8. Sanitation

8.1 Human waste and health

8.1.1 Faeces

Human faeces may contain a range of disease-causing organisms, including viruses, bacteria and eggs or larvae of parasites. The microorganisms contained in human faeces may enter the body through contaminated food, water, eating and cooking utensils and by contact with contaminated objects. Diarrhoea, cholera and typhoid are spread in this way and are major causes of sickness and death in disasters and emergencies. Some fly species (and cockroaches) are attracted to or breed in faeces, but while they theoretically can carry faecal material on their bodies, there is no evidence that this contributes significantly to the spread of disease. However, high fly densities will increase the risk of transmission of trachoma and *Shigella* dysentery. Intestinal worm infections (hookworm, whipworm and others) are transmitted through contact with soil contaminated with faeces and may spread rapidly where open defecation occurs and people are barefoot. These infections will contribute to anemia and malnutrition, and therefore also render people more susceptible to other diseases. The intestinal form of schistomiasis (also known as bilharzia), caused by parasitic worm species living in the veins of the intestinal tract and liver, is transmitted through faeces. Its complex lifecycle requires the faeces to reach water bodies where the parasite larvae hatch, pass a stage in aquatic snails and then become free-swimming infective larvae. Infection occurs through skin contact (wading, swimming) with contaminated water.

Children are especially vulnerable to all the above infections, particularly when they are under the stress of disaster dislocation, high-density camp living and malnutrition. While specific measures can be taken to prevent the spread of infection through contamination by human faeces (e.g. chlorinating the water supply, providing hand-washing facilities and soap), the first priority is to isolate and contain faeces.

8.1.2 Urine

Urine is relatively harmless, except in areas where the urinary form of schistosomiasis occurs. This parasitic infection, caused by *Schistosoma haematobium*, is similar to the one described in the section above, except this parasite species resides in the veins around the bladder and its eggs are excreted with urine. In these areas, urinating in water courses should be prevented; otherwise, indiscriminate urination is not a health hazard.

8.1.3 Sullage

Wastewater from kitchens, bathrooms and laundries is called sullage. It can contain disease-causing organisms, particularly from soiled clothing, but its main health hazard occurs when it collects in poorly drained places and causes pools of organically polluted water that may serve as breeding places for *Culex* mosquitoes. This genus of mosquitoes transmits some viruses as well as the parasitic disease lymphatic filariasis. Mosquitoes that transmit malaria do not breed in polluted water.

8.1.4 Solid waste

Rats, dogs, cats and other animals, which may be carriers (reservoirs) of disease-causing organisms are attracted to discarded food, cloth, medical dressings and other components of solid waste. Small rainwater collections in solid waste may serve as the breeding places for *Aedes* mosquitoes, vectors of the dengue virus. Deep, compacted burial and, in particular, incineration of medical waste are essential to eliminate the associated health risks. Inorganic waste, such as fuel ash, can be hazardous to health. Items such as empty pesticide containers should be crushed and buried to ensure that they are not accidentally recycled.

8.1.5 The importance of hygiene behaviour

The links between sanitation, water supply, and health are directly affected by hygiene behaviour. It is important to bear this in mind when considering technical options, so that facilities provided in emergencies are acceptable to the users and can be used and maintained hygienically. See Chapter 15 for more information on hygiene promotion.

8.2 Strategy for excreta disposal in emergencies

Excreta-disposal techniques referred to in this section are described more fully in section 8.3.

8.2.1 Situations demanding an emergency excreta-disposal response

Disaster-affected urban areas

Major health risks due to inadequate excreta disposal after disasters arise in urban areas following damage to existing systems, or when parts of a city receive large numbers of displaced or homeless people, so putting increased pressure on facilities that may already be under strain. A rapid assessment of damage and needs is required to decide what emergency actions to take.

The immediate response may include establishing or reinforcing sewage tankering services, to bypass blocked sewers or to carry out intensive septic tank or latrine emptying in periurban areas. Every effort should be made to allow people to use their existing toilets, through temporary repairs to broken sewers and sewage treatment works. In extreme situations, it may be necessary, as a temporary measure, to discharge sewage directly into a river or the sea, or to hold it in a safe, isolated place. If this is done, the public must be informed, and any places used for this purpose should be fenced off.

When sections of the population can no longer use their toilets, public facilities may need to be provided, by allowing access to schools, community centers, etc., or by setting up temporary public toilets. If available, chemical toilets may be placed on street corners and emptied by municipal workers. Simple drop-hole latrines can be placed over open inspection covers, allowing excreta to drop straight into a sewer, if the sewer is still in operation and sufficiently flushed with sewage. If not, then water tankers can be used to flush them one or more times per day. Storm drains can also be used for this purpose, but only after careful consideration of the environmental risks.

Where bucket latrines are normally used, the collection of night soil may be disrupted by the emergency. Continued use of buckets should be encouraged and alternative arrangements made for collection and disposal (e.g. a common neighbourhood deep-trench latrine) until collection has returned to normal. The protection and health of the workers involved in bucket collection should be a major concern. The use of bucket latrines should be replaced by hygienic alternatives as soon as possible.

In general, defecation in rivers and streams should be discouraged unless absolutely necessary, and then only if an area downstream of other human use can be designated for the purpose. Similarly, defecation in the sea should also be discouraged, especially when the population density is high or when bays, lagoons, or estuaries are used for fishing. If the sea is to be used, the tides, currents and prevailing winds should be studied so that excrement does not wash back on shore, and a specific area set aside for defecation.

A neighbourhood health committee should be organized as soon as possible (or if it already exists, identified and mobilized) to liaise with the public-health authorities in making more permanent arrangements for human excreta removal and for supervising general waste disposal.

Previous training exercises should have revealed material needs, and the items concerned should be in stock, or obtainable on loan from another government department or the private sector.

Postemergency activities should focus on ensuring a return to, or improvement on, levels of service prior to the disaster.

Disaster-affected rural areas

Disasters affecting sparsely-settled rural areas are less often of great concern, because of the lower concentration of people and lesser risk of faecal contamination through inadequate sanitation. In such situations, a focus on the protection of water sources is usually the priority. However, protection of water sources often requires efforts to improve excreta disposal, at least in certain areas, and an emergency may provide the opportunity to raise awareness of sanitation generally, and start a longer-term process of improvement.

Displacement emergencies

In displacement emergencies, large numbers of people find themselves in crowded conditions, in transit, or in camps, with inadequate sanitary facilities. Initial sanitary arrangements can be very simple. As a minimum, defecation should not be allowed where it can contaminate the water supply or food chain. Defecation should be discouraged along river banks; in the beds of rivers or wadis (possible future water sources); within 30 metres of wells or boreholes; within 10 metres of taps; on or above the surfaces prepared for rainwater catchment; within 30 metres uphill of a spring or 10 metres downhill; or within 10 metres of any water-storage tank or treatment plant.

Open defecation should also be discouraged along public highways, in the vicinity of hospitals, feeding centres, reception centres, food storage areas, food preparation areas, and in fields containing crops for human consumption. When it is impossible to establish defecation fields, open defecation should be limited to specific, well-defined areas, which should be closed as soon as alternative sites for defecation are available.

Along displacement routes, between transit points, there may be a lot of open defecation by the side of the road. Faeces should be picked up, daily if possible, and buried nearby. If open defecation is inevitable and people also stop overnight by the side of the road, people should be encourages to use one side of the road for defecation and the other side for cooking and resting.

It is usually necessary to set up a more structured system, such as defecation fields, or defecation trenches, that ensure better separation and containment of excreta. These may be followed by longer-term, but intermediate, measures, such as public trench latrines when the transit center or emergency settlement is likely to remain in place for more than a few weeks. However, as emergency settlements are often likely to remain for at least a year, then construction of family toilets, usually simple pit latrines, should begin without delay.

Communal facilities should be regularly cleaned by staff who are rewarded for their work, and who are adequately trained and equipped. Clean latrines help to encourage proper use of the facilities; dirty latrines inevitably lead to carelessness and unsanitary defecation practices in and around them. Routine inspection by supervisors is necessary to ensure that cleaning standards are maintained and that repairs are carried out. Staff may need to meet with the users to encourage clean use of the toilets.

As far as appropriate, user families should be involved in latrine construction programmes. They should be involved in the choice of technology and materials, siting and orientation of latrines, pit digging, slab installation, and superstructure building. The implementing agency should work closely with user families to encourage latrine construction, provide advice on siting and construction, and ensure that pits and finished latrines meet standards for stability, capacity and hygiene. The agency may provide tools and materials, as well as advice and information.

8.2.2 Gradual improvement

Although people may be able to reduce their water use drastically for a short period following a disaster, they can do nothing about their production of excreta. Whenever environmental health staff travel to a disaster-affected location they find people who have already established a pattern of excreta disposal, using whatever means are available. The general strategy should be to gain a rapid understanding of existing practice and take temporary steps to improve it, if necessary, and then make further improvements, responding to areas of greatest need as defined by disease incidence and lack of access to facilities.

Subsequent steps in an emergency excreta-disposal response involve more detailed assessment of damage to existing facilities, in the case of urban-based disasters, or of likely population movements and the development of needs and resources in the case of displacement emergencies. This more detailed assessment should prompt a series of actions and reassessments that ensure a constant improvement in sanitary arrangements. The various options available need careful consideration and discussion with the population concerned, to produce a strategy that takes account of short- and long-term public-health risk, cost, time and user preferences. Technical options that may be used in a programme for gradually improving excreta disposal are presented in section 8.3.

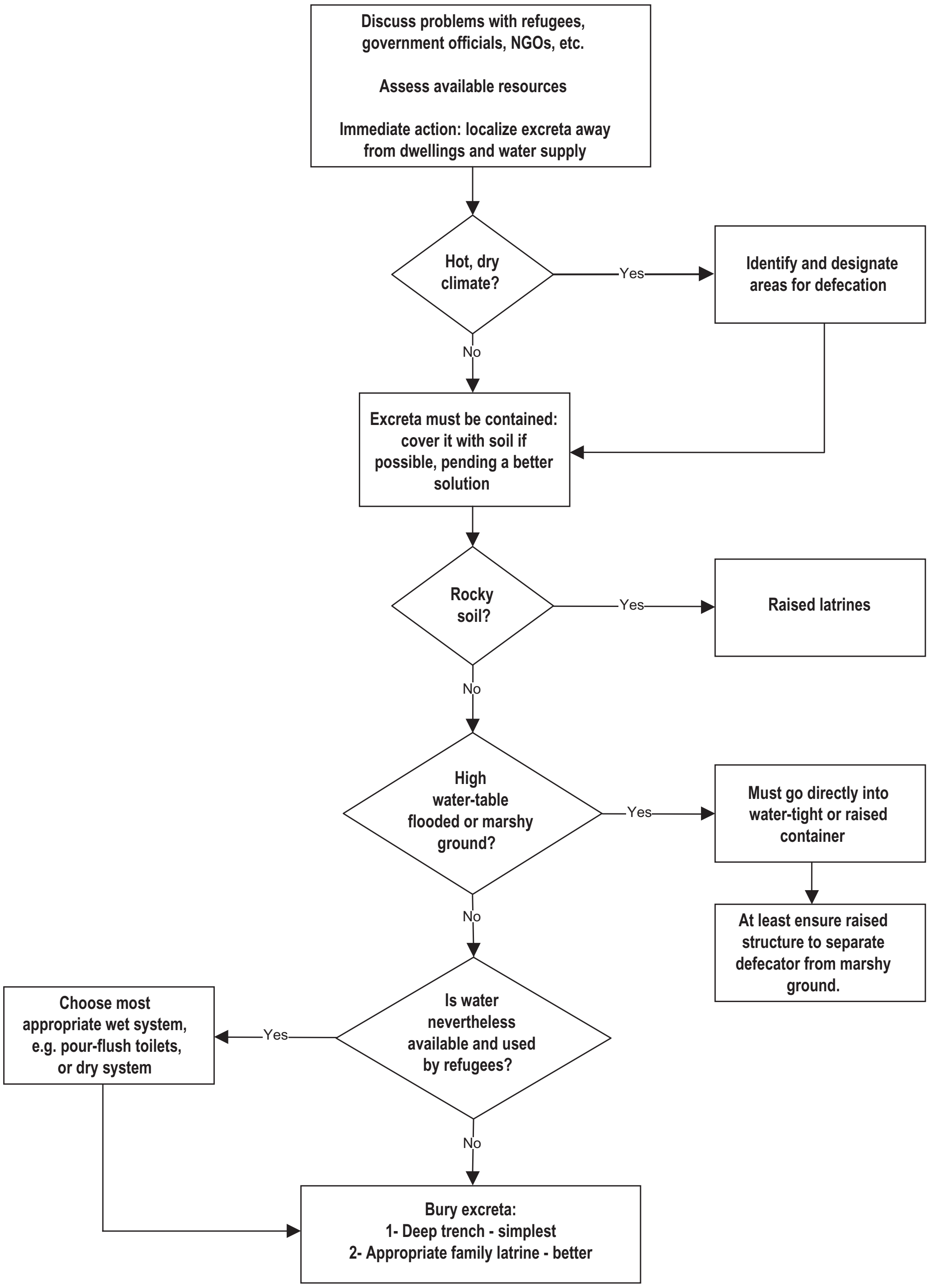
8.2.3 Technology choice

Figure 8.1 provides a guide to technology choice for excreta disposal in emergencies that takes into account the difficulties posed by different types of ground condition. Where the opportunity exists for selecting and planning an emergency settlement site, environmental health staff should be closely involved in ensuring that sites are chosen and laid out in a way that provides suitable conditions for sanitation. See Chapter 6.

Any successful measure for managing human excreta includes the principles of separation, containment and destruction. A simple pit latrine, for example, separates excreta from humans; it contains it within the pit, beneath the slab; and the excreta is destroyed by a process of decomposition and die-off of pathogens. Whatever form of toilet is designed and built in an emergency, it must fulfill these three functions to minimize health risks.

Excreta disposal measures must be designed and built to avoid contamination of water sources that will be used for drinking-water.

Figure 8.1 **Decision tree for excreta disposal in refugee camps**[1]



[1] Source: United Nations High Commissioner for Refugees (1999).

Consultation with the disaster-affected people is an essential aspect of technology choice. Whereas they are consumers with regards to water supply, they are producers with regards to excreta disposal and other aspects of sanitation. Sanitary arrangements and sensitivities vary a great deal between cultures, and different groups in the camp, such as men, women, or the elderly, may have special needs and wishes. A health committee is very important as a means of communicating with the disaster-affected people, for whom the living arrangements may be strange and disorienting. Sensitive and culturally-specific issues, such as arrangements for disposing of menstrual discharge, or for anal cleansing after defecation, can best be discussed with the health committee. For more information on consultation, see Chapter 15.

8.2.4 Assessment

Urban situations with existing facilities

A proper health assessment of the impact of damaged sanitation systems requires a sanitary survey. In particular, an assessment of the status of the sewage system is required as soon as possible after immediate disaster relief has been provided. Information should be gathered on the number of breaks or obstructions in sewer lines; the lengths and sizes of pipes that need to be replaced; and a list of the repair equipment required, such as pumps, bulldozers, excavating machinery, trucks, tools, construction materials, etc. An early estimate is also needed of the equipment, materials and labour necessary to restore sewage-treatment plants and pumping stations to working order.

In periurban areas where on-plot sanitation is likely to be the norm, assessments should identify the number of households without functioning toilets, the current arrangements made for excreta disposal by those households (including the use of neighbours' toilets), and requirements for immediate and postemergency action.

Displacement emergencies

In displacement emergencies, the assessment process is likely to be quite different, as the people concerned are likely to find themselves in situations they are not familiar with, with considerable loss of social cohesion. Key information includes the number of people currently affected and likely future population movements; existing excreta-disposal arrangements; predisaster excreta-disposal practices; ground conditions; availability of construction materials and tools; the workload and labour availability of the affected population; the water-supply and drainage situation; the general health of the displaced population; and the incidence and/or risk of excreta-related diseases.

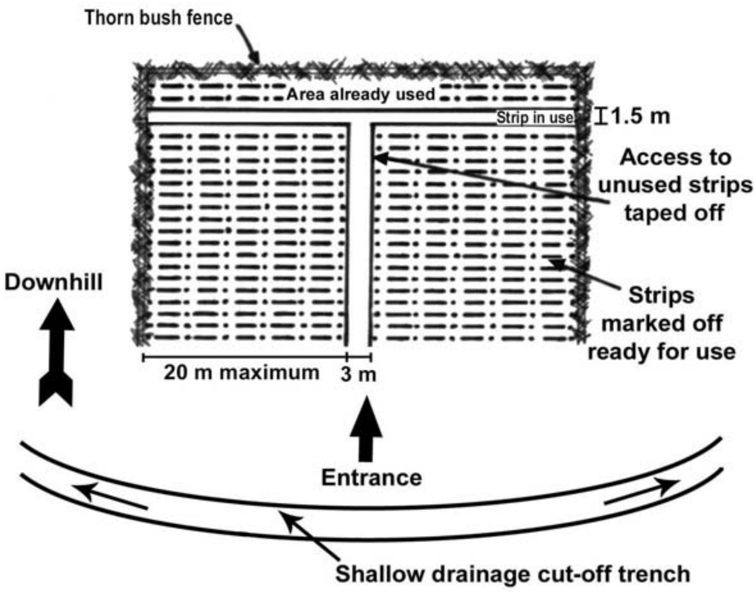
8.2.5 Standards

UNHCR recommend one toilet per family as the best option, one per 20 people as the second best option, and one per 100 people, or a defecation field, as the third best; recommendations are given for the design and construction of facilities, to ensure they are appropriate and correctly used (United Nations High Commissioner for Refugees, 1999). The Sphere Project recommendations are similar to those of UNHCR, but provide more detailed advice on the quality of toilet facilities and their acceptability to users (Sphere Project, 2000).

8.3 Techniques for excreta disposal in emergencies

The techniques in this section are described broadly in order of increasing permanency and complexity. In some emergency situations, several of these options are used at different stages of the response as the situation develops. The first three techniques–defecation fields, shallow trench latrines, and deep trench latrines–have mostly been used in displacement emergencies, but may be useful in any situation where temporary toilets are needed rapidly. The other techniques are widely used in stable situations, but can be adapted to any long-term emergency settlement. Whatever the technical option chosen, consideration should be given to hand-washing facilities and night lighting. The needs of small children should be given special attention. See Box 8.1 for further information.

Figure 8.2 **Open defecation field**[1]



[1] Source: Reed (1994).

> Box 8.1 **Excreta control and small children**
>
> Children's faeces are generally more infectious than those of adults, and many children are unable to control their defecation, so preventing indiscriminate defecation by small children should be a high priority. In short-term relief centres, it may be possible to provide parents with disposable napkins. Usually, however, this is not possible, and parents should be encouraged to clean up and dispose of children's faeces rapidly and hygienically. Shovels, small spades, or home-made digging tools made from wood should be available to parents to enable them to bury children's excrement.
>
> In Ethiopian relief camps in the mid-1980s, special defecation trenches for children were used successfully by the Save the Children Fund. Mothers sat on one side of the trench with their feet propped on the other side, and placed the children between their feet. When the children had defecated, they left via a hand-washing facility. Each time a mother left, a latrine guard shoveled earth over the faeces (Appleton & Save the Children Fund Ethiopia Team, 1987).

8.3.1 Defecation fields

A defecation field is illustrated in Figure 8.2. The area set aside should be of sufficient size to accommodate $0.25\,m^2$ per person per day excluding access paths. Separate areas for men and women are usually desirable. The field should be in a convenient place, but no nearer than 30 metres to other camp facilities. Ideally, it would be on land that slopes away from the camp and any surface water sources. The soil should be soft enough to dig easily in order to cover excreta.

Health education is required to obtain the cooperation and understanding of the user population. A defecation field requires an attendant, for providing information to users and for cleaning and maintenance.

Users should be directed to strips of land in the defecation field roughly 1.5 metres wide. They should use one strip until it is filled, usually entering by one access path and leaving by another. When a strip is filled, excreta is then covered by the attendant with at least 10 centimetres of soil and another strip is opened some metres away. The field is used systematically in this way, beginning with the strips furthest from camp. An improvement on this basic system is to dig shallow trenches (15 centimetres deep) in the strips, so that the excreta can be completely buried.

The active part of the field should be illuminated at night and demarcated with poles and pegs. Users should be guided to active strips by ropes or coloured tapes, as shown in Figure 8.3. A further improvement is the erection of walls of plastic sheeting, to divide the defecation field into smaller, more private areas, where this is culturally desirable.

8.3.2 Shallow trench latrines

Shallow trench latrines (see Figure 8.4) allow faeces to be buried and far better contained than in a defecation field. Approximately 3–5 metres length of shallow trench is needed for every 100 people, and it is preferable to have a number of shorter, shallow trenches. Trenches should never be used for more than a week before they are completely filled, compacted and replaced by new trenches. Shallow trench latrines should be sited in the same way as defecation fields.

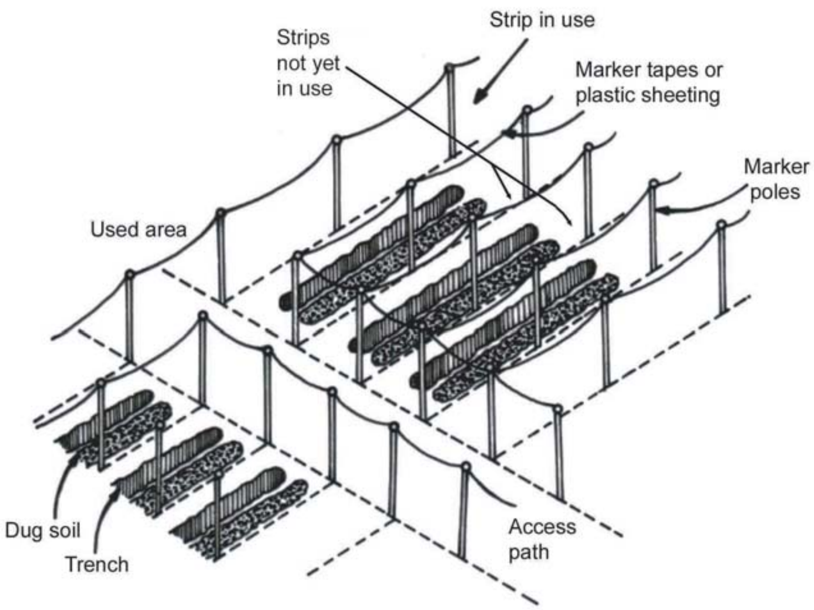
Consultation with the camp health committee will reveal whether it is better to arrange for each family in a tent or shelter to dig and use its own shallow trench. A stock of shovels should be kept for use by residents.

After each visit, the user should shovel into the trench sufficient soil to cover the excreta. Boards can be placed along the edges of the trench to provide stable footing and prevent the sides from caving in. When the trench is filled to within 30 centimetres of the top, or after a week's use (whichever comes first), it should be completely filled, compacted and marked for future identification, and a new trench should be dug and used.

8.3.3 Deep trench latrines

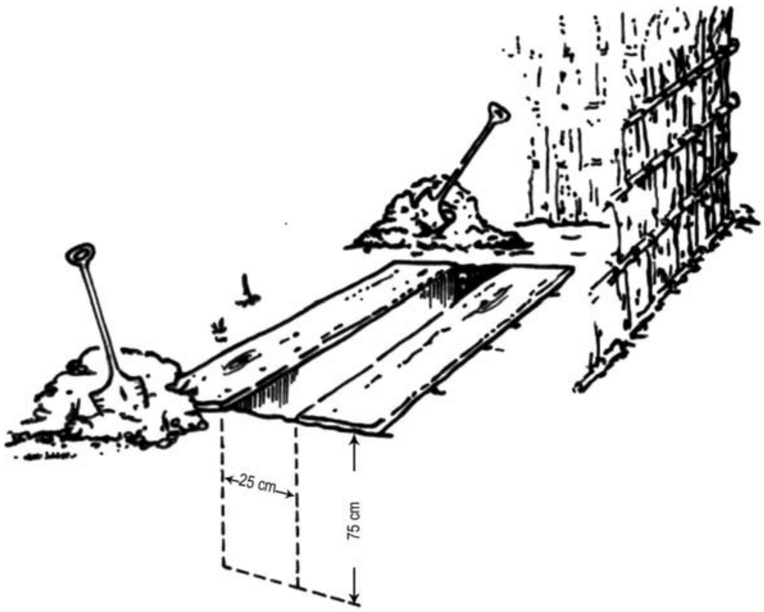
A further improvement is the deep trench latrine, which is deeper, longer and wider than the shallow trench latrine. It can last 1–3 months and is constructed as shown in Figure 8.5. It can be constructed from a variety of materials, including wooden planks and plastic squatting plates for the floor and plastic sheeting, and wooden planks or

Figure 8.3 **A trench defecation field with guidance markers[1]**



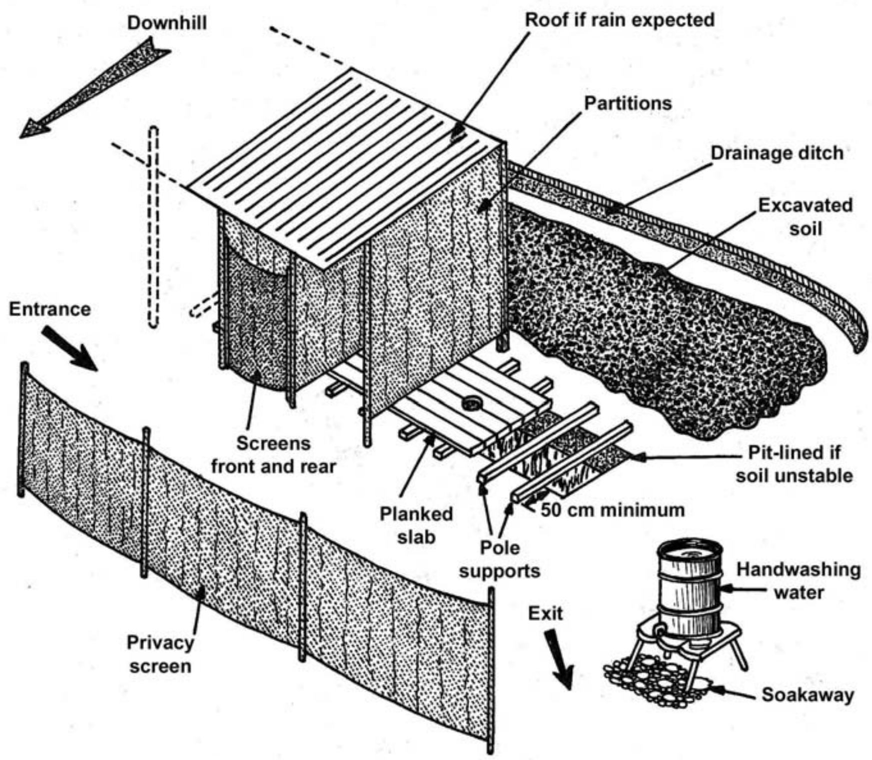
[1] Source: Reed (1994).

Figure 8.4 **Shallow trench latrine**[1]



[1] Source: Rajagopalan & Shiffman (1974).

Figure 8.5 **Deep trench latrine**[1]



[1] Source: Reed (1994).

metal sheets for the superstructure. In the former Yugoslav Republic of Macedonia, during 1999, most Kosovar refugee camps had 10-metre-long deep trench latrines, each provided with 10 plastic squatting plates and superstructures with wooden frames and either metal or plastic sheeting.

In the example shown, each deep trench can accommodate up to six cubicles, screened for privacy as shown. Each cubicle measures 90 centimetres wide by 80 centimetres high. At peak usage, it is reasonable to use an estimate of 50 people per day per cubicle, or 240 each day for each deep trench. Soil is piled up and used to cover excrement, as in a shallow trench system. The simple arrangement of using boards across the trench as foot rests can easily be improved on as time and materials allow. Eventually, however, a wooden cover with either squatting plates or seats can be constructed. There may be carpenters among the residents, and volunteers should be mobilized to help; such improvements, and the use of ashes and soil to cover excreta, can help to control flies.

A number of agencies now use plastic latrine slabs that can be placed in line over a deep trench to form a row of toilets that are rapid to construct and easy to keep clean.

8.3.4 Simple pit latrines

Individual simple pit latrines, either hand-dug or drilled, may be an option in lower-density, longer-term emergency settlements (Figure 8.6). Family latrines are normally preferred as they are more hygienic than public facilities, and there are long-term benefits in terms of maintenance.

A family can dig its own latrine if given advice and provided with tools. Initial, simple screening to provide privacy can be improved to give protection from the weather as needed. It is important for the control of flies, mosquitoes and odours that tight-fitting lids for the squatting holes are provided and are always closed by users after each visit to the latrine.

The latrine slab can be made of sawn timber, logs (with or without an earth covering), concrete, plastic, or a combination of two or more of these. The latrine superstructure may be made of a wooden framework covered with plastic sheeting, grass, or other local materials. Temporary superstructures may be replaced by the users with more permanent materials after the emergency phase. The choice of materials for slabs and superstructures will depend on considerations such as cost, local availability, environmental impact, and ease of use for families constructing their own latrines.

Normally the pit should be designed to last at least a year, and its volume should be calculated on the basis of about 0.07 m^3 per user per year. In unstable soils, the top 50 centimetres of the pit, or the whole depth of the pit, may need to be lined to prevent collapse. Pit linings may be made of many different materials, including brick, concrete, old oil drums or bamboo. Pit linings should normally not be watertight below 50 centimetres deep.

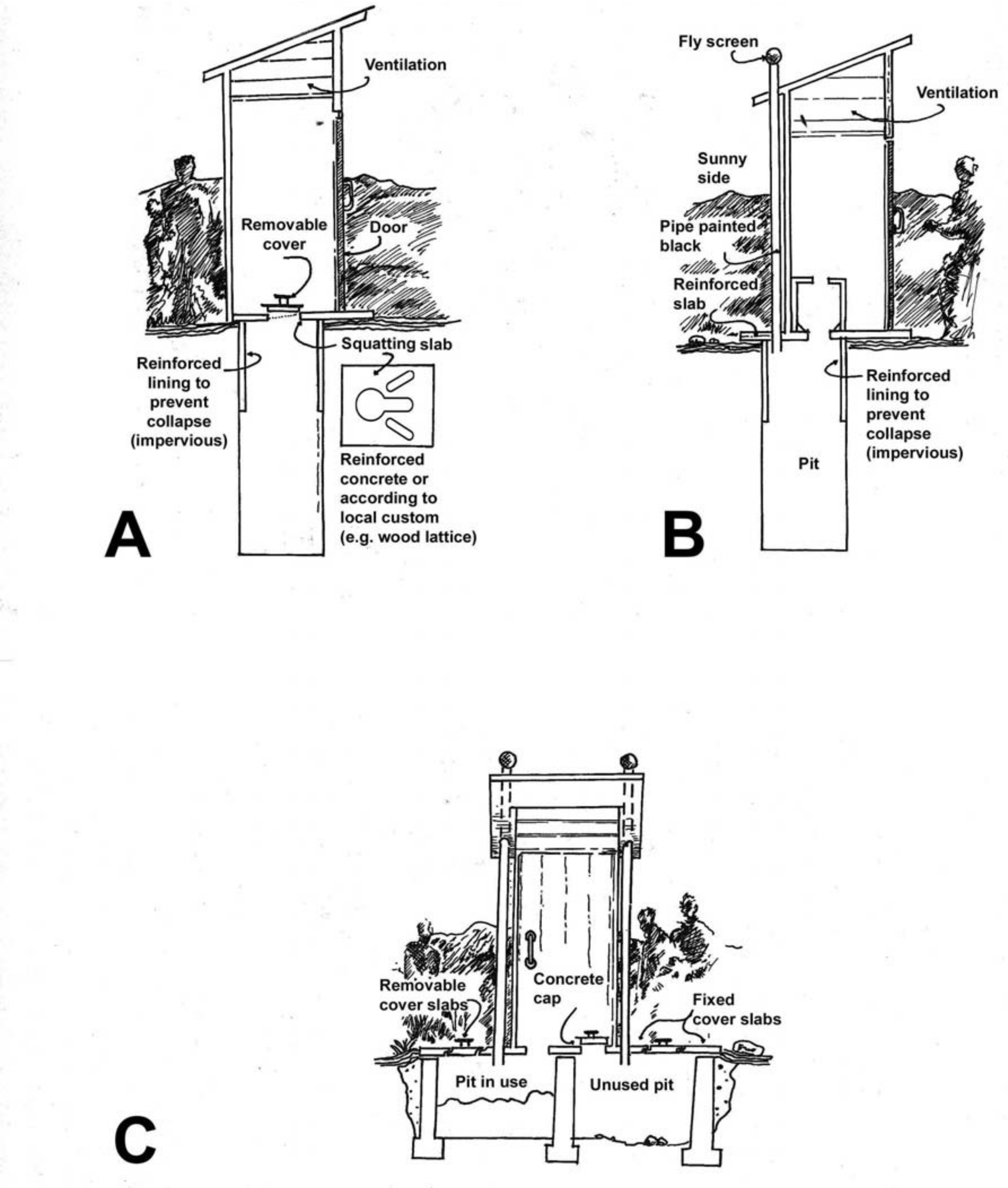
8.3.5 Other types of latrine

The simple pit latrine is the basis for the design of a number of other types of latrine, described below. Some may be appropriate for specific soil or site conditions. Most require more time, materials and specialist knowledge for their construction.

Ventilated improved pit (VIP) latrines

The VIP latrine incorporates one-way ventilation through the pit to reduce odours and insect breeding. While nonventilated latrines should have lids to reduce these problems (Figure 8.6 A), the VIP latrine does not require a cover over the defecation hole if there is sufficient wind to create an air flow up the pipe (Figure 8.6 B). The end of the ventilation pipe should be covered with mosquito netting. Flies that breed in the pit and then fly up the pipe towards the daylight cannot then leave the latrine, and flies on the outside

Figure 8.6 **Various types of pit latrine: (A) nonventilated; (B) ventilated; (C) twin-pit, ventilated**[1]



[1] Source: United Nations High Commissioner for Refugees (1999).

that are attracted by the smell coming from the top of the pipe are unable to enter the latrine. Pit design is as for the simple pit latrine.

Double-pit latrines

Double-pit latrines (Figure 8.6 C) are useful where there is limited room for digging new pits. The filled side can be emptied via an access hatch while the other side is being used. If the filling of one side takes sufficient time (at the very least, 6 months, better 2 years), emptying can be delayed until anaerobic decomposition has killed the pathogens. Double-pit latrines may be ventilated or nonventilated. A variation on this technique is the twin-pit latrine used with water-seal toilets. Two separate pits are used, joined to a water-seal toilet with a pipe with a Y-junction in an access chamber. Each separate pit is used in turn, as with the double-pit system, switching between pits being achieved by blocking one half of the Y-junction.

Raised or mound latrines can be used where there is a high water-table (Franceys, Pickford & Reed, 1992).

Composting latrines

The composting latrine can be used in lower-density, longer-term settlements, where the compost produced can be used in food production. It may take 12–24 months for the compost to become safe to handle, depending on the climate.

Water-seal latrines

Water-seal (or pour-flush) latrines are similar to simple pit latrines, but instead of having a squatting hole in the cover slab, they have a shallow toilet pan with a water seal. In the simplest type, excreta falls directly into the latrine pit when the pan is flushed with a small quantity of water. Pour-flush latrines can be connected at a later stage with either a septic tank, the effluent from which can be disposed of by means of subsurface-soil absorption, or a small-bore sewer system. It may be possible to install such latrines, depending on the lead time in setting up an emergency settlement; the length of its life (and hence the time available for incremental improvements); its location; and the availability of pour-flush pans.

8.3.6 Site selection for latrines

Latrines should be sited at least 30 metres from any water source. If the abstraction point is upstream of the latrine, the distance can be reduced provided that the groundwater is not abstracted at such a rate that its flow direction is turned towards the abstraction point (Franceys, Pickford & Reed, 1992). In heavily-fissured rock this distance may have to be increased substantially. Because pollution (faecal and chemical) tends to disperse downslope from its source, latrines should be sited *downhill* from any groundwater source, particularly if the bottom of the latrine is less than 2 metres above the water-table (see Figure 8.7).

Consideration should also be given to the pattern of usage of communal latrines. Such usage will probably not be uniform, but concentrated along lines of common travel (e.g. to and from feeding centres, schools, etc.). It may be necessary to close some latrines and open others at some stage, to adjust to demand.

Latrines should be sited no more than 50 metres from users' shelters, to encourage their use, but sufficiently far away (at least 6 metres) to reduce problems from odours and pests.

8.3.7 Management of excreta disposal facilities

One of the main reasons that sanitation facilities fail in emergencies is insufficient management. There are several reasons for this, including insufficient consultation with users at the design stage, leading to facilities that are not used as intended; insufficient resources provided for maintaining and cleaning public facilities; and inadequate supervision of self-build sanitation programmes, leading to incorrect siting and construction of latrines. Excreta disposal programmes in emergencies demand substantial resources and management support, from the assessment stage to decommissioning facilities or handing them over.

Figure 8.7 **Dispersal of pollution from its source[1]**

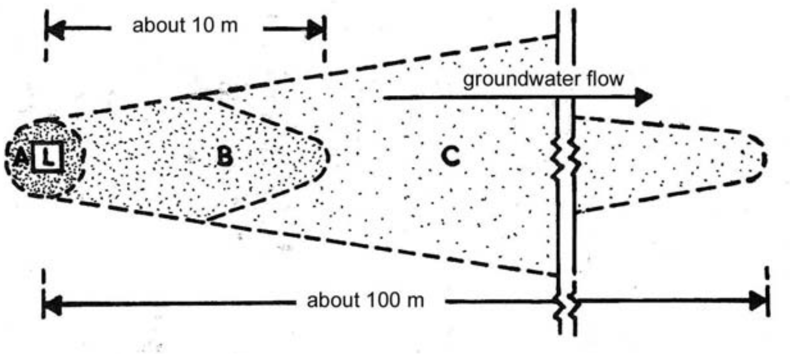
Key:

A. Pollution cone, spreading out about 1 metre all round, goes vertically downwards until the groundwater level is reached.

B. If the groundwater surface is less than about 3 metres deep, the pollution then spreads cone-wise, flowing with the groundwater. The groundwater can be diverted from its natural course if the area is within the circle of influence of pumping from a well. The bacterial content of the pollution spreads sideways and downwards, and becomes absorbed by the soil until, at about 10 metres from the source, it has virtually disappeared.

C. The cone of chemical pollution continues to spread until about 25 metres from the source, and then gradually reduces to almost nothing at a distance of about 100 metres.

L. Source of pollution at pit latrine, septic tank, or soakaway.



[1] Source: Pike (1987).

8.4 Disposal of wastewater (sullage)

8.4.1 Assessment of the problem and design of the response

The scale and nature of the wastewater problem should first be assessed. Important information includes: how much wastewater is produced, and by how much does production vary during the day and over longer periods; the nature of the wastewater, including whether it is likely to be contaminated with faeces, and characteristics pertinent to the disposal method to be used; the source of the wastewater; the location of risks or nuisances it may cause; and soil, topography, climate and other factors that may determine which disposal options are possible. In many emergency situations, it may be judged that the quantity and nature of the wastewater produced do not present a health risk sufficient to justify control activity. In others, efforts to limit the production of wastewater may be sufficient to keep the problem under control. In many situations, however, specific measures are needed to dispose of wastewater, and these are described below.

The response chosen should take the above factors into account, and be carried out in a way that complements concurrent activities in water supply and excreta disposal.

8.4.2 Wastewater disposal techniques

The main options for disposing of wastewater are to discharge it into water courses, with or without treatment, to infiltrate it into the soil, or to use it for irrigation (in which case most of the water is disposed of by infiltration, evaporation and evapotranspiration).

Disposal into water courses

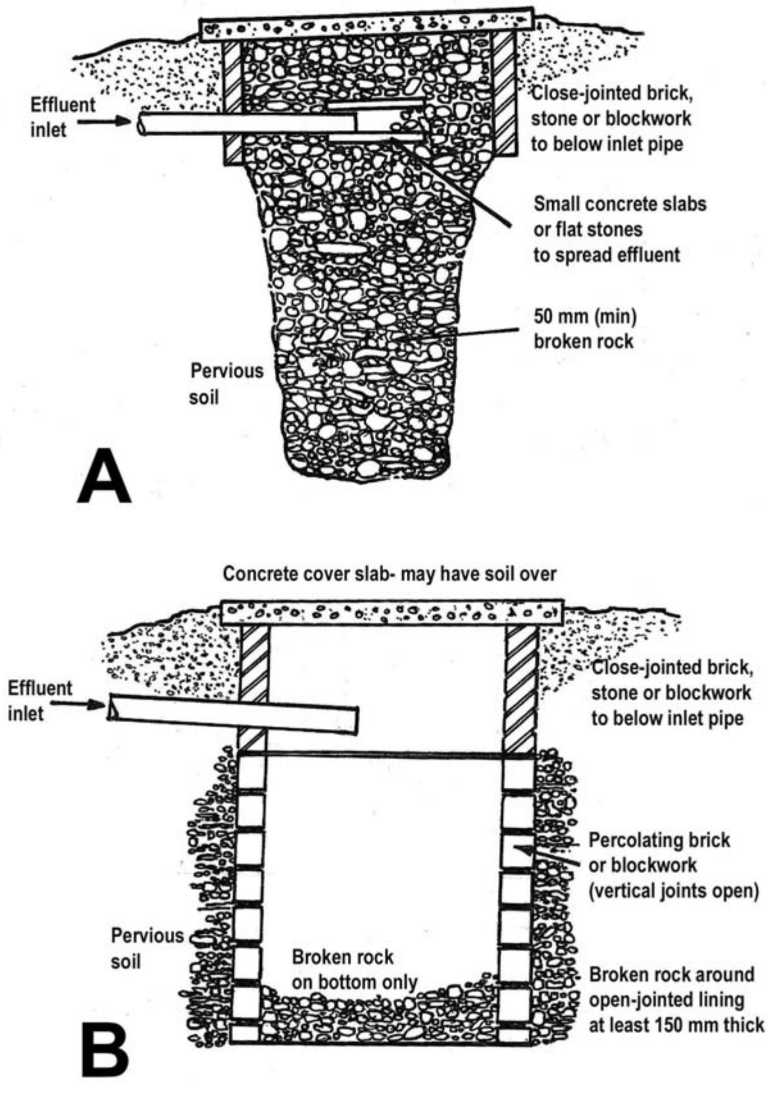
If nearby water courses suitable for accepting the type and quantity of wastewater produced are available, the best disposal method may be to direct the wastewater to them through pipes or open channels. It may be possible to make a connection to an existing drainage network and thereby to treatment and discharge installations. It is important for staff to investigate the drainage system as far as the final discharge point, to avoid creating or contributing to environmental pollution and contamination of water supplies. But where relatively small quantities of slightly contaminated wastewater are produced (for instance, the water spilled at a water collection point), discharge into a water course may have no significant environmental impact.

Infiltration techniques

Infiltration into the soil should be facilitated where large quantities of spilled or used water will accumulate, e.g. under water-distribution tanks and taps, outside bath houses and laundries, and near communal kitchen areas.

The simplest technique is to construct a soakaway (or soakage pit). This is an excavation at least 1.25 metres deep and 1.25 metres wide, filled with stones, that allows water to seep into the surrounding ground. It is sealed from above by an impermeable layer (oiled sacking, plastic or metal) to discourage insect breeding. Wastewater is fed by pipe into the center of the pit (Figure 8.8).

Figure 8.8 **Unlined (A) and lined (B) soakage pits with effluent inlets**[1]



[1] Source: Assar (1971).

In emergencies, soakaways may consist simply of pits filled with small stones or gravel into which wastewater is directed. As long as the level of the water in the pit does not rise above the top of the ground, insect breeding is minimal.

Soakaways can only dispose of a limited amount of water because they provide a relatively small area of soil surface for infiltration. Infiltration trenches, which are commonly used for disposing of the effluent from septic tanks, overcome this problem through a series of parallel trenches in which perforated pipes are laid in a bed of gravel.

Evaporation and evapotranspiration techniques

Where infiltration methods do not work effectively because of low soil permeability, wastewater may be disposed of by using it for irrigation. Even when infiltration methods are possible, it may be appropriate to use wastewater for vegetable gardening if irrigation water is scarce. Such a system might be considered for longer-term use, for instance, adjacent to a nutrition rehabilitation centre, health centre or school.

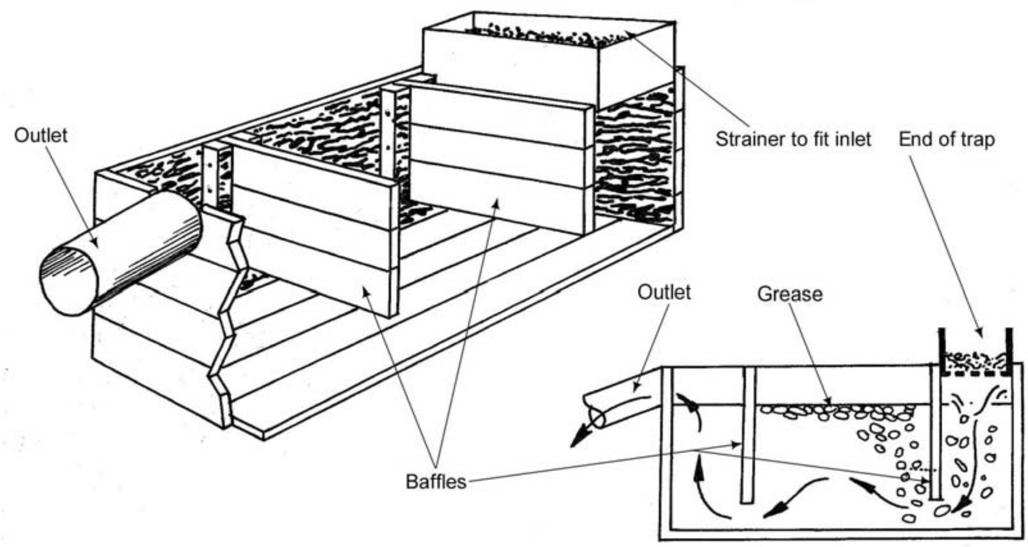
Water is applied to garden plots by simple flood irrigation, or by allowing it to collect in basins from where water is carried to plots. Care must be taken to allow flood-irrigated beds and storage basins to dry out regularly to avoid mosquito breeding.

A simpler system that does not involve irrigation, is to allow water to flow into shallow pans, where it simply evaporates. Alternatively, soap-free wastewater from spillage at water collection points may be used for watering livestock, but care should be taken not to create muddy and contaminated areas near water points.

Grease traps

Whatever the disposal method chosen, wastewater from the kitchen and laundry area should first be put through a grease trap (Figure 8.9). If hot water containing fat is run into an adequate supply of cold water, the fat solidifies and rises to the surface, where it can be skimmed off. A strainer is fitted to the inlet to catch any large particles which might pass through the trap and choke the inlet to the soakage pit. The first baffle prevents the entering water from disturbing the layer of grease, the second keeps the effluent from carrying it off. Grease traps are also effective at reducing the amount of sand and soap in wastewater.

Figure 8.9 **Grease trap**[1]



[1] Source: Skeet (1977).

8.5 Management of refuse

In many parts of the world, a disaster can cause transportation problems that disrupt waste-management systems that are inadequate even during normal times. Extra quantities of waste, or new forms of waste, such as rubble from destroyed buildings, or flood debris, may be generated by the disaster. Immediate problems that commonly follow disasters such as floods and hurricanes are blockage of roads and water courses and mixing of hazardous and nonhazardous wastes. The first priority is often the clearance of post-disaster debris to reduce health risks, open routes and lessen the psychological impact of the disaster.

8.5.1 Assessment of the problem and design of the response

As with wastewater, solid waste may not present a particular environmental health problem in emergencies. Where rural communities are displaced, for example, and they receive a dry ration of grain, pulses and oil distributed in bulk, there is likely to be very little solid waste produced. Assessments should seek to determine: the quantity of refuse produced by the affected population, and how that is likely to change over time (for example, as ration packaging changes, or as market activities develop or are reestablished); the density and composition of refuse produced; the composition of the refuse produced; existing patterns of refuse management, including storage and destruction; any collection, reuse and recycling activities already carried out; constraints on collection and transport, such as personnel reduction, the use of trucks for rubble removal in critical areas, and damaged or blocked routes. A population of 1000 people may commonly produce between 2–4 m^3 of solid waste per day (World Health Organization, 1991b).

The response chosen should take the above factors into account, and reflect knowledge about the possible duration of the emergency, the appropriate level of users' involvement, and the economic sustainability of different options. In some situations, it may be better to avoid launching a system of refuse collection and centralized disposal if it is unlikely that this can be sustained for more than a few months. In such cases, it may be better to focus attention on reduction, reuse and recycling of refuse, or stimulate local initiatives based on decentralized disposal methods.

8.5.2 Refuse storage

The number and size of refuse containers needed varies greatly from situation to situation, and can only be determined in practice through an assessment. But as a rule of thumb, one container of capacity 100–200 litres, preferably plastic or metal and with a tight-fitting lid, should be provided for every 10–20 families, placed not more than 15 metres from the shelter (United Nations High Commissioner for Refugees, 1999). Alternatively, one container of 50–100 litres may be provided for every 25–50 people (Pan American Health Organization, 1996). In some situations, large street-corner storage containers may be used, provided they have tight-fitting lids. In most cases, these recommendations will allow two days' worth of refuse to be stored.

In markets and commercial areas, large containers or collection bays may be needed. To control flies and rats, a market authority or committee should be established to manage cleaning of the market area and manage the refuse collection site. Certain wastes, such as waste from animal slaughtering, may need special containers to deal with the large quantities of liquids produced.

Arrangements for refuse storage, collection and transport should be made in consultation with the affected population and should aim to minimize nuisance and health risks.

8.5.3 Refuse collection and transport

Before starting the collection service, it is necessary to determine: the quantity of solid waste to be collected; how much waste will be generated; the frequency of the service; the quantity and size of collector trucks; the number of workers required; the final disposal method; and the disposal site.

For every 1000 residents, 2.5 workers should be appointed. Their tasks include cleaning streets and open spaces; collecting waste containers; cleaning facilities, markets, and the like; and transferring waste to the treatment or final disposal site. The number of workers will decrease as refugee services are organized (World Health Organization, United Nations Environment Programme, 1991).

Daily refuse collection is best, especially from kitchens, but collection not less than once a week is essential to minimize insect breeding (flies produce a new generation approximately every eight days in warm conditions).

One 5-ton truck will probably be sufficient for 10 000 people, but this depends on the quantity and density of refuse collected, the ease of collection, and the time required to transport refuse to the disposal site. Although any kind of truck may be used for emergency responses, compactor trucks are always preferable if these can be afforded. Otherwise, the truck should be chosen on the basis of the volume and density of waste to be collected. Handcarts can also be used in large, densely-populated settlements.

Collection routes and frequency will be determined according to waste generation. This information should be communicated to the population as soon as possible.

8.5.4 Treatment and disposal

This section deals with disposal of household refuse and market waste. Disposal of medical waste should be managed completely separately (see section 8.5.6).

Burial

In low-density settlements where relatively small quantities of refuse are produced, small refuse pits may be dug by each family.

Alternatively, a communal trench 1.5 metres wide and 2 metres deep can be excavated by hand for the refuse. Each day, refuse should be covered with 20–30 centimetres of earth. When the level in the trench is 40 centimetres below ground level, the trench should be filled with earth and compacted, and a new trench dug. A 1-metre long trench for every 200 camp residents will be filled in about a week (Pan American Health Organization, 1996).

If time and available labour permit, refuse should be separated into material that is biodegradable (vegetable matter), which should be dumped in one trench, and other material (bottles, can, plastic, etc.), which should be dumped in another. The trench for biodegradable refuse can be dug out after 6 months and used as compost.

Bottles and cans may be cleaned and recycled, but care should be taken to segregate all containers used for dangerous chemicals, such as pesticides. Containers that have contained pesticides should be crushed so that they cannot be reused. They should be buried far from any water source.

Sanitary landfill

In most cases, the use of sanitary landfills will be the best option for final disposal. When existing landfills are inoperative or inaccessible, the construction of new landfills will be necessary. The landfill site should be:

— located away from the settlement;
— accessible;
— on vacant/uncultivated land;
— located in natural depressions with slight slopes;
— downwind from the settlement;
— sited and organized to avoid surface water and groundwater pollution;
— in an area that is not exposed to landslides or earthquakes.

The site must be carefully selected, as it may be used as a permanent place for final disposal.

Earthmoving equipment may be needed to modify the site and to manage the landfill operation. It has been estimated that an area of 0.4–0.5 hectares (4000–5000 m^2) can serve 10 000 inhabitants (World Health Organization, United Nations Environment Programme, 1991).

Incineration

Incineration is a third possibility, but it is not usually suitable for the volume of domestic refuse produced by the general population, because it requires large incinerators and large amounts of fuel, and air pollution is almost inevitable. Incinerators should be located away from the settlement, on the opposite side from the direction of the prevailing wind. They should be built on an impervious base of concrete or hardened earth. Ash and any unburned refuse should be buried and covered with 40 centimetres of soil. In many countries, waste is partially burned at landfill sites. This has the advantage of reducing the volume of waste to be buried, but the smoke created is a nuisance and a hazard to health.

Waste recycling

It may be appropriate to encourage and facilitate recycling of refuse after collection and transport. Refuse can be sorted as an income-generating activity, producing paper, glass, metals and plastics for recycling, where these materials are present in significant quantities in the refuse. Measures should be taken to ensure that people sorting refuse for recycling are protected from health hazards, such as exposure to harmful chemicals, or cuts from sharps.

Composting is a practical way to treat the organic waste remaining after sorting. Simple methods produce good-quality compost for use in gardens. It may be possible to co-compost refuse and sludge from emptying latrines and septic tanks. In this case, special attention is required to ensure compost heaps attain and maintain adequate temperatures to kill pathogens. If there is any doubt about this, the compost should be stored for at least a year before use.

8.5.5 Disposal of rubble

Disasters often produce rubble from damaged buildings and other structures that far exceeds the capacity of solid waste management systems. This waste is not hazardous, but it hampers the emergency response by blocking roads and hiding the full extent of the damage, and blocks drainage channels, which leads to flooding and wastewater overflow.

It is necessary to take into account that all initial efforts are aimed at the rescue of buried people who may remain alive for up to seven days. Although quick and effective demolition methods are necessary, they should be carefully applied to prevent collapses that may produce even more damage.

After floods, accumulation of sludge both inside the house and outdoors may become a major problem. It is recommended that waste is removed manually from inside dwellings, mechanically from public roads, and then disposed of with other rubble. Ash produced by volcanic eruptions can be cleared by groups of workers, often from the affected community. New ash falls may need to be cleared every day or so.

Initial assessments of the affected areas and estimated tonnes of material to be cleared are crucial elements for demolition activities and waste management. These assessments should be rapid and general, as detailed research may usually be time-consuming, and a prompt response is required.

In highly developed urban areas, an average of 1.5 tonnes of building waste may be generated per square metre constructed (United Nations Environment Programme, International Environmental Technology Centre, 1992). In residential areas, this amount ranges from 0.5 to 1.0 ton per square metre constructed, depending on the materials used in each locality. Decisions on the demolition of damaged buildings are often difficult to make since costs, policies, structural risk and other factors must be first analysed.

The various components of rubble should be separated to facilitate recycling. Metals, mainly iron and steel, can be smelted for reuse. Concrete can be crushed for road-building, land reclamation, etc. Wood can be used as fuel. In many cases, the local population will spontaneously recover useful materials. This activity may need monitoring to reduce the risks of accidents and avoid legal problems. Final disposal may be in landfill sites.

8.5.6 Medical wastes

Special care must be taken with refuse from a field hospital or health centre. The main categories of waste of concern are: infectious waste; pathological waste; sharps; pharmaceutical waste; genotoxic waste; chemical waste; waste with high heavy metal content; pressurized containers; and radioactive waste (World Health Organization 1999c). Each type of waste requires specific measures for handling, storage, collection and destruction. In the case of simple health centers, particularly in rural areas, well-managed on-site burial may be appropriate. In larger centres producing a significant quantity of sharps and infected waste, incineration may also be required. When health facilities operate diagnostic laboratory services, radiological diagnosis and treatment facilities, pharmacies, etc., waste management is a specialized activity requiring trained and well-equipped staff, and the subject is beyond the scope of this book.

Waste management during triage and classification of victims

Triage and classification of victims generate potentially infectious waste. Since this is a rapid-response activity, it is highly recommended that all wastes generated during this stage, without exception, are stored in containers, preferably in red bags, that are properly labelled as “biocontaminated waste”. Direct contact with such wastes must be avoided.

Waste management during routine medical activities

Management will be similar for permanent (existing hospitals and health centres) and provisional (field hospitals) health facilities.

Wastes should be segregated at the point of generation according to their type:

- — biocontaminated wastes (including sharp materials);
- — chemical wastes (drugs, chemical solutions, etc.);
- — common wastes (paper, cardboard, glass, or the like; chemical product containers should be treated as chemical wastes).

For each hospital room, washable and easily disinfected PVC containers with a capacity of 40–50 litres should be used. Waste should be disposed of in coloured bags according to the following codification:

— red bags for biocontaminated wastes;
— yellow bags for chemical wastes;
— black bags for common wastes.

Hermetic plastic containers of 2–5 litre capacity or opaque glass bottles may be used to store sharp objects.

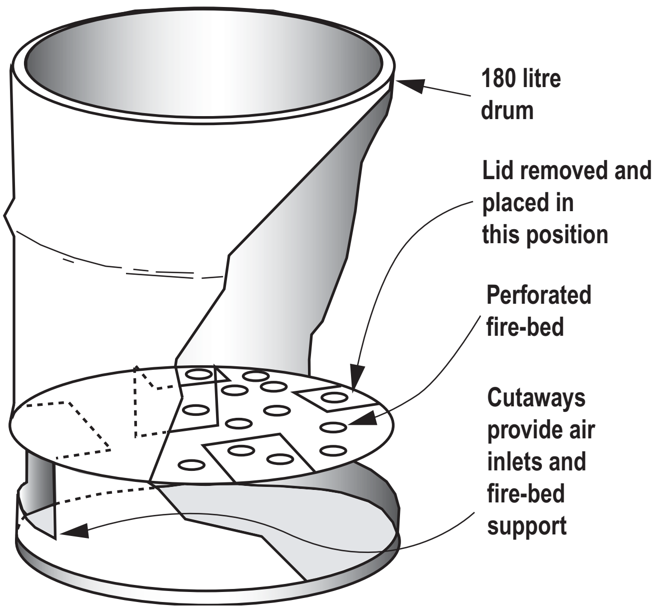
These wastes should then be collected separately every 12–24 hours. Small carts, preferably with lids, should be adapted to this end and the personnel assigned should be protected with aprons, masks, boots and gloves.

Treatment should be done according to the type of waste. Sharp materials should be disinfected with a 0.5% total chlorine solution before incineration or burial in a sharps pit. Biocontaminated wastes should be incinerated.

Burned biocontaminated wastes, disinfected sharp materials, and chemical wastes should be disposed of by burial on-site if possible. The burial area should be isolated and protected to avoid illegal recycling. However, this may not be possible in permanent health facilities, due to lack of space. In such cases, protected areas should be used at landfill sites to receive treated wastes. Common wastes may be managed by the municipal waste-collection service, as long as they do not contain hazardous material.

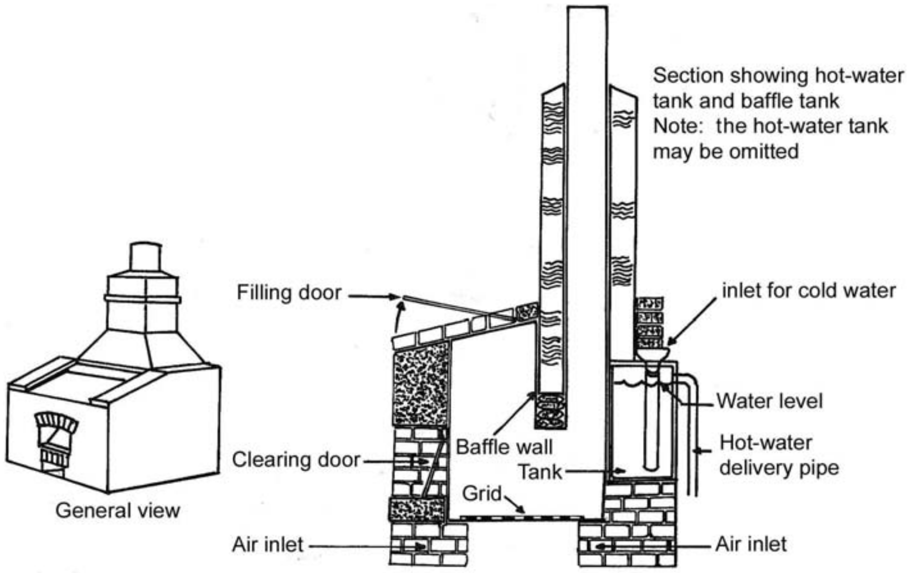
A temporary incinerator for medical waste can be made from an old 200-litre oil drum (Figure 8.10). However, this is unlikely to perform adequately, and although it may help reduce the volume of waste to be buried, it will produce a lot of black smoke and may only partially reduce the risk posed by the waste. In addition, the use of incinerators, as opposed to direct burial, creates an additional step in the disposal process, exposing workers to risk and increasing the chances of waste escaping into the environment. Brick-built incinerators, of sufficient performance, can be built, using designs that are readily available (e.g. Christen, 1996). A single-chamber brick incinerator

Figure 8.10 **Simple basket incinerator made from a discarded oil drum**[1]



[1] Source: Skeet (1977).

Figure 8.11 **Balleul single-chamber incinerator**[1]



[1] Source: Christen (1996).

(Figure 8.11) that incinerates at 300–400 °C may destroy 99% of microorganisms and greatly reduce the volume and weight of waste (World Health Organization 1999c).

8.6 Further information

For further information on:

— sanitation assessment and programme design, see: Sphere Project (2000), Davis & Lambert (2002), Harvey, Baghri & Reed (2002);

— latrine designs, see: Feachem & Cairncross (1978), Winblad & Kilama (1985), Franceys, Pickford & Reed (1992), Cairncross & Feachem (1993), Pickford (1995), Davis & Lambert (2002);

— solid waste management, see: United Nations Centre for Human Settlements (1989);

— surface water and wastewater drainage, see: Davis & Lambert (2002), World Health Organization (1991c);

— management of medical wastes, see: Reed & Dean (1994), World Health Organization (1999c).