Water softening:

Water softening is the process of removing hardness. Hardness is defined as the water‟s ability to consume soap. Besides making water more pleasing for washing purposes, softening water can also provide benefits of preventing encrustation and scaling inside boilers, water heaters, hot-water lines, as well as some industrial processes. Hardness is usually expressed in terms of "ppm as CaCO3", or ppm as calcium carbonate.

The home water softener industry usually measures hardness in the form of grains per gallon, of which 1 gpg equals about 17 ppm hardness. The terms, "hard water" and "soft water" are used loosely, as there are no accepted standards or "measuring scale" to determine if water is soft or hard.

The primary constituents in water that cause hardness are calcium (Ca) and magnesium (Mg), especially calcium. Iron (Fe) and manganese (Mn) can also promote to water hardness, but typically at a much lesser degree. Hardness caused by calcium and manganese is typically carbonate hardness, for the calcium and manganese exists in the water in the form of calcium bicarbonate, Ca(HCO3)2, and magnesium bicarbonate, Mg(HCO3)2. This form of hardness is usually referred to as carbonate hardness, or temporary hardness. On the other hand, the sulfate, chloride and nitrate salts of calcium are usually referred to as permanent hardness, since they cannot be readily precipitated. Water heaters suffer from hard water because when water containing calcium bicarbonate is heated, the insoluble carbonate form of calcium will be precipitated.

It is a property of water, which prevents the lathering of the soap. Hardness is of two types.

1. Temporary hardness: It is caused due to the presence of carbonates and sulphates of calcium and magnesium. It is removed by boiling.
2. Permanent hardness: It is caused due to the presence of chlorides and nitrates of calcium and magnesium. It is removed by zeolite method.

Hardness is usually expressed in gm/liter or p.p.m. of calcium carbonate in water. Hardness of water is determined by EDTA method. For potable water hardness ranges from 5 to 8 degrees.

Temporary hardness removal methods:

Boiling of Water:

Calcium carbonate – slightly soluble in water – present in the form Calcium bicarbonate because, it easily dissolves in water containing CO2.

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

Addition of Lime (CaO):

Hydrated lime [Ca(OH)2] is added to water

$$MgCO_3 + Ca(OH)_2 \rightarrow Mg(OH)_2 + CaCO_3$$

$$Mg(HCO_3)_2 + Ca(OH)_2 \rightarrow Ca(HCO_3)_2 + Mg(OH)_2$$

$$Ca(HCO_3)_2 + Ca(OH)_2 \; 2CaCO_3 + 2H_2O$$

Suitable only for Temporary hardness removal process.

Permanent hardness removal methods

1. Lime-Soda process
2. Base-Exchange process, generally called *Zeolite process*
3. Demineralization process

1. Lime-Soda process

Lime soda process is a method of softening hard water. This process is now obsolete but was very useful for the treatment of large volumes of hard water. In this process Calcium and Magnesium ions are precipitated by the addition of lime (Ca(OH)2) and soda ash (Na2CO3).

Chemistry of Lime Soda Process:

Lime addition removes only magnesium hardness and calcium carbonate hardness. In equation 5 magnesium is precipitated, however, an equivalent amount of calcium is added. The water now contains the original calcium noncarbonate hardness and the calcium non-carbonate hardness produced in equation 5. Soda ash is added to remove calcium non-carbonate hardness:

Na2CO3 + CaSO4 ---------Na2SO4 + CaCO3

Limitations of Lime Soda Process

Lime soda softening cannot produce a water at completely free of hardness because of minute solubility of CaCO3 and Mg (OH)2. Thus the minimum calcium hardness can be achieved is about 30 mg/L as CaCO3, and the magnesium hardness is about 10 mg/L as CaCO3.

We normally tolerate a final total hardness on the order of 75 to 120 mg/L as CaCO3, but the magnesium content should not exceed 40 mg/L as CaCO3.

2. Base-Exchange process, generally called *Zeolite process*

Zeolite or Base-Exchange or Cation exchange process

Zeolites are of two types:

1. Natural zeolite : Natural zeolite are non-porous. for example,natrolite ,Na2O.Al2O3.xSiO2.yH2O.

2. Synthtic zeolite : Synthtic zeolite are porous and posses get structure. They are prepared by heating together china clay,feldspar and soda ash. Such zeolites possess higher exchange capacity per unit weight than natural zeolites.

Zeolite – termed as *Green sand* – Na2O Al2O3 x.SiO2 y.H2O

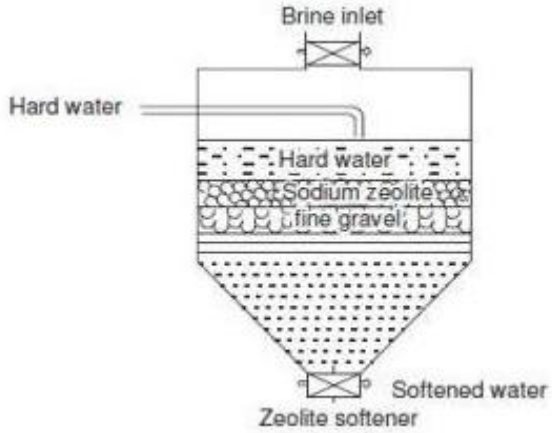
Zeolite or Resins have excellent property of exchanging their cations and hence during softening operation, the sodium ions of the zeolite get replaced by the calcium and magnesium ions present in hard water.

Used as filter media in sand filter (Zeolite sand bed)

• When Sodium is replaced by Calcium & Magnesium – backwashing is done – Again brine is added to regenerated the filter bed – excess brine is removed by back washing with water

• Filters – Gravity or Pressure (more common)

• Rate of filtration: 300 l/m2/min



• Zeolite process results in *Zero hardness* – not suitable for public supplies – small amount is processed and mixed with unsoftened water to obtain standard limits.