

Sanitation

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1 Introduction

1.1 Sanitation as a global problem

According to WHO and UNICEF, millions of children suffer from malnutrition, low school-attendance rates, and economic losses due to diarrhoeal diseases that are preventable by adequate sanitation. Human excreta spreads intestinal parasites, which affect 1.5 billion people around the world (WHO, 1998), and is also responsible for the transmission of diseases such as shistosomiasis, cholera, typhus, and many other infectious diseases affecting hundreds of millions of people. The most affected populations live in extreme poverty in developing countries, particularly in peri-urban and rural areas.

Table 13.I shows global sanitation coverage and that of developing countries in 1990 and 2000. It is worth noting the difference between rural areas (40%) and urban areas (83%). The sanitation coverage is even lower in the rural areas of the least developed countries (35%). Further, while there has been an important world-wide improvement in sanitary conditions between 1990 and 2000, the least developed countries have not improved at the same rate, as indicated by the very low sanitation figures.

Table 13.I: Sanitation Coverage Data (source : Global Assessment 2000, Who and UNICEF Joint Monitoring Programme, <http://www.wssinfo.org>).

	1990 Population served (%)	2000 Population served (%)
Global Sanitation Data		
Urban	79	83
Rural	28	40
TOTAL	51	60
Least Developed Countries		
Urban	73	71
Rural	33	35
TOTAL	41	44

1.2 The importance of sanitation

Studies (Esrey et al. 1991) have shown that the most significant reductions of diarrhoeal diseases are achieved via sanitation and hygiene promotion improvement, whereas improvement of water supply alone has a more limited impact on health (reduction of diarrhoeal morbidity of 36% through sanitation improvement and 16% through improvement of water quality alone), see Figure 15.2. Despite this, sanitation is often seen as a simple add-on to water supply projects and not considered as an independent solution to a need. In other cases, large investments made on water-distribution systems often have limited impact on health, due to the lack of sanitation activities on the same project.

Hence, when the general objective of a project is to reduce the risk of morbidity, water supply, sanitation and hygiene promotion interventions have to be planned and implemented in an integrated manner.

In some emergency contexts, where there are high concentrations of people in camps for refugees or internally displaced persons (IDPs), the risk of epidemic outbreaks (e.g. of cholera, bloody diarrhoea etc.) is high, as sanitary risks increase with increasing population density. Here, excreta control is a key factor that may limit the development and transmission of diseases. Thus, in an emergency intervention, provision of sanitary infrastructures, particularly those related to excreta disposal, must be considered as a priority.

Environmental Sanitation includes the following: excreta-disposal systems, waste-water disposal systems, solid-waste disposal systems, rain-water drainage systems, and vector control. This chapter deals essentially with the management and disposal of human excreta and briefly presents other aspects of environmental sanitation.

2 Sanitation-related diseases and their control

Pathogenic organisms that cause intestinal diseases (see Table 13.11), live in excreta or faecal materials of humans and animals. Infection of a human being occurs via:

- the direct contact of unclean hands with the mouth or with food and water;
- the use of water contaminated with faecal material;
- transmission through the fertilization of agricultural land with faecal material or black-water (effluent of wet latrines or sewerage systems);
- vector transmission.

The inappropriate disposal of solid and liquid waste contributes to the development and transmission of several types of diseases as it facilitates the development of pathogens, and of vectors (see Section 5.4).

Table 13.II shows a summary of a classification of pathogens according to the diseases they transmit and their origin.

Table 13.III shows the potential impact of sanitation and personal hygiene on the different groups of excreta-related diseases. For the majority of these diseases, excreta-disposal systems are one of the important control measures.

Table 13.II: Pathogens present in urine, excreta and grey-water (domestic wastewater)
(source: Franceys, Pickford & Reed, 1992).

Pathogen	Name of the disease	urine	Present in excreta	grey-water
Bacteria				
<i>Escherichia coli</i>	Diarrhoea	X	X	X
<i>Leptospira interrogans</i>	Leptospirosis	X		
<i>Salmonella typhi</i>	Typhus	X	X	X
<i>Shigella</i> spp.	Shigellosis		X	
<i>Vibrio cholerae</i>	Cholera		X	
Viruses				
<i>Poliovirus</i>	Poliomyelitis		X	X
<i>Rotaviruses</i>	Enteritis		X	
Protozoa - amoeba or cysts				
<i>Entamoeba histolytica</i>	Amoebiasis		X	X
<i>Giardia intestinalis</i>	Giardiasis		X	X
Helminths - parasite eggs				
<i>Ascaris lumbricoides</i>	Roundworm		X	X
<i>Fasciola hepatica</i>	Liver fluke		X	X
<i>Ancylostoma duodenale</i>	Hookworm		X	X
<i>Necator americanus</i>	Hookworm		X	X
<i>Schistosoma</i> spp	Shistosomiasis	X	X	X
<i>Taenia</i> spp	Tapeworm		X	X
<i>Trichuris trichiura</i>	Whipworm		X	X

Table 13.III: Impact of sanitation and personal hygiene on excreta-related diseases
(source: adapted from Cairncross & Feachem 1993).

	Category	Sanitation Impact
I	Faecal-oral non-bacterial	Negligible
II	Faecal-oral bacterial	Weak to moderate
III	Soil-borne helminths	Strong
IV	Cow and pig parasites	Strong
V	Water-borne helminths	Moderate
VI	Vectors (insects)	Weak to moderate

3 Key elements for the implementation of an environmental sanitation project

3.1 Importance of socio-cultural factors and of the community perception of sanitation

3.1.1 AN OBLIGATORY STEP

The success of sanitation projects depends on their acceptance by the community and of their suitability to the community's living conditions. This is true for all types of project, but it is especially important for sanitation programmes. Sanitation issues are intimately related to the habits and behaviour of the community, which are substantially affected by social and cultural factors.

Consequently, the first step towards the design of a sanitation project is the assessment of the different socio-cultural and behavioural factors related to sanitation. As such, the involvement of the community from the design and planning stages of the project is important. The relevance of the sanitation system to needs depends not only on a good technical design but also on its acceptance by the community, and must be adapted to their living habits. The importance of anal cleaning habits (usage of water, stones, paper etc.) is an example of how community habits influence the design of a sanitary system.

3.1.2 SOCIO-CULTURAL FACTORS, BELIEFS AND PRACTICES

Excreta control is a very sensitive issue for many communities and special attention is required to deal with cultural and religious factors. Defecation is often a private matter that people are hesitant to talk about due to embarrassment, disgust or other personal reasons.

Sanitation has a religious connotation for some cultures. For instance, people might bury excreta to eliminate bad spirits. For another example, in the emergency sanitation programme ACF carried out in the Mindanao region of the Philippines, the team realised after the construction of several latrines that those facing Mecca were not used. This factor had to be integrated into the construction of new latrines.

In other cultures it has a social connotation. Contact with excreta may be unacceptable or may be the responsibility of specific social groups, and addressing this issue might require different strategies depending on the structure of the society.

The links between the lack of sanitation and occurrence of diseases is not clear to many communities. However, the behaviour of individuals regarding sanitation has a logic and people are often conscious of the environmental causes leading to the deterioration of health. In general, there is an understanding of the environment, not only in a physical sense but also of its relationship with social and spiritual factors. This holistic vision of the environment is imbedded in many cultural beliefs and habits that affect sanitary behaviours and the use of water. Therefore, it is crucial to determine how

the beliefs, knowledge and management of the environment by the community affect sanitation and how these can be adapted for any potential programme. The most important thing is to be aware of, and respect, the beliefs of the community.

Community habits are not only related to beliefs but also to knowledge. For example, numerous communities around the world believe that children's excreta does not constitute any danger to health, when in fact children have a higher incidence of excreta-related diseases than adults (Thomson et al. 2001), so their excreta is more often pathogenic. This misconception is an important factor in the transmission of disease. Failing to consider this belief would largely reduce the impact of the project.

Community beliefs and practices have to be comprehensively analysed before choosing the technical designs and implementation methods of any sanitation project. Techniques such as KAP (Knowledge, Attitudes and Practices) assessments, and more participatory techniques, are used to perform this analysis. These techniques are presented in Chapter 15.

The results of these assessments allow the planning of:

- the method of implementation of the project (including the potential for community participation);
- technical characteristics of sanitary infrastructure (standard latrine designs, water use, maintenance etc.);
- and the location of the latrines (inside or outside the house, orientation of the door, indication for women, security for vulnerable groups etc.).

3.1.3 SANITATION AND GENDER

Gender is an important issue affecting a sanitation intervention because of the different perception among men and women regarding sanitation, different needs and habits, and because men and women play different roles in sanitation management.

Women are often responsible for hygiene and sanitation tasks in a community, and for the education of children. In general, women have a better perception of the impact of sanitation on health than men, and are often more pro-active on this issue. Therefore, they are an important means for disseminating information to all members of families within the community. Hence, the participation of women is a key factor in the success of a sanitation project.

Privacy and the risk of sexual abuse are also important when considering the needs of women. Concerning privacy issues, it is important to be aware that in many cultures it is unthinkable that men and women would share the same latrine. Access to public latrines or latrines outside of the house may also be forbidden for women in Muslim countries. For instance in Kountaya, Guinea Conakry, ACF segregated latrines according to gender. Concerning sexual violence, building latrines in isolated, bushy areas without lighting can be dangerous for women during the night, especially in refugee camps.

3.2 Sanitation promotion

Many people do not consider sanitation as a priority, due to lack of knowledge and awareness, and hence they are not convinced of its importance to health.

Although communities often request water and energy interventions, environmental sanitation is rarely asked for.

Consequently, when the need for a sanitation project is identified, the key issue is to stimulate demand through promotion activities. However, hygiene promotion must not be considered as a secondary task or simply as an activity attached to the construction of sanitation facilities. Hygiene-promotion techniques and methodologies are described in Chapter 15.

The acceptance of sanitation facilities by the community depends not only on their understanding of the impact of sanitation on health, but also on other social factors. For instance, it is possible

to promote community pride or ownership in the construction of new latrines. The ownership and use of a latrine by some people in a community, compared to others who continue to defecate in the open, may be used in social promotion, where latrine owners showcase their latrine to others, and thus promote the desire for having a latrine among the entire community. The technical design of the latrine has to integrate such factors. For instance, it is possible to promote the construction of VIP latrines, using the distribution of ventilation pipes to generate interest.

3.3 Working modes and community participation

Community participation is crucial for the success of sanitation projects. A higher level of community participation means a higher degree of ownership of the project by the community and an increased potential for success and sustainability of a clean environment. Considering the problems related to many people's interest in sanitation, it is of paramount importance to involve communities in each phase of the project, from the project definition to construction and maintenance. The degree of participation in a sanitation project is a measure of the degree of interest achieved in a community, and indicates the probability of success of the project.

Technically, sanitation works are not complicated. The role of the external technician consists of promoting the importance of sanitation, supporting people with materials if necessary and providing technical advice to the community.

Latrine construction (digging the latrine pit and building the superstructure) is mostly carried out by the community members themselves. Where concrete slabs are used in the latrine design, a slab workshop can be organised by the community, by the implementing organisation or by an external technician.

3.4 School sanitation and children's issues

Children are often one of the most vulnerable groups within communities, especially for health issues. They are generally more susceptible than adults to excreta-related infections, and prevalence of these diseases among school children is often relatively high. Schools are sites of high risk for disease transmission and must be considered an intervention priority for water and sanitation programmes.

Furthermore, as shown in previous sections, sanitation activities require a high level of support through hygiene promotion. Here, schools play an important role in the training and education of children. Children are more receptive to learning correct hygiene practices than adults, and a long-term impact on sanitation is more likely. An additional advantage of involving schools in hygiene promotion is the cooperation of teachers who are often qualified and have the trust of the children.

Sanitation interventions in schools have an impact on the entire community. On one hand the installations provide a model of correct sanitation, and on the other hand the children promote the construction of sanitation infrastructures and correct hygiene practices within their families. This is vital for a programme, considering that direct hygiene promotion with adults is often difficult, because of long-established beliefs and practices.

The sanitation facilities in schools need to be designed taking into account that they will be used by children, thus it is important to:

- set the height of the water points and hand-washing systems so that children may have access to them;
- take care with the dimensions of hole of the latrine slab;
- design ventilated latrines with an indirect entry and without doors, so that the cubicle remains sufficiently dark for fly control, as children tend to leave doors open;
- put emphasis on the maintenance of the structures, and involve the children in this through sensitisation about their correct use.

3.5 Sanitation and groundwater contamination

Groundwater contamination is a risk associated with the use of on-site sanitation. There is a risk of exposure to biological or chemical agents where the community's water is sourced from an aquifer close to the surface. This contamination is normally due to infiltration of these agents from latrines, leaching from solid-waste disposal sites or infiltration of domestic wastewater.

The risk of bacterial and viral contamination of groundwater depends on factors that include soil mineral composition and porosity, hydraulic gradient, soil organic content, soil pH and electrostatic properties, and rainfall. However, the most important factors are underground water flow and persistence of the micro-organisms in the environment. To be certain, a piezometric study and/or a tracer study should be carried out to define groundwater flow conditions accurately. It is impossible to define, a priori, the propagation pattern of bacterial pollution.

Nevertheless, according to the *Guidelines for drinking-water quality* (volume 3, WHO 1997), it is possible to define the minimum distance between latrines and water points using the following guidelines:

- in a non-saturated area, and therefore in the absence of groundwater flow, pollution migration is very limited: lateral pollution movement is almost non-existent and vertical movement is limited to 3 m (Figure 13.1.A). Nevertheless, in the event of massive infiltration of surface water (for example, heavy rain), the transport of pollution away from its source may be greater;
- in a saturated area with continuous groundwater flow, for a flow rate of 1-3 m/day, pollution moves up to 11 m in the direction of groundwater flow (Figure 13.1.B);
- in a fractured or karstic area, groundwater flow is difficult to predict, but is usually very rapid. Therefore, pollution can be carried over considerable distances. This was the case for a well rehabilitated by ACF in Myanmar in fractured micro-sandstone (under thin cover), where a correlation between high rainfall and a peak in pollution was observed.

However, it is not always possible to determine the exact nature and hydrological condition of underground formations, so a minimum safety distance of 30 metres between latrines and water points is widely recommended. If it is not possible to respect this distance, see Section 4.6 for technical options.

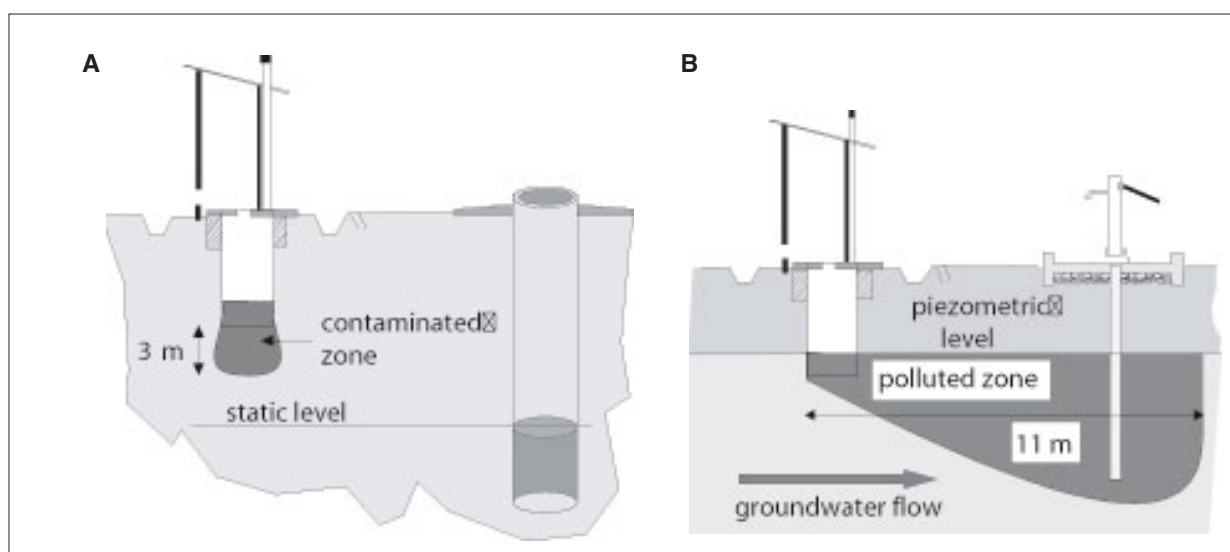


Figure 13.1: Migration of bacterial pollution.
A: non-saturated zone. B: saturated zone.

Box 13.1

Soil as a filter and decontamination agent.

Effluent that flows through unsaturated soil is decontaminated by filtration, adsorption and biological processes.

Protozoa and helminths are rapidly stopped by the filtering action of the soil, due to their relatively large sizes compared to soil pores. Bacteria and viruses are less easily fixed by soils. Table 13.IV presents the survival times of pathogenic organisms in different environments and Box 13.5 (in Section 4.3.6) shows infiltration rates according to the nature of the soil.

For bacteria (e.g. coliforms), a great decrease occurs in the first 50 mm of sandy soil.

Viruses are too small to be removed by filtration but are captured by adsorption onto the surface of soil particles, especially if the pH of the soil is low. The adsorption of viruses and bacteria is facilitated by soil clays, especially if groundwater flow is slow and contact time is long.

Table 13.IV: Epidemiological characteristics of excreted pathogens (adapted from Franceys, Pickford & Reed, 1992).

Pathogen	Latency period	ID ₅₀ ^a	Survival times for pathogens:		
			wastewater	soil	crops
Bacteria	0	>10 ⁴	from a few days to 3 months		
<i>Vibrio cholerae</i>	0	10 ⁸	~ 1 month	< 3 weeks	< 5 days
Faecal coliforms	0	~10 ⁹	~ 3 months	< 2 months	< 1 month
Virus	0	unknown	months	months	1-2 months
Enteroviruses ^b	0	100	~ 3 months	< 3 months	< 2 months
Protozoa (cysts)	0	10-100	from a few days to several months		
<i>Entamoeba</i> spp.	0	10-100	25 days	< 3 months	< 10 days
Helminths ^c	variable	1-100	months	months	months
<i>Ancylostoma</i> spp.	1 week	1	3 months	< 3 months	< 1 month
<i>Ascaris</i> spp.	10 days	several	~ 1 year	several months	< 3 months
Flukes ^d	6-8 weeks	several	life of the host ^e	hours ^e	hours ^e

a. ID₅₀ is the number of organisms required to cause the development of clinical symptoms in 50% of individuals.

b. Includes poliovirus.

c. Eggs or larvae.

d. Does not include *Fasciola hepatica* but includes *Schistosoma* spp.

e. Outside of an aquatic host, the pathogen element survives only a few hours. In a host it lives until the host dies.

4 Excreta disposal

Excreta-disposal systems may be classified according to the following criteria.

Final excreta-disposal site

– On-plot systems: where the disposal site for excreta is close to the home, such as latrines and septic tanks.

– Off-plot systems: where excreta is collected from the home and transported elsewhere to be treated or disposed of. The sewerage system is the most important example of this.

Necessity of water for operation

– Dry systems: do not require water for use, including simple pit latrines, ventilated improved pit (VIP) latrines and composting latrines.

– Systems using water: where the system requires water for operation, including flush toilets connected to septic tanks or sewerage systems.

The selection of an appropriate system is based on technical, cultural, economic and institutional criteria.

The following section details the technological characteristics of on-plot systems for individual, communal or public toilets.

Public toilets are normally installed in public places where people are present temporarily or occasionally, such as hospitals, nutritional centres, schools or markets. In these places the systems are managed by those who are responsible for the public place.

Communal or individual toilets are necessary for family sanitation. Individual toilets are the best solution, given that acceptance and maintenance of the system will be easier to manage. In this case, communal latrines are only implemented in specific cases such as an emergency situation or where there are construction problems such as a lack of time or materials.

4.1 Defecation in open areas

People defecate in open areas where there are no, or insufficient, latrines or where latrines present are not used. These open areas may be specific places that are widely accepted by the community as areas of defecation, such as refuse piles or under trees, and may be found inside or outside the living area of the community.

In principle, this practice should be stopped because of the associated health risks and damage to the environment. However, if this is not possible in the short-term due to lack of community motivation for latrine construction, or because of any other socio-cultural factors, it is possible to improve the situation. This can be done by promoting correct hygiene habits such as hand-washing the covering of faeces with soil and defecation at a safe distance from water points, homes and public places.

It is important to increase the demand for latrines in a community through the introduction of pilot projects. For example, the introduction of a pit latrine, with a slab and adapted superstructure, could help to overcome the resistance of the community to defecate inside a walled superstructure, and could be the first step of a more comprehensive latrine project.

In emergency situations such as in refugee or IDP camps, defecation fields can be set up as an initial and rapid response to extremely urgent needs (see Section 4.7).

4.2 Dry latrines

4.2.1 SIMPLE PIT LATRINE

The most common excreta-disposal system in many parts of the world is the simple pit latrine used by families (Figure 13.2). This type of latrine is a simple, rapid and economical means of excreta disposal. It is often used as the first step to improve environmental sanitation.

This latrine consists of a pit, where excreta accumulate, covered by a slab and protected by a superstructure. A lid can be used to cover the defecation hole in the slab in order to reduce bad smells and the entrance of flies into the pit.

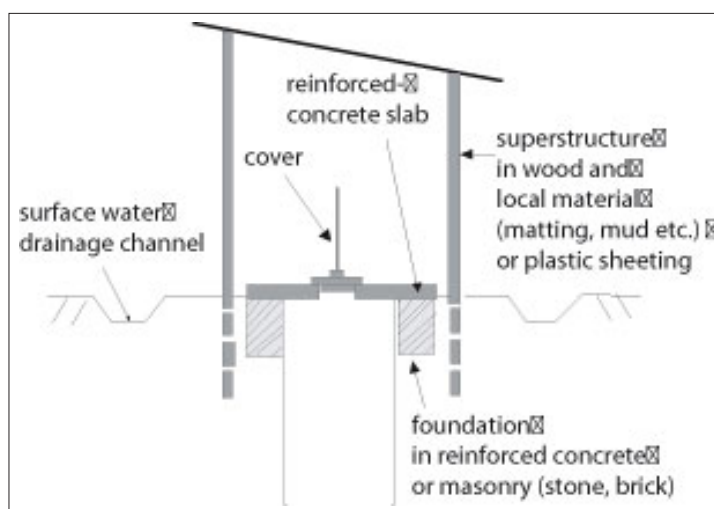


Figure 13.2: Simple pit latrine.

4.2.2 VENTILATED IMPROVED PIT (VIP) LATRINE

The VIP latrine (Figure 13.3) is an improved version of the simple pit latrine, and includes several advantages:

- it reduces smells, which makes the latrine more acceptable to users (if the latrine has an unpleasant smell, the promotion of further latrine construction and use is difficult);
- it allows the control of flies, which can be a vector of disease.

The ventilation of the pit is achieved via a pipe that runs from the pit to 50 cm beyond the top of the latrine roof. A fine mesh is placed on the exposed top of the pipe in such a way as to trap flies inside the pipe.

The air flow is created by the venturi effect due to the wind blowing across the top of the pipe. In hot weather, the heating of the vent pipe can also encourage air flow. This air circulation from the pit through the pipe also eliminates bad smells.

Flies are attracted to the pit by the smell exiting the ventilation pipe, but are prevented from entering by the mesh. A few will enter through the pit via the defecation hole and will lay eggs in the pit. The flies that develop will be attracted by the light from the top of the ventilation pipe if the inside of the superstructure is kept sufficiently dark. They are prevented from escaping by the mesh at the top of the pipe, and eventually die.

The correct construction and use of the latrine is essential for operational efficiency:

- The front part of the latrine must allow the access of incoming air and the defecation hole of the pit must remain open.
- The inside of the superstructure must remain fairly dark. Therefore, the door must remain closed, or alternatively, an indirect entrance is constructed that minimises the entry of light (see Section 4.2.3.4). This solution is preferable, as the users may not keep the door closed.
- The ventilation pipe must have a diameter of at least 150 mm (6") for smooth materials and 230 mm (9") for rough materials, to allow the easy passage of air and movement of flies up the pipe.
- The top of the pipe must be higher than the roof by at least 50 cm and must be dark-coloured to promote heating by the sun. If possible, it should be installed to receive direct sunshine.
- The latrine must be placed downwind of people's homes, with the front of the latrine (where the door is located) facing towards the prevailing wind, and the ventilation pipe at the back.

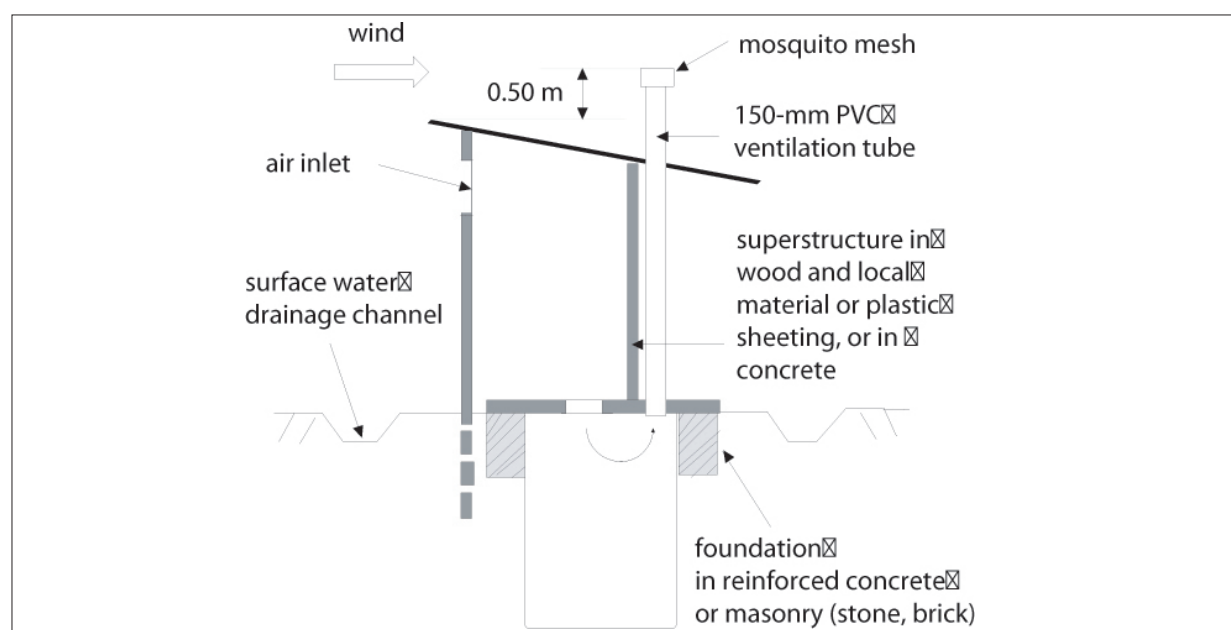


Figure 13.3: Ventilated Improved Pit (VIP).

4.2.3 CONSTRUCTION

4.2.3.1 Materials

Past experience indicates that it is better to use the same materials for the construction of latrines as for local housing. However, it may be more suitable to lower the standard of materials to achieve better coverage. The construction of latrines of a higher quality than that of local homes should be avoided because this would promote a standard that could not be met by the community and would, therefore, not encourage the construction of new latrines.

The introduction of new materials and methods should also be avoided in a latrine construction programme. It is more convenient to use local skills and materials since they are better understood by the community, who will also know how to maintain these materials. In this way, construction details, techniques, particularly for the superstructure, will depend on the materials used by communities in different regions, such as wood, thatch, woven grass, bamboo or earth.

4.2.3.2 The pit

1) Sizing

The dimensions of the pit depend on several parameters including the following:

- number of users;
- expected lifetime of the latrine;
- pit cleaning method;
- type of pit (if it is lined or not);
- type of soil (if it is impermeable or not, and rocky or not);
- habits regarding anal cleaning; and
- contamination risks (high water-table).

The volume of the pit may be calculated using the following formula, taking into account the factors listed above and according to the objectives of the latrine, as presented in Box 13.2:

$$V = n \cdot r \cdot y$$

where V = the useful volume (m^3), n = number of users, r = rate of accumulation of solids ($\text{m}^3/\text{person}/\text{year}$), y = useful life of the pit latrine (years).

Note. – A depth of 0.5 m is added to the calculated pit depth, which corresponds to the free space under the slab.

Box 13.2

Useful life of pit latrines.

For a properly functioning latrine, in terms of hygiene, queuing time, and privacy, the number of people per latrine must not exceed 20 (or 50 in the first phase of an emergency) according to SPHERE key indicators.

From a technical point of view, the useful life of latrines must not be less than 2 years, which is the minimum time for the adequate decomposition of excreta. Ideally, the useful life should be around 5 years, in order for latrine use to become an accepted part of a community's habits, which would help guarantee their long term maintenance.

When the useful life of a latrine is more than 1 year, a solids accumulation rate of $0.06 \text{ m}^3/\text{person}/\text{year}$ is used for dry pits and $0.04 \text{ m}^3/\text{person}/\text{year}$ for wet pits, considering that decomposition processes in wet pits are more efficient than those in dry pits (Franceys et al., 1992). These rates are multiplied by 2 for latrines whose useful life will be less than 1 year (high number of persons per latrine, e.g. in camps).

The final dimensions of the pit will also depend on the anal-cleaning habits of the community. For instance, the volume of the pit will need to be increased where stones are used.

Note. – The emptying of a full pit is difficult or impossible in many contexts where the community does not accept to do this task. Here, an increase in the pit dimensions will increase the time of filling, and hence, life of the latrine.

2) Design and construction

The pit can be circular, rectangular or square. Circular pits are more stable due to the arching effect of the earth around the hole, which evenly distributes stress around the pit. However, square or rectangular pits are often used as they are easier to dig than circular pits.

The sides of the pit have an impermeable lining, a permeable lining, or are unlined (Figure 13.4). If possible, where the soil is consolidated and there is no risk of contamination (see Table 13.V), the pit walls should remain unlined to facilitate drainage of liquids. Where walls are lined, the most common materials used for this include cement or cement blocks, reinforced concrete, stones and stabilised mud blocks.

Table 13.V: Type of pit depending on context.

Recommended type of pit	Context
Latrine with a water-proof lining	Water resource exploited within a perimeter of 30 m around the latrines, or in very permeable terrain (sand, gravel, fractured rocky environment), i.e. pollution can extend 30 m beyond the latrine; in this case, the pit will need frequent emptying (see Section 4.2.4)
Latrine with a permeable lining (open masonry-work)	Loose or non-stabilised soil, no risk of pollution
Latrine with unlined pit	Stable soil, no risk of contamination of the aquifer

The final selection of pit design will depend on the characteristics of the local context. Table 13.V summarises different cases.

Technical points to consider:

- If the construction is designed to last longer than 5 years it is advisable to build a reinforced permeable pit or septic tank and soakaway.

- The inclusion of a permeable pit significantly increases the operational life of the latrine due to the increase of the infiltration and biological activity. If the pit is impermeable, it is essential to provide a system for handling the effluent.

- It is always preferable to build some kind of protection in the upper 300 - 500 mm of the pit that will function as a seal against water infiltration and as a support to the slab.

- In some cases, the pit can be easily and quickly protected using the moulds for concrete rings used in the construction of hand-dug wells.

4.2.3.3 The slab

The latrine slab has two major functions: it covers the pit and supports the weight of users and, in some cases, the superstructure.

1) General characteristics

The latrine slab must be smooth, impermeable and easy to clean.

The slab or the internal floor must be sufficiently large so that users are comfortable. The dimensions between walls are normally at least 80 cm wide and 100 cm long, so that users do not touch the walls while they are inside the latrine.

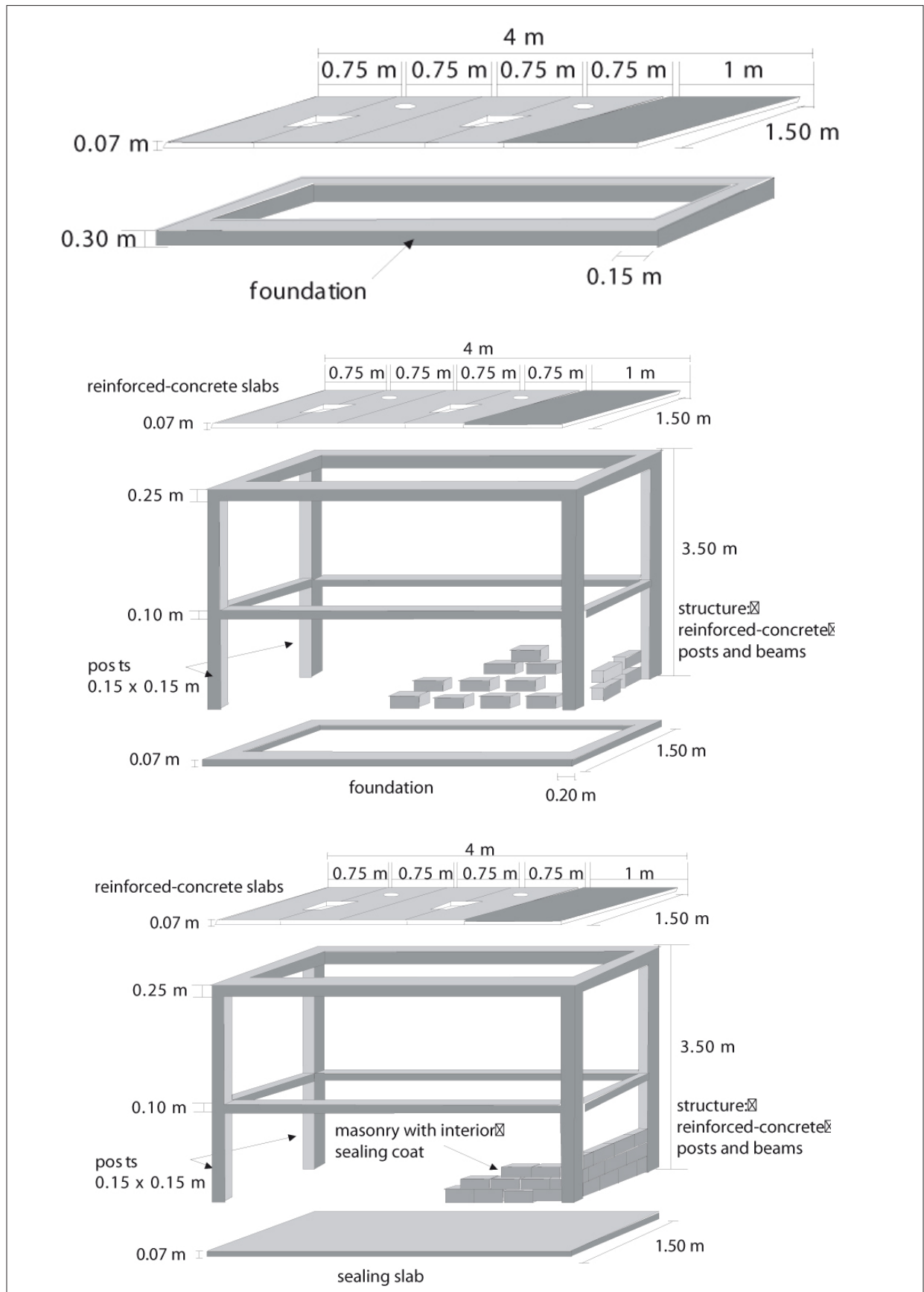


Figure 13.4: Pit and foundation of 2-station latrine.

A: slab on simple foundation, pit not lined. **B:** slab on masonry-lined pit. **C:** slab on watertight pit.

2) Design and construction

Latrine slabs are directly supported by the ground or by the pit lining. A correct design ensures that the slab is strongly supported and raised above the soil by at least 150 mm to avoid the entrance of surface water.

Slabs have square, rectangular, or circular shapes. They are submitted to different compression and tension forces, depending on their shape, and this can influence the materials and techniques used in construction.

Slabs can be built with traditional material such as wood (Figure 13.23, in Section 4.7.2) or with concrete. Pre-made slabs in plastic or metal can be also used, especially in emergency interventions (see Section 4.7).

Concrete slabs are a long-term solution for covering the latrine pit, but may be adapted to short-term interventions, as they are easy to make and transport, and cement is usually available and cheap. They are also useful because they can be assembled with other materials and make a water-tight seal.

There are two kinds of concrete slab: reinforced concrete slab (Table 13.VI, Figure 13.5 and Figure 13.6) and unreinforced concrete slab (Figure 13.7 & 13.8).

For an overview of construction techniques and specific information regarding the use of concrete, refer to Annex 14.

Reinforced concrete slab

There are two models; in one piece or two pieces (which is more easily transported).

Note. – The hole in which the ventilation pipe is installed may be made using a piece of pipe that is removed a few hours after pouring the concrete.

Unreinforced concrete slab

Unreinforced concrete slabs do not require steel reinforcement, so are cheaper.

Table 13.VI: Characteristics of latrine slabs.

Type of slab	Width (m)	Length (m)	Thickness (cm)	Cement bags 50 kg	Steel 6 mm (m)	Weight (kg)
2-part slab (1/2 slab)	0.75	1.5	7	1/2	21	210
1-part slab or removable slab	1	1.5	7	3/4	26	275

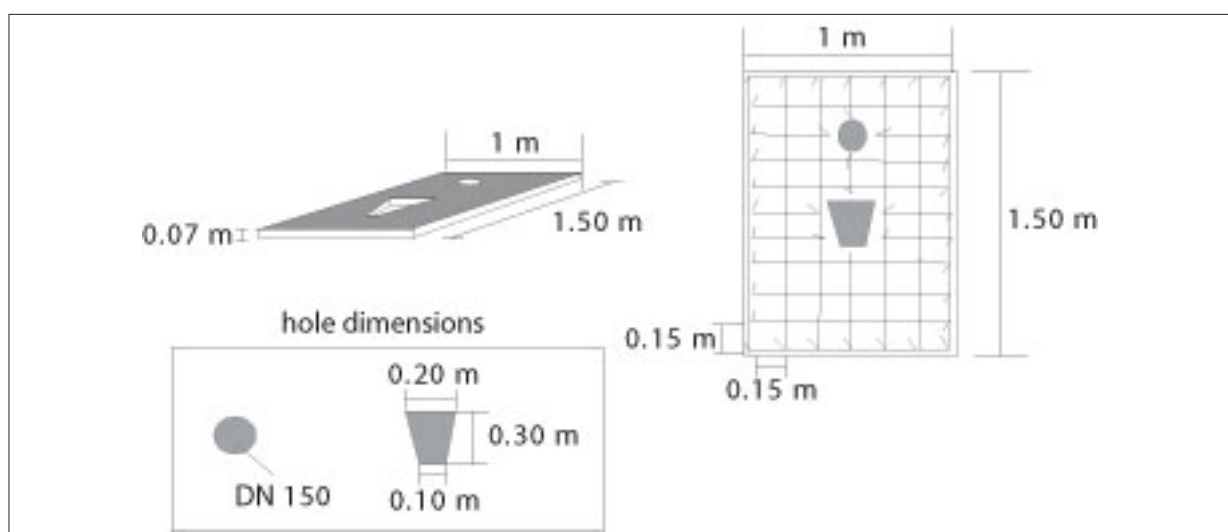


Figure 13.5: Reinforcement for a single slab.

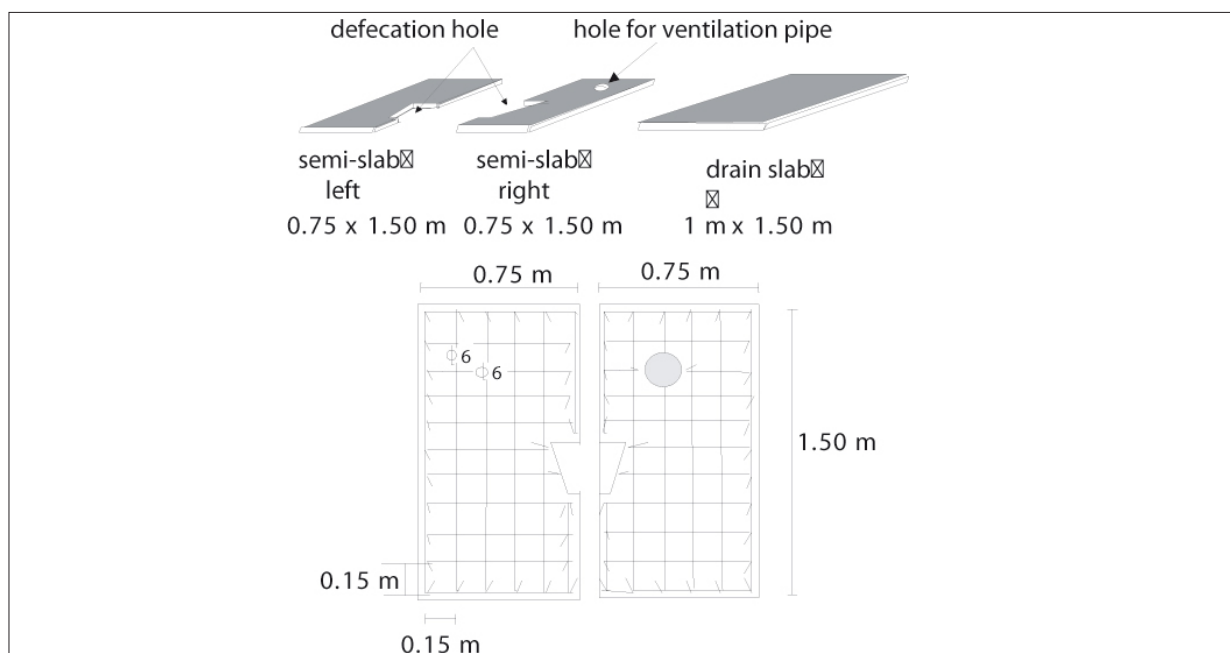


Figure 13.6: Reinforcement for a two-part symmetrical slab.

The best design of unreinforced slab is the domed slab as in Figure 13.7. The shape of this slab means that its underside remains in compression, which concrete resists better than tension. The concrete mix used for this type of slab must contain more cement than usual. The proportions should be: 1 part cement, 2 parts sand and 1.5 parts gravel (6-10mm). Two designs are used, one circular (Figure 13.7) and one rectangular (Figure 13.8). Unreinforced slabs are more fragile than reinforced ones, and more difficult to transport, especially the circular slab.

Note. – The unreinforced concrete slab does not include a second hole to accommodate a ventilation pipe (VIP type), so the design must include a cover for the defecation hole to control flies and odours.

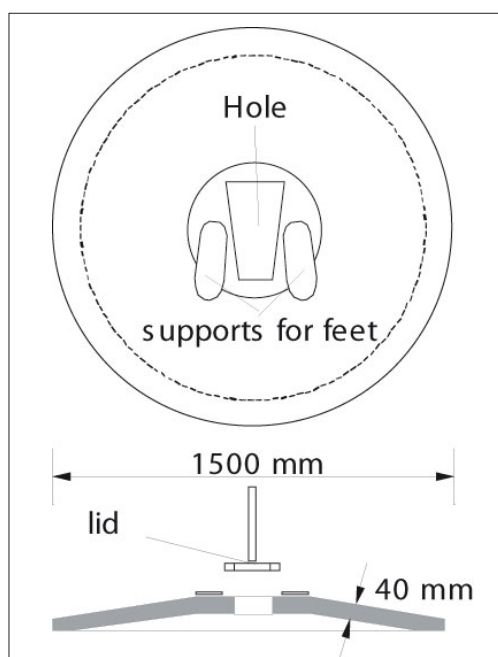


Figure 13.7: Round dome-shaped slab.

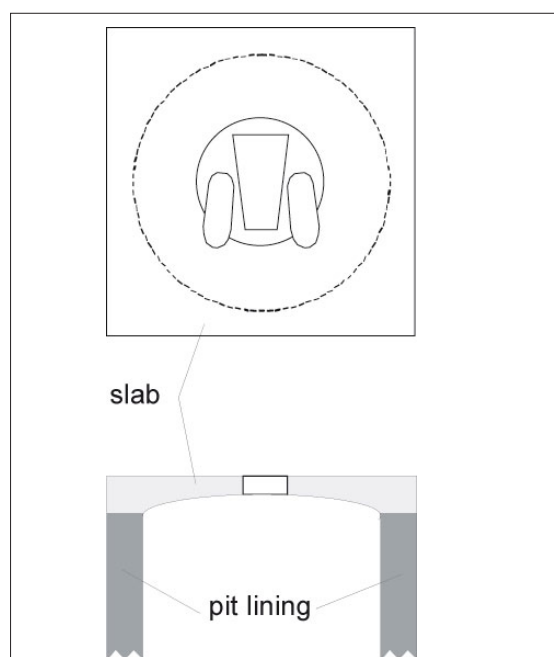


Figure 13.8: Rectangular dome-shaped slab.

4.2.3.4 The superstructure

The purpose of the superstructure is to provide privacy and an acceptable environment for the user.

The superstructure may be one of several different shapes (rectangular, circular, spiral etc.), and its characteristics will depend on local construction habits, on the latrine design and on its design life. Many sanitation projects leave the design and construction of the superstructure to the user. The design must be defined with the users and will depend on their capacity for construction (factors that include money, time, materials etc.)

From a technical point of view, few design points need to be considered: the roof can provide privacy as well as being important for protection against rain, and the door is an important factor for privacy and security (with the ability to lock). The VIP latrine superstructure must additionally guarantee darkness inside the superstructure and the entrance of air.

1) Particular models

Spiral-shaped structures

Although these superstructures (Figure 13.9) do not have doors, the interior is kept partially dark, which is an advantage for the VIP latrine, and it also reduces the faecal-oral transmission risk from hand contact with doors. This model is useful for public VIP latrines, for example, at schools where it is difficult for children to keep the door closed. The disadvantage is that it allows the free access of small children and animals, and the community must be vigilant about this. The spiral shape might require more materials for the walls than a simple design, but savings in materials or money are made due to the absence of the door, which is often expensive.

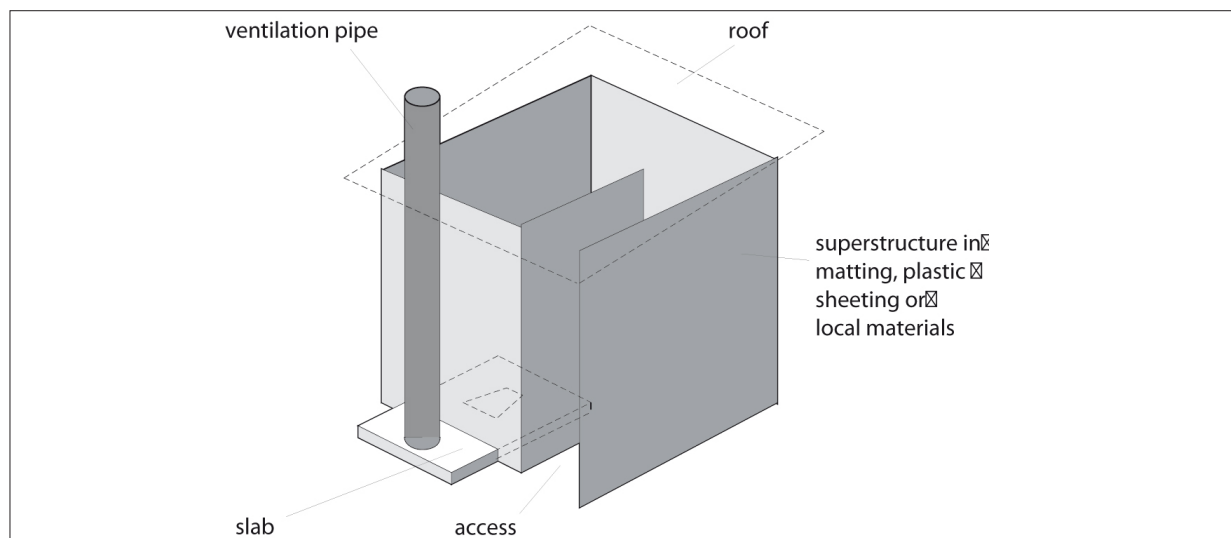


Figure 13.9: Spiral-shaped superstructure.

Reusable structures

A mobile structure is appropriate where there are no limitations of space and when the community is independent and motivated to build latrines. When the pit fills up the owner simply has to dig a new pit and to reinstall the old superstructure (including the slab) over the pit.

4.2.4 USE AND MAINTENANCE

Daily maintenance is limited to cleaning the slab and superstructure. For simple pit latrines, the hole needs to be covered always when the latrine is not being used. For the VIP latrine, the door

Box 13.3

Guatemala, Jutiapa 1999. Construction of ventilated latrines with reusable structure.

The latrines were built for communities affected by Hurricane Mitch. The model of ventilated latrine chosen allowed the entire structure, including the slab, ventilation pipe and superstructure, to be transported. This addressed the problem of pits filling up. The superstructure was fixed to a welded metal or wooden frame in order to facilitate reuse.



Figure 1: Transport of the latrine.



Figure 2: Slab support and pit.

must be kept closed, the mesh on top of the ventilation pipe needs to be checked for holes, and water must be poured down the ventilation pipe once a year to remove spiders' webs.

The emptying of the pit is usually a task that is difficult for users to undertake, often for cultural reasons, and also because it can create health risks when not carried out by specialist personnel with adequate training and protective equipment.

The filling and emptying cycle of a latrine depends on the size and type of the pit, the number of users, the rate of decomposition and the nature of the soil. Normally pits should be sized to be emptied every 4 to 6 years, which allows the adequate decomposition of excreta.

The emptying of pits containing fresh excreta presents significant problems due to active pathogens present in the sludge. This problem is managed differently in rural and urban areas:

- *In rural areas*, where there is land available, it is advisable to dig another pit for a new latrine. The original pit can be covered and the buried excreta will not cause any health risk. After 2 years, the excreta will no longer pose any health problems and the pit can be emptied and reused, with the excreta used as a fertiliser (see Section 4.5).

- However, *in urban areas*, where there is no space to dig new pits, the double-pit system, comprising two small pits used in rotation is preferable. Another solution, if there are no risks of water contamination, is to build very deep pits, which significantly increases the life of the latrine.

Manual pit emptying should be avoided, or carried out with adequate protection for workers, to minimise the risk of contamination with pathogens from the fresh faeces.

It is also possible to empty pits using a desludging pump (note that membrane pumps are more appropriate than mud pumps or dewatering pumps) and a sludge tanker to transport the sludge to an

appropriate place for disposal. It is important to for the sludge to be in a liquid form (it may need to be wetted and stirred) and to avoid the presence of plastic materials, wood, stones or other solid elements in the sludge. It is important to promote this message in the community in order to avoid these materials being thrown into latrine pits.

Sludge emptied from latrine pits is loaded with pathogens, and therefore the disposal site should be chosen with care. It should be isolated from the community, and should be a dedicated sanitary site such as a landfill or a sewage-treatment works.

4.3 Pour-flush latrines

4.3.1 THE PRINCIPLE

The pour-flush latrine is the most effective system to avoid bad smells and the proliferation of flies and mosquitoes, by keeping the pit isolated from the exterior. This latrine includes a water seal at the extremity of the pan (or bowl) in which the excreta is deposited. The seal remains full of water and guarantees that the pit is isolated.

This system requires water on a permanent basis, both for cleaning the pan and for maintaining the seal (between 1.5 and 2 litres minimum for each flush). Therefore, this solution is only applicable where the availability of water is guaranteed.

4.3.2 CONSTRUCTION

The major difference between wet and dry latrines is the use of water and the water seal, and the connection to specific pits. Therefore, only these aspects of wet latrines are more fully explored, below.

Water seal (Figure 13.10): in many countries it is possible to find the pan and the seal at reasonable prices. They can be made out of different materials including plastic, Plexiglas, high-density polyethylene (HDPE) or ceramics. It is also possible to make them in cement using a mould, if they cannot be purchased in the local market.

The use of water is an important factor when designing the pit, since it increases the volume of material that enters the pit. Where the soil is permeable it is possible to build a simple permeable pit, or even better, a septic tank, from where the effluent infiltrates into the soil. It is necessary to take care to prevent contamination of neighbouring water points (see Section 3.5). Where the soil is less permeable, the pit will fill up faster and hence there is a need to plan and organise emptying of the pit or construction of a new pit.

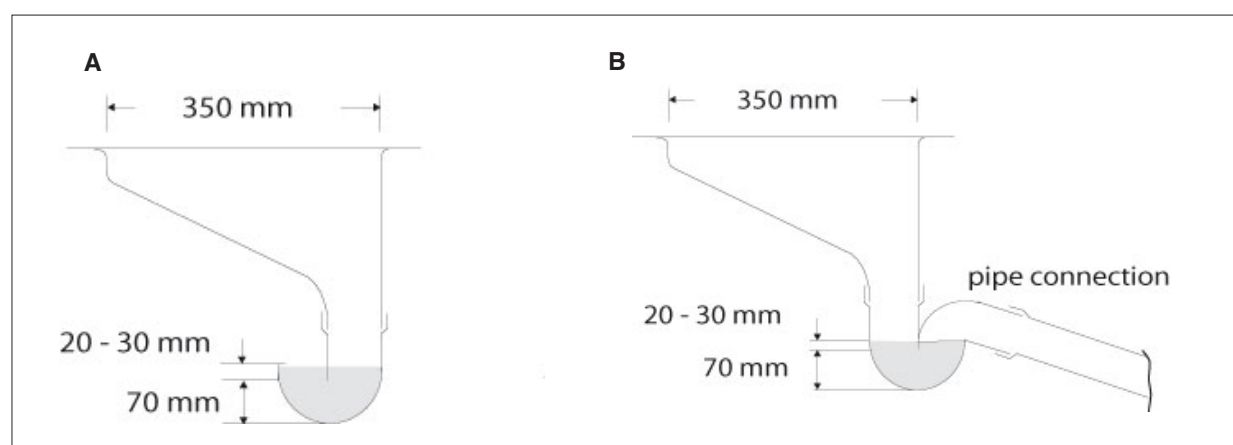


Figure 13.10: Water seal.

A: placed over the pit. B: with an off-set pit.

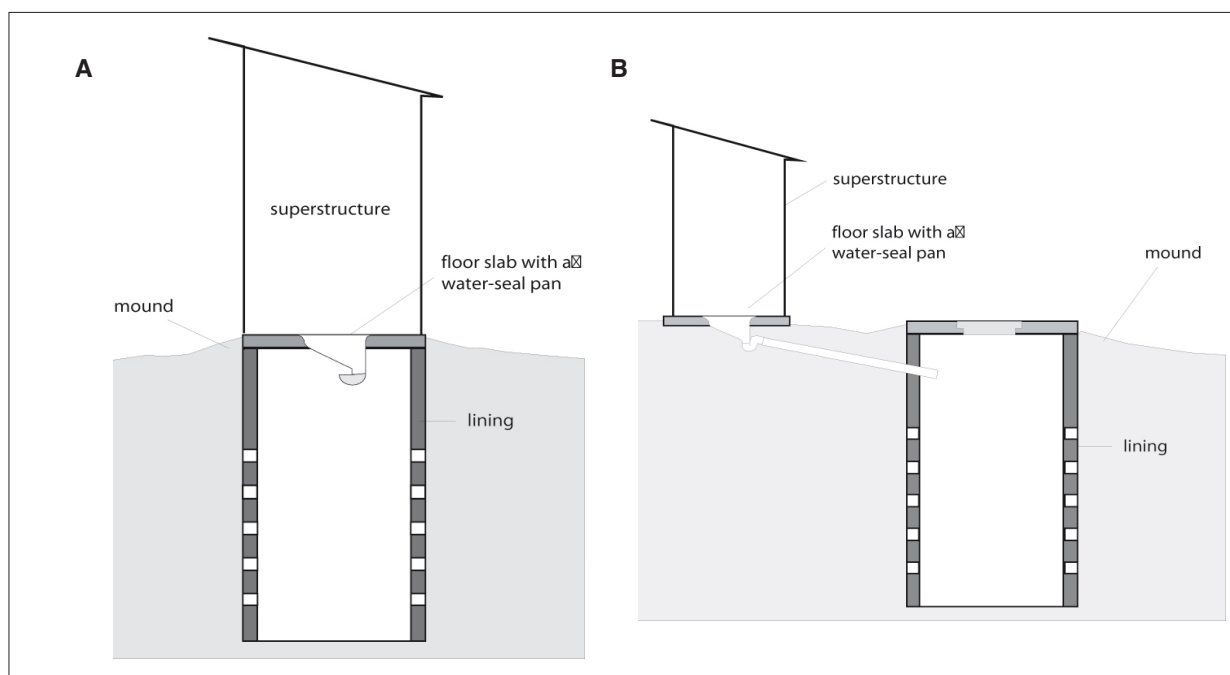


Figure 13.11: Latrines with water seal.
A: set on top of the pit. **B:** with an off-set pit.

The superstructure can be built over the pit (Figure 13.11.A), but the pan can also be set away from the pit, as the excreta can be carried by water in a connecting pipe (Figure 13.11.B). This is an advantage as it allows the toilet to be inside the house with the pit outside, and the latrine is more durable (when the pit fills up, it is sufficient to dig a new pit nearby and to remake the connection to the pan).

Where the pit is set away from the superstructure (Figure 13.11.B), more water is needed to carry the excreta, and obstructions can occur more frequently.

The diameter of the pipes or channel must be at least 75 mm and pipes must be laid along a straight line, as elbows or sharp curves can obstruct the flow and are more easily blocked. The least expensive pipes that can be used in this system are non-pressure drainage pipes. The minimum slope should be 1 / 30 for smooth pipes or 1 / 15 for rough pipes or channels.

Note. – In areas where there is a dry season in which water is scarce, it is possible for latrines over pits (Figure 13.11.A) to be designed in such a way that the water seal can be removed and a ventilation pipe can be fitted during the dry season, to create a VIP latrine.

4.3.3 SEPTIC TANK

4.3.3.1 The principle and its limitations

The septic tank is a waterproof underground tank that receives wastewater (‘black-water’ from toilets and / or ‘grey-water’ from cooking, bathing and laundry). It is the optimal on-site solution for toilets that function with water (Figure 13.12).

The septic tank comprises two chambers that are filled by wastewater that is transported via a pipe or channel, or falls directly from the latrine water seal. The wastewater is separated into sludge, liquid and scum within the septic tank, and this effluent undergoes different chemical and physical transformations before part of it exits the tank.

The septic tank is divided in two chambers, separated by a perforated partition wall or baffle (Figure 13.13).

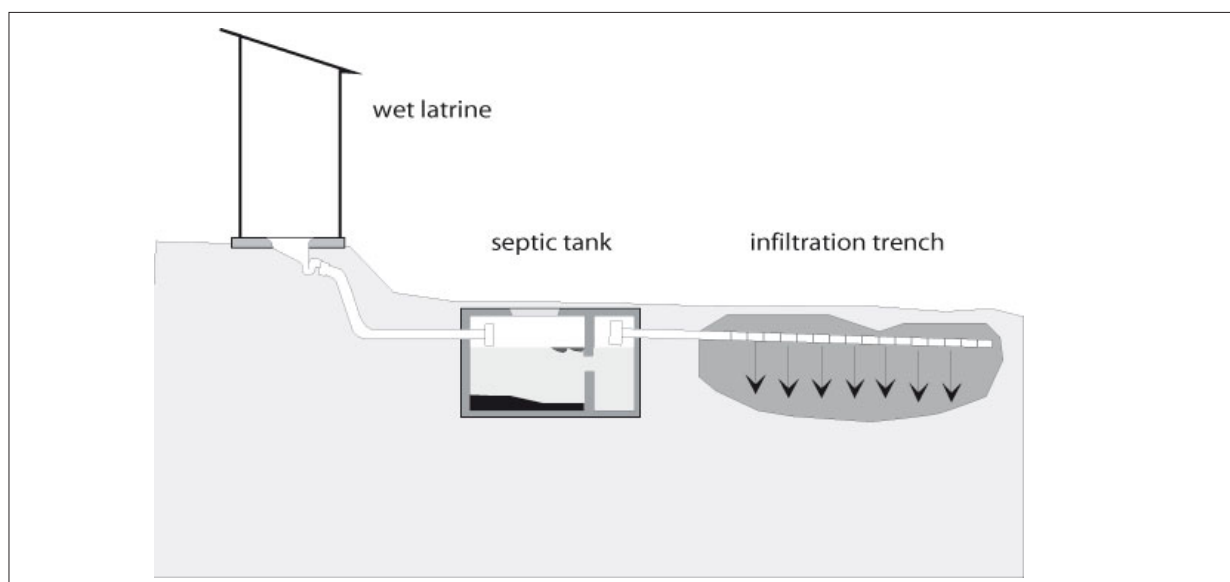


Figure 13.12: General view of wet toilet, septic tank and infiltration system.

The first chamber is the larger chamber where wastewater arrives and where the sedimentation and compaction of solids occurs. A thick layer of scum often forms on the liquid's surface here, due to grease, oil, soaps, detergents and other chemical products. In some cases it is preferable to install a grease trap before the tank to reduce the amount of products that reach the septic tank. Anaerobic processes, where bacteria decompose the organic matter in the wastewater, producing methane and carbon dioxide, occur in this chamber. The ideal temperature for this is 35° C. It is important to make sure that pesticides, antiseptic agents or chlorine, that prevent these digestion processes, are not present in the waste water.

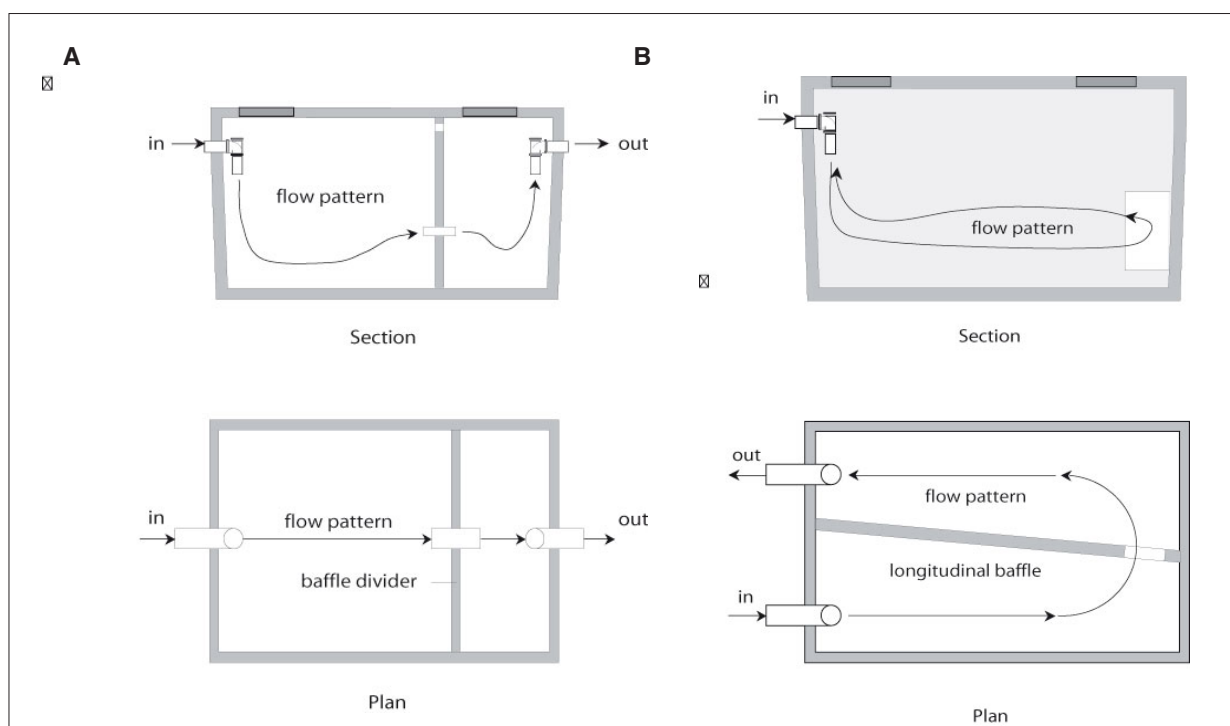


Figure 13.13: Septic tank flow pattern (adapted from Crites & Tchobanoglous, 1998).

A: interior baffle placed across tank. B: interior baffle placed longitudinally.

The second chamber is connected with the first in such a way that only liquids move between the two chambers. The decomposition process and production of gases continue. This chamber has an exit for the passage of liquid out of the tank. It is usual to install an elbow or a tee at the outlet, to ensure that effluent comes from below the scum layer and is grease-free.

The liquid effluent will leave the tank after a usual retention time of 1 to 3 days, allowing the removal of up to 80% of suspended matter. There are three alternative destinations for the effluent:

- further treatment, with direct connection to a sewerage system;
- infiltration in the soil (see Section 4.3.6);
- reuse for agricultural activities.

Septic tanks require certain conditions to ensure proper operating, therefore domestic wastewater treatment by a septic tank can be considered if:

- sufficient water is permanently available for washing the excreta from the pan down to the tank (>40 l/pers/d for all uses WELL/WEDC 1998);
 - it does not affect priority water uses, such as drinking, cooking, personal hygiene, vegetable garden watering;
 - the soil environment is suitable for tertiary treatment through infiltration and there is no risk for groundwater contamination;
 - there is sufficient land available for a system for each family (about 8 m² for the tank and about 30 m² for the infiltration system);
 - a desludging facility exists (private or public) and users can afford the service cost;
- Septic tanks are particularly appropriate when anal washing by water is a cultural habit.

4.3.3.2 Design of a septic tank (adapted from Franceys, Pickford & Reed, 1992)

The efficiency of the tank, and its design, depend on the wastewater retention time in the tank, on the entry system, on the water evacuation system and on the frequency of desludging the tank.

The volume of the tank can be calculated with the following formula (assuming that the retention time of the wastewater is 1 day):

$$V = A + B \text{ litres}$$

where A is the volume required for liquid retention and B is the volume required for sludge and scum accumulation.

- If a 24-hour retention time is chosen, then:

$$A = P \times q \text{ litres}$$

where P = number of persons using the septic tank, q = 90% of the daily water used per person (litres), if the tank is to receive black-water and grey-water, or q = estimate on the basis of the quantity required to flush the pan, the average number of users and the average number of flushes per user per day, if it is assumed that the tank will only receive black-water.

- The volume of sludge and scum (B) is:

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

where P = number of persons using the septic tank, N = number of years between desludging, F = design factor (see Table 13.VII), S = accumulation rate for sludge and scum (in litres per person per year, e.g. 25 litres per person per year for black-water only).

The following rules are used to determine the shape of the tank:

- the depth must be at least 1.80 m, with the outlet at least 0.3 m below the cover slab;
- the width should be at least 0.6 m, since this is minimum space in which a person is able to work (building or cleaning the tank). Some codes and practices recommend the length to be 2 to 3 times the width;

– for a tank of width X , the length of the first compartment should be $2X$ and the length of the second compartment should be X (Figure 13.14). Normally, the depth shall not exceed the total length.

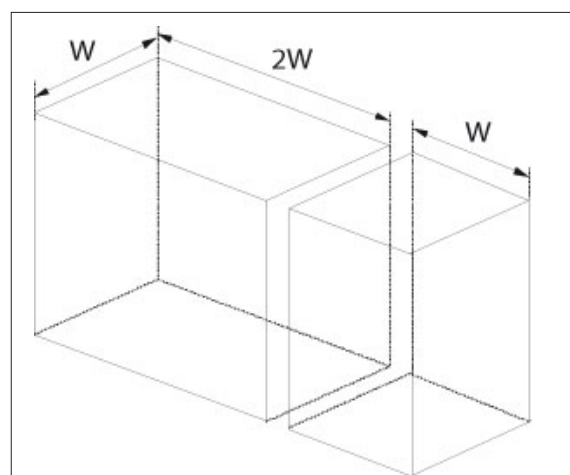


Figure 13.14: Design of the septic tank.

Table 13.VII: Values of the septic tank design factor F .

Number of years between desludging	Value of F ambient temperature		
	$> 20^{\circ}\text{C}$	$> 10^{\circ}\text{C}$	$< 10^{\circ}\text{C}$ during winter
1	1.3	1.5	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

4.3.4 AQUA-PRIVY

The aqua privy is a variation of a septic tank that has only one chamber. It consists of a water-tight tank placed immediately below the latrine (Figure 13.15). Excreta falls directly into the tank via a pipe which is submerged in the liquid in the tank, forming a water seal that prevents flies and mosquitoes from escaping, and preventing smells. The level of liquid in the chamber must be kept stable for anaerobic digestion to take place. The tank functions in a similar way to a septic tank. The effluent from the tank normally infiltrates into the soil via a soakaway pit.

The regular removal of sludge from the tank is essential for it to function correctly. For this purpose, it must be possible to open the lid of the tank. In some cases, the installation of a ventilation pipe, covered with mosquito mesh, is recommended in order to evacuate gases and minimise smells. The tank should have a volume of at least 1 m^3 in order to avoid turbulence that prevents sludge sedimentation.

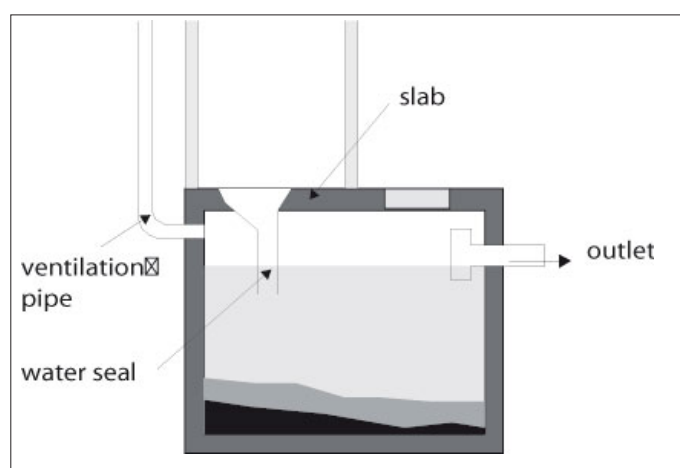


Figure 13.15: Aqua-Privy.

4.3.5 USE AND MAINTENANCE

Pour-flush latrines need the same daily maintenance as dry latrines. This consists of cleaning the superstructure, the slab and the pan. The water seal must be kept constantly maintained with water in order to function properly.

Septic tanks must be desludged regularly in order to function properly. They should be emptied when the level of solids is almost at the level of the bottom of the connection to the second chamber. If the solids are not removed by the end of the design period, the amount of solids will decrease the available volume to retain wastewater sufficiently long for adequate settling, flotation and stabilisation.

The septic tank is emptied by a vacuum tanker or a sludge pump connected to a sewage tanker. The sludge, which is contaminated with pathogens, should be treated at a sewage-treatment works or dumped into a sanitary landfill site isolated from the community.

Note. – When desludging, it is advisable to leave a layer of sludge at the bottom of the tank in order to restart biological decomposition.

4.3.6 DISPOSAL OF SEPTIC-TANK EFFLUENT

A septic tank is simply a combination of a retention tank and an anaerobic digestion chamber. The outflow of the tank is essentially equal to the inflow (except for some minor losses through removal of solids, filtration and evaporation, but this is not very representative). Even if the efficiency of the removal of suspended solids is good, the effluent will still contain a high concentration of pathogens and it is necessary to dispose it in a safe manner.

Effluent can be disposed of by:

- direct infiltration in the ground, with discharge into soakaway pits (Figure 13.16) or trenches;
- recycling for agricultural uses (Box 13.4) after a pre-treatment process;
- a sewerage system that collects and treats effluent, where infiltration is not effective or where there is a risk of groundwater contamination.

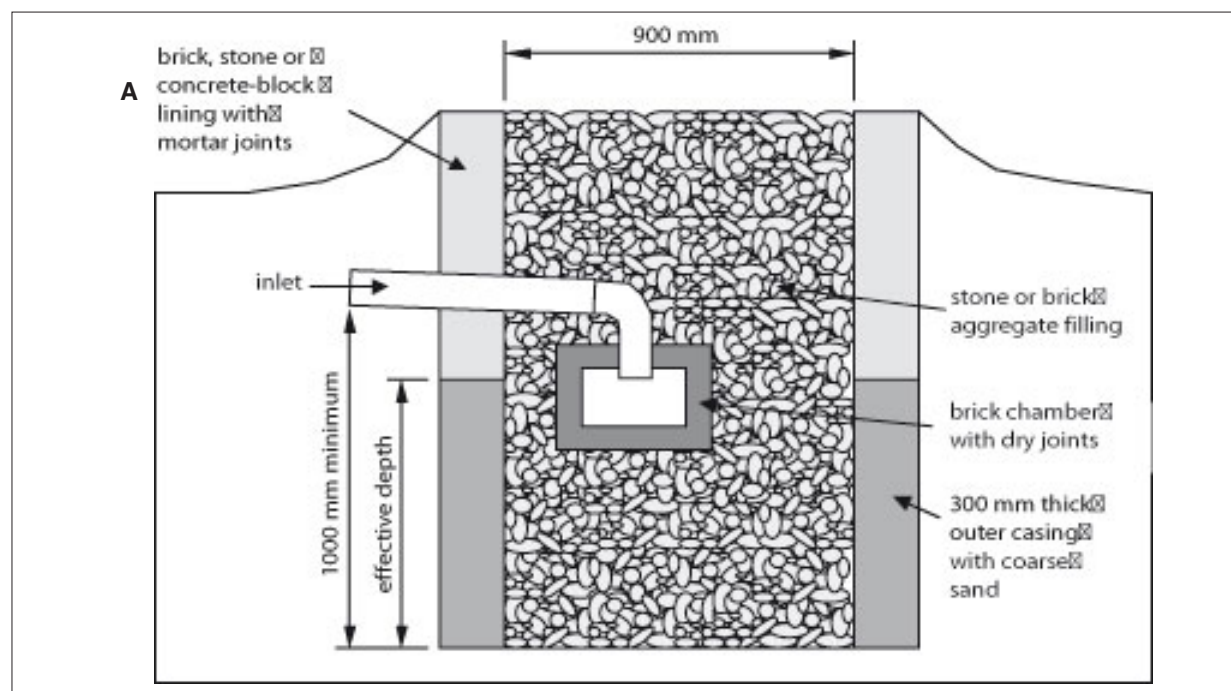


Figure 13.16: Soakaway pits. A: unlined pit.

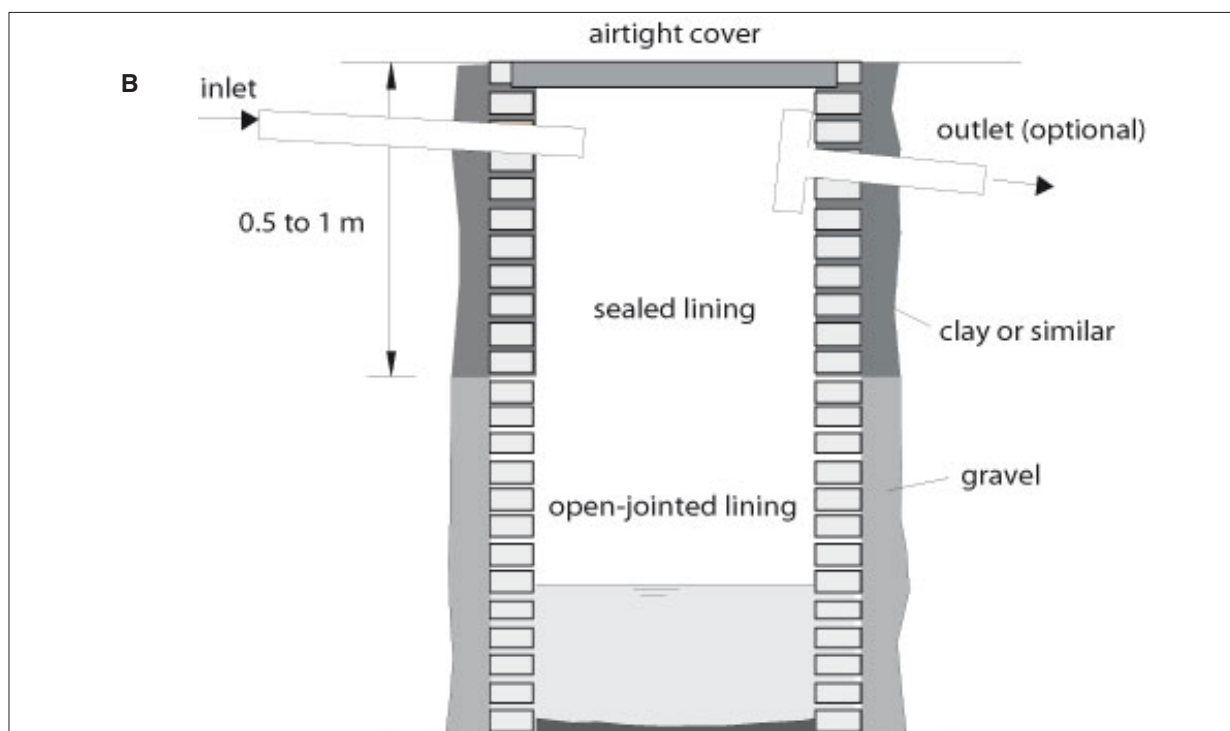


Figure 13.16: Soakaway pits. B: lined pit.

Soakaway pits are a common method used to dispose of the effluent of septic tanks that serve individual houses. They are usually 2 to 5 m deep, with a diameter of 1 to 2.5 m. The volume should be at least equal to that of the septic tank. The cover can be made of reinforced concrete and may be buried 200-300 mm deep in order to avoid the entry of insects.

The area required for the infiltration should be calculated using the infiltration data for different types of soils and the flow rate of the water to be treated (Box 13.5).

- *Unlined pits* (Figure 13.16.A) are filled with stones or broken bricks larger than 50 mm in size. If the main part of the pit is filled, the upper 50 cm should have a protection ring made out of blocks, bricks, or reinforced concrete in order to provide a standing support to the cover. The ring can be dome-shaped in order to reduce the size of the cover.

- *Lined pits* (Figure 13.16.B) are usually built with bricks, blocks, or cast concrete, as with latrine pits, and the infiltration capacity may be increased by filling the space between the lining material and soil with sand and gravel.

Box 13.4

Reuse of effluent.

Wastewater is too valuable to be thrown away in semi-arid and arid areas, and may be reused for farming (or to raise fish).

The use of wastewater for irrigation improves crop production, as it provides both moisture and nutrients (mainly nitrogen and phosphorous) that are beneficial for plants.

However, wastewater should be treated to eliminate or at least reduce the level of pathogenic contamination that poses human health risks. WHO recommends that for irrigation, except for those vegetables that are eaten without cooking, which should not be irrigated with wastewater, the treated wastewater should not contain more than one nematode egg per litre and no more than 1 000 faecal coliforms per 100 ml.

Infiltration trenches are an effective alternative to soakaway pits. This system consists of a 10-cm diameter pipe installed in a 30-50 cm wide and 60-100 cm deep trench which is filled with gravel (2-5 cm in diameter), then an impermeable layer to stop soil washing into the gravel, covered with soil to avoid erosion. The recommended slope of the trench 0.2 to 0.3%.

Box 13.5

Experimental values of the infiltration capacity of different soils.

The way water infiltrates into the soil depends on the type of soil. Clay will expand with humidity and make the soil impermeable. Silts and fine sands are sufficiently permeable to drain the water but they will become impermeable when the wastewater contains a high concentration of solids. Soils that have a large porosity allow water to drain easily and include sands, gravels, and fractured rocky soils. Organic soils have a large capacity to retain water. However the roots of trees and other plants create fractures in the soil through which water easily drains.

Type of soil	Infiltration rate of settled sewage (litres/m ² /day)
Coarse to medium sand	50
Fine sand, loamy sand	33
Sandy loam, loam	25
Porous silty clay and silty-clay loam	20
Compact silty loam, compact silty-clay loam and non-expandable clay	10
Expandable clay	< 10

Source: US Environmental Protection Agency, 1980

The useful infiltration area (S_i) is given by:

$$S_i = \frac{\text{volume of the effluent (l/day)}}{\text{infiltration rate (l/m}^2\text{/day)}}$$

The length of the infiltration trench is therefore equal to:

$$L \text{ (m)} = \frac{\text{infiltration area } S_i \text{ (m}^2\text{)}}{2 \times \text{depth of trench (m)}}$$

4.4 Advantages and disadvantages of simple, VIP and pour-flush latrines

Table 13.VII: Advantages and disadvantages of simple, VIP and pour-flush latrines.

Advantages/Disadvantages	Simple latrine	VIP latrine	Pour-flush latrine
<i>Construction</i>			
Simple technology	+++	++	+
Low cost (use of local materials possible)	+++	++	+
Construction time	+++	++	–
Potential for improvement	–	Possible upgrade to pour-flush latrine	Possible connection to a sewerage system
<i>Use & maintenance</i>			
No necessity for water	+++	+++	–
Easy to use	+++	+++	–
(efficiency of the system independent of its correct utilisation)		The interior needs to be dark	Water must be provided and used
Maintenance	++	++	+++ +*
Adaptation to type of anal cleansing	++ Adapted to water cleansing if plastic or concrete slab is installed and if soil conditions allow	++ Adapted to water cleansing if plastic or concrete slab is installed and if soil conditions allow	Possible blockages when solid materials are used
<i>Hygiene & comfort</i>			
Privacy	+	++	+++
	Latrine far from house (bad smell)	Latrine near the house	Latrine inside the house
Absence of smell	+	++	+++
Fly control	–	++	+++
Mosquito control	–	+	+++
Hygiene	+++ If correctly designed, built, used & maintained	+++ If correctly designed, built, used & maintained	+++ If correctly designed, built, used & maintained
Pleasant to use	Pit is visible	Pit is visible	+++

* Impermeable soil.

4.5 Composting latrines

4.5.1 ADVANTAGE AND DISADVANTAGES

Composting latrines allow the reuse of excreta for agriculture. This system has advantages and disadvantages summarised below (Table 13.VIII).

Table 13.VIII: Advantages and disadvantages of composting latrines.

Advantage	Disadvantage
Fertilisation of fields	Requires consistent use and maintenance, or the system fails and can cause sanitary risks Many communities will not accept the system
Income-generating activities	
Regular emptying of latrines permits their construction in rocky or high water-table contexts where deep pits cannot be dug	
Composting process kills pathogens	

This technology is only introduced into areas where compost is already used, because the introduction of the composting system is difficult if people do not have previous experience, and the management of such a latrine is time-consuming and requires constant effort.

It must be clearly established that the community will be interested in using or selling compost and that they will be ready to handle excreta, before implementing a composting-latrine programme. This assessment should include a market study. The introduction of this system into a new area should be preceded by a pilot programme with the participation of one or several volunteer families. The programme can be expanded according to the demand of the community, with positive results from the volunteer families.

4.5.2 COMPOSTING PROCESS

The composting process, facilitated by composting latrines, is an aerobic biological process that stabilises (dries and disinfects) excreta mixed with organic elements (leaves, paper) and inorganic elements (ash, soil) to produce a humus-like product that can be used as a soil additive. This product can be used by the community, or sold, after about four to six months.

An important characteristic of composting latrines is their ability to separate urine from excreta, to enhance the composting process and produce compost that is easy and safe to collect.

Urine can be stored in a jerrycan and used as a nitrogen-rich fertilizer, or diluted to use as an insecticide or fungicide to treat plants.

Three types of composting latrines implemented by ACF are presented in the following section.

4.5.3 EXAMPLES

4.5.3.1 LASF Composting latrine in Guatemala

Context

The double-chamber LASF latrine (*Letrinas Aboneras Secas Familiares* -Family Dry Composting Latrines) was first developed in the 1960's in Vietnam and then adapted to Guatemala in the late 1970's. It was later used in other Central American countries.

ACF carried out a LASF project between 2000 and 2002 (Table 13.IX) as part of a water and sanitation project for vulnerable farming communities in Western Guatemala.

The result of the programme was very positive, although it was implemented in a zone with no previous composting latrine experience. More than 95% of latrines were used, with 60% of the compost re-used after 1 year of operation.

Design

The design consists of an elevated latrine with a double chamber and a removable pan (Figure 13.17 & 13.18) that is not sealed to the slab, with access through the back wall.

The design must take into account the time it takes to fill up one chamber. Each one must therefore be sufficiently large to allow time for the complete decomposition of the excreta deposited in

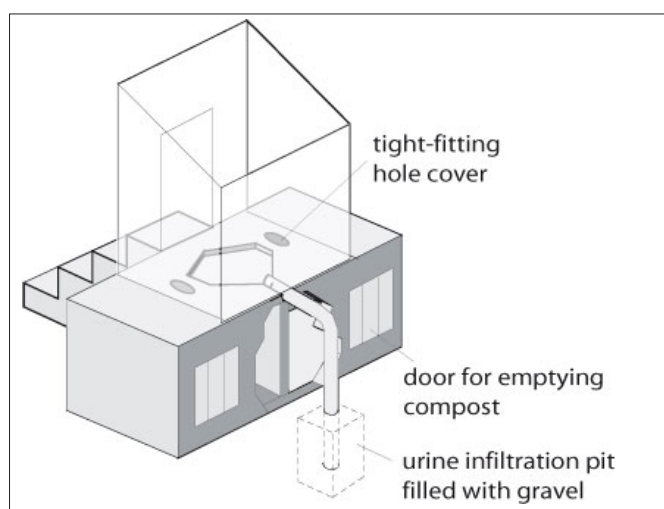


Figure 13.17: LASF design.

the other one (see Section 4.2.3.2). In Guatemala the normal dimensions of each chamber are: 0.8 m x 0.6 m x 0.8 m = 0.4 m³.

Urine and excreta are not deposited together. The urine is directed to an external container, for reuse, or to a soakaway pit.



Figure 13.18: LASF in Guatemala (ACF).

A: toilet pan (urine-excreta separation). B: emptying and storage of the compost.

Recommendations for use

While one chamber is being used, the second is closed while the excreta that was deposited during the previous 6 months undergoes aerobic decomposition. Every 6 to 8 months, the chamber that is full of composted excreta is emptied into bags that are stored in a dry place, the emptied chamber is put into use, and the other is closed for decomposition.

Strong capacity building and sanitation education components must be included in a LASF project, as well as training in storage and use of compost.

Treatment efficiency

Analyses of compost have been made, with results summarised in Table 13.IX.

- It is recommended to add a nitrogen-rich additive to this compost (urea, horse-manure compost etc.), given its low nitrogen content.
- Pathogen removal is excellent. After 3 months in a dry environment the majority of pathogens have died.

Table 13.IX: Average nutrient contents of 9 samples of human-excreta compost.

Nutrient	g/kg	Percentage of nutrient in the total weight of compost	Relative percentage of each nutrient
N	7.8	0.8%	13%
P ₂ O ₅	16.5	1.6%	27%
K ₂ O	37.3	3.7%	61%

4.5.3.2 Composting barrel latrine in El Salvador

Context

Oxfam in El Salvador designed a new version of the traditional composting barrel latrine in order to reduce the time and space needed for construction, and implemented this design in the country during the rehabilitation phase after the earthquake in 2001. ACF adopted this design in its El Salvador programme in areas where it had been already used.

Barrel latrines have three main advantages:

- excreta can be transported inside the barrels, which decreases the risks during handling and improves acceptance by communities;
- they accelerate the composting process;
- the barrel is inside the latrine pit with its upper part above ground level, which protects it from flooding.

Design

The latrine consists of a simple cabin over a 200-litre steel barrel (Figure 13.19) installed within the pit with only a 30-cm portion above the ground level. The barrel is equipped with a specially designed fibre-glass pan (double pan), with a 3” pipe for the evacuation of gas, and has four welded handles.

As for the LASF system, urine is guided toward the exterior through a flexible pipe to a soakaway pit.

Recommendations for use

Three people can remove the barrel when it is full (approximately every 3 months for a six-person family), and replace it with an empty barrel. The composting process continues in the first barrel, which is left closed, with a ventilation pipe, for 2 months in the shade or 2 to 3 weeks in the sun. Then the barrel is emptied onto the ground and the composted material is stored in bags in a dry, cool place.

Treatment process and efficiency

The treatment process is the same as for the LASF system, except that is accelerated by solar heating.

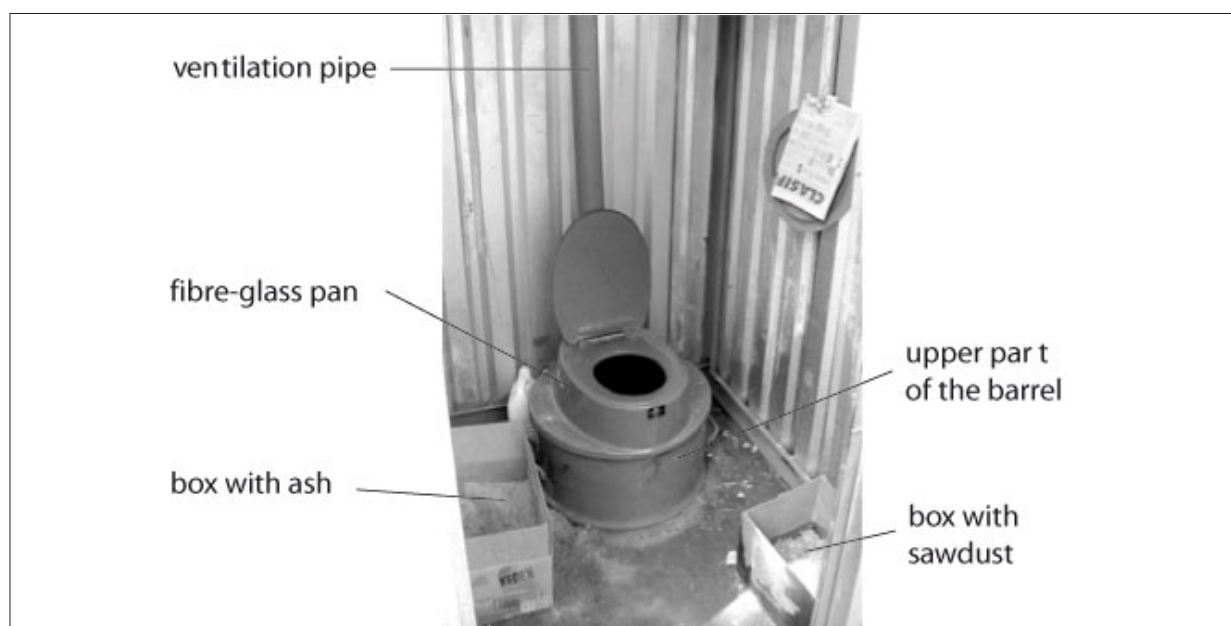


Figure 13.19: Example of composting barrel latrine (ACF, El Salvador).

4.5.3.3 Vault latrines in Kabul

Context

The majority of private households in Kabul, as in many other parts of Afghanistan, normally use a traditional vault latrine. Here, farmers organise the collection of excreta directly from the vault latrines for off-site composting. The latrines were not maintained during the previous decades of conflict and had fallen into a state of disrepair. At the same time, the collection of excreta decreased, leading to a great deterioration of sanitary conditions in the city. Numerous agencies undertook the rehabilitation of these traditional latrines. ICRC improved the traditional design (reinforcing the construction and adding a urine-evacuation pipe as well as a door to close the pit), and ACF adapted this model as described below.

Design

The latrine is placed in the street next to the wall of the household compound. The vault of the latrine has an opening facing the street so that it can be emptied from the outside of the compound.

The improved model, designed by ACF, includes (Figure 13.20.A):

- a stone masonry vault with a concrete bottom, which protects the shallow water table, and a shallow soakage trench placed in the back that allows the percolation of liquids;
- a metal trap-door that allows excreta collection from the street;
- a reinforced-concrete slab whose design allows the separation of urine from the excreta, and the collection water from anal cleansing and slab washing (Figure 13.20.B);
- a ventilation pipe equipped with mosquito netting;
- a superstructure made of mud bricks; and
- a roof made of wooden logs, mud and straw.

Emptying must be done every 45 days, on average, based on ACF experience.

In 2003, this system cost approximately US\$200.

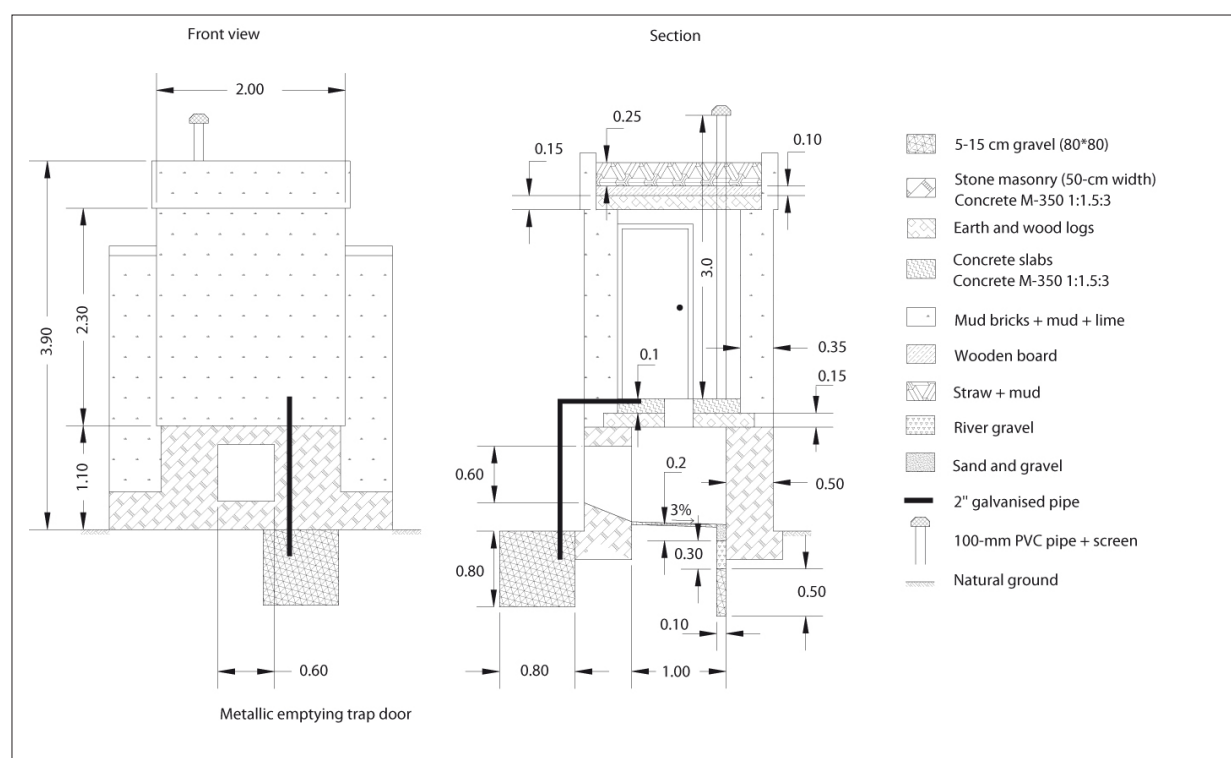


Figure 13.20: Vault latrine (ACF, Afghanistan). A: general design.

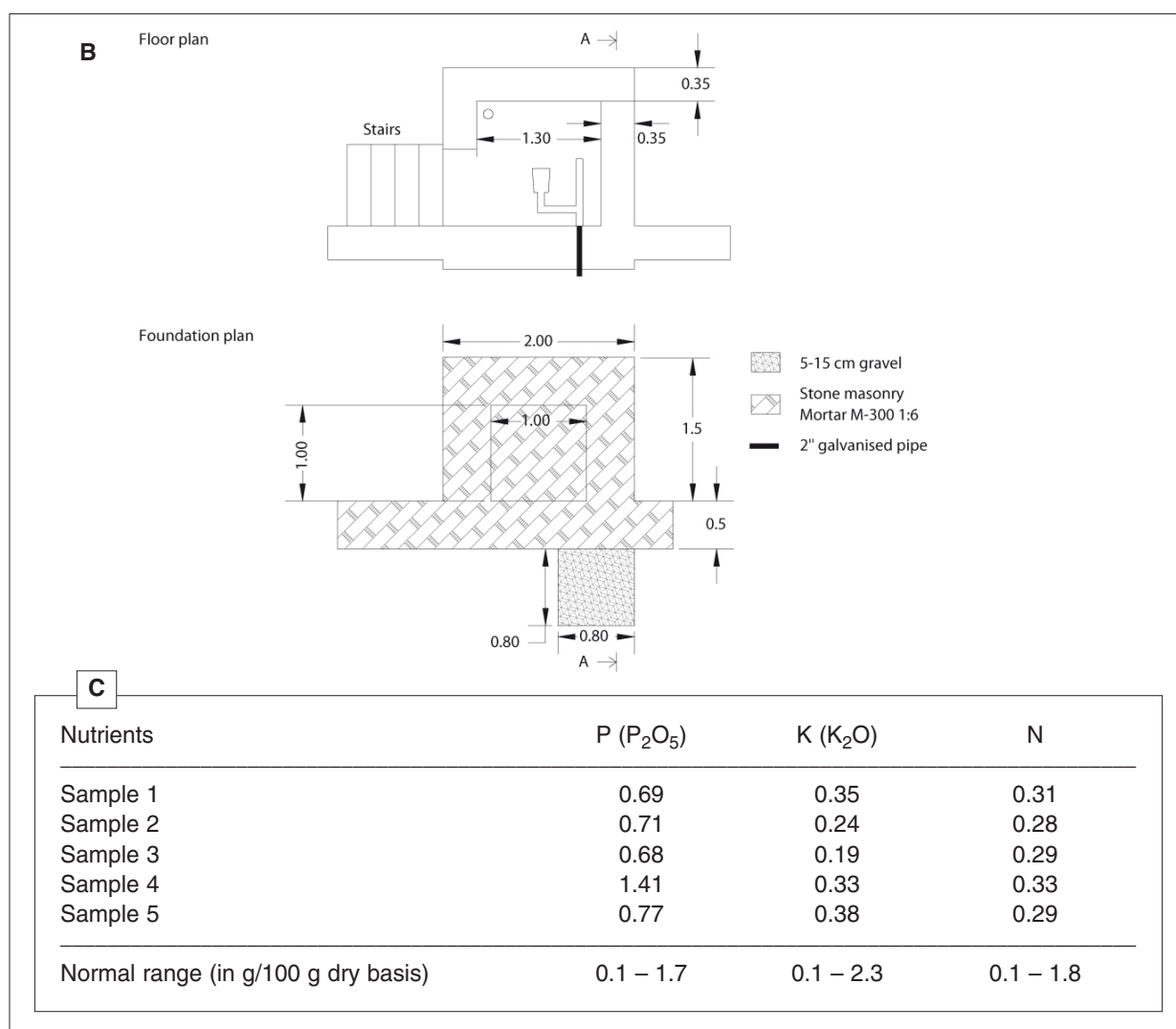


Figure 13.20: Vault latrine (ACF, Afghanistan).

B: slab, separation between urine and excreta. **C:** concentrations of some major elements in the compost of Aqa Ali Shams vs. normal range for compost (source : Brunt et al. 1985).

Design selection restrictions

This system should only be considered where the collection of excreta is a normal practice, because these latrines have no long-term storage capacity. Otherwise, the vault will be full after one or two months and excreta will flow into the streets.

Recommendations for use, and general comments

Traditionally, farmers from surrounding rural areas used to employ people to empty latrines and transport the excreta to their farms for compost production. The traditional excreta-collection system relied on a mutual free service: farmers received excreta at a low cost, and re-used it as fertilizer, while households had their latrines emptied for no cost. Further, this activity provided some income to those collecting and transporting the excreta.

Recently, the system broke down in many neighbourhoods of Kabul, because of:

- the increase in the urban population during the past two or three decades, that has decreased the area of farmland around the city and increased the number of latrines to be emptied,
- and the drought that has affected the region of Kabul since 1999, compelling many farmers to leave their land, and subsequently reducing the demand for fertilizer.

The main consequence of the deterioration of this system was that latrines in Kabul were no longer regularly emptied, leading to an increase in public health hazards.

To solve this problem ACF focused on the collection of excreta and the subsequent composting process. A partnership between an ACF-supported local neighbourhood committee and farmers from the area was established. The neighbourhood committee was responsible for the following:

- organisation of latrine-emptying and transport of excreta to farmers;
- purchase and provision of raw materials for compost production (including straw, sawdust etc.);
- composting of the excreta;
- storing and packaging of the compost for sale;
- sale of bags of compost to other farmers.

The farmers were responsible for the compost-production process, including the mixing of excreta with raw materials and regular turning of the mixture. ACF provided technical assistance, including training of farmers, choice of the composting recipes, and temperature monitoring of compost piles, and ensured the promotion of the compost for sale.

The aerobic decomposition process is more efficient in off-site composting than that in on-site composting latrines, because the material is repeatedly mixed and aerated.

With the assistance of the local population, ACF had rehabilitated more than 2 350 latrines in Kabul by the end of 2003.

4.6 Latrines for rocky and frozen ground, high groundwater levels and flood-prone areas

Latrine construction in rocky or frozen ground is difficult due to excavation problems. Special tools are required for excavation, such as chisels, sledge hammers, miner's bars or pneumatic hammers, and much effort and time is required to complete the work. Further, the low infiltration rate common in these terrains means that the pits quickly fill up. In these situations, it is preferable that the volume of pits is small and that pits are emptied frequently.

Latrine construction in areas with high groundwater levels is complicated because of contamination risks for groundwater, and consequently, nearby water points (see Section 3.5 on water-point contamination). Here, it is not always advisable to dig pits and use standard latrine designs.

Simple solutions have proven to be successful in these difficult contexts, as follows.

Double-pit latrine (for dry latrine or pour-flush system)

This design can be constructed in conditions where digging is restricted due to high groundwater levels or rocky ground, and also in non-problematic contexts, to increase the operational life of the latrine by making it easy to empty. The latrine consists of two relatively shallow pits, that can be built partially on top of the surface of the soil if digging is very restricted. When the first pit is full, the second, empty pit is used and the first, full pit is sealed. When the second pit becomes full, sufficient time (12-24 months) has passed for the excreta in the first pit to have undergone decomposition. The first pit is then emptied and is ready to be reused. Composted excreta can be thrown away or used as fertilizer (see Section 3.5).

Composting latrines

Composting latrines are very suitable for these difficult contexts. Vault latrines, double composting chambers, or barrel latrines can be built without digging a pit (see Section 4.5). These systems are of particular interest if there is a market to sell (or use) the fertilizer produced by composting of the excreta, as this provides a financial incentive for the community to adopt a proper latrine system.

Elevated pit latrine

For an elevated pit latrine in high groundwater areas (Figure 13.21), the pit is dug as deeply as possible during the final part of the dry season when the water table is at its lowest. The pit is lined

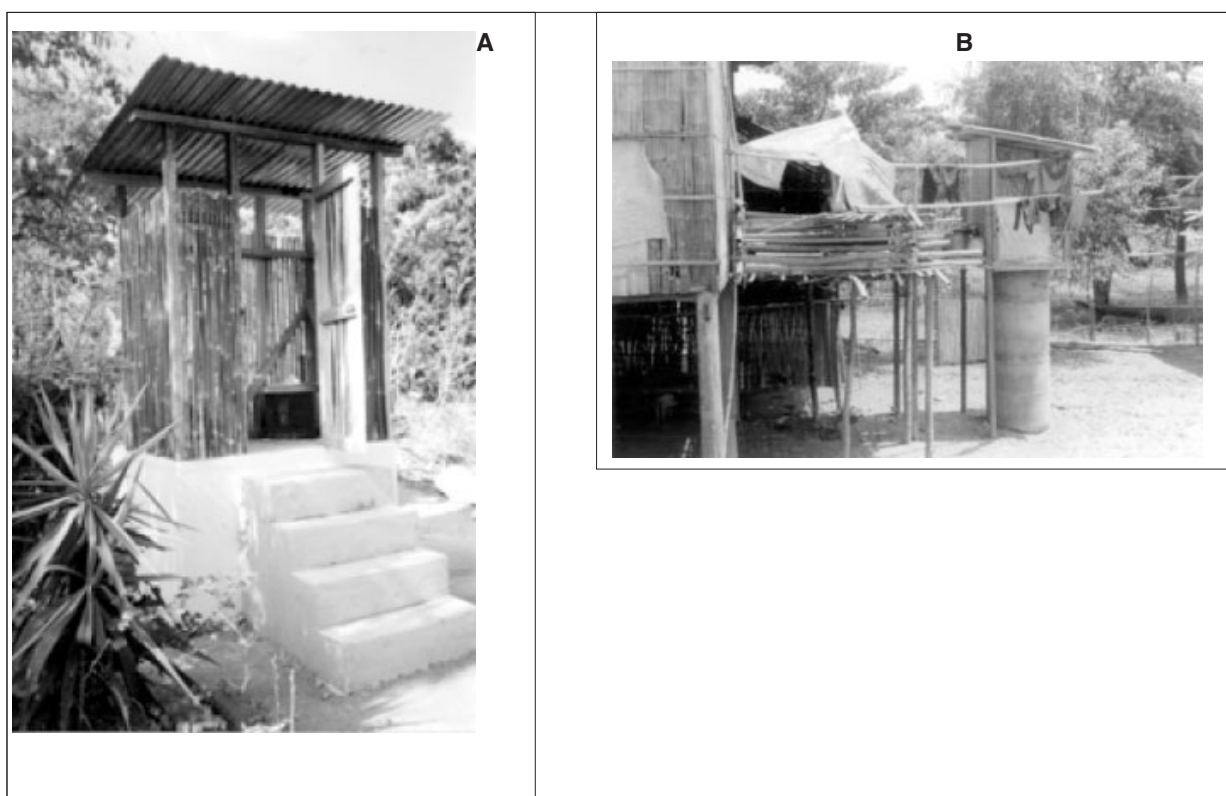


Figure 13.21: Elevated pit latrine.

A: for high groundwater areas (ACF, Guatemala). B: for flood-prone areas (ACF, Cambodia).

and protected to isolate it from the water-table that rises to the base of the pit during the wet season. The pit is extended above the ground level, until the required pit volume is achieved, through the construction of watertight walls or the use of large metal or prefabricated concrete bins placed into the pit.

Latrines built in *flood-prone areas* must be accessible even during floods, and also must prevent excreta from escaping from the pit and causing widespread contamination. Figure 13.21B shows an example of elevation of the pit through concrete rings that also protects the pit from water ingress.

Bucket or barrel latrine

The bucket latrine consists of a system where excreta is deposited in a bucket or a barrel that can be easily removed and emptied. This latrine requires a high level of sensitisation about its maintenance and emptying, given the potential sanitary risks. However, if it is used properly and has a safe emptying and disposal system, and is accompanied by an adequate maintenance and hygiene promotion programme, this can be an efficient system. This system requires daily cleaning and maintenance, with material inside the bucket or barrel deposited into a larger recovery tank, which in turn, is emptied on a daily basis at an appropriate treatment or disposal site.

4.7 Excreta control in IDP or refugee camps

Excreta control in these emergency situations must be implemented rapidly, as large concentrations of people create environments where the risk of epidemics (e.g. cholera and other diarrhoeas) is high and where people are very vulnerable.

The latrine design will evolve over different phases of the humanitarian response, in order to provide a quick and efficient intervention, from the first days of the emergency to the more permanent installation of the camp.

Objectives / activities by phase

Phase 1

- Identify areas where defecation generates sanitary risks (near water points, upstream from the camp for a river, near hospitals etc.) and control the access of people to these areas.
- Identify and delimit specific areas where people can defecate (defecation fields, Figure 13.22).
- Construct latrines at key public points: health centres, schools etc.

Phase 2

- Emergency communal latrine construction and maintenance.

Phase 3

- Family latrine construction

4.7.1 DEFECTION FIELDS OR TRENCHES

These installations, preliminary to the construction of latrines, allow the servicing of a large population quickly, decreasing the risk of propagation of faecal pollution (Table 13.X & Figure 13.22).

Defecation fields involve the delimitation of an area where people can defecate. They are more appropriate in dry places and dry climates because they are installed in open areas.

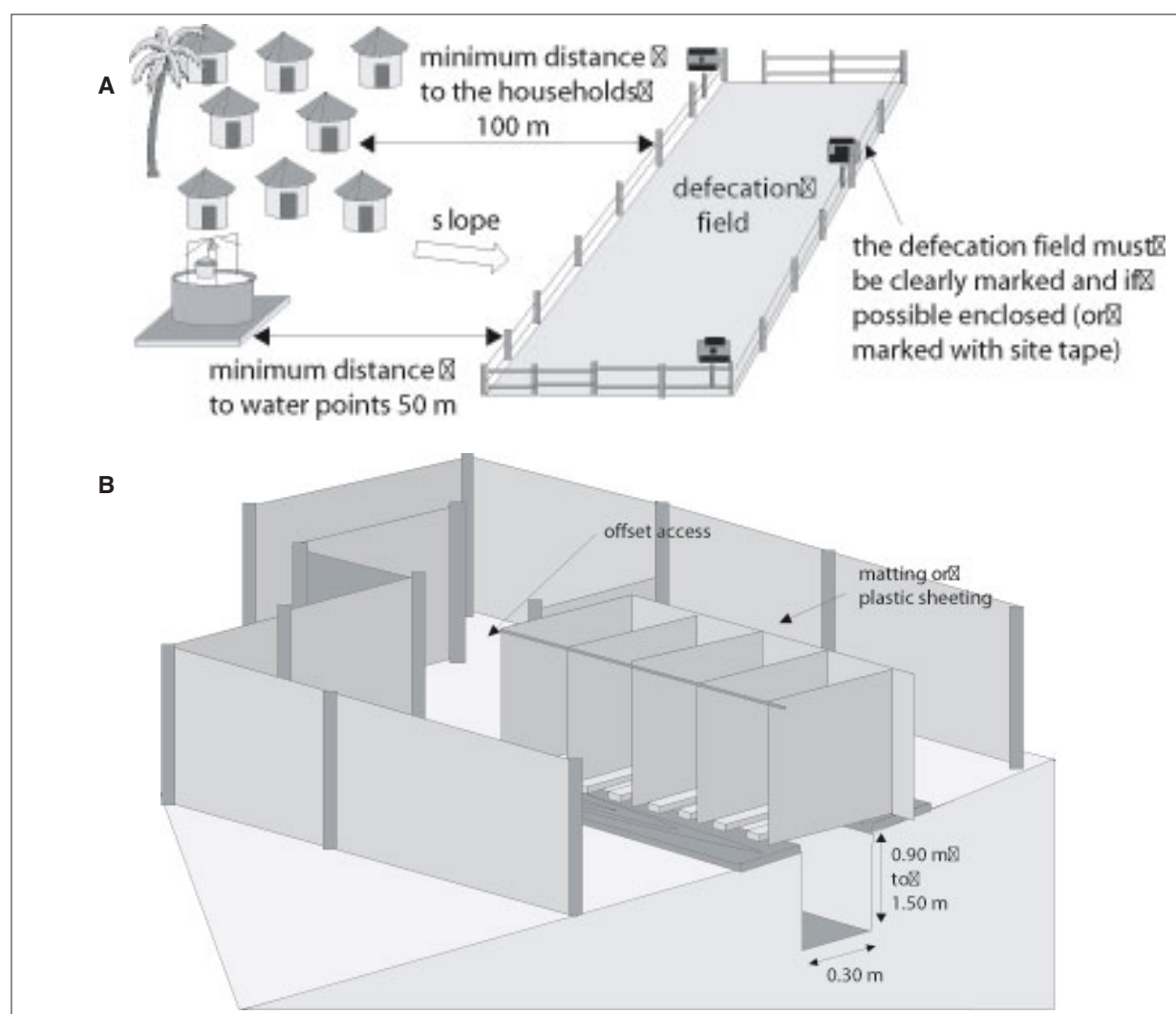


Figure: 13.22: Defecation management in the first (acute) phase of an emergency.

A: defecation field. B: defecation trench.

Table 13.X: Characteristics and construction of defecation fields or trenches.

Field area	< 5 m ² /pers
Distances to be maintained	
field – dwellings	100 m
field – water point	50 m downstream from water point
Trench length	2.5 m / 100 people
Distances to be maintained	
trench – water point	30 m
trench bottom – aquifer	2 m
Materials (for a 10 m long trench)	5 boards (L = 4 m, W = 0.2 m) 21 posts (2.5 m long, 0.1 m dia.) Plastic sheeting (L = 36 m, W = 2 m) 1 kg 7-cm nails
Personnel	4 people for 1 day (trench)
Tools	2 shovels, 2 picks, 2 buckets (12 l) 10 m of 4-mm cord 1 frame saw, 1 machete, 2 carpenter's hammers
Implementation	Trench digging (length: 10 m, depth: 1.5 m, width: 0.3 m) Protection of trench edges with wooden boards Digging of holes for posts Erection of enclosure (plastic sheeting or matting) Possible partitioning for privacy

Defecation fields can be improved with defecation trenches, where faeces are buried, decreasing the health risks. These trenches can be shallow (20-30 cm wide and 15 cm deep) or deeper if tools and human resources available. Defecation trenches can be dug very rapidly, either manually or, when available, with a mechanical excavator.

Wooden boards or logs can be placed across the trench to support the weight of the user over the trench. It is also recommended to make compartments with plastic sheeting or local materials to allow the privacy.

The faeces in the trench are normally covered daily with soil, to limit smells and fly infestation. Defecation trenches will fill rapidly, and new trenches will need to be dug every few days, depending on population numbers and the depth of the trenches.

Local representatives should be consulted to determine specificities regarding privacy, gender and children's issues, as these vary for different communities and cultures.

4.7.2 SIMPLE LATRINES

Latrines with wooden slabs (Table 13.XI & Figure 13.23) are a rapid solution to sanitation needs in camps, and are often used during the construction of more permanent latrines. However, this latrine design is normally used at household level, as they are difficult to clean and maintain at a camp level. Hygiene promotion must be carried out, and paid cleaning teams are often necessary.

The use of plastic or metal slabs for simple latrines is an efficient way to intervene quickly in an emergency context. These slabs should be part of an emergency stock.

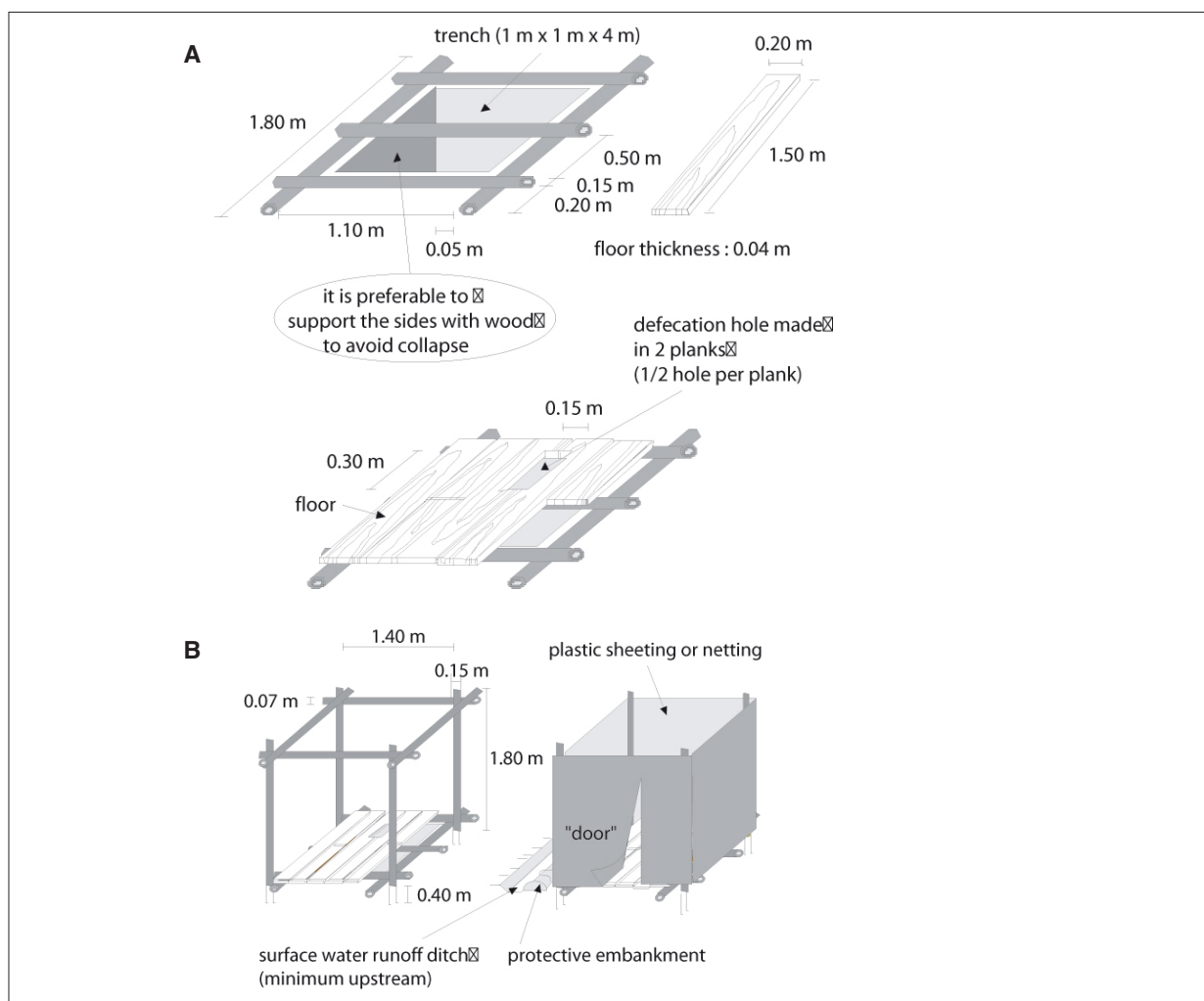


Figure 13.23: Simple wooden latrines.
A: trench and floor. B: superstructure.

Table 13.XI: Characteristics and construction of simple wooden latrines.

Materials (1 x 1 x 4 m trench, supported by beams every 0.50m)	10 x 1.40 m timber for the support (0.10 m dia.) 9 x 2.20 m timber for the structure (0.15 m dia.) 4 x 1.60 m timber for the reinforcement (0.07 m dia.) 10 boards (W = 0.20 m, L = 1.5 m) Plastic sheeting (W = 1.80 m, L = 7 m) 2 kg of 7, 10, and 12 cm nails
Personnel	3 people for 2 days (1 carpenter and 2 assistants)
Tools	2 shovels, 2 picks (hoes), 1 bucket, 2 carpenter's hammers 1 saw, 1 measuring tape 10 m of 8-mm cord
Construction	Trench digging (1 x 1 x 4 m) Installation of timbers, embedded in the ground Fixing the floor with nails Erecting posts and fixing the plastic-sheeting walls Installation of a drainage system around the latrines

4.7.3 SEMI-PERMANENT OR PERMANENT LATRINES

If the displaced people remain in the camp for several months or more, semi-permanent or permanent latrines must be built in order to guarantee proper sanitation. Construction can be carried out with the assistance of, or wholly by, the camp residents, depending on the level of their motivation and the strength of the hygiene-promotion programmes (see Sections 3 & 4).

5 Other environmental sanitation activities

5.1 Personal hygiene structures

5.1.1 FACILITIES FOR WASHING HANDS (AND ANAL CLEANING)

Washing hands is one of the most effective ways for the reduction of faecal-oral diseases. Water availability for this activity is absolutely necessary at the household level as well in public places where washing hands is a priority, for instance at public latrines or health posts. Washing hands is always important after defecation, even when water is used for anal cleaning, and latrines should be provided with facilities for washing.

For washing facilities, a connection can be made to an existing water-distribution system to create a water point. It is possible to create an independent water point where there is no piped water supply; for example, a well equipped with a handpump. Alternatively, small barrels or sealed containers, equipped with taps and containing chlorinated water, can be placed next to latrines, and offer a rapid and cost-effective solution. These are filled and maintained by the community on a daily basis. In all cases, adequate drainage must be constructed.

5.1.2 SHOWER AND LAUNDRY AREAS

The provision of access to washing facilities, coupled with the availability of drinking water adjacent to these facilities, is fundamental to limiting water-washed diseases.

5.1.2.1 Showers

Hygiene facilities have two main objectives: to support the promotion of safe hygiene habits, taking account of socio-cultural factors, and to reduce sanitary risks linked to stagnant water (vectors, water-point contamination) (Box 13.6).

Design features and construction considerations for showers are summarised in Table 13.XII and Figure 13.24. It is possible to use concrete, gravel or other materials for shower floors to avoid the production of stagnant water. In cold situations, hot water must be provided. ACF built showers with hot water in Chechen displaced people's camps in Ingushetia (Figure 13.24C) as well as in Iran after the earthquake of 2003.

Box 13.6

Requirements for the correct operation of showers and laundries.

Water must be readily available.

The floor must be essentially smooth with a small slope towards a drain leading to the exterior of the facility.

Measures that avoid stagnant water should be put in place, as follows:

- it is preferable to install the drain following the slope, and to let the water to infiltrate where the soil has sufficiently permeability;
- a grease-trap and soakaway pit are provided where infiltration rates are lower and where there is no natural slope for drainage (see Box 13.4);
- small plots or gardens can be planted where wastewater is drained to.

Tab 13.XII : Characteristics and construction of shower blocks (2 cubicles).

Distances to maintain	
shower – water point	50 m
shower – dwelling	10-250 m
Shower cubicles per block	≤ 10
Materials (5 m drain and 3 m infiltration trench)	2.5 m ³ stone, 5.5 bags cement, 0.55 m ³ bricks, 0.4 m ³ sand, 0.55 m ³ gravel 115 m of 6-mm reinforcing steel, 3 kg binding wire 9 pieces 2.5-m timber (width 0.15 m) 20 pieces 2.9-m timber (width 0.07 m) 35 m ² plastic sheeting 2 kg of 7 and 10-cm nails
Personnel	1 bricklayer and 4 assistants for 3 days
Tools	4 shovels, 4 picks, 2 buckets (12-l), 1 wheelbarrow, 1 spirit level, 1 pair of shears, 1 measuring tape, 2 carpenter's hammers, 1 saw, 2 trowels, 10 m of 4-mm cord
Construction	Digging foundations Filling with hardcore Preparation of reinforcement Pouring concrete, leaving enough run-off slope to avoid stagnant water Building low brick walls to take the poles for the structure Building roof and fixing plastic sheeting or matting Laying gravel to prevent mud in the corridor Constructing the drainage channel and infiltration trench or soakaway pit

5.1.2.2 Laundry areas

The washing of clothes, fundamental for personal hygiene, is often not carried out adequately because of the lack of facilities such as a laundry area, and is encouraged by the improvement of facilities coupled with hygiene promotion. Laundry areas also limit the risk of stagnant water from washing clothes (Box 13.6). The availability of space and of simple facilities to dry clothes must be considered when planning a laundry facility. Laundry areas are normally located near safe water points, preferably in the vicinity of springs or along streams, down-stream from the community or camp. These facilities also play an important social role, as they serve as social gathering point (specially for women), and this must be considered when deciding between a household- or community-based strategy.

Design characteristics and construction considerations for laundries are shown in Table 13.XIII & Figure 13.25.

Table 13.XIII: Characteristics and construction of laundry areas.

Materials (5 m channel, 3 m infiltration trench*)	4.3 m ³ stone, 10 bags cement ; 0.6 m ³ brick, 0.7 m ³ sand; 1 m ³ gravel, 230 m of 6-mm reinforcing steel, 1.5 kg binding wire
Personnel	1 bricklayer and 4 assistants for 3 days
Tools	4 shovels, 4 picks, 2 buckets (12-l), 1 wheelbarrow, 1 spirit level, 1 pair of shears, 1 measuring tape, 2 trowels, 10 m of 4-mm cord
Construction	As for shower block

* Also a soakaway is possible.

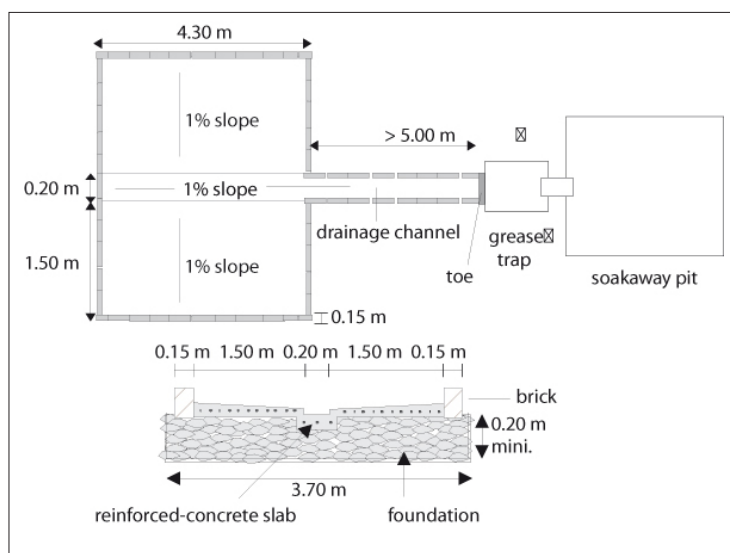


Figure 13.25: Washing area with soakaway pit.

5.2 Grease traps

Grease traps (Figure 13.26) facilitate the removal of grease and oil from wastewater. They are installed in the drainage systems of kitchens, showers, laundry areas and other washing facilities, and normally consist of a box (that can be one half of a metal 200-l drum) with baffles made from wood or other suitable materials. Water circulates freely through the baffles with the water level above the gap in the baffle, thus, trapping any floating oils and scum in the box. The grease trap should be emptied daily and the residues buried.

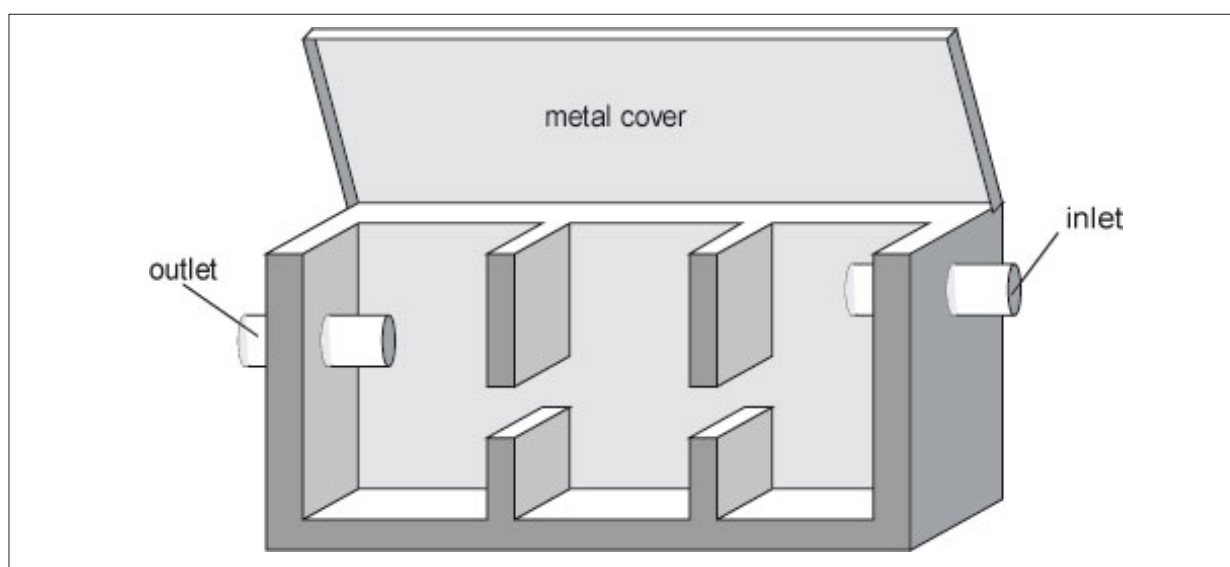


Figure 13.26: Grease trap, ACF Ingushetia 2003.

5.3 Surface-water drainage

Water is an ideal host environment for many bacteria and insects, and stagnant waters are a factor in the transmission of diseases that are water-borne or water-based, or carried by water-related insect vectors. Stagnant water may result from the blockage of water flow, by the accumulation of rain water, or as a result of wastewater from water-supply and sanitation systems. Drainage systems are also necessary to control run-off after heavy rainfall, that can potentially damage infrastructure.

The principle of drainage systems is to channel wastewater along natural slopes to transport it away from human habitation into a natural drainage system or artificial infiltration system.

Surface-water drainage systems should be planned after topographical studies to determine the slope of the terrain (see Chapter 11A). The dimensions of the drainage system will be a function of the volume of water that it will carry, the design and construction constraints associated with urban, village or rural contexts, and the resources available. Bridges, or platforms, that allow people and vehicles to move over drainage channels need to be designed into any system.

The main activities during drainage construction include: the sizing and measurement of a drainage network (which must include an analysis of the intensity and the periodicity of rainfall), the actual construction and maintenance of the system (which must include community participation), the protection of the channel margins against erosion (e.g. by soil stabilisation through tree-planting).

Drainage channels can be dug manually or by machine. For manual digging, it is important to involve the community. Channels may or may not be covered or protected. Protection can be made with concrete or stone, and must be removable to facilitate maintenance operations.

Maintenance of the system must be done on a regular basis as an accumulation of materials such as dead vegetation, refuse and silt may obstruct the water flow, leading to overflows and an unsafe environment.

5.4 Vector control

5.4.1 METHODOLOGY

Vector-control measures aim to reduce the risks of the development and transmission of diseases such as malaria, transmitted by *Anopheles* mosquitoes, rabies, which can be transmitted by rats, or a number of faecal-oral diseases transmitted by flies.

However, the presence of vector organisms does not necessarily imply a health risk. It is necessary to collate information about the health of the community (such as the incidence and types of diseases present), the hygiene habits of the community and the environmental sanitation risks, before implementing a vector-control programme.

Box 13.7 summarises the methodology of a vector-control intervention.

Box 13.7

Intervention Methodology for Vector Control.

Identification of the vector-related diseases and areas of risk.

Prevention measures for settlement in areas of risk.

Removal or modification of the vector-breeding sites:

- construction of a drainage system and elimination of stagnant waters or wet areas;
- refuse collection;
- sanitation measures in general.

Control of the vectors:

- cleaning of latrine slabs and superstructures;
- use of insecticides and rodenticides;
- tsetse-fly traps;
- hygiene-promotion programme.

Prevention measures:

- mosquito-net distribution: general distribution with special attention to maternity or health centres, and families with children under five;
- modification of dressing habits (e.g. using long sleeves to avoid insect bites);
- hygiene promotion for prevention.

Table 13.XIV lists the major vectors and the diseases that they transmit, the environments that favour their development, and the important measures that can be taken for their control.

Table 13.XIV: Vectors that can pose health risks.

Vector	Health risk	Favoured environment	Control measures
Flies	Eye infections (particularly among children), diarrhoeal diseases	Exposed food, excreta, dead animals	Improve environmental sanitation (collection and disposal of organic refuse, dead animals etc.) and use of VIP-type or pour-flush latrines Promote the use of screens on windows (houses, hospitals etc.) Spray refuse with insecticides
Mosquitoes	Malaria, filariasis, encephalitis	Stagnant water, mainly in the perimeter of flooded areas, and slowly flowing water bodies	Removal of stagnant water sites (puddles, cans, tyres etc.) or spraying with larvicide
	Yellow fever and dengue	Stored water in or near homes Pond or rain water accumulated in containers, cans or old tyres	Insecticide control by spraying mosquito-infested sites Promote the use of mosquito nets
Mites	Scabies, scrub typhus	Crowded areas and poor personal hygiene	
Lice	Epidemic typhus, relapsing fever		Improve personal hygiene In severe cases, spray people and clothes with insecticides suitable for use on humans
Fleas	Plague, murine typhus	Infected animals, particularly rats (see 'Rats' below)	Fumigate rodent burrows with insecticides Treatment of beds In severe cases, spray people and clothes with insecticides suitable for use on humans
Ticks	Relapsing fever, chickenpox	Infected animals (see 'Rats' below)	Chemical control in on the perimeter of the community Clear the vegetation to 50-100 m around the home or community In severe cases, use chemical control in houses (with caution)
Rats	Rat-bite fever, leptospirosis, salmonella	Food not correctly protected, refuse	Improve environmental sanitation Use rodenticides Use traps at refuse or food-storage sites

5.4.2 USE OF INSECTICIDES

The use of insecticides is recommended only in extreme cases because of the health risk to workers and the general population and the fact that insects develop resistance, making it necessary to use another product.

Insecticides are designed to be effective against larvae or adult insects, and are classified into three categories: digestive, contact, and fumigants. The use of deltamethrine as a contact insecticide has been tested and used by ACF teams to combat the spread of fleas and flies. The methodology used in Benaco, Tanzania, is cited in the following programme example.

5.4.2.1 Implementation on site

The aim of a contact insecticide is to put the insect in direct contact with the chemical. Therefore, the spray is directed either at the insects themselves, or at the surfaces with which they will be in contact, i.e. soil, bedding (for fleas), latrine walls (for flies).

5.4.2.2 Products and preparation of solutions

The product used in Benaco was deltamethrine, a synthetic pyrethroid which is commercially available under different brand names (k-Othrine®, Decamethrine®, NRDC 161®, Cislin®, Cedis® etc.). These products are commonly supplied as a powder (2.5% active ingredient) or a liquid (25 g active ingredient per l). The dosages given in Table 13.XV refer to use of the liquid form.

Table 13.XV: Use of insecticides.

Type of vector	Dilution	Use
Fleas	1 l for 500 l of water	Spray for floors and bedding
Flies	1 l for 100 l of water	Spray for latrines on walls

The proportion of atomised solution to be used is 1 l per 10 m² of treated surface. The atomiser is regulated at a flow of 1 l/min. For treatment against flies, 3 to 4 sugar lumps are used per litre of solution, which serves as bait and facilitates the fixing of the solution when sprayed on vertical walls.

A team is made up of several people equipped with manual sprayers (capacity 15-20 l). Two additional people are in charge of informing the local population about spraying.

One person is in charge of stock management and the preparation of solutions, and a driver is responsible for the transport of the equipment and solution to the spraying site.

The intervention plan is as follows:

- day 1: inform the population and prepare for them to leave their houses during spraying on day 2;
- day 2: supply sites with the vehicle, then spray.

5.4.2.3 Organisation of storage premises and preparation of insecticides

Several precautions must be taken at the time of the preparation and use of insecticides, particularly those for external use. These precautions are listed in Table 13.XVI and the preparation area is illustrated in Figure 13.27.

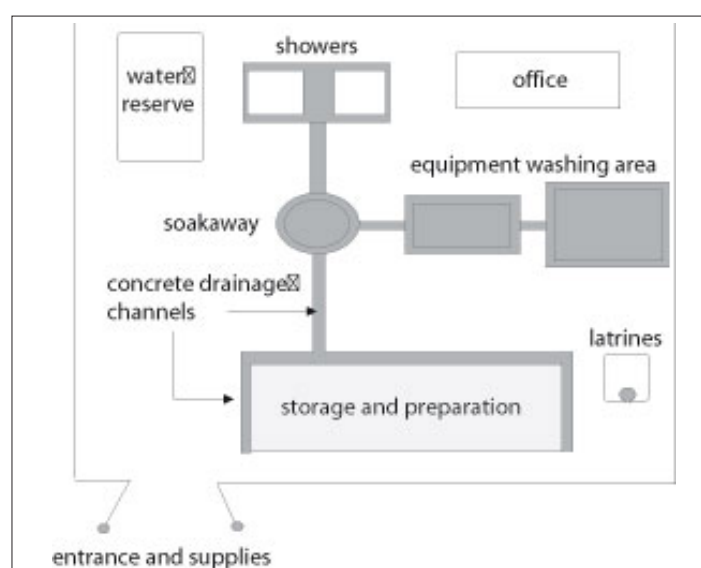


Figure 13.27: Insecticide preparation area.

Table 13.XVI: Precautions to be taken during the preparation and use of insecticides.

Protection of personnel	Mask, gloves, goggles, overalls, boots
Washing of preparation & spraying material	Once a day, systematically
Washing of clothes	Once a week, systematically
Facilities required	Showers, washing tubs, concrete drainage channels, soakaway

5.5 Management of solid waste

5.5.1 INTRODUCTION

The quantity and type of solid waste generated by a community depends on their living habits, which are related to their economic status. In general, wealthier communities produce more solid waste.

Domestic waste favours the development of disease vectors such as flies and rodents, and looks and smells unpleasant. It can also cause environmental hazards by blocking natural or constructed drainage systems, and increasing the risk of floods.

5.5.2 BURIAL

Domestic or collective refuse pits, where waste is buried, are one of the best solutions to combat the spread of vectors (Table 13.XVI & Figure 13.28). They are covered daily with earth, which limits the generation of smells and proliferation of insects, and accelerates decomposition. The refuse pit must be protected from children and animals by a fence, and from surface run-off by a surrounding drainage channel. It is better to bury biodegradable waste than to incinerate it.

In rural areas refuse can be reused and controlled more easily. It is possible to develop family strategies where each home has its own refuse pit. Refuse is deposited daily in pits dug by the families themselves, and covered by a layer of soil. The pit is backfilled with soil when full, and a new pit is dug. It is possible to produce compost for reuse if only organic matter is put in the pit.

Tab 13.XVI : Characteristics and construction of refuse pits.

Volume of waste	0.5 l /person/day
Distances to be maintained:	
pit – water point	30 m downstream of water point
pit – dwellings	20 m
bottom of the pit– aquifer	2 m
Materials	10 x 1.40 m timber for the support (0.10 m dia.)
(2 m ³ hole waterproof	10 x 1.40 m timber for the fence (0.10 m dia.)
to a depth of 0.50 m)	Plastic sheeting (W= 1 m, L = 11 m)
	40 nails (7-cm)
Personnel	2 people for 1.5 days
Tools	2 shovels, 2 picks, 1 bucket, 1 carpenter's hammer, 5 m of 8-mm cord
Construction	Hole digging (2 m deep) Installation of wooden struts in staggered rows Gathering of earth to cover waste Installation of a protective fence and drainage channel

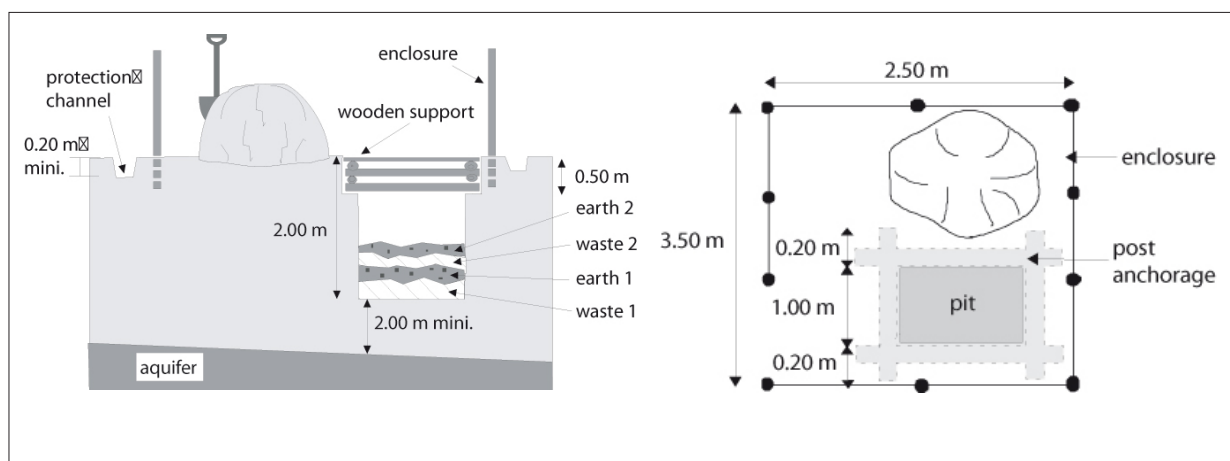


Figure 13.28: Refuse pit.

5.5.3 INCINERATION

Incineration is advisable for the treatment of contaminated waste from hospitals or dispensaries, as well as for non-biodegradable waste. It can be done near living areas, including urban environments, although care must be taken in siting and designing the incinerator to avoid fire risks and contamination by toxic smoke.

An incinerator can be easily constructed using a metal barrel (noting that it becomes more susceptible to corrosion with heat, Figure 13.29). A brick-built incinerator is recommended for more permanent use (Figure 13.30).

Each type of incinerator design comprises a furnace with a hatch to remove ashes and regulate air flow, as well as a chamber for the waste with a loading trap at the top.

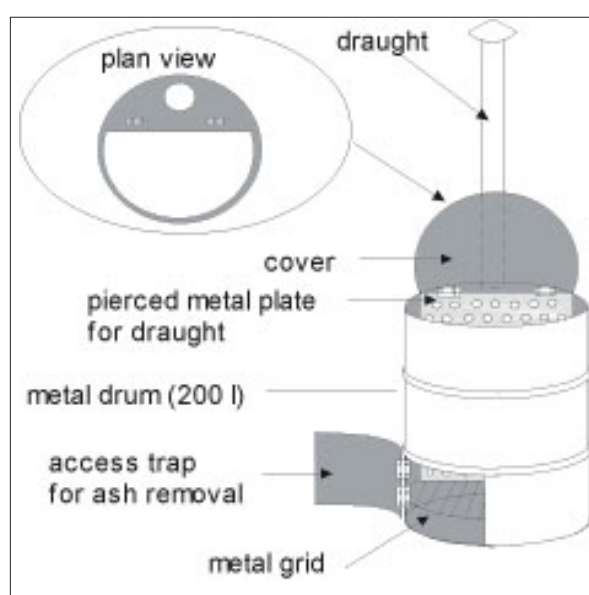


Figure 13.29: Simple incinerator.

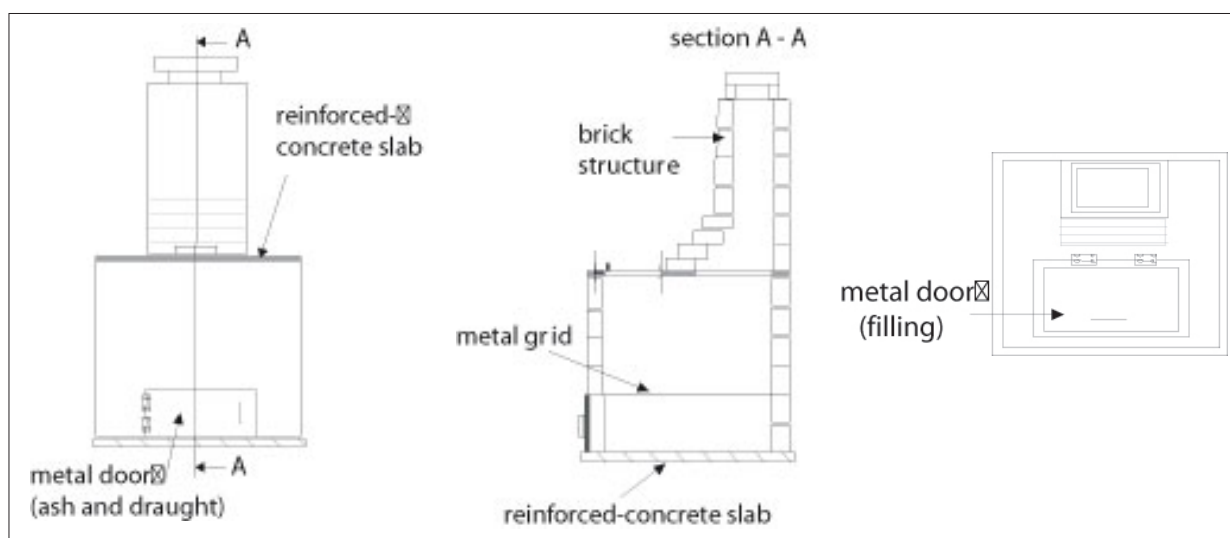


Figure 13.30: Brick-built incinerator.

Box 13.8**Key aspects for refuse collection in an urban context.**

The promotion of key social habits: collection and disposal of waste at specific locations, proactive participation of the community.

The refuse-collection system: emptying of dustbins and containers.

The identification of areas for final disposal: landfills.

The transport of containers to landfills using animal-drawn carts, tractors and on-road vehicles. The creation of micro-enterprises that are equipped with tools and transport for refuse collection and which receive direct payment from the community.

The separation of refuse at the final destination for treatment by burial, incineration or reuse by composting or recycling.

The coordination between different actors: community, municipal water and sanitation services, health structures and other local organisations.

5.5.4 URBAN CONTEXTS

Low-income urban areas are normally characterised by poor sanitary conditions (Box 13.9). Open and unprotected refuse tips and inadequate space for digging pits are common, leading to serious public health risks. Here, community systems for refuse disposal, and sanitary landfills, offer the best solutions for waste disposal

Box 13.8 summarises key aspects for the implementation of refuse collection in an urban context.

Note. – The community should actively participate in the running of the system, to ensure its sustainability. The community must also appreciate that the service has a cost which it must meet, at least in part. The system requires trained staff for its operation and maintenance and also an effective management system for the removal, transport and disposal of refuse at a sanitary landfill.

Box 13.9**The effect of rapid population increases in urban areas.**

Rapid urban growth in the last half of last century, due to migration from rural areas, has led to the incapacity of governments of developing countries to provide appropriate lodging and services. This has resulted in the development of peri-urban neighbourhoods characterised by poor living conditions with significant health risks.

Sanitary services present a particular problem in less well-established urban areas built without proper planning or authority, where the majority of impoverished people are located. The World Bank (2000) estimates that nearly 26% of the global urban population, over 400 million people, has limited access to simple sanitation systems as latrines. Further, many peri-urban areas lack adequate drainage and solid-waste removal systems. Environmental sanitation systems adopted by the communities are often inadequate and contribute to a highly contaminated environment that promotes the transmission of diseases. Therefore, peri-urban areas have worse health indicators than rural areas, including child mortality rates and the rates of incidence of diseases related to excreta and the environment.

Peri-urban neighbourhoods are rapidly created where families occupy empty space and build their home using any available material such as cardboard, wood, clay, iron sheets or plastic. These neighbourhoods are often constructed illegally and do not follow any urban planning or municipal codes. They comprise highly populated areas with no basic services and no infrastructure. There are normally large social and security problems in these neighbourhoods.

5.5.5 MANAGEMENT OF HEALTH-CENTRE WASTE

Health-centre waste poses serious health risks given the presence of contaminated material and dangerous articles including syringe needles and glass eye droppers. Apart from the physical danger of this material, needles and eye-droppers protect viruses from the action of chemical disinfectants and from the outside environment. Thus, a syringe deposited with solid waste can easily contaminate a person pricked by the needle.

Health-centre waste is normally treated by incineration, burial or other simple technologies. These strategies are most appropriate in small facilities in rural areas, but must consider that:

- most of the risks occur before the waste arrives at the incinerator or medical-waste pit due to inadequate management of waste disposal and storage (mainly in small or medium-sized health centres). Therefore the cooperation of hospital staff supervisors and the administration is required to ensure proper work habits of the staff;

- the provision of incinerators is not sufficient if they are not used properly by hospital staff, therefore, they must be supported by a training programme.