EWCE 333
Wastewater Engineering and Sanitation

Lecture 3

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Lecture Outlines

Topics	Reference
• On-site sanitation systems for rural & low income urban communities • Simple pit technology – design considerations and design • Two pit latrine systems – design considerations and design	Water Supply and Sanitation - Feroz Ahmed and Mujibur Rahman ITN -BUET

Low Cost Sanitation Technologies

- **Pit Latrine**

- **Pour-flush Latrines** (where a water seal is maintained with low-volume of flushing)

All forms of pit latrines are not fully sanitary.

With slight modifications in design and with some interventions, conventional pit latrines could be improved to be hygienic.

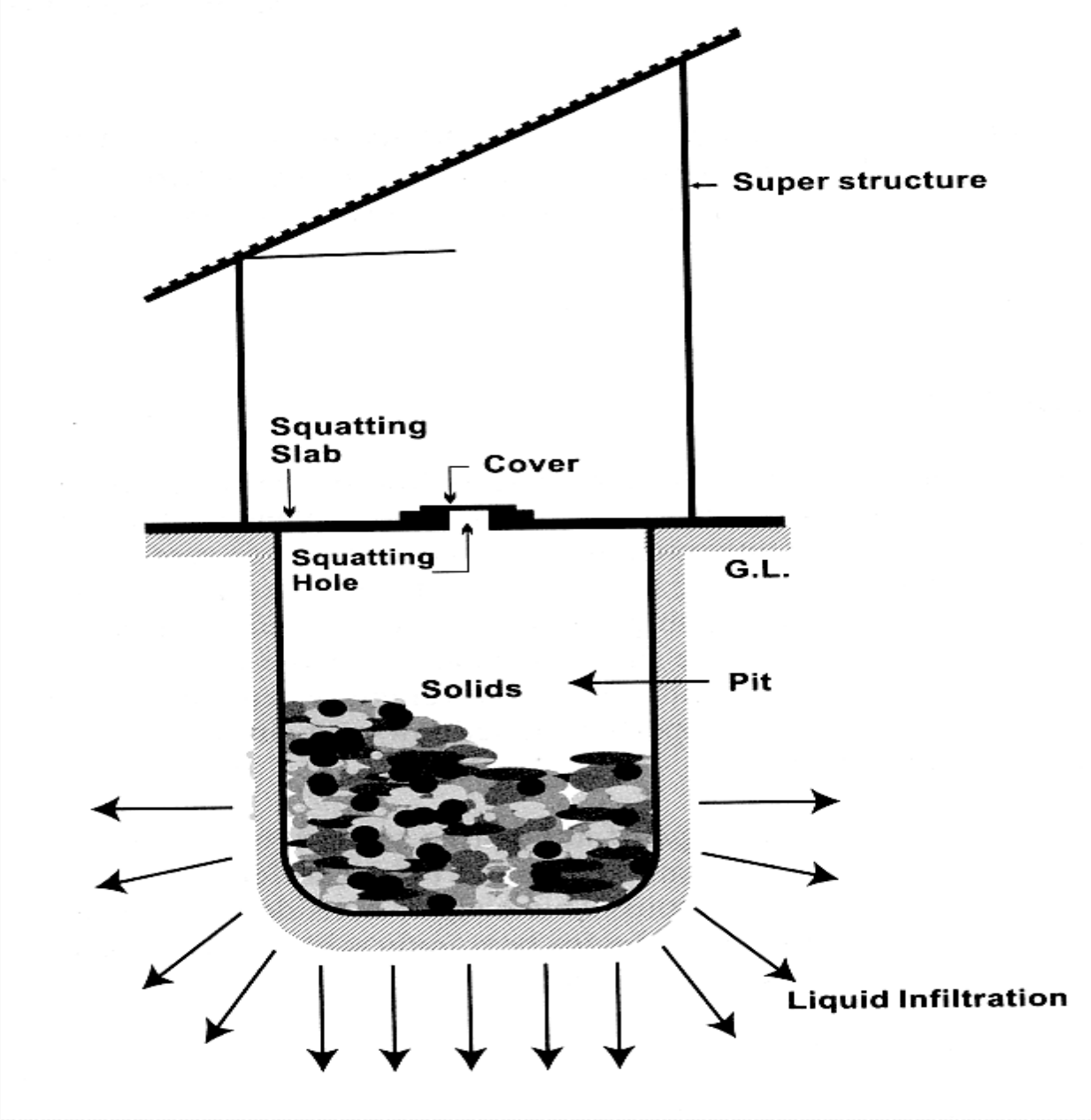
Pit Latrine Technologies

The major types of pit latrines include:

- Simple or Home-made pit latrines
- Ventilated Improved Pit (VIP) Latrines
- Reed Odorless Earth Closet (ROEC)

Pit Latrine Technologies



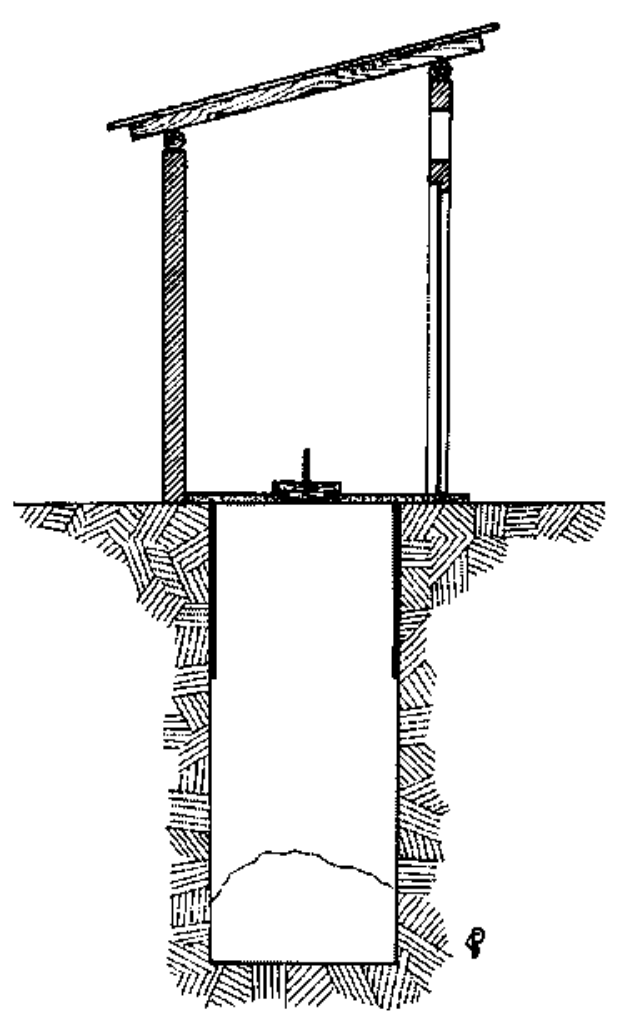


Pit Latrine Technologies

- Most common and simplest form of excreta disposal in developing countries
- Consists of a manually dug or bored hole into the ground, an appropriate seat or squatting slab and a shielding superstructure
- Urine and other liquids soak into the ground and solid materials are retained and decomposed in the pit

Types of Pit Latrines

- **Direct pit latrine**- Excreta falls directly into a pit underneath the user



Types of Pit Latrines

- **Off-set pit latrine**- Excreta pass through a short pipe or a channel to a pit a few meters away

- **Partly off-set pit latrine**- When part of the pit is under the shelter and part is outside

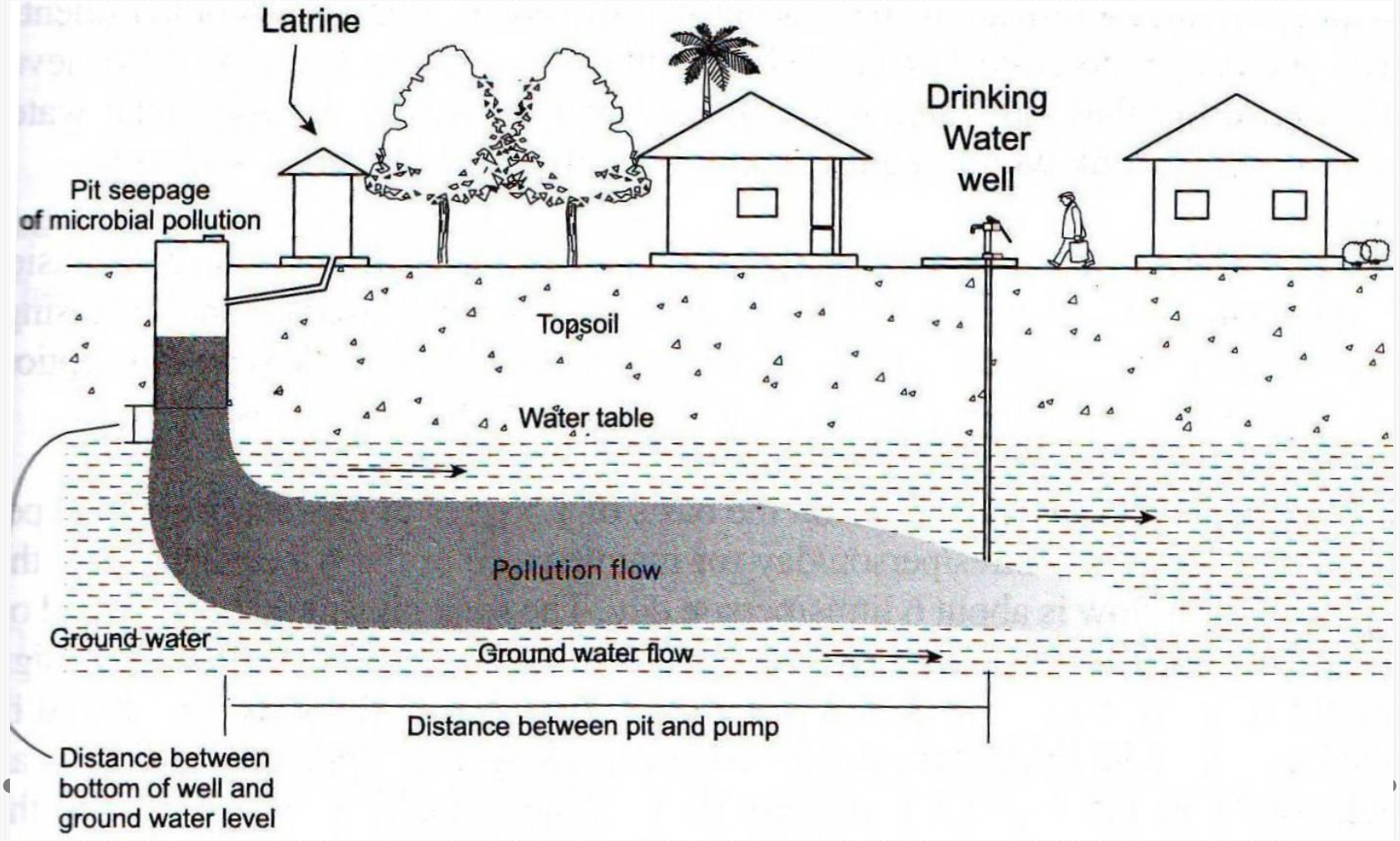
Design Considerations for Pit Latrines

- Pit width - ≤1.5 m (commonly 1.0-1.5 m), to avoid expensive construction of cover slab
- Soils with permeability ≥ 2.5 mm/hour to allow liquid infiltration into soil.
- Pits in unstable soils must be fully lined (otherwise, collapse of superstructure).

Materials used: concrete blocks, bricks, cement-stabilized soil blocks, masonry, perforated oil drums etc.

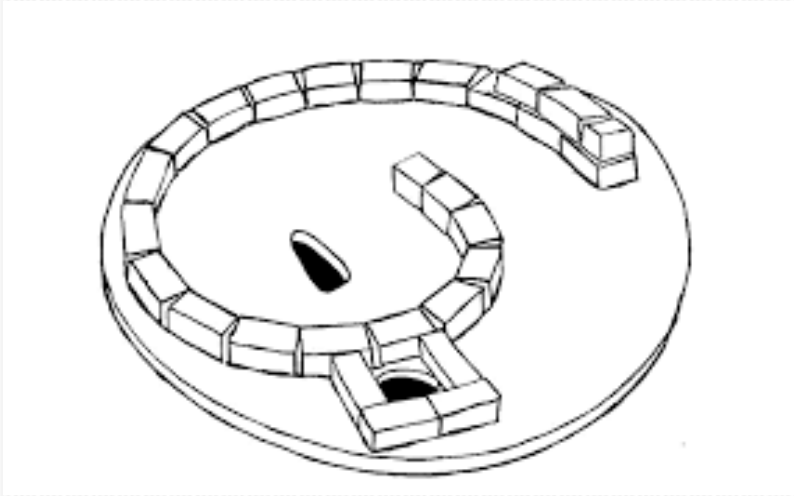
Design Considerations for Pit Latrines

- Distance between pit and a source of drinking water ≥10.0m should be provided (to avoid possible contamination).



Design Considerations for Pit Latrines

- Distance between pit bottom and water table ≥2m.
- Adequate ventilation by leaving openings above and below door or by constructing a spiral wall without door.



Design Considerations for Pit Latrines

- Pit depth: depends on ground water table, soil condition.

- 5-ring pits (@ 1 ft. per ring) are common.

Design of Pit Latrines

Effective Pit Volume:

$$V = C \times P \times N \ldots\ldots (1)$$

where, V = Effective volume of the pit, m^3

C = Solids accumulation rate, m^3/person/year

P = Number of persons, (expected to use the latrine)

N = Design life, years

Design of Pit Latrines

Typical values of C:

- Wet pit: 0.04 m^3/person/year (0.02 - 0.04)

- Dry pit: 0.06 m^3/person/year (0.03 - 0.06)

Note: Accumulation rate is lower for wet pit (i.e., pit below GWT) because biodegradation is faster under wet condition

Design of Pit Latrines

Effective Pit Volume, $V = (\pi d^2/4)\, h$ ..... (2)

where, d = diameter of pit, m

h = effective depth of pit, m

Assuming a suitable d (maximum permissible d is 1.5 m) of pit, h can be obtained.

Usually a free space of 0.5 m is kept at top of the pit.

Total depth of pit, $H = h + 0.5$ ..... (3)

Advantages of Pit Latrines

- Low investment for construction.
- No expert inputs are required during construction.
- Design is readily available; local materials can be used
- Free from the risk of falling a child into it and hence suitable for children.

Advantages of Pit Latrines

- Excrements are better contained than in open defecation.
- Unit can serve one or several households.
- Easy operation and maintenance.
- Pit latrines use no water for flushing.

Disadvantages of Pit Latrines

- Potential odor and flies problem in simple pit latrine.
- Require access to open ground and digging of new pits or emptying of existing ones every few years.
- Emptying of pits can be very difficult (may require manual labor, pits may collapse). Also manual desludging poses health hazard

Disadvantages of Pit Latrines

- Toilets cannot be situated in houses, hence lack of privacy and safety concerns especially during night time.
- Re-location of individual leach-pits difficult in densely populated areas
- They cannot be used at all in crowded areas, on rocky ground, where the groundwater level is high or in areas periodically flooded

Design Problem for Pit Latrines

Problem 1:

Local authority in a village is offering pre-cast concrete rings of 1.0 m diameter and 0.3 m depth of concrete slab to cover it at a subsidized rate.

Design a simple pit latrine for a family of 7.

The soil is unconsolidated/loose and the GWT is 5.0 m below the ground surface.

The family wants the latrine to serve for 4 years.

(Note: Change design parameter as you find appropriate.)

Design Problem for Pit Latrines

Solution:

Effective Pit Volume

$V = C \times P \times N$

$= 0.06 \times 7 \times 4 = 1.68\ m^3$

Cross sectional area of pit = $(\pi d^2/4)$

$= 0.785\ m^2$

Effective Pit depth = 1.68/0.785 = 2.14 m

Design Pit depth = 2.14 + 0.5 = 2.64 m (free board/space =0.5m)

No. of rings required = 2.64/ 0.3 = 8.8 ≈ 9 rings (Height of ring = 0.3m)

But to use more than 5-6 rings is not realistic.

Design Problem for Pit Latrines

Considering N = 3 yrs

$V = 0.06 \times 7 \times 3 = 1.26\ m^3$

Effective Pit depth = 1.26/0.785 = 1.61 m

Design depth = 2.11 m

Rings required = 2.11/ 0.3 = 7 rings

Possible but construction could be difficult.

Actual depth of pit = $7 \times 0.3 = 2.1 + 2 = 4.1m$

Design Problem for Pit Latrines

Considering N = 2 yrs
$V = 0.84\ m^3$

Effective Pit depth = 1.07 m

Design depth = 1.57 m

Rings required = 1.57/ 0.3 = 5.23 ≈ 6 rings

Actual depth of pit = 6 × 0.3 = 1.8 m
1.8 + 2 = 3.8 < 5m (ok)

Design Problem for Pit Latrines

Also recommended:

1) A vent pipe for the pit
(150 mm dia. PVC pipe, top of the vent pipe is 500mm higher than highest point of roof)

2) Use of suitable cover for the squatting hole, when latrine not in use

Design Problem for Pit Latrines

Problem 2:
Repeat the problem 1,
if the latrine has to serve 2 families, each with 7 members.

GWT is high, located 4.0 m below the ground surface.

Design life cannot be less than 2 years and a 2.0 m gap must be provided between the pit bottom and GWT.

Design Problem for Pit Latrines

Problem 3:
A farmer excavated 1.5 m x 2.0 m x 2.5 m (depth) pit for construction of a room which he now wants to convert into a pit latrine.

Requirements/ constraints are:
(i) Water availability is limited
(ii) Excreta cannot be seen through squatting hole.

Design a suitable latrine and find design life for 6 persons. Consider low GWT.

The pit is to be constructed as a permanent one with brick lining.