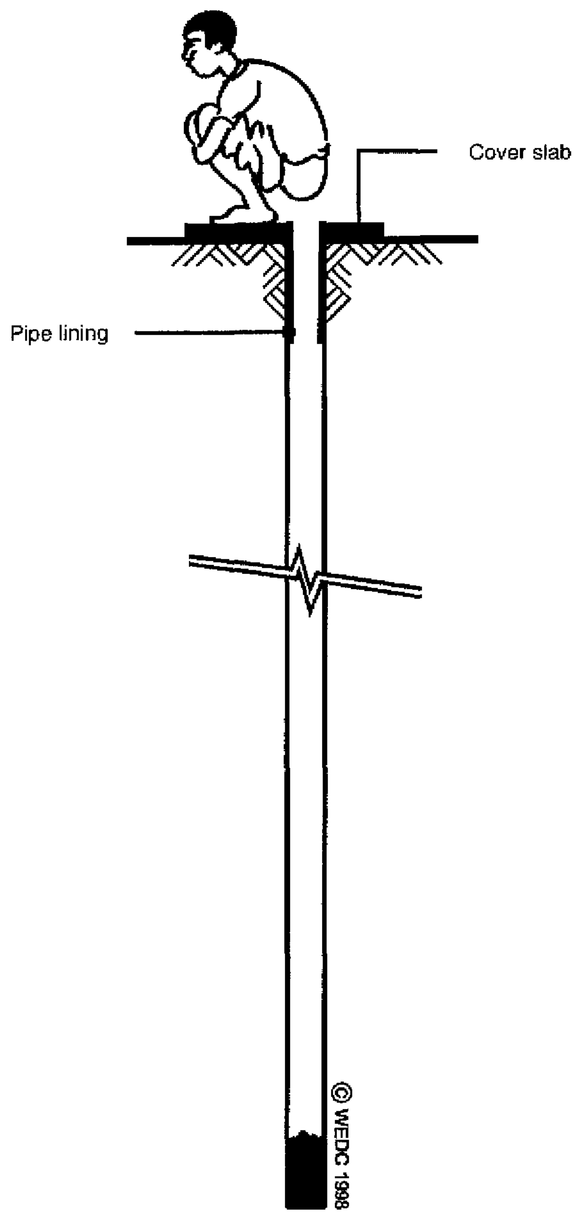


Figure 6.11. Borehole latrine

Drilling boreholes for latrines, Bangladesh

Borehole latrines nearing completion, Bangladesh

6.5.8 Sewerage systems

In sites with existing sewerage systems it is logical to make use of this by constructing toilet blocks directly over or slightly offset from sewers (Figure 6.12). Checks should be made to ensure that the system is functioning properly and is able to cope with the increased load. An adequate quantity of water (20-40 litres per user per day) is also required for flushing.

Advantages: An existing disposal system is already in place; and system is relatively quick to implement.

Constraints: Expansion possibilities may be limited; may cause problems due to overloading of system or after the population has moved on; an adequate water supply required for flushing; and freezing may cause blockages.

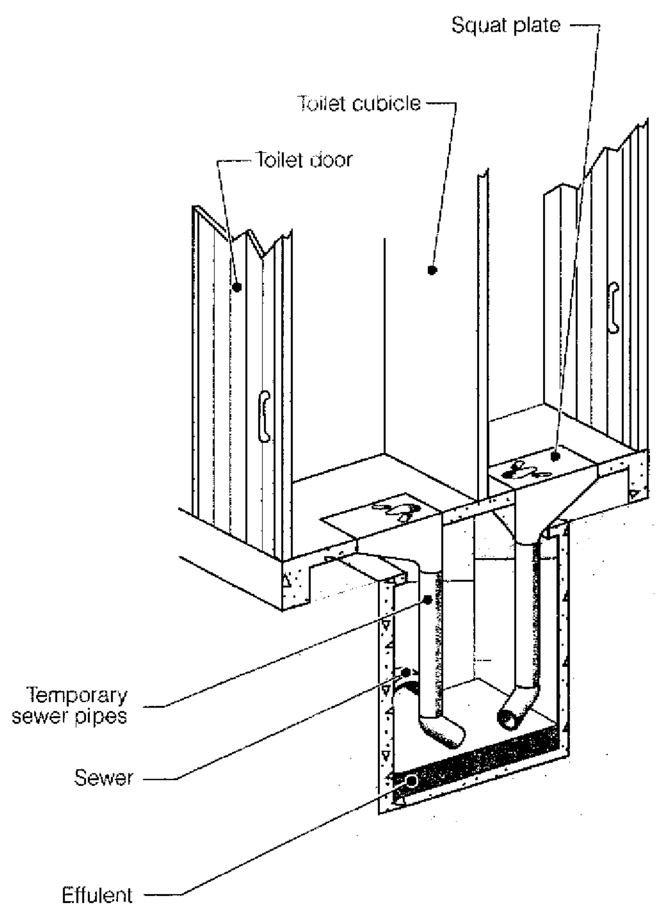


Figure 6.12. Temporary toilet block over existing sewer

6.6 Strategies for difficult conditions

In some situations it may be impossible to use traditional infiltration techniques (such as simple pit latrines) for excreta disposal. This is likely to be the case:

- where the water table is very close to the ground surface, limiting excavation;
- where groundwater sources are likely to be contaminated easily;
- where there is hard rock close to the surface, making excavation very difficult;
- where the ground is so soft that pit walls collapse before an adequate depth can be reached; and
- in flood-affected areas.

Figure 6.13 demonstrates how pollution from a latrine pit travels towards the water table. Generally, the base of the pit must be at least 1.5m above the wet season water table to prevent contamination, but in some geological conditions this may be insufficient. If there is a conflict between latrine provision and water supply it is usually easier and cheaper to develop another water source than provide alternative excreta disposal facilities. This may not always be possible, however, and wherever the groundwater level is high, protective measures should be taken, especially where groundwater is used as a source of drinking water.

If groundwater resources are not exploited for water supply in the area, the prevention of groundwater contamination should be of secondary importance to the provision of adequate excreta disposal facilities.

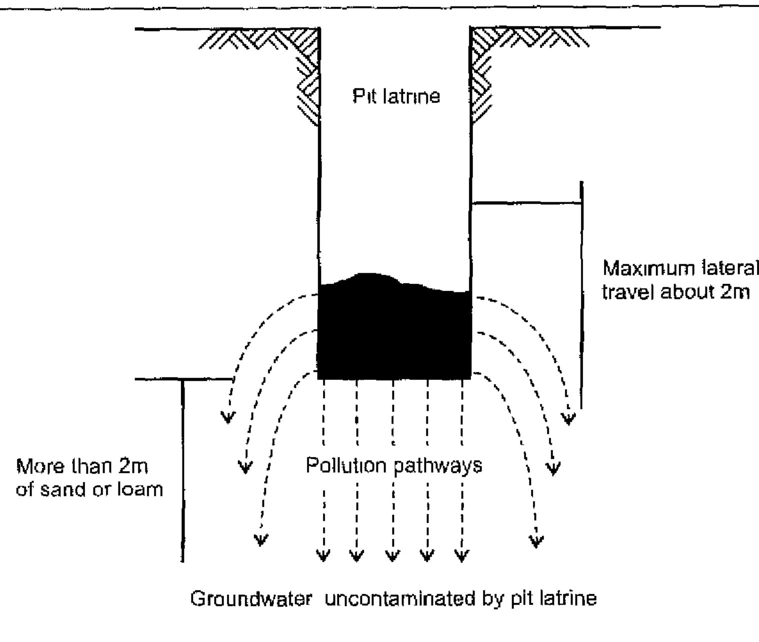
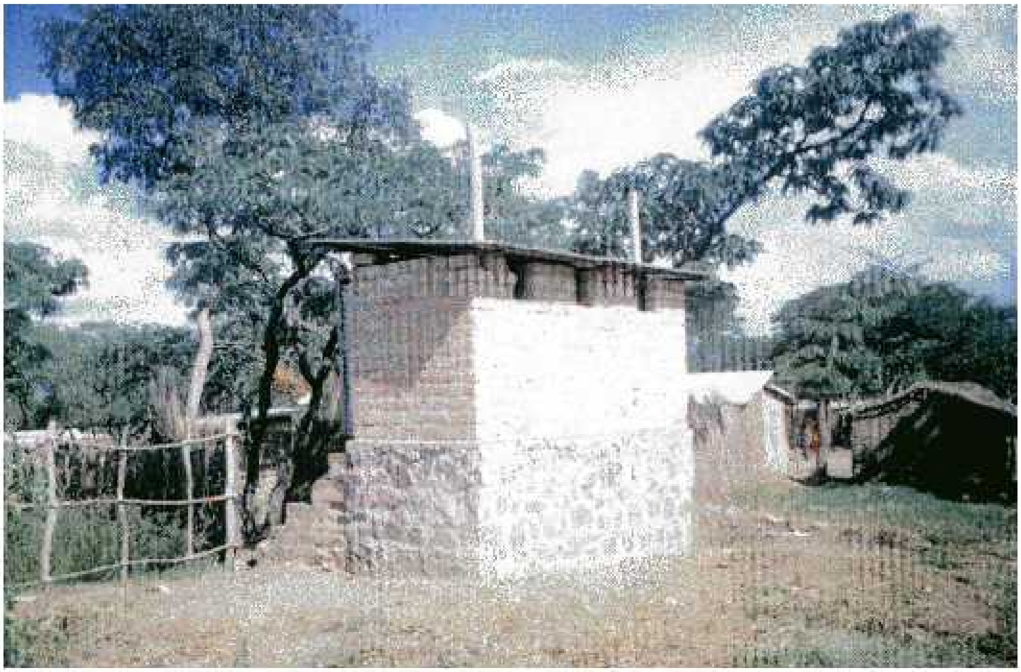


Figure 6.13. Pollution from a pit latrine above the water table



Raised VIP latrines, Tanzania

6.6.1 Raised pit latrines

Where the groundwater table is within a few metres of ground level, or excavation of the ground is extremely difficult, then a raised pit latrine may be a viable solution. This can be in the form of a simple pit latrine or a VIP latrine in which the pit is built upwards above the ground level. This increases cost and construction time considerably and family members may be unable to construct this type of latrine by themselves, but it is a relatively simple measure to minimise groundwater pollution.

6.6.2 Twin pit latrines

Where it is not feasible to dig a deep pit it may be easier and cheaper to dig two shallow pits side by side. This principle can be applied to simple pit latrines, VIP latrines or pour-flush latrines. The superstructure should be built over both pits, each of which has its own drophole. One pit is then used until it is full, at which point it is sealed and the second pit is used. If the contents of the first pit are left to stand for at least two years, virtually all of the pathogenic organisms will have died and the waste will be relatively safe to handle. Unlike a composting latrine (see 6.6.5-6), the pit contents are not a good fertiliser, although they may help to improve the quality of the soil to which they are added. Figure 6.14. illustrates a raised twin-pit VIP latrine.

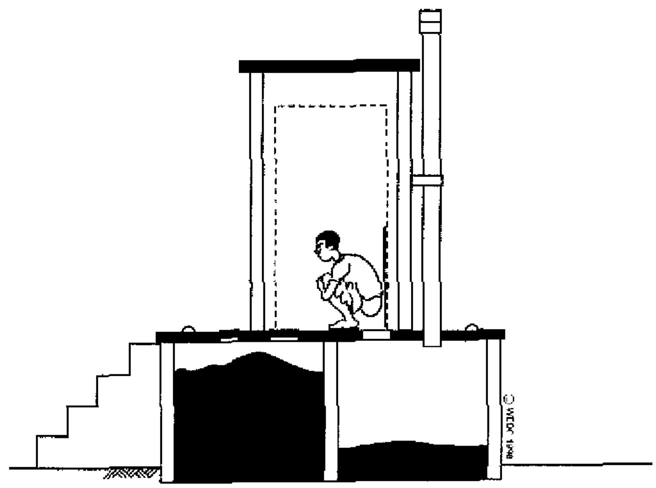


Figure 6.14. Raised twin-pit ventilated latrine

6.6.3 Sand-enveloped pit latrines

Where there is a high risk of groundwater contamination, and it is important to prevent this, a sand envelope can be constructed around a lined latrine pit to reduce pollution (Figure 6.15). This envelope is usually about 0.5m thick and acts as a filter to minimise the transmission of disease-causing micro-organisms. It should not be assumed that this will stop contamination completely. Where the risk of pollution of nearby groundwater sources is especially high, and there is no viable alternative, it may be appropriate to construct sand-enveloped raised pit latrines.

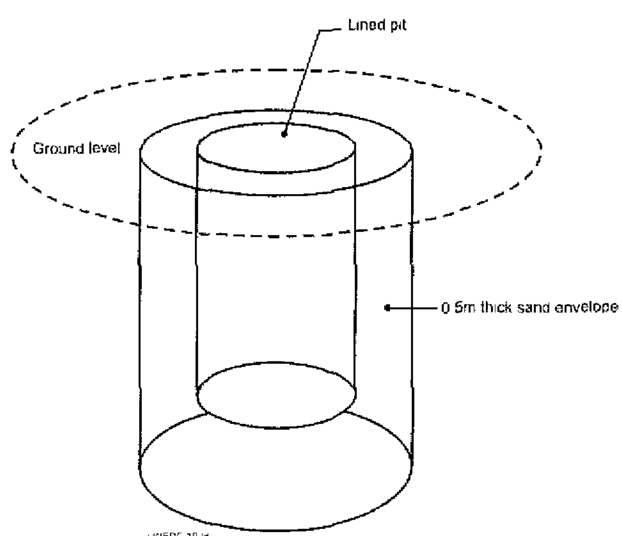


Figure 6.15. Sand-enveloped pit

6.6.4 Sealed pits/tanks

Groundwater contamination can also be prevented if the disposal pit or tank is fully lined and sealed, so that the contents are unable to infiltrate into the surrounding ground. The construction of fully lined pits is expensive and time-consuming, however, and is likely to be impractical where family latrines are desired. The second disadvantage is that such pits will need to be emptied relatively regularly, since no infiltration is able to occur.

6.6.5 Anaerobic composting latrines

Anaerobic composting latrines use a dry disposal system in which urine and faeces are managed separately. The deposited faecal matter is dried by exposure to heat or the sun and the addition of lime, ash, sawdust or earth, which controls the moisture content. Vegetable or other organic waste can also be added to control the chemical balance. The latrine contents are then isolated from human contact for a specified period to reduce the presence of pathogens and make the waste safe for handling. This period should be at least ten months and some practitioners recommend longer periods of two years or more. The longer the waste is stored the more pathogens will be destroyed. The waste may then be re-used as fertiliser or as fuel

The primary difficulty in using this type of toilet is the separation of urine and faeces. Users have to be made aware of the importance of separation and the addition of ash after defecation. Such a system is unlikely to work where water is used for anal cleansing since this will increase the moisture content. This type of latrine is rarely appropriate in the initial stages of an emergency, unless the population is already accustomed to using similar systems. It requires no water and can be adopted where infiltration techniques are impossible, however, and may be a viable longer term option.

Figure 6.16 illustrates a double-vault latrine where one vault is used initially then sealed when full. The second vault is then used until that is full, at which point the first vault can be emptied and re-used. The vault size must be carefully calculated to ensure that the waste is retained for an appropriate period of time (see 6.8.8)

Heavy usage — as is likely in many emergency situations — may lead to serious problems because of inadequate time for decomposition.

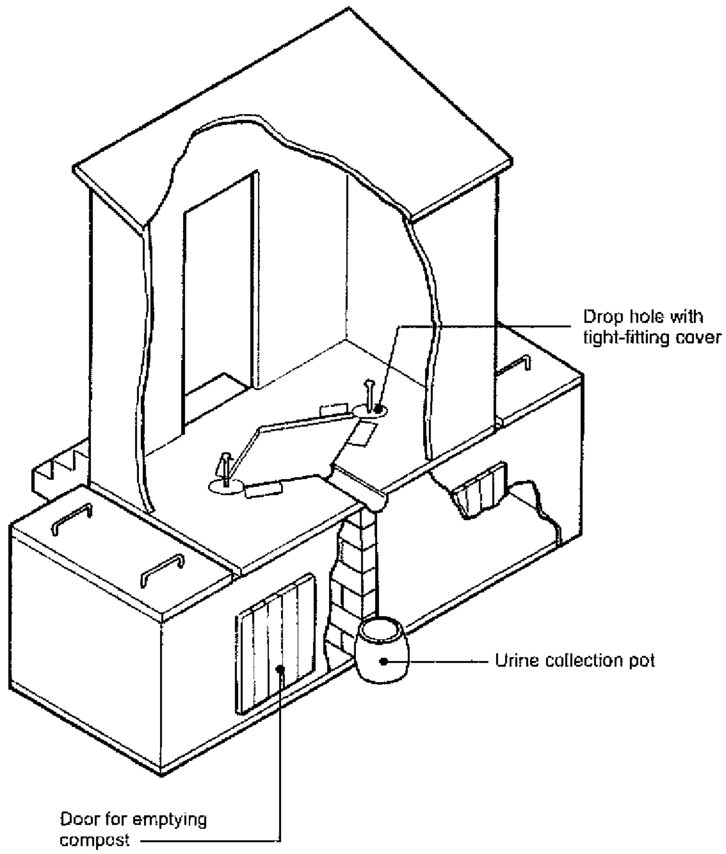


Figure 6.16. Double-vault composting latrine

6.6.6 Aerobic composting latrines

Aerobic composting latrines use a similar method to the anaerobic composting latrine and the intended outcome is the same — to reduce excreta to a safe re-usable state. The main difference is that urine does not need to be separated from faecal matter. New wastes must be separated from old, however, and air must be able to circulate freely. In a composting latrine, bacteria, worms, or other organisms are used to break down organic matter to produce compost. This is encouraged through the addition of organic refuse, such as vegetable waste, to the toilet chamber. The final compost produced can then be used as fertiliser for agricultural purposes.

Continuous composting toilets are expensive to construct and have only proved successful in small communities in industralised countries. Like all composting latrines, this type of disposal system requires considerable user awareness and understanding, and is most appropriate where the affected population has some experience of this type of technology. In general, it is not an appropriate emergency excreta disposal system.

6.6.7 Septic tanks

A septic tank is designed to collect and treat toilet wastewater and other grey water (Figure 6.17). Its use is likely to be appropriate where the volume of wastewater produced is too large for disposal in pit latrines, and water-borne sewerage is uneconomic or unaffordable. Septic tanks are therefore particularly suited to systems involving high water use, especially where water is used for anal cleansing.

Wastes from toilets, and sometimes kitchens and bathrooms, pass though pipes to a water-tight tank where they are partially treated. After one to three days the liquid wastes leave the tank and are carried to a secondary treatment system. This is usually some form of under-ground disposal system, sewer or secondary treatment facility.

The treatment process in a septic tank occurs in four stages:

Settlement: Heavy solids settle to the base of the tank to form a sludge which must occasionally be removed; about 80 per cent of the suspended solids can be separated from the liquid in a well-designed tank.

Flotation: Grease and oil float to the surface to form a layer of scum; over time this scum layer becomes thick and the surface may be hard.

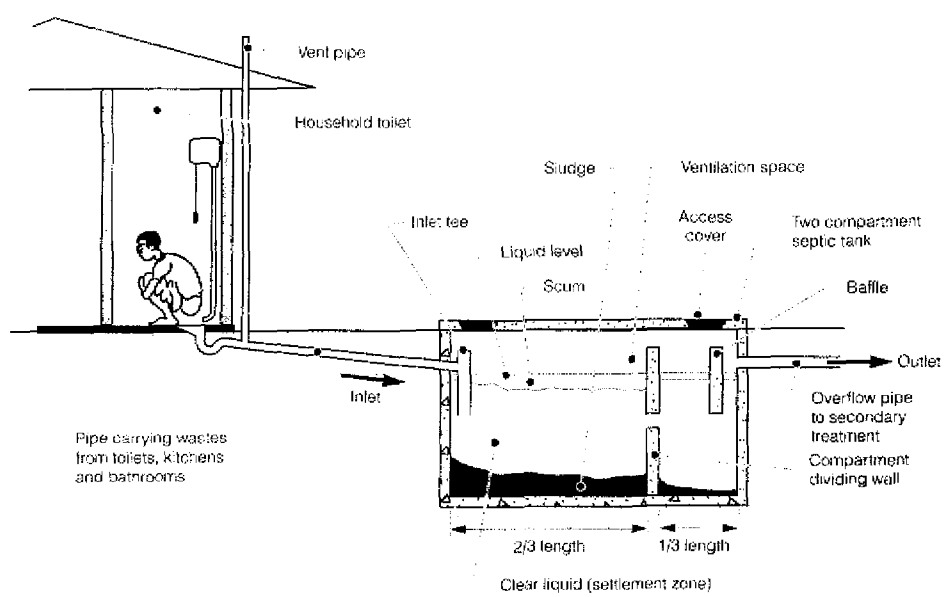


Figure 6.17. Wastewater treatment using a septic tank

Sludge digestion and consolidation: The sludge at the bottom of the tank is compressed by the weight of new material settling on top, increasing its density; and organic matter in the sludge and scum layers is broken down by bacteria which convert it to liquid and gas.

Stabilisation: The liquid in the tank undergoes some natural purification but the process is not complete; the final effluent is anaerobic and will contain pathogenic organisms such as roundworm and hookworm eggs.

The final effluent leaving the septic tank must be disposed of in an appropriate location such as a sealed pit or sewerage system.

6.6.8 Aqua privies

An aqua privy (Figure 6.18) is simply a latrine constructed directly above a septic tank. Aqua privies are appropriate where pit latrines are socially or technically unacceptable but the volume of sullage is small. The amount of water required for flushing is much smaller than for a septic tank because of the location of the tank. The water-seal pan and extension of the drop pipe 75mm below the water surface helps to exclude odours from the superstructure. The tank of the aqua privy must be watertight to maintain a constant liquid level in the tank. The outlet pipe should extend at least 50mm below the water surface to provide an odour seal.

Communal aqua privy, Bangladesh

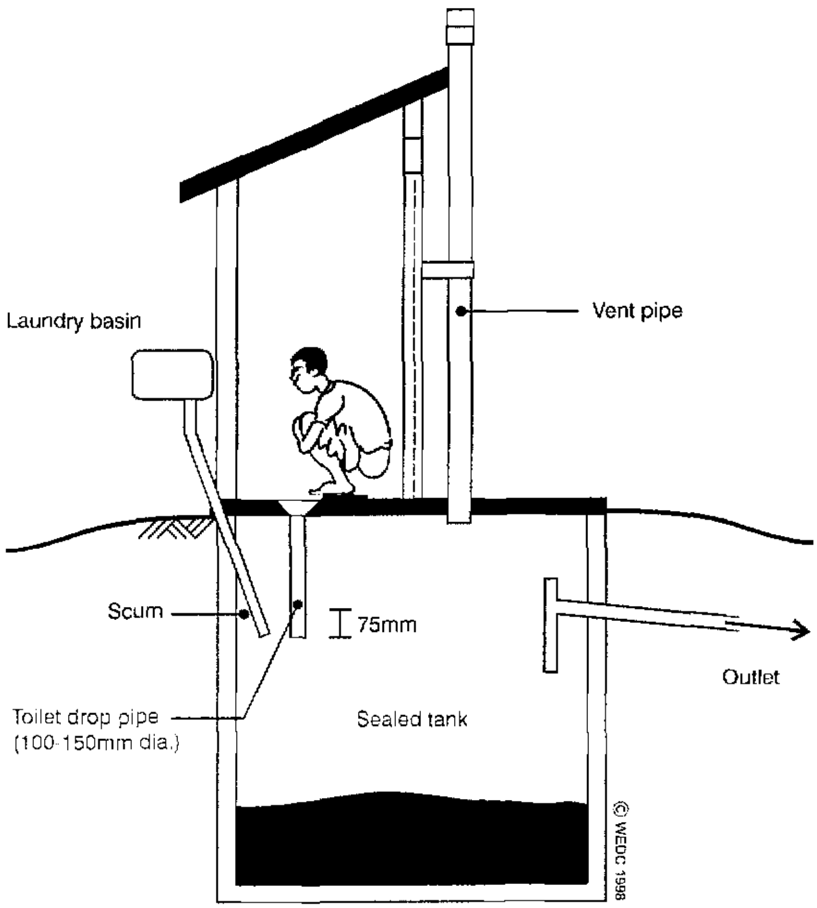


Figure 6.18. Aqua privy

6.6.9 Sewerage systems

Sewerage systems are not common in emergency situations, although they may be used where the affected population remains or relocates in an urban area. Most sewerage systems need at least 20-40 litres of water per user per day to be flushed into the system (Adams, 1999). In addition, pumped sewerage systems and sewage treatment works may require a back-up power supply to keep the system running. This may be a major undertaking.

6.7 Intervention levels

The selection of appropriate actions depends primarily on the actual scenario and the intervention level required. The following tables (6.2-6.4) indicate the most appropriate general options for immediate, short-term and long-term measures for four different scenarios, depending on the amount of space available.

Table 6.2. Recommended interventions for space of more than 30m^2* per person

<table>
<tr><th>Scenarios and recommended interventions</th><th>The affected population go through a transit camp immediately after a disaster</th><th>The affected population remain in a temporary location for up to six months</th><th>The affected population stay in the affected area immediately after a disaster</th><th>The affected population move to a new area and are likely to remain for more than a year</th></tr>
<tr><td>Immediate action</td><td colspan="4">■ Clearing of scattered faeces
■ Controlled open defecation
■ Shallow trench latrines
■ Repair of existing facilities
■ Temporary communal or family latrines</td></tr>
<tr><td>Short-term measure</td><td colspan="2">■ Semi-permanent family latrines
■ Semi-permanent shared latrines</td><td colspan="2"></td></tr>
<tr><td>Long-term measure</td><td colspan="2"></td><td colspan="2">■ Permanent family latrines
■ Upgrading of existing facilities</td></tr>
</table>

*Total available space (including space for non-dwelling areas)

Table 6.3. Recommended interventions for space of 20-30m^2 per person

Scenarios and recommended interventions	***The affected population go through a transit camp immediately after a disaster***	***The affected population remain in a temporary location for up to six months***	***The affected population stay in the affected area immediately after a disaster***	***The affected population move to a new area and are likely to remain for more than a year***
Immediate action	The same as Table 6.2			
Short-term measure	■ Semi-permanent communal latrines ■ Semi-permanent shared latrines			
Long-term measure			■ Permanent shared or communal latrines ■ Upgrading of existing facilities	

Table 6.4. Recommended interventions for space of less than 20m^2 per person

Scenarios and recommended interventions	***The affected population go through a transit camp immediately after a disaster***	***The affected population remain in a temporary location for up to six months***	***The affected population stay in the affected area immediately after a disaster***	***The affected population move to a new area and are likely to remain for more than a year***
Immediate action	The same as Table 6.2			
Medium-term measure	■ Semi-permanent communal latrines			
Long-term measure			■ Permanent communal latrines ■ Upgrading of exciting facilities	

These options are not exhaustive but provide an outline of the main actions to be considered in each scenario.

6.8 Design and construction

In the design and construction of any latrine it is important to consider the following four key factors:

- Safety
- Comfort
- Privacy
- Health

6.8.1 Siting latrines

Perhaps the most important design factor regarding latrine construction is **where** the latrine should be sited. The following factors are important siting selection criteria; each latrine constructed should be:

- not more than 50m away from dwellings to be served;
- at least 30m away from water storage and treatment facilities;
- at least 30m away from surface water sources;
- at least 30m horizontal distance from shallow groundwater sources (more in coarse or fissured ground);
- downhill of settlements and water sources, where possible;
- at least 50m away from communal food storage and preparation areas;
- close to handwashing facilities; and
- easily accessible to all intended users including children, old people, pregnant women and disabled people

Accessibility is a key issue since this is likely to influence how often latrines are used, and hence whether indiscriminate defecation takes place or not. Security of users, especially women and children, must also be considered, particularly where communal latrines are in place. If necessary, facilities can be lit at night for security and convenience.

6.8.2 Construction materials and tools

The single most important factor in the selection of construction materials and tools is local availability. It is inefficient and inappropriate to import expensive materials if suitable materials are available locally. Possible construction materials include:

- Wood
- Grass
- Mud
- Earth blocks
- Bamboo
- Leaves
- Bricks
- Cement
- Gravel
- Sand
- Corrugated iron sheeting
- Plastic sheeting
- Cloth or sacking

There is often a tendency to focus on the use of typical relief agency materials, such as plastic sheeting, when there may be much better local alternatives available. Tools are often available locally, and although these may sometimes be of lower quality than imported ones, they are likely to be much more cost-effective, and the local population will be more accustomed to their use. Heavy equipment, or specialised equipment, may also be available and this may influence the selected construction method as well as the overall technology choice.

6.8.3 Superstructure design

To the user, the superstructure is likely to be the most important part of the latrine. For this reason alone, due attention must be given to its design. In some cultures people prefer to defecate in the open and a superstructure may not be required. In general, however, the superstructure must provide the necessary privacy for the comfort and dignity of the users. Materials and techniques used for the superstructure should generally be the same as those used for people's shelters, as this will facilitate ease of construction.

In areas of high rainfall, or for VIP latrines, a roof will be essential, although roofing materials may be stolen where shelter is a priority. In other situations roofs may not be necessary. The superstructure may have a door where desired, or a spiral-shaped entrance can be constructed. The superstructure can, more or less, be of any size and shape that the user desires, although a minimum base area of $1m^2$ is recommended.

Although the superstructure has little direct impact on the health benefits of the latrine (with the possible exception of a VIP latrine), its design is likely to influence whether the latrine will be used and looked after. It is therefore essential that the users are involved in the superstructure design, to ensure that it is socio-culturally acceptable and to promote the users' pride in their toilet.

6.8.4 Latrine slabs

An important component of a pit latrine is the latrine slab situated above the pit. The purpose of the latrine slab is to cover the top of the pit and, sometimes, to provide a surface on which the user puts their feet. The slab should be able to support the weight of a person, be easy to clean, and should be sloped slightly towards the squat-hole to allow liquid to drain. Figure 6.19 shows a typical cross-section of a latrine slab.

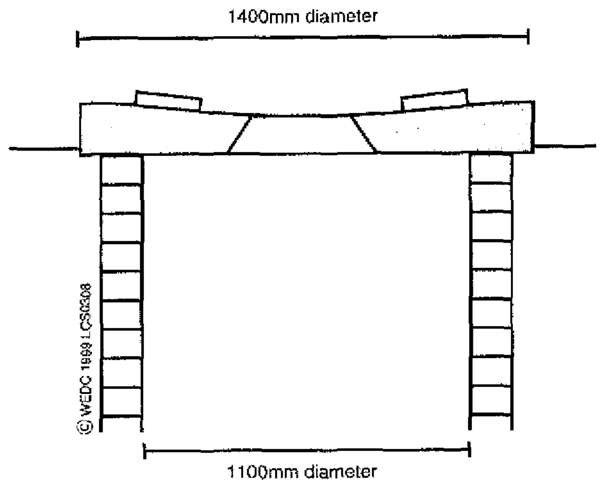


Figure 6.19. Cross-section of latrine slab with footrests

In many cases, the slab is likely to be the most expensive component of a simple pit latrine, since its production may entail skilled labour, cement, gravel and reinforcement.
In the early stages of an emergency, many agencies use pre-moulded plastic squatting plates. These are appropriate for immediate rapid implementation and are often suitable for use in emergency trench latrines, health centres, schools and reception centres. However, for long-term use it is more efficient to use locally manufactured slabs where possible.

The squat-hole in the latrine slab should be large enough to allow defecation and urination without fouling the floor, whilst being small enough for the young and old to span in safety. Ideally, this should be a 'keyhole' shape, about 160mm in diameter and 250mm long.

Slabs can be made of concrete, wood, ferrocement or plastic. Concrete is currently the preferred material since it is cheap, durable, easy to clean and simple to manufacture. Most concrete slabs are reinforced with steel bars to prevent breaking (Figure 6.20), and reinforcing bars should be placed near the base of the slab to carry the tension forces.

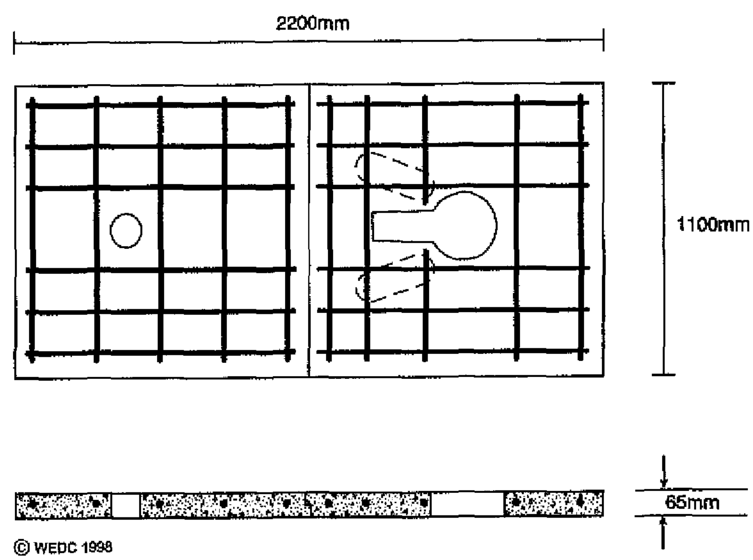


Figure 6.20. Reinforced latrine slab

The amount of reinforcement will depend on the size of the slab and the load to be carried. Table 6.5 gives suggestions for the amount of reinforcement required for different slabs. Slabs may be rectangular or circular.

Table 6.5. Spacing for steel reinforcing bars in pit latrine slabs

Slab thickness (mm)	*Steel bar diameter (mm)*	*Spacing of steel bars (mm) in each direction for minimum spans of:*				
		1m	**1.25m**	**1.5m**	**1.75m**	**2m**
65	6	150	150	125	75	50
65	8	250	250	200	150	125
80	6	150	150	150	125	75
80	8	250	250	250	200	150

Slabs without reinforcement can be made provided the slab is domed (Figure 6.21). The dome shape causes all the forces in the slab (apart from the rim) to be compressed so reinforcement is not needed. Domed slabs are cheaper than reinforced slabs but more care is required in their manufacture and transport. Such slabs have a typical diameter of 1.2-1.5m.

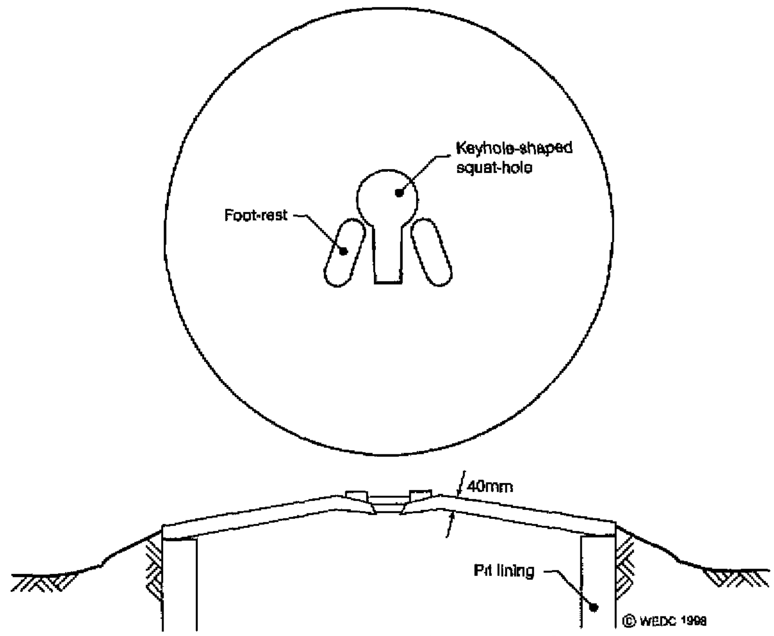


Figure 6.21. Domed latrine slab

Wooden slabs can also be used where concrete is too expensive or is unavailable. Wooden slabs can consist of whole poles covered in mud or soil (Figure 6.22), or can be sawn-timber platforms.

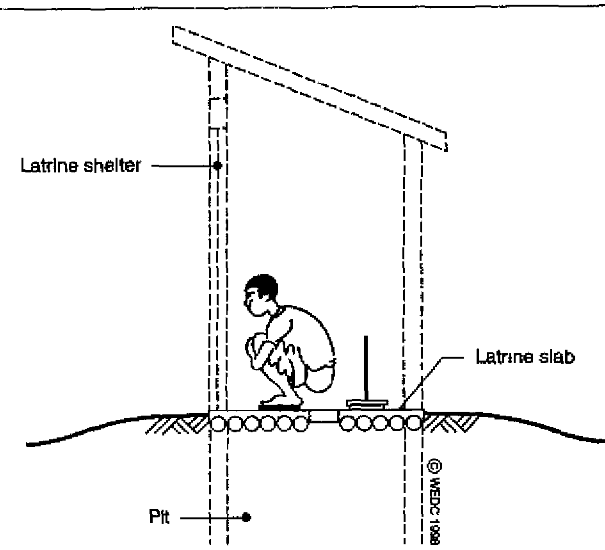


Figure 6.22. Wood and mud latrine slab

Pits with wooden slabs can be improved by placing a small concrete slab (San-plat) on top to cover the area used for defecation. The slab is quite small (typically 400mm x 600mm) but it covers the area of slab most likely to be fouled.

6.8.5 Making concrete

Concrete is a mix of cement, sand, gravel (aggregate) and water. Generally one of the two following design mixes is used:

Cement	Sand	Aggregate	
1	2	4	*Mix 1*
1	3	6	*Mix 2*

Mix 1 will be slightly stronger than Mix 2 due to the increased proportion of cement. In both cases gravel makes up approximately 60 per cent of the volume of concrete. The ratio of water to cement is generally:

Water	Cement	
1	2	*or*
1	3	

Concrete should be mixed on a clean, level mixing area. The following process should be adopted:

1. Measure out appropriate volumes of cement, sand and aggregate (according to the mix ratios above).
2. Shovel half the aggregate onto the mixing area.
3. Add half the sand.
4. Add half the cement.
5. Add the remaining sand.
6. Add the remaining cement.
7. Add the remaining aggregate.
8. Form a 'well' in the middle of the mix and add a small amount of water.
9. Mix the constituents together.
10. Continue adding water and mixing until uniform consistency is obtained.

Once the concrete is poured into the mould it must be **compacted** to eliminate voids (air holes). This can be done manually by using a wooden plank to pound the concrete surface.

The final stage of concrete preparation is **curing**, which simply means keeping the concrete damp while it sets. Concrete can be cured by covering, regular spraying or submerging in water.

The strength and workability of concrete is affected by the:

- concrete mix;
- water/cement ratio; and
- the curing process.

6.8.6 Squat-hole covers

The squat-hole cover for a simple pit latrine is designed to cover the hole when not in use, and to minimise flies and odour. A common problem concerning these covers is that they are often not replaced on the hole after use. This may be due to worries of faecal–hand contamination, or may be because covers are taken away for alternative uses.

In some cases, the cover is designed with a long handle, or is tied with a piece of string to the surrounding superstructure. An alternative design for a squat-hole cover is illustrated in Figure 6.23. Here, a hinged cover is used which can be opened and closed with the use of an attached piece of string, by hand, or even with the user's foot. The hinges can be made from old tyre rubber, which is available in most situations. The rubber hinges can be attached to the reinforcement within a concrete latrine slab, or tied to the wooden poles of a wooden slab.

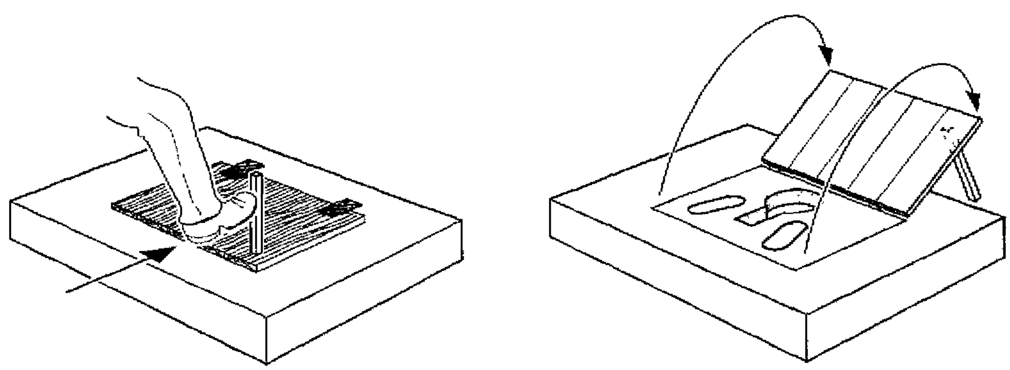


Figure 6.23. Squat-hole cover

6.8.7 Ventilation pipes

For VIP latrines it is important that the ventilation pipe is properly designed. A wide variety of materials can be used, such as uPVC, asbestos cement, fired clay, concrete or even mud covered bamboo or reed. If the pipe is smooth inside (such as plastic or asbestos cement) then an internal diameter of 150mm should be sufficient. Otherwise vent pipes should be at least 200mm diameter or square. The pipe should extend at least 0.5m above the superstructure roof to ensure the air flow is unobstructed.

The fly screen on top of the ventilation pipe should be made of mesh of about 1.2-1.5mm spacing. Mosquito netting is often used. The gases given off by the decomposition of excreta are very corrosive. For this reason, fly mesh made from mild steel will rot very quickly and plastic mesh will last about two years Aluminium or stainless steel are the best materials to use.

6.8.8 Pit excavation and lining

Most single pits for household or family use are about 1m across and 3m deep. It is difficult to excavate pits less than 0.9m diameter because there is not enough room for the person to work. There is no maximum size for a pit and sizes vary greatly.

The best shape for a pit (in plan view) is circular. Circular pits are more stable because of the natural arching effect of the ground around the hole – there are no sharp corners to concentrate the stresses (Figure 6.24). Pits with flat sides are much more likely to need supporting and require a bigger area of lining than a circular pit of the same internal volume. Many communities prefer to excavate square or rectangular pits, however, as their construction is similar to the process used for building domestic houses.

In general, the top 0 5m of a pit should always be lined, but the decision as to whether to line the rest of the pit will depend on the type of soil in which the pit is dug. When a pit is first excavated it may appear stable, and it may be impossible to tell whether or not the walls will collapse after some time. One way in which this can be assessed is to examine other excavations (such as hand-dug wells) in the area. If existing excavations have not collapsed and are not lined, then it is fairly safe to assume that pit latrine excavations will not need lining. Where there is doubt it is advisable to line the pit. Table 6.6 suggests the types of soil that, in general, do and do not require lining.

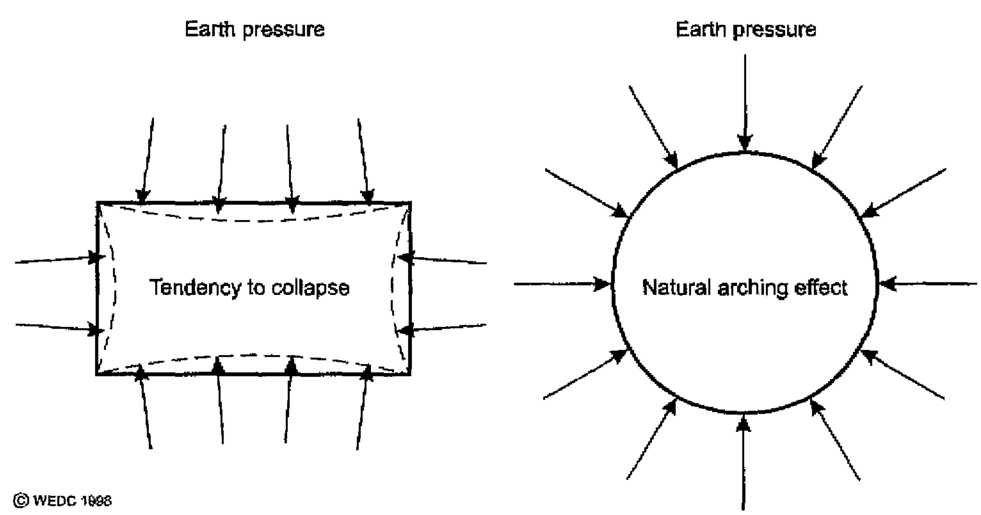


Figure 6.24. Stress concentrations on rectangular and circular pits