Water Supply & Sanitary Engineering (DI05006021)

Unit 3: Treatment of Water

Lecture 10: Sedimentation Processes

GTU Diploma Engineering

Lecture Agenda

- Principles of Sedimentation
- Stokes' Law and Particle Settling
- Plain vs. Coagulation-aided Sedimentation
- Types of Sedimentation Tanks
- Key Design Parameters (SOR, Detention Time)
- Inlet, Outlet, and Sludge Removal
- Tank Efficiency and Short-Circuiting

Principles of Sedimentation

- Definition: Sedimentation is the process of removing solid particles heavier than water by gravity settling.
- When the velocity of flowing water is reduced, the turbulence that keeps particles in suspension is minimized.
- Particles naturally fall to the bottom of the tank, leaving clarified water at the top.
- The settled mass of particles is called 'sludge'.

Stokes' Law

- The settling velocity (Vs) of a discrete spherical particle in a viscous fluid is given by Stokes' Law.
- $Vs = (g * (G - 1) * d^2)/(18 * v)$

- Where: g = acceleration due to gravity, G = specific gravity of particle, d = particle diameter, v = kinematic viscosity of water.
- Key takeaway: Settling velocity is highly dependent on particle diameter (d squared). Doubling the particle size increases settling speed by four times.

Plain vs. Coagulation-Aided Sedimentation

Concept 1	Concept 2
Plain Sedimentation: Water is retained in a reservoir for days or weeks. Removes heavy sand/silt. No chemicals used. Requires massive land area.	Sedimentation with Coagulation (Clarification): Water is pre-treated with coagulants. Removes fine silt, clay, and organics. Detention time is only 2 to 4 hours. Much smaller footprint.
Modern municipal plants almost exclusively use coagulation-aided sedimentation due to space constraints and higher raw water pollution.	

Types of Sedimentation Tanks

- Based on Flow Direction:
- 1. Horizontal Flow Tanks: Typically rectangular. Water flows straight from one end to the other.
- 2. Radial/Up-flow Tanks: Typically circular. Water enters the center and flows radially outward and upward toward the edges.
- Based on Operation:
- Fill-and-Draw type (obsolete, batch process)
- Continuous Flow type (standard in all modern plants)

Key Design Parameters: Surface Overflow Rate (SOR)

- Also known as Surface Loading Rate.
- Formula: SOR = Total Flow (Q) / Surface Area of Tank (A). Units: Liters/m2/day or m3/m2/day.
- Concept: It represents the upward velocity of the water. For a particle to settle, its downward settling velocity (Vs) must be greater than the upward overflow rate (SOR).
- It is the most critical parameter in clarifier design. Tank depth is surprisingly less important than surface area.

Other Design Parameters

- Detention Time (t): The theoretical time water spends in the tank. t = Volume / Flow rate (Q). Usually 2.5 to 4 hours for alum flocs.
- Flow Velocity (V): The horizontal speed of water through a rectangular tank. Must be low enough to prevent scouring (resuspending settled sludge). Max usually 0.3 m/min.
- Weir Loading Rate: The volume of water passing over a unit length of the outlet weir per day. Too high a rate pulls flocs out of the tank.

Inlet and Outlet Arrangements

- Inlet Zone: Designed to dissipate the high velocity of incoming water and distribute it evenly across the tank width/depth using baffle walls with orifices.
- Outlet Zone: Uses a 'Weir' (a notched barrier) to collect the clarified water from the top surface gently.
- V-notch weirs are commonly used to ensure uniform flow even if the tank is not perfectly leveled.

Sludge Collection and Removal

- Sludge accumulates at the bottom and must be removed before it turns septic or occupies too much volume.
- Rectangular Tanks: Use mechanical chain-and-flight scrapers that drag sludge to a hopper at the inlet end.
- Circular Clarifiers: Use slowly rotating radial arms equipped with squeegees that push sludge to a central hopper.
- Removal: Sludge is drawn off via hydrostatic pressure or sludge pumps for further treatment/disposal.

Tank Efficiency and Short-Circuiting

- Theoretical detention time is rarely achieved due to 'Short-Circuiting'.
- Short-Circuiting occurs when water takes a fast, direct path from inlet to outlet, bypassing the main volume of the tank.
- Causes: Density currents (temperature differences), wind effects on the surface, or poor inlet baffle design.
- Effect: Reduces actual settling time, leading to floc carry-over into the filters.
- Mitigation: Proper baffling and maintaining low flow velocities.

Summary

- Sedimentation relies on gravity to settle flocs, governed by Stokes' Law.
- Surface Overflow Rate (SOR) is the most critical design parameter.
- Mechanical scrapers continuously remove sludge to maintain tank volume.
- Next Lecture: We will look at Filtration, the polishing step to catch what didn't settle.