Environmental Engineering - II
CE 4141

Course Co-ordinator:

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Learning Objectives

- To introduce with different types of sanitation and their management systems
- To understand the proper hygienic behaviour for controlling the disease transmission
- To understand the wastewater collection, transport and treatment systems

Course Outlines

- Environmental sanitation
- Sanitation options/systems
- Low-cost sanitation technologies
- Environmental pollution
- Environmental management
- Environmental impact assessment

Environmental Sanitation

- Definition of sanitation
- Objectives/principles of sanitation
- Classification of wastes
- Interrelationship between water, sanitation and health education
- Role of sanitation in controlling the transmission of excreta-related disease

Reference Books

- Water supply and sanitation – M. Feroze Ahmed and Md. Mujibur Rahman
- Water supply and sanitary engineering – S. C. Rangwala

Environmental Sanitation

Sanitation: Sanitation may be defined as the science and practice of effecting healthful and hygienic conditions, and involves the study and use of hygienic measures such as:

- Safe, reliable water supply
- Proper drainage of wastewater
- Proper disposal of all human wastes
- Prompt removal of all refuse

Objectives of sanitation

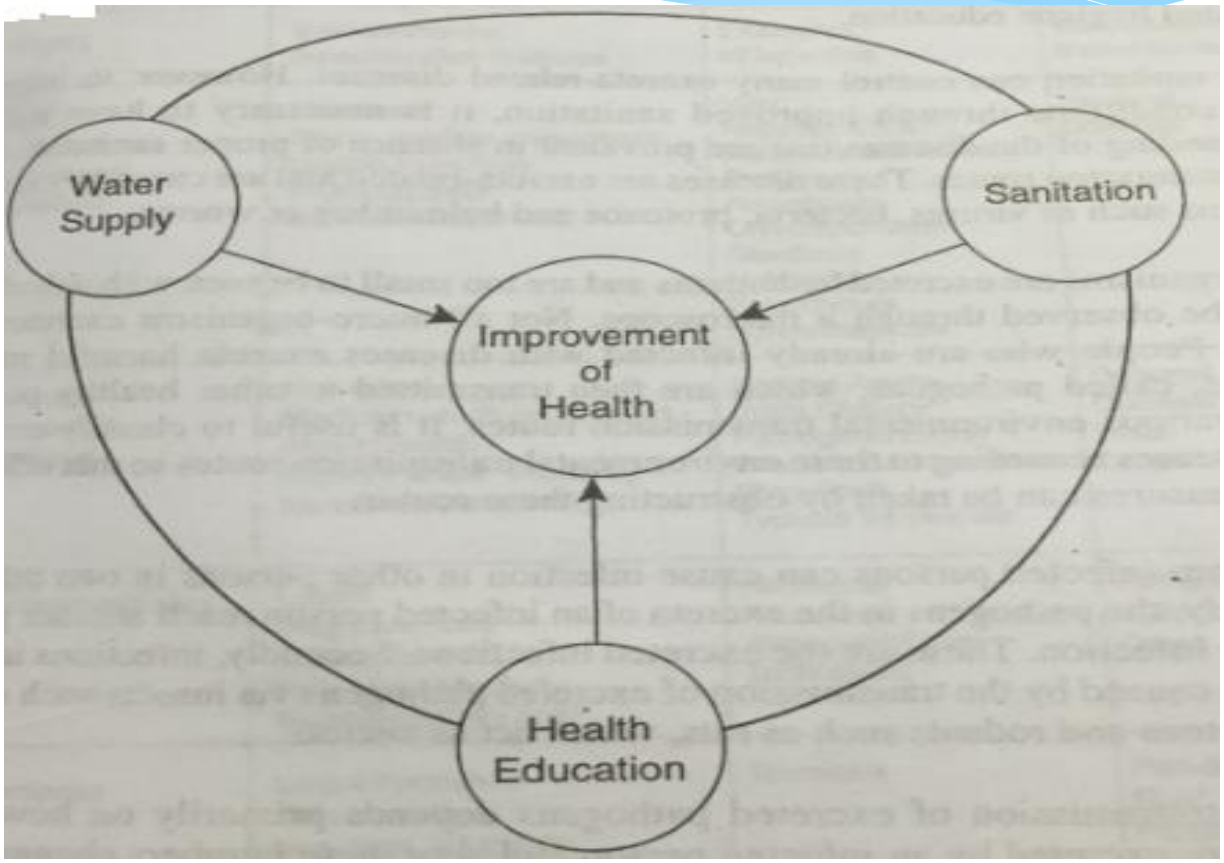
- ✓ to have improved public health
- ✓ to minimize environmental pollution

Environmental Sanitation

Interrelationship between water, sanitation and health education

IDWSS (1981-1990)

- 122 deaths for every 1000 live births in 1981
- Infant mortality rate was 110 in 1990
- Low sanitation coverage (6% of rural population) and absence of health education
- Infant mortality rate decreased to 77 per 1000 live births in 1996 due to gradual improvement of sanitation coverage (33% of rural and 42% of urban population in 1993)



Environmental Sanitation

Interrelationship between water, sanitation and health education

Bangladesh Demographics Profile 2018

Population	157,826,578 (July 2017 est.)
Death rate	5.4 deaths/1,000 population (2017 est.)
Drinking water source	**improved:** urban: 86.5% of population rural: 87% of population total: 86.9% of population **unimproved:** urban: 13.5% of population rural: 13% of population total: 13.1% of population (2015 est.)

Environmental Sanitation

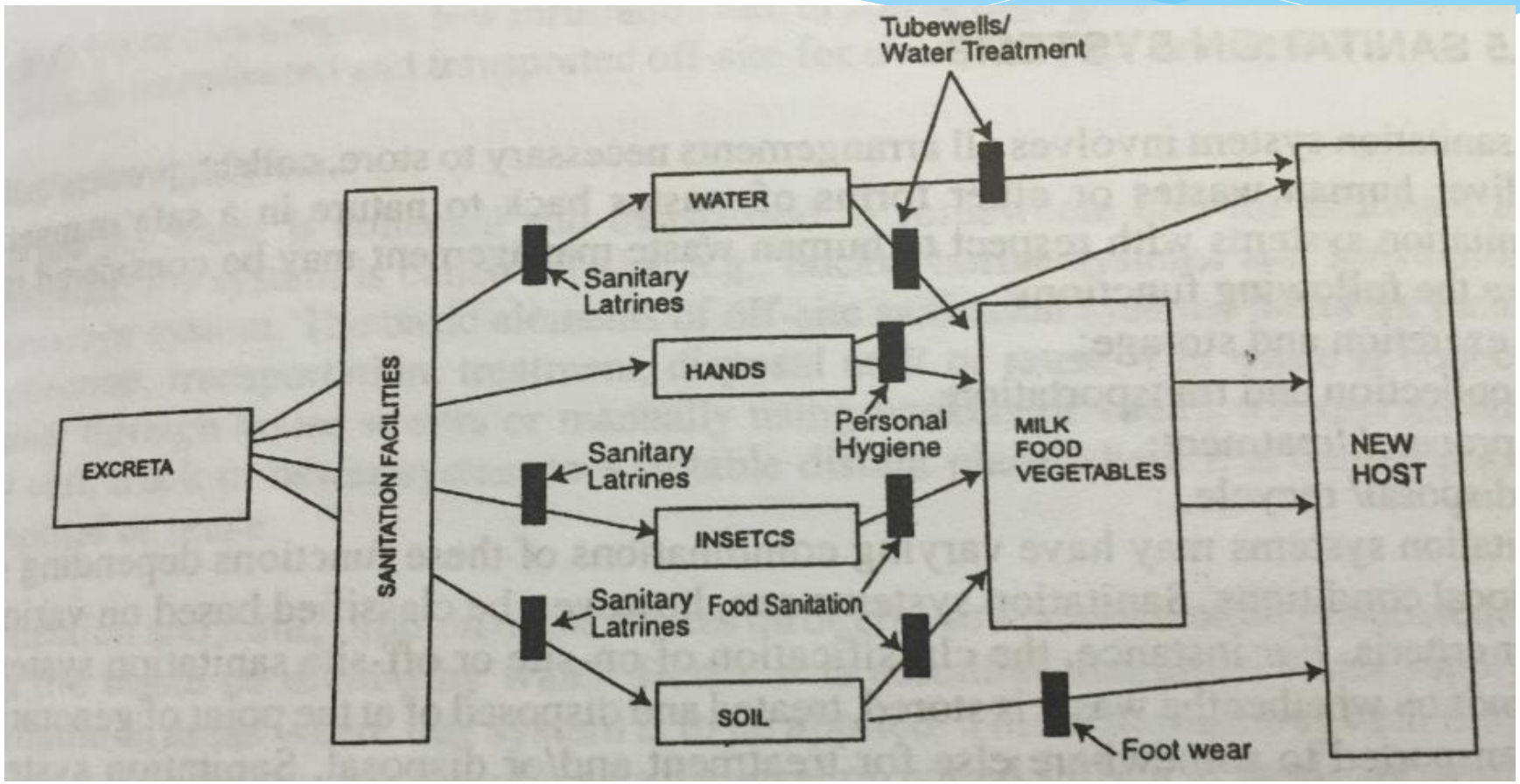
Interrelationship between water, sanitation and health education

Bangladesh Demographics Profile 2018

Sanitation facility access	**improved:** urban: 57.7% of population rural: 62.1% of population total: 60.6% of population **unimproved:** urban: 42.3% of population rural: 37.9% of population total: 39.4% of population (2015 est.)
Infant mortality rate	**total:** 31.7 deaths/1,000 live births (2017 est.)

Environmental Sanitation

Role of sanitation in controlling the transmission of excreta-related disease



Environmental Sanitation

Let's see a video about importance of hygienic practices

Classification of Wastes

Human Waste: human faeces and urine only. No dilution with water. Also called night soil.

Municipal sewage/wastewater: domestic and industrial discharges, storm water, groundwater infiltration and inflow.

Domestic sewage: Sanitary conveniences e.g. water closets, urinals, baths, sinks etc.

Sullage: Kitchens and wash basins.

Industrial wastes: Industrial processes such as manufacturing and food processing.

Classification of Wastes

Storm water: surface runoff during and immediately after the rainfall.

Solid wastes: useless or unwanted solid materials such as paper and paper products, wood, plastics, leather and rubber materials, rags, glass, metal and stone etc.

Sanitation Options/Systems

- Definition of sanitation systems
- Functions of sanitation systems
- Types of sanitation systems
- Suitability of different types of sanitation systems
- Factors affecting the selection of suitable sanitation systems
- Factors effecting the sanitation systems in Bangladesh

Sanitation Systems

A **sanitation system** involves all arrangements necessary to **store, collect, process and deliver** human wastes or other forms of wastes back to nature in a safe manner.

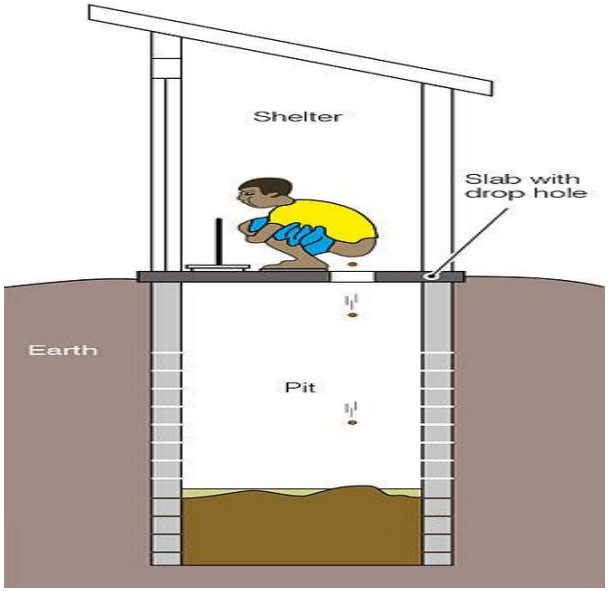
Function of sanitation system:

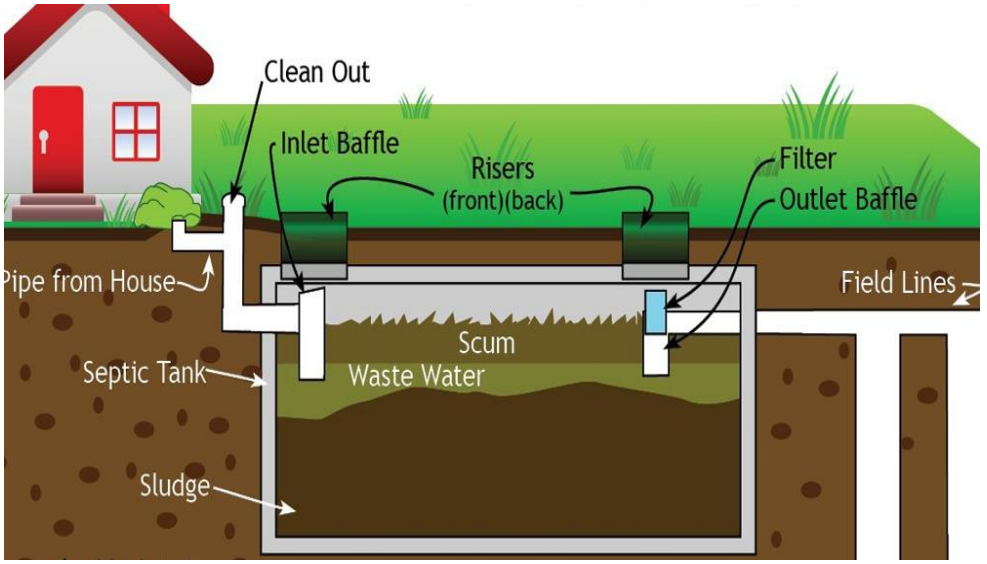
- Excretion and storage
- Collection and transportation
- Process/treatment
- Disposal /recycle

Types of Sanitation Systems

On-site systems: When the wastes are collected, treated and disposed of at the point of generation it is called on-site systems.

Example: Pit latrine, septic tank systems





Types of Sanitation Systems

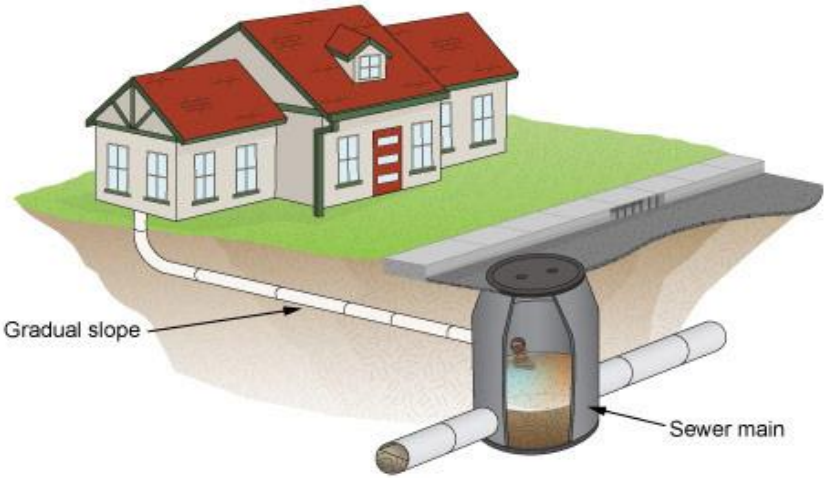
Suitability of on-site systems

- Rural areas with low population density
- Low water consumption
- Low infiltration rate of soil
- Low groundwater table areas

Types of Sanitation Systems

Off-site systems: When the wastes are collected and transported to somewhere else for treatment and disposal, it is called off-site systems.

Example: Bucket latrine systems, conventional sewerage systems



Types of Sanitation Systems

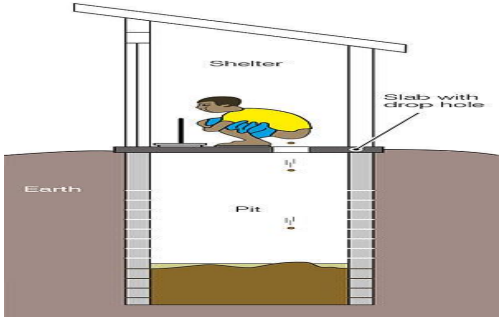
Suitability of off-site systems

- Rural/urban areas with high population density
- high water consumption
- high infiltration rate of soil
- high groundwater table areas

Types of Sanitation Systems

Dry systems: In dry systems no water is used for the dilution of the waste.

Example: Pit latrine systems (on-site), bucket latrine systems (off-site)

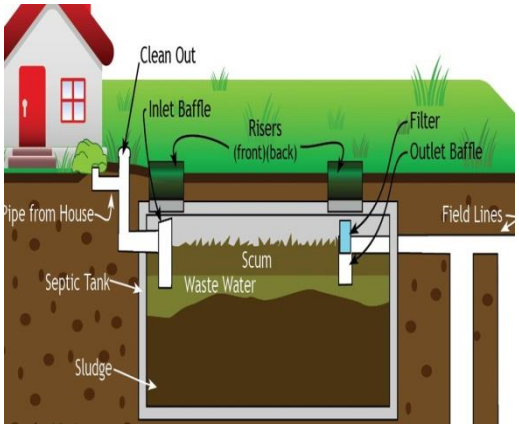


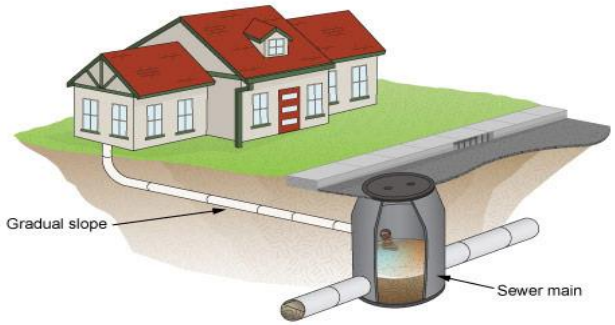
Suitability: Pipe water supply is not available

Types of Sanitation Systems

Wet systems: **In wet systems the waste is diluted with flushes of water.**

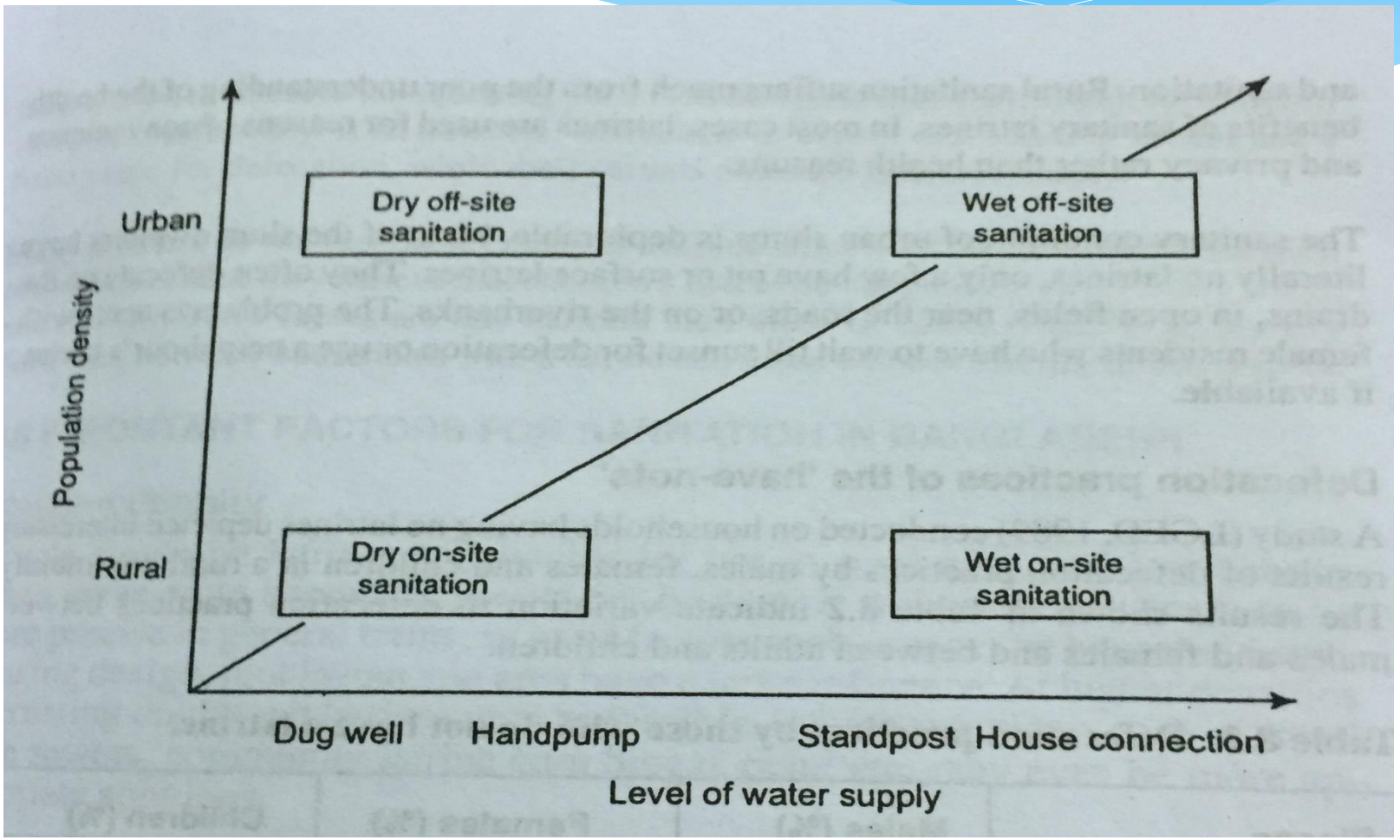
Example: septic tank systems (on-site), conventional sewerage systems (off-site)





Suitability: Pipe water supply is available

Appropriateness of Sanitation Systems



Problems of sanitation faced in Bangladesh

- **Housing Density:** 300 people per hectare
- **Water supply service level:** 30 l/c/d
- **Difficulties associated with pit latrines:** 1 m elevated pit with 0.6 m impermeable lining
- **Operation and maintenance**

Problems of sanitation faced in Bangladesh

- **Soil permeability:** 2.5 mm/h
- **Groundwater pollution:** 1-2 m unsaturated soil but can travel upto 100 m in gravel below water table

  - 2 m between bottom of pit and water surface

  - 10 m away from water sources

Any Question?

Thank you

Low-cost sanitation technologies

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Low-cost sanitation technologies

- Simple Pit Latrines
- Ventilated Improved Pit (VIP) Latrines
- Reed Odourless Earth Closet (ROEC) Latrines
- Compost Latrines
- Pour-Flush Latrines
- Aqua Privies
- Septic Tank System
- Communal Sanitation Systems

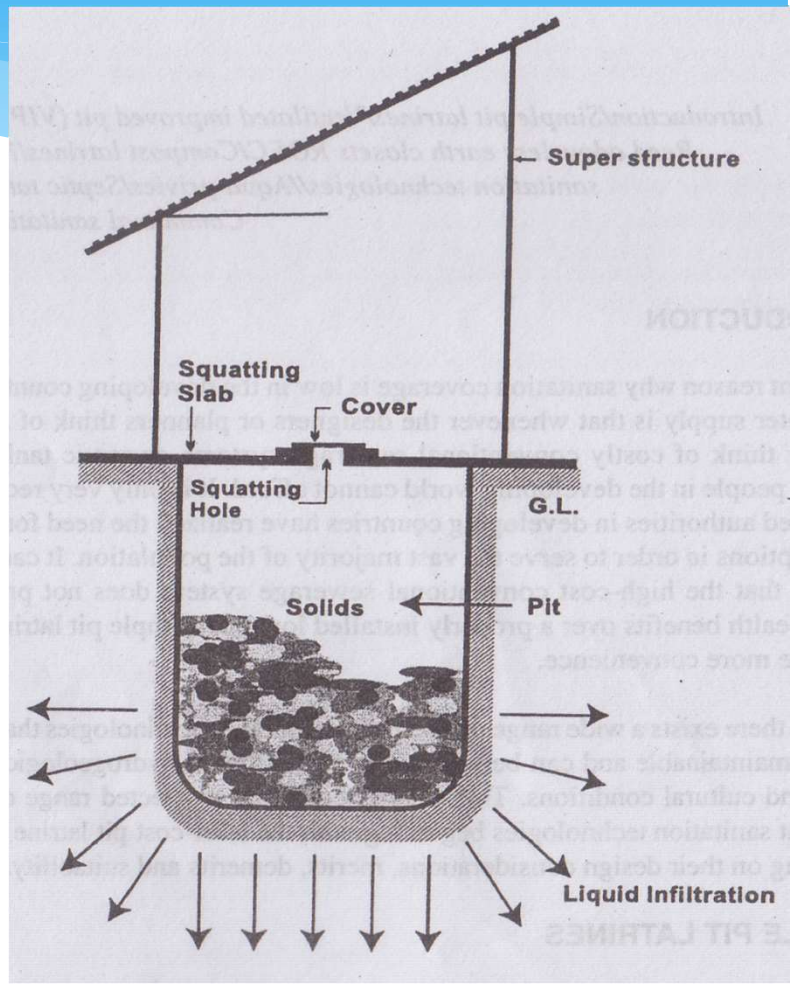
Simple Pit Latrines

Basic Components:

- a manually dug or bored hole into the ground
- an appropriate seat or squatting slab
- a superstructure

Basic Principle:

- Urine and other liquids soak into the ground
- Solid materials are decomposed



Simple pit latrine

Suitability of Pit Latrines

- Most common and simplest form of excreta disposal in many developing countries
- Widely used in low-income urban communities
- Most appropriate for individual householders

Simple Pit Latrines

Based on the location of pit, pit latrine are three types. These are

- **Direct pit latrine:** When excreta fall directly into a pit underneath the user, it is called a direct pit latrine.
- **Offset pit latrine:** When excreta pass through a short pipe or a channel to a pit a few meters away, it is called offset pit latrine.
- **Partly pit latrine:** When part of the pit is under the shelter and part is outside, where a removable cover allows the contents to be taken out, it is called partly offset pit latrine.

Simple Pit Latrines

General design considerations:

- **Pit Size:** Not more than 1.5 m wide.
- **Soil permeability:** Low permeability below 2.5 mm/h are unsuitable.
- **Lining:** Concrete ring, bricks, cement-stabilized soil blocks, masonry, perforated oil drums etc.
- **Safe distance:** At least 10 m

Pit Latrine Design

Effective pit volume

$$V = C \times P \times N$$

Where,

V = effective pit volume in m3

C = solids accumulation rate in m3/person/year

P = number of users

N = design life of pit in years

Pit Latrine Design

Kalbermatten et al. (1980) suggested the following equation for a pit latrine of depth not exceeding 4 m.

$$V = 1.33 \times C \times P \times N$$

Where,

V = effective pit volume in m3

C = solids accumulation rate in m3/person/year

P = number of users

N = design life of pit in years

Pit Latrine Design

Table 1: Solids accumulation rates (m3/person/year)
Source: Kalbermatten et al. (1980)

Wet pit		Dry pit	
Anal cleansing: water	Anal cleansing: solids	Anal cleansing: water	Anal cleansing: solids
0.04	0.06	0.06	0.09

Pit Latrine Design

Design a pit latrine for a household of 8 persons for a period of 5 years. The groundwater table is 4 m below the ground surface. People are using water for anal cleansing. A safe distance need to be maintained to protect the groundwater contamination.

Pit Latrine Design

Design a pit latrine for a household of 8 persons for a period of 5 years. The groundwater table is 4 m below the ground surface. People are using water for anal cleansing. A safe distance need to be maintained to protect the groundwater contamination.

$$V = 1.33 \times C \times P \times N = 1.33 \times 0.06 \times 8 \times 5 = 3.192 \text{ m}^3$$

Assume, dia of pit = 1.25 m

$A = 1.23 \text{ m}^2$

Depth of pit = V/A = 2.59 ≈ 2.6 m

A lining of 0.6 m need to be provided to protect the groundwater contamination.

Advantages and Disadvantages

Advantages:

- Least costly
- Easily constructed and maintained
- Prevents hookworm transmission
- Offers a better solution than open defecation and unhygienic hanging latrines.

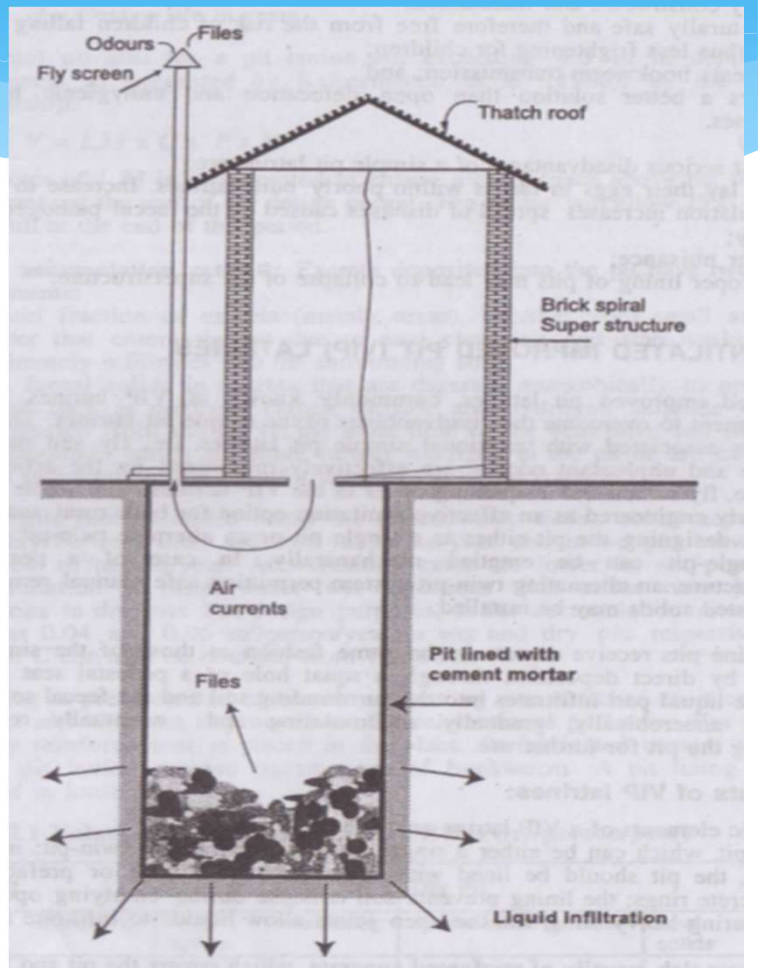
Disadvantages:

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

Ventilated Improved Pit (VIP) Latrines

Basic Components:

- A Pit – single pit or alternating twin-pit
- A cover slab - usually made of concrete; contain two holes: one squat hole and the other for the vent pipe
- a superstructure – privacy and protection from rain and sun
- Vent pipe and flyscreen – keep the latrine free from flies, mosquitoes and unpleasant odours

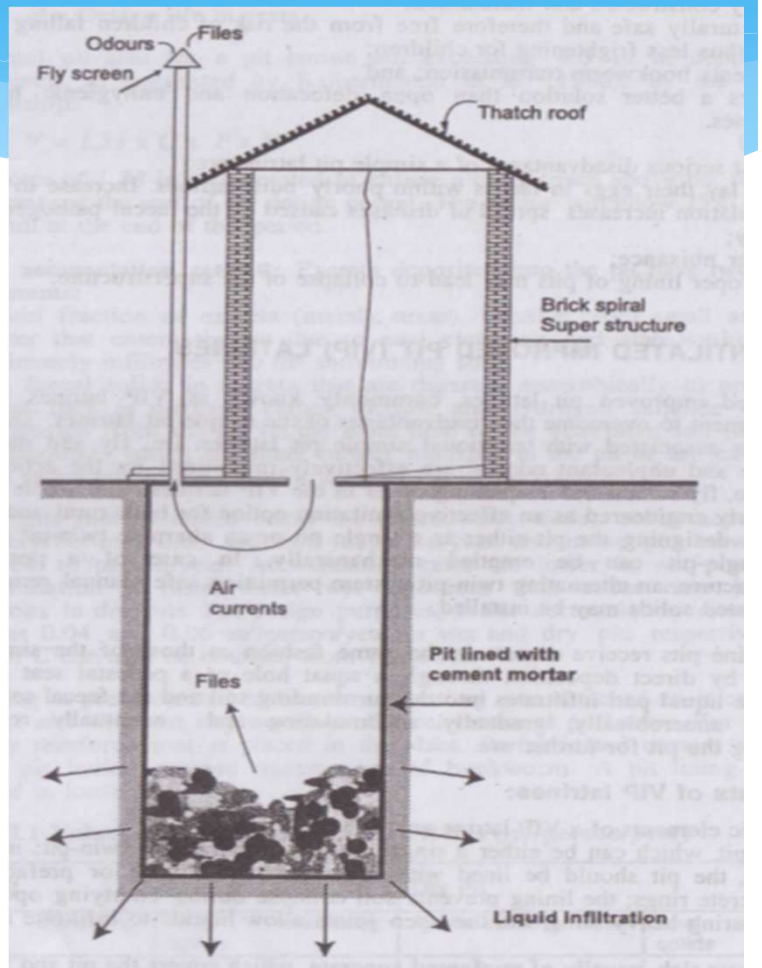


VIP latrine

Ventilated Improved Pit (VIP) Latrines

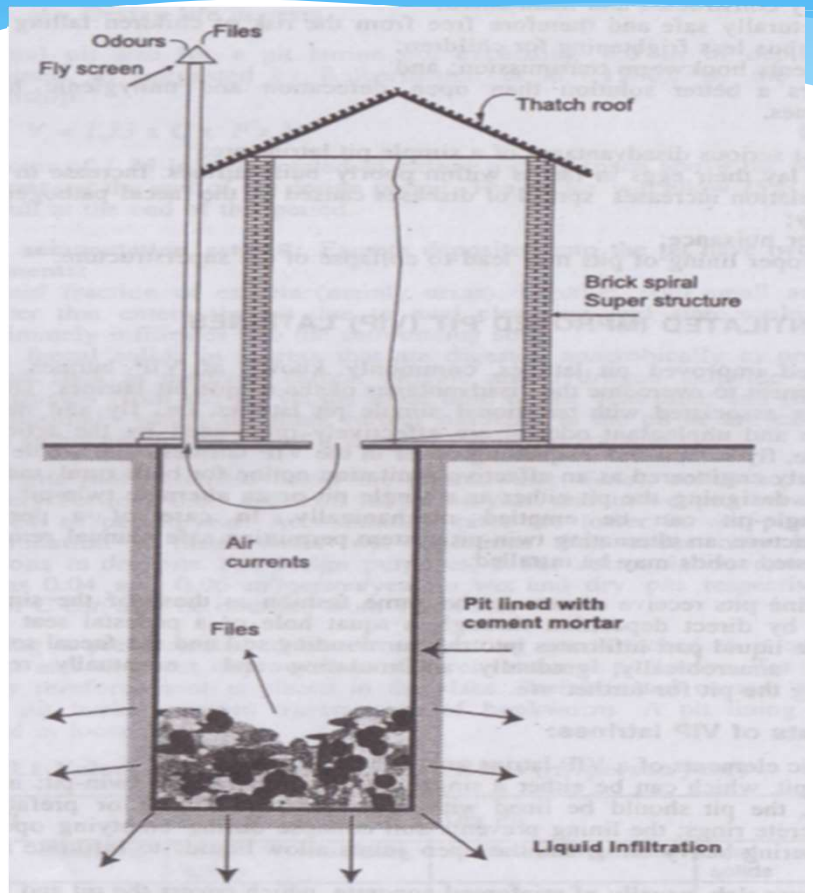
Basic Principle:

- The disadvantages of the simple pit latrine are minimized by using vent pipe and fly screen
- Urine and other liquids infiltrates into the surrounding soil
- Solid materials are anaerobically digested

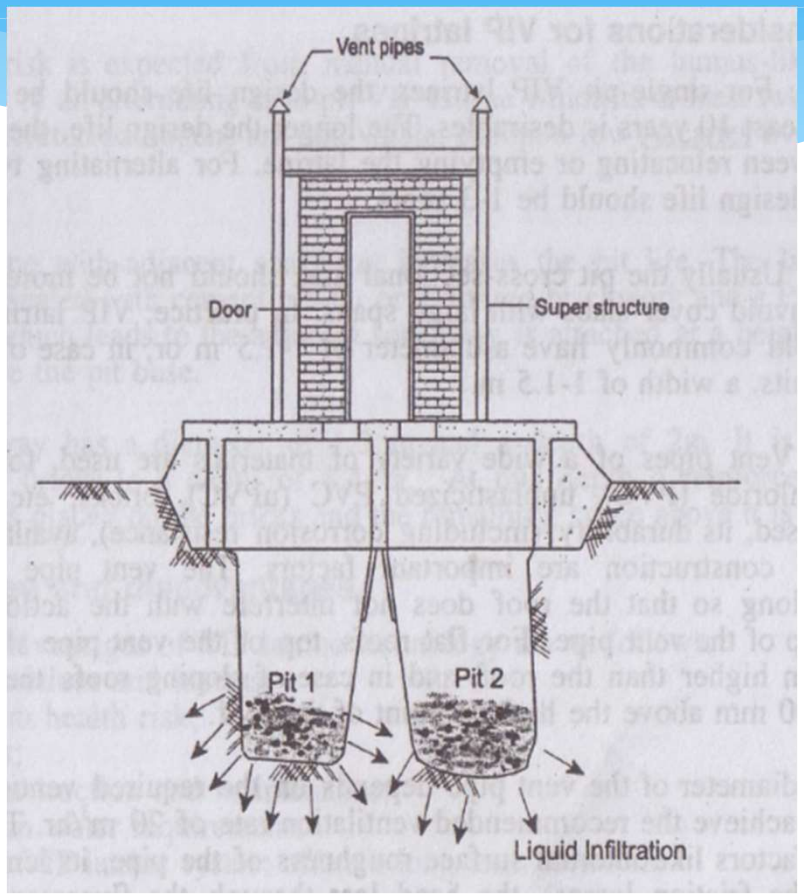


VIP latrine

Differences between single and alternating twin-pit VIP Latrines



Single pit VIP latrine



Alternating twin-pit VIP latrine

General design considerations

❑ **Design life:**

- For single pit VIP latrines:10 years
- For twin-pit VIP latrines:1-3 years

❑ **Dimensions:**

- Pit cross-sectional area ≤ 2 m2
- Pit diameter or width = 1-1.5 m

❑ **Vent pipe:**

- Polyvinyl chloride (PVC), unplasticized PVC (uPVC), bricks etc.
- Length-Sufficiently long: For flat roofs-500 mm and for sloping roofs-500 mm above the highest point

General design considerations

- **Diameter of vent pipe:**
  - PVC - 150 mm dia
  - Brick – 230 mm square
  - Others- 230 mm dia
- **Flyscreen:**
  - Mesh aperture ≤ 1.2 m x 1.5 m
  - Corrosion resistant materials-stainless steel screens

Advantages and Disadvantages

Advantages:

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

Disadvantages:

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

Problems

Design a VIP latrine for a family of 10 persons. The family uses water for anal cleansing. The groundwater table is only 2 m below the ground surface.

Problems

Design a VIP latrine for a family of 10 persons. The family uses water for anal cleansing. The groundwater table is only 2 m below the ground surface.

Solutions:

Case 1: Single pit option

Assume, pit design will be dry pit hence, C = 0.06 m3/p/year

V = C x P x N = 0.06 x 10 x 5 = 3 m3

Assume, square pit of width = 1.5 m

Pit depth = V/A = 3/2.25 = 1.3 ≈ 1.5 m

Pit dimension = 1.5 m x 1.5 m x 1.5 m

Provide 0.5 m clay lining or lean concrete as seal at the bottom of pit

Problems

Design a VIP latrine for a family of 10 persons. The family uses water for anal cleansing. The groundwater table is only 2 m below the ground surface.

Solutions:

Case 2: Alternating twin-pit option

Assume, emptying period = 2 years

V = C x P x N = 0.06 x 10 x 2 = 1.2 m3

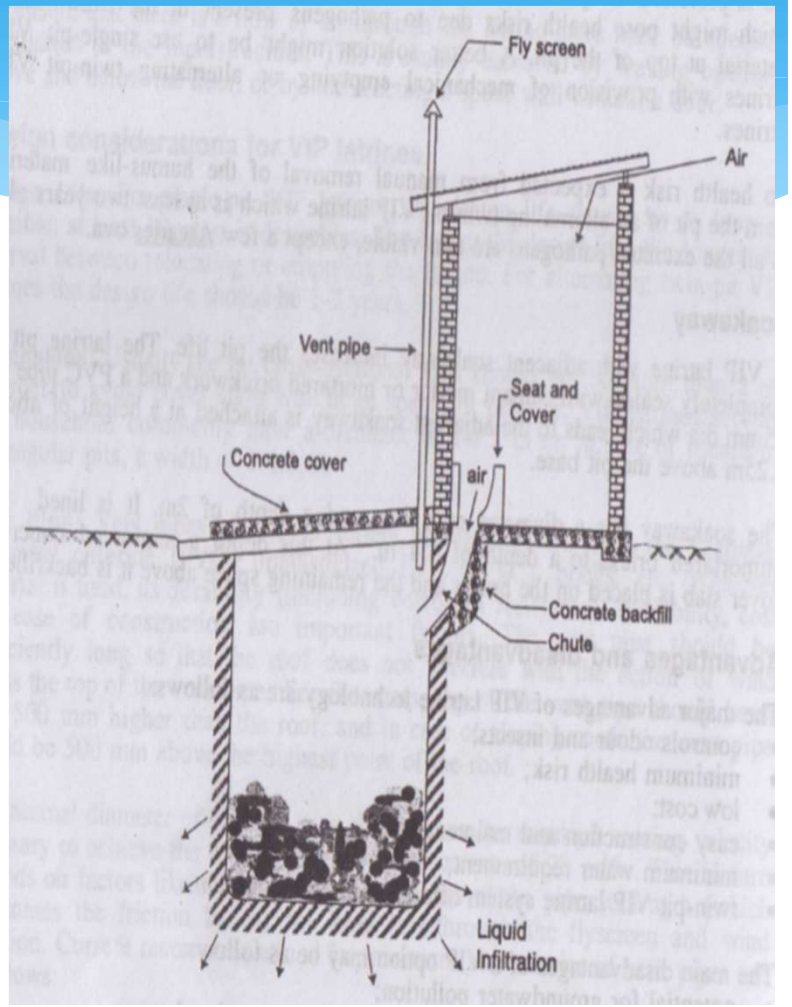
Pit dimension = 1 m x 1 m x 1.5 m

Provide 0.5 m clay lining or lean concrete as seal at the bottom of pit

Reed Odourless Earth Closet (ROEC)

Basic Components:

- A Pit – fully offset pit
- A cover slab - usually made of concrete
- a superstructure – privacy and protection from rain and sun
- Vent pipe and flyscreen – keep the latrine free from flies, mosquitoes and unpleasant odours
- A curve chute

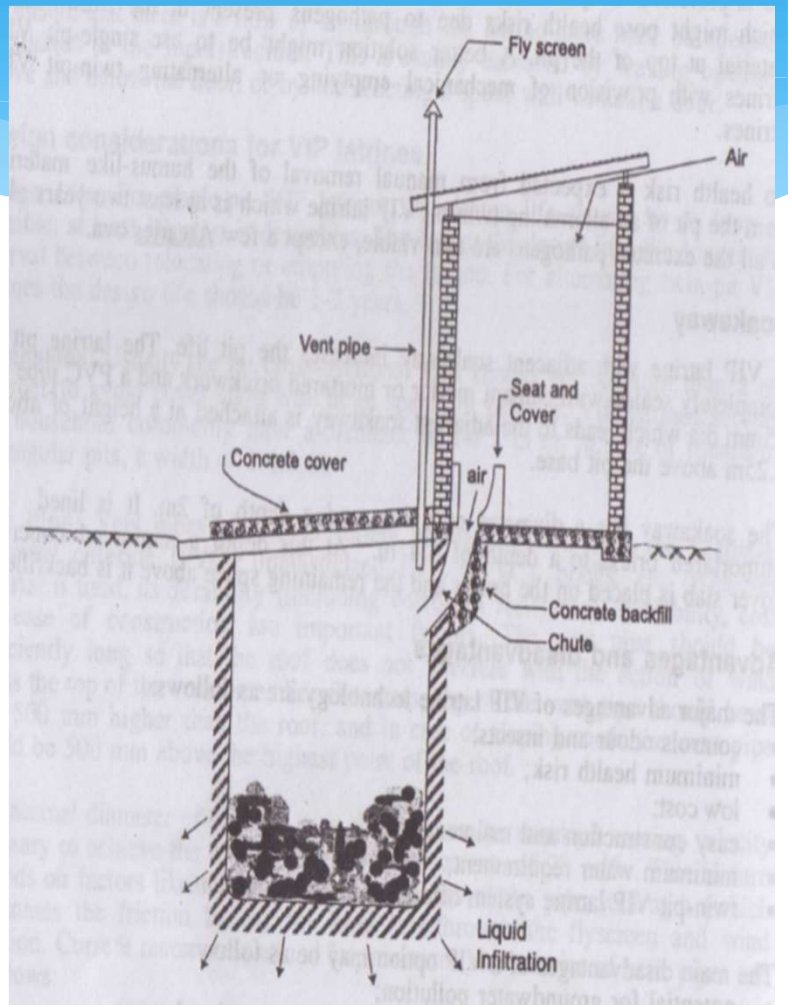


ROEC latrine

Reed Odourless Earth Closet (ROEC)

Basic Principle:

- The disadvantages of the VIP latrine are minimized by providing fully off-set pit, curve chute
- Urine and other liquids infiltrates into the surrounding soil
- Solid materials are anaerobically digested



ROEC latrine

Advantages and Disadvantages

Advantages:

- 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 emptied without disturbing the superstructure and it can be a permanent facility
- There is no danger of users, particularly children, falling into it
- More acceptable to users because the excreta cannot be seen

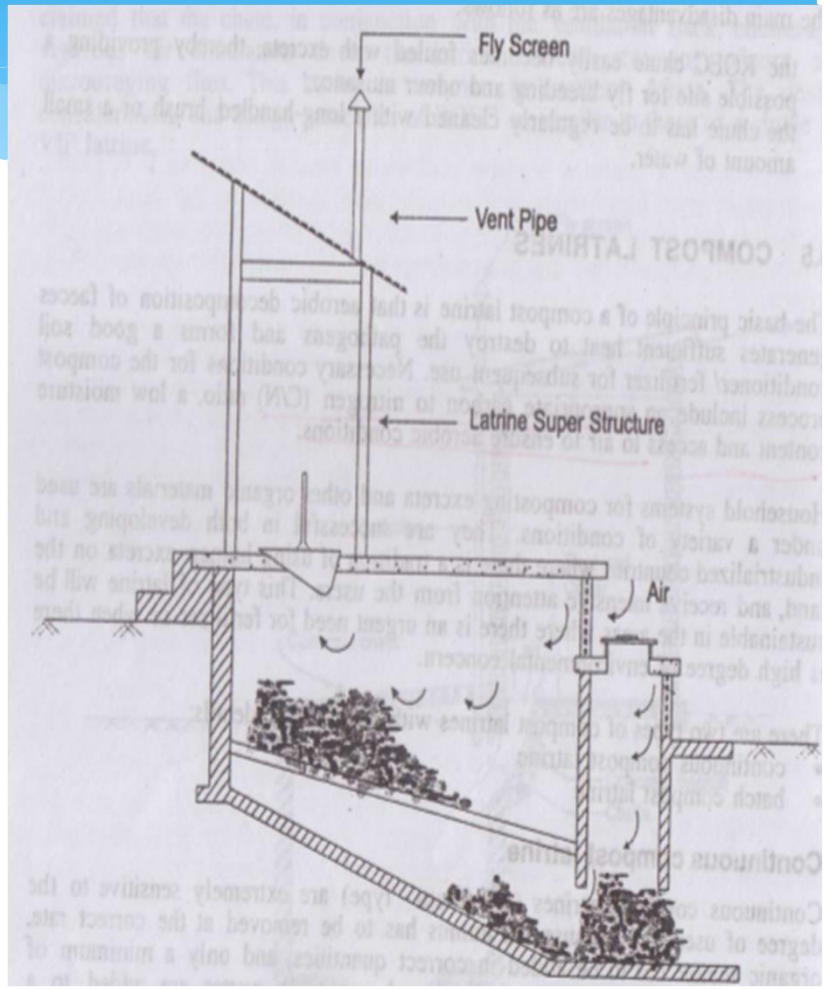
Disadvantages:

- ROEC chute becomes fouled with excreta, thereby providing a possible site for fly breeding and odour nuisance
- Regular cleaning of chute is required with a long-handled brush or small amount of water

Compost Latrine

Basic Principle:

- Aerobic decomposition of faeces generates sufficient heat to destroy the pathogens and forms a good soil conditioner/fertilizer for subsequent use.
- Necessary conditions: an appropriate carbon to nitrogen (C/N) ratio, a low moisture content and access to air to ensure aerobic condition.

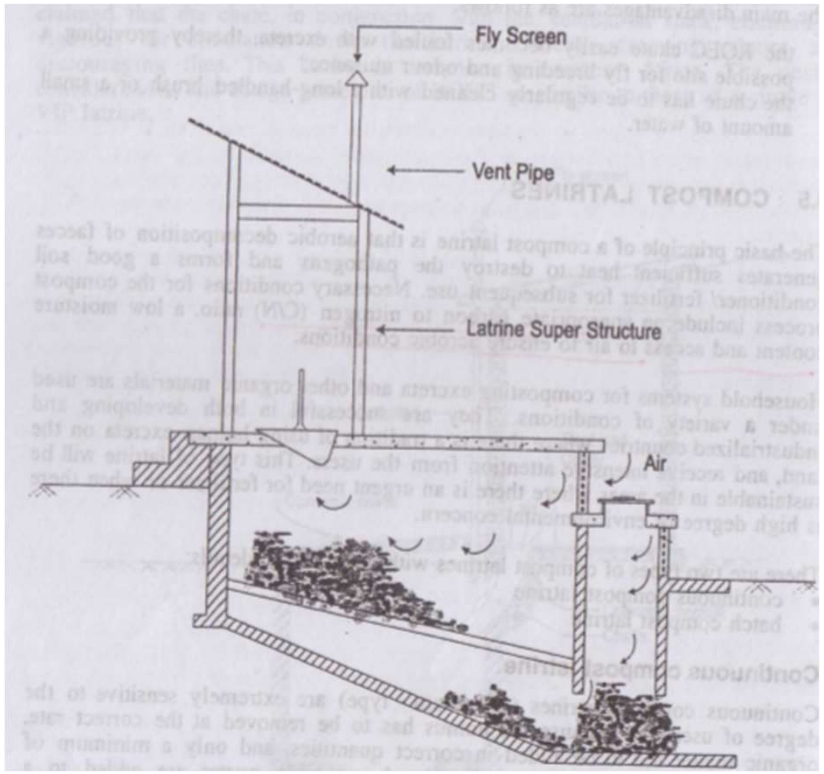


Compost latrine

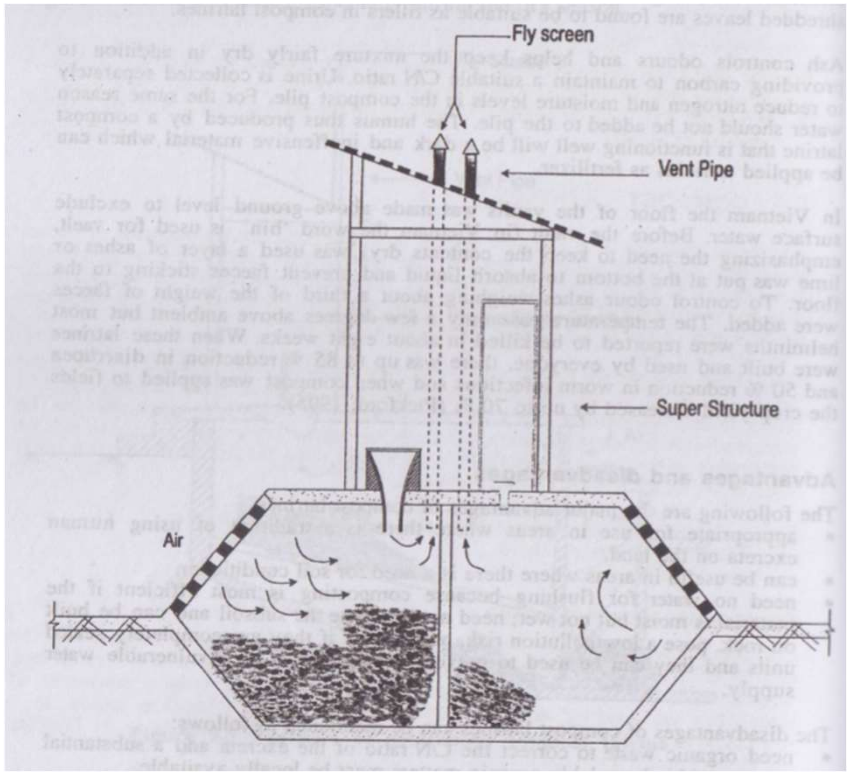
Compost Latrine

Types:

- Continuous compost latrine
- Batch compost latrine



Continuous compost latrine



Batch compost latrine

Advantages and Disadvantages

Advantages:

- Appropriate for use in areas where there is a tradition of using human excreta on the land
- 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 materials is moist
- Low pollution risk of groundwater

Disadvantages:

- Need organic waste to maintain C/N ratio
- Not suitable for areas where people prefer water for anal cleansing

Problems

A farmer excavated a pit measuring 1.5 m x 2.0 m x 2.5 m depth to use the excavated soil in the construction of an extra room for his son who is coming home after graduation from university in a town. Now he wants to convert this pit into a latrine to serve his family of six members for a long period. His son does not like to see excreta below while defecating. The water supply in the village is through hand pump tubewells which means that the quantity of water available for latrine is limited. Furthermore, the groundwater table is very low. Anal cleansing practice in the village is by using water. Design a suitable sanitary latrine to be build over the excavated pit.

Problems

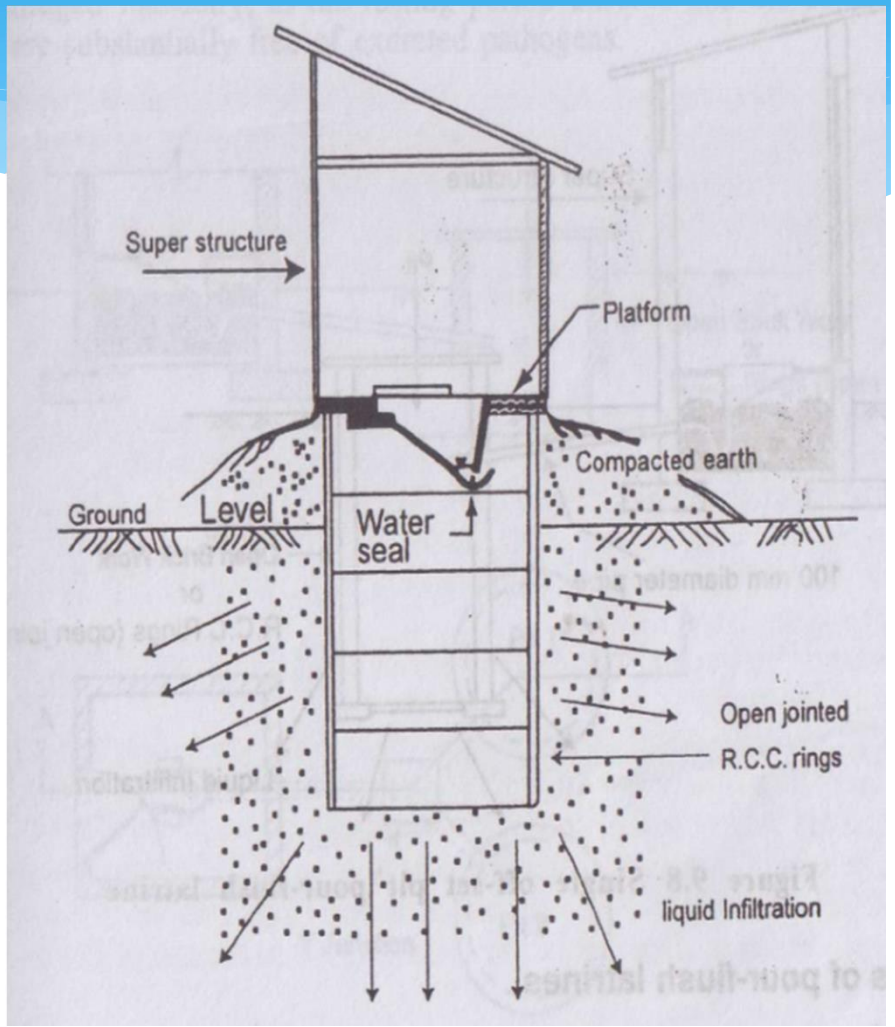
Four necessary conditions:

- **The excavated pit is to be used**
- **The system should be a low-cost one**
- **Water available for use in the latrine is limited**
- **The excreta must not seen during defecation**

Pour-flush sanitation technologies

Basic Components:

- Single or alternating twin leach pits
- A superstructure – privacy and protection from rain and sun
- Latrine pan with integral water seal

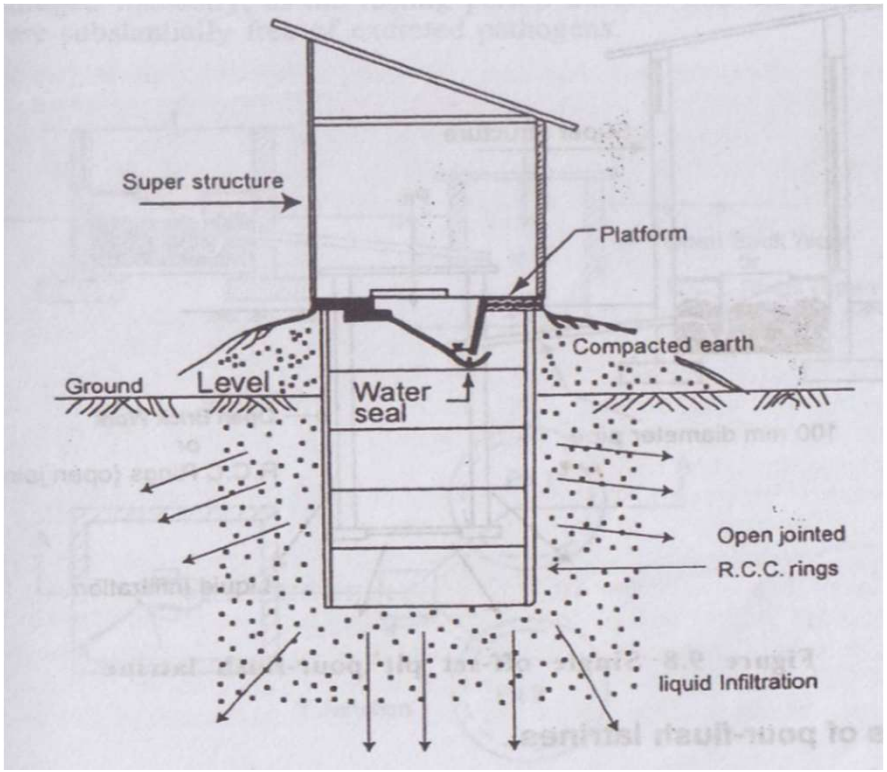


Pour-flush latrine

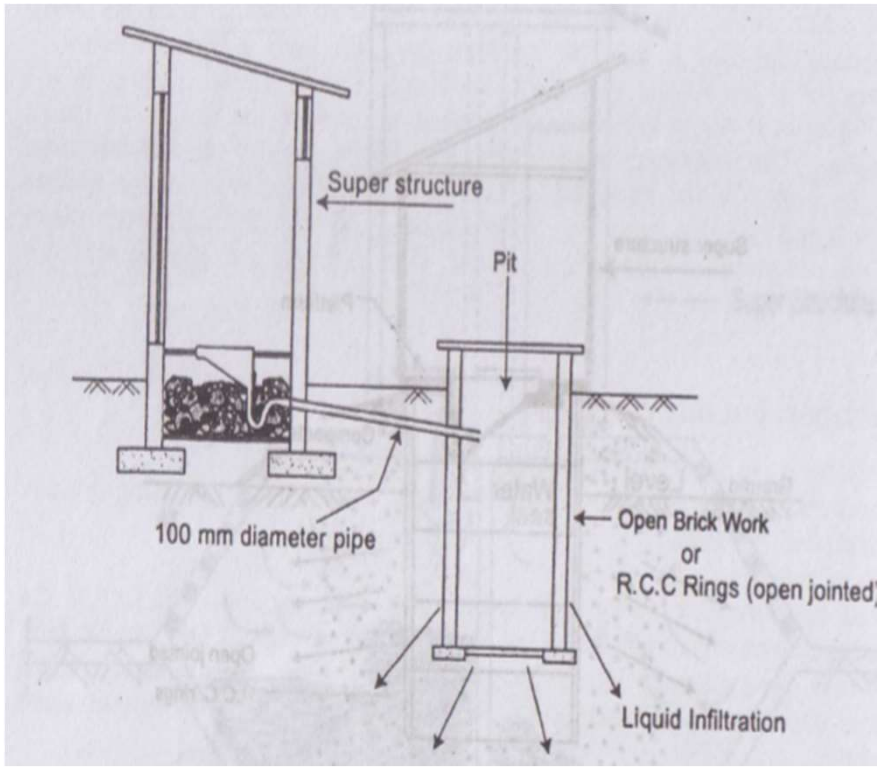
Pour-flush sanitation technologies

Types:

- Direct pit pour-flush latrine
- Off-set pit pour-flush latrine



Single pit pour-flush latrine

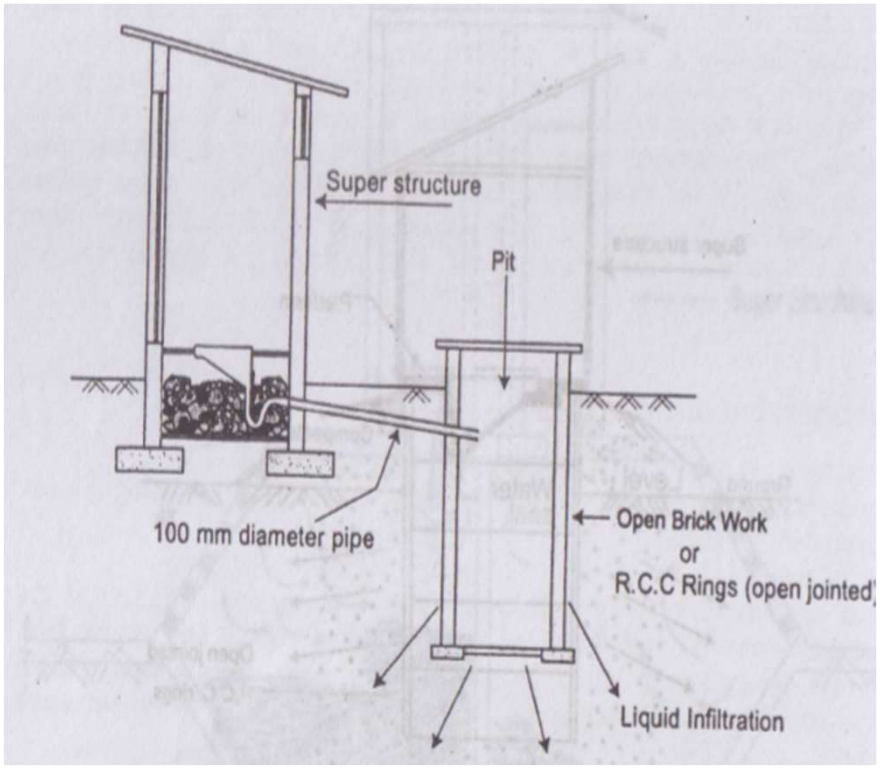


Off-set pit pour-flush latrine

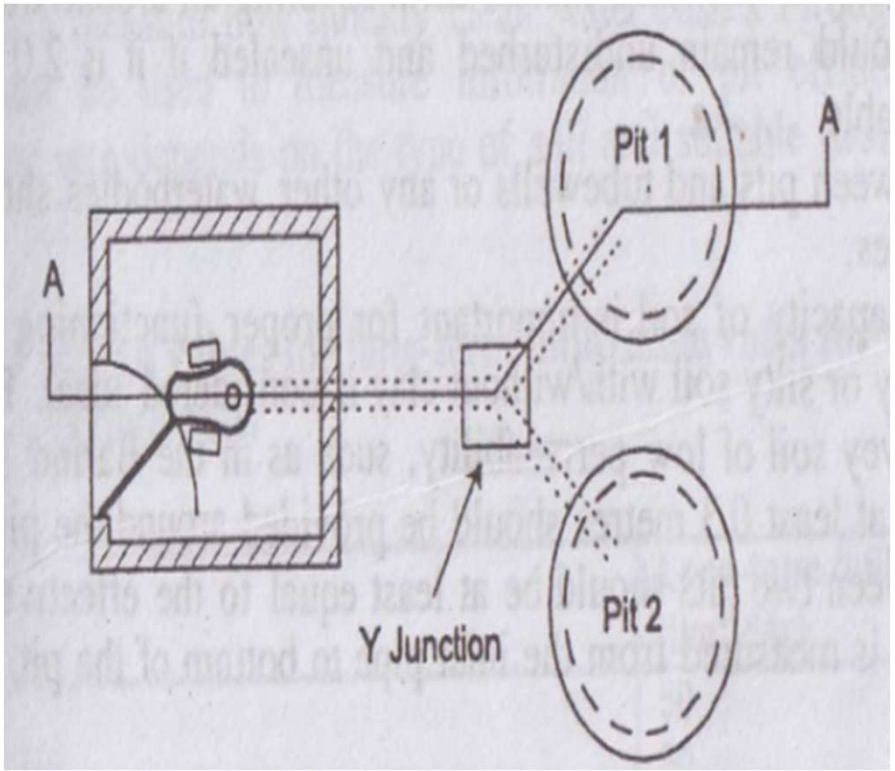
Pour-flush sanitation technologies

Types of off-set pit:

- Single off-set pit pour-flush latrine
- Alternating twin off-set pit pour-flush latrine



Single off-set pit pour-flush latrine



Twin off-set pit pour-flush latrine

Functions of Pour-flush latrines

- After each use, the latrine is manually pour-flushed through the pan and trap with about 2-3 litres of water. Some of the clean flush water remains in the trap and maintains the water seal, thus providing the barrier against odours and insects.
- Around 5-10 lpcd of wastewater enter into the pit. The pit should have sufficient volume to store these amount of water and soil must have sufficient long-term infiltration capacity.

Suitability of Pour-flush latrines

- May be used in both rural and urban areas
- Water supply is adequate for flushing and maintaining water seal
- Single pits may be suitable in urban areas only if they can be desludged mechanically.
- Twin-pits are recommended if the pits are to be desludged manually

General design considerations

❑ **Shape of pit:**

- Can be circular, square, rectangular or even triangular depending on the size and shape of site

❑ **Minimum water requirement:**

- 2-3 litres

❑ **Pit depth:**

- Should not exceed 1.8 m to protect groundwater pollution.

❑ **Lining materials:**

- Burnt clay, concrete, brick masonry, bamboo etc.

General design considerations

❑ **Inlet position:**

- Should be at least 0.5 m above the highest ground water level

❑ **Free space over inlet:**

- Usually 0.5 m above the inlet

❑ **Elevated pit:**

- In flood-prone areas, the pits should be constructed on elevated earthen mounds with at least 1.5 m earth covering all around the pits.

❑ **Safe distance:**

- At least 10 m.

General design considerations

❑ **Infiltration capacity:**

- Sandy or silty soil would be good
- If soil are compacted clay of low permeability then a sand envelope of at least 0.3 m should be provided around the pit

❑ **Distance between two pits:**

- Should be at least equal to effective depth of the pit
- Effective depth is measured from the inlet pipe to bottom of pit

Design of Pour-flush leach pits

Side wall area required for infiltration,

$$A_i = Q/I$$

Q = waste water flow

I = Long-term infiltration

Generally, Q varies from 5-20 lcd

Design of Pour-flush leach pits

The pit volume corresponding to side wall area,

$$V_i = \pi D^2 h/4$$

Where, h = height of sidewall area = $A_i/\pi D$

$$V_i = A_i D/4 = Q D/4I$$

For alternating twin-pits, the effective volume of the pit

$$V_s = C \times P \times N$$

Design of Pour-flush leach pits

For single pit pour-flush latrines, the effective volume,

$$V = Vs + Vi$$

Problems

Table 9.2: Design values for long-term infiltration rates for various types of soil (Mara, 1996)

Soil Type	Long-term infiltration rate ($l/m^2/day$)
Sand	50
Sandy loam	30
Porous silty loam, porous silty clay loam	20
Compact silty loam, clay	10

Problems

Design a leach pit for both single and alternating twin off-set pit pour-flush latrines serving a family of ten members living in a peri-urban area. Wastewater flow is 15 lcd and the soil is a porous silty loam.

Problems

Design a leach pit for both single and alternating twin off-set pit pour-flush latrines serving a family of ten members living in a peri-urban area. Wastewater flow is 15 lcd and the soil is a porous silty loam.

Pit volume with respect to infiltration:

$$I = 2\ l/m^2/day$$

$$Q = 10 \times 15 = 150\ l/day$$

$$Ai = Q/I = 150/20 = 7.5\ m^2$$

$$Vi = Ai \times D / 4 = 7.5 \times 1.2 / 4 = 2.25\ m^3$$

Problems

Design a leach pit for both single and alternating twin off-set pit pour-flush latrines serving a family of ten members living in a peri-urban area. Wastewater flow is 15 lcd and the soil is a porous silty loam.

Pit volume with respect to solids storage:

$$N = 2 \text{ years}$$

$$C = 0.06 \text{ m3/p/year}$$

$$Vs = CPN = 0.06 \times 10 \times 2 = 1.2 \text{ m}^3$$

Problems

Design a leach pit for both single and alternating twin off-set pit pour-flush latrines serving a family of ten members living in a peri-urban area. Wastewater flow is 15 lcd and the soil is a porous silty loam.

Single pit pour-flush system:

$$V = Vs + Vi = 1.2 + 2.25 = 3.45\ m^3$$

$$h = V/(\pi D^2/4) = 3.45/(\pi \times 1.2^2/4) = 3.05\ m$$

Assume, 0.5 m clear space,

Total depth = 3.05 + 0.5 = 3.55 m

Problems

Design a leach pit for both single and alternating twin off-set pit pour-flush latrines serving a family of ten members living in a peri-urban area. Wastewater flow is 15 lcd and the soil is a porous silty loam.

Alternating twin-pit pour-flush system:

$$Vi = 2.25\ m^3$$

$$h = V/(\pi D^2/4) = 2.25/(\pi \times 1.2^2/4) = 1.98\ m$$

Assume, 0.5 m clear space,

Total depth = 1.98 + 0.5 = 2.48 m

Advantages and Disadvantages

Advantages:

- Less expensive compared to conventional latrines
- Offers appropriate and hygienic solution for excreta disposal
- Can be upgraded to connect to a sewer system or septic tank system
- Eliminate odours, insects and fly breeding
- Can be located inside the house.

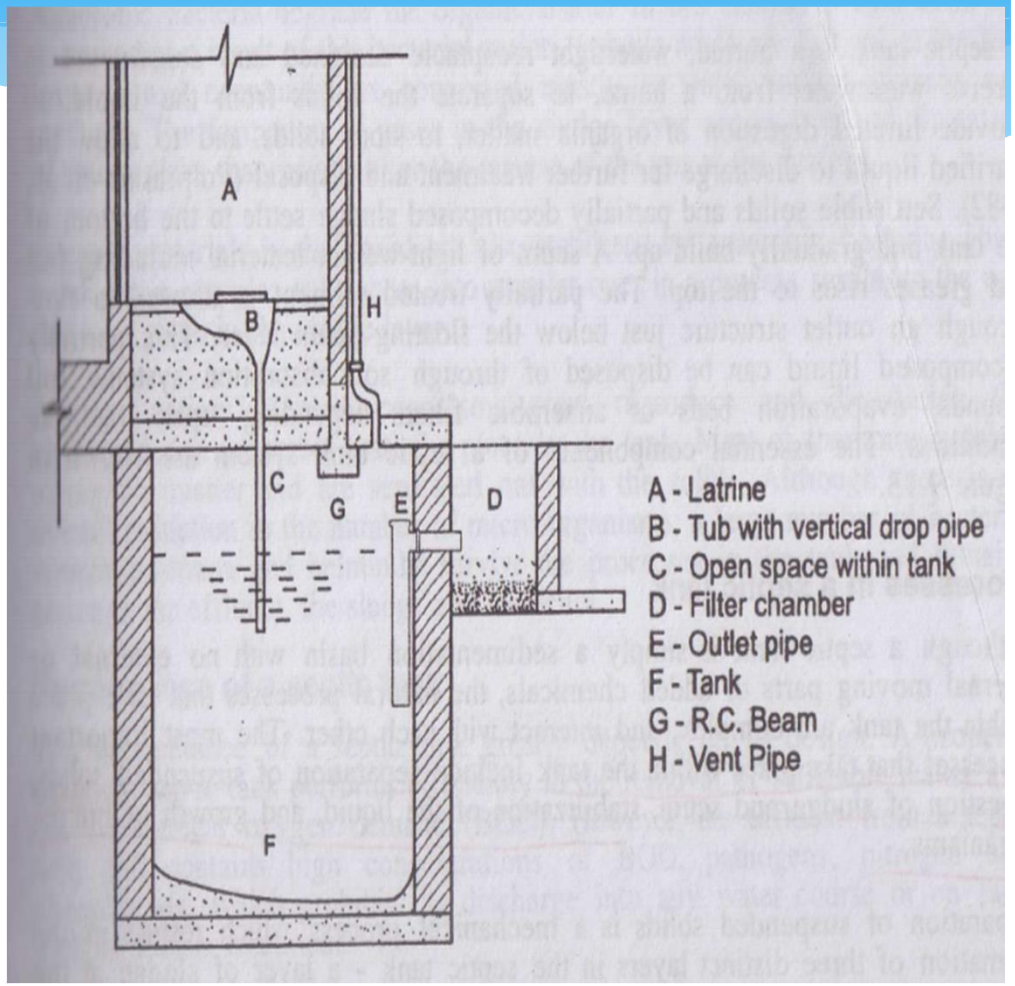
Disadvantages:

- Available water 5 lit/p/day is required throughout the year
- Water seal may be clogged easily if garbage is thrown into it
- Construction is difficult in high groundwater table and low permeable soil

Aqua Privies

Basic Components:

- Squatting plate with integral submerged drop pipe - to act as water seal
- A superstructure – privacy and protection from rain and sun
- A small septic tank – discharges effluent to an adjacent drainage field or a soak pit
- A soak pit

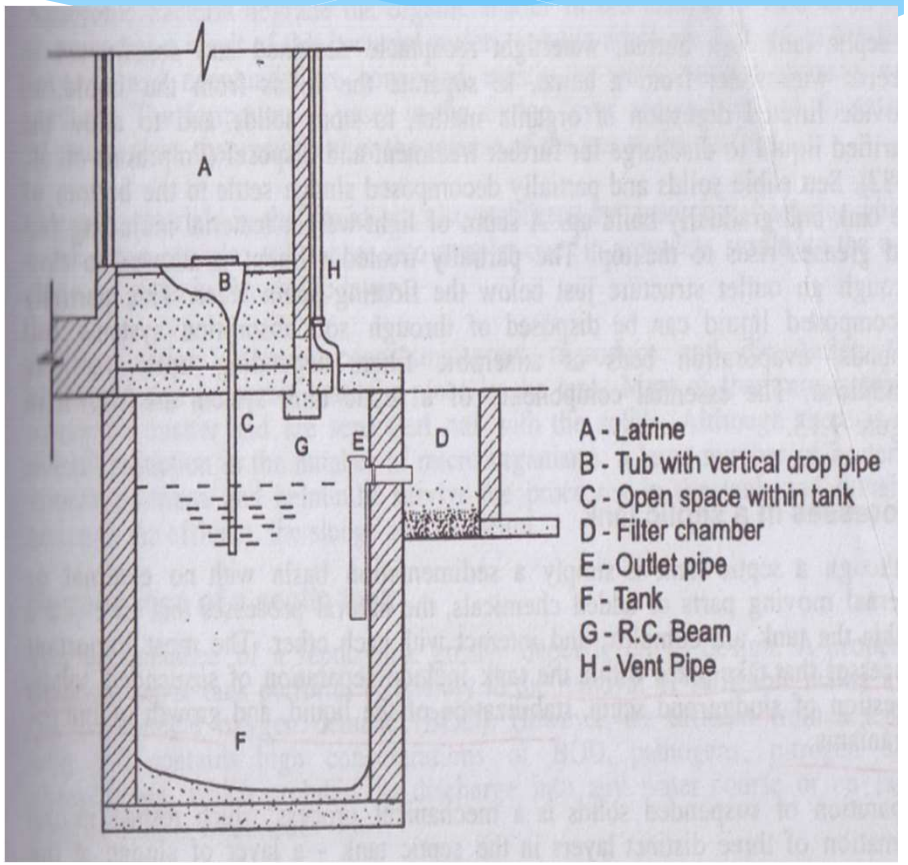


Aqua privy

Aqua Privies

Basic principles:

- Excreta directly enter into the tank without flushing, where they settle and are decomposed anaerobically
- Liquid discharges through outlet pipe to an adjacent drainage field or a soak pit



Aqua privy

General design considerations

❑ **Tank volume:**

- 1.5 litres/p/day solids + 4.5 litres/p/day wastewater to maintain water seal

❑ **Soak pit design:**

- Effluent flow = 8 litres/p/day
- Infiltration rate = 10 litres/m^2/day

❑ **Septic tank design:**

- Sludge accumulation rate = 0.03-0.04 m^3/p/year
- Tank will fill upto 2/3 of its volume
- Liquid depth = 1-1.5 m

General design considerations

❑ **Desludging period:**

- 2-3 years

Advantages and Disadvantages

Advantages:

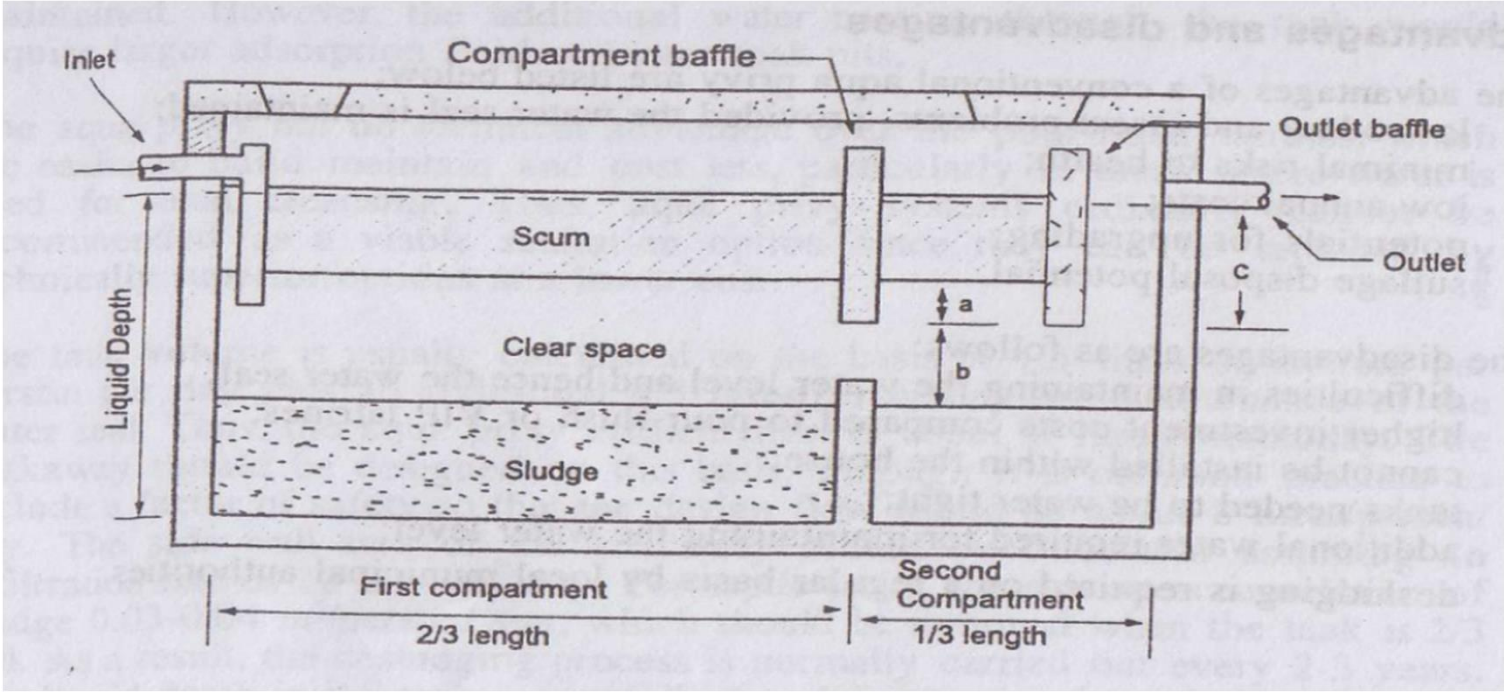
- Low odour and insect problems if the water seal is maintained
- Minimum risks to health
- Low annual cost
- Potentials for upgrading
- Sullage disposal potential

Disadvantages:

- Difficult to maintain water level inside the tank hence failure can occur
- Higher investment cost compared to pour-flush or VIP latrines
- Desludging is required on a regular basis by local municipal authorities

Septic Tank System

Definition: A septic tank is a buried, watertight receptacle designed and constructed to receive wastewater 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.

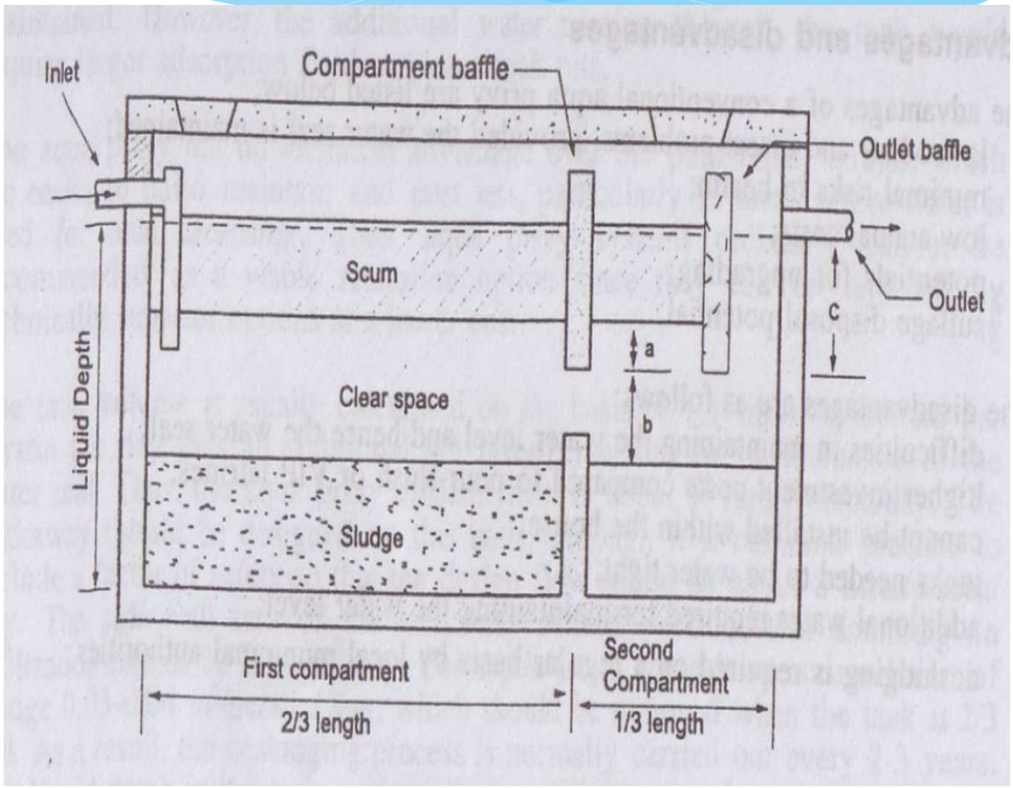


Septic tank

Septic Tank System

Processes in a septic tank:

- Separation of suspended solids
- Digestion of sludge and scum
- Stabilization of the liquid
- Growth of micro-organism

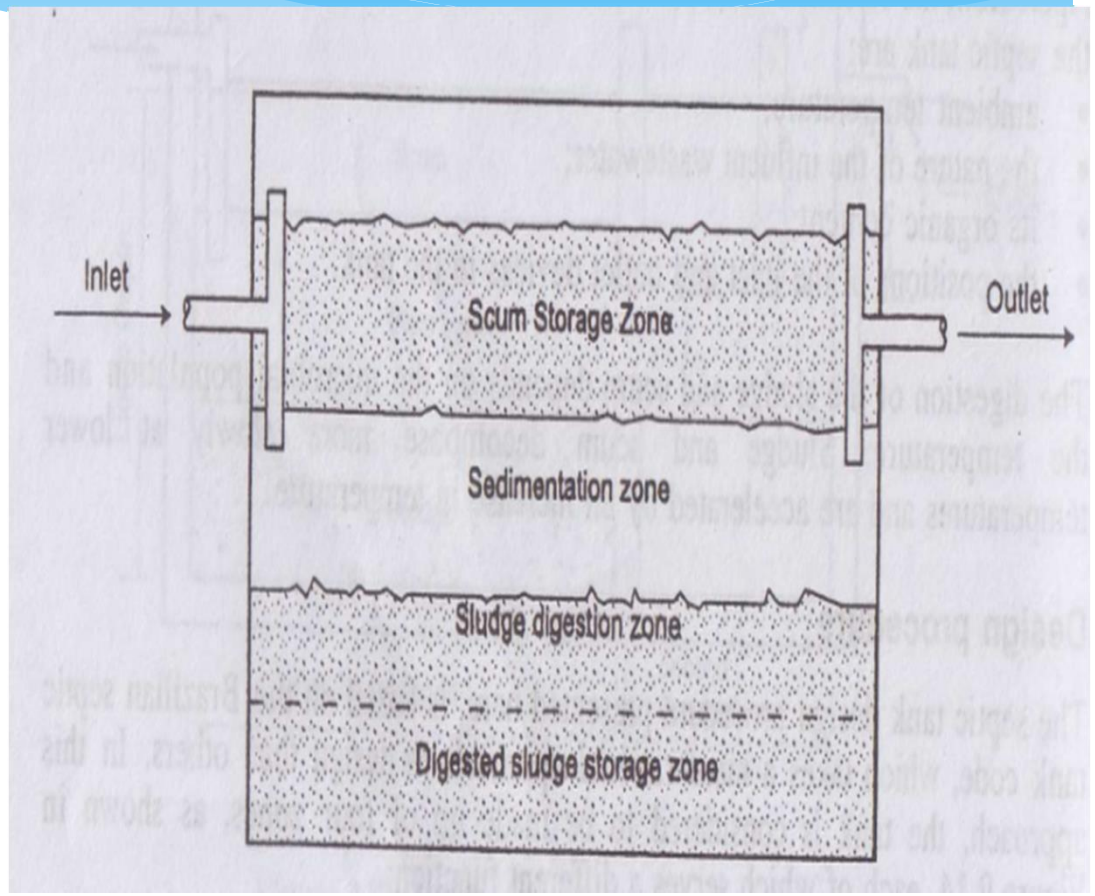


Septic tank

Septic Tank System

Design Procedure:

- Scum storage zone
- Sedimentation zone
- Sludge digestion zone
- Digested sludge storage zone



Functional zones

Septic Tank System

Design Procedure:

- **Scum storage zone**

Scum accumulates at approximately 30-40% of the sludge accumulation rate.

$$V_{sc} = 0.4\ V_{sl}$$

- **Sedimentation zone**

$$t_h = 1.5 - 0.3 \log (Pq)$$

But should not less than 0.2 days

Here,

t_h = minimum mean hydraulic retention time (days)

P = popupation

Q = wastewater flow per person (l/day)

Septic Tank System

Design Procedure:

$$V_h = 10^{-3} P q t_h$$

- **Sludge digestion zone**

$$t_d = 30 (1.035)^{35-T}$$

$$V_d = 0.5 \times 10^{-3} P t_d$$

Here,

t_d = time required for anaerobic digestion

P = popupation

T = temperature (^oC)

Septic Tank System

Design Procedure:

- **Digestion sludge storage zone**

$$V_{sl} = C \times P \times N$$

Here,

C = sludge accumulation rate

P = popupation

N = desludging period

C = 0.06 m^3/p/y N<5

C = 0.04 m^3/p/y N>5

Septic Tank System

Design Procedure:

$$V_h = 10^{-3} P\, q\, t_h$$

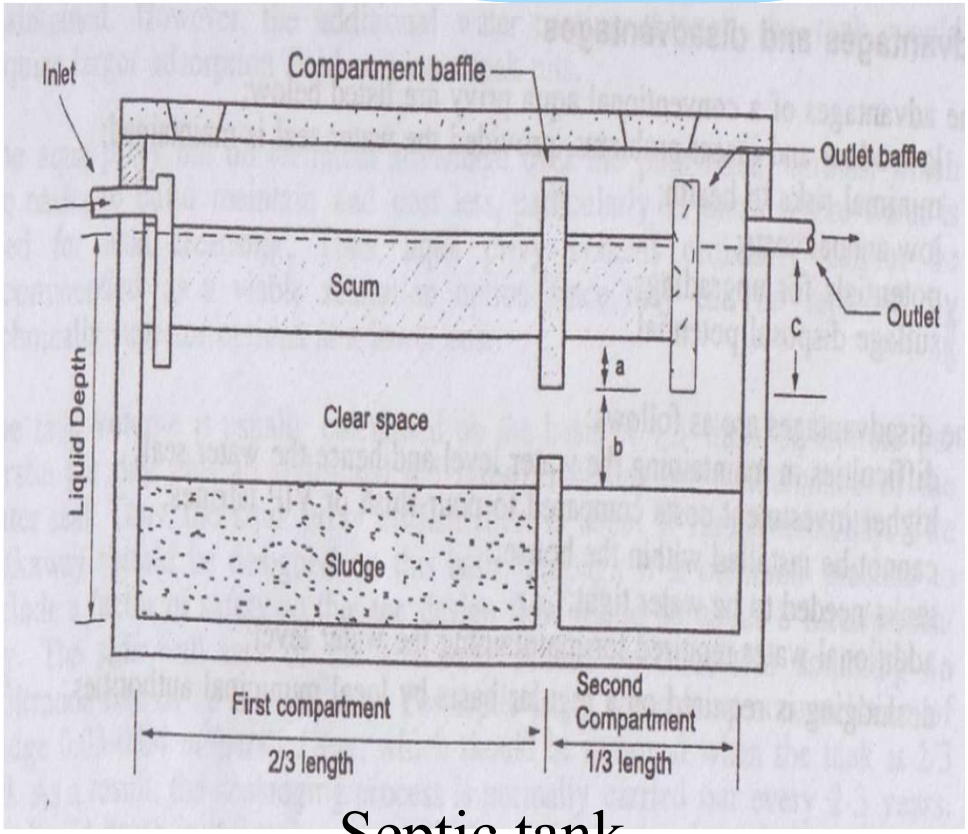
- **Overall design capacity**

$$V = V_{sc} + V_h + V_d + V_{sl} = V_h + V_d + 1.4V_{sl}$$

Septic Tank System

Clear space depth: comprise of submerged scum clear depth and the sludge clear depth.

Submerged scum clear depth: It is the distance between the underside of the scum layer and the bottom of the outlet tee, should be at least 75 mm.



Septic tank

Septic Tank System

Sludge clear depth: **It is the distance between the top of the sludge layer and the bottom of the outlet tee.**

$d_{sc} = 0.82 - 0.26\ A$

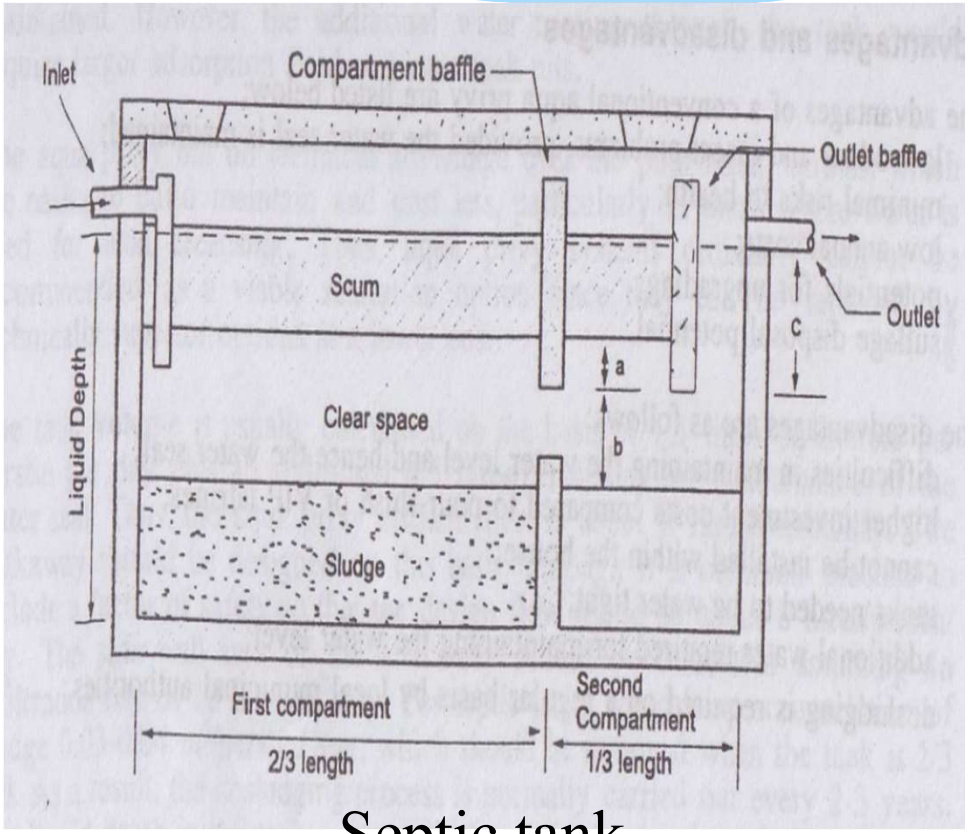
Should not be less than 0.3 m.

Total clear space depth

$= (0.075 + d_{sc})$

Sedimentation depth = V_h/A

The greater depth is the desired depth



Septic tank

Problems

Design a septic tank to serve a household of 12 persons who produce 90 lpcd of wastewater. The tank is to be desludged every three years.

Problems

Design a septic tank to serve a household of 12 persons who produce 90 lpcd of wastewater. The tank is to be desludged every three years.

Design Procedure:

- **Sedimentation zone**

$$t_h = 1.5 - 0.3 \log (Pq) = 1.5 - 0.3 \log (12 \times 90) = 0.58 \text{ days}$$

$$V_h = 10\text{-}3\ P\ q\ t_h = 10^{-3} \times 12 \times 90 \times 0.58 = 0.63\ m^3$$

Problems

Design Procedure:

- **Sludge digestion zone**

Assume, design temperature = 25^0C

$$t_d = 30\ (1.035)^{35-T} = 30 \times (1.035)^{35-25} = 42.3 \text{ days}$$

$$V_d = 0.5 \times 10^{-3}\ P\ t_d = 0.5 \times 10^{-3} \times 12 \times 42.3 = 0.25\ m^3$$

- **Digestion sludge storage zone**

$$V_{sl} = C \times P \times N = 0.06 \times 12 \times 3 = 2.16\ m^3$$

Problems

- **Overall effective volume:**

$$V = V_h + V_d + 1.4V_{sl} = 0.63 + 0.25 + (1.4 \times 2.16) = 3.90 \ m^3$$

Tank effective depth:

Assume, cross-sectional area, $A = 3 \ m^2$

Maximum depth of sludge, $d_{sl} = V_{sl} / A = 2.16 / 3 = 0.72$ m

Maximum submerged scum depth, $d_{ss} = 0.4 \ V_{sl} / A = 0.4 \times 2.16/3$

$= 0.29$ m

Scum clear depth = 0.075 m (minimum)

Sludge clear depth = $0.82 - 0.26 \times 3 = 0.04$ m < 0.3 m

0.3 m is adopted

Problems

Total clear space depth =0.075 + 0.3 = 0.375 m

Depth required for sedimentation = V_h / A = 0.63 / 3 = 0.21 m < 0.375 m

The total clear space depth is the controlling factor in the design.

Total effective depth = 0.72 + 0.29 + 0.375 m = 1.385 m

Overall internal dimension = 1 m x 3 m x 1.5 m

Use a two-compartment septic tank with the first compartment volume of 3 m^2 and the second compartment volume of 1.5 m^3.

Site selection

Site selection criteria for disposal of septic tank effluents:

Soil permeability:

- **Should be moderate to rapid**
- **Percolation rate should be 24 minutes per cm or less**

Groundwater table:

- **At least 1.22 m below the bottom of the sub-surface absorption field or soak pit during wet season.**

Site selection

Site selection criteria for disposal of septic tank effluents:

Impervious layers:

- **Should be more than 1.22 m below the seepage bed or the pit bottom**

Safe distance:

- **Should not be within 15.24m of a stream or other water body.**

Flood area:

- **Should not be installed in frequent flooding area**

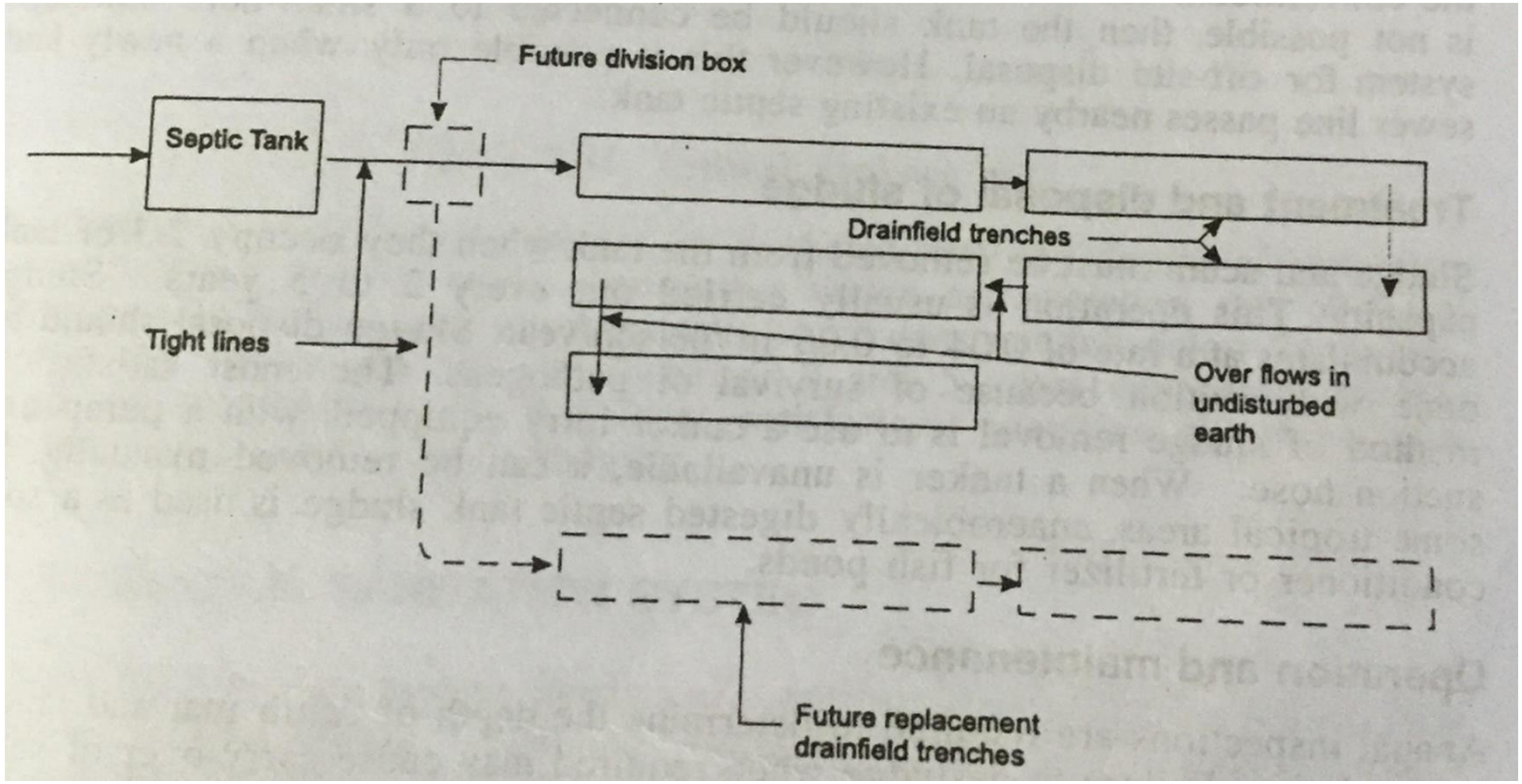
Sub-surface absorption systems

Three types:

- **Absorption trenches**
- **Absorption beds or seepage beds**
- **Soakage pit**

Sub-surface absorption systems

Absorption trenches



Sub-surface absorption systems

Absorption trenches:

$$L = NQ/(2DI)$$

Where, L = trench length (m)

N = number of users

Q = wastewater flow (litres/capita/day)

D = effective depth of trench (m)

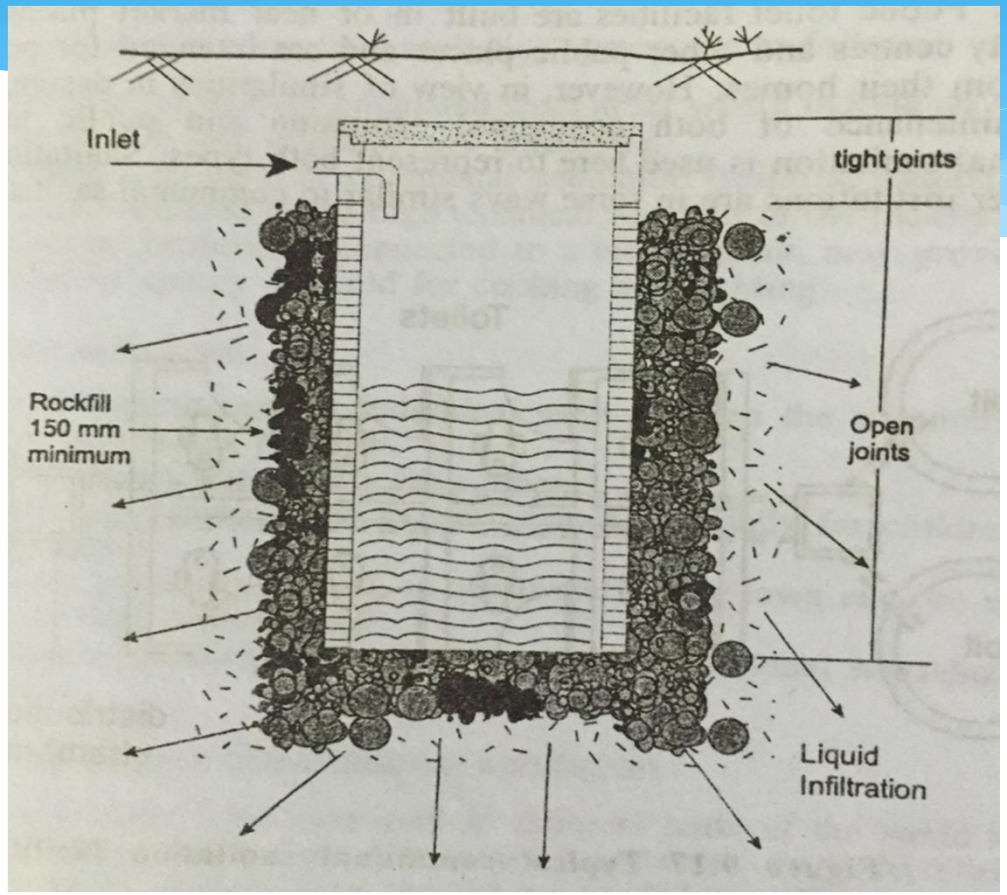
I = design infiltration rate (litres/m^2/day) = 10 litres/m^2/day

Sub-surface absorption systems

Seepage bed: A trench usually exceeding 36 in. (approx. 1 m) in width containing clean, coarse aggregate and a system of distribution piping through which partially treated sewage may seep into the surrounding soil.

Sub-surface absorption systems

Soakage pit:



Diameter = 2 to 3.5 m

Depth = 3 to 6 m

Problems

Design a soak pit for the disposal of effluent from the septic tank if the soil is sandy loam with a long-term infiltration rate of about 30 l/m²/d.

Problems

Design a soak pit for the disposal of effluent from the septic tank if the soil is sandy loam with a long-term infiltration rate of about 30 l/m²/d.

Effluent flow = 90 x 12 = 1080 litres/day

Long-term infiltration rate = 30 litres/m²/day

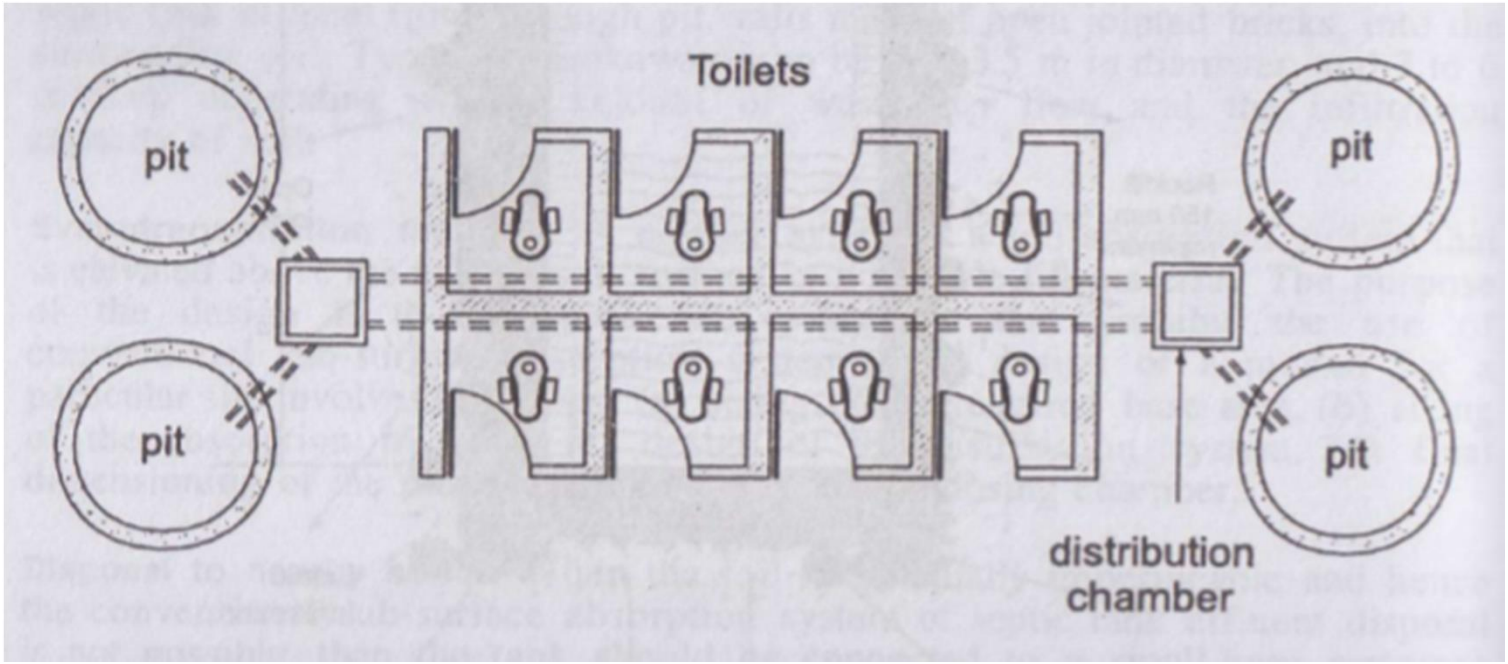
The infiltration area required = Q/I = 1080/30 = 36 m²

Assume diameter of soak pit = 1.5 m

Effective depth = 36/π x 1.5 = 7.63 m

Communal Sanitation System

A communal sanitation system consists of a number of squatting facilities with a common disposal system.



Suitability of Communal Sanitation System

- **Sewerage systems are not feasible both technically and economically**
- **On-site individual sanitation systems are not possible due to housing density or ground condition**

Distinguish between Communal Sanitation and public toilet facilities

- **Communal sanitation facilities are built outside household plots in communities**
- **Public toilet facilities are built in or near the market place, commercial areas, city centres, other public places and are intended for people who are away from their homes**

Advantages and Disadvantages

Advantages:

- The option is suitable for densely populated slum areas where individual on-site system is technically and economically unfeasible
- The users can share total costs of communal sanitation facilities, leading to low per capita cost compared to the high technical standard of the facility
- Communal sanitation facilities if connected to a biogas plant, may provide significant amount of energy required for cooking and lighting

Disadvantages:

- Lack of commitment by individual users to keep the communal facilities clean and operating properly
- Lack of privacy particularly for women
- Difficult to use at night and bad whether condition for childrean and elderly people

- What is the primary reason for failure of communal and public toilet facilities?
- How can these systems be sustainable?

- **Sulavh constructed a 54 seat communal facility at Patna in 1982**
- **Produce 55 m3 of biogas a day**
- **Gas was used to power a 10 kVA generator**
- **Generated electricity was used to light the adjoining park, street lights along 4 kilometres of busy city road**

Air Pollution

Air pollution can be defined as the presence of one or more contaminants like dust, mist, smoke, odour etc in excess quantities that causes injurious to human beings, plants, animals and properties.

Importance of Air

For physiological requirements of an adult man

- **14 kg of air**
- **1.5 kg of food**
- **2 kg of water**

People can survive without

- **food for 5 weeks**
- **water for 5 days**
- **air for few munities only**

Composition of Air

Constituent	Percentage by volume
Nitrogen	78.10
Oxygen	20.90
Carbon dioxide	0.04
Water vapour, ozone, argon, krypton, carbon monoxide etc.	0.96

Technical Definition / Short Notes

Aerosols: An aerosol is a particle of solid or liquid matter of such minute size that it can remain suspended in the atmosphere for a long period of time.

- **Liquid particles: spherical in shape**
- **Solid particles: spheres, filaments and various irregular shape**

Technical Definition / Short Notes

Smoke: **The vaporous matter, with suspended particles of carbon, arising from something burning, is known as the smoke.**

- **Particle size:** **less than 1 µ**
- **Tobacco smoke:** **0.25 µ**

Technical Definition / Short Notes

Fog: The visible moisture in the atmosphere is known as fog.

- **Mass of smoke, dust etc.**

Haze: A thin vapour of fog, smoke, dust, etc. in the air is known as the Haze.

Mist: A cloud of dust, gas, etc. or a large mass of water vapour like a light fog is known as the Haze.

Green-house Effect

The term green-house is used to mean a building made mainly of glass with heat and humidity regulated for growing plants.

Green-house Effect

The term green-house is used to mean a building made mainly of glass with heat and humidity regulated for growing plants.

- **Carbon dioxide (Co_2): Most abundant gas**
- **Nitrous oxide (N_2O): Biogenic gas emitted by deforestation, biomass burning, nitrogenous fertilizers and fossil fuel combustion**
- **Methane (CH_4): Anaerobic decomposition in biological systems, biomass burning, land fills and wet lands**

Green-house Effect

other gases- ozone (o_3), nitrogen oxide (NO), sulphur dioxide ($S o_2$): **fossil fuel burning and manufacturing processes of chemicals**

Green-house effect:

- **ocean gets warmed up by the rise in temperature, sea level would rise flooding low-lying regions**
- **In temperature regions, winter will be shorter and warmer and the summer will be longer and hotter**
- **Plants and animals will be affected and ecosystem will be unbalanced**

Green-house Effect

Green-house effect:

- **increase in rainfall to the extent of about 10%**
- **Tropics may become wetter and the sub-tropics may become more drier**
- **Plants will grow bigger with the increase in carbon-dioxide in the air**

Solution to minimize green-house effect:

- **reduction of fossil fuels combustion**
- **rely on renewable source of energy like bio-gas, nuclear, solar and wind**

Green-house Effect

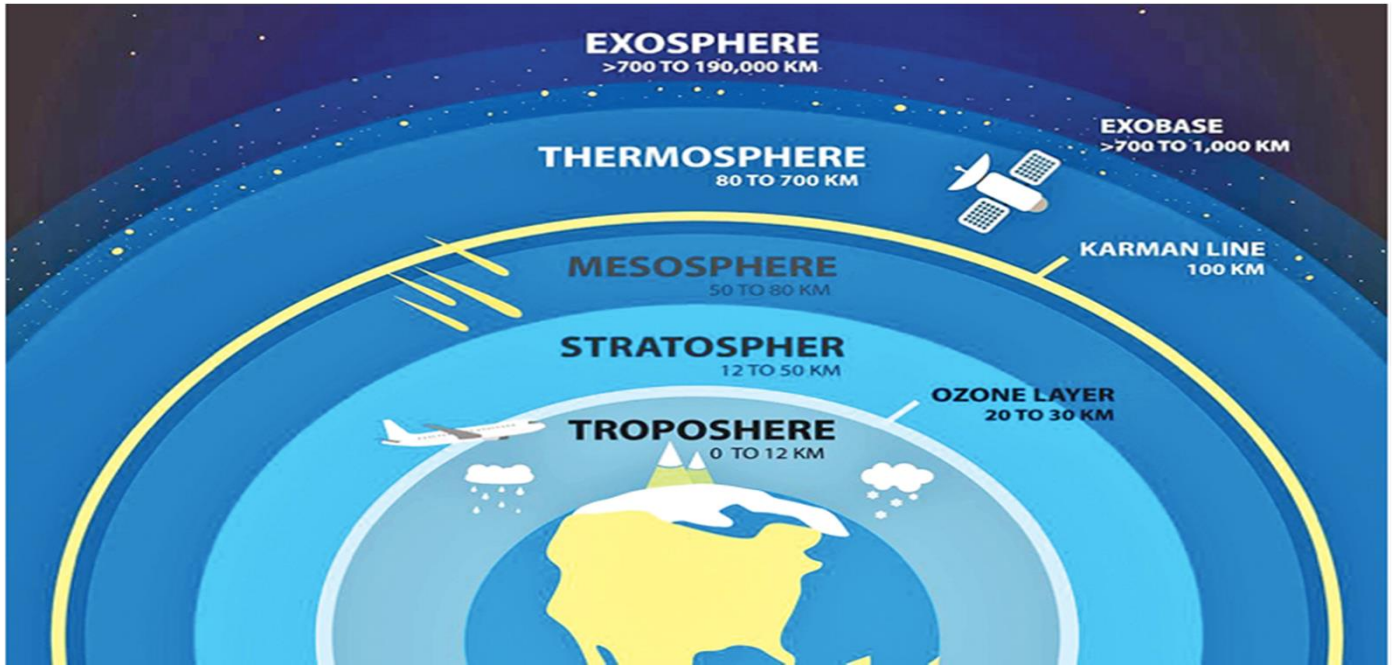
Solution to minimize green-house effect:

- **dispose the green-house gases elsewhere than in the atmosphere**
- **learn to adopt and accept the changing climate**

Ozone layer

An ozone layer is present in the atmosphere upto a distance of about 60 km with concentration of the order of 1 in 10000 upto 20 to 25 km.

- **It acts as an umbrella against the harmful ultraviolet radiation reaching the earth**
- **Entire quantity of ozone would form a layer of 3 mm**



Effects of Ozone on Human Health

Ozone level in p. p. m	Observed effects
0.20	No ill effects
0.30	Nose and throat irritation
1 to 3	Extreme fatigue after two hours
9	Severe trouble with lungs

Adverse Effects of Ultraviolet Radiation

- **Damage of immune system**
- **Disturbance in eco-system**
- **Effect on crop yield especially that of timber**
- **Increase of skin cancer and eye ailments**
- **Shorter life of paints and plastics**

Sources of Air Pollution

- **Natural sources**
- **Artificial sources**

- **Natural sources**
- **Atmospheric reaction**
- **Dust and aerosol**
- **Micro-organisms**
- **Pollens**
- **Radioactive minerals**

Sources of Air Pollution

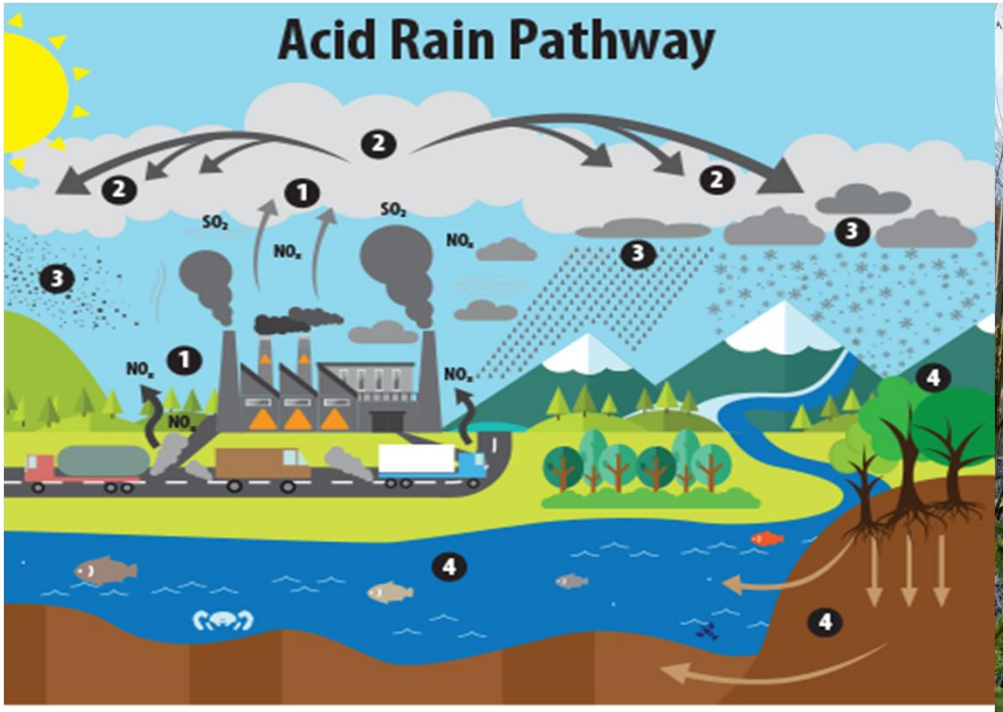
- **Artificial sources**
- **Combustion of fuels**
- **Industries**
- **Thermal power houses**
- **Vehicular pollution**

Effects of Air Pollution

- **Effect on certain materials**
- **Effect on human health**
- **Effect on physical features of atmosphere**
- **Effect on vegetation**

Acid Rain

- **pH falls to 5 or below**
- **Source of energy: Sulphur and nitrogen**
- **Sulphuric acid, sulphurous acid, nitric acid, nitrous acid**



This image illustrates the pathway for acid rain in our environment:
(1) Emissions of SO_2 and NO_x are released into the air, where (2) the pollutants are transformed into acid particles that may be transported long distances. (3) These acid particles then fall to the earth as wet and dry deposition (dust, rain, snow, etc.) and (4) may cause harmful effects on soil, forests, streams and lakes.

Harmful Effects of Acid Rain

- **It can acidify fresh waters of lakes, rivers, storage reservoirs, springs, well, etc.**
- **Human being can be effected by neurological diseases.**
- **It has the potential to convert forests into waste lands**
- **It is a versatile destroyer with planetary or universal implications**
- **It is dangerous to the living organism as it can destroy life**
- **It may have damaging effects like corrosions of metals, weakening of textiles etc.**
- **It serves as a poison to the wild life**

Water Pollution

Any physical, biological or chemical change in water quality that adversely affects living organisms or makes water unsuitable for certain use is referred as **Water pollution.**

Sources of Water pollution:

- **Point source pollution**
- **Non-point source pollution**

Water Pollution

Point source pollution: Point source pollution is defined as any single identifiable source of pollution from which pollutants are discharged**.**

Example: Industrial discharge, factory smoke stack, municipal sewage etc.

Point source pollution sources are discrete and identifiable and hence **easy to monitor and regulate**.

Water Pollution

Non-Point source of pollution: When a source of pollution cannot be readily identified i.e, sources are scattered or diffuse they are called Non-Point source of pollution**.**

Example: run off from farm lands, construction sites, parking lots, agriculture logging, animal waste etc.

.

Water Pollution

Sources of Water Pollution:

Source of water pollution	Comment
Water and sewage company works	Organic wastes and sometimes industrial wastes. Aluminum residues from water treatment.
Petroleum industry	Oil spills from ships, oil super tanker disasters and offshore drilling operations.
Acid rain	Formed by combination of SO_2 and NO_2 with water in the atmosphere.
Radioactive materials	Present in wastes and (i) uranium and thorium mining and refining (ii) nuclear power plants and (ii) industrial, medical and scientific use

Water Pollution

Causes of Water Pollution:

- **Biochemical Oxygen Demand (BOD)**

The sewage and other organic matter discharged to a water body are degraded by micro-organisms – requiring oxygen. The amount of oxygen consumed by the microbes is the Biochemical Oxygen Demand (BOD). Although some natural BOD is always present, BOD is often **indication of the presence of sewage and other organic waste**. **High levels of BOD can deplete the oxygen in water**.

Water Pollution

Causes of Water Pollution:

- **Nutrients**

A Nutrient is a substance required for life, it **promotes growth**. But remember that nutrient acquires more suspicious face at high concentrations. Synthetic fertilizers are composed of nutrients. When discharged to water, the nitrogen and phosphorous they contain become available to water organisms. Nutrients are also discharged as organic matter, which contains nutrients that become to water organisms as the organic matter degrades.

Water Pollution

Causes of Water Pollution:

- **Suspended solids / Sediments**

Suspended solids are physical pollutants. They are always naturally present in water to some extent and as usual, it is **an excess that is deleterious**. Fine particles from soil runoff can remain suspended in water and increase its turbidity or cloudiness. This can **stunt the growth of the aquatic plants by limiting the amount of sunlight**.

Water Pollution

Causes of Water Pollution:

- **Oil and grease**

Oil spills are a major problem in near-coastal waters and can kill or adversely affect fish, other aquatic organisms and birds and mammals. **Spills can kill or reduce populations of organisms living in coastal sands and rocks, and may kill the worms and insects that serve as food to birds and other animals**.

Water Pollution

Causes of Water Pollution:

- **Bacteria, Viruses and protozoa**

The concern associated with micro-organisms infectious disease. Micro-organisms are naturally found in water and elsewhere in the environment and can cause infection. However, the **microbes causing the greatest concern are usually associated with human activities**. Non-point sources include run-off from livestock operations and storm water runoff, especially that associated with combined sewer overflow. Poorly performing municipal sewage treatment plant are point sources of pathogenic micro organisms.

Water Pollution

Effect of water pollution:

- **Human being**

On consuming polluted water following effects are observed on human beings. Amoebic dysentery, Skin cancers, Cholera, Typhoid fever, Damage of nervous system, Genetic mutations/ birth defects, Hepatitis, Malaria.

Water Pollution

Effect of water pollution:

❖**Plants and animals**

- Lower crop yields
- Harmful to aquatic life and wild life
- Excess growth of algae can kill aquatic life
- Reduce Photosynthesis
- Disrupts food chain and food web.

Water Pollution

Control measures for preventing water pollution :

- Setting up effluent treatment plans to treat waste
- Recycling of water must be encouraged
- Industrial wastes must be treated before discharge
- Educate Public for preventing water pollution and the consequences of water pollution
- Strict enforcement of water pollution control act
- Continuous monitoring of water pollution at different places
- Developing economical method of water treatment
- River, streams, lakes and other water reservoirs must be well protected from being polluted

Noise Pollution

- When the sound waves are periodic, regular and of long duration, they produce a pleasing effect and such a sound is known as the **musical sound.**
- When the sound waves are non-periodic, irregular and of short duration, they produce a displeasing effect and such a sound is known as the **noise pollution.**
- The intensity of sound wave combined with the reception characteristics of ear is known as the **loudness**.

Noise Pollution

Noise Pollution

Effects of sound pollution:

- **It creates uncomfortable living conditions**
- **It creates bad effects on blood pressure, muscular strain and sleep**
- **It leads to fatigue and reduce work efficiency of person**
- **It may result shorten memory, high blood pressure, nervous irritability, strain and some psychological reactions**
- **It may cause reduction in gastric activity, dizziness, rise in breathing, cardiovascular problems, heart disease etc.**

Noise Pollution

Temporary threshold shift (TTS): **It means any loss of hearing which the ear recovers. It has been due to the metabolic changes in the ear and failure to return to the normal biochemical state before further exposure takes place.**

Permanent threshold shift (PTS): **It is produced by the noise which produces TTS and is exposed for a long time.**

The sound is measured in decibels (db).

Effect of Noise on Human Being

Noise level in db	Effects
0	Threshold f audibility
105	Significant change in pulse rate
110	Stimulation of reception in skin
120	Pain threshold
130-135	Nausea, vomiting, dizziness, etc.
140	Pain in ear and prolonged exposure may result in insanity, etc.
150	Burning of skin
160	Minor permanent damage, if prolonged
190	Major permanent damage, if prolonged

Noise Pollution

Acceptable noise levels: **The maximum level of noise which will neither annoy the occupants nor damage the acoustics of the building is termed as the acceptable noise level.**

It depends on the following factors:

- **nature of the noise**
- **type and use of the building**
- **time of fluctuation of the noise**
- **background noise**

Noise Level for Different Structure

Type f building	Noise level in db
Radio and T. V. studios	25 to 30
Auditoriums and music rooms	35 to 40
Small officers, court rooms, libraries	40 to 45
Hospitals	40 to 50
School's	45 to 50
Residential buildings and restaurants	45 to 55
Large public offices, banks and stores	50 to 60
Factories	60 to 65

Control of Noise Pollution

- **Ear protection aids**
- **Design of doors and windows**
- **Enclosures**
- **Improvement in working method**
- **Legislative measures**
- **Planning of trees**
- **Town planning**
- **Treatment of walls, floors, and ceilings**
- **Vibration damping**

Noise Level for Different Structure

Type f building	Air pollution	Noise pollution
Duration	The sources polluting air persist for some period of time	The sources can be controlled immediately
Effect on human health	It adversely affects human health and may lead to tragic events	It may not by itself adversely affect the human health
Importance	It has gained high importance due t its serious harmful effects	Its importance is related t better environmental conditions only
Nature of phenomena	It is an international phenomena	It is a local phenomena
Nature of substances	It may contain toxic substances	It does not contain harmful substances
Treatment	It is most essential and shall be strictly enforced as per legal requirements	It does not prove fatal even if not treated properly

Any Question?

https://www.youtube.com/watch?v=6FYIMj003-A

Any Question?

Thank you