Water Supply & Sanitary Engineering (DI05006021)

Unit 8: Sewage Treatment and Disposal

Lecture 33: Primary Sewage Treatment

GTU Diploma Engineering

Agenda

- Objective of Primary Treatment
- Principle of Sedimentation
- Types of Settling Tanks (Clarifiers)
- Key Design Parameters
- Sludge and Scum Removal Mechanisms
- Efficiency of Primary Treatment

Objective of Primary Treatment

- Primary treatment aims to remove settleable organic and inorganic solids from wastewater.
- It relies entirely on physical settling (gravity).
- The organic solids that settle at the bottom form a highly putrescible substance called 'Primary Sludge'.
- Reducing the suspended solids greatly reduces the organic load (BOD) that the secondary biological treatment must handle.

Principle of Sedimentation

- Sedimentation relies on Stoke's Law, where particle settling velocity depends on particle size and density.
- In sewage, organic particles are light (Specific Gravity approx 1.01 to 1.02) and settle very slowly.
- To allow settling, the flow velocity must be drastically reduced compared to grit chambers.
- Flow in a primary clarifier is kept calm and laminar, avoiding turbulence that would resuspend particles.

Types of Sedimentation Tanks

- Primary sedimentation tanks are also called Primary Clarifiers.
- They are generally classified by their shape and flow direction:
- 1. Rectangular Tanks: Horizontal flow from one end to the other.
- 2. Circular Tanks: Radial flow from a central inlet to a peripheral weir.
- Both types perform effectively; selection depends on site constraints, economics, and operator preference.

Circular Clarifiers

- Wastewater enters through a central column and flows upward into a stilling well.
- Flow then moves radially outward towards the perimeter of the tank.
- The clarified water overflows a V-notch weir at the perimeter.
- A slowly rotating bridge (scraper mechanism) pushes the settled sludge to a central hopper for removal.

Rectangular Clarifiers

- Long, narrow concrete basins. Length to width ratio is typically 3:1 to 5:1.
- Wastewater enters through baffles at one end to distribute flow evenly.
- Water flows horizontally to the effluent weirs at the far end.
- A chain-and-flight mechanism moves continuously along the bottom to push sludge to a hopper at the inlet end.

Design Parameters: Detention Time

- Detention Time (t) is the theoretical average time a drop of water spends in the tank.
- Formula: t = Volume of Tank (V) / Flow Rate (Q)
- Typical detention time for primary clarifiers: 1.5 to 2.5 hours.
- If detention time is too short, solids won't settle.
- If detention time is too long (¿ 3 hours), sewage may turn septic and create foul odors.

Design Parameters: Surface Overflow Rate (SOR)

- Surface Overflow Rate (SOR) is the volume of water applied per unit surface area per day.
- Formula: SOR = Flow Rate (Q) / Surface Area (A)
- Expressed in m3/m2/day or liters/m2/day.
- It is the most critical design parameter. It represents the settling velocity of the slowest settling particle that is 100% removed.
- Typical SOR for primary clarifiers: 30 to 50 m3/m2/day.

Design Parameters: Weir Loading Rate

- Weir Loading Rate is the volume of water passing over a unit length of the exit weir per day.
- Formula: Flow Rate (Q) / Total Length of Weir (L).
- Typical values: 125 to 250 m3/m/day.
- If the rate is too high, the strong current near the weir will lift settled sludge and carry it out with the effluent (carryover).
- V-notch weirs are commonly used to ensure uniform flow distribution across the entire perimeter.

Efficiency of Primary Treatment

- Primary clarifiers are highly efficient relative to their operational cost.
- Typical Removals:
- Suspended Solids (TSS): 50% to 70% removed.
- Biochemical Oxygen Demand (BOD): 25% to 40% removed.
- By removing settleable solids, we indirectly remove the BOD associated with those solid particles.
- Dissolved organics (like dissolved sugar) pass right through primary treatment.

Chemical Enhanced Primary Treatment (CEPT)

- Chemicals (coagulants like Alum or Ferric Chloride) can be added before the clarifier.
- These chemicals neutralize particle charges, causing fine and colloidal solids to clump together (flocculate).
- Heavier flocs settle much faster and more completely.
- CEPT increases TSS removal to 80-90% and BOD removal to 50-60%.
- Trade-off: High chemical costs and significantly increased sludge volume.

Summary

- Primary treatment uses gravity in sedimentation tanks (clarifiers) to remove settleable organic solids.
- Tanks can be circular (radial flow) or rectangular (horizontal flow).
- Surface Overflow Rate (SOR) and Detention Time are the defining design parameters.
- Effectively removes 50-70% of Suspended Solids and 25-40% of BOD.
- Generates primary sludge which must be removed frequently to prevent septicity.

Next Lecture: Secondary Sewage Treatment

- In the next lecture, we tackle Secondary Treatment.
- We will focus on Aerobic biological processes.
- How do microorganisms consume dissolved organic matter?
- Key technologies: Trickling Filters and the Activated Sludge Process (ASP).