11.14. Hard and soft Water

A water is said to be a soft water if it produces sufficient lather with the soap and water is described as being hard if it forms an insoluble scum before it forms a lather with soap. The hardness of natural water is generally caused by presence of the bicarbonates and sulphates of calcium and magnesium but infact all soluble salts that form a scum with soap cause hardness.

$$Ca^{2+}(aq.) + 2C_{17}H_{35}COO^-(aq.) \rightarrow (C_{17}H_{35}COO)_2Ca$$
$$Mg^{2+}(aq.) + 2C_{17}H_{35}COO^-(aq.) \rightarrow (C_{17}H_{35}COO)_2Mg$$

Anion of soap — Insoluble precipitates

Soap will not produce lather with water until all the calcium and magnesium ions have been precipitated. Hard water thus wastes soap. Hardness of water is of two types.

(*a*) Temporary hardness

(*b*) Permanent hardness.

(a) Temporary hardness : This is due to the presence of bicarbonates of calcium and magnesium. Rain water dissolves small quantities of CO_2 from the atmosphere forming a very dilute solution of carbonic acid. This water attacks calcium and magnesium carbonates in any rocks over which it flows and the soluble hydrogen carbonates or bicarbonates are formed.

$$CaCO_3 + H_2O + CO_2 = Ca(HCO_3)_2$$

Temporary hardness in water is easily removed by boiling, as the bicarbonates decompose readily and the insoluble carbonates are precipitated.

$$Ca(HCO_3)_2 \xrightarrow{\text{boil}} \underset{\text{(insoluble)}}{CaCO_3} + H_2O + CO_2$$

$$Mg(HCO_3)_2 \xrightarrow{\text{boil}} \underset{\text{(insoluble)}}{MgCO_3} + H_2O + CO_2$$

Temporary hardness can also be removed by Clark's process which involves the addition of slaked lime [$Ca(OH)_2$].

$$Ca(HCO_3)_2 + Ca(OH)_2 \rightarrow \underset{\text{(insoluble)}}{2CaCO_3} + 2H_2O$$

It is essential to add only the calculated amount of $Ca(OH)_2$ because excess will cause artificial hardness.

(b) Permanent hardness : Permanent hardness is introduced when water passes over rocks containing the sulphates or chlorides of both of calcium and magnesium. This type of hardness can not be removed by boiling or by the addition of slaked lime. Many substances are used for the removal of this type of hardness. The substances used to remove the hardness of water are known as water softeners. The