Water Supply & Sanitary Engineering (DI05006021)

Unit 8: Sewage Treatment and Disposal

Lecture 34: Secondary Sewage Treatment: Aerobic Processes

GTU Diploma Engineering

Agenda

- Principles of Biological Treatment
- Aerobic vs. Anaerobic Processes
- Attached Growth vs. Suspended Growth
- Trickling Filters: Design and Operation
- The Activated Sludge Process (ASP)
- Secondary Clarifiers

Principles of Biological Treatment

- Primary treatment removes solids, but dissolved and colloidal organic matter remains.
- Secondary treatment is a biological process.
- We create an optimal environment for microorganisms (mainly bacteria) to consume the dissolved organics as food.
- The bacteria convert the dissolved organic matter into new bacterial cells (biomass), carbon dioxide, and water.
- The newly formed biomass (sludge) is then settled out in a secondary clarifier.

Aerobic Systems

- Aerobic bacteria require dissolved oxygen to survive and metabolize organics.
- Aerobic processes are faster, highly efficient (90%+ BOD removal), and generally do not produce foul odors.
- However, they are energy-intensive because massive amounts of air must be mechanically supplied.
- Key aerobic systems: Trickling Filters and Activated Sludge Process.

Attached vs. Suspended Growth

Concept 1	Concept 2
Attached Growth Systems (e.g., Trickling Filters): Microorganisms grow on a solid medium (rocks, plastic). Wastewater trickles over them.	
Suspended Growth Systems (e.g., Activated Sludge): Microorganisms are mixed freely in the liquid. They are kept suspended by mechanical agitation or aeration.	
Attached growth is generally simpler to operate but requires more land.	
Suspended growth is more compact and flexible but requires intensive operational control.	

Trickling Filters: Components

- A trickling filter consists of a bed of highly permeable media (crushed rock, gravel, or specialized plastic modules).
- A rotary distributor uniformly sprays primary effluent over the top of the bed.
- An underdrain system collects the treated liquid at the bottom and allows air to ventilate upward.
- The depth of the filter medium is typically 1.5 to 2.5 meters for rock media.

Trickling Filters: The Biological Zoogleal Film

- A sticky, gelatinous layer of microorganisms called the 'zoogleal film' or 'biofilm' grows on the media.
- As wastewater trickles over this film, the bacteria absorb and metabolize the dissolved organics.
- Oxygen is absorbed from the air circulating through the void spaces in the media.
- Over time, the biofilm grows thicker. The inner layers become anaerobic and lose their grip on the media.

Trickling Filters: Sloughing

- When the biofilm becomes too thick, the inner anaerobic layer weakens its attachment to the media.
- The hydraulic force of the wastewater washes the biofilm off the rocks.
- This periodic shedding of the biological slime layer is called 'sloughing'.
- The sloughed-off biomass exits the filter with the effluent and must be settled out in a secondary clarifier.

Activated Sludge Process (ASP)

- ASP is a suspended growth process and the most widely used secondary treatment method globally.
- Primary effluent enters an Aeration Tank, where it is mixed with a heavily concentrated mass of microorganisms called 'Activated Sludge'.
- The mixture of wastewater and microbes is called Mixed Liquor Suspended Solids (MLSS).
- Air is continuously pumped into the tank via diffusers or surface aerators to provide oxygen and maintain mixing.

ASP: The Role of Return Sludge

- After aeration (typically 4-8 hours), the mixed liquor flows to a Secondary Clarifier.
- The bacteria clump together (flocculate) and settle to the bottom as sludge.
- To maintain a high concentration of bacteria in the aeration tank, a portion of this settled sludge is pumped back to the inlet.
- This is called Return Activated Sludge (RAS). It ensures the incoming food immediately meets a massive hungry bacterial workforce.

ASP: Key Operating Parameters

- F/M Ratio (Food to Microorganism Ratio): The balance between incoming BOD (food) and MLSS (microorganisms). Proper ratio ensures efficient treatment and good settling.
- Mean Cell Residence Time (MCRT) or Sludge Age: The average number of days a bacterium stays in the system.
- Excess sludge that is not returned (Waste Activated Sludge, WAS) must be removed daily to maintain the system balance.

Secondary Clarifiers

- Follows both Trickling Filters and ASPs.
- Purpose: To separate the biological mass (sloughed film or activated sludge flocs) from the treated water.
- The effluent from the secondary clarifier is typically very clear, with 85-95% of BOD and Suspended Solids removed.
- Design is similar to primary clarifiers but requires careful consideration of sludge settling characteristics (Sludge Volume Index, SVI).

Summary

- Secondary treatment relies on aerobic bacteria to consume dissolved organics.
- Trickling Filters are attached-growth systems relying on a zoogleal film and natural sloughing.
- Activated Sludge Process (ASP) is a suspended-growth system relying on active aeration and sludge recirculation (RAS).
- Both systems require a secondary clarifier to remove the resulting bacterial biomass from the treated effluent.

Next Lecture: Sludge Digestion

- We have treated the water, but now we have tons of sludge (Primary + Secondary WAS).
- Next lecture covers Anaerobic Treatment and Sludge Digestion.
- We will look at how we safely treat and dispose of this biological waste.
- Key technologies: Anaerobic Digesters and Sludge Drying Beds.