sludged at appropriate times (for example, every one or two years of sludge accumulation), the soakage system is likely to become blocked, leading to the failure of the whole system.

2.3.2.1 Septic tank

Septic tanks are commonly used where the volume of wastewater produced is too large for disposal in a pit latrine and water-borne sewerage is inappropriate because it is too costly, too far from the house, or unavailable. They may not be so common in rural areas, as they require a large amount of water for flushing.

The latrine (or toilet) consists of a pan or pedestal whose outlet is connected to a septic tank.

The system requires a constant and reliable water supply for efficient use and septic tanks are usually a relatively expensive sanitation option.

A septic tank comprises a sealed tank with an inlet and outlet. It is commonly constructed with two compartments, to improve the efficiency of solids settlement (Figure 2.9). Waste from toilets, sometimes kitchens and bathrooms, are flushed into the septic tank through connecting pipes. After typically one day's retention, partially treated effluent flows from the tank to an infiltration system, or local sewer if available.

During the retention period, solids settle out by gravity and undergo a process of anaerobic decomposition in the tank. This results in the production of water, gases, sludge and a layer of floating scum. The settled solids gradually form sludge on the tank base, which must be removed periodically to give space for more solids to settle.

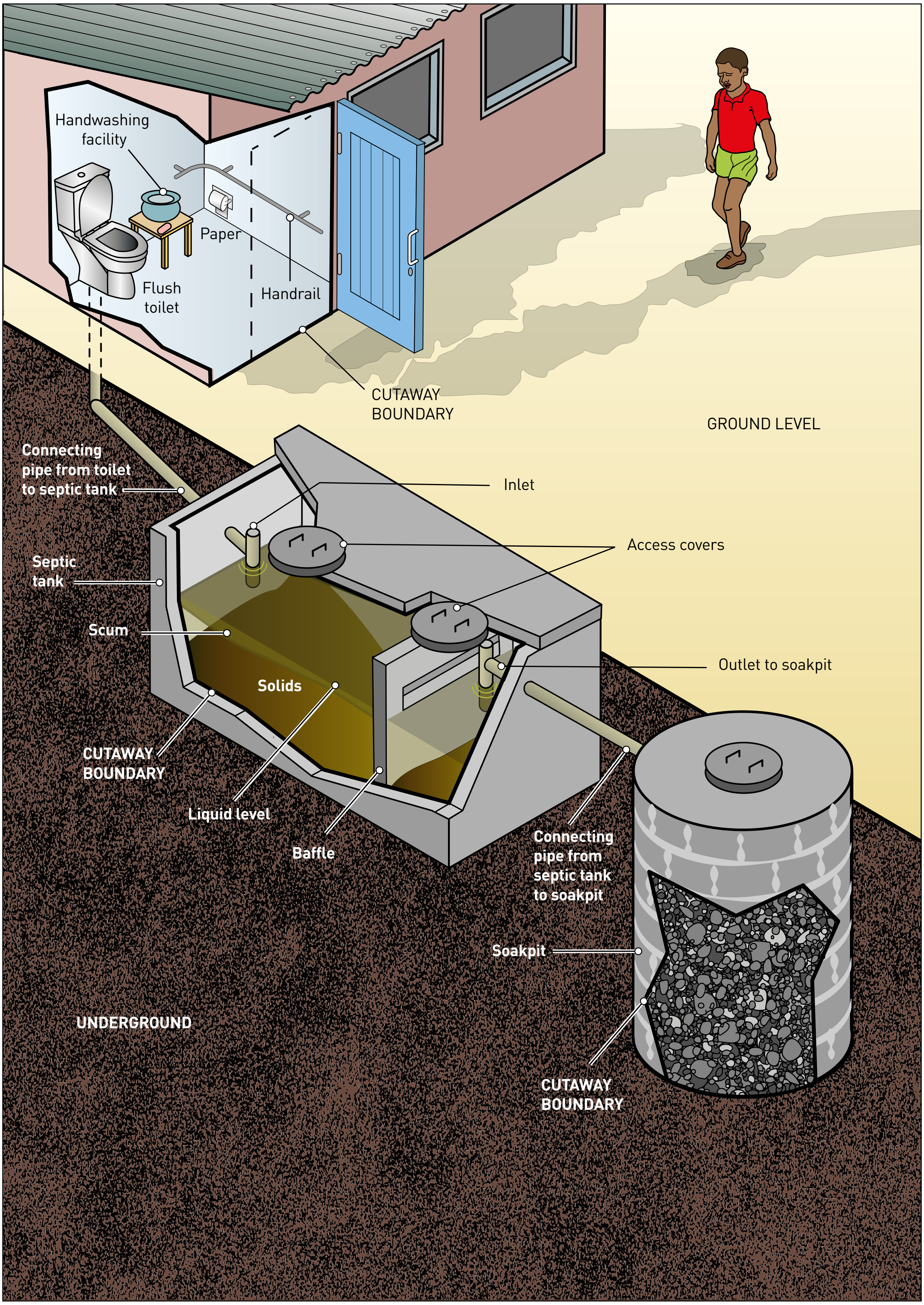


Figure 2.9 Septic tank

Source: WEDC for WHO

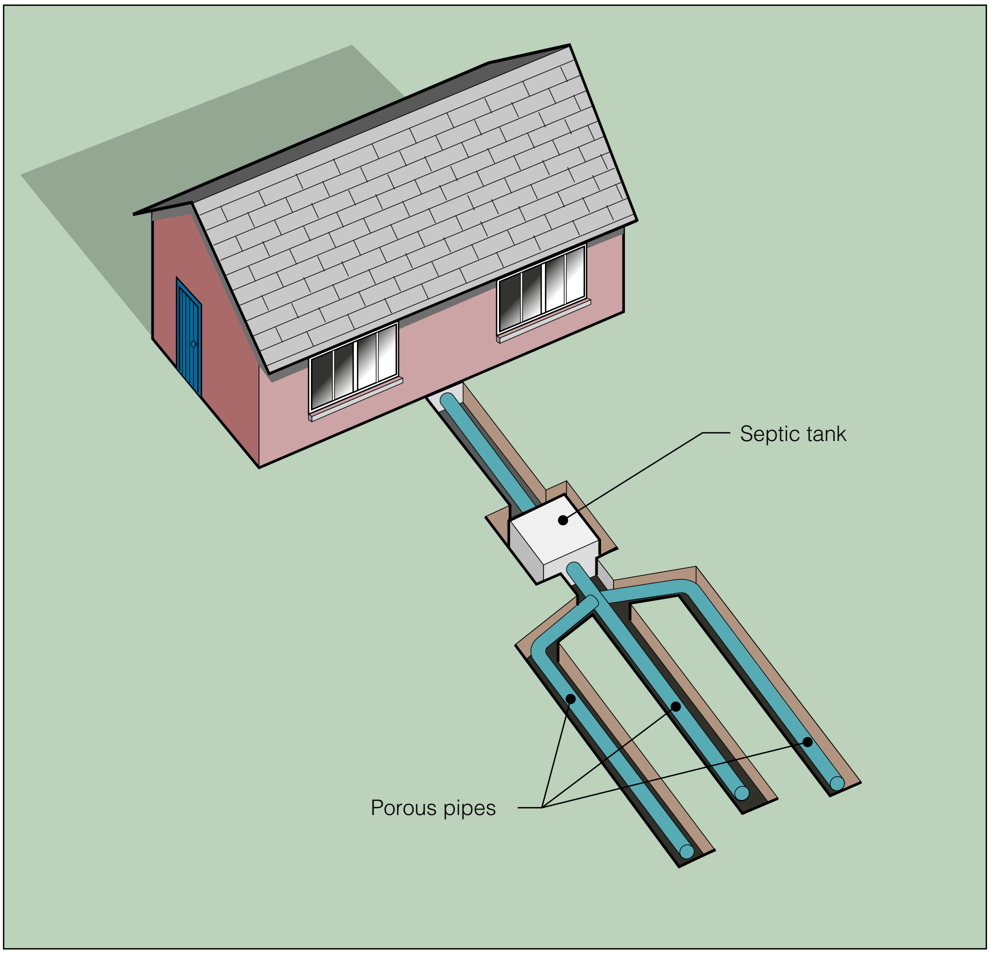


Figure 2.10 Infiltration trench on a flat site

2.3.2.2 Infiltration of liquid effluent from septic tanks

The liquid in the septic tank undergoes partial natural purification but the process is not complete. The effluent which flows out of the septic tank may contain pathogenic organisms and must be properly disposed of (i.e. never into open drains).

Where the soil permeability and ground conditions are suitable, common disposal methods are by absorption into the ground using an infiltration trench (Figure 2.10) or soak pit. These systems distribute the effluent into the soil, where it becomes purified by filtration and biological processes.

A large area of land is normally required as septic tank effluent infiltrates very slowly. This limits the plot size and housing density for which septic tanks are a feasible option.

Where the soil permeability is not sufficient for such soakage systems to work, above ground systems, such evapo-transpiration beds, can be constructed. Alternatively, the effluent can be carried away by a piped system for off-site disposal.

Most failures of septic tank and aqua privy systems are initially due to the failure of the effluent disposal system. This may be due to poor effluent disposal system design or poor design and operation of the tank.

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2.4 Sludge accumulation rates

When designing the size required for a pit or vault, the designer needs to consider the long-term average rate of accumulation of solid material (sludge) in the pit. Special design guidance is available in various publications (such as in Franceys et al., 1992) for the design of septic tanks and aqua privies. For the more common sealed-lid, VIP or pour-flush latrines, the figures in Pickford (1995, p.41) can be used.

For small pits or vaults, designed to be emptied after perhaps only two years, the figures in Table 2.3 (that allow for long-term decomposition and compaction) should be multiplied by a factor of 1.5.

The maximum depth to which a pit should be allowed to fill is normally within 0.5m of the surface, to prevent splashing and help to reduce odours and fly-breeding. This allowance needs to be made when calculating the volume of pit required, to retain the accumulating sludge before either emptying or abandoning the pit.

Table 2.3 Sludge accumulation rates for different conditions

Anal cleansing materials and pit conditions	Sludge accumulation rate (litres per person per year)
Wastes retained in water[1] and degradable anal cleansing materials used	40
Wastes retained in water and non-degradable anal cleansing materials used	60
Wastes retained in dry conditions and degradable anal cleansing materials used	60
Wastes retained in dry conditions and non-degradable anal cleansing materials used	90

[1] The term 'Wastes retained in water', when applied to a pit latrine, means that the wastes are in a section of a pit that is below the water table.

2.5 Non-networked ('stand-alone') on-site sanitation

The toilet options introduced in this unit are all considered to be 'on-site' systems. However, there are increasingly situations where the faecal sludge or septage generated in the different arrangements of pits and tanks needs to be emptied and removed to another location, away from the plot where the toilet is located. The means by which this can be done in a safe and effective manner has been overlooked for many years in the context of rural areas.

With the requirement now for governments to demonstrate progress towards achieving "*safely managed sanitation for all*" under the SDG target for sanitation, the safe removal, transport and treatment/disposal of faecal sludge and septage generated in pits and tanks is receiving greater attention. The resulting improvements in knowledge, techniques and monitoring is being largely driven by the urgent need to ensure safely managed sanitation in urban settings – which will be considered further within that context in later units of this module.

Under the SDG sanitation service ladder, safely managed sanitation services are defined as where there is:

> "Use of improved facilities that are not shared with other households and where excreta are safely disposed of in situ or transported and treated offsite."

Source: JMP, 2017

In rural settings, where space is available and ground conditions allow (e.g. stable soils, limited risk of pit collapse or flooding), there is much greater opportunity to avoid the need to transport and treat excreta off-site. To support in situ disposal, the excreta can either be:

- safely disposed in situ by remaining stored and only emptied when the excreta are safe to handle, being free of pathogens following a sufficient period of storage; or
- emptied and buried on site (i.e. on the same plot as the latrine) in a safe manner.

The dry latrine options presented in this unit offer the best opportunity for safe disposal of excreta in situ. For this to be the case however, the latrine has to be correctly maintained while in use and the contents of the pit or tank ideally then left to decompose for a sufficient period of time before it can be considered safe to handle. Pour-flush latrines also offer this opportunity, although they are likely to require a longer period of storage before the faecal pathogens present in excreta have died off.

Where a single pit is in use, to provide storage of excreta without fresh excreta being added to the pit requires a new latrine to be constructed if the users are to have continued access to a latrine. This in turn adds significant costs to the household.

2.5.1 Supporting safer in-situ disposal

There are a number of developments in sanitation technologies and systems to support safer forms of in-situ disposal. These do not rely on being connected into further stages of the sanitation chain (i.e. transport off-site to a treatment facility or disposal site) once the excreta are removed (if at all) from the pit or tank. Such developments are being addressed through two main approaches:

- Improving the opportunities and means by which pits and tanks can be safely and effectively emptied; and
- Having systems that do not produce faecal sludge or produce less sludge that would then need to be removed from the pit or tank.

Examples of latrine designs that support these aspects, are summarized here.

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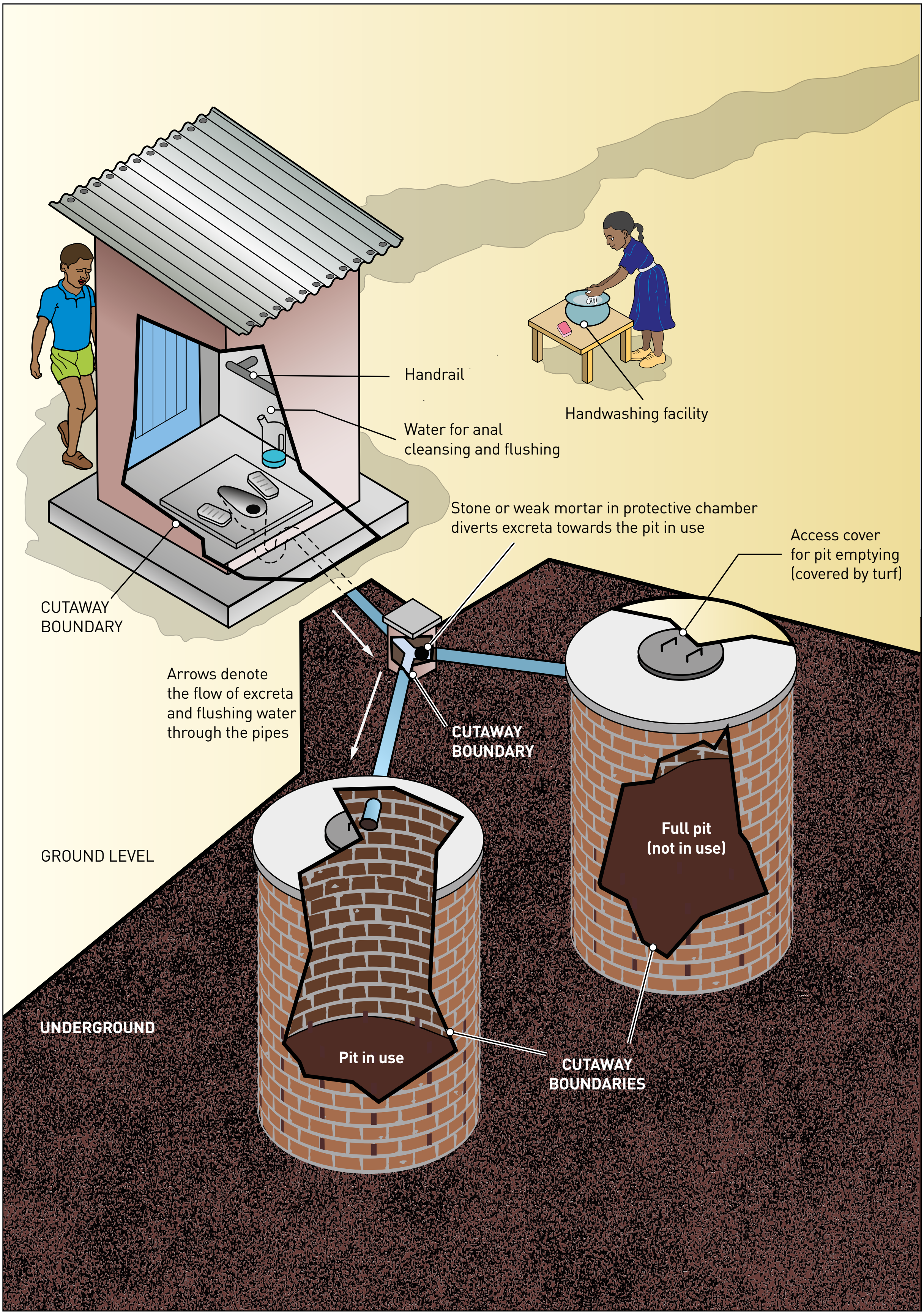

Figure 2.11 Alternating / twin-pit latrine

Source: WEDC for WHO

- **Alternating / twin pits**: Both dry and water-based latrines can make use of alternating, or twin-pit, arrangements. Alternating pits are often used when it is not possible to dig deep pits, but they can also be a more suitable arrangement where emptying and perhaps using decomposed excreta from the pit is socially acceptable. One pit is used at a time (Figure 2.11). When this pit is full, it is closed and the contents are left to decompose, while the second pit is used.

  When sufficient time is allowed for the pathogens in the closed pit to die off, the contents can be safely removed and used to as a soil conditioner. The recommended time to allow all pathogens to die-off is two years, particularly where the contents of the pit will be wet. Each pit should therefore be designed to take at least two years to fill.

  Where the contents of the pit or vault is kept very dry (such as in a dehydrating latrine where the urine is separated from the faeces, there may be additional ventilation and heating of the vault and the addition of dry materials), then the time taken for all pathogens to die-off may be reduced.

  Where the design and construction of the latrine allows for easy and safe access (via a removable cover slab over a pit, or plate in the side of a sealed above-ground vault), the household can take responsibility for the emptying procedure.

- **Fossa Alterna**: This is a form of dry alternating-pit technology, that is designed to produce an earth-like product to be used as a nutrient-rich soil conditioner. Each pit in the fossa *alterna* is dug to a maximum depth of 1.5m, making it easier to empty. A constant supply of cover material (such as soil, ash, and/or leaves) needs to be available, so that a small amount can be added to the pit after each defecation (not urination). This material introduces various organisms that help with the degradation of the sludge, as well as creating more aerobic conditions.

  With one pit used at a time, the contents of the full pit are left to degrade into a dry material that can be manually removed easily and safely. The addition of carbon-rich bulking material speeds up the degradation process, so the content is ready to be removed and used more quickly than for other alternating pit latrines. Water should not be added to the pits (other than small amounts of anal cleansing water), to encourage the aerobic conditions required for rapid degradation. The *fossa alterna* is particularly suited to water-scarce areas and where poor soils can benefit from the addition of the soil conditioner produced in the pits.

- **Tiger Worm toilets**: In recent years, agencies have been developing toilets that use worms to transform the faecal material into vermicompost. In the case of Tiger Worm Toilets (TWTs), they consist of a pour-flush latrine connected to a concrete chamber which acts as the biodigester. The chamber contains an organic bedding layer (such as coconut husks or woodchip) that the tiger worms live in, on top of drainage layers consisting of sand, gravel and stone or charcoal. The effluent that emerges from these layers is either directed to an infiltration system or collected in an external container where it can be collected by the household and used as a fertilizer

/ soil conditioner. The worms ingest, digest and absorb organic waste and excrete what is known as vermicompost. Tiger Worms can survive purely on faeces without needing other organic material, unlike other worms used in composting toilets. This process can reduce the volume of faeces by up to 80%. TWTs are therefore designed to treat faecal sludge *in-situ* while reducing the volume of the by-product that will eventually need to be emptied. As a result, the overall size of the system, its emptying frequency and maintenance costs are all reduced. (Furlong et al., 2016).

- **Biogas**: This system uses a biogas reactor to collect, store and treat the excreta that enters into it. This results in the production of a digestate (slurry) and biogas. As an option, it is well suited to rural communities where there is a good source of organic material for the biogas reactor to function (typically animal dung, or organic waste from markets or kitchens, as well as human excreta) together with a use for the slurry and biogas that are generated.

  Biogas systems consist of a watertight tank in which liquid slurry is generated as the combination of animal dung, vegetable waste and human excreta ferments to produce methane and other gases (Figure 2.12). The tank has an airtight cover with a pipe to carry away the gas, which, if culturally acceptable, can be used as fuel for cooking, lighting or powering internal combustion engines. Due to the high volume and weight of the digestate that is generated, it should be used onsite, or locally where possible – often as a nutrient-rich fertilizer applied to farmland. The biogas reactor can also work in situations where urine is separated from the faeces, such as in a dehydrating latrine.

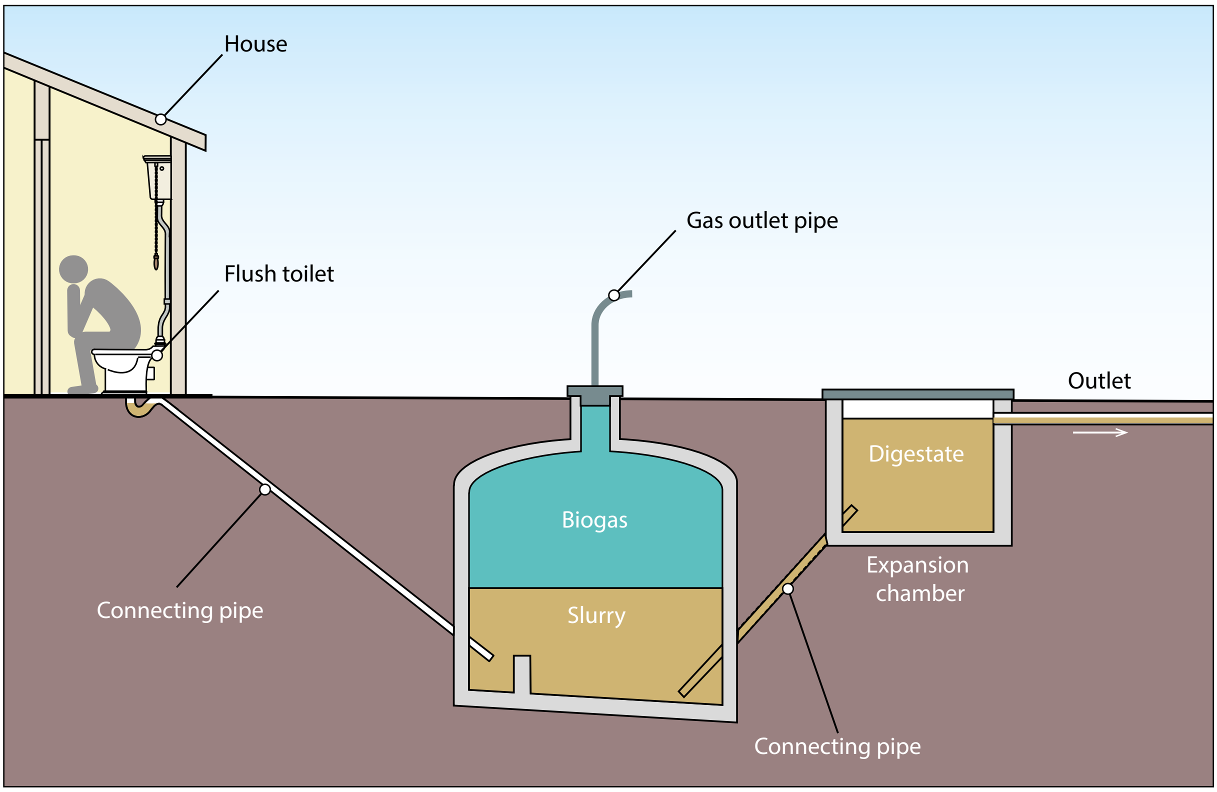

Figure 2.12 Flush toilet connected to a biogas tank

Source: WEDC for WHO

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Human faeces are rarely used alone to feed biogas systems (except communal systems). Instead, they are typically added to systems fed principally by animal dung.

Many pathogens die off in the tank but the digestate, which is a good fertilizer, will still contain roundworm eggs, so requires careful handling to prevent direct ingestion of pathogens from hands or via uncooked food.

2.5.2 Further innovations in toilet designs

A number of innovative toilet designs have resulted from the Bill & Melinda Gates Foundation's *Reinvent the Toilet Challenge* initiated in 2011. These designs seek to remove pathogens from excreta and recover valuable resources from it, while operating without the need for connected water, sewers or electricity. Many are effectively on-site sanitation solutions but are perhaps more suited to settings with access to resources and markets for the modern materials involved (many use plastic materials for a number of the components), as well as services and skills for maintenance and repair.

Other innovations have also developed in parallel to the initiative in recent years, attempting to reduce the need for water to operate the toilet and subsequently handle the excreta. They include modern designs of composting toilets, waterless units, units that make use of anaerobic digestion, heating and forced drying.

Further details are in the publication *A Collection of Contemporary Toilet Designs* (Shaw, 2014).

ONLINE USB

2.6 Summary

This unit presents some key influences of rural settings on the suitability of sanitation facility and service options.

The appropriateness of some common onsite sanitation facilities is explained further, together with introductory technical details about them.

Consideration is given to design and operational innovations that support safer in-situ management (emptying, treatment and/or disposal) of excreta, where the facility does not need to connect to off-site infrastructure.

2.7 References and further reading

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WEDC Guides

The following WEDC Guides provide an overview of 3 types of pit latrine:

Guide 25 Simple pit latrines

Guide 26 Pour-flush latrines

Guide 27 Ventilated improved pit (VIP) latrines

All WEDC guides are available to download from:
www.lboro.ac.uk/research/wedc/resources/pubs/guides/

Roll-over images

A list of risk factors for some of the technologies discussed in this unit are available from the WHO sanitary survey forms available online and on your USB pendrive:

A simple pit latrine

Septic tank

Alternating / twin pit latrine

Credits

Author:	Rebecca Scott
Editor:	Rod Shaw
Illustrator:	Rod Shaw
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