Water Supply & Sanitary Engineering (DI05006021)

Unit 8: Sewage Treatment and Disposal

Lecture 31: Biochemical Oxygen Demand (BOD) and Chemical Oxygen Demand (COD) Tests

GTU Diploma Engineering

Agenda

- Concept of Oxygen Demand
- Biochemical Oxygen Demand (BOD) Defined
- The Standard BOD5 Test Procedure
- BOD Kinetics and Calculations
- Chemical Oxygen Demand (COD) Defined
- BOD vs. COD Comparison

The Concept of Oxygen Demand

- Aerobic bacteria require dissolved oxygen (DO) to break down organic matter in sewage.
- The more organic matter present, the more oxygen the bacteria will consume.
- If discharged into a river, high organic load rapidly depletes the river's DO.
- Depleted DO can lead to fish kills and septic, foul-smelling conditions.
- Measuring this 'oxygen demand' quantifies the pollution potential of the sewage.

Biochemical Oxygen Demand (BOD)

- BOD is the amount of oxygen required by aerobic microorganisms to decompose biodegradable organic matter.
- It is an indirect measure of the concentration of biodegradable organics.
- The standard test measures oxygen consumed over 5 days at 20°C (denoted as BOD5).
- Why 5 days? It was originally based on the maximum travel time of rivers in the UK from source to sea.

The Standard BOD5 Test Procedure

- 1. Dilute the sewage sample with specially prepared, fully oxygenated dilution water.
- 2. Dilution water contains nutrients (N, P) and buffer solutions to support bacterial growth.
- 3. Measure the initial Dissolved Oxygen (DO_initial) using the Winkler method or a DO probe.
- 4. Incubate the sample in the dark at 20°C for exactly 5 days.
- 5. Measure the final Dissolved Oxygen (DO_final).

BOD Calculation

- BOD5 (mg/L) = (DO_initial - DO_final) * Dilution Factor
- Dilution Factor = (Volume of diluted sample) / (Volume of undiluted sewage sample)
- Example: If 10 mL of sewage is diluted to 300 mL, Dilution Factor = 30.
- If DO_initial = 8.5 mg/L and DO_final = 3.5 mg/L after 5 days.
- BOD5 = (8.5 - 3.5) * 30 = 5.0 * 30 = 150 mg/L.

BOD Kinetics: Carbonaceous vs. Nitrogenous

- First Stage BOD (Carbonaceous BOD or CBOD): Oxygen used to oxidize carbon-based compounds. Dominates the first 5-8 days.
- Second Stage BOD (Nitrogenous BOD or NBOD): Oxygen used by nitrifying bacteria to oxidize ammonia to nitrites and nitrates.
- Nitrification typically begins after 8-10 days, hence the 5-day test primarily measures CBOD.
- Inhibitors can be added to the BOD test to suppress nitrification if only CBOD is desired.

Limitations of the BOD Test

- Time-consuming: Results take 5 days, making it unsuitable for real-time process control.
- Requires acclimated seed bacteria: If toxic substances are present, bacteria may die, giving artificially low BOD readings.
- Measures only biodegradable organics: Does not account for non-biodegradable plastics or certain industrial chemicals.
- Precision is typically lower than purely chemical tests.

Chemical Oxygen Demand (COD)

- COD is the oxygen equivalent of the organic matter that is susceptible to oxidation by a strong chemical oxidant.
- Instead of bacteria, we use Potassium Dichromate (K2Cr2O7) in an acidic medium (H2SO4) at high temperatures.
- The test measures the total organic matter (both biodegradable and non-biodegradable).
- It does not measure oxygen consumed by bacteria, but chemically oxidized carbon.

The COD Test Procedure

- 1. Add known excess amount of Potassium Dichromate, Sulfuric Acid, and silver sulfate (catalyst) to the sample.
- 2. Reflux (boil) the mixture for 2 hours.
- 3. The organic matter reduces the dichromate ion (orange) to chromic ion (green).
- 4. Titrate the remaining unreacted dichromate with Ferrous Ammonium Sulfate (FAS) to determine how much was consumed.
- 5. The consumed dichromate is proportional to the COD.

Comparison: BOD vs. COD

Concept 1	Concept 2
BOD measures biodegradable organics; COD measures both biodegradable and non-biodegradable organics.	
BOD takes 5 days; COD takes 2-3 hours.	
COD values are almost always higher than BOD values for a given sample.	
BOD involves biological processes (living organisms); COD involves harsh chemical reactions.	
COD is unaffected by toxic substances in the wastewater.	

The BOD/COD Ratio

- The ratio of BOD to COD helps determine the 'treatability' of the wastewater.
- Typical untreated domestic sewage has a BOD/COD ratio of 0.4 to 0.8.
- Ratio ¿ 0.5: Highly biodegradable. Biological treatment will be highly effective.
- Ratio ¡ 0.3: Largely non-biodegradable or toxic. Requires physical-chemical treatment methods.
- As sewage undergoes biological treatment, the ratio decreases because BOD is removed faster than total COD.

Summary

- BOD measures the biodegradable organic fraction over 5 days at 20°C.
- Dilution is essential in BOD testing for high-strength wastes.
- COD measures total organic fraction using potassium dichromate in just a few hours.
- COD is always greater than BOD.
- The BOD/COD ratio dictates whether biological treatment is feasible.

Next Lecture: Preliminary Sewage Treatment

- With sewage characteristics understood, we move to actual treatment.
- Next lecture covers Preliminary Sewage Treatment.
- We will discuss the removal of floating objects and heavy inorganic grit.
- Key components: Screens, Grit Chambers, and Comminutors.