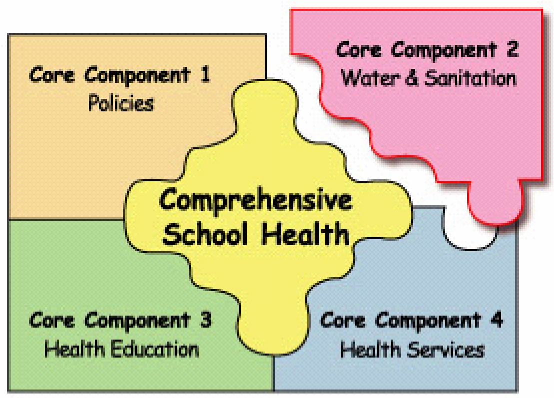
Selecting an Appropriate Technology for Human Excreta Disposal

Description of tool:
This tool provides information that could help schools seeking to build or upgrade sanitation facilities to choose suitable and sustainable technologies. A number of excreta disposal technologies are described, with particular emphasis on the operations and maintenance requirements of each, as experience has shown this to be a key factor in determining long-term project success.

The information in this tool was adapted by UNESCO from the following publication:

Brikké F. and Bredero M., 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.** Geneva: World Health Organization and IRC Water and Sanitation Centre.
http://www.who.int/water_sanitation_health/hygiene/om/en/wsh9241562153.pdf
Description of document:
This document aims to help decision-makers identify the most appropriate technology for their water-supply and sanitation improvement projects, taking into account the conditions in the project area. The document focuses on developing countries, and provides essential information on the types of water-supply and sanitation technologies available, including descriptions of the operation and maintenance requirements of the technologies, the actors involved and the skills they must have or acquire. It also addresses potential problems, including those that have been identified in prior water-supply and sanitation projects. Two basic principles outlined in this document are that communities need to be involved in selecting technologies from the start of the process, and that planners should adopt a demand-driven approach.



This information or activity supports Core Component #2 of the FRESH framework for effective school health: **water, sanitation & the environment.** It will have a greater impact if it is reinforced by activities in the other three components of the framework.

Selecting an Appropriate Technology for Human Excreta Disposal[1]

1. Introduction

The provision of safe water and appropriate sanitation facilities at school is one of the four components of the FRESH framework for comprehensive school health programming because of the tremendous positive impact that such measures have both for the health and education of school-age children. Clean water—for drinking, washing and food preparation—and safe human excreta disposal are crucial for preventing the spread of infections that cause illness, disability and death among millions of children each year. Health status, and as the result, school enrolment, attendance, retention and learning can all be expected to improve when children have access to appropriate water and sanitation facilities. School authorities must ensure that on school grounds, at least, this is the case.

Where such facilities are lacking or in poor repair, schools may need the support of government and/or private financing and expertise to provide or refurbish them. It is equally important to have the support of the local community. Ideally, schools will be partners in a community wide effort to ensure appropriate water and sanitation facilities for all, and in this regard, their most important contribution may be to advocate for and support such efforts.

Whether the school or another agency takes the lead, the advantages of a community-wide, or at least, community-supported, approach include:

- the benefits of providing safe water and sanitation facilities at school will be reinforced (or undermined) by the availability (or lack) of facilities in children's homes and the community;
- construction requires a capital investment and some degree of skilled labour, both of which community members may be able to provide;
- community involvement helps to ensure that social, gender, cultural and religious aspects are sufficiently considered when designing the project;
- community involvement makes the community members responsible for the choice of technology and makes them aware of the financial, managerial and technical implications of their choice, including the future operations and maintenance (O&M) tasks associated with the technology;
- even if the project is initially supported by funding from the government or a non-governmental development organization (NGO), users and communities must ultimately assume the responsibilities of operating, maintaining and managing their water-supply and sanitation systems.

When facilities are not used properly (or not used at all), or when they are not operated and maintained properly, they are likely to fall into disrepair and significant investments may be lost. **The success and sustainability of water-supply and sanitation projects is largely dependent on choosing an appropriate technology, and planning to ensure that the ongoing and long-term operations and maintenance requirements of the technology chosen will be met.** In fact, O&M considerations—such as the availability and cost of consumables needed for operations; or for spare parts, equipment and technical expertise required for preventive maintenance and repair; and the designation of responsibility for managing and paying for these things—should be a key factor in choosing the technology and designing the project. Since this is often the "weak link" in water-supply and sanitation projects, this tool focuses on that aspect—operations and maintenance—of various project options.

A variety of options for the **safe disposal of human excreta** currently exists and many methods have been extensively tested in the field. Those described below are a few examples of technologies which have been used successfully in developing countries. In keeping with the purpose of this document, following a brief description of the technology, emphasis is given to the tasks, technical abilities and materials needed to correctly operate and maintain the facilities over the long term. For additional options, see the source document. For a description of some common technologies for **water-supply systems**, see Selecting an Appropriate Technology for Water-Supply Projects or the source document.

2. Factors that influence the selection of community sanitation technology

The factors that influence the choice of sanitation technology can be categorized into technical, environmental, institutional and community factors (Table 2.1). To aid the technology selection process, the factors can be further classified as to whether they are of general relevance to the selection process, or specifically relevant to the O&M component. Sanitation interventions need to be planned with a comprehensive approach, so that all these factors are properly addressed.

TABLE 2.1 Factors that Influence the Selection of Community Sanitation Technology

Factors of general relevance	Factors specifically relevant to O&M
1. Technical factors	
• design preference (substructure, floor slab, squatting or raised seat, superstructure); • technical standards and expected lifetime of the technology; • availability of construction materials; • cost of construction.	• O&M requirements; • ease of access; • use of decomposed waste; • pit-emptying technique.
2. Environmental factors	
• soil texture, stability, permeability; • groundwater level; • control of environmental pollution; • availability of water; • possibility of flooding.	• O&M implications for environmental protection; • protection against groundwater contamination; • protection from flooding.
3. Institutional factors	
• existing national/local strategies; • roles and responsibilities of actors implied; • training capacity; • availability of subsidies and loans; • availability of masons, carpenters, plumbers, sanitary workers, pit-emptiers and pit-diggers.	• pit-emptying services (municipal/private); • sewerage maintenance capacity; • potential involvement of the private sector; • national budget allocations for sanitation; • training and awareness education; • monitoring.

TABLE 2.1 Factors that Influence the Selection of Community Sanitation Technology (Continued)

Factors of general relevance	Factors specifically relevant to O&M
4. Community factors	
• **sociocultural aspects:** taboos, traditional habits, religious rules and regulations, cleansing material, preferred posture, attitude to human faeces, gender-specific requirements; • **motivational aspects:** convenience, comfort, accessibility, privacy, status and prestige, health, environmental cleanliness, ownership; • **discouraging factors:** darkness, fear of falling in the hole, or of the pit collapsing, or of being seen from outside, smells; insect nuisance; • **social organization factors:** role of traditional leadership, religious leaders, schoolteachers, community-based health workers; • **other factors:** population densities, limited space for latrines, presence of communal latrines.	• O&M costs; • O&M training and awareness for sanitation; • health awareness and perception of benefits; • presence of environmental sanitation committee; • women's groups; • social mobilization on hygiene and sanitation behaviour.

Factors to consider when choosing a sanitation system for excreta disposal include:

- the initial cost of the technology and the costs of O&M;
- demand and use (what is the population density, and will the system be used in homes, schools, market places?);
- climate (temperature, humidity and rainfall);
- soil and topography (infiltration properties of the soil, and the direction of the groundwater flow);
- water availability (for waterborne systems);
- cultural beliefs, values and practices around sanitation;
- the availability of technical skills (are there local craftsmen or technicians with the necessary skills to install and/or carry out O&M of the system?);
- agriculture (what are the characteristics of local agriculture and home gardening?)

3. Human Excreta Disposal Technology

3.1 Waterborne systems for excreta disposal

Wastewater coming from kitchens and bathrooms is termed “sullage” (or grey water). “Sewage” (or black water), includes sullage and human excreta from waterborne facilities. Sewage is called “sludge” when it becomes a thick mud.

In areas of high population density, wastewater can pose a serious public-health threat, such as when it surfaces during flooding, or when there is no proper drainage. Not only would it cause foul odours, but it would also be a source of pathogens. If sewer pipes break, or if wastewater stagnates because the soil absorbs poorly, the wastewater could seep into the drinking-water supply and contaminate it.

The problems associated with waterborne waste disposal are: the high water consumption; the sewer system often becomes blocked; and the high capital and O&M costs.

Some O&M considerations associated with four options for dealing with a full pit latrine are shown in Table 4.3. Disposal options are considered in Table 4.4.

3.2 Dry sanitation systems for excreta disposal

One dry sanitation method is to dehydrate the human faeces. Special collection devices, which divert urine into a separate container for storage, allow faeces to be dehydrated fairly easily. The urine can be used directly as a fertilizer, since urine contains most of the nutrients and the risks from pathogens are relatively low. The classic example of an ecological sanitation system based on dehydration is the Vietnamese double-vault toilet. In Northern Vietnam, a common practice was to fertilize rice fields with fresh excreta. To combat this hazardous practice, in 1956, the health authorities started campaigns to construct double-vault dry latrines, and followed this up with health education programmes. It is now widely used in Vietnam, and to some extent in Central America, Mexico and Sweden.

A second dry sanitation method is to compost the human faeces. This involves a biological process in which bacteria and worms break down the organic material under controlled conditions (e.g. temperature, moisture, and airflow) and make humus. If the composting conditions are properly controlled, the humus is free of human pathogens and is an excellent soil conditioner. A drawback of this method is that in many developing countries it is likely that the composting conditions would not be controlled properly, which could lead to humus contaminated with pathogens.

The health aspects of dry sanitation systems, either by dehydration or composting, are not well understood yet and these technologies cannot be recommended without a clear understanding of how they function, especially where O&M are unlikely to be adequate. In addition, the most unfamiliar aspect of dry sanitation is that it requires some handling of human faeces at household level, which for many is still taboo and may involve health risks. Nevertheless, if communities wish to consider ecological sanitation technologies, they should be made aware of the importance of maintaining the technology in good working order, and of the consequences should the technology malfunction.

The most common problems with dry sanitation are:

- The faeces become wet (>25% humidity), and therefore smells persist, flies breed, and pathogens survive. This could be caused by leaking urine conduits or blocked vent pipes, or poor maintenance of the system. Absorbents like ash, lime, sawdust, husks, crushed dry leaves, peat moss and dry soil are used to absorb excess moisture, as well as to reduce smells and make the pile less compact. Ventilation also helps to dry the contents, and also removes smells, allows flies to escape and, in the case of composting toilets, provides oxygen for the decomposition process.

- Cleaning material is used inappropriately after defecation.

4. Improved traditional pit latrine[1]

4.1 The technology

Traditional latrines usually consist of a single pit covered by a slab with a drop hole and a superstructure. The slab may be made of wood (sometimes covered with mud) or reinforced concrete. The superstructure provides shelter and privacy for the user. Basic improvements include:

- a hygienic self-draining floor made of smooth, durable material and with raised foot rests;
- a tight-fitting lid that covers the drop hole, to reduce smells and keep insects out of the pit;
- a floor raised at least 0.15 m above ground level, to prevent flooding;
- an adequately lined pit, to prevent the pit collapsing (e.g. when the soil is unstable);
- an adequate foundation, to prevent damage of the slab and superstructure.

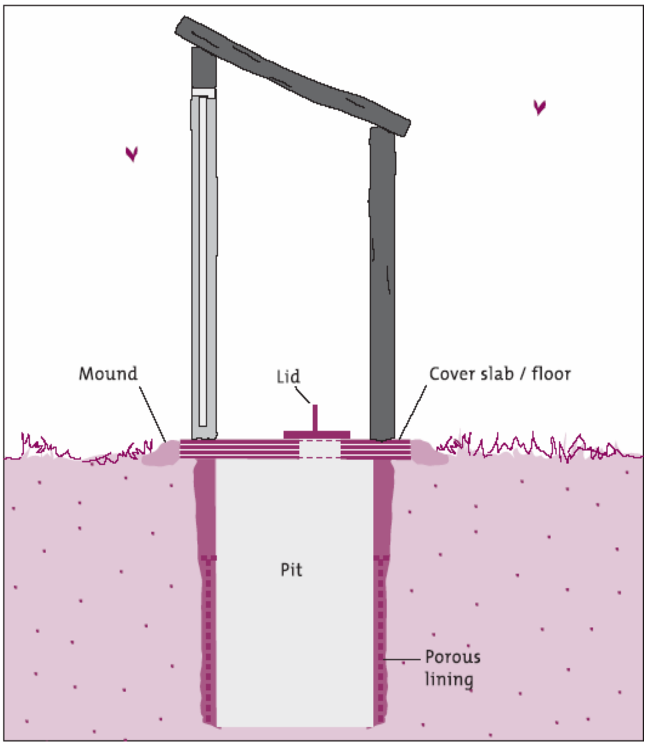


Figure 4.1 Traditional pit latrine

The pits can be square, rectangular or circular, usually 1.0–1.5 m wide. The depth (usually 3–5 m) depends on the soil and groundwater conditions. In unstable soil, or when the pit is going to be emptied, some kind of lining (e.g. old oil drums or stones) is needed. A foundation may be needed to support the slab and superstructure.

As a general rule, pits should be at least 15–30 m from sources of drinking-water. The actual distance will depend on local hydrogeological conditions, such as soil characteristics, and groundwater depth and flow. When groundwater levels are high, or when the soil is too hard to dig, the pit latrine may have to be raised above ground level.

Initial cost: Initial costs of construction should include materials (50–80%), transportation (0–25%) and local labour (15–35%). Actual costs will depend on: the pit volume; the quality of the pit lining, slab and superstructure; whether materials are available locally; and the local costs of materials and labour.

Area of use: Rural and low-income urban areas. Mainly used as a household facility and for rural institutions.

4.2 Main O&M activities

Operation of pit latrines is quite simple, and consists of regularly cleaning the slab with water (and disinfectant) to remove any excreta and urine. The tight-fitting lid over the drop hole should be replaced after use, to ensure insect control and to reduce odours. In addition,

[1] Sources: Wegelin-Schuringa (1991); Franceys, Pickford & Reed (1992).

appropriate anal cleansing materials should be available in or near the latrine. Ash or sawdust can be sprinkled into the pit to reduce the smell and insect breeding. Nonbiodegradable materials, such as stones, glass, plastic, rags, etc., should not be thrown into the pit, as they reduce the effective volume of the pit and hinder mechanical emptying.

Monthly maintenance includes checking the slab for cracks, checking the superstructure for structural damage, ensuring that the lid remains tight-fitting, and ensuring that the surface water continues to drain away from the latrine. Before the pit latrine becomes full, a decision must be made as to the location of a new pit. Time must be allowed for digging the new pit and transferring the slab and superstructure to it. The contents of the old pit must then be covered with at least 0.5 m of top soil, to hygienically seal it off. When latrines are used by a single household, O&M tasks are implemented by the household or by hired labour. If several households use the latrine, arrangements for rotating the cleaning tasks have to be made, to avoid social conflict. Pits can only be emptied manually if their contents have been left to decompose for about two years. Otherwise, when a pit is full, it must be emptied mechanically, or a new pit has to be dug.

Table 4.1 Actors and their roles

Actors	**Roles**	**Skills required**
User	Use the latrine, close the lid, keep the latrine clean, inspect the latrine and perform small repairs on it.	☺
User or local labour	Dig a new pit; shift, or transfer the slab and superstructure.	☺
Local mason	Build and repair the latrine.	🛠🛠
Health department	Monitor latrines and hygienic behaviour of users, and train users in hygienic behaviour.	🛠🛠🛠

☺ Simple (often requires gender-specific awareness-raising, and training activities to change behaviour and build capacity). 🛠🛠 Technical skills. 🛠🛠🛠 Highly qualified.

Table 4.2 O&M technical requirements

Activity and frequency	**Materials and spare parts**	**Tools and equipment**
Daily		
• Clean the drop hole, seat and shelter;	• Water, soap.	• Brush.
• clean the handle of the lid.	• Water, soap.	• Brush.
Monthly		
• Inspect the floor slab and lid.		
Occasionally		
• Repair the slab, lid, seat or superstructure.	• Cement, sand, water, nails, local building materials.	• Bucket or bowl, trowel, saw, hammer, knife.

Table 4.2 O&M technical requirements (Continued)

Activity and frequency	Materials and spare parts	Tools and equipment
Depending on size and number of users		
• Close the pit with soil, dig a new pit, shift cover and superstructure;	• Soil, local building materials and nails (if available).	• Shovels, picks, bucket, knife, hammer, saw, etc.
• empty the pit (if applicable).	• By hand: water.	• By hand: shovel, bucket.
	• By mechanical means: water, spare parts for machinery.	• By mechanical means: equipment for emptying the pit.

4.3 Potential problems

- the slab floor cracks, because it was constructed with unsuitable materials or because the concrete was not cured properly, and the cracks provide a habitat for parasites;
- the latrine lid gets damaged or falls into the pit;
- in hard soils it may be impossible to dig a proper pit;
- pits often fill up too quickly in soils with low infiltration and leaching capacity;
- when children are afraid of using a latrine, special children's latrines may be constructed with a smaller drop hole.

Table 4.3 What to do with a full pit latrine?[A]

1. Stop using the latrine	2. Empty latrine by hand	3. Empty by simple mechanical means	4. Empty using a tanker
Back-fill the top of the latrine with soil, and build another. If possible, build twin-pit latrines, which are shallow and "reusable".	Dig out the contents of the latrine using a spade and bucket.	Use a simple device (e.g. MAPET) with a manpowered suction pump, that is easy to manoeuvre in narrow streets and courtyards.	Use a motorized tanker with a vacuum pump.
Limitation(s): • Many families or schools do not have sufficient space to build another latrine, and they continue to use the one they have. This creates very high health risks.	Limitation(s): • This method involves very high health risks. • If the pit is not "lined" with walls of stones, bricks or concrete, it might collapse when it is emptied. • Sludge could be deposited in an unsafe place.	Limitation(s): • The informal sector does not always have the necessary equipment. • The suction pump may not be powerful enough to raise sludge from a deep latrine. • If the pit is not "lined" with walls of stones, bricks or concrete, it could collapse when it is emptied. • Sludge could be deposited in an unsafe place.	Limitation(s): • Large vehicles have problems manoeuvring in narrow streets and courtyards. • Motorized tankers are expensive to buy. • Users pay more for the service.

[a] Adapted from Pickford & Shaw (1997).
A full pit latrine is defined as one that is filled to within one-half metre of ground level.

Table 4.4 What to do with sludge from pit latrines and septic tanks?[b]

Possible solutions	Method
Disposal into water	Sludge can be disposed into water, if it is left untouched for about two years. However, untreated sludge poses very high risks to health and the environment.
Disposal onto land	Sludge can be disposed onto land, if it is left untouched for about two years. However, untreated sludge poses very high risks to health and the environment.
Composting	Mix the sludge with 2–3 times its volume of vegetable waste. Turn it several times in the first few weeks, then heap it into a pile and leave it for several weeks. After this, it can be used as fertilizer.
Household bio-gas units	Add latrine or septic tank sludge to bio-gas units (mainly used with animal waste).
Drying beds	Sludge flows into a shallow tank that allows drainage, and is covered with a layer of sand. The sludge is then lifted after about one week.
Solid-liquid separation	Solids are separated from the liquid wastes by sedimentation or rough filtering. The solids are then lifted.
Anaerobic digestion	Sludge from the latrine is added to wastewater sludge, and separated by sedimentation at wastewater treatment plants.
Extended aeration	The sludge is aerated. O&M is expensive.
Sewerage system	Sludge is discharged into wastewater treatment plants. The rate of discharge is important for this method to work properly.
Waste stabilization ponds	The sludge is treated in waste stabilization ponds, either with municipal wastewater, or separately.

[b] Adapted from Pickford & Shaw (1997).

5. Ventilated improved pit latrine[1]

5.1 The technology

Ventilated Improved Pit (VIP) latrines are designed to reduce two problems frequently encountered with traditional latrine systems: bad odours and insect proliferation. A VIP latrine differs from a traditional latrine by having a vent pipe that is covered with a fly screen. Wind blowing across the top of the vent pipe creates a flow of air which draws odours out from the pit. As a result, fresh air is drawn into the pit through the drop hole and the superstructure is kept free of smells. The vent pipe also plays an important role in fly control. Flies are attracted by light and if the latrine is suitably dark inside, they will fly up the vent pipe towards the outside light, where they are trapped by the fly screen and die of dehydration. Female flies, searching for an egg-laying site, are attracted by the odours from the vent pipe, but are prevented from flying down the pipe by the fly screen at its top. VIP latrines can also be constructed with a double pit. The latrine has two shallow pits, each with its own vent pipe, but only one superstructure.

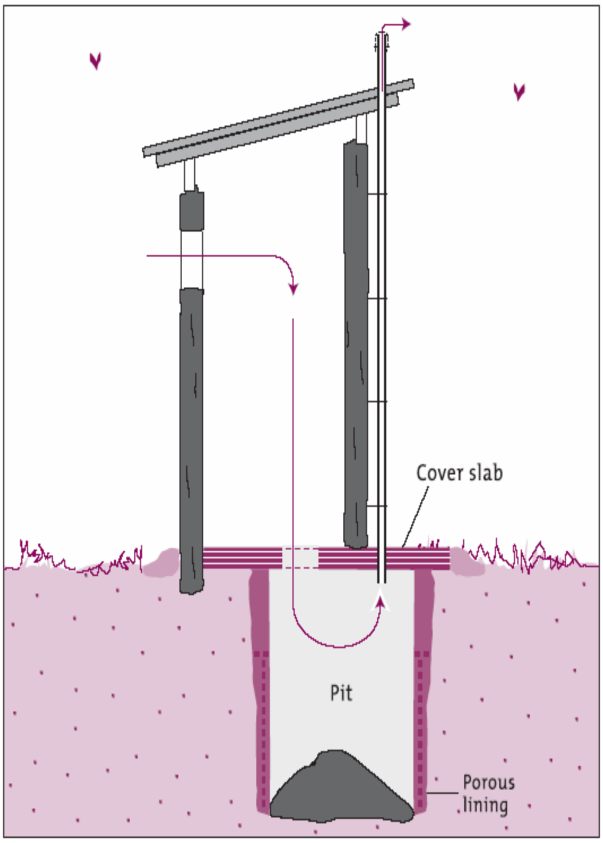


Figure 5.1 Ventilated improved pit latrine

The cover slab has two drop holes, one over each pit, but only one pit is used at a time. When one becomes full, the drop hole is covered and the second pit is used. After about two years, the contents of the first pit can be removed safely and used as soil conditioner. The first pit can be used again when the second pit has filled up. This alternating cycle can be repeated indefinitely.

Initial cost: A single-pit VIP family latrine costs US$ 70–400, while the double-pit VIP version costs US$ 200–600. These costs include materials (60–80%), transportation (5–30%) and local labour (10–25%). Actual costs will depend on the pit volume; the quality of the lining, slab and superstructure; whether materials are available locally; and local prices.

Area of use: Household and community level in rural and periurban areas.

5.2 Main O&M activities

Operation of pit latrines is quite simple and consists of regularly cleaning the slab with water and disinfectant, to remove any excreta and urine. The door must always be closed so that the superstructure remains dark inside. The drop hole should never be covered as this would impede the airflow. Appropriate anal cleaning materials should be available for the latrine users. Nonbiodegradable materials, such as stones, glass, plastic, rags, etc. should not be thrown into the pit, as they reduce the effective volume of the pit and hinder mechanical emptying.

[1] Sources: Smet et al. (1988); Wegelin-Schuringa (1991); Franceys, Pickford & Reed (1992).

Every month, the floor slab should be checked for cracks, and the vent pipe and fly screen inspected for corrosion or damage, and repaired if necessary. The superstructure may also need to be repaired (especially light leaks). Rainwater should drain away from the latrine. When the contents of the pit are 0.5 m below the slab, a new pit should be dug and the old one covered with soil. Alternatively, the pit could be emptied mechanically.

Where latrines are used by a single household, O&M tasks are implemented by the household, or by hired labour. If several households use the latrine, arrangements have to be made to rotate the cleaning tasks, to avoid social conflicts. If pits are not emptied mechanically, they can be emptied manually, but only after their contents have been left to decompose for about two years. Otherwise, new pits must be dug when a pit is full. If double-pit latrines are used, the users need to understand the concept of the system fully to operate it properly. User education has to cover topics such as the reasons for using only one pit until the time for switch-over; the use of excreta as manure; and the need to leave the full pit for about two years before emptying. The users must also know how to switch pits and how to empty them, even if they do not do these tasks themselves. If these tasks are carried out by the private (informal) sector, the workers have to be educated about the system and its operational requirements.

Table 5.1 Actors and their roles

Actors	Roles	Skills required
User	Keep the latrine clean, inspect and perform small repairs, empty the full pit and switch to the new one, dig a new pit and replace the latrine.	☺
Local unskilled labour (sweepers/ scavengers)	Dig pits, transfer structures, empty full pits in double-pit systems, perform small repairs, solve small problems.	⚒⚒
Local mason	Build, repair and transfer latrines.	⚒⚒
Health department	Monitor latrines and the hygienic behaviour of users, educate users in good hygiene practices.	⚒⚒⚒

☺ Simple (often requires gender-specific awareness-raising, and training activities to change behaviour and build capacity). ⚒⚒ Technical skills. ⚒⚒⚒ Highly qualified.

Table 5.2 O&M technical requirements

Activity and frequency	Materials and spare parts	Tools and equipment
Daily		
• Clean the drop hole, seat and superstructure.	• Water, soap.	• Brush, bucket.
Monthly		
• Inspect the floor slab, vent pipe and fly screen.		

Table 5.2 O&M technical requirements (Continued)

Activity and frequency	Materials and spare parts	Tools and equipment
Every 1–6 months		
• Clean the fly screen and the inside of the vent.	• Water.	• A twig or long flexible brush.
Occasionally		
• Repair the slab, seat, vent pipe, fly screen or superstructure.	• Cement, sand, water, nails, local building materials.	• Bucket or bowl, trowel, saw, hammer, knife.
Depending on size and number of users		
• Dig a new pit and transfer latrine slab and superstructure (if applicable);	• Sand, possibly cement, bricks, nails and other local building materials.	• Shovels, picks, buckets, hammer, saw, etc.
• switch to the new pit when the old pit is full;		• Shovels, buckets, wheelbarrow, etc.
• empty the old pit (if applicable).	• By hand: water. • By mechanical means: water and spare parts for the machinery.	• By hand: shovel, bucket. • By mechanical means: equipment for emptying the pit.

5.3 Potential problems

- the quality of the floor slab is poor because inappropriate materials were used in its construction, or because the concrete was not properly cured;
- inferior quality fly screens are easily damaged by the effects of solar radiation and foul gases;
- badly-sited latrines can get flooded or undermined;
- children may be afraid to use the latrine because of the dark, or out of fear of falling into the pit;
- if the superstructure allows too much light to come in, flies will be attracted to the light coming through the squat hole and may fly out into the superstructure, which can jeopardize the whole VIP concept;
- in latrines that rely on solar radiation for the air flow in the vent pipe, rather than on wind, odour problems may occur during the night and early morning hours;
- leakage between pits occurs because the dividing wall is not impermeable or the soil is too permeable;
- in hard soils it may be impossible to dig a proper pit;
- pits should preferably not reach the groundwater level and must be 15–30 m from ground and surface water sources;
- VIP latrines do not prevent mosquitoes from breeding in the pits;
- VIP latrines cost more to construct than simple pit latrines and the community may not be able to bear the higher costs;
- cultural resistance against handling human waste may prevent households from emptying their own pit latrines, but usually local labour can be hired to do the job.

6. Double-vault compost latrine[1]

6.1 The technology

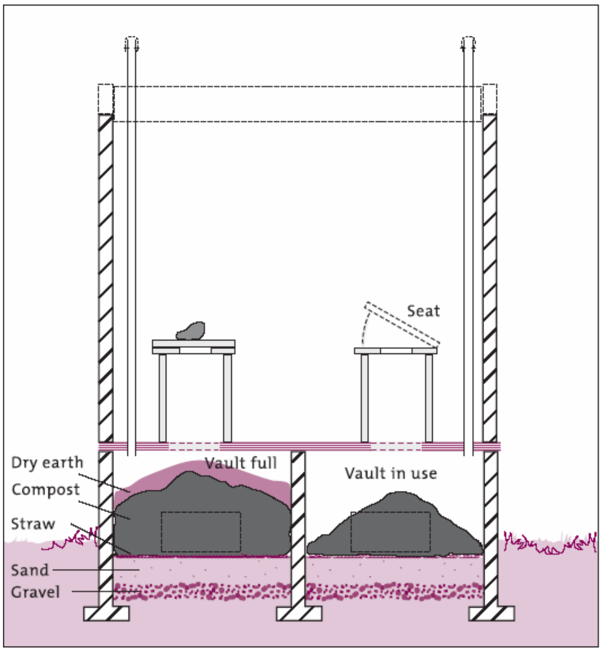


Figure 6.1 Double-vault compost latrine

The double-vault compost latrine consists of two vaults (watertight chambers) to collect the faeces. Urine is collected separately, because the contents of the vault should be kept relatively dry. Initially, a layer of absorbent organic material is put in the vault, and after each use the faeces are covered with ash (or sawdust, shredded leaves or vegetable matter) to reduce smells and soak up excessive moisture. The organic material also ensures that sufficient nitrogen is retained in the compost to make it good fertilizer. When the first vault is three-quarters full, it is completely filled with dry, powdered earth and sealed, and the contents allowed to decompose anaerobically. The second vault is then used and when it is three-quarters full, the first vault can be emptied (even by hand) and the contents used as fertilizer. The vaults should be large enough to keep the faeces long enough for them to become pathogen-free (at least two years). A superstructure is built over both vaults, and each has a squat hole that can be sealed off. The latrine can be built anywhere, since the vaults are watertight and there is no risk of polluting the surroundings. Where there is rock or a high water-table, the vaults can be placed above ground. A ventilation pipe keeps the aerobic system active, which is essential for composting. Double-vault latrines have been successfully used in Vietnam and Central America (El Salvador, Guatemala, Honduras, Nicaragua).

6.2 Main O&M activities

Initially, some absorbent organic material is put into the empty vault (layer of ashes or lime) to ensure that liquids are absorbed and to prevent the faeces from sticking to the floor. After each use, or whenever available, wood ash and organic material are added. When urine is collected separately it is often diluted with 3–6 parts of water and used as a fertilizer. Water used for cleaning should not be allowed to go into the latrine as it will make the contents too wet. When the vault is three-quarters full, the contents are levelled with a stick, the vault is filled to the top with dry powdered earth, and the squat hole is sealed. The second vault is then emptied with a spade and bucket, after which the vault it is ready for use. The contents dug out of the second vault can be safely used as fertilizer. To help keep down the number of flies and other insects, insect-repelling plants (such as citronella) could be grown around the latrine.

Potential users of a vault latrine technology should be consulted extensively, to find out if the system is culturally acceptable, and if they are motivated and capable of operating and maintaining the system properly. The project agency will need to provide sustained support to ensure that users understand the system and operate it properly.

[1] Winblad & Kilama (1985); Franceys, Pickford & Reed (1992).

Table 6.1 Actors and their roles

Actors	Roles	Skills required
User/household	Use latrine, remove urine, help keep latrine clean, inspect and perform small repairs, help to empty the pit and switch over to the new pit.	☺
Local mason	Build and repair latrines.	⚒⚒
Local pit emptier	Empty the pit and switch over to the new pit, check the system and perform small repairs.	⚒⚒
External support organization	Investigate whether the double-vault technology is appropriate, monitor users' O&M and hygienic behaviour and provide feedback, train users and local artisans.	⚒⚒⚒

☺ Simple (often requires gender-specific awareness-raising, and training activities to change behaviour and build capacity). ⚒⚒ Technical skills. ⚒⚒⚒ Highly qualified.

Table 6.2 O&M technical requirements

Activity and frequency	Materials and spare parts	Tools and equipment
Daily		
• Clean the toilet and superstructure, empty the urine collection pot.	• Water, lime, ashes.	• Brush, water container.
After each defecation or whenever available		
• Add ashes or other organic small material.	• Wood ashes and organic material.	• Pot to contain the material, shovel.
Monthly		
• Inspect the floor, superstructure and vaults.		
When necessary		
• Repair the floor, superstructure or vaults; • use humus as fertilizer.	• Cement, sand, water, nails, local building materials. • Humus.	• Bucket or bowl, trowel, saw, hammer, knife. • Shovel, bucket, wheelbarrow.
Depending on size and number of users		
• Close the full vault after levelling and adding soil; • empty the other vault, open its squat hole and add 10 cm of absorbent organic material before using; • store the humus, or use it directly.	• Water, absorbent organic material.	• Shovel and bucket.

6.3 Potential problems

- users do not understand how to operate the system properly and leave the latrine contents too wet, which makes the vault malodorous and difficult to empty;
- users are too eager to use the latrine contents as fertilizer and do not allow sufficient time for the compost to become pathogen-free;
- the double-vault compost latrine can only be used where people are motivated to use human excreta as a fertilizer;
- the double-vault compost latrine is not appropriate where water is used for anal cleansing.

7. Pour-flush latrine[1]

7.1 The technology

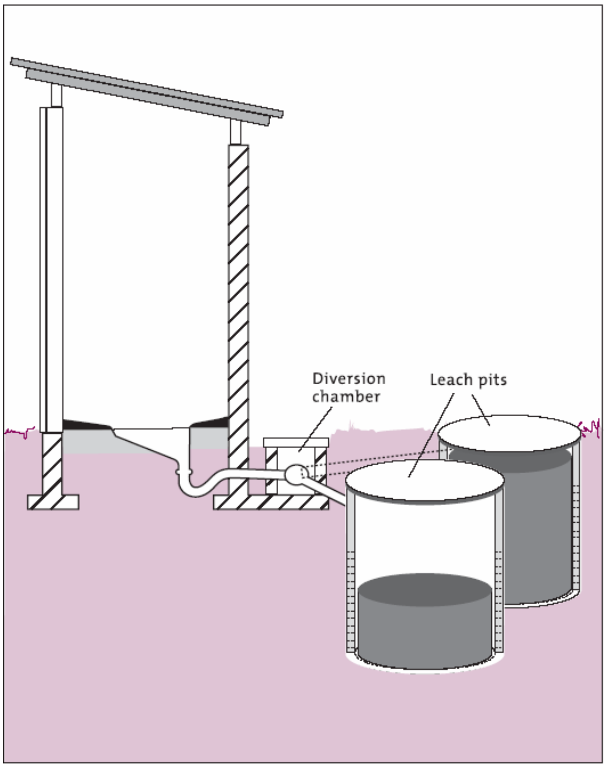


Figure 7.1 Pour-flush latrine

Pour-flush leaching pit latrines overcome the problems of flies, mosquitoes and odour by having a pan with a water seal (a U-shaped conduit partly filled with water) in the defecation hole. After using the latrine, it is flushed by pouring water in the pan. The latrine pits are usually lined to strengthen the walls, and the soil should be adequately permeable for infiltration. The concrete floor slab with the pan is either on top of the leaching pit (direct system), or a short distance from one pit (single offset) or two pits (double offset). In offset systems, a short length of PVC tubing slopes down from the U-trap to the pit, or in case of a double-pit system, to a diversion box which diverts the flush into one of the two pits. The double offset system enables the two pits to be used alternately. When the first pit is full, it should be left for at least 12–18 months, to allow time for the pathogens to be destroyed. After this time, the contents of the first pit can be safely removed even by hand and used as organic fertilizer. The first pit is then ready to be used when the second pit fills up. Double-offset pits are usually smaller than single pits because they need to last for only 12–18 months. Pour-flush latrines are most suitable where people use water for anal cleansing and squat to defecate, but they are also popular in countries where other cleansing materials are common. Pour-flush latrines may be upgraded to a septic tank with a drainage field or soakaway, or may be connected to a small-bore sewerage system.

[1] Winblad & Kilama (1985); Wegelin-Schuringa (1991, 1993); Bakhteari & Wegelin-Schuringa (1992); Franceys, Pickford & Reed (1992); van de Korput & Langendijk (1993).

Initial cost: A single-pit system costs US$ 30–100, and a double-pit system US$ 75– 212. The prices include costs for labour and materials, and for a brick lining and a concrete platform (the superstructure was not included in most cases). Organizational costs are also not included. The lowest prices were in Asia, the highest in Africa, and those in South America were between the two.

Area of use: Rural or periurban areas where sufficient water is available and the soil is permeable.

Flushing: About 2–5 litres per flush, mainly depending on the pan design and the distance to the pit.

7.2 Main O&M activities

Before use, the pan is wetted with a little water to prevent faeces sticking to the pan. After use, the pan is flushed with a few litres of water. If water is scarce, water already used for laundry, bathing, etc. may be used. No material that could obstruct the U-trap should be thrown into the pan. The floor, squatting pan or seat, door handles and other parts of the superstructure should be cleaned daily with brush, soap and water. Wastewater from bathing or washing clothes should not be drained into the pit (except when used for flushing), but disposed of elsewhere. Monthly, the pan and U-trap should be checked for cracks, and the diversion box for blockage. If the excreta does not flush quickly, the PVC pipes or diversion box may become choked and they must be unblocked immediately using scoops and long sticks.

When full, single pits should be abandoned and covered with at least 0.5 m of soil, and a new pit dug. If they are not to be abandoned, they should be emptied by mechanical means. A pit can only be emptied manually if the excreta have been left to decompose for at least 12–18 months. In this time, the excreta will have decomposed into harmless humus, which makes a good fertilizer. In a double-pit system, users should regularly monitor the level of the pit contents. If one pit is almost full, the second pit should be emptied. Again, this can safely be done by hand, but only if the pit to be emptied has been properly closed for at least 12–18 months. The pipe leading to the full pit should then be sealed and the flow diverted to the emptied pit.

If latrines are used by a single household, O&M tasks are carried out by the household itself, or by hired labour. If several households use the latrine, arrangements should be made to rotate cleaning tasks among the households. The users need to understand the concept of the system fully to be able to operate it properly. User education must include the reasons for using one pit at a time, the need to leave a full pit for about two years before emptying, and the use of excreta as manure. The users also need to know how to switch from one pit to another, and how to empty a pit, even if they do not perform these tasks themselves. If these tasks are carried out by the private (often informal) sector, the labourers should also be educated in the concept of the system and its O&M requirements.

Table 7.1 Actors and their roles

Actors	Roles	Skills required
User	Use the latrine, flush it, keep it clean, and inspect it and perform small repairs.	☺
Sanitation worker	Use the latrine, flush it, keep it clean, and inspect it and perform small repairs.	🛠🛠
Local mason	Build and repair latrines.	🛠🛠
Health department	Monitor latrines and the hygienic behaviour of users, train users in hygienic behaviour.	🛠🛠🛠

☺ Simple (often requires gender-specific awareness-raising, and training activities to change behaviour and build capacity). 🛠🛠 Technical skills. 🛠🛠🛠 Highly qualified.

Table 7.2 O&M technical requirements

Activity and frequency	Materials and spare parts	Tools and equipment
Daily		
• Clean the squatting pan or seat and shelter.	• Water, soap.	• Brush, water container.
Monthly		
• Inspect the floor, squatting pan or seat, and U-trap for cracks; • inspect the diversion box for blockage.		
Occasionally		
• Unblock the U-trap, PVC pipes or diversion box;	• Water.	• Flexible stick or other flexible tools.
• repair the squatting pan or seat, U-trap or shelter.	• Cement, sand, water, nails, local building materials.	• Bucket or bowl, trowel, saw, hammer, knife.
Depending on size and users		
• Close a full pit with soil and dig a new pit (in the case of a single-pit system);	• Soil, several local building materials, and nails.	• Shovels, picks, bucket, hammer, knife, saw, etc.
• or, empty the pit;	• By hand: water.	• By hand: shovel, bucket.
	• By mechanical means: water, spare parts for machinery.	• By mechanical means: pit-emptying equipment.
• divert excreta flush to the other pit (in the case of a double pit).	• Water, sand, cement, bricks, clay, etc.	• Shovel, bucket.

7.3 Potential problems

- the U-trap becomes blocked because of bad design or improper use;
- the U-trap is damaged because the unblocking was not done correctly (sometimes U-traps are broken on purpose to prevent blockage);
- diversion boxes or PVC pipes become blocked;
- excreta in double pits may not decompose completely, because the pits are too close to each other without an effective seal between them and liquids percolate from one pit to the other;
- full-flush pans are sometimes used when pour-flush pans are not available, but they require more water (7–12 litres per flush), which may be a problem if water is limited;
- leaching pits only function in permeable soils;
- latrines must be 15–30 m from water sources;
- pour-flush latrines should only be used in areas with adequate water for flushing;
- pour-flush latrines are not suitable if it is common practice to use bulky materials, such as corncobs or stones, for anal cleansing, because they cannot be flushed through the U-trap;
- an offset system requires more water for flushing than a direct pit system.

8. Septic tank and aqua privy[1]

8.1 The technology

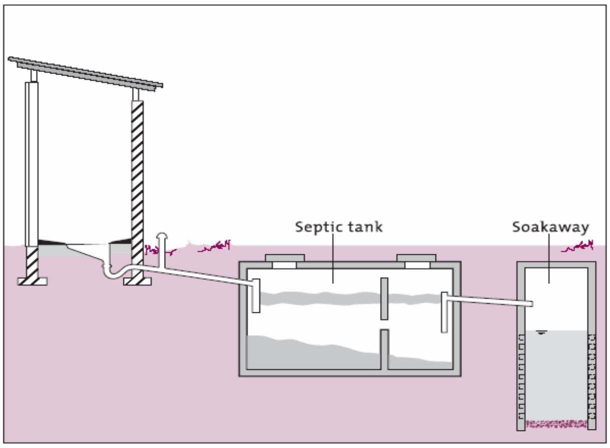


Figure 8.1 **Septic tank and aqua privy**

Septic tanks and aqua privies have a water- tight settling tank with one or two compartments. Waste is flushed into the tank by water from a pipe that is connected to the toilet. If the septic tank is under the latrine, the excreta drop directly into the tank through a pipe submerged in the liquid layer (aqua privy). If the tank is away from the latrine (septic tank), the toilet usually has a U-trap. Neither system disposes of wastes: they only help to separate the solid matter from the liquid. Some of the solids float on the surface, where they are known as scum, while others sink to the bottom where they are broken down by bacteria to form a deposit called sludge. The liquid effluent flowing out of the tank is as dangerous to health as raw sewage and should be disposed of, normally by soaking it into the ground through a soakaway, or by connecting the tank to sewer systems. The accumulated sludge in the tank must be removed regularly, usually once every 1–5 years, depending on the size of the tank, number of users, and kind of use. If sullage is also collected in the tank, the capacity of both the tank and the liquid effluent disposal system will need to be larger. If the soil has a low permeability, or if the water table is high, it may be necessary to connect the tank to a sewer system, if available.

Every tank must have a ventilation system to allow methane and malodorous gases to escape. The gases are generated by bacteria during sewage decomposition, and methane

[1] Kaplan (1991); Wegelin-Schuringa (1991); Franceys, Pickford & Reed (1992).

in particular is highly flammable and potentially explosive if confined in the tank. Septic tanks are more expensive than other on-site sanitation systems and require higher amounts of water. Aqua privies are slightly less expensive and need less water for flushing.

Initial cost: US$ 90–375 (including labour and materials).

Area of use: In rural or periurban areas where water is available.

Water needed per flush: 2–5 litres, if a pour-flush pan or aqua privy is used.

8.2 Main O&M activities

Regular cleaning of the toilet with normal amounts of soap is unlikely to be harmful, but large amounts of detergents or chemicals may disturb the biochemical processes in the tank. In aqua privies the amount of liquid in the tank should be kept high enough to keep the bottom of the drop pipe at least 75 mm below the liquid level. A bucket of water should be poured down the drop pipe daily to maintain the water seal, and to clear scum from the bottom of the drop pipe, in which flies may breed. Adding some sludge to a new tank will ensure the presence of microorganisms and enhance the anaerobic digestion of the excreta. Routine inspection is necessary to check whether desludging is needed and to ensure that there are no blockages at the inlet or outlet. The tank should be emptied when solids occupy between one-half and two-thirds of the total depth between the water level and the bottom of the tank. Organizational aspects involve providing reliable services for emptying the tanks, ensuring that skilled contractors are available for construction and repairs, and controlling sludge disposal.

Table 8.1 Actors and their roles

Actors	Roles	Skills required
User	Flush the toilet, keep it clean, inspect vents, control contents of the tank, contact municipality or other organization for emptying when necessary, and record dates tank was emptied.	🛠
Sanitation service	Empty the tank, control tank and vents, repair if needed.	🛠🛠
Agency	Monitor the performance of the tank and the teams that empty it, train the teams.	🛠🛠🛠

🛠 Basic skills. 🛠🛠 Technical skills. 🛠🛠🛠 Highly qualified.

Table 8.2 O&M technical requirements

Activity and frequency	Materials and spare parts	Tools and equipment
Daily		
• Clean the squatting pan or seat and shelter.	• Water.	• Brush, water container.
Monthly		
• Inspect the floor, squatting pan or seat, and U-trap.		

Table 8.2 O&M technical requirements (Continued)

Activity and frequency	Materials and spare parts	Tools and equipment
Regularly		
• Ensure that the entry pipe is still submerged (for aqua privies).	• Water.	• Stick.
Occasionally		
• Unblock the U-trap;	• Water.	• Flexible brush or other flexible material.
• repair the squatting pan or seat, U-trap or shelter.	• Cement, sand, water, nails, local building materials.	• Bucket or bowl, trowel, saw, hammer, knife.
Annually		
• Control the vents;	• Rope or wire, screen materials, pipe parts.	• Scissors/ wire-cutting tool, pliers, saw.
Every one to five years		
• Empty the tank.	• Water, fuel, lubricants, etc.	• Vacuum tanker (large or mini), or MAPET equipment.

8.3 Potential problems

- many problems arise because inadequate consideration is given to liquid effluent disposal;
- large excreta flows entering the tank may disturb solids that have already settled, and temporarily increase the concentration of suspended solids in the effluent;
- if the water seal is not maintained in an aqua privy, the tanks will leak and cause insect and odour problems;
- this system is not suitable for areas where water is scarce, where there are insufficient financial resources to construct the system, or where safe tank emptying cannot be carried out or afforded;
- if there is not enough space for soakaways or drainage fields, small-bore sewers should be installed;
- aqua privies only function properly when they are well designed, constructed and operated;
- septic tank additives (such as yeast, bacteria and enzymes), which are often sold for "digesting scum and sludge" and for "avoiding expensive pumping", are not effective.

9. Manual pit emptying technology (MAPET)[1]

9.1 The technology

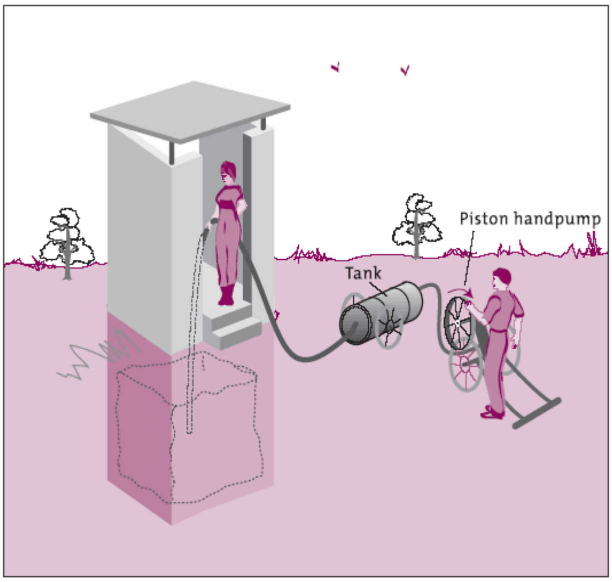


Figure 9.1 MAPET system

The Manual Pit Emptying Technology (MAPET) uses manually operated equipment to empty the latrine pit. Its main components are a piston handpump and a 200-litre vacuum tank, both mounted on pushcarts, and connected by a 3/4- inch (2-cm) hosepipe. A 4-inch (10-cm) hosepipe is used to drain the sludge from the pit. When the handpump wheel is rotated air is sucked out of the vacuum tank, which sucks sludge from the pit through the 4-inch hosepipe and into the tank. The effective pumping head is 3 m, depending on the viscosity of the sludge. The sludge is usually buried in a hole close to the pit, or taken to a nearby disposal point (e.g. a disposal field, or sludge transfer station). The equipment is small and hand-operated, and is therefore particularly suitable for high-density settlements with narrow streets, where conventional vacuum tankers have no access. The maximum width of the MAPET, for example, is 0.8 m. Motor-driven vacuum tankers built on small tractors are available, and they use the same principle as the MAPET.

Initial cost: US$ 3000 in Dar es Salaam, Tanzania, in 1992 dollars (Muller & Rijnsburger, 1994). The price included the costs of procuring all the parts and materials locally: gas, welding rods, paint, transportation, and labour for assembly.

Area of use: In unplanned and low-income urban areas, especially where access for motor vehicles is poor and where double-pit systems cannot be applied.

Cost of operation: In 1992, US$ 2.50 per tank load of 200 litres in Dar es Salaam, Tanzania (Muller & Rijnsburger, 1994).

9.2 Main O&M activities

The emptying job starts with contacting the customer, negotiating the price, picking up the MAPET equipment from its parking place and taking it to the customer's house (which may take from 30–60 minutes). A hole is dug for sludge disposal and the latrine sludge is prepared for pumping. This preparation entails mixing the sludge with water (to make it more liquid) and paraffin (to reduce the smell). After connecting the hosepipes, the sludge can be pumped. Depending on the viscosity of the sludge and the pumping head, it can take 5–20 minutes to fill up one 200-litre tank with sludge. When a tank is full, the hosepipes are disconnected and the tank is manoeuvred next to the dug hole in its discharge position. The sludge is then discharged into the hole by opening a pressure release valve. After putting the tank back in its original position, it can be used to pump sludge again. This routine is repeated until the required amount of sludge has been taken out of the pit. The equipment is then cleaned and returned to the neighbourhood parking place.

[1] Muller & Rijnsburger (1994).

Minor repairs, such as spot welding loose parts and repairing tyre punctures, are carried out in small workshops in the area where the MAPET team operates, and are paid for by the team. Costs reach a maximum of US$ 25 per month. Larger repairs and special maintenance mainly involve repairing or replacing bearings, valves and guides; replacing the piston leather (once a year); and replacing the tyres. The jobs are done by trained mechanics in a specialized workshop.

Although the service can be provided privately, it is more normal for the service to be provided by the local sewerage departments. The responsibilities of a sewerage department include:

- training and licensing the pit emptiers;
- manufacturing the MAPET equipment and providing the specialized maintenance for it;
- monitoring the team's performance and making adjustments in the event of poor functioning, particularly when it concerns public health.

Table 9.1 Actors and their roles

Actors	Roles	Skills required
Latrine user/owner	Contact the MAPET team, negotiate the number of tank loads to be removed, negotiate the cost.	🛠
MAPET team	Empty the pits; stay in contact and negotiate with users; organize, carry out and pay for minor maintenance; and contact the workshop when major repairs are needed.	🛠🛠
Mechanic	Carry out the more specialized repairs and maintenance of the equipment.	🛠🛠
Sewerage department	Monitor performance of the MAPET team, train the pit emptiers and mechanics, organize transportation, and maintain equipment.	🛠🛠🛠

🛠 Basic skills. 🛠🛠 Technical skills. 🛠🛠🛠 Highly qualified.

Table 9.2 O&M technical requirements for MAPET

Activity and frequency	Materials and spare parts	Tools and equipment
Regularly		
• Minor repairs, such as tyre punctures or small welding jobs.	• Rubber, glue, welding rods, spokes.	• Basic bicycle repair equipment, basic welding equipment, bucket.
Occasionally		
• Repair or replace handpump parts; • repair the wheels.	• Timber, gas, pipe, water valves. • Bearings, tyres.	• Basic mechanical workshop tools. • Same as above.
Annually		
• Replace the leather cup in the handpump.	• Leather cup.	• Basic mechanical workshop tools.

9.3 Potential problems

- flat tyres, broken metal parts that require welding, wheel bearings that wear out rapidly, a damaged wheel, worn-out pump elements (bearings, valves, pistons), a corroded tank;
- the system is not suitable if the sludge has to be transported more than 0.5 km to the burying site or transfer station;
- transfer stations are only feasible if the municipalities facilitate the secondary collection and treatment of the sludge;
- potential demand for MAPET service is high, but the system needs to be marketed more aggressively.

10. Soakaway[1]

10.1 The technology

A soakaway is a pit for collecting the liquid effluent from a septic tank, which is then allowed to infiltrate the ground. The capacity of the pit should be at least equal to that of the septic tank. The pit may be filled with stones, broken bricks, etc., in which case no lining is needed, or it may be lined with open-jointed masonry (often with a filling of sand or gravel between the lining and the soil to improve infiltration). The top 0.5 m of the pit should be lined solidly, to provide firm support for the reinforced concrete cover. The cover is sometimes buried by 0.2–0.3 m of soil to keep insects out of the pit. The size of the soakaway is determined mainly by the volume of liquid effluents produced, and by local soil conditions. With large effluent flows, drainage trenches may be more economical than soakaways. Planting trees adjacent to, or over, a soakaway can improve both transpiration and permeability.

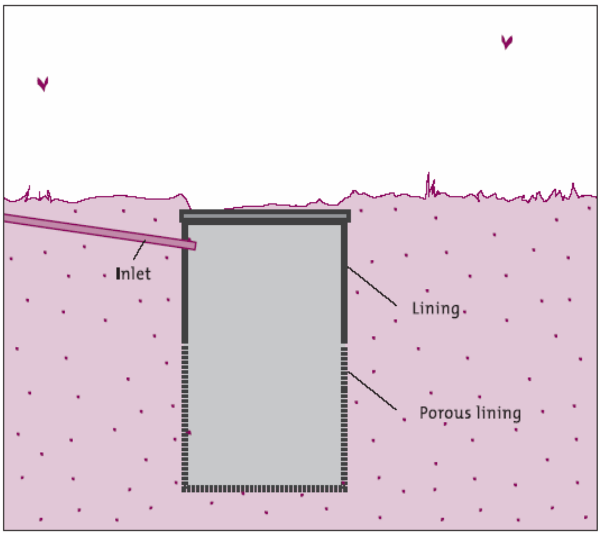


Figure 10.1 Soakaway

Area of use: In rural or periurban areas where sufficient water is available, the soil is permeable, and there is no bedrock or groundwater near the surface.

10.2 Main O&M activities

Hardly any activities are required to operate the system, except when the soakaway or septic tank overflows. Then the tank outflow should be cleaned and the delivery pipe unblocked, if necessary.

[1] National Environmental Health Association (1979); Kaplan (1991); Franceys, Pickford & Reed (1992).

Table 10.1 Actors and their roles

Actors	Roles	Skills required
Householder/user or local caretaker	Check the outflow tank and performance of the soakaway.	🛠
Local artisan	Repair broken parts, remove obstructions in delivery pipes.	🛠🛠
Agency department	Monitor performance of the systems, train users/caretakers and local artisans, provide assistance with big problems.	🛠🛠🛠

🛠 Basic skills. 🛠🛠 Technical skills. 🛠🛠🛠 Highly qualified.

Table 10.2 O&M technical requirements

Activity and frequency	Materials and spare parts	Tools and equipment
Once a month		
• Check the outflow of the tank boxes and clean them.	• Water.	• Brush, tools to open the access.
Whenever necessary		
• Repair the pipe connection to the soakaway.	• Water, materials for dismantling pipes.	• Brush, shovel, and tools to open the access, and to dismantle connector pipes.

10.3 Potential problems

- the soakaway overflows – this is a particular problem if both toilet wastes and sullage are collected in the septic tank and the tank was designed for toilet wastes only;
- the system is not suitable if there is not enough space or water, or sufficient financial resources for construction, where the soil is not permeable enough or is too hard to dig out (bedrock), or where the groundwater is close to the surface.

11. Drainage field[1]

11.1 The technology

Drainage fields consist of gravel-filled underground trenches, called leachlines or drainage trenches, that allow the liquid effluent from a septic tank to infiltrate the ground. Open-jointed (stoneware) or perforated (PVC) pipes lead the liquid effluent into the drainage field. Initially, infiltration may be fast, but after several years the soil clogs and an equilibrium infiltration rate is reached. If the sewage flow exceeds the equilibrium rate of the soil, sewage will eventually surface over the drainage field. Pressure can be taken off drainage fields by reducing the amount of water and solids flowing into the solids interceptor tank (e.g. by installing toilets that use less water – "low-flush" toilets), or by preventing sullage from entering the tank.

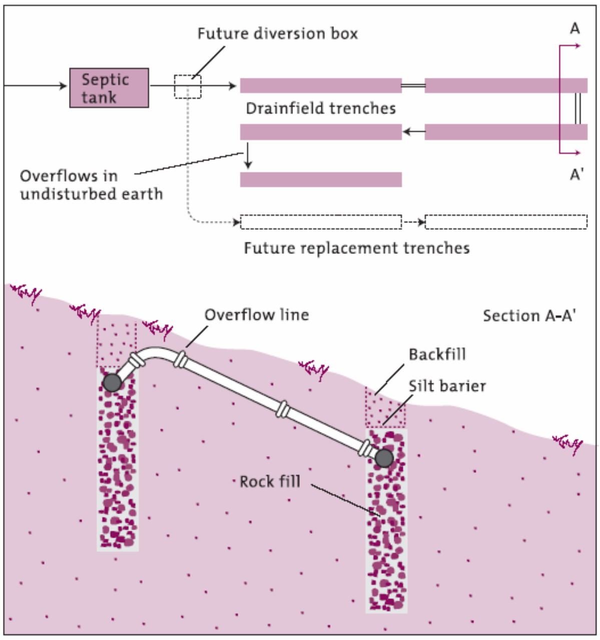


Figure 11.1 Drainage field

The drainage trenches are usually 0.3–0.5 m wide and 0.6–1.0 m deep (from the top of the pipes). The trenches are laid with a 0.2–0.3% gradient of gravel (20–50 mm diameter), and a 0.3–0.5 m layer of soil on top. A barrier of straw or building paper prevents the soil from washing down. The trenches should be laid in series so that as each trench fills, it overflows to the next one. This ensures that each trench is used either fully, or not at all. The trenches should be 2 m apart, or twice the trench depth if this is greater than 1 m. The bottom of a trench should be at least 0.5–1 m above groundwater, bedrock or impermeable soil, and the slope of the land should not exceed 10%.

An area of land equal in size to the drainage field should be kept in reserve, either to allow the field to be extended in the future, or to allow another drainage field to be dug if the first becomes clogged. Drainage fields are often used instead of soakaways, where larger quantities of liquid effluent are produced.

11.2 Main O&M activities

Hardly any activities are required to operate the system, except to watch for field overflows, switching to a second drainage field every 6–12 months, and determining the dates of switching (if applicable). The tank outflow should be cleaned, and checked that it is in good working order (if not, it should repaired). Sometimes, it may be necessary to unblock the delivery pipe. Diversion boxes should be cleaned from time to time, based on experience from operating the system. Plant growth should be controlled, to prevent roots from entering the pipes or trenches. Minor O&M and bookkeeping may be organized and carried out by households, groups of households or the community organization. The responsible government department needs to monitor the performance of drainage fields, and train users, organizations, artisans and caretakers on the technical aspects of their O&M.

[1] National Environmental Health Association (1979); Kaplan (1991); Franceys, Pickford & Reed (1992).

Table 11.1 Actors and their roles

Actors	Roles	Skills required
Householder/user or local caretaker	Check the outflow tank and performance of the drainage field, and control plant growth.	🛠
Local artisan	Repair broken parts, remove obstructions in delivery pipes.	🛠🛠
Agency	Monitor system performance, train users/caretakers and local artisans in the use of the system, provide assistance with major problems.	🛠🛠🛠

🛠 Basic skills. 🛠🛠 Technical skills. 🛠🛠🛠 Highly qualified.

Table 11.2 O&M technical requirements

Activity and frequency	Materials and spare parts	Tools and equipment
Regularly		
• Control plant growth.		• Shovel, bucket, machete, etc.
Every month		
• Clean the diversion boxes.	• Water.	• Shovel, brush.
Once a month		
• Check tank outflow pipe and clean it.	• Water.	• Brush, tools to open the access hole.
Once every 6–12 months		
• Switch to another drainage field.	• Bricks or other material to block pipes.	• Tools to open the diversion box.
Occasionally		
• Unblock the delivery pipe.	• Water, piping, glue.	• Shovel, knife, saw, long stick or flexible brush.

11.3 Potential problems

- overflowing leachlines, unpleasant odours, groundwater contamination and social conflict (over siting of the drainage fields, odours, etc.);
- there is not enough water to use or maintain the system;
- there is not enough space or financial resources for construction;
- the permeability of the soil is poor;
- the bedrock or groundwater are close to the surface.

[1] Adapted from: Brikké F. and Bredero M., 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.* Geneva: WHO and IRC.