Water Supply & Sanitary Engineering (DI05006021)

Unit 8: Sewage Treatment and Disposal

Lecture 37: Low-Cost Sanitation and Decentralized Systems

GTU Diploma Engineering

Agenda

- The Need for Low-Cost Sanitation
- Pit Privies (Latrines)
- Aqua Privies
- Septic Tanks: Design and Working
- Effluent Disposal: Soak Pits and Dispersion Trenches
- Imhoff Tanks

The Need for Low-Cost Sanitation

- Centralized underground sewerage is capital-intensive and requires a reliable piped water supply to flush solids.
- In rural areas, isolated dwellings, or developing peri-urban slums, these conditions are rarely met.
- Open defecation poses severe public health risks (cholera, typhoid, hookworm).
- On-site (decentralized) sanitation provides a localized, affordable, and hygienic method to isolate human waste from the environment.
- Key principle: Treat and dispose of the waste right where it is generated.

Pit Privy (Pit Latrine)

- The simplest form of on-site sanitation.
- Consists of a hand-dug hole (pit) in the ground, covered by a slab with a drop hole, and surrounded by a superstructure for privacy.
- Depth is usually 2 to 3 meters.
- Liquids infiltrate into the surrounding soil; solids accumulate and decompose anaerobically in the pit.
- When the pit fills to within 0.5m of the top, it is covered with soil, and a new pit is dug (or the pit is emptied).

Improvements: VIP Latrine

- VIP = Ventilated Improved Pit Latrine.
- Solves the two main problems of basic pits: odors and flies.
- A tall vent pipe fitted with a fly screen at the top is added to the pit.
- Wind passing over the pipe creates an updraft, pulling fresh air down through the toilet hole and exhausting odors through the pipe.
- Flies attracted to the pit are drawn toward the light at the top of the vent pipe, get trapped by the screen, and die.

Aqua Privy

- An aqua privy features a watertight tank located immediately under the latrine floor.
- The drop pipe extends below the liquid level in the tank, creating a water seal.
- The water seal entirely prevents odors and insects from entering the superstructure.
- Solids digest anaerobically in the tank. The displaced liquid effluent overflows into a soak pit.
- Requires daily addition of water to maintain the water seal.

The Septic Tank: Overview

- The most common on-site treatment system for homes with piped water supply.
- A septic tank is a watertight, rectangular underground settling tank.
- It performs two functions simultaneously:
- 1. Sedimentation: Settles out heavy organics (sludge) and floats light organics (scum/grease).
- 2. Digestion: Anaerobic bacteria slowly break down the accumulated sludge at the bottom.
- The clarified effluent (which is still highly polluted) exits the tank for further soil treatment.

Septic Tank: Design Features

- Usually constructed of concrete or brickwork. Minimum width is 0.75m, minimum depth is 1.0m.
- Length to width ratio is generally 2:1 or 3:1.
- Detention time is designed for 12 to 36 hours (usually 24 hours).
- Inlet and outlet pipes are fitted with T-fittings or baffles.
- Baffles prevent incoming flow from stirring up the sludge and prevent floating scum from escaping into the outlet.

Septic Tank: Maintenance

- The anaerobic digestion process reduces sludge volume, but does not eliminate it.
- Over time, the sludge layer at the bottom and scum layer at the top will thicken.
- This reduces the effective volume of the clear zone, reducing detention time.
- Septic tanks must be de-sludged (pumped out by a vacuum truck) every 1 to 3 years.
- Failure to pump leads to solids washing out and destroying the soak pit.

Effluent Disposal: Soak Pits

- The effluent from a septic tank or aqua privy is septic, odorous, and contains pathogens. It cannot be discharged to open drains.
- A Soak Pit (Seepage Pit) is a covered, porous-walled chamber that allows effluent to slowly soak into the surrounding soil.
- Usually circular, lined with dry brick or stone masonry (open joints).
- The soil acts as a natural biological filter, providing secondary aerobic treatment as the liquid percolates down.
- Only suitable in permeable soils (sandy/loamy) with a deep water table.

Effluent Disposal: Dispersion Trenches

- If the soil is less permeable or the groundwater table is relatively high, soak pits cannot be used.
- Alternative: Dispersion Trenches (Drainfield or Leachfield).
- Effluent is distributed through a network of perforated pipes laid in shallow, gravel-filled trenches.
- This spreads the effluent over a much larger surface area than a single pit.
- The shallow placement utilizes the highly active aerobic bacteria present in topsoil for treatment.

Imhoff Tanks

- An improvement over the septic tank for larger communities or small towns.
- It is a two-story tank designed by Karl Imhoff.
- Upper Compartment: Acts strictly as a settling chamber (primary clarifier).
- Lower Compartment: Acts strictly as an anaerobic sludge digester.
- Solids settle in the upper chamber and slide through a slot into the lower chamber.
- Advantage: Biogas bubbles generated in the lower digester cannot enter the upper settling chamber, ensuring the sewage remains fresh (non-septic).

Summary

- Decentralized sanitation is vital for areas without centralized sewerage.
- VIP latrines and Aqua Privies offer simple, effective odor and fly control.
- Septic tanks provide primary settling and partial digestion but require regular de-sludging.
- Soak pits and dispersion trenches use the natural soil for secondary treatment of septic effluent.
- Imhoff tanks provide superior performance by physically separating the settling and digestion processes.

Unit 8 Conclusion

- This concludes Unit 8 on Sewage Treatment and Disposal.
- We have covered the entire journey: from measuring pollution (BOD), through Preliminary, Primary, and Secondary treatment.
- We learned about sludge handling and final safe disposal methods.
- Finally, we explored practical, low-cost decentralized alternatives.