WATER SOFTENING

WATER AND SALTS

All the water we drink or use mainly comes from rain. This water so much loved by our grandmothers for their washing is practically free of salts but is acidic because, when passing through the air, it collects carbon dioxide (CO_2) which, combining with water, becomes carbonic acid (H_2CO_3).

Acid water, flowing through soil and on rocks, dissolves and collects a quantity of minerals. Not all of the rocks, however, are dissolved by water to the same extent and as a result not all the water contained the same kind and the same quantity of salts. The rocks most easily dissolved are calcareous rocks which mainly consist of calcium and magnesium carbonates ($CaCo_3$ and $MgCO_3$). As a result of the action exerted by carbonic acid these turned into soluble bicarbonates of calcium and magnesium , $Ca(HCO_3)$ and $Mg(HCO_3)_2$.

For this reason the main component of natural water are calcium, magnesium and bicarbonates. Also contained in water are other minerals but to lesser extent since they are rarer in nature and dissolved in water to minor extent.

HARD AND SOFT WATER

In water chemistry, soft water means water without calcium and magnesium which are the minerals that make up hardness in water. Hard water is hence water rich in hardness minerals and software is that having a low contact of them. Hardness is measured in milligrams per litter (mg/l) as CaCO3.

Hardness minerals are either replaced or removed by softening. “Alkalinity” is word that indicates the total content of bicarbonates in natural water and this is an important datum in relation to hardness.

In fact the portion of hardness corresponding to alkalinity is called “temporary hardness” because this is unstable owing to the fact that calcium bicarbonates are easily turned into insoluble calcium carbonate as a result of high temperature and release carbon dioxide in the process.

$$Ca(HCO_3)_2 + \text{Heat} \rightarrow CaCO_3 + H_2O + CO_2$$

The remaining hardness, that is the difference between total and temporary, is called “permanent” hardness because it is stable and has the tendency to give rise to insoluble compounds, although to much lesser extent.

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CONSEQUENCES OF USES OF HARD WATER

The most evident defect of hard water is its giving rise to calcium. The harder the water the thicker the scaling can be seen anywhere and is the source of danger, waste and severe damage.

1) HARDNESS IN HEATING BOILERS

A chemically well balanced water can lead to scaling when heated and this is proved by the thick scaling frequently found inside boilers even when water hardness is limited. It has been shown that even water of 200 mg/l as CaCO3 can give rise to 4.2g of scaling per cubic meter of water heated to 60 deg C and 25.8 g if the temperature is raised to 80 deg C.

A scaled boiler is a source of great danger as overheating and explosions may occur. Finally scaling does not protect the boiler from corrosion.

2) HARDNESS IN PIPING

Even cold water, especially when this has an original scaling quality, can cause thick scaling within pipes with an initial reduction of flow rate gradually increasing up to a point occlusion and pipe replacement. The same, or even worse occurs with drains.

Beside the above, hardness is also responsible for the scale deposits in fixtures, cooking utensils and other equipment contacted by hot water.

ION EXCHANGE

Ion exchange remove unwanted ions from raw water by transferring them to a solid material, called an ion exchanger, which accepts them while giving back an equivalent number of a desirable species stored on the ion exchanger skeleton. The ion exchanger has a limited capacity for storage of ion on its skeleton, called its exchange capacity. Because of this the ion exchanger eventually becomes saturated with unwanted ions. It is then washed with a strong regenerating solution containing the desirable species of ions, and these then replace the accumulated undesirable ions, returning the exchange material to a usable condition. This operation is a cyclic chemical process, and the complete cycle usually includes back washing, regenerating and service.

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SOFTENING BY SODIUM CYCLE CATION EXCHANGE.

Softening is the simplest of the ion exchange processes. It removes hardness from water, including iron and manganese if these constituents can be kept in the reduced ionic form. When the ion exchange bed is saturated with the hardness constituents, the exchanger is regenerated with sodium chloride brine.
The chemical reaction for sodium cation exchange process is shown below:

$$2R\text{-}Na + Ca(HCO3)2 \rightarrow R2\text{-}Ca + 2NaHCO3$$

At exhaustion, the exchanger is regenerated by sodium chloride brine :

$$R2\text{-}Ca + 2NaCl \rightarrow 2R\text{-}Na + CaCl2$$

Ion exchanger (resin) is represented by R in the above equations.