LECTURE-03

LOW COST SANITATION TECHNOLOGIES

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Introduction:

- An important reason why sanitation coverage is low in the developing countries compared to water supply is that whenever the designers or planners think of sanitation they mostly think of costly conventional sewerage systems or septic tank systems which most people in developing world cannot afford.

- High-cost conventional sewerage systems does not provide for additional health benefits over a properly installed low-cost simple pit latrine; it may only provide for convenience.

Fortunately, there exists a wide range of alternative sanitation technologies that are low-cost, easily maintainable and can be selected to suit different hydrological, socio-economic and cultural conditions.

Simple pit latrines:

- A pit latrine consists of a manually dug or bored hole into the ground, an appropriate seat or squatting slab and a superstructure erected over it. The pit is simply a hole in the ground into which excreta fall. Urine and other liquids soak into the ground and solid materials are retained and decomposed in the pit.

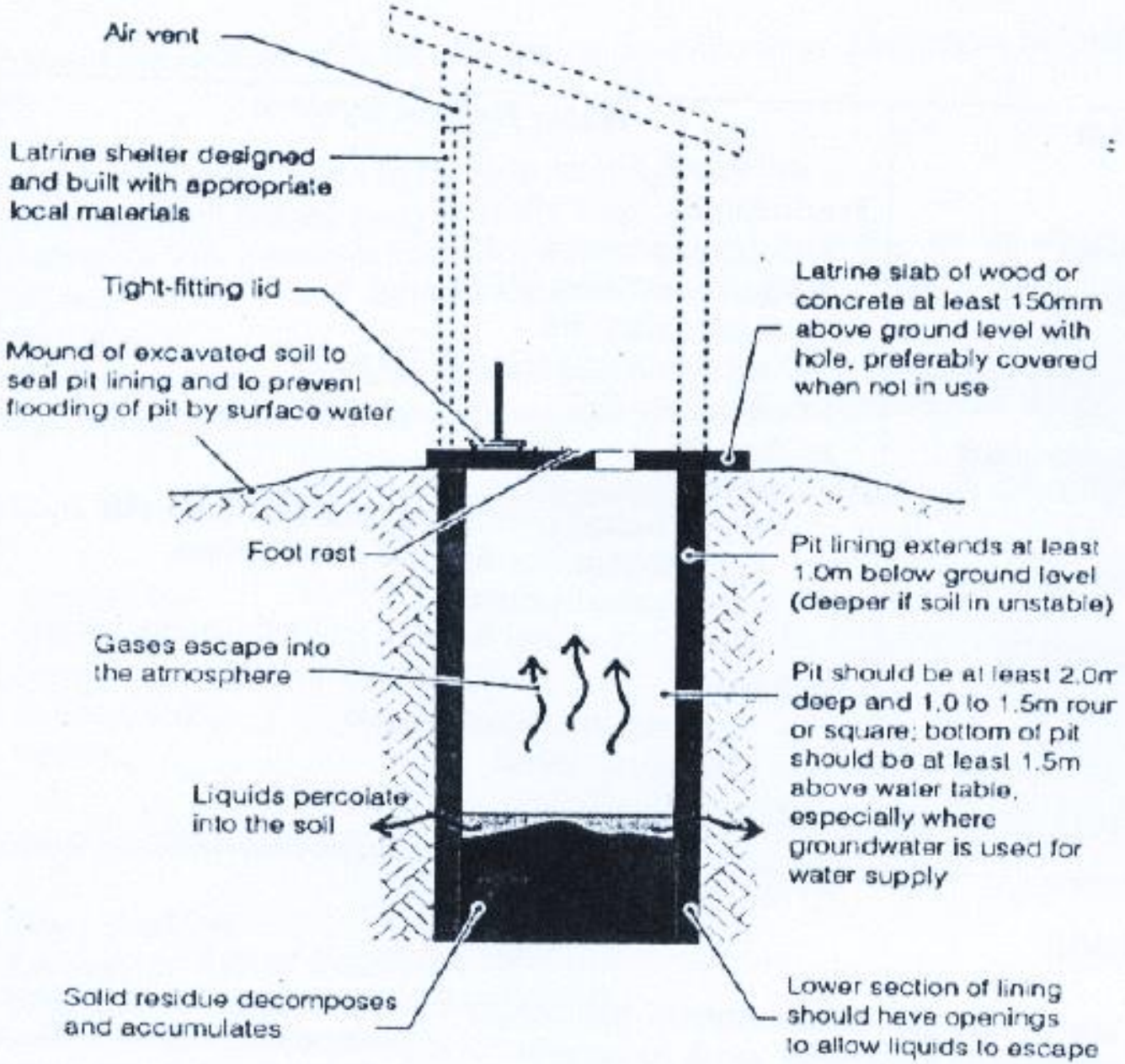


Figure: Simple pit Latrine

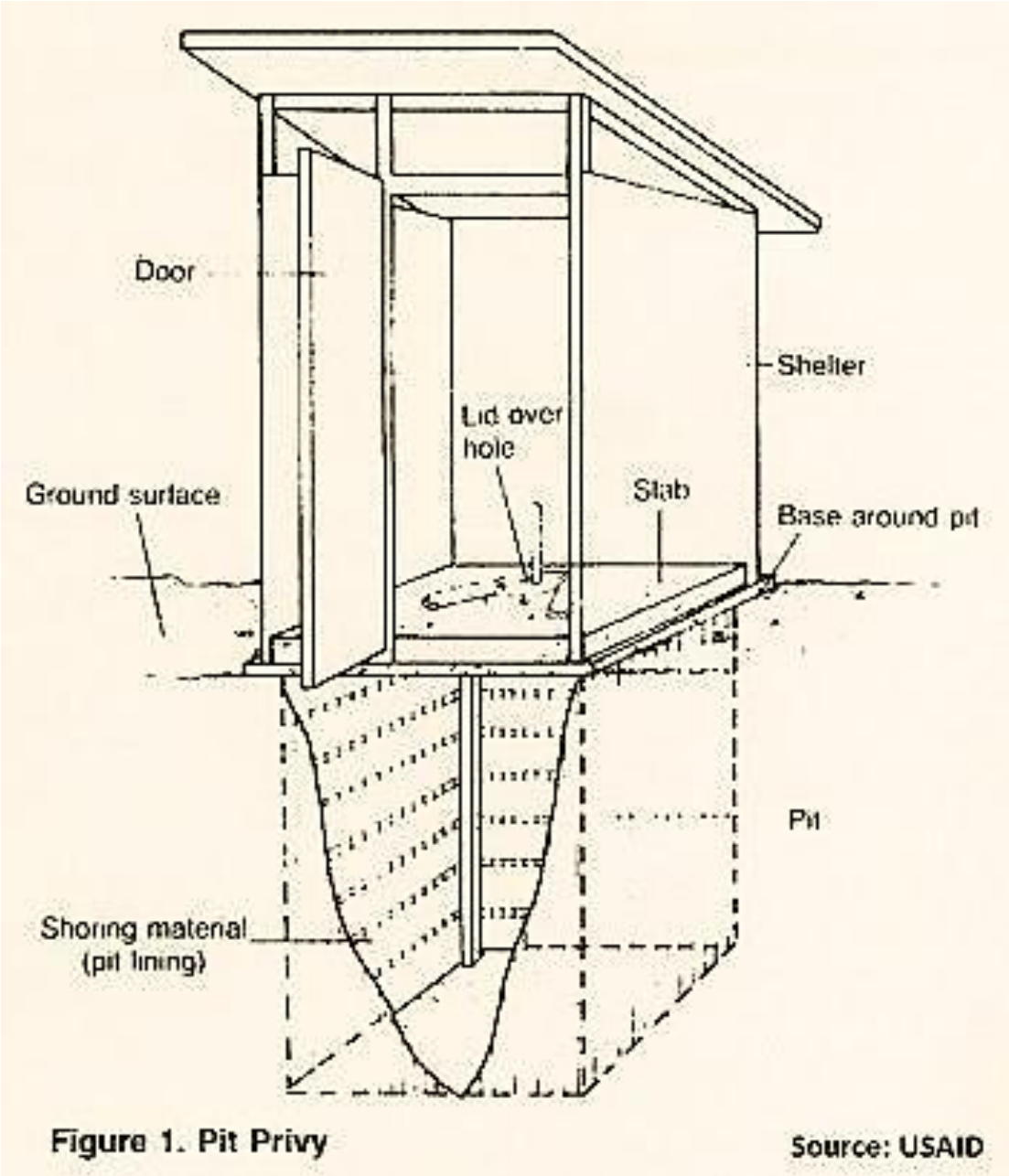


Figure 1. Pit Privy **Source: USAID**

❑ General design considerations for pit latrines:

- Pit should be as large as possible. However it should not be more than 1.5m wide.
- Soils with low permeability (below 2.5 mm/hour) are unsuitable for pit latrines as the liquid portion of excreta is unable to infiltrate into the soil.
- Pits in unstable soils must be fully lined.
- Safe distance between the latrine pit and a source of drinking water at least 10m should be provided.

Pit latrine design:

Effective pit volume: It depends on the solids accumulation rate, the number of users and the desired life of pit. The effective volume can be calculated as:

V=CxPxN

V=Effective volume of the pit

C= Solids accumulation rate,

P= Number of persons

N= Design life in years

According to Kalbermatten et.al (1980)

V=1.33x CxPxN

Solids accumulation rate:

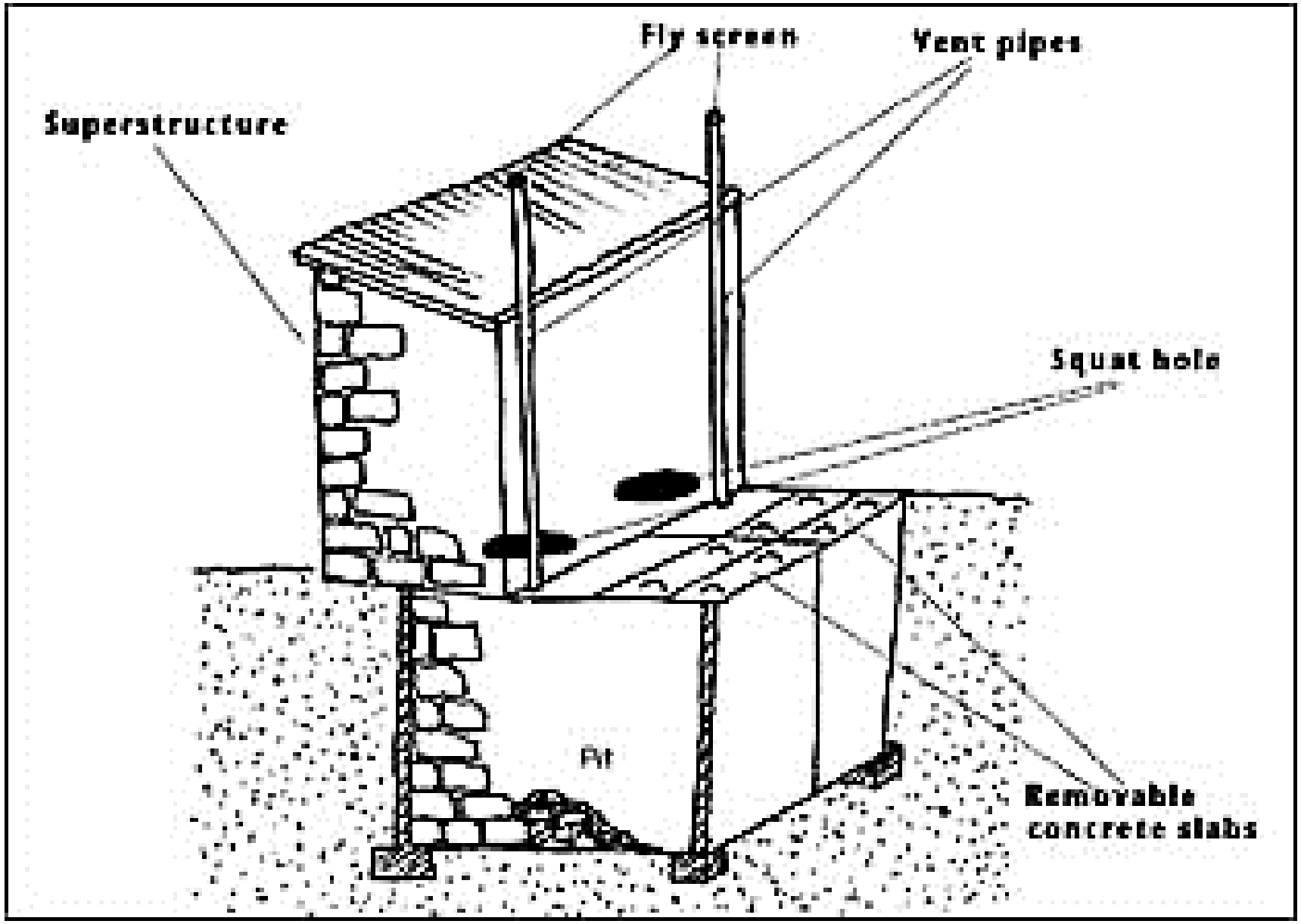
Excreta deposited into the pits have two essential components:

Liquid fraction of excreta , together with small amount of water that enters the pit due to anal cleansing and slab washing which ultimately infiltrates into the surrounding soil.

The faecal solids in excreta that are digested anaerobically to produce

(i) Gases such as methane, carbon dioxide and hydrogen sulphide which are exhausted from the pit via the squat hole or the vent pipe and

(II) Soluble compounds which are either further oxidized in the pit or are carried into the surrounding soil by infiltrating of the liquid fraction.


Fly screen
Vent pipes
Superstructure
Squat hole
Pit
Removable
concrete slabs

Why volume in wet pit is less than in dry pit?

In dry pits, solids accumulation rate 0.06 $\frac{\frac{m^3}{person}}{year}$. In wet pits solids accumulation rate 0.04 $\frac{\frac{m^3}{person}}{year}$

Solids accumulation rates are lower in wet pits because biodegradation is faster under wet conditions than under only just moist condition in dry pits. Anaerobic bacteria divide the solid pit into three types of biogas:

1. CH_4
2. CO_2
3. H_2S

ADVANTAGES OF PIT LATRINES:

Least costly

- Easily constructed and maintained
- Structurally safe and free from the risk of children falling into it.
- Prevents hookworm transmission.
- Offers a better solution than open defecation and unhygienic hanging latrines.

DISADVANTAGES OF PIT LATRINES:

- Flies lay their eggs in faeces within poorly built latrines.
- Odor nuisance
- Improper lining of pits may lead to collapse of the superstructure.

How to overcome the disadvantages of simple pit latrines:

- Ventilated Improved Latrines are an improvement to overcome the disadvantages of the simple pit latrines . The main problems associated with traditional simple pit latrines i.e. fly and mosquito nuisance and unpleasant odours are effectively minimized by the action of a vent pipe, fly screen and a squatting cover in the VIP latrines.

Elements of VIP latrines:

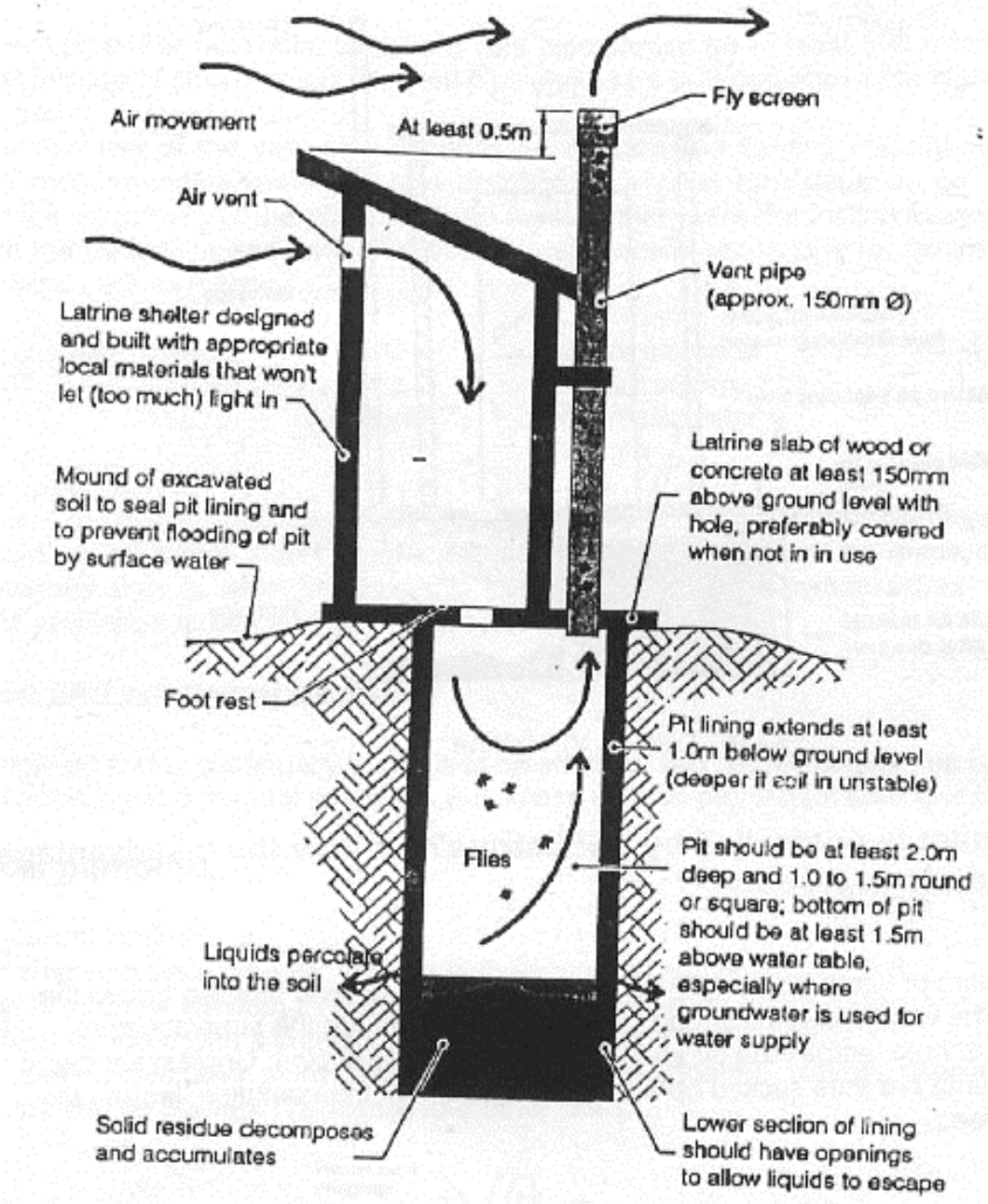
- The pit which can be either a single pit or an alternating twin pit.
- A cover slab usually of reinforced concrete which covers the pit.
- A super structure for privacy and protection from rain and sun which can be built according to the choice of users.
- The vent pipe and the fly screen which keeps the latrine free from flies, mosquitos and unpleasant odors.

- **Single pit VIP latrines:**

It consists of one pit, a vent pipe, and a superstructure and are suitable where mechanical emptying is possible when the pit is full.

- **Alternating twin pit VIP latrines:**

It has two separate pits, each with their own vent pipe. Only one squat hole and pit are used at a time , the squat hole over the pit being closed by a concrete plug when the pit is full. After 1-3 years , its squat hole is covered up and the second pit is put into service.


Air movement
At least 0.5m
Fly screen
Air vent
Vent pipe
(approx. 150mm Ø)
Latrine shelter designed and built with appropriate local materials that won't let (too much) light in
Mound of excavated soil to seal pit lining and to prevent flooding of pit by surface water
Latrine slab of wood or concrete at least 150mm above ground level with hole, preferably covered when not in in use
Foot rest
Pit lining extends at least 1.0m below ground level (deeper if soil in unstable)
Flies
Pit should be at least 2.0m deep and 1.0 to 1.5m round or square; bottom of pit should be at least 1.5m above water table, especially where groundwater is used for water supply
Liquids percolate into the soil
Solid residue decomposes and accumulates
Lower section of lining should have openings to allow liquids to escape

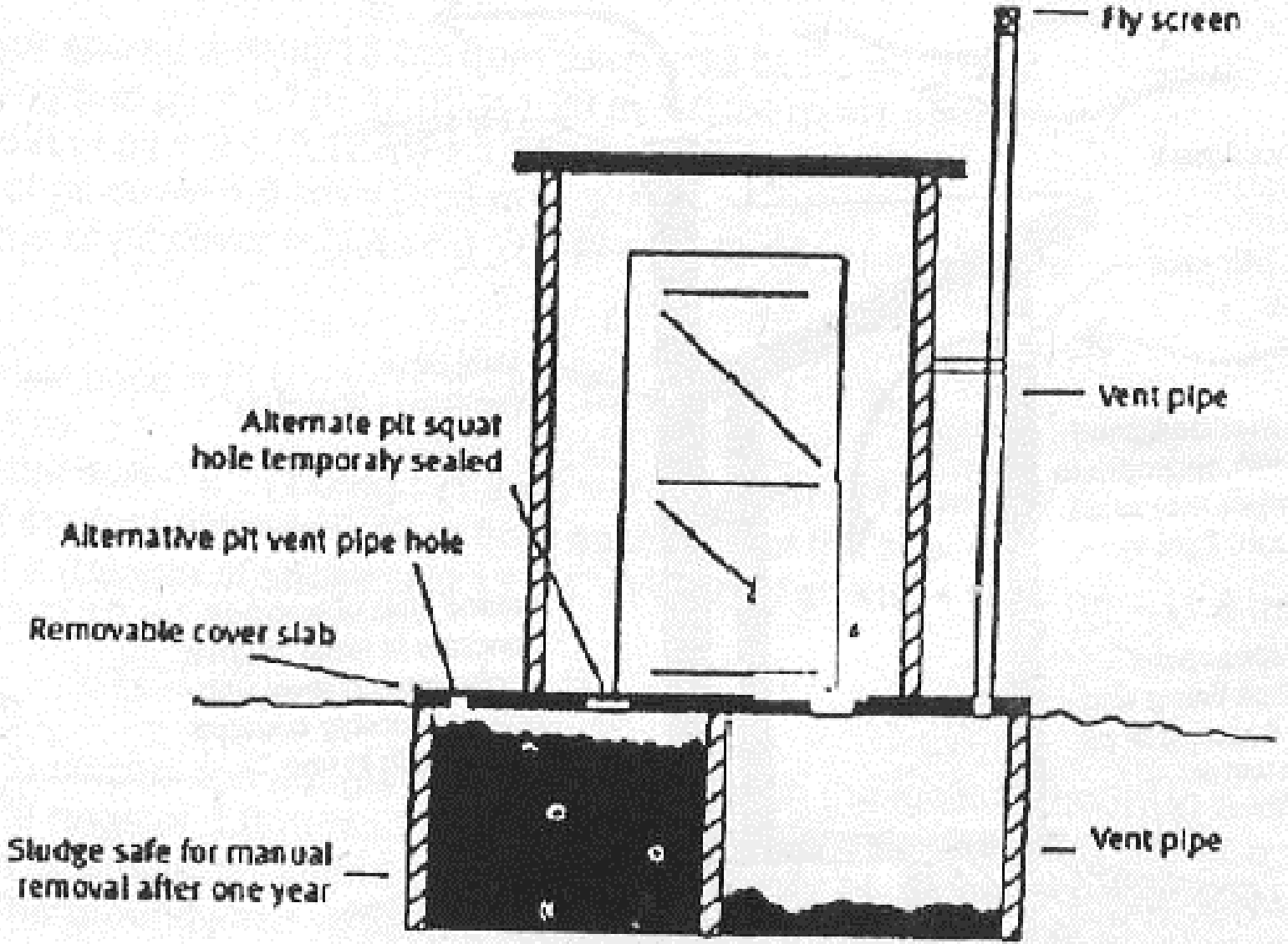


Figure: Twin-pit VIP latrine

ADVANTAGES OF VIP LATRINE:

- Controls odour and insects.
- Minimum health risk.
- Low cost
- Easy construction and maintenance
- Minimum water requirement
- Twin-pit VIP latrine system offers a long-term solution

DISADVANTAGES OF VIP LATRINE:

- Potential of groundwater pollution
- Lack of space for relocating the pit in densely populated areas
- Difficulty of construction in rocky and high water table areas

REED ODOURLESS EARTH CLOSET (ROEC):

- With ROEC, the pit is fully off-set from the superstructure and is connected to the squatting plate by a curved chute.
- It is fitted with a vent pipe to control odour and insect nuisance. It is claimed that the chute , in conjunction with the ventilation stack, encourages vigorous air circulation down the latrine, thereby removing odours and discouraging flies. This latrine is common in south Africa.

ADVANTAGES OF ROEC:

- ROEC pit can be made larger as the superstructure is fully off-set and thus can have a longer life than VIP latrine.
- Pit can be easily emptied without disturbing the superstructure.
- There is no danger of users, particularly children falling into it.
- It may be more acceptable to users because the excreta can not be seen.

DISADVANTAGES OF ROEC:

The ROEC chute easily becomes fouled with excreta, thereby providing a possible site for fly breeding and odour nuisance.

The chute has to be regularly cleaned with a long-handled brush or a small amount of water.

Compost Latrines:

- The basic principle of a compost latrine is that aerobic decomposition of faeces generates sufficient heat to destroy the pathogens and forms a good soil conditioner for subsequent use.

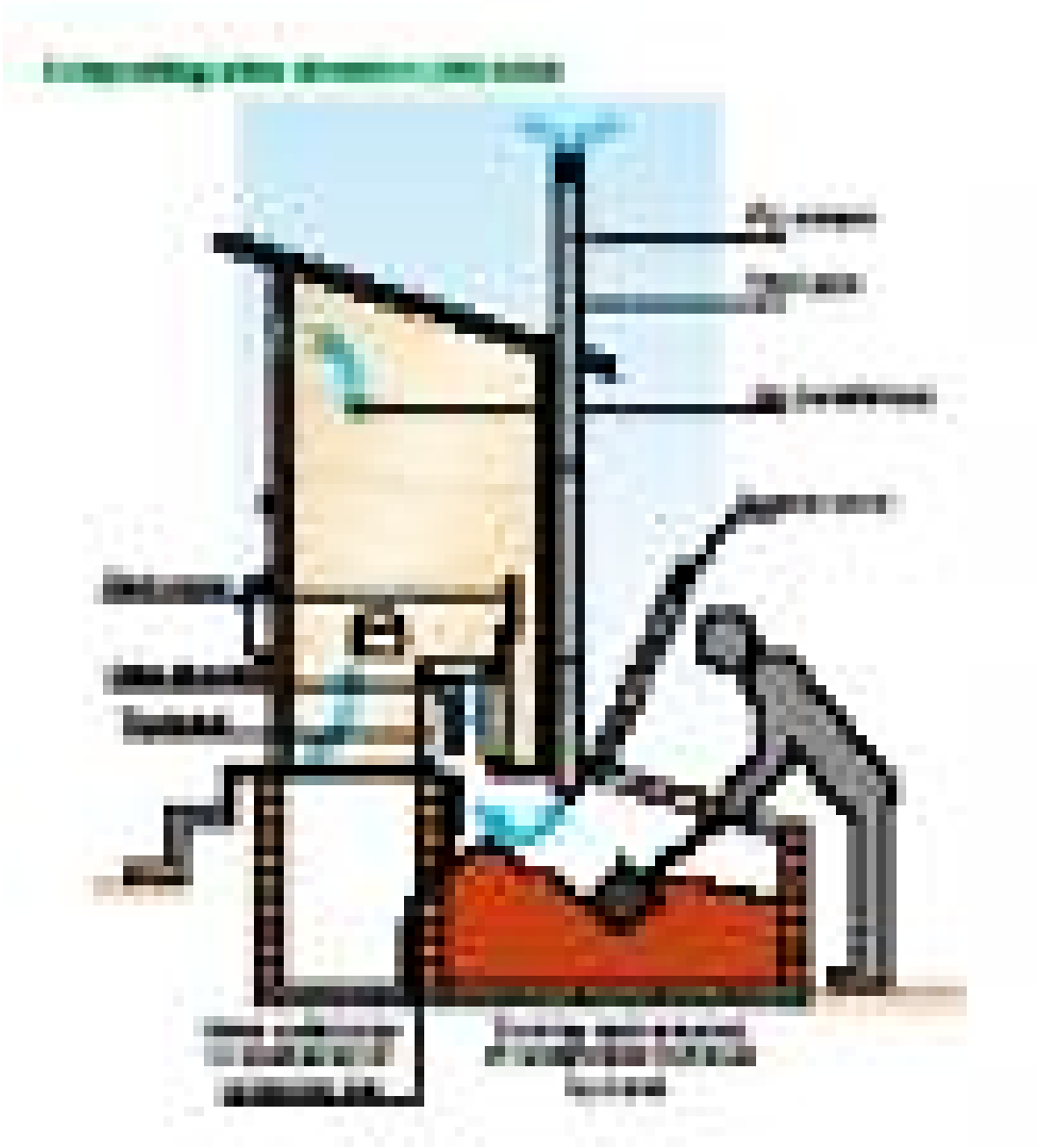
- Necessary conditions for the compost process include an appropriate carbon to nitrogen ration (C/N ratio), a low moisture content and access to air to ensure aerobic conditions.

ADVANTAGES OF COMPOST LATRINES:

- Appropriate for use in areas where there is a tradition of using human excreta on the land.
- It can be useful in areas where there is a need for soil conditioner.
- Need no water for flushing because composting is most efficient if the material is moist but not wet; need not penetrate the subsoil and can be built on rock.
- Pose a low pollution risk.

DISADVANTAGES OF COMPOST LATRINES:

- Need organic waste to correct the C/N ration of the excreta and a substantial amount of biodegradable organic matters must be locally available.
- Need care in their operation, and should be applied where users are keen to operate the system carefully to obtain compost for fields or gardens.



Pour Flush Sanitation Technologies:

It has three major components are:

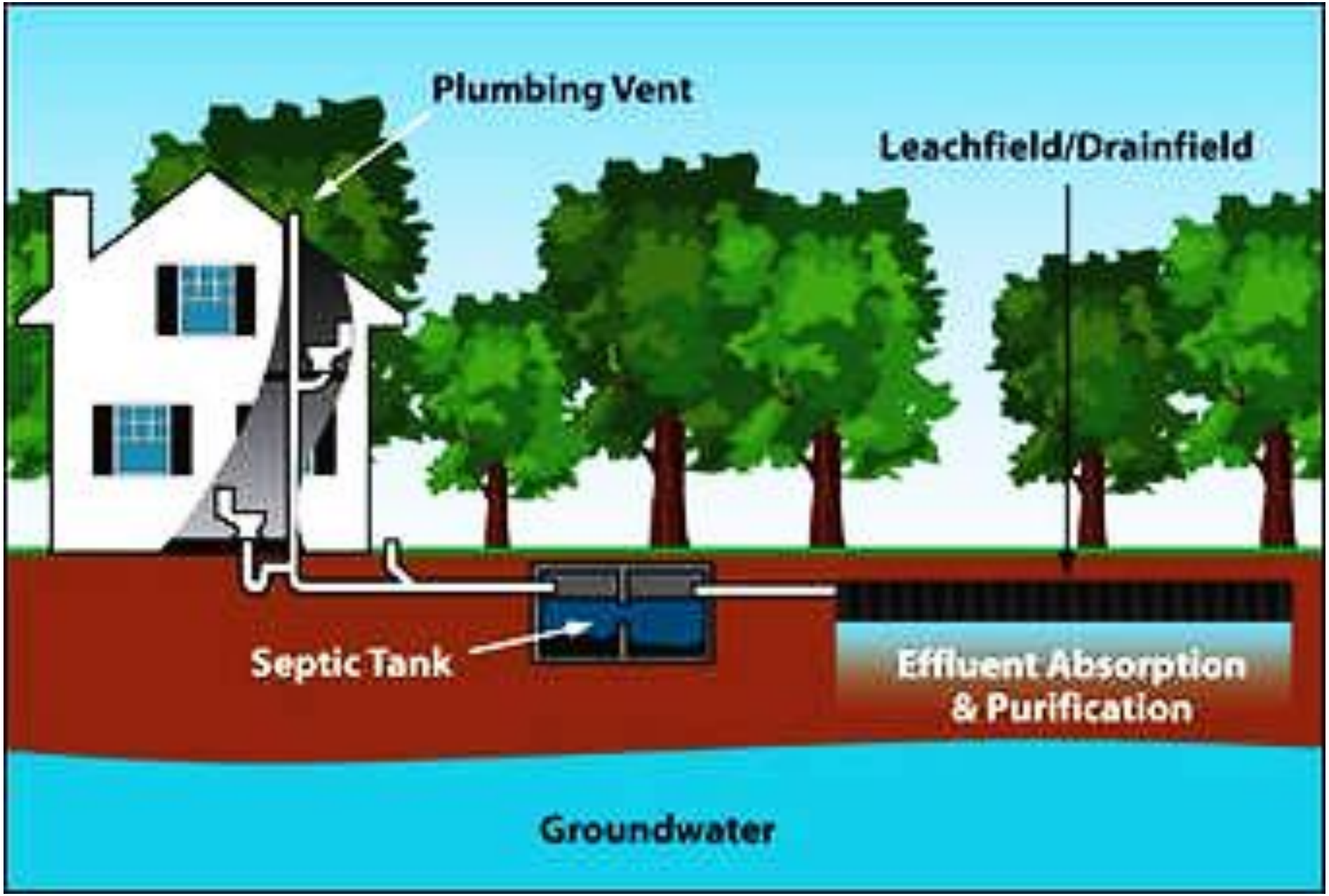
- The superstructure
- The latrine pan with its integral water seal
- A single or alternating twin leach pits

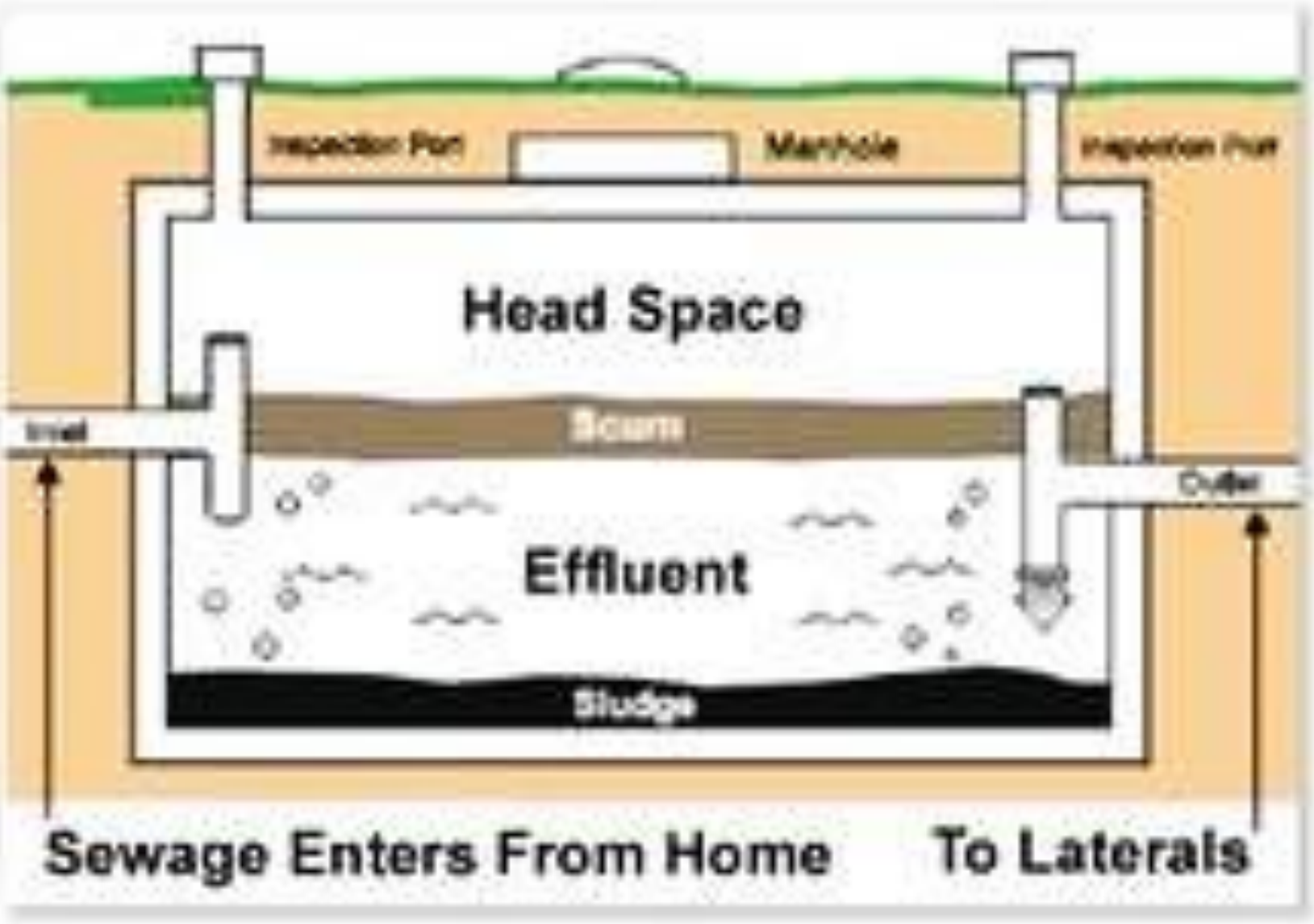
There are two basic types of pour flush latrines:

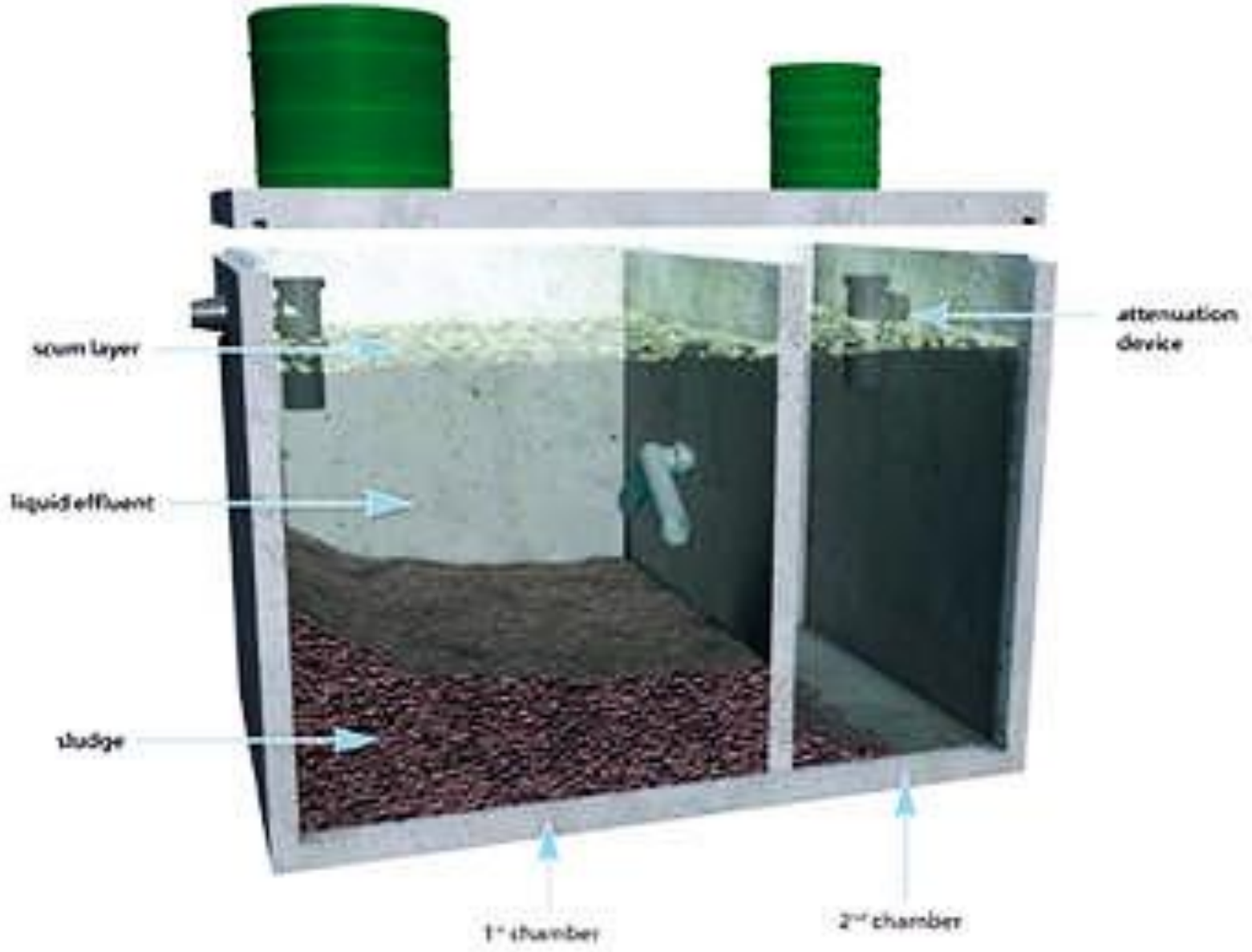
1. Direct pit pour flush latrine
2. Off-set pit pour flush latrine

❑ Septic Tank System:

- It is a buried watertight receptacle designed and constructed to receive waste water from a home, to separate the solids from the liquid, to provide limited digestion of organic matter, to store solids and to allow the clarified liquid to discharge for further treatment and disposal.
- Settable solids and partially decomposed sludge settle to the bottom of the tank and gradually build up.


Plumbing Vent
Leachfield/Drainfield
Septic Tank
Effluent Absorption
& Purification
Groundwater


Inspection Port
Manhole
Inspection Hole
Head Space
Inlet
Scum
Outlet
Effluent
Sludge
Sewage Enters From Home
To Laterals


scum layer
liquid effluent
sludge
attenuation device
1st chamber
2nd chamber

❑Processes in a septic tank system:

The most important processes that takes place within the septic tank includes:

1. Separation of suspended solids
2. Digestion of sludge and scum
3. Stabilization of the liquids
4. Growth of micro-organisms

Performance of a septic tank:

It depends on its design. Under normal design conditions, reduction in BOD of 25-30% and is in suspended solids of up to 70% have been reported. The high reduction in BOD and SS can now be obtained by prolonging the retention time, which in most cases may not be practicable.

The factors which effect the performance of the septic tank are:

1. Retention time
2. Ambient temperature
3. The nature of influent wastewater
4. Its organic content
5. The positions of the inlet and outlet devices in the tank

Design of Septic Tank:

Scum Storage

Sedimentation Storage

Sludge digestion

Digested sludge zone

Scum storage: $V_{sc} = 0.4V_{sl}$; SL= sludge

Sedimentation storage zone:

$$t_r = 1.5 - 0.3\log(pq)$$

t_r= time required for sedimentation, days

$$V_h = 10^{-3}pqt_r$$

q= per capita wastewater discharge (lit/capita/day)

P=No. of persons

Sludge digestion: $t_d = 30x(1.035)^{35-T}; days$

T =Ambient temp.=20°C~25°C

$$V_d = 0.5x10^{-3}\text{x p}t_d$$

Sludge storage: $V_{sl} = CPN$

When, N$\leq$ 5 $year$; $C = 0.06\ \frac{\frac{0.06m^3}{person}}{year}$

When, N> 5 year; $C = 0.04\ \frac{\frac{0.06m^3}{person}}{year}$

Overall design capacity:

$$V = V_{sc} + V_H + V_D + V_{SL}$$
$$= 1.4V_{SL} + V_H + V_D$$

Clear Space Depth:

Scum clear depth=Minimum 0.075m

Sludge clear depth= 0.82-0.26A (minimum 0.30m)

A=Tank surface area;

Minimum total clear space depth= 0.075+0.30=0.375m

See Example 5 from reference 1. page 150.