Water Supply & Sanitary Engineering (DI05006021)

Unit 3: Treatment of Water

Lecture 14: Miscellaneous Water Treatment

GTU Diploma Engineering

Lecture Agenda

- The Problem with Iron and Manganese
- Methods of Iron/Manganese Removal (Aeration)
- Causes of Taste and Odour in Water
- Treatment for Taste and Odour (Activated Carbon)
- Introduction to Desalination
- Principles of Reverse Osmosis (RO)
- Applications and Limitations of RO

The Problem with Iron and Manganese

- Source: Very common in groundwater (borewells) where oxygen levels are low.
- In anaerobic conditions, Iron and Manganese exist in their soluble forms (Fe2+ and Mn2+). The water looks clear when pumped.
- Issues:
- When exposed to air, they oxidize into insoluble forms (Fe3+), turning the water yellow, brown, or black.
- Stains laundry and plumbing fixtures severely.
- Promotes the growth of 'Iron Bacteria' which create slimy, foul-smelling deposits in pipes.

Removal of Iron and Manganese

- The fundamental strategy is Oxidation followed by Filtration.
- Step 1: Aeration. Water is cascaded over trays or sprayed into the air. The oxygen in the air reacts with the soluble iron.
- Reaction: 4Fe(HCO3)2 + O2 + 2H2O -¿ 4Fe(OH)3 (precipitate) + 8CO2
- Step 2: Settling/Filtration. The insoluble rust precipitate (Fe(OH)3) is then easily removed using a standard sand filter.
- For stubborn Manganese, chemical oxidants like Chlorine or Potassium Permanganate are used instead of just air.

Causes of Taste and Odour

- Dissolved Gases: Hydrogen sulfide (H2S) gives a 'rotten egg' smell. Often found in groundwater.
- Organic Matter & Algae: Decaying vegetation or algae blooms in surface reservoirs release smelly oils (earthy or fishy odors).
- Industrial Pollution: Phenols or other synthetic chemicals discharged into rivers.
- Chlorination By-products: Chlorine combining with organics or phenols can create strong medicinal or chemical tastes.

Treatment for Taste and Odour

- 1. Aeration: Excellent for stripping volatile gases like H2S and volatile organic compounds (VOCs) out of the water.
- 2. Powdered Activated Carbon (PAC): The most common method. PAC is a highly porous form of carbon.
- Mechanism: Adsorption. The foul-smelling molecules stick to the massive internal surface area of the carbon particles.
- PAC is dosed into the water before the clarifier and settles out with the floc.
- 3. Copper Sulfate: Added to reservoirs to kill algae blooms before they reach the plant.

Introduction to Desalination

- Desalination is the removal of dissolved salts from seawater or brackish groundwater.
- Why needed? Freshwater scarcity. As traditional sources dry up, coastal cities must turn to the ocean.
- Methods:
- Thermal: Multi-Stage Flash distillation (boiling water and capturing condensation). Highly energy-intensive.
- Membrane: Reverse Osmosis (RO). Now the dominant technology globally due to better energy efficiency.

Principles of Osmosis

- Normal Osmosis: If you separate fresh water and salt water with a semi-permeable membrane, nature wants to balance the concentration.
- Fresh water will naturally flow THROUGH the membrane into the salt side to dilute it.
- This natural flow creates 'Osmotic Pressure'.
- The membrane has microscopic pores that let water molecules pass, but block salt ions (Na+, Cl-).

Reverse Osmosis (RO) Process

- To purify water, we must fight nature. We apply massive external pressure to the salty side.
- If the applied pressure exceeds the natural osmotic pressure, the flow is reversed.
- Pure water is forced OUT of the salty side, through the membrane, leaving the concentrated salts behind.
- Required Pressure: For seawater, pressures can be as high as 60 to 80 bar (800-1100 psi).

RO System Components

- 1. Extensive Pre-treatment: Crucial! Sand, silt, or algae will instantly plug the expensive RO membranes. Requires microfiltration and anti-scalants.
- 2. High-Pressure Pump: The heart (and main energy consumer) of the system.
- 3. Membrane Assembly: Usually spiral-wound polyamide membranes housed in pressure vessels.
- 4. Energy Recovery Device (ERD): Captures the pressure from the reject brine stream to help power the pump, saving massive amounts of electricity.

Applications and Limitations of RO

- Applications:
- Seawater desalination for coastal cities.
- Treating brackish inland groundwater.
- Producing ultra-pure water for electronics and pharmaceutical industries.
- Limitations:
- High energy consumption and operational cost.
- Generates a highly concentrated toxic brine waste that is difficult to dispose of without harming marine life.
- Membranes are fragile and degrade with chlorine, requiring dechlorination beforehand.

Unit 3 Summary

- Iron and Odours are removed via aeration and activated carbon.
- Reverse Osmosis utilizes high pressure to overcome osmotic forces, removing dissolved salts.
- We have now covered the entire water treatment train: from raw water intake, coagulation, sedimentation, filtration, disinfection, to specialized treatments.