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The Water, Engineering and Development Centre is one of the world's leading education and research institutes for developing knowledge and capacity in water and sanitation for sustainable development and emergency relief.

We are committed to the provision of effective, evidence-based and appropriate solutions for the improvement of basic infrastructure and essential services for people living in low- and middle-income countries. With over 45 years of experience, we offer expert advice and quality learning opportunities for sector professionals.

Founded in 1971, WEDC is based in the School of Civil and Building Engineering at Loughborough University, one of the top UK universities. Being a part of a leading university gives us a recognised platform of independence and quality.

What makes us stand out from the crowd is our outreach to practitioners. We use our knowledge base and our applied research work to develop the capacity of individuals and organizations throughout the world, promoting the integration of social, technical, economic, institutional and environmental activities as foundations for sustainable development.

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23 – Latrine pit design

WEDC Developing knowledge and capacity in water and sanitation

GUIDE 23

Latrine pit design

This guide examines some of the factors that need to be taken into account when planning and designing a latrine pit (or twin pits), including the location of a latrine, its shape, volume, liquid capacity and life.

Contents

Associated reading:
Latrine pit excavation and linings

Refer to other guides in this series for further information about the range of latrine types suitable for low-income communities.

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Liquid capacity

Pour-flush latrines and those that are also used for bathing or laundry can store a significant amount of liquid. In dry pits table this liquid will tend to accumulate on the surface of the pit sludge and gradually rise until the surface of the pit wall allows the liquid to infiltrate into the surrounding soil (Figure 7).

In impermeable soils, the use of pour-flush latrines or allowing wastewater from bathing and laundry to enter the pit quickly could fill the pit with liquid. This problem is seen most often in peri-urban areas where water consumption is higher. The solution is to either:

- empty the solids out of the pit more frequently so that there is more room for liquid storage;
- dig an overflow pit to take the excess liquid;
- find alternative disposal methods for the bathing or laundry liquids; or
- use another sanitation system designed to accommodate the additional liquid (such as a septic tank with infiltration).

Pit life

The life of the pit is the time taken for it to fill.

In rural areas, single pits should usually be dug as deep as possible so that it takes a long time for them to fill. A minimum design life of ten years is recommended.

In urban areas, where pit emptying, is carried out it makes more sense to limit pit depth to about 1.5 metres. People usually prefer to have a small amount of the contents emptied more frequently, than a large amount occasionally, as it is a more affordable option.

Why don't we use the top half metre of a pit latrine?

A pit is usually considered full when the contents reach 0.5m from the pit slab. There are a number of reasons for this.

If the pit is to be replaced when it is full, then 0.5m of soil on top of the wastes will make the area safe to walk over so anyone treading over the site will not sink in.

It will also prevent domestic animals from burrowing into the pit, looking for food.

The soil layer will prevent any fly larvae that may have been breeding in the waste from escaping.

Furthermore, the increased incidence of problems with odour, flies and splashing as the content reaches close to the top. The pit contents will also be visible which may offend users and dissuade them from using the latrine.

Wet pits or dry pits?

Pits that are partly below the water table and therefore permanently contain water are known as 'wet pits'.

Generally, micro-biological activity is greater in wet conditions than dry ones. Also the solids can be more efficiently compacted under water (there will be fewer voids).

It is also thought that the flow of water through the pit carries more of the wastes into the surrounding soil than happens in a dry pit.

This is why the sludge accumulation rate for wet pits is much lower than for dry ones.

Volume

The volume of a pit affects how long it will take to fill and hence its life before emptying or replacement. Estimating how long that will be is not easy. The key factors affecting the rate at which a pit fills are:

- the number of users;
- the volume of fresh human waste deposited into the pit;
- the volume of other wastes; and
- the sludge accumulation rate.

In the absence of local knowledge the figures given in Table 3 could be used. These figures are long-term accumulation rates. In shallow pits (such as are used for twin pit latrines) these rates will be too low. In this case, you should increase the figures by 50%.

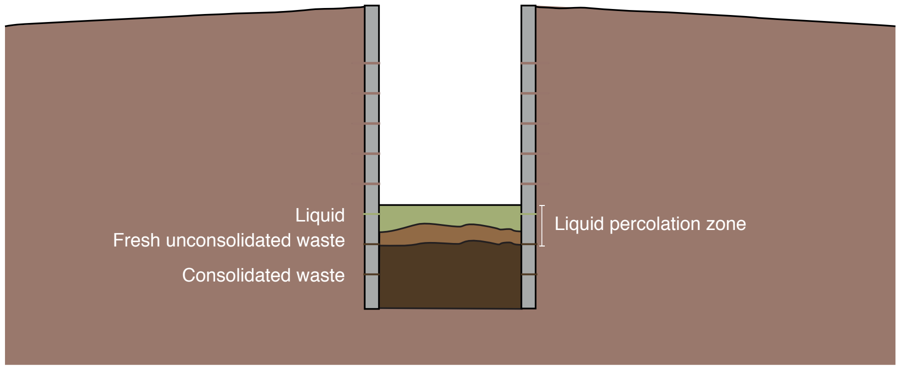


Figure 6. Liquid percolation zone in a pit latrine

Pit location

A latrine is no use if users can't reach it. This is particularly important if the latrine is a long way from the house and/or if some of the users have difficulty walking. So access to the latrine is a major consideration in the location of the latrine which will in turn impact on the design of the latrine pit.

Key design features

When planning and designing a latrine, make sure:

- to plan to build the latrine as close as possible to the living area;
- the access path is at least 120cm wide and built of materials that give a smooth but non-slip finish;
- slopes and steps are kept to a minimum and if essential slopes are designed at less than 1 in 12;
- a hand rail next to the steps or a slope is included; and
- the path is designed to be easy to see at night.

Assuming there is no possibility or concern as a result of polluting groundwater, the location of a pit for excreta disposal depends on the type of latrine used.

Remember a latrine will last a family many years. All the users may be fit and active when the latrine is built but this may not be the case in years to come.

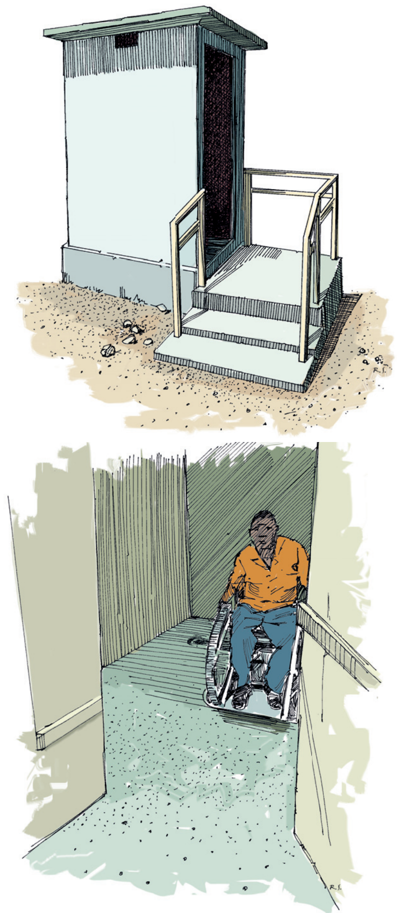


Figure 1. Consideration should be given to all users, particularly those with mobility difficulties

Simple pit latrines should be built away from the home to prevent nuisance from odour and flies. A distance of about 10 metres is usual but some users feel that the convenience of a nearby latrine outweighs the inconvenience caused by the odour and flies, so choose to locate them closer to the home.

Pour-flush latrines can be built very close to, or as part of a house, provided the house has good foundations to prevent subsidence and the pit lining is strong enough to withstand forces placed on it by the weight of the house wall.

VIP latrines, if properly designed, can also be placed close to the house provided the ventilation pipe rises above the roof of the dwelling and there is free access for air to flow into the superstructure.

Distance from a water source

Much of the liquid and organic matter deposited in a pit will eventually seep into the surrounding soil. These liquids are hazardous and could contaminate nearby water sources. Fortunately most natural soils are very efficient at removing the hazardous elemants so, given sufficient time, natural processes will neutralize the contamination. The two most important factors governing natural purification are the depth to the water table and the distance between the latrine and the water source.

Depth to water source

Table 1 suggests the minimum distance between the bottom of the pit and the highest level of the groundwater table to ensure total removal of organic wastes. If the pit meets this criteria then it can be located as little as 10m from the water source.

Lateral separation

If the depth to the water table is less than that suggested in Table 1 then the groundwater will be contaminated and require further time to purify itself. Table 2 suggest the maximum lateral separation between the pit and the water source. If you are not sure of the ground conditions then Figure 2 suggests a safe distance of 40 metres between the latrine and a water point.

Shape

The best shape for a pit (as viewed from above) is circular. Circular pits are more stable because of the natural arching effect of the ground around the hole and there are no corners to concentrate the stresses (Figure 4). Pits with flat sides are much more likely to need supporting and require a larger area of lining than a circular pit of the same internal volume.

However the shape is not particularly important and many communities prefer to excavate square or rectangular pits, as their construction is similar to the process used for building domestic houses.

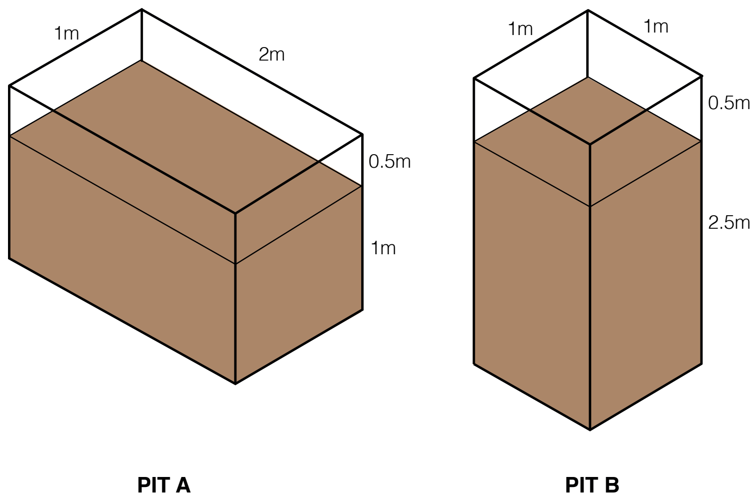


Figure 6. Two pits with the same total volume but a different effective volume

Table 3. Sludge accumulation rates

Wastes deposited and conditions	Sludge accumulation rate (litres per person per yr) Box 3
Wastes retained in water* *Degradable anal cleaning materials used (e.g. paper*	40
Wastes retained in water *Non-degradable anal cleaning materials used (e.g. stones, sticks)*	60
Wastes retained in dry conditions *Degradable anal cleaning materials used*	60
Wastes retained in dry conditions *Non-degradable anal cleaning materials used*	90

** The term 'wastes retained in water' when applied to a pit latrine means that the wastes are in a section of the pit below the water table.*

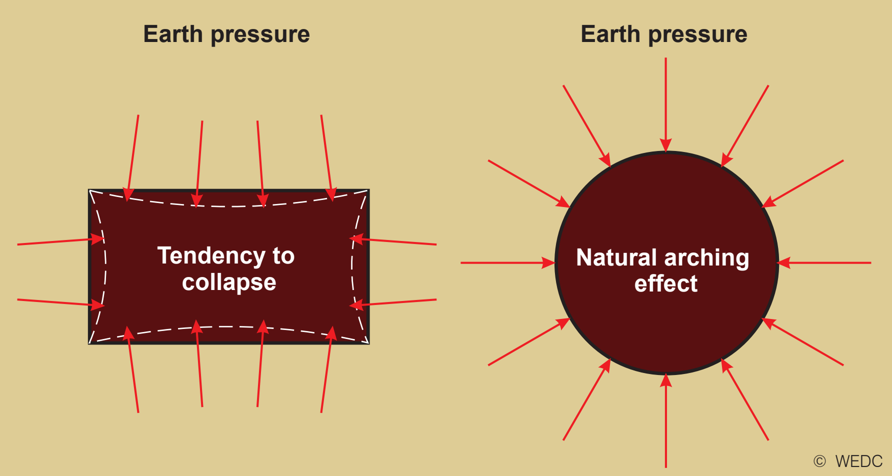


Figure 4. Stress concentrations on rectangular and circular pits

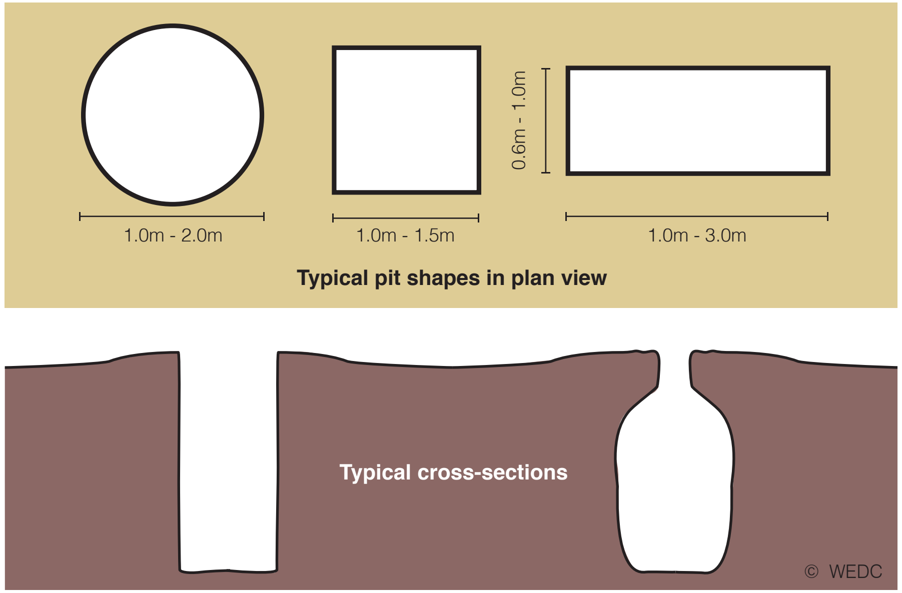


Figure 5. Typical pit latrine shapes

Table 1. Assessment of risk following attenuation of micro-organisms within the unsaturated zone

Rock types in unsaturated zone	Depth to water-table (minimum depth) (metres below base of pit)		
	<5	5-10	>10
Fine sand, silt and clay	■	□	□
Weathered basement*	■	■	□
Medium sand	■	■	□
Coarse sand and gravels	■	■	■
Sandstone/limestones fractured rock	■	■	■

■ Significant risk that micro-organisms may reach water-table at unacceptable levels
□ Low to very low risk that micro-organisms may reach water-table at unacceptable levels i.e. travel time through the unsaturated zone greater than 25 days

* where the weathered material is soft and easily dug. Where weathered rock is competent and therefore potentially fractured would be considered as fractured rock.

Table 2. Minimum separation distances between pollution points and groundwater sources

Soil/rock type	Approximate minimum distance (m)
Silt	10*
Fine silty sand	15
Weathered basement (not fractured)	25
Medium sand	50
Gravel	500
Fractured rocks	Not feasible to use horizontal separation as protection

Note: 10m is the minimum distance an infiltration system should be from a water source because of the risk of pollution from localised pollution paths such as fissures, crack and disturbances caused by construction.*

These figures are for individual latrines. Pollution from large numbers of latrines in a small area (such as an urban slum) will be far greater. In this situation find another water source.

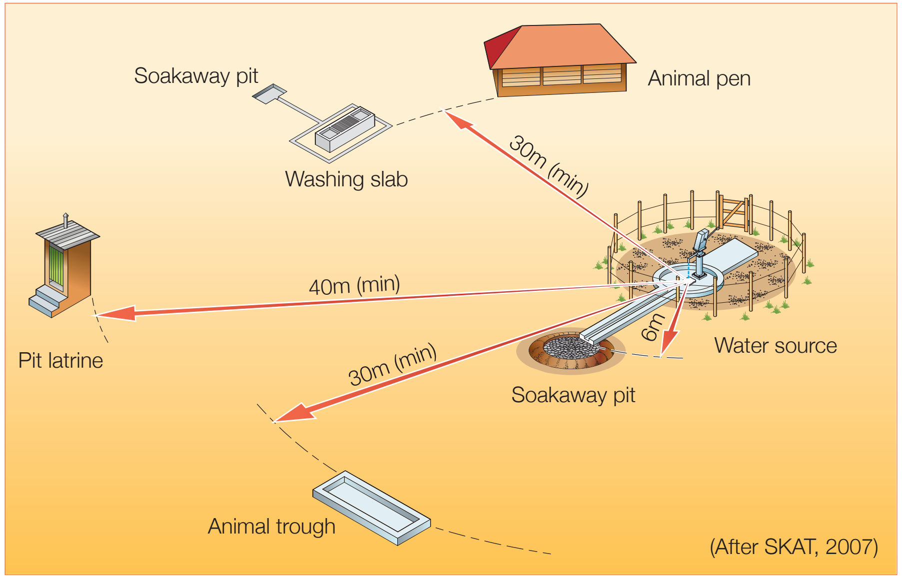


Figure 2. The location of a latrine at a safe distance from water sources is 40m (minimum)

Figure 3. Digging a circular pit

Typical pit shapes are shown in Figure 5.

The shape of a pit also affects how long it will take to fill. For the same volume, a wide shallow pit will fill more quickly than a deep narrow one. This is because the top 0.5m of the pit is not used and so is effectively wasted.

Figure 6 shows two pits A and B, each having a total volume of three cubic metres.

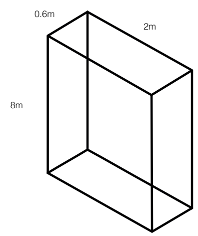
Pit A has a useable volume of two cubic metres whilst pit B has a useable volume of two and a half cubic metres.

Pit shapes in Uganda

In Uganda, pits are frequently over 8m deep, 2m long but only 0.6m wide.

This shape is preferred by the builders as it enables workers to climb in and out of the pit without using a ladder.

Instead, the workers cut foot holes in the side of the walls alternately on opposite sides of the pit.



Effect of shape on the quantity of pit lining

Suppose we dig a pit latrine 1.5m *square* and 3m deep.

The volume of the pit will be:

$1.5 \times 1.5 \times 3 = 6.75m^3$

The area of the pit lining will be:

$1.5 \times 3 \times 4 = 18m^2$

The area of the slab will be:

$1.5 \times 1.5 = 2.25m^2$

Consider the characteristics of a circular pit of the same depth (3m) and volume ($6.75m^3$). The plan area of the pit (i.e. the area as though looking from above) will be the volume divided by the depth:

$6.75m^3 \;/\; 3m = 2.25m^2$

As the area of a circle is equal to πr^2 then the radius of the pit will be:

$(2.25 / \pi)^{½} = 0.85$ m

The length of the perimeter of the pit is equal to:

$2 \times \pi \times 0.85 = 5.34m$

Therefore the area of the pit lining will be:

$5.34 \times 3 = 16.02m^2$

This is nearly $2m^2$ less than that required for the square pit.