AIR POLLUTION

Air pollution is defined as "presence in the outdoor atmosphere of one or more contaminants, such as dust, fumes, gas, mist, odour, smoke or vapour, in quantities, of characteristics, and of duration such as injurious to human, plant or animal life or to property, or which unreasonably interferes with comfortable enjoyment of life and property".

Aerosol : It is a dispersion of solid or liquid particles of microscopic size in gaseous media, such as smoke, fog or mist.

Dust : It is a loose term applied to solid particles larger than colloidal particles and capable of temporary suspension in air or other gases. Dusts do not tend to flocculate except under electrostatic forces; they do not diffuse but settle under the influence of gravity. (Size : 1 – 200 μm)

Droplet : It is a small liquid particle of such size and density as to fall under still conditions but which may remain suspended under turbulent conditions.

Fly-ash : It is finely divided particles of ash entrained in fuel gases arising from the combustion of fuel. The term is generally applied to the gas-borne ash from boilers using pulverised fuel (coal) firing.

Fog : It is a loose term applied to liquid dispersed aerosols in air by condensation.

Fume : It is solid particles generated by condensation from the gaseous state, generally after volatilization from melted substances, and often accompanied by a chemical reaction such as oxidation. (Size: 0.1 to 1 μm)

Mist : It is a loose term applied to dispersions of liquid particles in atmosphere, the dispersion large size. (Size: 5–100 μm)

Particle : It is a small discrete mass of solid or liquid matter.

Smoke : It is finely divided aerosol particles resulting from incomplete combustion. It consists mainly of carbon and other combustible material. (Size: 0.01 to 1 μm)

Soot : It is collection of particles of carbon impregnated with 'tar' formed in the incomplete combustion of carbonaceous material.

Vapour : It is the gaseous form of matter which normally exists in a liquid or solid state.

CLASSIFICATION OF AIR POLLUTION

Air pollution exists in three distinct categories

1. **Personal air pollution**

   This refers to exposure of an individual to dust, fumes and gases.

   e.g. person indulges in cigarette, cigar or pipe smoking.

2. **Occupational air pollution**

   This represents the type of exposure of individuals to potentially harmful concentration of aerosols, vapours and gases in their working environment.

3. **Community air pollution**

   This represents most complex of the three varieties since it involves pollution from a variety of sources and contaminants and factors which cause adverse social, economic and health effects. Not only does community air pollution affect many individuals, but it can also exert a significant impact on man's total environment including plants, animals, property and the weather itself.

SOURCES OF AIR POLLUTION

There are two main sources of air pollution

1. **Natural air pollution sources**

   Atomosphere is polluted due to following natural causes :

   (*i*) Wind-blown dust
   (*ii*) Smoke, fly-ash, gases from forest fires
   (*iii*) Micro-organisms
   (*iv*) Gases and odours from swamps and marshes
   (*v*) Fog
   (*vi*) Volcanic ash and gases

   Pollutants from various natural sources

   - Pollutant natural sources
   - SO_2 Volcanoes
   - H_2S Volcanoes, biological action in swamp areas
   - CO Forest fires, ocean
   - NO-NO_2 Bacterial action in soil
   - NH_3 Biological decay
   - Hydrocarbons
   - (CH_4, etc.) Biological processes
   - CO_2 Biological decay, release from oceans
   - O_3 Oxygen and ozone in stratosphere and their downward transport

2. **Man-Made air pollution sources**

   Sources of pollution due to man's activities are following

Source	Category	Examples	Pollutants
Dust-producing process	Crushing, grinding, Screening, demolition, milling	Road mix plants, Construction work, Grain elevators	Mineral and organic particulates
Combustion	Fuel burning	Home oven, power plants	Oxides of sulphur, oxides of nitrogen.
	Motor vehicles	Cars, buses and trucks	Carbon monoxide, Smoke, fly-ash, organic vapour, metal oxide, particles and odours
	Refuse burning	Open burning of refuse	
Manufacturing processes	Metallurgical plant	Smelters, steel mills, non-ferrous industries, etc. of sulphur.	Metal fumes, lead, arsenic and zinc fluorides and oxides
Chemical plants	Petroleum refineries, pulp mills, fertilizer plants, cement mills	H_2S, oxides of sulphur, fluorides, organic vapour, particles, odours	
Agricultural activities	Crop spraying, dusting Field burning	Pest and weed control	Organic phosphates, chlorinated hydrocarbons, arsenic, lead Smokes, fly-ash and soot
Nuclear energy activities	Ore preparation Nuclear fissions Nuclear device testing	Crushing, grinding screening Nuclear reactors Atmospheric explosions	Uranium and dust beryllium Agron-4] Radioactive fallous

EFFECTS OF AIR POLLUTION

1. **Effect on Vegetation**

   Vegetation exposed to atmosphere containing heavy amounts of sulphur dioxide is severly damaged. It is also affected by ozone and nitrogen dioxide.

2. Effect on Human beings and Animals

People suffer from respiratory diseases when exposed to atmosphere in which concentration of the sulphur dioxide is in excess of safe limits, and their visibility is affected when exposed to higher temperature. The death rate of people suffering with cardiac or pulmonary diseases, when exposed to atmosphere contaminated with sulphur dioxide, is found to be higher.

Due to incomplete combustion of fuels from petrol engines, industrial operations, etc., carbon monoxide is liberated. When air containing CO is inhaled, CO combines with the haemoglobin of the blood, depriving the tissues of oxygen. It has been found that when carbonyl haemoglobin saturation level of blood is about 20%, it harms heart and also impairs tissues restricting the oxygen. When in excess of 10%, it is found to cause headaches.

When nitrogen dioxide level in the air is above tolerable limits, respiratory illness among children has been observed.

When oxygen content in the air is above 500 mg/m^3 and photochemical action is high, people have been found to have asthmatic attacks. Irritation of throat, nose or eyes are some other minor problems experienced in these conditions.

In general, air pollution decreases visibility. It is also found that it makes the town or city more cloudy, more foggy and is subjected to more acid rains.

3. Effect on Materials

Air pollutants affect materials in the following ways and cause economic losses

(*i*) Abrasion (*ii*) Deposition of materials (*iii*) Direct chemical attack

(*iv*) Indirect chemical attack (*v*) Corrosion

Material	Air Pollutants	Effect on Materials
Metals	SO_2, acids, gases	Tarnishing of surface, loss of metal, etc.
Paints	SO_2, H_2S and particulates	Discolouration
Textiles	SO_2, acid, gases	Reduction in tensile strength
Ceramics	–do–	Discolouration

AIR POLLUTION METEOROLOGY

Atmospheric conditions can have profound effects on pollution and its harmfulness, and air pollution meteorology is concerned with the description of the transport of pollutants from sources to receptors.

Pollutants emitted into the atmosphere are subject to following four types of effects :

$\left.\begin{array}{l}\text{(1) Transport}\\ \text{(2) Dilution}\end{array}\right\}$ cause dispersion of pollutants in the atmosphere

(3) Modification

(4) Removal

Temperature and Pressure Relationship in the Lower Atmosphere

Change of temperature with altitude has great influence on the motion of air pollutants.

e.g., very stable atmospheric conditions result in only limited vertical mixing.

Stability Conditions

Value of the lapse rate in the lower portion of the troposphere has a profound influence on the vertical motion of the air. Good vertical mixing minimizes immediate ground-level effects of air pollutants, since contaminants may be quickly diluted through their dispersal into higher regions. If air does not vigorously mix upwards, pollutants which are released at low levels tend to remain there. *Stable* atmosphere is defined as the one which does not exhibit much vertical mixing or motion.

Degree of mixing is primarily dependent upon following

(1) Temperature gradient

(2) Mechanical turbulence

The possibility of thermal mixing can be determined by comparison of actual (environmental) temperature gradient or lapse rate to adiabatic lapse rate.

Internal energy decreases thereby decreasing temperature. Upon reaching new height, if temperature of the air particle is same as the temperature of the environment, then environmental lapse rate is exactly same as

6. **Trapped Plume.** It occurs when pollutant is emitted into an unstable layer of air trapped between inversions both below and above stack height. Diffusion of pollutants is severely restricted to the layer between two stable regions.

Factors Affecting Behaviour of Plume

(1) General characteristics of the terrain surrounding a stack and location and nature of buildings relative to a stack

An empirical thumb rule for stacks located on or near to a building is, $H_{stack} \geq 2\ 2.5.\ H_{building.}$

(2) Separation of flow around buildings. The flow separates to form a large '*cavity*' behind a building. Backflow occurs within the cavity so that downwind sources are carried upwind if emitted in the regions of separated flow. Pollutants remain in the cavity because of very poor mixing between cavity and the main stream.

Similarly separation can occur behind a cliff, where plume can be carried to the ground when wind blows over a cliff.

Separation behind a cylinder or chimney will also result in *downwash* of the effluent trapped in the separated regions. Thus plume may not rise above the stack level and may even be carried downward on the backside of the stack. This occurs when stack velocity is about equal or less than the ambient velocity.

AIR-POLLUTION CONTROL

Following methods are useful in controlling air pollution :

1. **By Zoning**

In this method, adopt zoning system at the planning stage itself. A separate zone or area is set aside for industries thereby reducing ill effects of air pollution on the urban dwellers.

Zoning of the industries is done based on the type of industries, their functions, etc. Every city has its own zoning rules.

Zoning of industries is based on following :

(*i*) Functions : These include industries such as linkages for industry, sidings, etc.

(*ii*) Performance : *Here industries are classified according to their nuisance value as follows :*

(*a*) Traffic congestion

(*b*) Abnoxious and hazardous

(*c*) Industrial nuisance such a smoke, noise, dust, odour, etc.

Separate areas may be earmarked according to their performance as stated.

In India, zoning system varies from city to city.

2. **At the Source**

Air-pollution can be controlled at the source by following four ways:

(*i*) Raw material substitution : If one raw material results in a pollution problem while a substitute material does not, obviously substitute would be more desirable. The raw material may contain an ingredient which is not essential but is a pollution source. If non-essential ingredients can be removed prior to processing the raw material, pollution potential can be minimised.

e.g. use low-sulphur fuels to replace high-sulphur fuels.

(*ii*) Process modifications. Pollution reduction can frequently be achieved by new or modified processes.

e.g. use of exhaust hoods and ducts over several types of industrial ovens has allowed the recovery of valuable solvents that could have become air pollutants.

(*iii*) Equipment alterations : Equipment alterations such as use of floating roof tanks rather than vented tanks can cut down on evaporation losses. Newer types of equipment are less pollution-prone.

e.g. basic oxygen furnaces that are replacing the open-hearth furnaces in the steel industry, pose less of a pollution problem.

(*iv*) Removal of pollutants at source: Sometime costly control equipment is necessary to remove pollutants from the main gas stream. In such cases it is simpler to remove pollutants at the source. It is normally more economical to remove these pollutants while they are present in relatively higher concentrations rather than at some point away from the source where the pollutants are diluted by gases from other processes or air.

3. **By Devices**

Due to different process in industries, various type of gases are liberated alongwith particulates. To arrest these entering, atmosphere, control devices are used depending on collection capacity and processes used by the particular industry.

Types of Devices used for Dust collections *(based on method of their removal)*

(*i*) Internal Separators.

These devices separate the dust in the gases. These are manufactured in various shapes and sizes. *Following types are commonly used :*

(*a*) *Gravity-settling Chamber :* This consists of a chamber in which dust is separated from the gas by reducing velocity of the gas. Due to this, dust particles settle down in the chamber. As size of the chamber for very low velocities of the gas required is very large and cost is prohibitive, velocity in the chamber is generally kept between 0.3 to 3.0 m/sec. By this, coarser particles are removed. It is capable of removing only the large particles of size 25 to 50 μm dia.

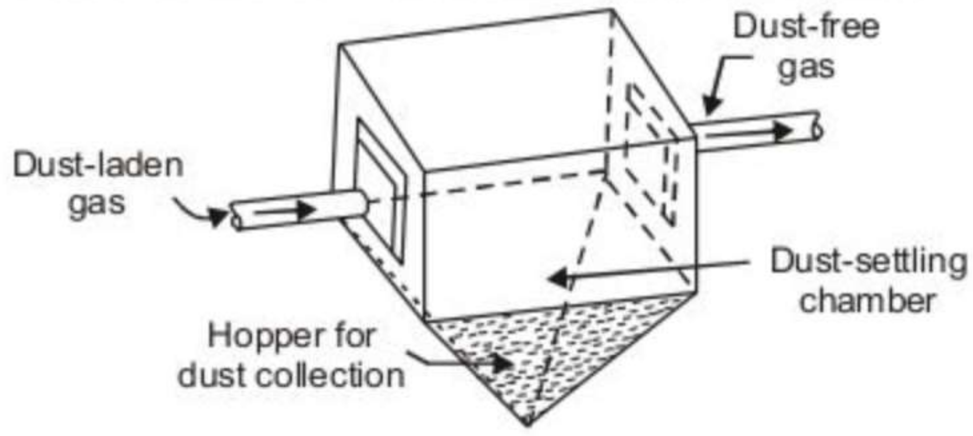
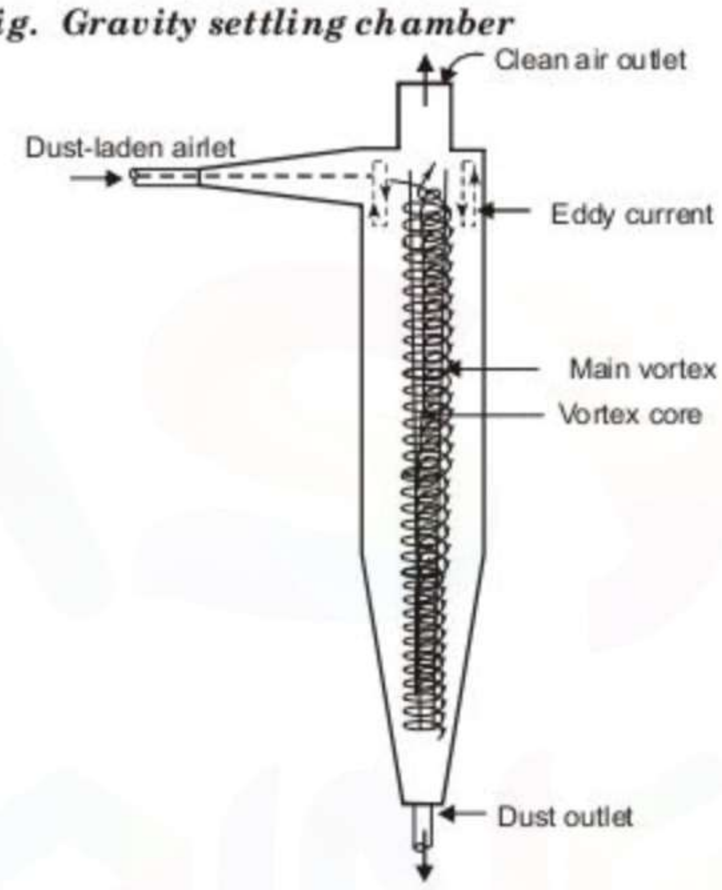


Fig. Gravity settling chamber

(*b*) *Cyclone:* When a gas travels in a double vertex, the particles contained in it are separated. The cyclone works on this principle.

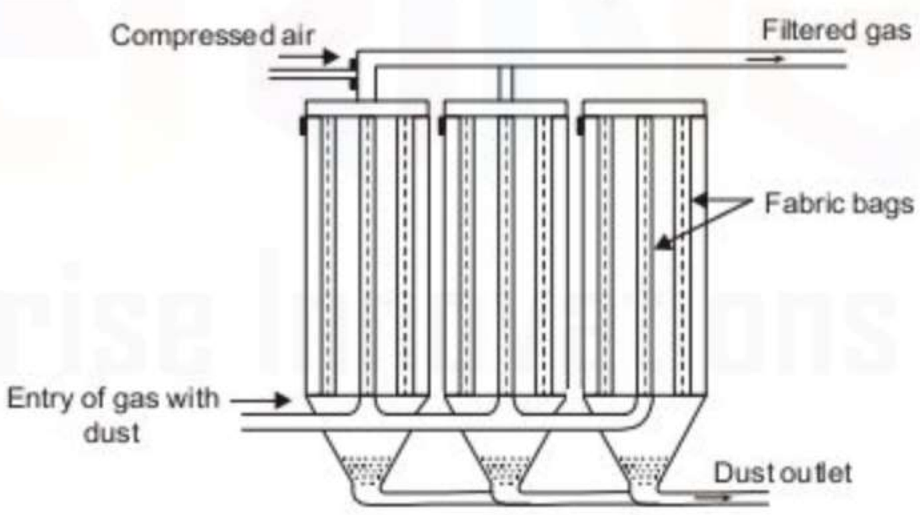
Gas is first allowed to spiral down at the inner surface and then it spirals upwards at central portion of the cyclone. Due to inertia, dust particles tend to settle on the surface of the cyclone wall. From here they are led away to the receiver.

Cyclones are very efficient and can handle a number of operations. They are suitable for removing particles of size of 10–40 μm.



(*c*) *Fabric filters :* Here, gas with the dust is allowed to pass through a fabric (cloth) to which dust gets attached. If gas is flowing at low velocity and contains considerable amount of larger particulates, these settle down by sedimentation. Fine particles are also attached to the fabric due to electrostatic charges.

These bags are fitted with hopper at bottom. Gas enters from the bottom through the hopper. The heavy particles settle down in the hopper due to gravity. Finer particles are deposited on the fabric of the bag. For clearing the bags, compressed air is blown in the reverse direction.



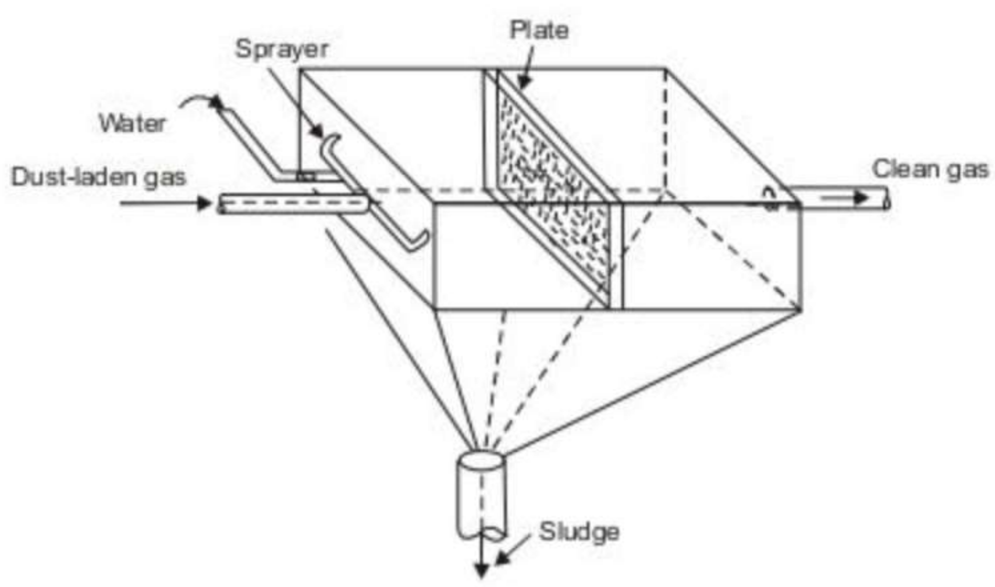
(*ii*) Wet-collection Devices

Wet washers and scrubbers are devices using mixed phases of gas and liquid. Object of the scrubber or washing device is to transfer suspended particulate matter in the gas to the scrubbing liquid which can readily removed by the gas cleaning device. This leaves the gas clean to pass onwards to the process for which it is being used, or alternatively to be discharged to the atmosphere.

Two common wet-collectors used are following :

(*a*) *Cyclonic scrubbers :* In this device, aerosol is admitted in a centrifugal fashion. Water is impinged at the entrance of the gas. Plates are provided to remove moisture from the gas after the dust is removed. This should be followed by a control equipment like a gravity-settling chamber or cyclones.

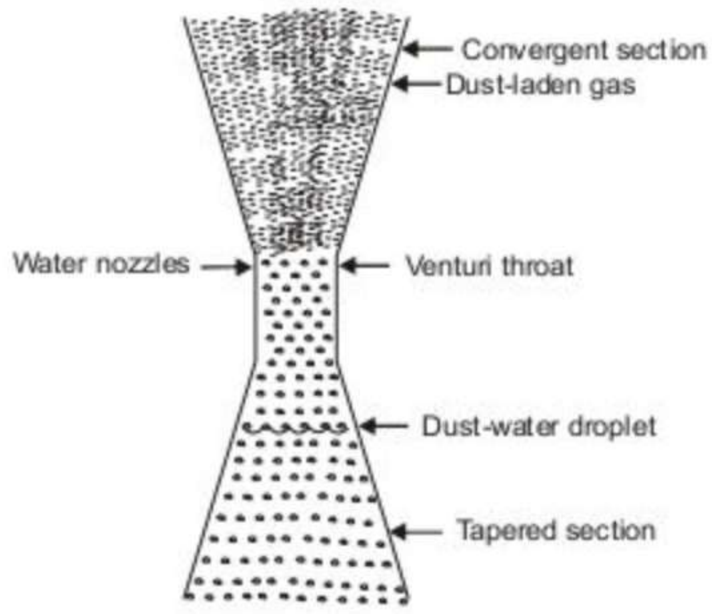
Dust particles of size 5 μm can be separated with 90% efficiency in a cyclonic scrubber. It can clean about 2000 litres of gas per minute.



(b) ***Venturi scrubbers :*** Venturi scrubber consists of a venturi throat through which dirty gas passes at a velocity of 3400 to 12600 mm per minute. Water is added in the direction of flow so that water enters at the throat.

Venturi scrubber can clean about 4000 litres of gas per minute. The efficiency is about 99% and can clean very fine particles.

If moisture has to be removed from the gas, a cyclonic separator is used after the venturi scrubber.



(iii) Electrostatic Precipitator

It is a device by which the dust in a gas is removed by electrostatic attractions.

Gas is allowed to enter the electrostatic precipitator through narrow vertical gas passages which are formed by parallel rows of grounded collecting electrodes. Insulated high-voltage wires of about 40-50 kV are placed in the centre of each passage. Thus, dirty gas passes between high-voltage wires and the grounded plates.

High voltage in the wires produces billions of electrons and bombards the gas molecules, which become positive and negative ions. Positive ions return to the negative wire electrode and gain electrons while negative ions combine with the dust particles and make them negative ions.

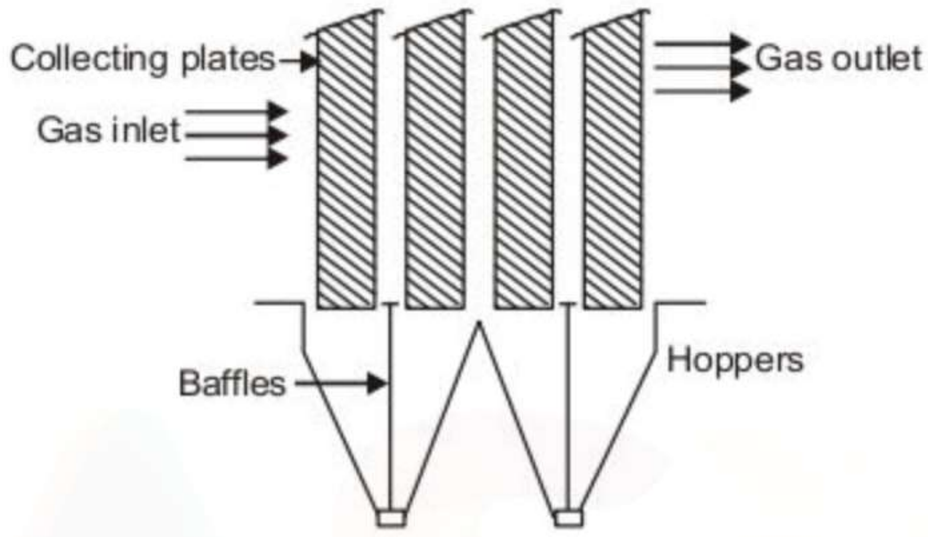


Fig. ESP Electrodes with dust collecting hoppers

Negatively charged dust particles collect at the positively charged plates.

When thickness of the dust layer increases to more than 6 mm, electrical attraction becomes weak. A sharp gap is given which causes the dust layer to separate and fall down into the hopper.

Electrostatic precipitator has an efficiency of 99.9% and can clean up to 150,000 litres of gas per minute at a temperature of 600° C.

4. By Stacks

When small quantities of air pollutants are released at a source, these can be absorbed without producing noticeable pollution. However, if quantity of pollutants released is large, and air has a limited capacity, the pollution becomes high. If pollutants are carried away to some distance or taken to high altitudes, they are reduced in concentration by diffusion and dilution. Pollutants are taken to high altitudes by means of stacks.

Diffusion of pollutant in air depends on following factors :

(i) Atmospheric temperature

(ii) Speed and direction of wind

Height and diameter of stack required is designed to keep the ground level concentration within permissible limits. Concentration at ground level varies inversely with the square of the stack height and is maximum at a distance of 5-10 m stack height.

Some authors suggest following :

- Height of the stack must be 2.5 times the height of the surrounding buildings.
- Velocity of the exit gases should not be more than 20 m/sec.

5. By Vegetation

To reduce spreading of air pollutant emanating from industrial sources, growing green vegetation around the industry has been recommended by many scientists. Studies (Waren 1973, Fleming 1967) indicate that there are large differences among species vis-a-vis the response to air pollutants. Hence cultivation of pollution resistant species represents the best possibility of reducing injury by air pollutants. The degree of resistance depends on type of pollutant.

COMPOSITION OF CLEAN AND DRY ATMOSPHERIC AIR

Component	*Concentration (ppm)*
Nitrogen (N_2)	780,900
Oxygen (O_2)	209,500
Argon (Ar)	9,300
Carbon dioxide (CO_2)	320
Neon (Ne)	18
Helium (He)	5.2
Methane (CH_4)	1.5
Krypton (Kr)	1
Hydrogen (H_2)	0.5
Nitrous Oxide (N_2O)	0.2
Carbon monoxide (CO)	0.1
Xenon (Xe)	0.08
Ozone (O_3)	0.02
Ammonia (NH_3)	0.006
Nitrogen dioxide (NO_2)	0.001
Nitric Oxide (NO)	0.0006
Sulphur dioxide (SO_2)	0.0002
Hydrogen Sulfide (HS_2)	0.0002

EXERCISE – I

MCQ TYPE QUESTIONS

1. A small discrete mass of solid or liquid matter is called
(*a*) particle (*b*) dust (*c*) fume (*d*) droplet

2. Pollution of air due to smoking by a person is classified under
(*a*) personal air pollution
(*b*) occupational air pollution
(*c*) community air pollution
(*d*) none of these

3. Air pollution from a variety of sources and contaminants which cause adverse social, economic and health effects, is classified under
(*a*) personal air polluton
(*b*) occupational air pollution
(*c*) community air pollution
(*d*) none of these

4. Due to incomplete combustion of fuels from petrol engines, the gas liberated is
(*a*) CO_2 (*b*) CO (*c*) N_2 (*d*) He

5. The category of devices by which dust is separated from a gas is called
(*a*) internal separator (*b*) fabric filter
(*c*) cyclone scrubber (*d*) none of these

6. A device which consists of bags to which dust in a gas flowing in it attaches itself, is called
(*a*) cyclone (*b*) fabric filter
(*c*) separator (*d*) filter

7. A device in which gas is allowed to mix with water and then impinges on a plate is called
(*a*) cyclons scrubber (*b*) fabric filter
(*c*) water filter (*d*) separator

8. A device in which dust in a gas is removed by electrostatic attraction is called
(*a*) cyclone scrubber
(*b*) fabric filter
(*c*) electrostatic precipitator
(*d*) none of these

9. Aerosols are defined as
(*a*) finely divided liquid droplets or solid particles
(*b*) finely divided liquid droplets
(*c*) solid particles
(*d*) toxic gases

10. Carbon monoxide in air effects
(*a*) heart (*b*) skin
(*c*) eye (*d*) hair

11. Carbon monoxide has more affinity with haemoglobin than oxygen for about
(*a*) 2000 times (*b*) 100 times
(*c*) 200 times (*d*) 20 times

12. Looping occurs when
(*a*) vertical temperature gradient is super-adiabatic and air is turbulent
(*b*) vertical temperature gradient is super-adiabatic but less than isothermal
(*c*) temperature gradient is positive
(*d*) all of these

Excreta disposal

Excreta disposal is undoubtedly one of the key elements of any emergency sanitation programme. Containment and safe disposal of human excreta is the primary barrier to transmission of excreta-related disease. Implementing agencies often focus solely on the quantity of toilets in emergency situations, however, and pay scant attention to their quality and usage.

6.1 Associated risks

6.1.1 Sources of disease

Inadequate and unsafe disposal of human faeces can lead to the contamination of ground and water sources, and can provide breeding sites for flies and mosquitoes which may carry infection. In addition, faeces may attract domestic animals and vermin which can both increase the potential for disease. It can also create an unpleasant environment in terms of odour and sight.

The introduction of safe excreta disposal can reduce the incidence of intestinal infections and helminth infestations. Excreta-related communicable diseases include cholera, typhoid, dysentery (including shigellosis), diarrhoea, hookworm, schistosomiasis and filariasis (Franceys et al., 1992). The likelihood of all these diseases, and especially epidemics such as cholera, increases significantly when a population is displaced.

6.1.2 Transmission of disease

Transmission of excreta-related diseases is largely faecal–oral or through skin penetration. Figure 6.1 illustrates the potential transmission routes for pathogens found in excreta.

Poor hygiene practice, particularly involving food and hands, may be a major cause of disease transmission, even where appropriate excreta disposal facilities are in place. For this reason it is difficult to obtain a direct correlation between the incidence of excreta-related disease and the provision of appropriate facilities.

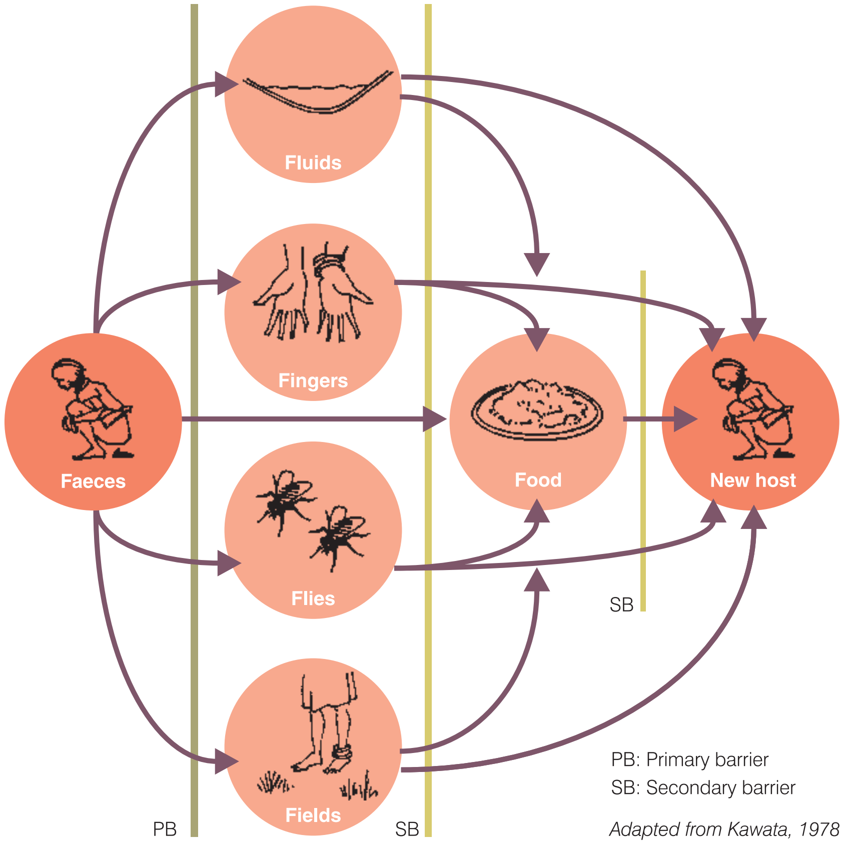


Figure 6.1. Transmission of disease from faeces

6.1.3 High-risk groups

Children under five years of age are most at risk from communicable diseases since their immune systems have not developed. Increased malnutrition, as is common in emergencies, increases this risk further. Since young children are unaware of the health risks associated with contact with faeces it is essential that faeces are safely contained.

Severely malnourished children and adults are at increased risk from diarrhoeal disease, as are elderly people especially if exhausted after travelling considerable distances.

6.2 Selection criteria for excreta disposal

In selecting appropriate excreta disposal interventions there are many criteria that must be considered. These include:

- Socio-political factors
- Socio-cultural factors
- Available space

- Ground conditions
- Water availability
- Anal cleansing material
- Menstruation
- User-friendliness (for children, etc.)
- Time constraints
- Design life
- Mandate of agency
- Financial constraints
- Availability of local materials
- Transportation means
- Human resources
- Operation and maintenance

6.2.1 Socio-political factors

The host country or central authorities are often reluctant to allow family units or long-term solutions to be provided for a displaced population. This is often because they do not want the affected population to feel that they are going to stay permanently in the affected area. This is generally unnecessary since people do not want to stay anyway, but where the authorities believe this, temporary communal facilities may have to be provided. If appropriate, permission for family or shared facilities should still be sought.

6.2.2 Socio-cultural aspects

The facilities provided should be as compatible as possible with the previous practices of the affected population and, where people have been displaced, also with those of the indigenous society. People are much more likely to use latrines if they are accustomed to the type of technology used. In addition, in some cultures it is unacceptable for different cultural groups to use the same latrine and this must be considered. Consultation with different groups within the affected community is essential to ascertain these factors.

6.2.3 Space

The availability of space will influence the type, design and density of latrines. For example, where space is limited family latrines may not be an option. Also, there may not be enough space to replace full pit latrines, meaning that some provision for pit emptying is required (see 6.9), or the distribution of latrines within the site may be severely limited.

6.2.4 Ground conditions

Ground conditions have a particular impact on latrines that rely on soil infiltration (such as pit latrines). The main considerations are:

- Bearing capacity of the soil (to support superstructure)
- Soil stability (to prevent pit collapse and allow excavation)
- Depth and ease of excavation possible
- Infiltration rate
- Groundwater pollution risk

See Chapter 4 for more detailed information.

6.2.5 Water availability

An important constraint in deciding on wet or dry excreta disposal systems is the availability of water in the area. Often the quantity of water available in emergency situations is severely limited. If this is the case it is likely to be inappropriate to use latrines which rely on heavy water use, such as water closets. This factor must be weighed against whether the population will use dry systems, however. Where the local custom is to use water for anal cleansing this must be also be considered.

6.2.6 Anal cleansing material

The importance of anal cleansing materials should not be underestimated. These can have a big effect on sludge accumulation rates (see 6.8.9) and water use. It is important to consider the materials the community members usually use and the materials currently available. Care should be taken to avoid making assumptions by speaking to community members and inspecting existing defecation sites to determine what materials are being used in the present situation.

6.2.7 Menstruation

Women and girls of reproductive age need access to appropriate materials for the absorption and disposal of menstrual blood. Latrines should therefore allow for the disposal of women's sanitary protection, or provide women with the necessary privacy for washing and drying sanitary protection cloths in a hygienic manner. There may also be a need to supply appropriate materials for this use.

6.2.8 Time constraints

Time is especially important in the immediate stage of an emergency, when the aim is to provide facilities rapidly in order to minimise the spread of excreta-related disease in the affected area. Possible time-constrained scenarios include:

- the sudden occurrence of a natural disaster where most infrastructure is destroyed (e.g. flood or earthquake); and
- the mass movement of an affected population to an area where there are no facilities (i.e. movement of refugees or internally displaced people).

In the above scenarios, it is likely to be appropriate to begin with the provision of simple communal facilities which can be constructed quickly. The life span of these facilities will depend on how quickly the affected population can be mobilised to construct improved family units and how long the people are likely to be displaced.

Another time constraint could be the time taken to procure equipment and materials due to the scarcity of local resources. Where this is the case, immediate emergency measures should be taken until appropriate materials can be obtained.

6.2.9 Design life

The design life of the facilities to be constructed must be considered from the onset. If the affected population is staying in a temporary camp and it is known that they will be moving within a fixed period of time, temporary facilities must be designed accordingly. Conversely, if it known that the population will be staying in the area indefinitely, solutions must be designed for long-term use. Often it is not known how long a situation will last and this is a frequent cause of controversy. Latrine programmes, therefore, should be designed in such a way that they can be adapted to suit changing circumstances.

6.2.10 Mandate of agency

Some implementing agencies have a mandate to deal with the initial stages of an emergency and after that to withdraw from the affected area or hand over activities to another agency. Furthermore, if the mandate of the agency is 'direct emergency response' then a relationship has to be worked out between it and those responsible for longer term solutions, otherwise tension may be created which could adversely affect the population concerned.

It is therefore essential that all agencies should consider a long-term solution in their outline design, allowing flexibility for upgrading even if they do not have any intention of implementing these plans themselves. Such an approach will help to ensure continuity from direct response to long-term solutions.

6.2.11 Financial constraints

The financial resources available to the implementing agency may influence the choice between communal or family facilities, and the type and quality of latrine selected. For this reason it is important that a draft budget is produced in the outline programme design and that materials (including transportation) and labour are properly costed.

6.2.12 Availability of local materials and tools

If facilities can be constructed from local materials this may reduce the implementation time and cost considerably. For these reasons it is important to ascertain what resources are available and whether they can be used without adverse effect on the local environment and economy. Detailed designs that rely on high-quality imported materials may be totally inappropriate when the logistics of procuring and transporting these items is considered.

6.2.13 Human resources

The skills and experience of the available personnel may be important constraints or opportunities for selecting appropriate interventions. Complex technical designs may be inappropriate if construction personnel are unable to implement them. If staff have solid experience of particular construction techniques, however, it may be appropriate to use these, although the high turnover of staff in some situations should be considered.

6.2.14 Operation and maintenance

The operation and maintenance (O&M) of latrines should be given equal emphasis to their construction. If responsibility for O&M has to be taken by the implementing agency (i.e. the end-users will not, or cannot, clean and maintain facilities) then only communal facilities should be provided. If community members are willing to take on the responsibility for O&M, however, family latrines may be a more appropriate option.

The availability of cleaning materials, the ease of cleaning of latrine slabs or basins, and facilities for emptying pits must also be considered in latrine selection and design.

6.3 Communal or family latrines?

It is widely accepted that family excreta disposal facilities are preferable to communal facilities. Many of the factors outlined in Section 6.2 may influence this decision, however.

6.3.1 Operation and maintenance

Perhaps the most important factor concerning the choice between communal and family latrines is operation and maintenance. Field experience tends to indicate that there is a direct relationship between the ratio of facilities to the affected population and the involvement of

Table 6.1. Advantages and disadvantages of communal and family latrines (adapted from Adams, 1999)

Factor	***Communal***	***Family***
Speed of construction	Can be constructed fast by well-trained and well-equipped team, although rate of construction limited by number of staff and equipment.	May take considerable time to train families in the initial stages, but large numbers of latrines may be built quickly.
Technical quality	Quality of design and construction easier to control but innovative ideas from users may be missed.	Potential for innovative ideas of users, but more difficult to ensure good siting and construction.
Construction costs	Use of materials can be easily controlled but labour must be paid for.	Construction labour and some materials may be free of charge, but families may not have the time or the right skills.
Maintenance costs	Maintenance, repair and replacement costs are easier to predict and plan, but staff are required to clean and maintain facilities in long-term.	Users take responsibility for cleaning and maintenance but recurrent costs are less predictable.
Technical possibilities	Heavy equipment and specialised techniques may be used where necessary (e.g. rocky ground).	Families may not be able to dig in hard rock or build raised pit latrines where the water table is high.
Cleaning and hygiene	Users do not have to clean latrines, but these are often dirty, and a greater mix of users increases the risk of disease transmission.	Latrines are often cleaner but many users may prefer not to be responsible for construction, cleaning and maintenance.
Access and security	Latrines may be less accessible and more insecure, particularly for women.	Latrines are often more accessible (closer to dwellings) and safer.
Development issues	People may lose or not acquire the habit of looking after their own latrine.	People keep or develop the habit of managing their own latrine.

that population in O&M activities. Responsibility for O&M of communal latrines is often the source of tension or resentment, and as a result facilities may not be adequately maintained leading to increased health hazards.

It is also important to consider that it is possible to implement one type of facility parallel to another in such a way that they complement each other. For example, communal latrines may be provided for new arrivals at a refugee camp but after a short period of time these are replaced with family latrines.

6.3.2 Advantages and disadvantages

There are many advantages and disadvantages of both communal and family latrines. The final decision will depend on a variety of factors as outlined in Table 6.1.

6.3.3 Communal latrine scenarios

It is likely that in the following scenarios communal latrines will be the most appropriate or only option:

- Hard shelters (schools, public buildings, factory buildings, emergency centres)
- Enclosed centres (prisons, hospitals, orphanages, feeding centres, etc.)
- Difficult physical conditions (e.g. rocky ground, high water table level)
- Over-crowded peri-urban areas
- Crowded camps with little available space (population density >300 per hectare)
- Transit camps where facilities are temporary
- Where the local authorities do not permit family units

6.4 Immediate measures

Immediate measures are designed for use in the initial stage of an emergency only.

6.4.1 Clearing of scattered excreta

Where indiscriminate open defecation is practiced the first step in excreta disposal is to provide designated defecation sites and clear existing scattered faeces. This is an unpleasant task and in some cultures it may be especially difficult to find willing and suitable personnel, but it is essential to minimise the spread of faecal-oral disease. Faeces can be covered with lime and should be removed to a safe disposal site such as a pit. Workers must be provided with appropriate tools and protective clothing.

6.4.2 Controlled open field defecation

In the initial stages of an emergency, areas where people **can** defecate, rather than where they cannot, should be provided immediately. These should be located where excreta cannot contaminate the food chain or water sources. Open areas or fields surrounded by screening may be set up (Figure 6.2), with segregated sites for each sex. People should be encouraged to use one strip of land at a time and used areas must be clearly marked. It is also possible to use internal partitions to provide more privacy and encourage greater use.

It is essential that defecation areas are:

- far from water storage and treatment facilities;
- at least 50m from water sources;
- downhill of settlements and water sources;
- far from public buildings or roads;
- not in field crops grown for human consumption; and
- far from food storage or preparation areas.

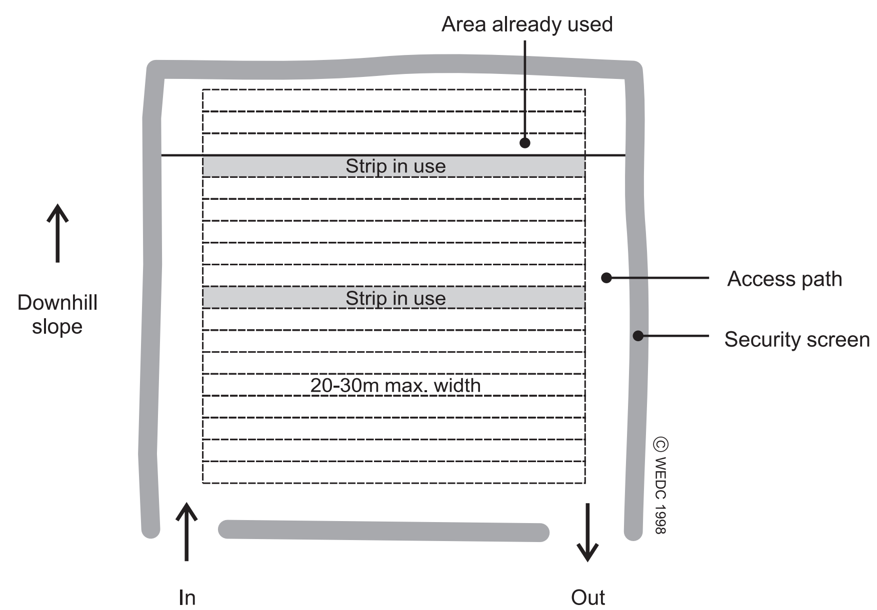


Figure 6.2. Open defecation field

Advantages: It is rapid to implement; minimal resources are required; and it minimises indiscriminate open defecation.

Constraints: There is a lack of privacy for users; considerable space is required; it is difficult to manage; ther is potential for cross-contamination of users; and it is better suited to hot dry climates.

6.4.3 Shallow trench latrines

A simple improvement on open defecation fields is to provide shallow trenches in which people can defecate (Figure 6.3). This allows users to cover faeces and improves the overall hygiene and convenience of an open defecation system. Trenches need only be 20-30cm wide and 15cm deep, and shovels may be provided to allow each user to cover their excreta with soil.

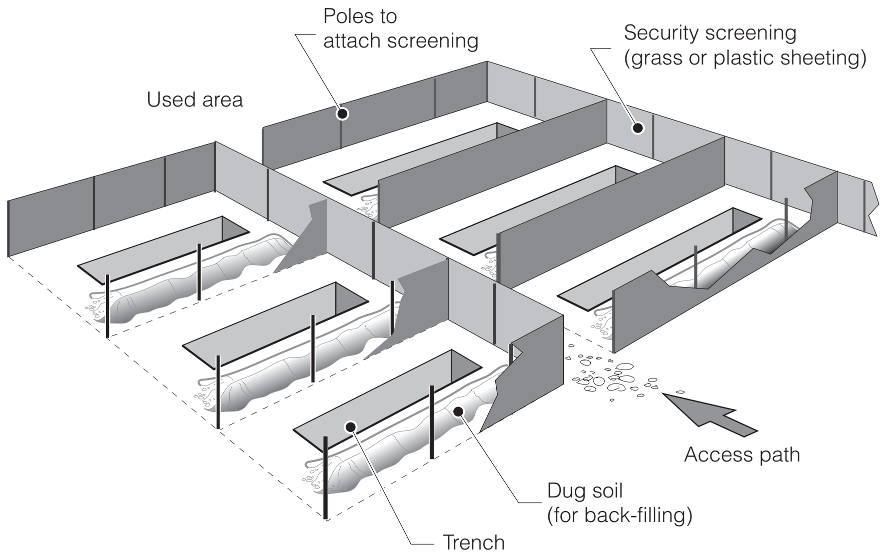


Figure 6.3. Trench defecation field

Advantages: It is rapid to implement (one worker can dig 50m of trench per day); and faeces can be covered easily with soil.

Constraints: There is limited privacy; a short life-span; and considerable space is required.

6.4.4 Deep trench latrines

Deep trench latrines are often constructed in the immediate stage of an emergency and will be appropriate if there are sufficient tools, materials and human resources available (see 6.5.3).

6.4.5 Shallow family latrines

In some situations it may be more appropriate to provide shallow family (rather than trench) latrines. This is particularly suitable where people are keen to build their own latrines or have experience of latrine construction. A shallow pit of approximately 0.3m x 0.5m and 1m deep may be excavated. Wooden foot rests or a latrine slab (approximately 0.8m x 0.6m) can be placed over this, overlapping by at least 15cm on each side. This latrine should be an immediate measure only and back-filling should occur when the pit is full to within 0.2m of the slab. A simple superstructure for privacy can be made from local materials (Figure 6.4).

Advantages: There is increased privacy; it is rapid to implement; reduced labour input is required from agency; and it allows people to actively participate in finding an appropriate solution.

Constraints: The community must be willing and able to construct family latrines; it can be difficult to manage siting and back-filling of pits; and large tools and materials required.

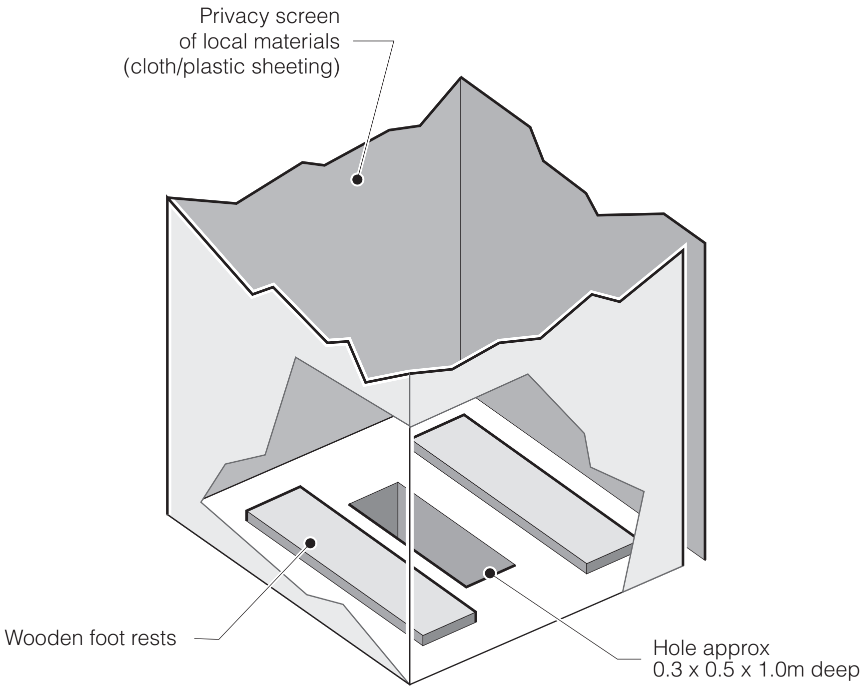


Figure 6.4. Shallow family latrine

6.4.6 Bucket/container latrines

In situations where there is limited space it may be appropriate to provide buckets or containers in which people can defecate. These should have tight-fitting lids and should be emptied at least daily. Disinfectant may be added to reduce contamination risks and odour. Containers can be emptied into a sewerage system, a landfill site or waste-stabilisation ponds. This measure will only be appropriate where there are no other immediate action options and users find the method acceptable, so it is not used in most situations.

Advantages: Defecation containers can be procured easily and transported; once the containers are provided only the final disposal system need be constructed; and they can be used in flooded areas.

Constraints: Many people find the method unacceptable; large quantities of containers and disinfectant are required; extensive education regarding final disposal is required; and containers may be used for alternative purposes.

6.4.7 Storage tank latrines

In some emergency situations, such as in flooded areas or where ground excavation is difficult, large storage tanks can be situated above ground with wooden platforms and a simple superstructure fitted above. Here the user must climb steps to the latrine and the effluent is collected in the tank. This is suitable as an immediate or short-term measure only and the tank is likely to require regular emptying. A suitable emptying mechanism and final disposal site are therefore needed from the onset.

Advantages: Large storage tanks are often available in relief shipments; they are rapid to construct; and they can be used on rocky ground or in flooded areas.

Constraints: Regular emptying is required; a large number of tanks may be needed which could be used for other purposes; and appropriate materials must be available to build steps and simple superstructures.

6.4.8 Packet latrines

In some emergency situations relief agencies have provided disposable packet latrines. These are plastic packets (similar in appearance to a plastic bag) in which the user can defecate. The packets contain a blend of enzymes which assists the breakdown of the excreta and must be disposed of in a safe place.

Advantages: Packets are lightweight and easy to transport; and may be used where space is severely limited or in flooded areas.

Constraints: The method may not be acceptable to affected population; and final disposal site must be clearly marked, accessible and used.

6.4.9 Chemical toilets

Chemical toilets are commonly used on a temporary basis in developed countries. These are normally single prefabricated plastic units incorporating a sit-down toilet, lockable door and effluent tank containing chemicals to aid digestion and reduce odour. They have been used in emergency situations such as the Kosova refugee crisis in 1999. In general, however, they are an expensive and unsustainable solution.

Advantages: They are hygienic; and odour is minimised.

Constraints: They are high cost; difficult to transport; and require regular emptying.

6.4.10 Repair or upgrading of existing facilities

In some emergency situations the affected community may remain or be displaced in sites where there are existing sanitation facilities. These facilities may have been damaged, however, or may be inappropriate for the changed circumstances. In such cases the repair or upgrading of these facilities is likely to be the most appropriate intervention measure, but it will depend on how quickly this can be implemented as to whether this may be an appropriate immediate measure.

Advantages: The basic infrastructure is in place to build on; and indigenous technology and materials are used.

Constraints: There are limited expansion possibilities; and repair and upgrading may take time.

6.5 Technology choice: Longer term intervention

Once it has been decided whether communal or family facilities should be provided, and what the design life of these should be, the choice of technology must be made. The selection criteria outlined in Section 6.2 should be used to make this decision.

6.5.1 Open defecation

In some emergency situations it may be perfectly acceptable for the affected population to practice open defecation. Indeed, in some cultures defecating inside a latrine superstructure is unacceptable. Where people are accustomed to open defecation it may be appropriate to continue this, providing there is adequate space and vegetation to allow people to find an appropriate defecation space so that the risk of disease transmission is minimised. Such situations can be assessed in terms of excreta disposal space rather than facilities.

Advantages: There is no cost; and no construction activities are required.
Constraints: Practice is unsuitable where people are living in overcrowded conditions; large space is needed; and this is only acceptable if the population is already accustomed to such practice.

6.5.2 Simple pit latrines

Pit latrines are by far the most common technology choice adopted in emergency scenarios. This is because they are simple, quick to construct and generally inexpensive. Figure 6.5 shows a typical simple pit latrine.

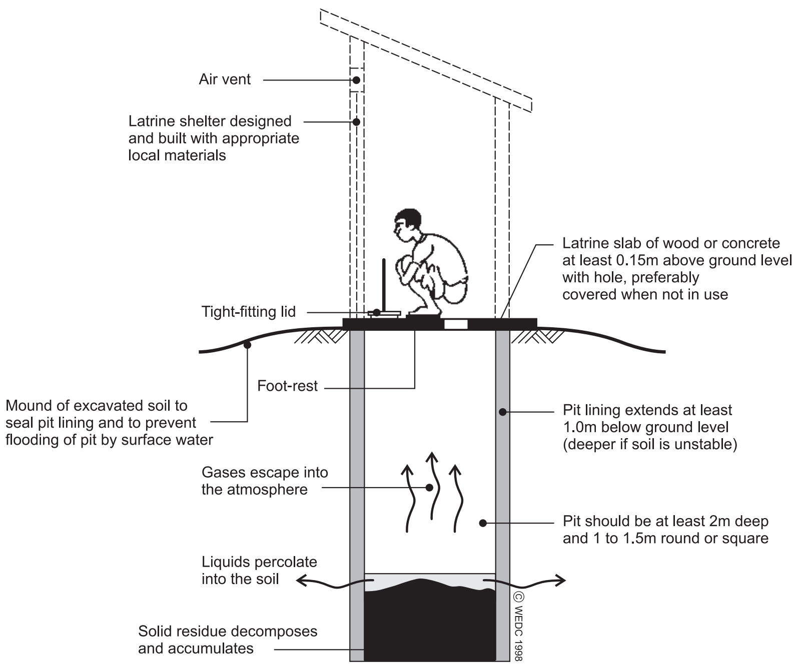


Figure 6.5. Simple pit latrine

The pit should be 2m or more in depth and covered by a latrine slab. The slab should be firmly supported on all sides and raised above the surrounding ground level to prevent surface water entering the pit. If the soil is unstable, the pit should be lined to prevent collapse (see 6.8.7). A squat or drophole is provided in the slab which allows excreta to fall directly into the pit. This can be covered with a removable lid to minimise flies and odour.

The superstructure can be made from materials available locally, such as wood, mud and grass, or can be a more permanent structure of bricks and mortar. The rate at which pits fill will depend on the sludge accumulation rate and the infiltration rate of the soil. Design and construction details can be found in Section 6.8.

Advantages: They are cheap; quick to construct; operate without water; and easily understood.

Constraints: They are unsuitable where the water table is high, soil is too unstable to dig or ground is very rocky; and often have odour problems.

6.5.3 Deep trench latrines

If communal latrines are to be constructed, a common option is the construction of deep trench latrines (Figure 6.6). These operate on exactly the same principle as the simple pit latrine but involve the siting of several cubicles above a single trench. Care should be taken to not put too many latrines side by side. The recommended maximum length of trench is 6m, providing six cubicles.

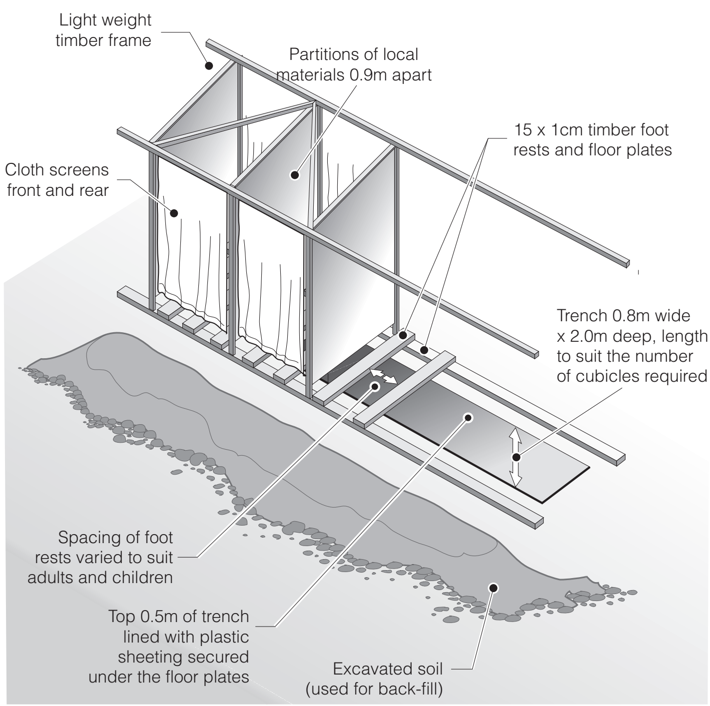


Figure 6.6. Deep trench latrines

Trenches should be about 0.8m wide and at least the top 0.5m of the pit should be lined. Wooden platforms can be used above the trench and covered with plastic sheeting and soil. Simple wooden footrests may be used beside each drophole in the immediate stage, to be replaced with plastic or concrete latrine slabs later.

Advantages: The same advantages as simple pit latrine.

Constraints: The same constraints as simple pit latrine; and cleaning and maintenance of communal trench latrines are often poorly carried out by users.

Simple trench latrines, Bangladesh

6.5.4 VIP latrines

The Ventilated Improved Pit (VIP) latrine (Figure 6.7) is an improved pit latrine designed to minimise odour and flies. A vent pipe is incorporated into the design to remove odourous gases from the pit. This should ideally be situated outside the latrine interior, should extend at least 50cm above the latrine superstructure, and should be painted black to increase solar heating of the air in the vent pipe, causing it to rise (see 6.8.7 for more details). Air should be able to flow freely through the squat hole and vent pipe, therefore no drophole cover is required.

The open end of the pipe is covered with a gauze mesh or fly-proof netting which is designed to prevent flies entering the pit and to trap any flies trying to leave.

The superstructure interior should be kept reasonably dark to deter flies, but there should be a gap, usually above the door, to allow air to enter. This gap should be at least three times the cross-sectional area of the vent pipe (Franceys et al., 1992). Air flow can be increased by facing the door of the superstructure towards the prevailing wind. Each drophole should have its own compartment and there should always be **one vent pipe per compartment.**

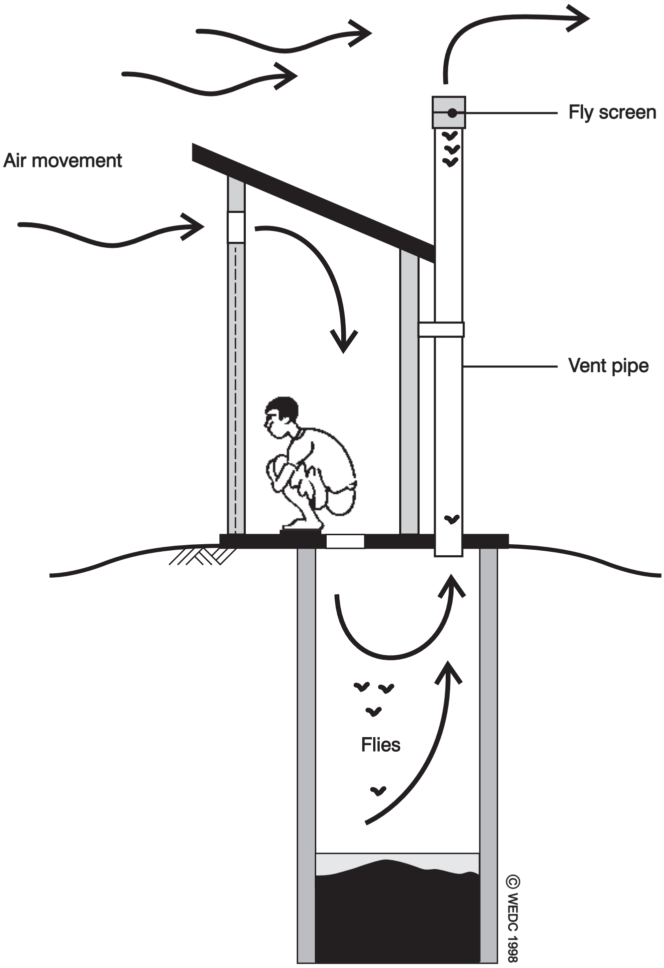


Figure 6.7. Ventilated improved pit latrine

Advantages: Odour and flies are reduced; and a good quality long-term solution.

Constraints: VIPs are difficult and expensive to construct properly; design and operation are often not fully understood; construction may take time; dark interior may deter young children from using the latrine; design does not deter mosquitoes; and there is an increased odour outside.

6.5.5 Pour-flush latrines

Pour-flush latrines rely on water to act as a hygienic seal and to help remove excreta to a wet or dry disposal system. The most simple pour-flush latrines use a latrine pan incorporating a shallow U-bend which retains the water (Figure 6.8). After defecation, a few litres of water must be poured, or thrown, into the bowl in order to flush the excreta into the pit or sewerage system below.

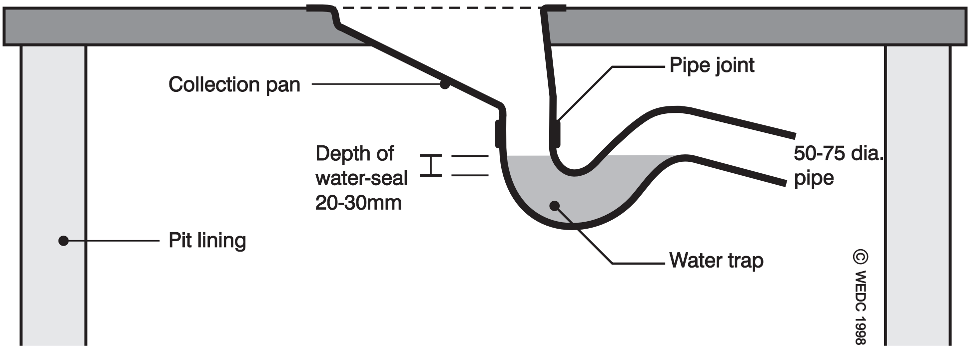


Figure 6.8. Cross-section of typical water-seal pan

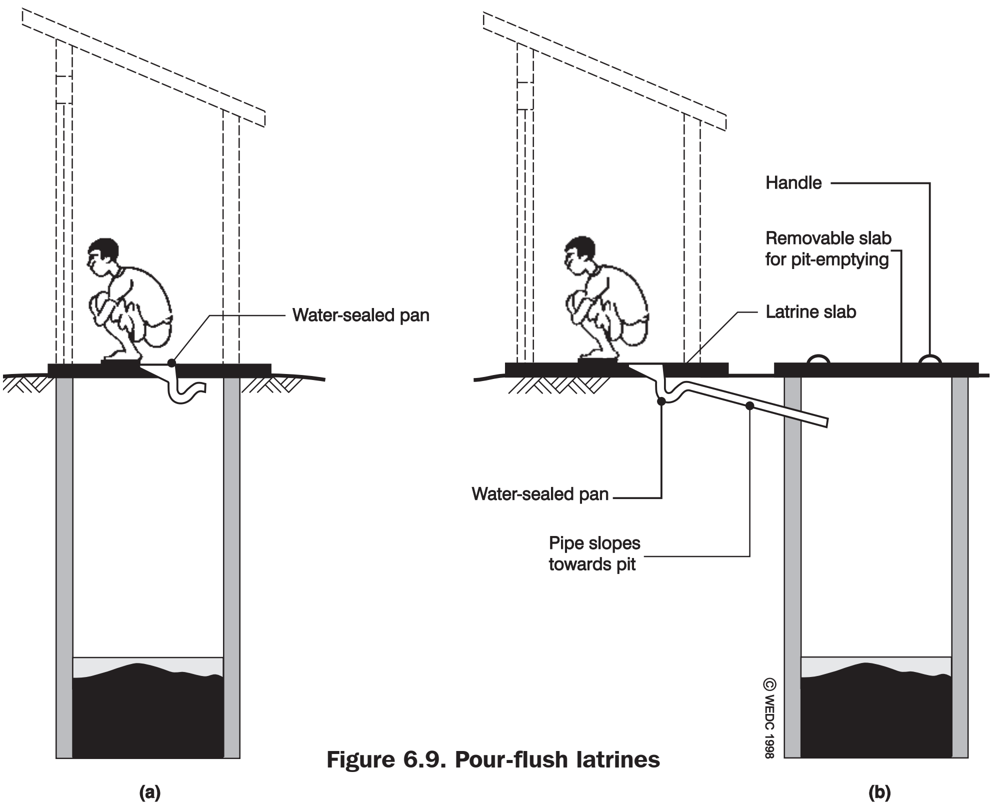


Figure 6.9. Pour-flush latrines

Pour-flush latrines may be constructed directly above a pit or may be offset, whereby the waste travels through a discharge pipe to a pit or septic tank (Figure 6.9).

Advantages: There is a lack of odour, ideal where water is used for anal cleansing; and they are easy to clean.

Constraints: An increased quantity of water required; solid anal cleansing materials may cause blockages; and they are more expensive than simple pit latrines.

6.5.6 Over-hung latrines

An over-hung latrine consists of a superstructure and floor built over water (Figure 6.10). A squat hole in the floor allows excreta to fall directly, or via a chute, into the water below. Over-hung latrines are rarely appropriate and should only be considered if other options are not possible, such as in areas prone to continued flooding. The receiving water must be sufficiently deep throughout the year, preferably should be saline to prevent human consumption, and should be flowing away from settlements.

Advantages: May be the only option in flooded areas.

Constraints: Can only be used where the contamination of the watercourse will have no adverse effect downstream; cannot be used over still water or where water is used for recreation, washing etc.; and superstructure must be solidly constructed and safe for users.

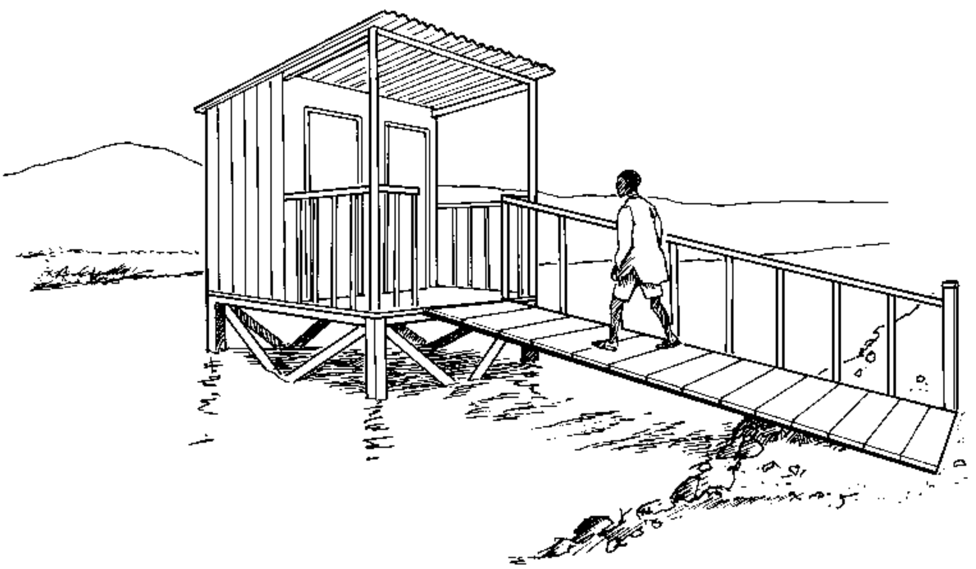


Figure 6.10. Over-hung latrine

Overhung latrine, Bangladesh

6.5.7 Borehole latrines

A borehole drilled by machine or hand-powered auger can be used as a latrine (Figure 6.11). This has a typical diameter of 400mm and a depth of 4-8m. At least the top 0.5 m should be lined although it is rarely necessary or appropriate to line the entire depth.

Borehole latrines are most appropriate in situations where boring/drilling equipment is readily available, where a large number of latrines must be constructed rapidly, and where pits are difficult to excavate, either due to ground conditions or lack of a suitable labour force.

Advantages: The borehole can be excavated quickly if boring equipment is available; suitable in hard ground conditions (where there are no large stones or rocks); and appropriate where only a small workforce is available.

Constraints: Drilling equipment is required; there is a greater risk of groundwater pollution; life span is short; sides are liable to be fouled, attracting flies; and there is a high likelihood of blockages.

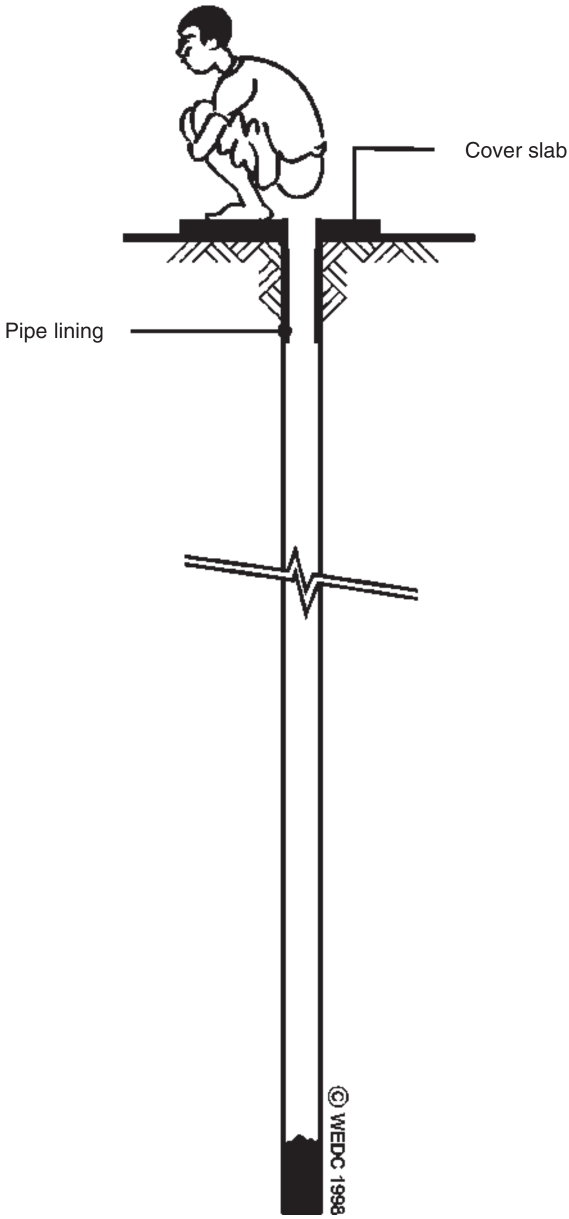


Figure 6.11. Borehole latrine

Drilling boreholes for latrines, Bangladesh

Borehole latrines nearing completion, Bangladesh

6.5.8 Sewerage systems

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

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

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

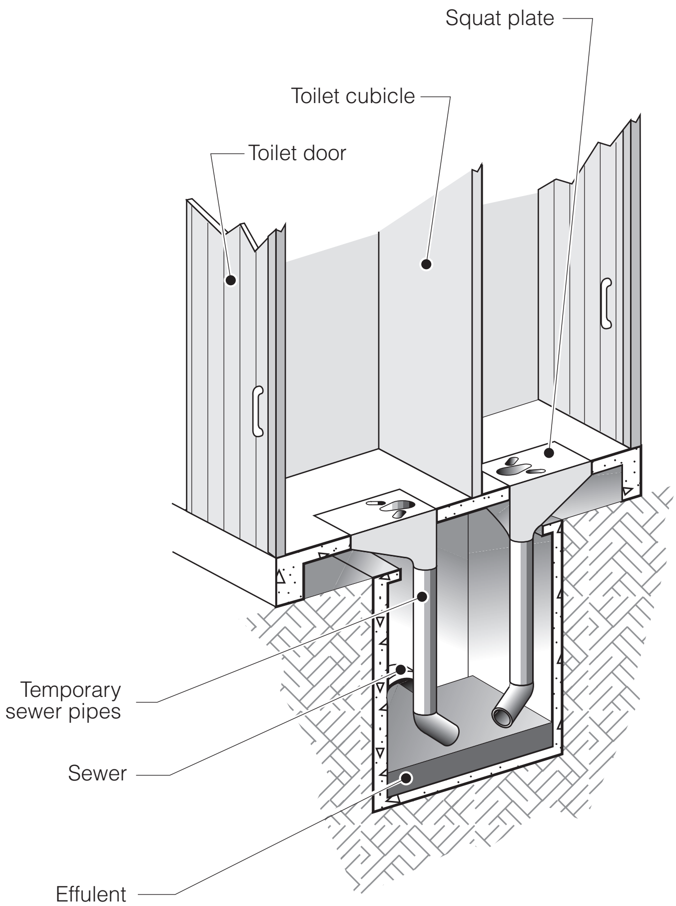


Figure 6.12. Temporary toilet block over existing sewer

6.6 Strategies for difficult conditions

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

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

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

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

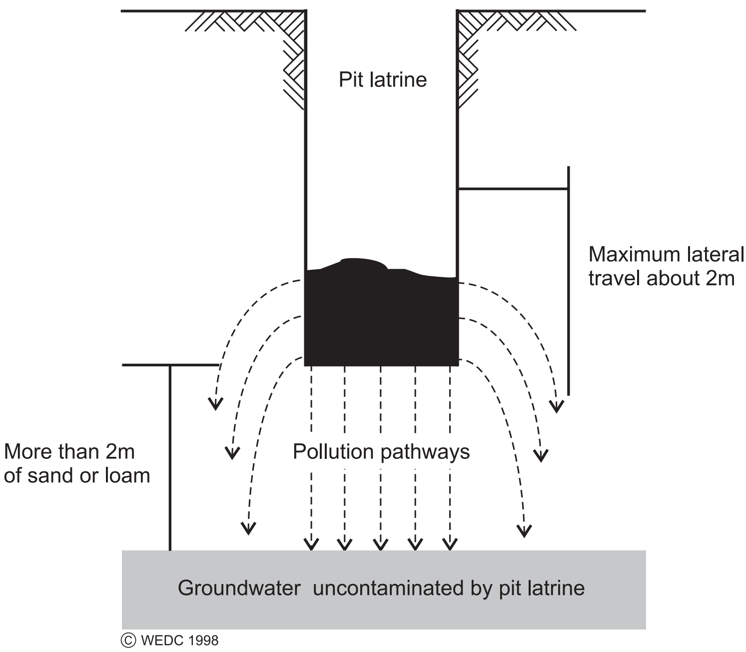


Figure 6.13. Pollution from a pit latrine above the water table

Raised VIP latrines, Tanzania

6.6.1 Raised pit latrines

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

6.6.2 Twin pit latrines

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

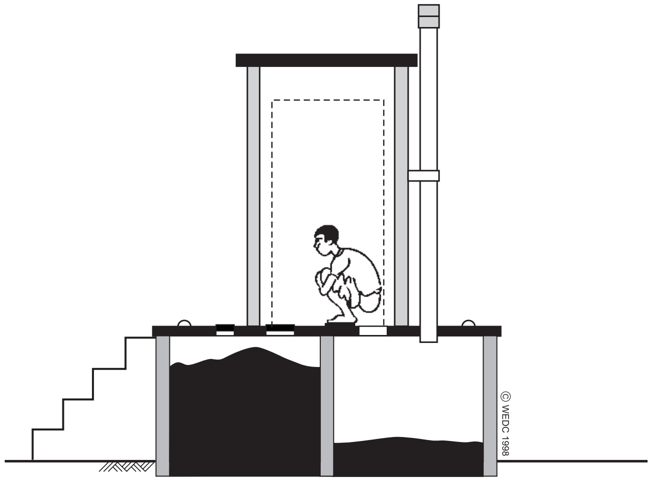


Figure 6.14. Raised twin-pit ventilated latrine

6.6.3 Sand-enveloped pit latrines

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

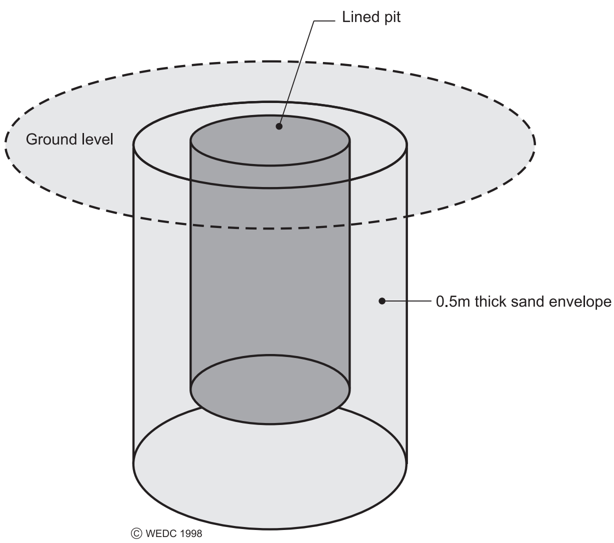


Figure 6.15. Sand-enveloped pit

6.6.4 Sealed pits/tanks

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

6.6.5 Anaerobic composting latrines

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

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

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

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

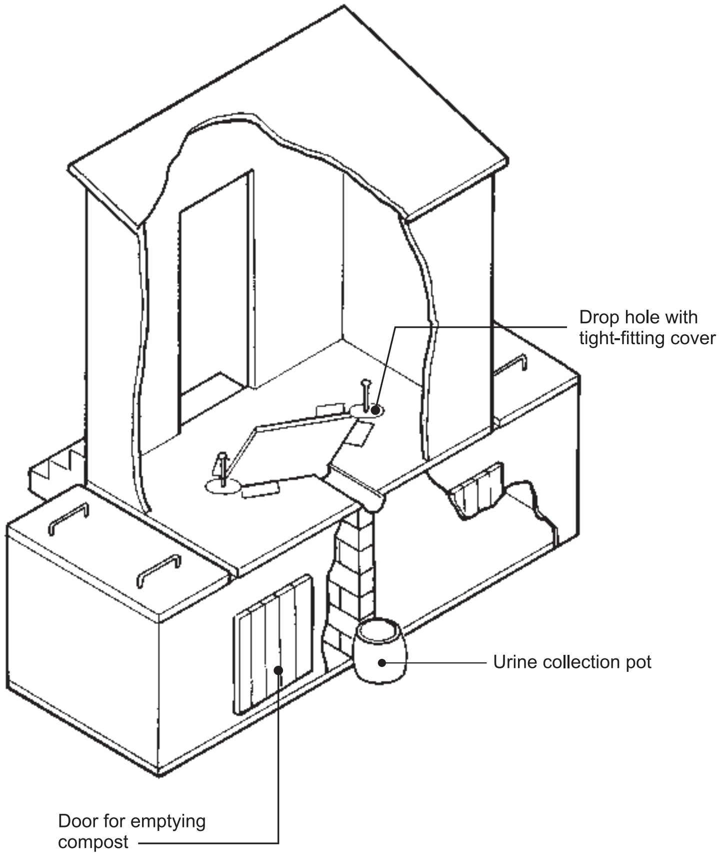


Figure 6.16. Double-vault composting latrine

6.6.6 Aerobic composting latrines

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

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

6.6.7 Septic tanks

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

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

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

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

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

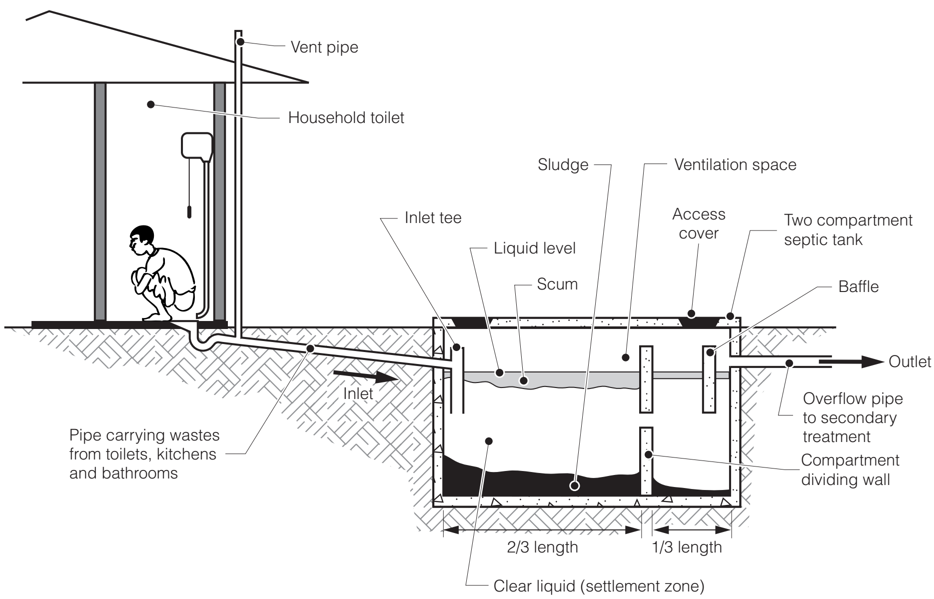


Figure 6.17. Wastewater treatment using a septic tank

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

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

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

6.6.8 Aqua privies

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

Communal aqua privy, Bangladesh

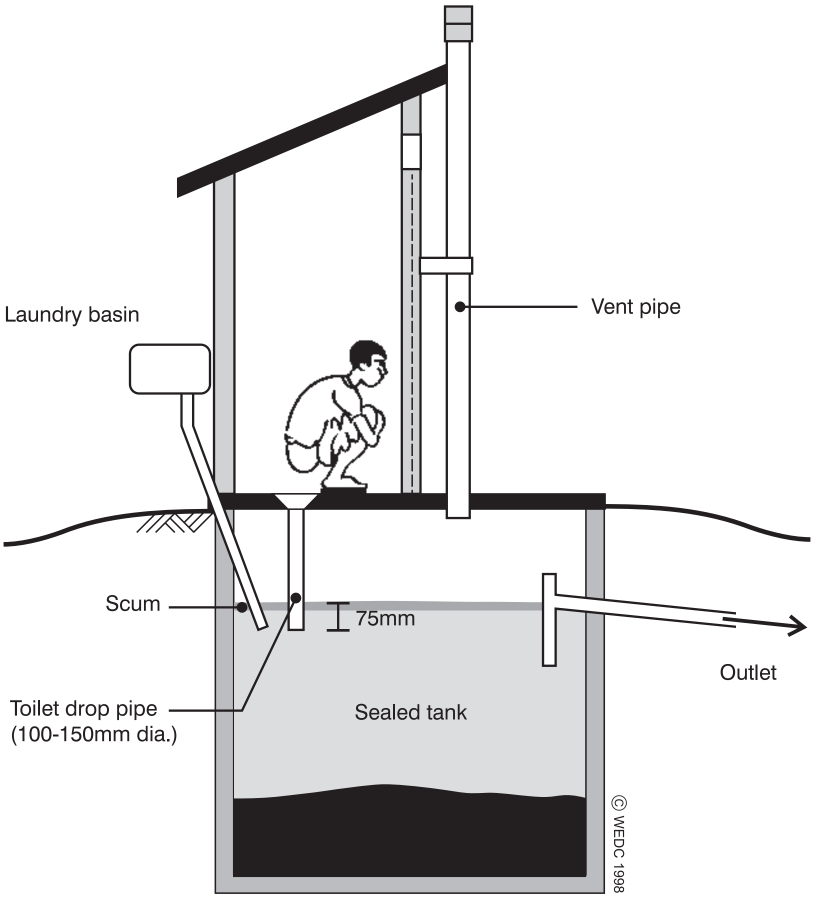


Figure 6.18. Aqua privy

6.6.9 Sewerage systems

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

6.7 Intervention levels

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

<table>
<tr><th colspan="5">Table 6.2. Recommended interventions for space of more than $30m^{2}$* per person</th></tr>
<tr><th>Scenarios and recommended interventions</th><th>The affected population go through a transit camp immediately after a disaster</th><th>The affected population remain in a temporary location for up to six months</th><th>The affected population stay in the affected area immediately after a disaster</th><th>The affected population move to a new area and are likely to remain for more than a year</th></tr>
<tr><td>Immediate action</td><td colspan="4">■ Clearing of scattered faeces
■ Controlled open defecation
■ Shallow trench latrines
■ Repair of existing facilities
■ Temporary communal or family latrines</td></tr>
<tr><td>Short-term measure</td><td colspan="2">■ Semi-permanent family latrines
■ Semi-permanent shared latrines</td><td colspan="2"></td></tr>
<tr><td>Long-term measure</td><td colspan="2"></td><td colspan="2">■ Permanent family latrines
■ Upgrading of existing facilities</td></tr>
</table>

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

Table 6.3. Recommended interventions for space of 20-30m² per person

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

Table 6.4. Recommended interventions for space of less than 20m² per person

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

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

6.8 Design and construction

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

- Safety
- Comfort
- Privacy
- Health

6.8.1 Siting latrines

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

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

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

6.8.2 Construction materials and tools

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

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

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

6.8.3 Superstructure design

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

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

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

6.8.4 Latrine slabs

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

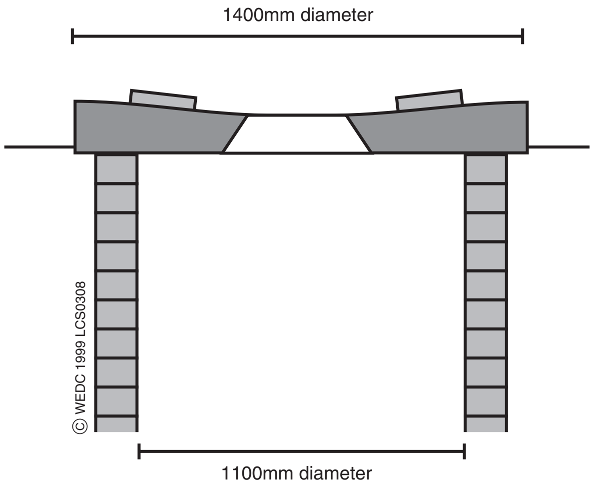


Figure 6.19. Cross-section of latrine slab with footrests

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

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

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

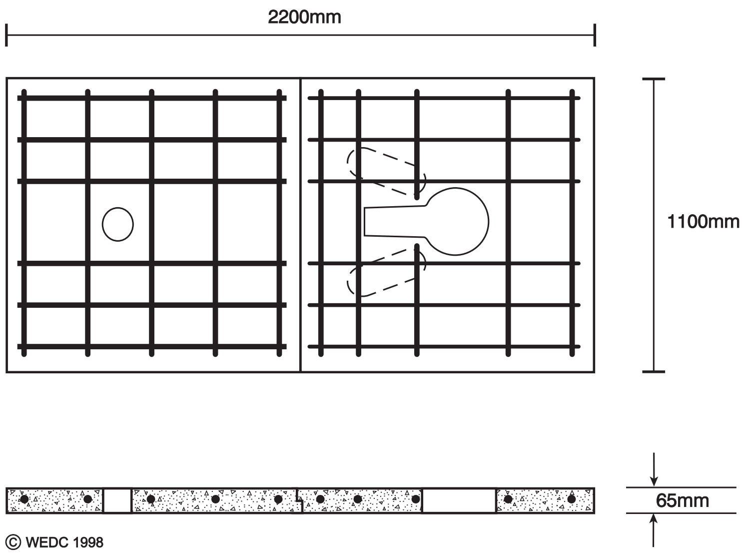


Figure 6.20. Reinforced latrine slab

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

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

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

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

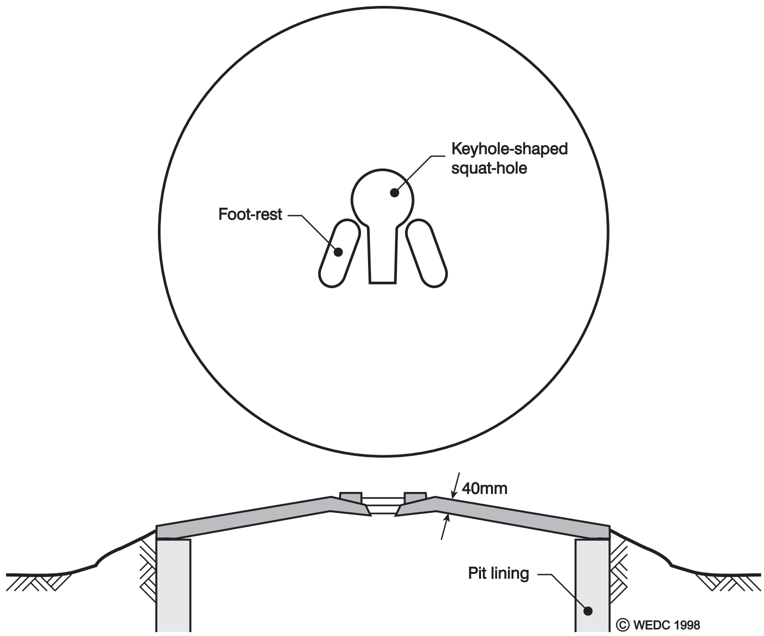


Figure 6.21. Domed latrine slab

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

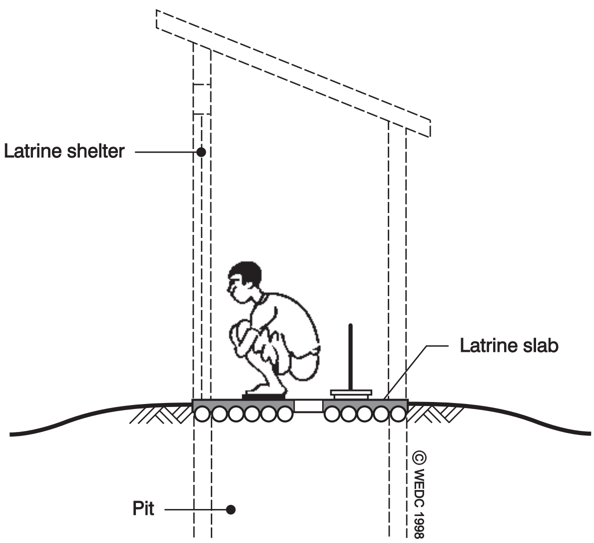


Figure 6.22. Wood and mud latrine slab

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

6.8.5 Making concrete

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

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

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

Water	Cement	
1	2	*or*
1	3	

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

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

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

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

The strength and workability of concrete is affected by the:

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

6.8.6 Squat-hole covers

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

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

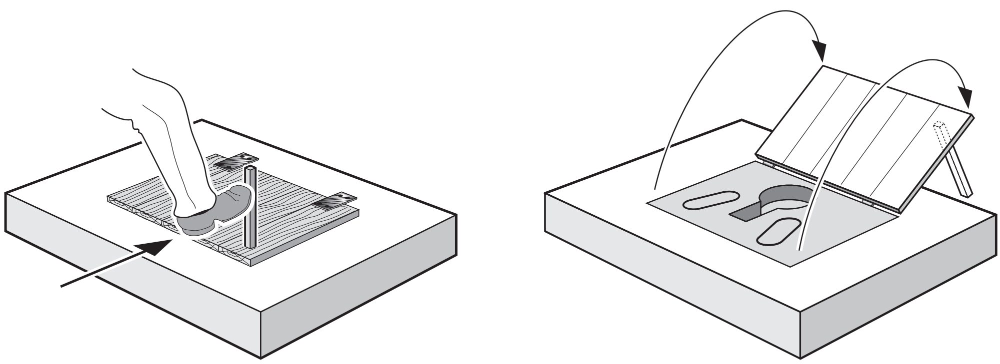


Figure 6.23. Squat-hole cover

6.8.7 Ventilation pipes

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

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

6.8.8 Pit excavation and lining

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

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

In general, the top 0.5m of a pit should always be lined, but the decision as to whether to line the rest of the pit will depend on the type of soil in which the pit is dug. When a pit is first excavated it may appear stable, and it may be impossible to tell whether or not the walls will collapse after some time. One way in which this can be assessed is to examine other excavations (such as hand-dug wells) in the area. If existing excavations have not collapsed and are not lined, then it is fairly safe to assume that pit latrine excavations will not need lining. Where there is doubt it is advisable to line the pit. Table 6.6 suggests the types of soil that, in general, do and do not require lining.

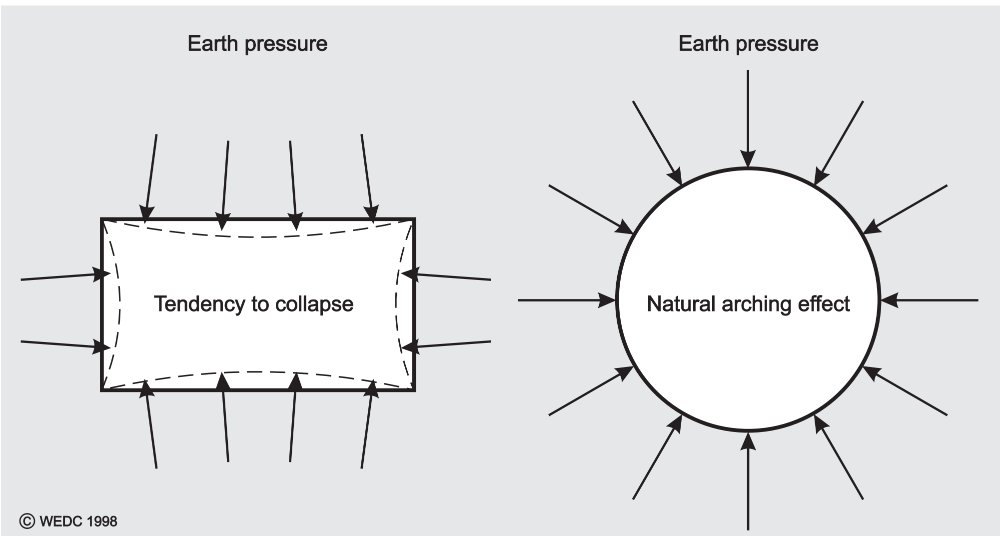


Figure 6.24. Stress concentrations on rectangular and circular pits

Table 6.6. Lining requirements for different soil types

Soils that require lining	***Soils that do not require lining***
Soft sands and gravels Unconsolidated soils Filled land Compressed mudstones and shales	Soils with significant clay content Most consolidated sedimentary rocks Soils with high proportion of iron oxides (laterites)

Failed unlined trench latrines, Sudan

The following are commonly used pit lining materials:

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

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

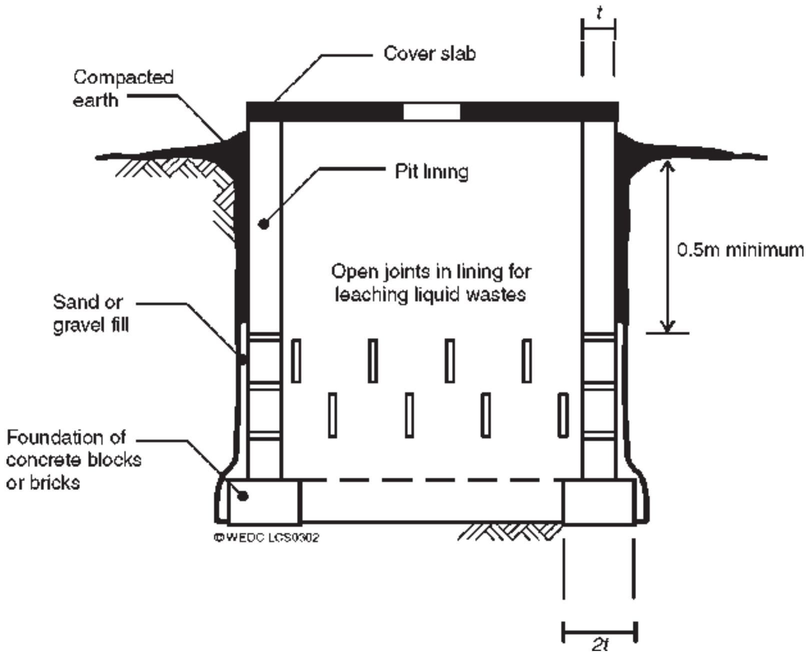


Figure 6.25. Shallow pit with lining

6.8.9 Sizing pits

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

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

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

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

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

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

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

Table 6.7. Suggested maximum sludge accumulation rates[a]

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

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

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

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

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

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

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

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

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

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

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

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

6.8.10 Septic tank design

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

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

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

$$\mathbf{A = Q \times T/24}$$

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

Table 6.8. Recommended septic tank retention times

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

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

$$\mathbf{B = P \times N \times F \times S}$$

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

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

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

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

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

Table 6.9. Value of sludge digestion factor 'F'

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

6.9 Emptying pits

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

6.9.1 Mechanical pumps

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

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

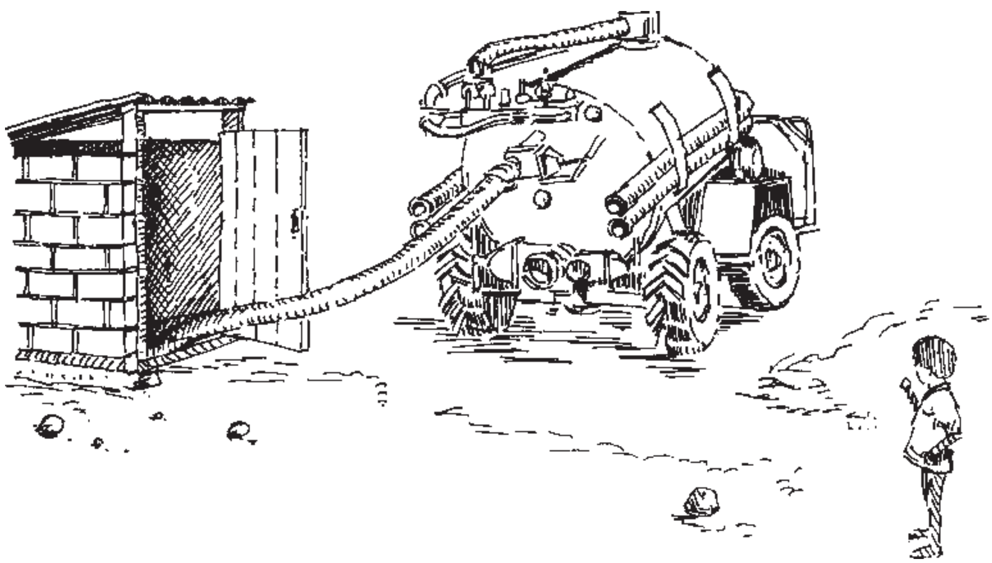


Figure 6.26. Vacuum tanker emptying latrine pit

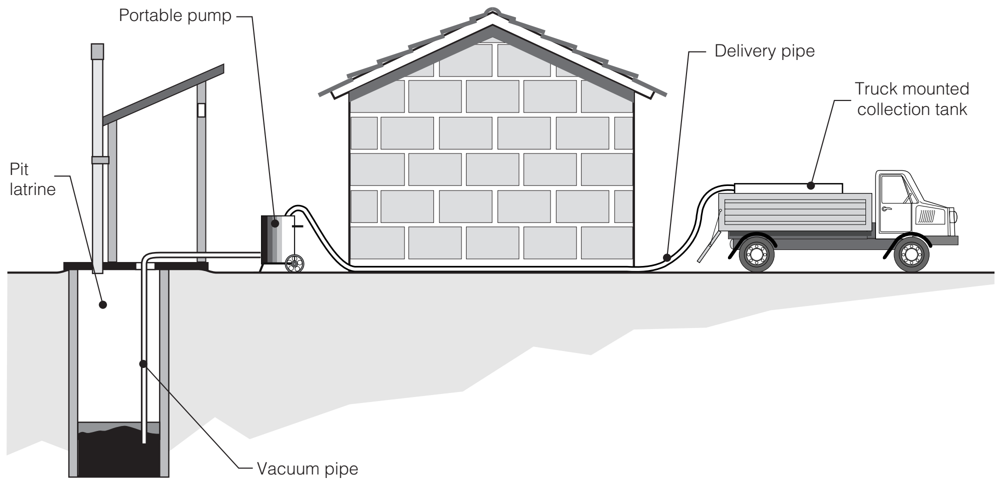


Figure 6.27. Vacuum tanker with remote pumping unit

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

6.9.2 Hand-operated pumps

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

6.9.3 Manual emptying

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

6.9.4 Sludge reduction

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

6.9.5 Sludge disposal

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

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

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Greenhouse Effect

The greenhouse effect is a natural phenomenon crucial for sustaining life on Earth. It involves the trapping of heat in the Earth's atmosphere by greenhouse gases, such as carbon dioxide (CO_2), methane (CH_4), water vapor, nitrous oxide (N_2O), and others. These gases allow sunlight to enter the atmosphere, but they trap some of the outgoing infrared radiation, preventing it from escaping into space. While this natural greenhouse effect maintains a habitable temperature range on Earth, human activities have significantly intensified it, leading to what is commonly referred to as the enhanced greenhouse effect.

Causes of the Greenhouse Effect:

1. **Burning of Fossil Fuels:** The combustion of fossil fuels, including coal, oil, and natural gas, releases large amounts of CO_2 into the atmosphere, contributing to the enhanced greenhouse effect.
2. **Deforestation:** The clearing of forests reduces the number of trees available to absorb CO_2 through photosynthesis, disrupting the natural carbon balance.
3. **Industrial Activities:** Certain industrial processes release potent greenhouse gases such as methane and nitrous oxide, contributing to the overall warming of the planet.
4. **Agricultural Practices:** Livestock farming, rice cultivation, and the use of certain fertilizers release methane and nitrous oxide, adding to the greenhouse gas concentration.

Common Greenhouse Gases:

Greenhouse gases (GHGs) are gases in Earth's atmosphere that contribute to the greenhouse effect by trapping heat. While there are several greenhouse gases, some are more prevalent and influential than others. Here are some common greenhouse gases:

1. **Carbon Dioxide (CO2):**
    - **Source:** Mainly comes from the burning of fossil fuels (coal, oil, and natural gas), deforestation, and certain industrial processes.
    - **Impact:** CO2 is the primary greenhouse gas responsible for human-induced climate change. It has a long atmospheric lifetime and contributes significantly to global warming.
2. **Methane (CH4):**
    - **Source:** Produced during the decay of organic waste in landfills, livestock digestion, rice cultivation, and fossil fuel extraction.
    - **Impact:** Methane is more effective at trapping heat than CO2, although it stays in the atmosphere for a shorter time. It plays a substantial role in short-term climate change and contributes to warming.
3. **Nitrous Oxide (N2O):**
    - **Source:** Emitted from agricultural and industrial activities, as well as during the combustion of fossil fuels and solid waste.
    - **Impact:** Nitrous oxide has a higher warming potential than CO2 and contributes to both global warming and stratospheric ozone depletion.
4. **Water Vapor (H2O):**
    - **Source:** Naturally present in the atmosphere. Its concentration is influenced by temperature and human activities.
    - **Impact:** While water vapor is a natural greenhouse gas, human activities primarily influence other greenhouse gases. The role of water vapor in climate change is more indirect and complex.
5. **Chlorofluorocarbons (CFCs):**

- **Source:** Historically used in refrigeration, air conditioning, and aerosol propellants. Production has decreased due to international agreements like the Montreal Protocol.
- **Impact:** Although CFCs are potent greenhouse gases, their atmospheric concentrations have decreased significantly due to international efforts. They also contribute to ozone depletion.

6. **Ozone (O_3):**
    - **Source:** Present in the Earth's stratosphere and troposphere. Ozone in the troposphere is a component of smog and is a greenhouse gas.
    - **Impact:** Ozone in the troposphere contributes to warming, while stratospheric ozone protects life on Earth by absorbing harmful ultraviolet (UV) radiation.

It's important to note that the different greenhouse gases have varying atmospheric lifetimes and warming potentials. Some, like methane and nitrous oxide, are more potent on a per-molecule basis but have shorter atmospheric lifetimes compared to CO_2. Addressing these gases requires a comprehensive approach to reduce emissions and enhance overall environmental sustainability.

Impact of the Greenhouse Effect:

1. **Global Warming:** The Earth's average temperature is rising, leading to climate change characterized by shifts in weather patterns, altered precipitation, and more frequent and severe extreme events.
2. **Melting Ice Caps and Glaciers:** Rising temperatures contribute to the melting of polar ice caps and glaciers, leading to rising sea levels and threatening coastal areas.
3. **Ocean Acidification:** Increased CO_2 levels are absorbed by the oceans, leading to acidification that harms marine life, particularly organisms with calcium carbonate shells.
4. **Changes in Ecosystems:** The warming climate disrupts ecosystems, affecting the distribution and behavior of plant and animal species, potentially leading to species loss.

5. **Extreme Weather Events:** The frequency and intensity of extreme weather events, such as hurricanes, droughts, and heatwaves, are on the rise.

Remedial Measures:

1. **Transition to Renewable Energy:** Shift from fossil fuels to renewable energy sources such as solar, wind, and hydropower to reduce CO2 emissions.
2. **Energy Efficiency:** Improve energy efficiency in industries, transportation, and buildings to decrease overall energy consumption and emissions.
3. **Afforestation and Reforestation:** Planting trees and restoring forests helps absorb CO2 from the atmosphere, acting as a natural carbon sink.
4. **Sustainable Agriculture:** Adopt sustainable agricultural practices to reduce methane emissions and minimize the environmental impact of farming.
5. **International Cooperation:** Engage in global efforts and agreements, such as the Paris Agreement, to collectively address climate change and set emission reduction targets.
6. **Technological Innovation:** Invest in and deploy technologies that capture and store carbon emissions, contributing to overall greenhouse gas reduction.
7. **Public Awareness and Education:** Increase public awareness about the impact of human activities on the climate and promote sustainable practices at individual and community levels.

Addressing the greenhouse effect and mitigating its consequences require concerted efforts at the individual, community, national, and global levels. By implementing these remedial measures, humanity can work towards a more sustainable and resilient future.

Solid waste management

Solid waste refers here to all non-liquid wastes. In general this does not include excreta, although sometimes nappies and the faeces of young children may be mixed with solid waste. Solid waste can create significant health problems and a very unpleasant living environment if not disposed of safely and appropriately. If not correctly disposed of, waste may provide breeding sites for insect-vectors, pests, snakes and vermin (rats) that increase the likelihood of disease transmission. It may also pollute water sources and the environment.

7.1 Associated risks

7.1.1 Disease transmission

Decomposing organic waste attracts animals, vermin and flies. Flies may play a major role in the transmission of faecal-oral diseases, particularly where domestic waste contains faeces (often those of children). Rodents may increase the transmission of diseases such as leptospirosis and salmonella, and attract snakes to waste heaps.

Solid waste may also provide breeding sites for mosquitoes. Mosquitoes of the *Aedes* genus lay eggs in water stored in discarded items such as tins and drums; these are responsible for the spread of dengue and yellow fevers. Such conditions may also attract mosquitoes of the *Anopheles* genus, which transmit malaria. Mosquitoes of the *Culex* genus breed in stagnant water with high organic content and transmit microfilariases (Médecins Sans Frontières, 1994), appropriate conditions are likely to arise where leachate from waste enters pooling water.

In times of famine or food scarcity, members of the affected population may be attracted to waste heaps to scavenge for food; this is likely to increase the risk of gastro-enteritis, dysentery and other illnesses.

7.1.2 Pollution

Poor management of the collection and disposal of solid waste may lead to leachate pollution of surface water or groundwater. This may cause significant problems if the waste contains toxic substances, or if nearby water sources are used for water supplies.

Where large quantities of dry waste are stored in hot climates this may create a fire hazard. Related hazards include smoke pollution and fire threat to buildings and people.

7.1.3 Effect on morale

The effect of living in an unhygienic and untidy environment may lead people to become demoralised and less motivated to improve conditions around them. Waste attracts more waste and leads to less hygienic behaviour in general.

7.2 Sources and types of solid waste

7.2.1 Sources of solid waste

In most emergency situations the main sources of solid waste are:

- Medical centres
- Food stores
- Feeding centres
- Food distribution points
- Slaughter areas
- Warehouses
- Agency premises
- Markets
- Domestic areas

Appropriate solid waste management strategies may vary for institutional, communal and domestic sources, depending on types and volumes of waste. Waste from medical centres poses specific health hazards and for this reason is considered separately in Chapter 8.

7.2.2 Type and quantity of waste

The type and quantity of waste generated in emergency situations varies greatly. The main factors affecting these are:

- the geographical region (developed or less-developed country or region);
- socio-cultural practices and material levels among affected population;
- seasonal variations (affecting types of food available);
- the stage of emergency (volume and composition of waste may change over time); and
- the packaging of food rations.

In general, the volume of waste generated is likely to be small and largely degradable where the population is of rural origin and the food rations supplied are unpackaged dry foodstuffs. Displaced urban populations are more likely to generate larger volumes of non-degradable waste, especially where packaged food rations are provided.

Guideline values suggest that each person is likely to produce 0.5-1.0 litres of refuse per day with an organic content of 25 to 35 per cent and a moisture content between 10 and 60 per cent (Adams, 1999). However, this is likely to vary greatly and estimates should be made locally.

Different categories of solid waste include:

Organic waste:	Waste from preparation of food, market places, etc.
Combustibles:	Paper, wood, dried leaves, packaging for relief items, etc. (high organic and low moisture content)
Non-combustibles:	Metal, tin cans, bottles, stones, etc.
Ashes/dust:	Residue from fires used for cooking
Bulky waste:	Tree branches, tyres, etc.
Dead animals:	Carcasses of domestic animals and livestock
Hazardous waste:	Oil, battery acid, medical waste
Construction waste:	Roofing, rubble, broken concrete, etc.

Children and solid waste in a refugee camp, Turkey

Collected market waste, Tanzania

7.3 Initial steps

In order to establish effective solid waste management in the affected area the following process should be used:

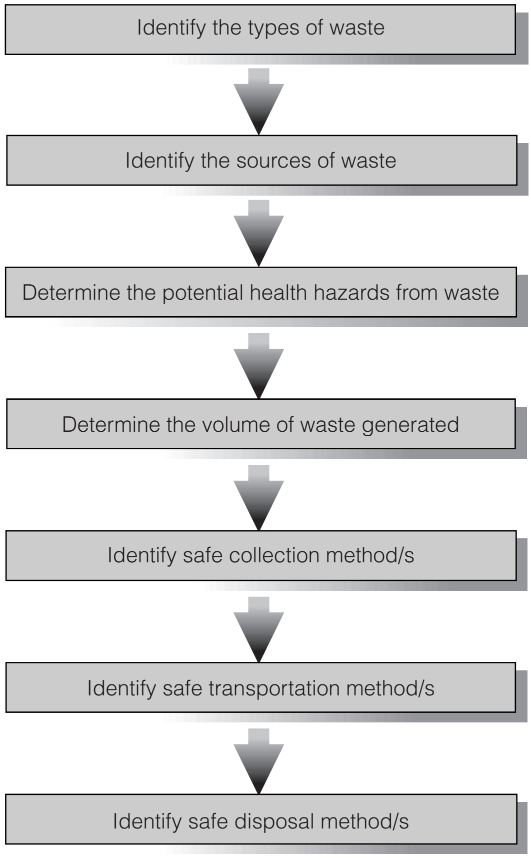

Figure 7.1. Initial steps in solid waste management

7.4 Key components of solid waste management

Solid waste management can be divided into five key components:

- Generation
- Storage
- Collection
- Transportation
- Disposal

7.4.1 Generation

Generation of solid waste is the stage at which materials become valueless to the owner and since they have no use for them and require them no longer, they wish to get rid of them. Items which may be valueless to one individual may not necessarily be valueless to another. For example, waste items such as tins and cans may be highly sought after by young children.

7.4.2 Storage

Storage is a system for keeping materials after they have been discarded and prior to collection and final disposal. Where on-site disposal systems are implemented, such as where people discard items directly into family pits, storage may not be necessary. In emergency situations, especially in the early stages, it is likely that the affected population will discard domestic waste in poorly defined heaps close to dwelling areas. If this is the case, improved disposal or storage facilities should be provided fairly quickly and these should be located where people are able to use them easily. Improved storage facilities include:

- Small containers: household containers, plastic bins, etc.
- Large containers: communal bins, oil drums, etc.
- Shallow pits
- Communal depots: walled or fenced-in areas

In determining the size, quantity and distribution of storage facilities the number of users, type of waste and maximum walking distance must be considered. The frequency of emptying must also be determined, and it should be ensured that all facilities are reasonably safe from theft or vandalism.

7.4.3 Collection

Collection simply refers to how waste is collected for transportation to the final disposal site. Any collection system should be carefully planned to ensure that storage facilities do not become overloaded. Collection intervals and volumes of collected waste must be estimated carefully.

7.4.4 Transportation

This is the stage when solid waste is transported to the final disposal site (see 7.6 for more details). There are various modes of transport which may be adopted and the chosen method depends upon local availability and the volume of waste to be transported. Types of transportation can be divided into three categories:

- Human-powered: open hand-cart, hand-cart with bins, wheelbarrow, tricycle
- Animal-powered: donkey-drawn cart
- Motorised: tractor and trailer, standard truck, tipper-truck

7.4.5 Disposal

The final stage of solid waste management is safe disposal where associated risks are minimised. There are four main methods for the disposal of solid waste:

- Land application: burial or landfilling
- Composting
- Burning or incineration
- Recycling (resource recovery)

The most common of these is undoubtedly land application, although all four are commonly applied in emergency situations. Details of disposal on-site and off-site can be found in Sections 7.5 and 7.7 respectively.

7.5 On-site disposal options

The technology choices outlined below are general guidelines for disposal and storage of waste on-site, these may be adapted for the particular site and situation in question.

7.5.1 Communal pit disposal

Perhaps the simplest solid waste management system is where consumers dispose of waste directly into a communal pit. The size of this pit will depend on the number of people it serves. The long-term recommended objective is six cubic metres per fifty people. The pit should be fenced off to prevent small children falling in and should generally not be more than 100m from the dwellings to be served. Ideally, waste should be covered at least weekly with a thin layer of soil to minimise flies and other pests. Figure 7.2 illustrates a simple communal pit.

Advantages: It is rapid to implement; and requires little operation and maintenance.

Constraints: The distance to communal pit may cause indiscriminate disposal; and waste workers required to manage pits.

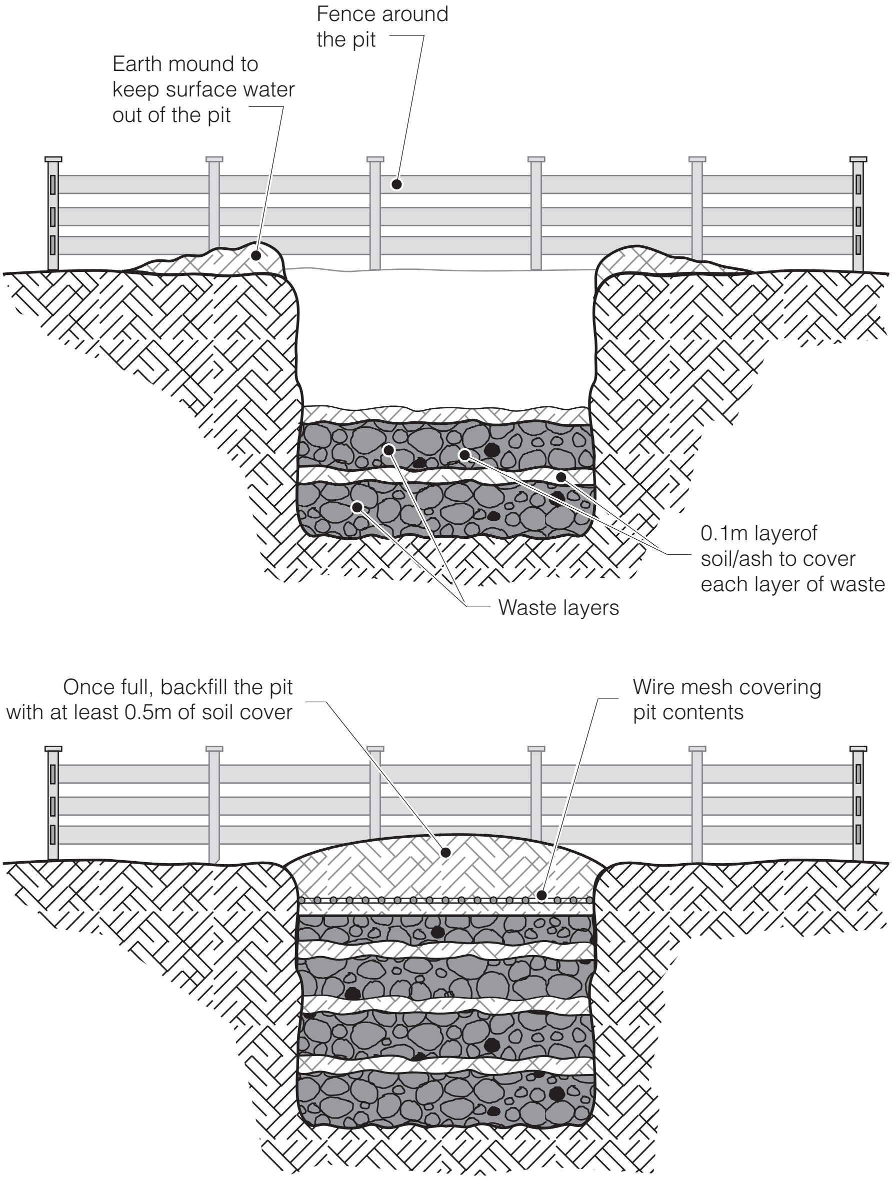

Figure 7.2. Communal solid waste pit

7.5.2 Family pit disposal

Family pits may provide a better long-term option where there is adequate space. These should be fairly shallow (up to 1m deep) and families should be encouraged to regularly cover waste with soil from sweeping or ash from fires used for cooking. This method is best suited where families have large plots and where organic food wastes are the main component of domestic refuse.

Advantages: Families are responsible for managing their own waste; no external waste workers are required; and community mobilisation can be incorporated into hygiene promotion programme.

Constraints: Involves considerable community mobilisation for construction, operation and maintenance of pits; and considerable space is needed.

7.5.3 Communal bins

Communal bins or containers are designed to collect waste where it will not be dispersed by wind or animals, and where it can easily be removed for transportation and disposal. Plastic containers are generally inappropriate since these may be blown over by the wind, can easily be removed and may be desirable for alternative uses. A popular solution is to provide oil drums cut in half (Figure 7.3). The bases of these should be perforated to allow liquid to pass out and to prevent their use for other purposes. A lid and handles can be provided if necessary.

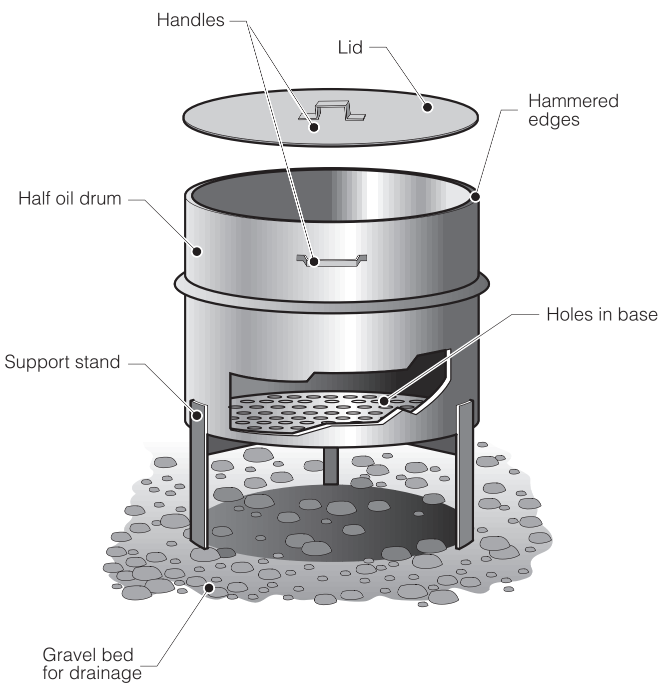

Figure 7.3. Communal bin made from an old oil drum

In general, a single 100-litre bin should be provided for every fifty people in domestic areas, every one hundred people at feeding centres and every ten market stalls. In general, bins should be emptied daily.

Advantages: Bins are potentially a highly hygienic and sanitary management method; and final disposal of waste well away from dwelling areas.

Constraints: Significant collection, transportation and human resources are required; system takes time to implement; and efficient management is essential.

7.5.4 Family bins

Family bins are rarely used in emergency situations since they require an intensive collection and transportation system and the number of containers or bins required is likely to be huge. In the later stages of an emergency, however, community members can be encouraged to make their own refuse baskets or pots and to take responsibility to empty these at communal pits or depots.

Advantages: Families are responsible for maintaining collection containers; and potentially a highly sanitary management method.

Constraints: In general, the number of bins required is too large; significant collection, transportation and human resources are required; takes time to implement; and efficient management essential.

7.5.5 Communal disposal without bins

For some public institutions, such as markets or distribution centres, solid waste management systems without bins can be implemented, whereby users dispose of waste directly onto the ground. This can only work if cleaners are employed to regularly sweep around market stalls, gather waste together and transport it to a designated off-site disposal site. This is likely to be appropriate for vegetable waste but slaughterhouse waste should be disposed of in liquid-tight containers and buried separately.

Advantages: System rapid to implement; there is minimal reliance on actions of users; and it may be in line with traditional/usual practice.

Constraints: Requires efficient and effective management; and full-time waste workers must be employed.

7.6 Transportation options

Where bins or collection containers require emptying, transportation to the final disposal point is required. As described, waste transportation methods may be human-powered, animal-powered or motorised.

7.6.1 Human-powered

Wheelbarrows are ideal for the transportation of waste around small sites such as markets but are rarely appropriate where waste must be transported considerable distances off-site. Handcarts provide a better solution for longer distances since these can carry significantly more waste and can be pushed by more than one person. Carts may be open or can be fitted with several containers or bins.

7.6.2 Animal-powered

Animal-powered transportation means such as a horse or donkey with cart are likely to be appropriate where they are commonly used locally. This may be ideal for transportation to middle distance sites

7.6.3 Motorised

Where the distance to the final disposal site is great, or where the volume of waste to be transported is high, the use of a motorised vehicle may be the only appropriate option. Options include tractor and trailer, a standard truck, or a tipper-truck, the final choice depending largely on availability and speed of procurement.

Figure 7.4 illustrates a number of refuse collection vehicles and containers.

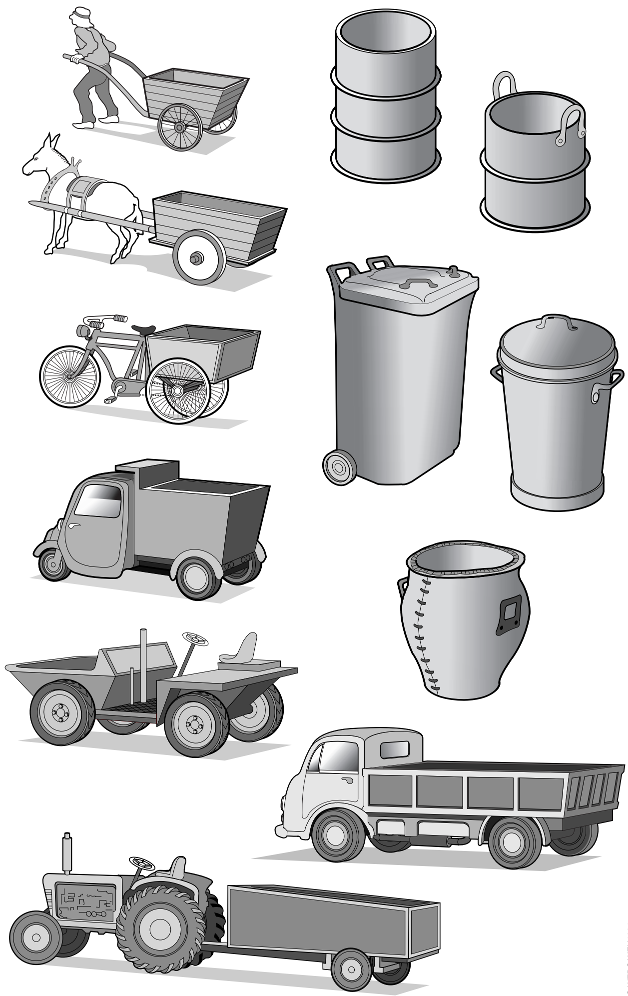

Figure 7.4. Refuse collection containers and vehicles

For large volumes of waste it may sometimes be appropriate to have a two-stage transportation system requiring a transfer station. For example, waste is transported by handcart to a transfer station where it is loaded into a truck to be taken to an off-site disposal site several kilometres away (Figure 7.5).

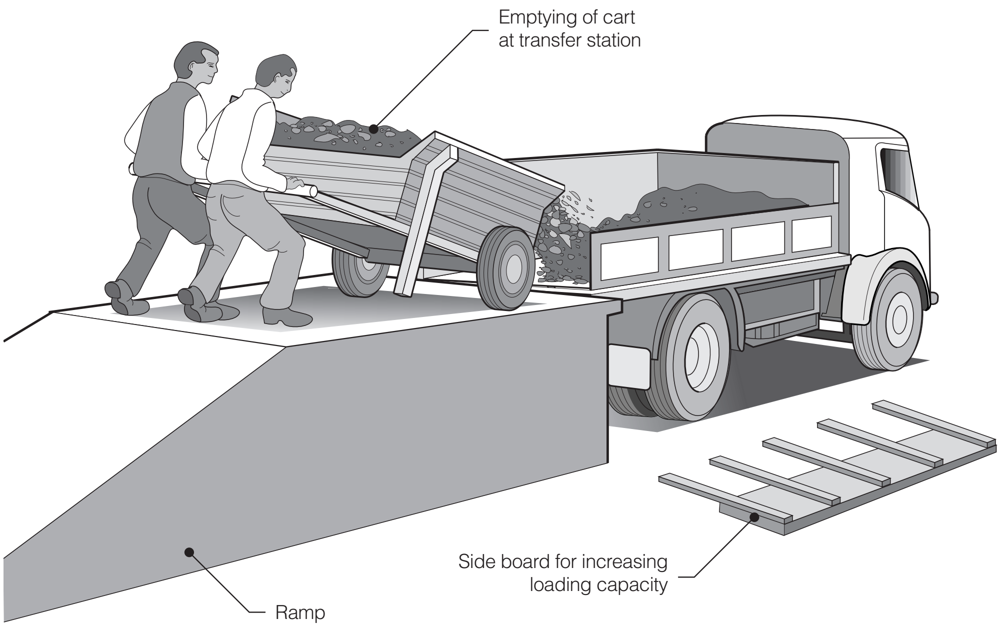

Figure 7.5. Emptying a cart at a transfer station

7.7 Off-site disposal options

The technology choices outlined below are general options for the final disposal of waste off-site.

7.7.1 Landfilling

Once solid waste is transported off-site it is normally taken to a landfill site. Here the waste is placed in a large excavation (pit or trench) in the ground, which is back-filled with excavated soil each day waste is tipped. Ideally, about 0.5m of soil should cover the deposited refuse at the end of each day to prevent animals from digging up the waste and flies from breeding (Figure 7.6).

The location of landfill sites should be decided upon through consultation with the local authorities and the affected population. Sites should preferably be fenced, and at least one kilometre downwind of the nearest dwellings.

Advantages: A sanitary disposal method if managed effectively.
Constraints: A reasonably large area is required.

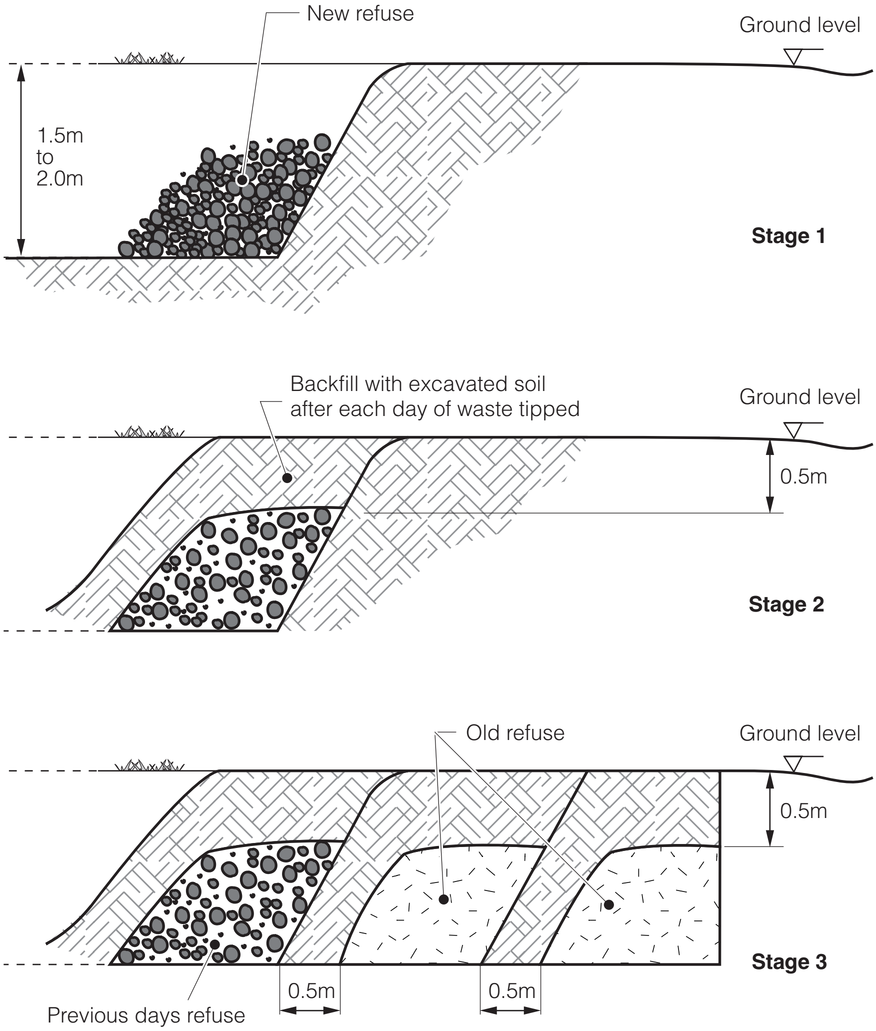

Figure 7.6. Simple landfilling

7.7.2 Incineration

Although burning or incineration is often used for the disposal of combustible waste, this should generally only take place off-site or a considerable distance downwind of dwellings. Burning refuse within dwelling areas may create a significant smoke or fire hazard, especially if several fires are lit simultaneously. Burning may be used to reduce the volume of waste and may be appropriate where there is limited space for burial or landfill. Waste should be ignited within pits and covered with soil once incinerated, in the same manner as landfilling. The same constraints for siting landfill sites should be applied here also.

Advantages: Burning reduces volume of combustible waste considerably; and it is appropriate in off-site pits to reduce scavenging.

Constraints: There can be smoke or fire hazards.

7.7.3 Composting

Simple composting of vegetables and other organic waste can be applied in many situations. Where people have their own gardens or vegetable plots, organic waste can be dug into the soil to add humus and fibre. This makes the waste perfectly safe and also assists the growing process. This should be encouraged wherever possible, particularly in the later stages of an emergency programme.

Properly managed composting requires careful monitoring of decomposing waste to control moisture and chemical levels and promote microbial activity. This is designed to produce compost which is safe to handle and which acts as a good fertiliser. Such systems require considerable knowledge and experience and are best managed centrally. In general, they are unlikely to be appropriate in emergencies.

Advantages: Composting is environmentally friendly; and beneficial for crops.

Constraints: Intensive management and experienced personnel are required for large-scale operations.

7.7.4 Recycling

Complex recycling systems are unlikely to be appropriate but the recycling of some waste items may be possible on occasions. Plastic bags, containers, tins and glass will often be automatically recycled since they are likely to be scarce commodities in many situations. In most developing country contexts there exists a strong tradition of recycling leading to lower volumes of waste than in many more developed societies.

Advantages: Recycling is environmentally friendly.

Constraints: There is limited potential in most emergency situations; and it is expensive to set up.

7.8 Intervention levels

Table 7.1 indicates general intervention strategies for the storage and disposal of solid waste in different emergency scenarios.

Table 7.1. Recommended interventions for different scenarios

<table>
<tr><th>Scenarios and recommended interventions</th><th>The affected population go through a transit camp immediately after a disaster</th><th>The affected population remain in a temporary location for up to six months</th><th>The affected population stay in the affected area immediately after a disaster</th><th>The affected population move to a new area and are likely to remain for more than a year</th></tr>
<tr><td>Immediate action</td><td colspan="4">■ Clearing of scattered waste
■ Burning and burial of waste on site
■ Temporary communal pits
■ Temporary communal bins and off-site disposal
■ Repairing or upgrading of existing facilities</td></tr>
<tr><td>Short-term measure</td><td colspan="2">■ Communal pits
■ Family pits
■ Communal bins and off-site disposal</td><td colspan="2"></td></tr>
<tr><td>Long-term measure</td><td colspan="2"></td><td colspan="2">■ Communal pits
■ Family pits
■ Communal bins and off-site disposal
■ Repairing or upgrading of existing facilities
■ Recycling</td></tr>
</table>

7.9 Protective measures

In order to minimise disease transmission there are several protective measures that can be undertaken. These concern equipment for staff and the siting and management of disposal sites.

7.9.1 Staff

It is important that workers employed to collect and transport solid waste are provided with appropriate clothing and equipment. Gloves, boots and overalls should be provided wherever possible. Where waste is burned, or is very dusty, workers should have protective masks. Water and soap should be available for hand and face washing, and changing facilities should be provided where appropriate.

7.9.2 Siting of disposal sites

The location of all disposal sites should be determined through consultation with key stakeholders including local government officials, representatives of local and displaced populations, and other agencies working in the area. Appropriate siting should minimise the effects of odour, smoke, water pollution, insect vectors and animals.

On-site disposal is generally preferred since this requires no transportation and staff needs are low. This is appropriate where volumes of waste are relatively small, plenty of space is available and waste is largely organic or recyclable.

If the volumes of waste generated are large, or space within the site is severely limited, it may be necessary to dispose of waste off-site. Where off-site disposal is to be used the following measures should be taken in selecting and developing an appropriate site:

- Locate sites at least 500m (ideally 1 kilometre) downwind of nearest settlement.
- Locate sites downhill from groundwater sources.
- Locate sites at least 50m from surface water sources.
- Provide a drainage ditch downhill of landfill site on sloping land.
- Fence and secure access to site.

Careful assessment should be made to determine who owns the proposed site and to ensure that apparently unused areas are not in fact someone's farm or back yard.

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Water, sanitation, hygiene and health

A PRIMER FOR HEALTH PROFESSIONALS

World Health Organization

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Why this primer?

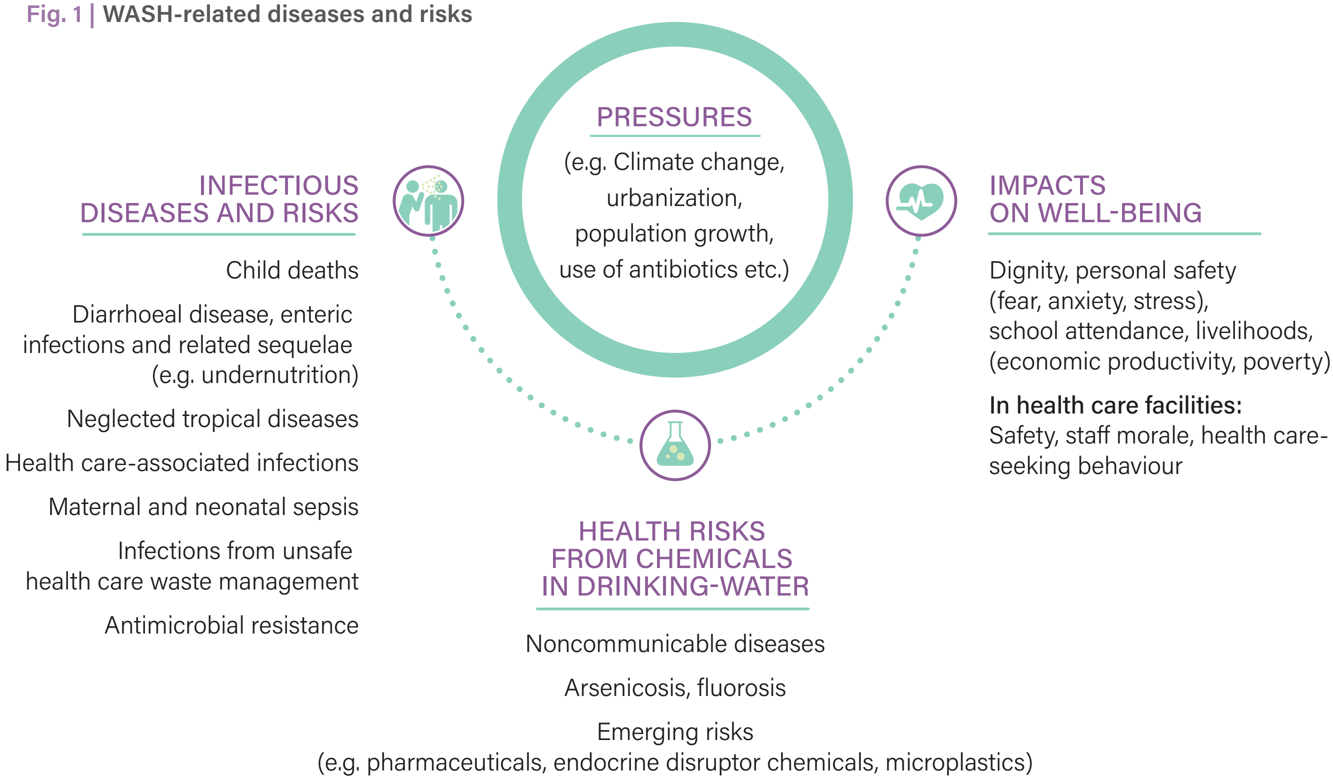
Safe water, sanitation and hygiene (collectively known as WASH) are crucial for human health and well-being. Yet, millions of people globally lack adequate WASH services and consequently suffer from or are exposed to a multitude of preventable illnesses. Lack of safe WASH negatively impacts quality of life and undermines fundamental human rights. Poor WASH services also weaken health systems, threaten health security and place a heavy strain on economies.

So, what can health professionals do to maximize positive impacts from WASH interventions? This primer aims to guide health professionals on engaging with WASH-related issues. It gives an overview of WASH interventions and the status of WASH services globally and outlines key linkages with health. It provides examples of key actions that health actors can take to ensure WASH efforts effectively protect public health and highlights World Health Organization (WHO) activities to support those actions.

WASH-RELATED HEALTH BURDEN

WASH-related diseases and risks are wide ranging (Fig. 1). They include infections transmitted by the faecal–oral route, health impacts from exposures to chemicals and other contaminants in drinking-water, as well as impacts on well-being. WASH-related diseases and risks can be exacerbated by a number of factors including climate change, population growth, rapid urbanization or, in the case of antimicrobial resistance, antibiotic use.

Fig. 1 | WASH-related diseases and risks



Worldwide, in 2016, **1.9 million deaths** and **123 million disability-adjusted life-years (DALYs)** could have been prevented with adequate WASH (Table 1). The WASH-attributable disease burden amounts to 4.6% of global DALYs and 3.3% of global deaths. The burden of deaths among children under 5 years is 13%.[1]

Table 1. | Disease burden from inadequate WASH, 2016[a]

DISEASE	DEATHS	DALYS (THOUSANDS)	POPULATION-ATTRIBUTABLE FRACTION
Diarrhoeal diseases	828 651	49 774	0.60
Soil-transmitted helminth infections	6 248	3 431	1
Acute respiratory infections	370 370	17 308	0.13
Malnutrition[b]	28 194	2 995	0.16
Trachoma	<10	244	1
Schistosomiasis	10 405	1 096	0.43
Lymphatic filariasis	<10	782	0.67
SUBTOTAL: drinking-water, sanitation and hygiene	*1 243 869*	*75 630*	*NA*
Malaria	354 924	29 708	0.80
Dengue	38 315	2 936	0.95
Onchocerciasis	<10	96	0.10
SUBTOTAL: water resource management	*393 239*	*32 740*	*NA*
Drownings	233 890	14 723	0.73[c]
SUBTOTAL: safety of water environments	*233 890*	*14 723*	*NA*
TOTAL: inadequate water, sanitation and hygiene	**1 870 998**	**123 093**	**NA**

DALYs, disability-adjusted life-years; NA, not applicable.
[a] Disease burden estimates are for low- and middle-income countries (LMICs); diarrhoea, acute respiratory infections and drownings include disease burden in high-income countries (HICs).
[b] Includes disease burden from protein–energy malnutrition and consequences in children aged under 5 years only.
[c] Population-attributable fraction is 0.74 for LMICs, 0.54 for HICs.

INFECTIOUS DISEASE RISKS

DIARRHOEAL DISEASE

829 000

WASH-related deaths are from diarrhoeal disease.[1]

- Diarrhoea is the **second leading cause of death** among children aged under 5 years.
- **Just 2 pathogens**, rotavirus and *Escherichia coli*, are responsible for most cases of moderate-to-severe diarrhoea in low-income countries. Other important pathogens include *Cryptosporidium* and *Shigella*.[2]
- **Cholera can kill within hours if left untreated.** Cholera is still endemic in 69 countries, resulting in an estimated 2.9 million cases and 95 000 deaths per year worldwide.[3]

WaterAid/Dennis Lupenga

NEGLECTED TROPICAL DISEASES (NTDs)

NTDs affect more than

1 billion people

in 149 countries.

All NTDs require WASH to sustain elimination and control efforts and for morbidity management.

- Provision of safe drinking-water is a **key component of the campaign to eradicate Guinea worm.**
- **Sanitation prevents soil-transmitted helminth infections and schistosomiasis:** 24% of the world's population are infected with soil-transmitted helminths, causing stunting and cognitive impairment among children.[4] More than 220.8 million people in 52 countries in which schistosomiasis is endemic required preventive treatment for schistosomiasis in 2017.[5]
- **Sanitation and water for facial cleaning is part of the strategy to eliminate trachoma,** which is the cause of blindness or visual impairment in 1.9 million people.[6]
- Adequate water management practices **can prevent mosquitoes from breeding.** Mosquitoes are vectors for dengue and other arboviruses, mainly in urban centres. About half of the world's population is at risk of dengue.[7]
- Adequate access to water **facilitates safe food handling practices** that prevent foodborne infections.
- **Clean water is vital for the management of NTD morbidity,** including surgical procedures for trachomatous trichiasis, and self-care for lymphatic filariasis, yaws, cutaneous leishmaniasis and Buruli ulcer.

ENTERIC INFECTIONS AND UNDERNUTRITION

- Poor WASH contributes to undernutrition through diarrhoea, intestinal parasite infections, and possibly through environmental enteric dysfunction (inflammation of the gut lining).
- In 2018, **149 million (21.9%) children aged under 5 years** had stunted growth and 49.5 million (7%) globally were at risk of wasting.[8]

HEALTH CARE SETTINGS

- **More people die every year from unsafe care than lack of care.** Between 5.7 and 8.4 million deaths are attributable to poor quality care each year in low- and middle-income countries (LIMCs).[9] WASH in health care facilities is fundamental to the provision of safe, quality care.
- An estimated **15% of patients in LMICs acquire one or more infections** during a hospital stay.[10]
- **Infections associated with unclean births account for 26% of neonatal deaths and 11% of maternal mortality;** together these account for more than 1 million deaths each year.[11,12] In some African countries, up to 20% of women get a wound infection after a caesarean section.[13,14]

In health care facilities, inadequate WASH contributes to **unhygienic environments** and the spread of infections.

- **Health care waste managed unsafely exposes health care workers, patients and their families, and the community to preventable infections, toxic effects and injuries.** In 2010, unsafe injections were responsible for as many as 33 800 new HIV infections, 1.7 million hepatitis B infections and 315 000 hepatitis C infections.[15]

The **over-reliance on antibiotics** as a result of poor WASH conditions further drives the emergence of antimicrobial resistance.

- Each year hundreds of millions of cases of diarrhoea are treated with antibiotics. Universal access to WASH could reduce this by 60%.[16]
- **Prophylactic use of antibiotics after giving birth is common in many countries** where WASH is inadequate and infectious disease risks are high. In some countries, 90% of women giving birth vaginally receive antibiotics before discharge from hospital.[17]
- Worldwide, almost **one third of sepsis-related neonatal deaths** each year may be attributable to resistant pathogens.[18]
- Inadequate disposal of wastewater contributes to the spread of antimicrobial-resistant bacteria and genes in the environment and to increased exposure of individuals to resistant bacteria in local communities. Antimicrobial residues in wastewater can also promote resistance within environmental bacteria and subsequent resistant infections.

EVIDENCE OF HEALTH IMPACTS FROM WASH

The causal chain from WASH interventions to health as illustrated by the F-diagram is well established. However, health impacts from WASH are difficult to evaluate compared to the effect of clinical interventions. The overall body of epidemiological evidence confirms the beneficial impacts of safe WASH on key health outcomes, although the quality of the evidence is typically weak – which is common with complex environmental health interventions.

HEALTH RISKS FROM CHEMICALS IN DRINKING-WATER

- In contrast to the acute and immediate nature of waterborne microbial disease, most chemical contaminants only have an effect after a long period of exposure. Chemicals with public health significance that people are exposed to through drinking-water include arsenic and fluoride (naturally present in many ground waters), lead (from household plumbing materials) and nitrate (from sewage contamination or agricultural runoff). WHO lists guideline values or "safe maximum concentrations" for more than 100 chemicals.[19]

  At least 140 million people in 50 countries are drinking water containing excessive levels of arsenic.[20] Long-term exposure to high levels of arsenic in drinking-water and food can cause skin lesions and cancer. It has also been associated with cardiovascular disease and diabetes. In utero and early childhood exposure has been linked to impaired cognitive development and increased deaths in young adults.

- Contaminants such as pharmaceuticals, endocrine disruptors and microplastics have the potential to reach drinking-water although the concentrations generally found in drinking-water or its sources are unlikely to pose a risk to human health.[21, 22]

IMPACTS ON SOCIAL AND ECONOMIC WELL-BEING

- **Safe WASH contributes to social and economic well-being.** Safe water at home decreases time spent collecting water, allowing time for livelihoods, child care, school attendance and play. Safe sanitation at home and at school ensures dignity, privacy and safety, especially for women and adolescent girls.
- **In health care facilities, inadequate WASH conditions have a negative impact on staff morale, patient health care-seeking behaviour and their overall health care experience.** Poor WASH in health care facilities deters patients, particularly pregnant women, from seeking care.

BURDEN ON HEALTH SYSTEMS AND ECONOMIES

Economic benefits of investing in water and sanitation are considerable.

The economic benefits include an overall estimated gain of 1.5% of global gross domestic product and almost US$ 5 return on every dollar invested in water and sanitation services. This is due to reduced health care costs for individuals and society, and greater productivity in the workplace through better access to WASH facilities.[23]

In many countries, only a small fraction of health spending goes to primary prevention.

In countries that are members of the Organisation for Economic Co-operation and Development (OECD), less than 3% of health spending goes towards public health and disease prevention activities.[24]

The vast majority of financing for WASH comes from outside the health sector.

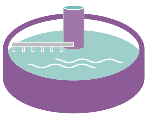
WASH budgets typically come from separate allocations within ministries and financing partners (e.g. bilateral donors, development banks and nongovernmental organizations) that do not compete with funding for health programmes. Limited health budgets can be used to support coordination with the WASH sector to maximize health outcomes. Likewise, well-targeted WASH sector spending, coordinated with health sector priorities, can have a huge influence on prevention and save health sector money.

What are WASH interventions?

WASH systems have many of the same elements as health systems. WASH interventions encompass technologies, behaviour change and systems strengthening to ensure sustainable monitoring, regulation and financing of WASH services. WASH is often seen as an expensive set of interventions requiring major infrastructures, but many WASH interventions can be implemented relatively quickly and cheaply. WASH interventions may target households or institutions such as health care facilities and schools.

Safe drinking-water

Improving access to safe drinking-water supplies may involve constructing or improving water supply systems or services such as provision of piped water on-site, public standpipes, boreholes, protected dug wells, protected springs or rainwater. It should also involve risk assessment and management approaches, such as water safety planning, to ensure the success and sustainability of the improvements put in place. Low-cost strategies to treat and safely store drinking-water at the point-of-use (e.g. filters, chlorine tablets, safe storage containers) can provide an intermediate solution while longer-term infrastructure improvements are being planned and implemented.



Sanitation

A safe sanitation system is designed and used to separate human excreta from human contact at all steps of the sanitation service chain from safe toilets and containment (in some systems with treatment in-situ) through conveyance (in sewers or by emptying and transport), to treatment and final disposal or end use. A holistic approach to addressing faecal risks from toilets to safe use or disposal is facilitated through sanitation safety planning. As a household moves away from open defecation towards use of better sanitation services, and ultimately to safely managed systems, health benefits increase.

Hygiene

Hygiene interventions include promoting handwashing with soap at critical times. A broader definition may include food hygiene measures (e.g. washing, covering, cooking and storage of food), environmental hygiene (e.g. cleaning of surfaces), menstrual hygiene, or hygiene interventions specific to prevention and control of particular diseases (e.g. face washing for trachoma, shoe wearing for soil-transmitted helminths, and animal management for zoonotic diseases).

WASH services are delivered and financed by a multitude of stakeholders including national and local government authorities, utilities, regulatory bodies, communities and households. In many countries, coordination mechanisms exist at the national or local levels. For example, joint sector reviews are government platforms which aim to discuss, review progress and set priorities on WASH in the country concerned.[25]

RISK ASSESSMENT AND MANAGEMENT

WHO water- and sanitation-related guidelines (drinking-water quality, sanitation and health, safe use of wastewater, and recreational water safety) are underpinned by the principles of risk assessment and management. Water safety planning and sanitation safety planning consist of the systematic identification, prioritization and management of health risks throughout the water or sanitation system. For drinking-water, that means from catchment to consumer and for sanitation, from toilets to the point of disposal or reuse.

The process of national target-setting for WASH is vital for countries to ensure that resource allocation reflects the need to extend coverage to those who are unserved as well as to upgrade existing services. That involves assessing the current services used by people in the country and the capacity to extend and improve these services before reviewing and possibly revising existing targets and policies. The health sector should be involved to ensure that the targets that are set meet public health objectives.

What is the situation globally?

GLOBAL POLICY CONTEXT

THE SUSTAINABLE DEVELOPMENT AGENDA

6 CLEAN WATER AND SANITATION

"Ensure availability and sustainable management of water and sanitation for all"

Sustainable Development Goal (SDG) 6 includes eight targets on drinking-water, sanitation and hygiene, quality and sustainability of water resources and two targets on the means of implementation. WHO monitors progress towards five of those targets.

3 GOOD HEALTH AND WELL-BEING

Universal WASH is fundamental for achieving several health-related SDGs including:

- **3.1** reducing maternal mortality
- **3.2** ending preventable deaths of newborns and children under 5 years of age
- **3.3** ending NTDs and combating waterborne disease
- **3.8** achieving universal health coverage
- **3.9** reducing deaths and illness from water contamination

SDG6 HAS SEVERAL IMPLICATIONS FOR THE WASH SECTOR THAT REQUIRE STRENGTHENED LINKS WITH HEALTH:

- **Focus on safely managed services instead of infrastructures**

  SDG6 has set an ambitious objective of ensuring that drinking-water and sanitation services are managed in a way that protects human health.

- **Hygiene is included in the targets**

  Handwashing facilities with soap and water is included as a hygiene indicator under the household SDGs.

- **Institutional settings are monitored**

  Assessments of the status of WASH in schools and health care facilities are now produced at global, regional and country levels.

- **Strong focus on reducing inequalities**

  The WHO/UNICEF Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP) reports on inequalities in use of basic WASH services including through reporting by wealth quintiles, urban or rural settings and increasing available subnational data allowing analysis by province, district or cluster level. Vulnerable groups are identified through better integration with health programmes that focus on the most disadvantaged and marginalized populations.

- **Recognizing the need for better understanding of the enabling environment and financing in WASH**

  Understanding the capacity of countries to meet their national targets and make progress towards international targets helps with planning, investment and prioritization of WASH service delivery including in areas with a high burden of disease.

HUMAN RIGHTS TO DRINKING-WATER AND SANITATION

Access to sustainable water and sanitation services is a critical aspect of equity and is recognized by the United Nations as a fundamental human right which obliges countries to ensure drinking-water and sanitation services are available, accessible, of quality, affordable and acceptable.[26]

ACCESS TO WASH SERVICES

HOUSEHOLDS

DRINKING-WATER

In 2017, **71% of the global population** (5.3 billion people) used a safely managed drinking-water service – that is, one located on premises, available when needed, and free from contamination.

90% of the global population (6.8 billion people) used at least a basic service. A basic service is an improved drinking-water source that can be accessed within 30 minutes (roundtrip).

Approximately **785 million people** lack even a basic drinking-water service, including 144 million people who are dependent on surface water.

By 2025, **half of the world's population** will be living in water-stressed areas.

Globally, at least **2 billion people** use a drinking-water source contaminated with faeces.[27]

The **WHO/UNICEF Joint Monitoring Programme (JMP) for Water Supply, Sanitation and Hygiene** supports national, regional and global monitoring and reporting of progress on drinking-water, sanitation and hygiene in households, health care facilities and schools. The JMP database includes more than 5000 national data sources enabling the production of estimates for more than 200 countries, areas and territories. JMP uses service ladders for benchmarking and comparison across countries at different stages of development (www.washdata.org/).

SANITATION

In 2017, **45% of the global population** (3.4 billion people) used a safely managed sanitation service.[a]

31% of the global population (2.4 billion people) used private sanitation facilities connected to sewers from which wastewater was treated.

2 billion people still do not have **basic sanitation facilities** such as private toilets or improved latrines.[27]

14% of the global population (1.0 billion people) used toilets or latrines where excreta were disposed of in-situ.

74% of the world's population (5.5 billion people) used at least a basic sanitation service.[b]

673 million still defecate in the open, for example in street gutters, behind bushes or into open bodies of water.

At least **10% of the world's population** is thought to consume food irrigated by using wastewater.

Only **40 out of 152 countries** are on track to achieve basic sanitation for all by 2030. Rapid acceleration is needed to meet SDG6.2.

[a] Use of an improved sanitation facility which is shared with other households and where excreta is safely disposed of in-situ or transported and treated off-site.

[b] Use of improved facilities that are not shared with other households. This includes flush/pour flush to piped sewer system, septic tanks or pit latrines, ventilated improved pit latrines, composting toilets or pit latrines with slabs.

Nearly

3/4 of the population

in least-developed countries lacked handwashing facilities with soap and water.[27]

60% of the global population had basic handwashing facilities with soap and water available at home.

78 countries (and 3 out of 8 SDG regions) had estimates for basic handwashing facilities at home, representing 52% of the global population. Many high-income countries lacked data on hygiene.

3 billion people still lacked basic handwashing facilities at home: 1.6 billion had limited facilities lacking soap or water, and 1.4 billion had no facility at all.

WaterAid/Ernest Randriarimalala

KEY GLOBAL WASH DAYS

World Water Day
22 March

Hand Hygiene Day
5 May

Menstrual Hygiene Day
28 May

Global Handwashing Day
19 October

World Toilet Day
19 November

HEALTH CARE FACILITIES

Around 1 in 4 health care facilities **lack basic water services** – that is, an improved water source located on premises. That means that 2 billion people are going to use health care facilities that do not have a protected source of water on-site.[28]

Around **1 in 5 facilities** have no sanitation service. That means that more than 1.5 billion people use health centres with no toilets or improved latrines.

Globally, **42% of health care facilities** lack hand hygiene facilities at the point of care and 40% do not have systems to segregate waste. Good hand hygiene is one of the most effective ways to reduce health care-associated infections and can reduce the risk of diarrhoeal diseases.

Compared to hospitals, smaller facilities like clinics, health centres and health posts are **twice as likely** to lack water or sanitation services.

SCHOOLS

In most countries for which data were available, fewer than **50% of schools** had toilets that were accessible for students with limited mobility.[29]

19% of schools had no drinking-water service, i.e. an improved source with water was unavailable at the time of the survey.

23% of schools had no sanitation service, i.e. they had an unimproved facility or no facility at all.

36% of schools had no hygiene service, i.e. no handwashing facility or no water was available.

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WASH SYSTEMS AND FINANCE

The key findings on WASH systems from the GLAAS 2019 report:[30]

1. WASH policies and plans are not backed by adequate human and financial resources. Less than 15% of countries surveyed reported having sufficient financial resources to implement their WASH plans.

2. While 3/4 of countries have national standards for drinking-water and wastewater, institutions tasked with regulatory oversight for WASH service delivery are overstretched and unable to undertake the required surveillance. Only 12% of surveyed countries reported that urban drinking-water surveillance is conducted at 100% of the required frequency.

3. National financial systems to support decision-making are weak. While over 75% of countries have financing plans for WASH, more than half of these plans are insufficiently used in decision-making.

4. National WASH policies and targets increasingly reflect SDG ambitions, aiming to provide universal coverage to those left behind and to reach higher levels of service. However, large funding gaps remain between what is needed to reach WASH targets and what is available. Twenty countries reported a funding gap of 61% between identified needs and available funding.

The UN-Water Global Analysis and Assessment of Sanitation and Drinking-Water (GLAAS) examines the extent to which countries develop and implement national policies and plans for WASH, monitor, regulate and take corrective action, and coordinate these parallel processes with sufficient financial and human resources and support from strong national institutions. **TrackFin (Tracking Financing to WASH)** is a methodology used to identify and track WASH financial flows at the national or subnational level in a consistent and comparable manner, using an approach similar to the national health accounts.

Why does WASH matter for health programmes?

Integrating WASH into health programmes such as those focusing on antimicrobial resistance, cholera prevention and control, emergencies, infection prevention and control, maternal, neonatal and child health, NTDs, nutrition and universal health coverage can increase synergies and impacts.

Impact on multiple diseases – helps break the cycle of disease and poverty

Infectious diseases are most common among populations that are poor, vulnerable and marginalized and that have the poorest access to WASH services. This contributes to a vicious cycle of disease and poverty, as affected individuals can incur high health expenditure and debts, as well as becoming less economically productive. In addition, people who are ill are more vulnerable to opportunistic infections, and therefore more affected by poor WASH (e.g. people living with HIV/AIDS).

Disease data are a powerful argument for WASH action in the most affected or at-risk populations

Hard-to-reach populations for which providing WASH services is complex or expensive in terms of service delivery and infrastructure are often the most affected by, or most at risk of, diseases. Disease data are needed for the WASH sector to better target WASH service delivery to those areas and thereby maximize the health impacts. Cholera provides an important example of such targeting: the global goal of elimination could be reached by improving WASH services to only approximately 4% of the population who live in hotspots in the affected countries.

Cost savings for the health system

Almost every dollar invested in water and sanitation services yields a return of US$ 5 due to reduced health care costs for individuals and society, and greater productivity.[23] For example, preventing a cholera outbreak means that a health care facility does not need be converted into a treatment facility. Instead, it can continue providing the essential services that are critical to health such as antenatal care and regular vaccinations among others.

Efficiency and reinforcement for co-delivering interventions

Health programmes at the community level can provide important entry points for other activities that can improve WASH behaviour and enhance impact and sustainability. For example, hygiene promotion can be included as part of mass drug administration or vaccination campaigns.

Quality and uptake of health interventions or services

In health care facilities, better WASH conditions enable effective infection prevention and control of health care-associated infections; improve staff morale and occupational health and safety; improve patient satisfaction; prevents infections and save money. In addition, distribution of soap or water treatment products alongside messaging can increase demand for and uptake of both targeted and routine vaccines and/or other services such as HIV testing and antenatal care.

WASH is essential to reach disease control and elimination targets

NTDs like trachoma, schistosomiasis and soil-transmitted infections can be controlled using a variety of strategies such as preventive chemotherapy, but WASH conditions must be improved to reduce or interrupt transmission and prevent rebounding of infection and disease. WASH is a key element in the global roadmap for NTDs, as well as to control cholera (*Ending cholera – a global roadmap to 2030*) and in the Global vector control response (2017–2030).

How can health professionals engage on WASH issues?

WASH services are often delivered by non-health actors, but the health community's engagement is essential to ensure WASH services effectively protect public health. At the global level, health guidelines, policies and financing mechanisms ought to recognize and include, where relevant, WASH standards and best practices, which are essential to meeting many health aims. At the national level, health policy-makers and planners would benefit from engaging and coordinating with WASH actors, to align, prioritize and jointly monitor key indicators that are fundamental to many health aims.

Fig. 2. illustrates some key health sector functions in WASH

Fig. 2 | Key health sector's functions in WASH

Below are some examples illustrating how the health sector can engage on WASH-related issues:

1. Ensure health care facilities have and sustain adequate WASH services to ensure quality care and prevent infections.

In Tajikistan, the Ministry of Health used the WASH Facility Improvement Tool to set national targets and update national standards on WASH in health care facilities and the tool is included in the draft national health strategy.

2. Share health surveillance data to inform WASH service delivery and to support outbreak prevention efforts.

In Ethiopia, a national framework for collaboration between WASH and NTD programmes has been developed. Under this framework, joint mapping of NTD endemicity and WASH situation was conducted which helped strengthen WASH efforts in areas with a high disease burden.

3. Contribute to coordination processes on WASH to ensure WASH-related health risks are adequately considered in service delivery.

In Peru, sanitation safety planning brought together stakeholders from the municipality, including health authorities, to identify health risks related to the direct use of untreated wastewater for irrigation of green spaces of a public park and to implement adequate control measures.

4. Contribute to health-protecting norms and standards on WASH.

In Lao People's Democratic Republic, the Ministry of Health has embedded WASH-related risk assessment and management into WASH standards and regulations by explicitly requiring Water Safety Plan implementation by urban and rural water suppliers within their national drinking-water quality standards.

5. Include WASH in relevant global and national health policies and strategies.

The Global Fund, which invests more than US$ 4 billion per year, in 100 countries, to end AIDS, tuberculosis and malaria, for the first time, is mainstreaming health care waste management in its programme guidance, country grants and funding guidance. This will increase attention and investments in this underfunded area important for environmental and human health.

6. Include WASH promotion and monitoring within health programmes to maximize and sustain health impact.

In Zambia, WASH is a key pillar of the national cholera prevention and control plan and during the cholera outbreak in Lusaka in 2018, targeted household water treatment and hygiene messaging was rapidly rolled out in the affected areas.

Main WHO actions on WASH

KEY ACTIONS

1. Guidelines and tools

Provide up-to-date guidelines and tools that support standard-setting and regulations on drinking-water safety, recreational water quality, sanitation safety, safe use of wastewater in agriculture and aquaculture, safe WASH in health care facilities and schools, and WASH monitoring.

2. Country support

Empower countries through technical cooperation and capacity-building on national policies and regulatory frameworks, national systems for WASH monitoring, and national WASH target-setting.

3. Evidence and monitoring

Monitor, research and report reliable and credible WASH data to inform policies and programmes including WASH risk factors and burden of disease, the status of key indicators for WASH, progress towards WASH-related SDG targets, WASH systems and financing, wastewater and SDG6 interlinkages.

4. Coordination and advocacy

Coordinate and engage with multisectoral partners, global and regional platforms to strengthen WASH regulations, policies, multisectoral collaborations and coordinating networks of practitioners and partners in the field of WASH.

5. WASH in health programmes

Support coordinated actions between WASH and health programmes to increase synergies and impacts.

6. Response to emerging issues

Respond to issues such as climate change and WASH, and the impact of water scarcity on public health.

WHO AIMS TO:

- support the health sector in effectively addressing WASH-related health risks: and
- assist non-health actors in understanding and maximizing the positive health impacts of their work.

PRIORITY AREAS

WHO'S VISION:

"To substantially improve health through the safe management of water, sanitation and hygiene services in all settings."

DRINKING-WATER QUALITY AND SAFETY

Provide authoritative and objective information on human health risks associated with drinking-water contaminants in national contexts, working with partners to promote effective risk management and surveillance.

SANITATION AND WASTEWATER

Improve safety and health benefits of sanitation and wastewater interventions, supporting safe use of wastewater and sludge waste in the circular economy, and improving recreational water quality.

WASH IN HEALTH CARE FACILITIES

Support the development of country standards and policies, monitoring, facility-based improvements and, together with UNICEF, a global movement in support of a new World Health Assembly resolution (www.washinhcf.org).

EVIDENCE AND MONITORING

Under the integrated monitoring initiative for SDG6

JMP: Support monitoring and reporting of progress on drinking-water, sanitation and hygiene.
GEMI: Produce methodology, data and estimates on safely treated wastewater.
GLAAS and TrackFin: Provide policy- and decision-makers with a global analysis of WASH-enabling environments and financing.
Burden of disease: Evidence and reporting on WASH-related risk factors and burden of disease.

INTEGRATING WASH INTO HEALTH PROGRAMMES

Integrate WASH into programmes including those on cholera, NTDs, antimicrobial resistance, emergencies, infection prevention and control, universal health coverage, maternal, neonatal and child health and nutrition.

For more information, see the WHO Water, Sanitation and Hygiene Strategy 2018–2025

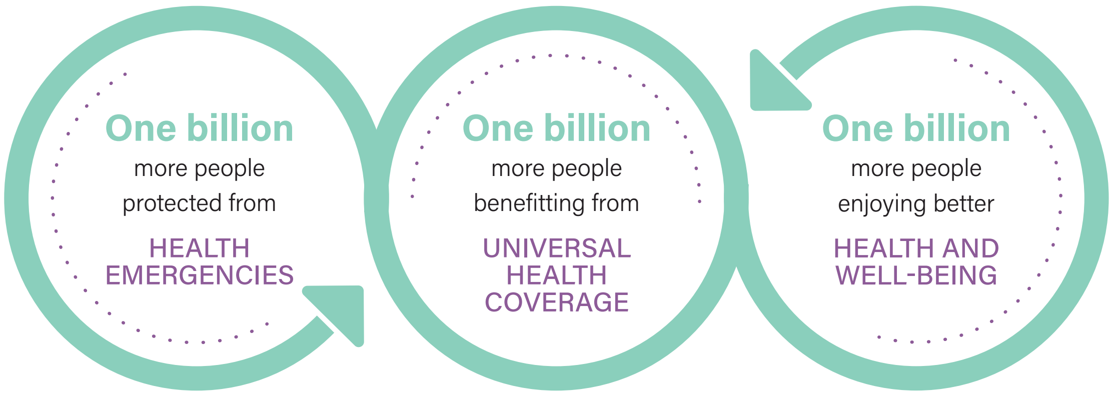
→ www.who.int/water_sanitation_health/publications/wash-strategy-2018-2025/en/

WASH WITHIN WHO'S THIRTEENTH GENERAL PROGRAMME OF WORK 2019–2023 (GPW 13)

GPW 13 describes how WHO contributes to the health of three billion people: one billion becoming "healthier populations" through multisectoral actions and addressing environmental risk factors and health determinants; one billion benefiting from better emergency preparedness and response; and one billion with universal health coverage (UHC) (Fig. 3). WASH will be a key element for achieving all these targets.

WASH elements for the targets include: increased access to safely managed drinking-water and sanitation in households, and targets associated with UHC linked to WASH in health care facilities. Other indicators, largely linked to essential health services, child and maternal mortality, and antimicrobial resistance, will require improving water, sanitation and energy services in health care facilities.

Fig. 3 | GPW 13: a set of interconnected strategic priorities and goals to ensure healthy lives and promote well-being for all at all ages.



Concept of IEE / EIA

The concept of IEE/EIA was first introduced in USA in 1970 AD under United States Environmental Law. This concept spread worldwide particularly after UN Earth Summit held in 1992 at Rio De Janeiro, Brazil. In the context of our country, government of Nepal introduced the National Environment Impact Assessment Guideline in 2050 BS. The Environment Protection Act 2053 and Environment Protection Regulation 2054 were then formulated. A new environment protection act was introduced by government of Nepal in 2076 BS. Such acts and guidelines provide a legal framework that requires developers to assess and mitigate the environmental impacts of any development project. IEE/EIA is a tool to identify and manage the effects of a development project to the environment.

Initial Environmental Examination (IEE)

It is a preliminary environmental assessment for small projects with relatively low environmental risk. If IEE provides solutions to the identified environmental problems, then EIA is not necessary. If EIA becomes necessary, IEE serves as a valuable precursor to full EIA. The methodology involved in initial environmental examination (IEE) are as below:

- Project description
- Environmental screening
- Preparation of TOR
- Approval of TOR by concerned body
- Conducting Environmental Assessment
- Preparation of IEE Report
- Submission of IEE Report

If the IEE report submitted is approved by concerned authority, the project is implimented. If it donot get approved, EIA is needed.

Environmental Impact Assessment (EIA)

A systematic process identifying potential environmental and social impacts due to a project.

Features:

- Advises regulators (decisionmakers) on project's environmental (and social) impacts so they can make the best decision;
- NEVER SAYS IF A PROJECT SHOULD GO AHEAD OR NOT;

- Facilitates informed and transparent decision-making while avoiding, reducing or mitigating impacts (alternatives);
- A science and an art presenting impact identification/ prediction AND mitigation and project management.

It is the more extensive environmental assessment process for relatively larger project with potentially significant environmetal impacts. Its methodology includes:

- Project description
- Environmental screening
- Preparation of TOR and Scoping
- Approval of TOR and Scoping
- Environmental Assessment
- Preparation of draft EIA report
- Disclosure of draft EIA report for comments and review
- Submission of EIA report

If the EIA report submitted gets approved then the project is implimented otherwise, redesigning of project is necessary.

Principles Of EIA

a. .Sustainability – the EA process will result in environmental safeguards
b. Integrity – the EA process will conform to agreed standards
c. Utility – the EA process will provide balanced, credible information for decision making
d. Cost Effectiveness
e. Transparency
f. Certainty
g. Participation
h. Practicality

Difference Between IEE And EIA

Importance Of IEE / EIA

- To identify the environmental impacts

- To assess whether the impacts can be mitigated
- To recommend the corrective and preventive mitigation measures
- To examine the enviromental implications
- To inform the decision makers and concerned parties about the environmental implication
- To advise whether the development project should go ahead or not.

Role of EIA

- Purpose of EIA is to provide environment its due place in decision making process.
- It may prevent the use of developmental activity for political benefits.
- Provide a procedure for full consideration of the possible adverse environmental impacts of policies, programs, activities, projects before any decision being taken.
- Prevents "behind closed door" process of decision making.
- Opportunity to present recommendations to the decision maker on the suitability of the project.
- Alternate approach, choice of technology and sites can be thoroughly examined.
- The public can contribute to the decision making process through written and oral contributions or by appearances at public enquiries and hearing etc.

Types of Environmental Impacts

Some of the environmental impacts are :

a. Direct Impact
b. Indirect Impact
c. Cumulative impacts and
d. Induced Impact

Direct Impacts:

Direct impacts occur through direct interaction of an activity with an environmental, social, or economic component.

For example, a discharge of any industry or an effluent from the Effluent Treatment Plant (ETP) from the industrial estates into a river may lead to a decline in water quality in terms of high biological oxygen demand (BOD) or dissolved oxygen (DO) or rise of water toxins.

Indirect Impacts:

Indirect impacts on the environment are these which are not a direct result of the project, often produced away from or as a result of a complex impact pathway. The indirect impacts are also known as secondary or even third level impacts.

For example, ambient air SO_2 rise due to stack emissions may deposit on land as SO_4 and cause acidic soils. Another example of indirect impact is the decline in water quality due to rise in temperature of water bodies receiving cooling water discharge from the nearby industry.

This may, in turn, lead to a secondary indirect impact on aquatic flora in that water body and may further cause reduction in fish population. Reduction in fishing harvests, affecting the income of fishermen is a third level impact. Such impacts are characterized as socioeconomic (third level) impacts.

The indirect impacts may also include growth- inducing impacts and other effects related to induced changes to the pattern of land use or additional road network, population density or growth rate (e.g. around a power project). In the process, air, water and other natural systems including the ecosystem may also be affected.

Cumulative Impacts:

Cumulative impact consists of an impact that is created as a result of the combination of the project evaluated in the EIA together with other projects causing related impacts. These impacts occur when the incremental impact of the project is combined with the cumulative effects of other past, present and reasonably foreseeable future projects.

Induced Impacts:

The cumulative impacts can be, due to induced actions of projects and activities that may occur if the action under assessment is implemented such as growth inducing impacts and other effects related to induced changes to the pattern of future land use or additional road network, population density or growth rate. Induced actions may not be officially announced or be part of any official plan. Increase in workforce and nearby communities contributes to this effect.

They usually have no direct relationship with the action under assessment and represent the growth- inducing potential of an action. New roads leading from those constructed for a project, increased recreational activities, and construction of new service facilities are examples of induce actions.

However, the cumulative impacts due to induced development or third level or even secondary indirect impacts are difficult to be quantified. Because of higher levels' of uncertainties, these' impacts cannot be normally assessed over a long time horizon. An EIA practitioner usually can only guess as to what such induced impacts may be and the possible extent of their implications on the environmental factors.

History of Environmental Assessment in Nepal

. For the first time a national level policy on environment management was incorporated in Seventh Five Year Plan (1985-1990).

. The policy emphasized to carry out EIA for all major development projects such as tourism, water resources, infrastructure, forestry and industry.

. The Nepal Government/National Planning Commission (NPC) and IUCN developed and endorsed the National Conservation Strategy (NCS) in this period for sustainable management of natural resources and the protection of the environment. .

The NCS for Nepal was prepared jointly as an inter-sectoral umbrella policy at the national level for addressing environmental issues during the development process.

Eighth Five Year Plan (1991-1995) and the Nepal Environmental Policy and Action Plan (1993) reemphasized the need for an EIA system to integrate environmental concerns into the development process. .

The Eight Five Year Plan anticipated the establishment of a national system for EIA and stipulated that EIA be conducted at the stage of feasibility study. Considering the NCS mandatory and constraint on policy and plan for the preparation of EIAs in Seventh Five Year Plan. .

First National EIA Guideline was endorsed in September 1992 and gazetted in July 1993.

Tenth Five Year Plan, 2003 Conservation of biodiversity through management of buffer zone involving local user groups, promote & encourage Eco-tourism in the protected areas.

Conservation of biological diversity will be achieved through the utilization of landscape approach, community participation, and soil conservation in sustainable way forming basis for development.

Regulatory Framework

The Constitution of Nepal

Fourteenth Plan 2013-2016

Rural Energy Policy, 2006

Acts and Rules

Environment Protection Act, 1997 and Environment

Protection Rules, 1997 (amendment 1999, 2007)

Local Government Operation Act, 2074 (2017)

- Aquatic Animals Protection Act, 1961 and first amendment, 1998
- Water Resources Act, 1992
- Solid Waste Management Act, 2011
- Child Labor (Prohibition and Regulation) Act, 2000
- Labor Act, 2074 (2017)

Guidelines/Frameworks

- National EIA Guidelines, 1993
- Environmental and Social Framework 2018

Standards

- National Ambient Air Quality Standards, 2003
- Nepal Vehicle Mass Emission Standards, 1999
- Generic Standard for discharging industrial effluent in inland surface water, 2001

International Polices and Conventions

- Safeguard Policy Statement 2009
- World Bank Safeguard Policy (OP 4.01 Environment Assessment)
- Convention on Biodiversity (CBD), 1993
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 1973
- Convention (No.169) Concerning Indigenous and Tribal Peoples in Independent Countries, 1989

Constitution of Nepal

Right to clean environment

(1) Every citizen shall have the right to live in a clean and healthy environment.

(2) The victim shall have the right to obtain compensation, in accordance with law, for any injury caused from environmental pollution or degradation.

(3) This Article shall not be deemed to prevent the making of necessary legal provisions for a proper balance between the environment and development, in development works of the nation.

Duties of citizens

Every citizen shall have the following duties:

(a) to safeguard the nationality, sovereignty and integrity of Nepal, while being loyal to the nation,

(b) to abide by the Constitution and law,

(c) to render compulsory service as and when the State so requires,

(d) to protect and preserve public property.

Environment Protection Act, 2053

Clause 7: Prevention and control of pollution

(1) Nobody shall create pollution in such a manner as to cause significant adverse impacts on the environment or likely to be hazardous to public life and people's health, or dispose or cause to be disposed sound, heat radioactive rays and wastes from any mechanical devices, industrial enterprises, or other places contrary to the prescribed standards.

(2) If it appears that anyone has carried out any act contrary to Subsection (1) and caused significant adverse impacts on the environment, the concerned agency may prescribe necessary terms in regard thereto or may prohibit the carrying out of such an act.

Section 3 of the Act requires the proponent to conduct an IEE and EIA in relation to the prescribed proposals. .

Section 4 of the Act prohibits implementation of development proposals without prior approval of the concerned agencies or Ministry of Environment (MoEnv) as specified by the Act. .

Section 5 of the Act provides that all the IEE/EIA of the development proposals should be presented to the concerned agencies for approval.

Environment Protection Rules, 2054

प्रारम्भिक वातावरणीय परीक्षण गर्नुपर्ने प्रस्तावहरू (जलस्रोत र उर्जा क्षेत्र) :

१. विद्युत लाईन निर्माण अन्तर्गत :

(ग) १३२ के.भी. वा सोभन्दा बढी क्षमताको विद्युत प्रसारण लाइन निर्माण गर्ने ।

(घ) विद्यमान २२० के.भी. वा सो भन्दा बढी क्षमताको विद्युत प्रसारण लाइनबाट ट्याप गरी नयाँ आउटडोर सवस्टेशन निर्माण गर्ने ।

२. विद्युत उत्पादन अन्तर्गत :

(क) १ मेगावाटदेखि ५० मेगावाट क्षमतासम्मको जलविद्युत उत्पादन आयोजना निर्माण गर्ने ।

(ख) १ मेगावाटदेखि ५ मेगावाट क्षमतासम्मको खनिज तेल वा ग्याँसबाट विद्युत उत्पादन आयोजना सञ्चालन गर्ने ।

प्रारम्भिक वातावरणीय परीक्षण गर्नुपर्ने प्रस्तावहरू (जलस्रोत र उर्जा क्षेत्र) :

(ऊ१) नवीकरणीय ऊर्जा क्षेत्र

(क) १ मेगावाटदेखि १० मेगावाट क्षमतासम्मको सौर्य उर्जाबाट विद्युत उत्पादन आयोजना सञ्चालन गर्ने,

(ख) १ मेगावाटदेखि १० मेगावाट क्षमतासम्मको वायु उर्जाबाट विद्युत उत्पादन आयोजना सञ्चालन गर्ने,

(ग) ०.५ मेगावाटदेखि २ मेगावाट क्षमतासम्मको जैविक ऊर्जाबाट विद्युत उत्पादन आयोजना सञ्चालन गर्ने,

(ओ) फोहोर मैला व्यवस्थापन क्षेत्र

१. घर एवं आवास क्षेत्रहरुबाट निस्कने फोहोरमैलाको सम्बन्धमा देहायको काम गर्ने :

(क) वार्षिक १,००० देखि ५,००० टनसम्म फोहोरमैला जमिनमा भर्ने ।

(ख) ५ देखि १० हेक्टरसम्मको क्षेत्रमा फैलिएको ट्रान्सफर स्टेशन र रिसोर्स रिकोभरी एरि या सम्बन्धी काम गर्ने ।

(ग) ५ देखि १० हेक्टरसम्मको क्षेत्रमा फैलिएको रसायन, यान्त्रिक वा जैविक तरिकाबाट फोहोर मैला छनौट, केलाउने, तह लगाउने र पुनः प्रयोग गर्ने ।

(घ) ५ देखि १० हेक्टरसम्मको क्षेत्रमा फैलिएको कम्पोष्ट प्लाण्ट सम्बन्धी काम गर्ने ।

(ङ) ५० लाखभन्दा बढी लागतको ढल निकास आयोजना सञ्चालन गर्ने ।

५ करोड रुपैंयाँदेखि २५ करोड रुपैयाँसम्म लागत लाग्ने कुनै विकास कार्य, भौतिक क्रियाकलाप वा भू—उपयोग परिवर्तन गर्ने कुनै योजना वा कार्यक्रम सञ्चालन गर्ने ।

वातावरणीय प्रभाव मूल्यांकन गर्नुपर्ने प्रस्तावहरू (जलस्रोत र उर्जा क्षेत्र) :

२. ५० मेगावाटभन्दा बढी क्षमताको जलविद्युत उत्पादन आयोजना निर्माण गर्ने ।

३. विद्युत उत्पादन अन्तर्गत :

(क) १ मेगावाटभन्दा बढीको कोइला वा आणविक विद्युत उत्पादन आयोजना सञ्चालन गर्ने,

(ख) ५ मेगावाटभन्दा बढीको खनिज तेल वा ग्याँसबाट विद्युत उत्पादन आयोजना सञ्चालन गर्ने ।

वातावरणीय प्रभाव मूल्यांकन गर्नुपर्ने प्रस्तावहरू (जलस्रोत र उर्जा क्षेत्र) :

(ऊ१) नवीकरणीय ऊर्जा क्षेत्र

(क) १० मेगावाटभन्दा बढी क्षमताको सौर्य उर्जाबाट विद्युत उत्पादन आयोजना सञ्चालन गर्ने ।

(ख) १० मेगावाटभन्दा बढी क्षमताको वायु उर्जाबाट विद्युत उत्पादन आयोजना सञ्चालन गर्ने ।

(ग) २ मेगावाटभन्दा बढी क्षमताको जैविक ऊर्जाबाट विद्युत उत्पादन आयोजना सञ्चालन गर्ने ।

(ओ) फोहोर मैला व्यवस्थापन क्षेत्र

१. १०,००० भन्दा बढी जनसंख्यालाई टेवा पुर्‍याउने उद्देश्यले सञ्चालन हुने फोहोरमैला व्यवस्थापन कार्य गर्ने ।

२. घर एवं आवास क्षेत्रहरुबाट निस्कने फोहोरमैलाको सम्बन्धमा देहायको काम गर्ने :

(क) वार्षिक ५,००० टनभन्दा बढी फोहोरमैला जमिनमा भर्ने ।

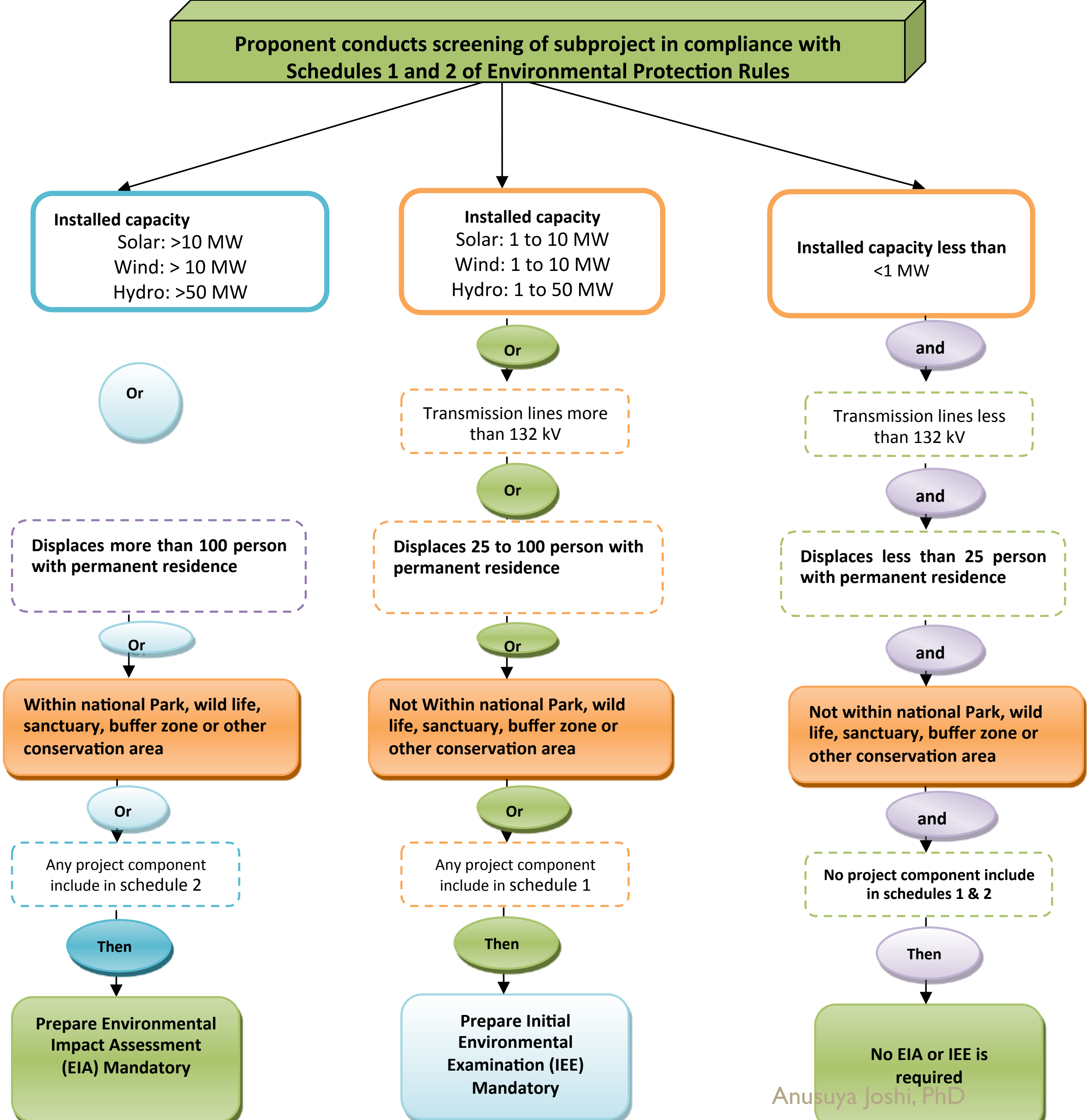
(ख) १० हेक्टरभन्दा बढी क्षेत्रमा फैलिएको ट्रान्सफर स्टेशन र रिसोर्स रिकोभरी एरिया सम्बन्धी काम गर्ने ।

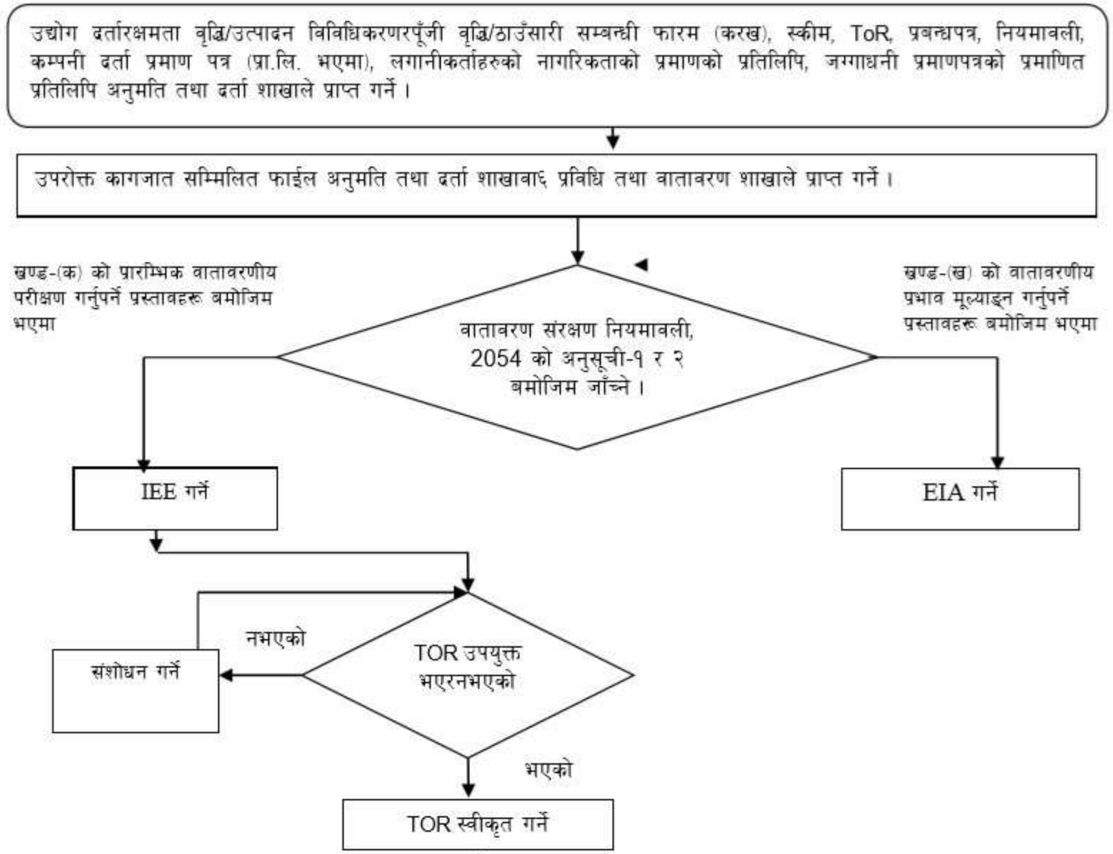
(ग) १० हेक्टरभन्दा बढी क्षेत्रमा फैलिएको रसायन, यान्त्रिक वा जैविक तरिकाबाट फोहोरमैला छनौट, केलाउने, तह लगाउने र पुनः प्रयोग गर्ने ।

(घ) १० हेक्टरभन्दा बढी क्षेत्रमा फैलिएको कम्पोष्ट प्लाण्ट सम्बन्धी काम गर्ने ।

(ङ) कम्तीमा १०,००० जनसंख्या भएको शहरी क्षेत्रबाट निस्कने फोहोरमैला गाड्ने काम गर्ने ।

२५ करोड रुपैयाँ भन्दा बढी लागत लाग्ने कुनै विकास कार्य, भौतिक क्रियाकलाप वा भू– उपयोग परिवर्तन गर्ने कुनै योजना वा कार्यक्रम सञ्चालन गर्ने ।


Proponent conducts screening of subproject in compliance with Schedules 1 and 2 of Environmental Protection Rules
Installed capacity
Solar: >10 MW
Wind: > 10 MW
Hydro: >50 MW
Installed capacity
Solar: 1 to 10 MW
Wind: 1 to 10 MW
Hydro: 1 to 50 MW
Installed capacity less than <1 MW
Or
Or
and
Transmission lines more than 132 kV
Transmission lines less than 132 kV
Or
and
Displaces more than 100 person with permanent residence
Displaces 25 to 100 person with permanent residence
Displaces less than 25 person with permanent residence
Or
Or
and
Within national Park, wild life, sanctuary, buffer zone or other conservation area
Not Within national Park, wild life, sanctuary, buffer zone or other conservation area
Not within national Park, wild life, sanctuary, buffer zone or other conservation area
Or
Or
and
Any project component include in schedule 2
Any project component include in schedule 1
No project component include in schedules 1 & 2
Then
Then
Then
Prepare Environmental Impact Assessment (EIA) Mandatory
Prepare Initial Environmental Examination (IEE) Mandatory
No EIA or IEE is required
Anusuya Joshi, PhD



IEE प्रतिवेदन साथ निम्नानुसारको कागजातहरु पेश गर्नु पर्ने :

क) राष्ट्रिय स्तरको दैनिक पत्रिकामा उद्योगको नाम, ठेगाना, कित्ता नं., उद्देश्य र क्षमता स्पष्ट हुने गरी प्रकाशित १५ दिने सार्वजनिक सूचनाको सक्कल प्रति ।

ख) गा.वि.स. /न.पा. मा सूचना टाँस गरेको सम्बन्धमा सूचना टाँसको मुचुल्काको सक्कल प्रति ।

ग) चौतर्फी संधियारहरु सहित न्यूनतम ७ जना सम्मिलित सर्जमिन मुचुल्का ।

घ) गा.वि.स. /न.पा. को सूचना टाँस भएको मितिले १५ दिनभित्र राय/सुझाव/उजुरी परे/नपरेको व्यहोरा सहितको उद्योग दर्ताको लागि सिफारिश पत्र ।

ङ) जग्गाधनी लालपूर्जाको प्रमाणित प्रतिलिपि ।

च) जग्गा भाडा सम्झौता (जग्गा भाडामा लिएको हकमा) ।

छ) वडा नं तथा कि.नं. समेत स्पष्ट उल्लेख भएको प्रमाणित नापीको नक्सा ।

ज) गा.वि.स. /न.पा. बाट चारकिल्ला प्रमाणित पत्र ।

झ) वातावरण संरक्षण नियमावलीको अनुसूची-५ मा उल्लेखित ढाँचाको IEE प्रतिवेदन ।

ञ) रुपन्देही र कपिलवस्तु जिल्लामा प्रस्तावित उद्योगका हकमा लुम्बिनी विकास कोषबाट लुम्बिनी गुरु योजनाको वाउण्ड्री वाल तथा भैरहवा लुम्बिनी सडक खण्डबाट उद्योग स्थलको दूरी सम्बन्धी पत्र ।

ट) कबुलियतनामा ।

नोट: १) नेपाल सरकारको सम्बन्धित निकायले तोकेको मापदण्ड भए सो अनुसारको विवरण र कागजातहरु ।

EIA गर्नु पर्ने प्रस्ताव

↓

स्किम, Scoping Document, TOR , राष्ट्रिय स्तरको दैनिक पत्रिकामा प्रकाशित ज्ञछ दिने सार्वजनिक सूचनाको सक्कल प्रति, गा.वि.स.रन.पा. को सूचना ६ाँस भएको मितिले ज्ञछ दिन भित्र रायरसुझाव सहितको पत्र र पेश भएका अन्य कागजातहरु विभाग समक्ष पेश गर्ने ।

↓

स्किम, Scoping Document, TOR र पेश भएका अन्य कागजातहरु आदिमा राय सुझाव सहित उद्योग मन्त्रालय मार्फत विज्ञान, प्रविधि तथा वातावरण मन्त्रालय पठाउने ।

↓

उपरोक्त Scoping Document / TOR स्वीकृत भई आएपछि EIA प्रतिवेदन सहित निम्न कागजातहरु पेश गर्न सूचित गर्ने ।

(क) सार्वजनिक सुनुवाईको पुष्ठ
(ख) सो सम्बन्धको राय सुझाव
(ग) गा.वि.स./न.पा.को सिफारिश पत्र

↓

उपरोक्त EIA प्रतिवेदन एवं कागजातहरु अध्ययन गर्ने र राय सुझाव सहित उद्योग मन्त्रालय मार्फत विज्ञान, प्रविधि तथा वातावरण मन्त्रालय पठाउने तथा छलफलमा भाग लिने ।

↓

विज्ञान, प्रविधि तथा वातावरण मन्त्रालयबाट EIA स्वीकृत भई सो को प्रमाणित प्रतिवेदन प्राप्त गर्ने ।

↓

प्राप्त प्रमाणित EIA प्रतिवेदन अनुमति तथा दर्ता शाखामा पठाउने ।