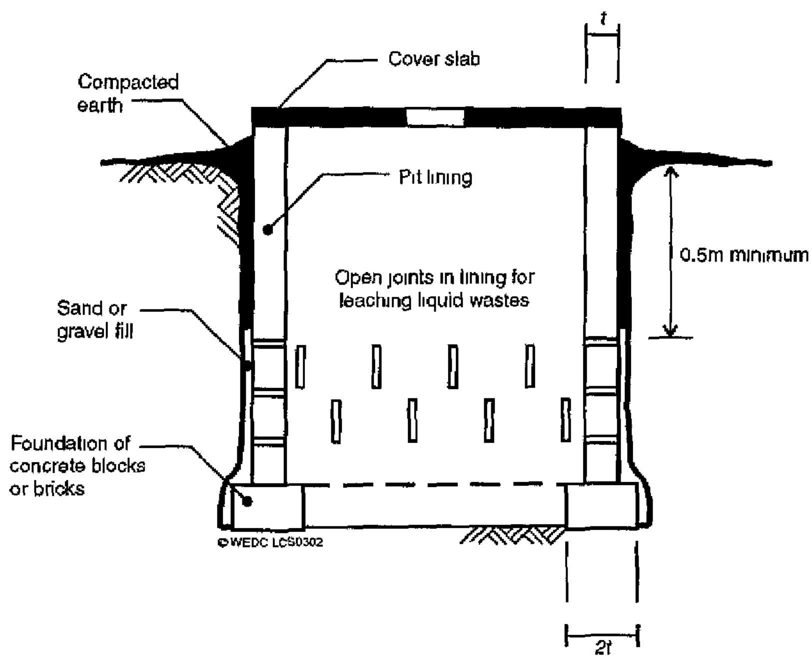

Figure 6.25. Shallow pit with lining

6.8.9 Sizing pits

In order to size pits or tanks it is important to determine the rate at which sludge (including faeces, urine and anal cleansing material) will accumulate, and the rate at which effluent will infiltrate into the surrounding ground. The top 0.5m of a pit should not be filled, this is to allow safe back-filling and to prevent splashing, unpleasant sights and increased incidence of problems with odour and flies.

The approximate size of the pit in m^3 can be calculated from the following equation:

$$\text{Volume of pit, } V = \frac{(N \times S \times D)}{1000} + 0.5A \qquad \rightarrow \text{Equation 1}$$

Where: N = number of users
S = sludge accumulation rate (litres/person/year)
D = design life (years)
A = pit base area (m^2)

If the size of the pit is fixed, the time taken to fill it can be calculated by rearranging Equation 1 to find the design life:

$$\text{Design life, } D = \frac{(V - 0.5A) \times 1000}{(N \times S)}$$

Sludge accumulation rates vary greatly and local figures should be obtained if possible. In the absence of local knowledge, Table 6.7 gives guideline sludge accumulation rates for different wastes and conditions.

Table 6.7. Suggested maximum sludge accumulation rates[a]

Wastes deposited and conditions	*Sludge accumulation rate 'S' (litres per person per year)*
Wastes retained in water where degradable anal cleaning materials are used	40
Wastes retained in water where non-degradable anal cleaning materials are used	60
Wastes retained in dry conditions where degradable anal cleaning materials are used	60
Wastes retained in dry conditions where non-degradable anal cleaning materials are used	90

[a] *Source: Franceys et al., 1992*

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

In many emergency situations latrines are subjected to heavy use and exreta and anal cleansing materials are added much faster than the decomposition rate. Where this is the case it is suggested that these sludge rates be increased by 50 per cent.

Worked example: A dry pit latrine is to be used by 20 people for a period of two years, and degradable corncobs are used for anal cleansing. The base of the pit is to be 1m by 1m square.

N = 20
S = 60 l/year (from Table 6.7)
A = 1 x 1 = $1m^2$
D = 2 years

$$V = \frac{N \times S \times D}{1000} + 0.5A$$

$$\Rightarrow V = \frac{20 \times 60 \times 2}{1000} + 0.5 = 2.9\ m^2$$

Since the cross-sectional area is $1m^2$, this pit would therefore need to be 2.9m deep.

The pit is considered full when the sludge reaches 0.5 m below the latrine slab. At this stage the pit should be replaced or emptied.

Important note: This method assumes that liquid wastes are absorbed by the surrounding ground. If liquid remains in the pit it will fill much more quickly. This is likely to happen where large volumes of water are used, where pit walls have a low infiltration capacity, or where the pit is poorly ventilated. It should also be noted that soil pores become clogged with time, reducing or even stopping infiltration. For this reason, pits should be over-sized rather than under-sized, especially where soil infiltration rates are relatively low.

Infiltration rates for different soil types are difficult to determine; for more information refer to Section 4.3.2.

6.8.10 Septic tank design

In designing a septic tank, in general, the length of the first compartment should be twice the length of the second. Guidelines for the sizing of a septic tank are given below.

> Total tank volume (C) = clear liquid retention volume (A) + sludge and scum volume (B) + ventilation space (V)

Clear liquid retention volume is the volume required for storing the liquid wastewater:

$$A = Q \times T/24$$

Where: A = retention volume (m^3)
Q = volume of wastewater treated per day (m^3)
T = tank retention time (hours)

Table 6.8. Recommended septic tank retention times

Daily wastewater flow	*Retention time 'T' (hours)*
Less than $6m^3$	24
Between 6 and $14m^3$	33 – 1.5Q
Greater than $14m^3$	12

The volume required for storing sludge and scum can be estimated by:

$$B = P \times N \times F \times S$$

Where: B = required sludge and scum volume (m^3)

P = number of people served
N = number of years between desludging (2-5 years)
F = factor for sludge digestion rate (see Table 6.9)
S = rate of annual sludge and scum production (m^3/person/year)
Generally, S = 0.025m^3/person/year for toilet wastes only
S = 0.040m^3/person/year for toilet wastes and sullage

Ventilation space (V) is the volume of air space required between the top of the liquid and the base of the cover. This should be of a depth of 300mm, and is to allow for scum above the liquid and space for gases to escape to the ventilation system.

Total tank volume, $C = A + B + V$

The minimum size required to produce the necessary calm conditions in a septic tank is 1.3m^3. If the value of A + B is less than this then the value 1.3m^3 should be used. This minimum value does not apply to aqua privies however.

Table 6.9. Value of sludge digestion factor 'F'

Years between desludging	*Average air temperature*		
	Greater than 20°C all year	*Between 10°C and 20°C all year*	*Less than 10°C in winter*
1	1.3	1.15	2.5
2	1 0	1.15	1.5
3	1.0	1.0	1.27
4	1.0	1.0	1.15
5	1.0	1 0	1.06
6 or more	1.0	1.0	1.0

6.9 Emptying pits

Many of the technology choices described above involve the construction of a pit or tank which does not rely on infiltration but will need emptying if used in the long term. Where possible, pits should be appropriately sized or replaced to prevent the need for regular emptying. This is not always possible, often due to lack of space, and where this is the case facilities for emptying must be in place. Pit emptying is most difficult where pits fill fast, where hard or plastic anal cleansing materials are used, and where vehicular access is difficult.

6.9.1 Mechanical pumps

The easiest and most hygienic method for emptying latrines is to use a vacuum tanker (sometimes know as a 'sludge-gulper') which is a truck with a large tank fitted with a mechanical pump (Figure 6.26). After pumping out the contents of the pit, the tanker can be driven to a safe disposal site, such as an off-site underground pit or sewage treatment works, where the contents can be emptied.

Vacuum tankers are good at removing liquids but poor at removing solid material. Dry pits or pits containing large quantities of solid materials such as stones, sticks, plastic bags, etc. cannot be emptied. Another problem with vacuum tankers is that they are very large and may be difficult to manoeuvre close to latrines.

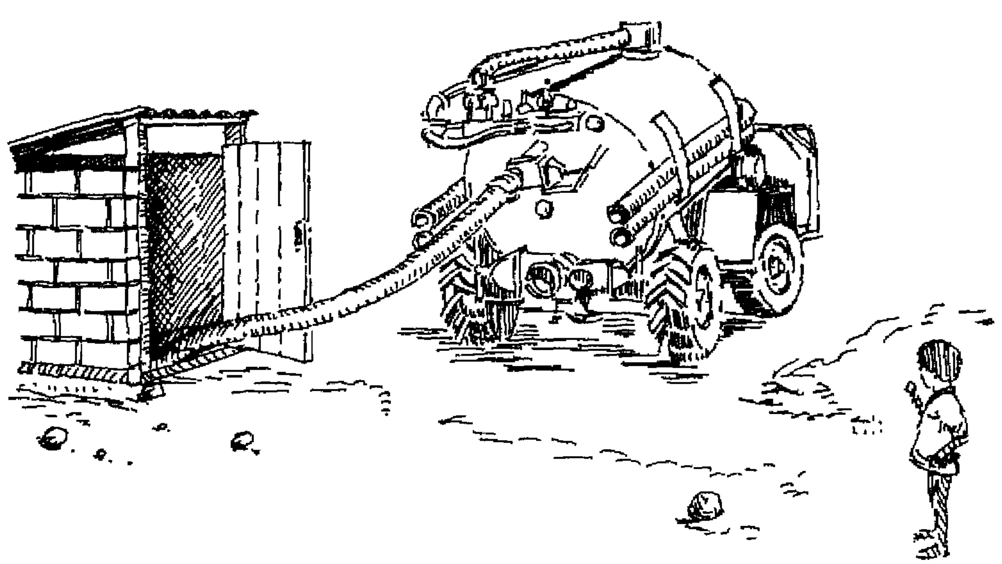

Figure 6.26. Vacuum tanker emptying latrine pit

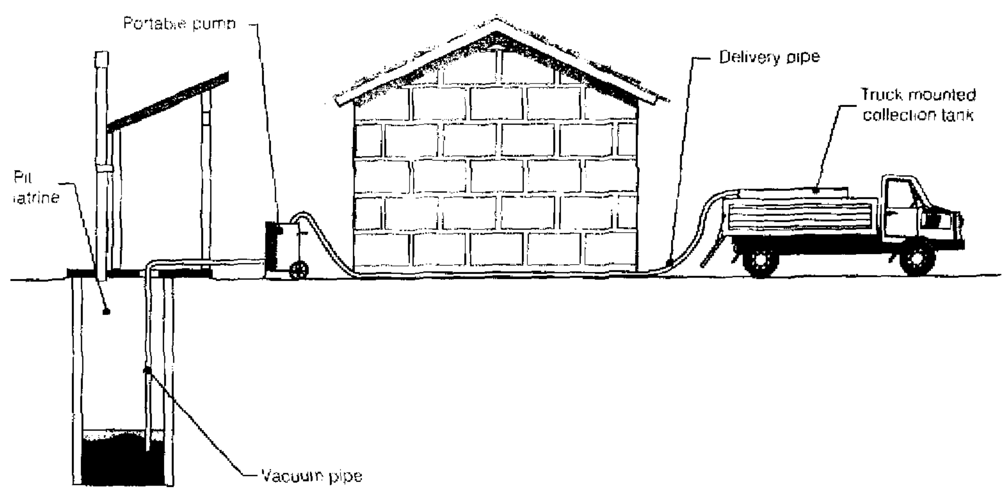

Figure 6.27. Vacuum tanker with remote pumping unit

Where a purpose-built vacuum tanker is unavailable or inappropriate, a collection tank can be mounted on a flat-bed truck, and a portable pump used to pump the waste from the pit to the tank (Figure 6.27). Such pumps must be carefully selected, particularly where hard anal cleansing materials are used, and specialist sewage pumps are recommended. Again, this is most suitable for wet conditions, and if necessary a small volume of water can be pumped into the pit first and stirred into the sludge to help liquify it.

6.9.2 Hand-operated pumps

Hand-operated latrine-emptying pumps are available in some countries. These are usually mounted on a hand-pushed cart which can be wheeled close to the pit to be emptied. These are much slower in operation than a mechanical pump and experience in their use is likely to be necessary. Such pumps are most appropriate if available and used locally, and where pit contents are wet.

6.9.3 Manual emptying

As a last resort, pits can be emptied of waste manually. This generally involves workers climbing into the pit and using shovels and buckets to take the waste out. This can then be placed in a wheelbarrow, or truck, and taken to a safe off-site disposal site. This should only be attempted once a pit has been closed and the contents left to decompose for some time (preferably at least two years).

Failed unlined trench latrines, Sudan

The following are commonly used pit lining materials:

- Pre-cast concrete rings
- Cast in-situ concrete
- Clay rings
- Oil drums
- Soil/cement blocks
- Local dressed stone
- Burnt bricks
- Concrete blocks
- Termite resistant timber
- Ferrocement

Bamboo and cane can only be used for short-term pits (usually less than two years). Figure 6.25 shows details of the construction of a shallow pit with lining.

6.9.4 Sludge reduction

Sludge reducing agents have been developed to speed up the sludge digestion process. These bioadditives are designed to boost one or more of the three basic ingredients of digestion: nutrients, enzymes and bacteria. If successful, such bioadditives could be added to pit latrine contents so that pits will require emptying less frequently. Recent trials have indicated that some bioadditives are successful in reducing sludge volumes and reducing fly infestation (Redhouse, 2001), however there appear to be significant constraints in their application. Due to the generally faster rate of sludge accumulation in emergencies it is not yet known how appropriate such technologies are in emergency sanitation programmes.

6.9.5 Sludge disposal

Sludge that has been left undisturbed for over two years is not a hazard to the environment. It can safely be spread anywhere convenient such as a garden or refuse tip. Its fertiliser value is not good but it will add humus and fibre to the soil which will promote plant growth.

Open disposal of fresh sludge into water or onto land is undesirable as it is an environmental and health hazard The best solution is to bury sludge in pits where it cannot come into contact with humans or animals, and will not contaminate groundwater sources. Alternatives are to mix it with the influent at a nearby sewage works or compost it with domestic refuse.

References and further reading

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