Lecture Five: Hardness

Assistant Lecturer :Wasan Jassim Hassan

Introduction

- Water hardness is the ability of water to precipitate soap. Hard water is water that requires a large amount of soap to produce foam and leaves deposits on the walls of hot water pipes, boilers, and water distribution systems.
- Soap precipitates in hard water due to the presence of calcium and magnesium ions, as well as other multivalent metal ions such as iron, aluminum, tin, and zinc. Hardness salts in water are usually present as carbonates, bicarbonates, chlorides, sulfates, and nitrates.
- Hard water is formed when rainwater falls to the ground and dissolves salts from the soil. The solubility of soil salts increases due to the presence of carbon dioxide produced by decomposition processes in the soil.

Types of Water Hardness

1. Temporary Hardness (Carbonate Hardness):

This type of hardness is caused by calcium and magnesium carbonates and bicarbonates. It can be removed by boiling, which causes these salts to precipitate.

2. Permanent Hardness (Non-carbonate Hardness):

This hardness is caused by sulfates, chlorides, and nitrates of calcium and magnesium. It cannot be removed by boiling.

Pseudo Hardness

- Some natural waters (like seawater) contain high concentrations of sodium ions. These may interfere with soap and prevent foaming, but they do not cause true hardness. This is called pseudo hardness.

Notes

- Hardness varies depending on the water source.
- Surface water is usually less hard than groundwater due to geological factors.
- Hardness is mainly due to calcium and magnesium ions.
- It is expressed as calcium carbonate ($CaCO_3$) in mg/L.

Classification of Water Based on Hardness

- Soft water: 10–60 mg/L
- Moderately hard: 120–180 mg/L
- Hard water: 180–1200 mg/L
- Very hard water: Above 1200 mg/L

Methods of Determining Hardness

1. Calculation Method:

This method calculates hardness as calcium carbonate based on the concentration of metal ions in water using equivalent weights.

- Formula:
- Hardness (as $CaCO_3$) =
- (Ion concentration × Equivalent weight of $CaCO_3$) ÷ Equivalent weight of the ion

- This method is accurate but difficult to apply regularly because it requires complete analysis of all ions.

EDTA Titration Method

- This method uses disodium ethylenediaminetetraacetate (Na2EDTA).
- Suitable for drinking water, surface water, groundwater, and wastewater.
- Works for all concentration ranges.
- Measures hardness caused by calcium and magnesium ions only.

Relationship Between Hardness and Alkalinity

- Both hardness and alkalinity are expressed as $CaCO_3$ (mg/L).
- Carbonate and bicarbonate alkalinity is equivalent to part of total hardness.
- If total hardness > alkalinity:
- Carbonate hardness = alkalinity
- Non-carbonate hardness = total hardness − alkalinity
- If total hardness ≤ alkalinity:
- All hardness is carbonate hardness.

Homework

1. Explain methods of removing temporary hardness with equations.

2. Explain methods of removing permanent hardness with equations.