CHARACTERISTICS OF NATURAL WATER

The chemical composition of natural water is derived from many different sources of solutes, including gases and aerosols from the atmosphere, weathering and erosion of rocks and soil, solution or precipitation reactions occurring below the land surface and cultural effects resulting from human activities.

PROBLEMS WITH HARD WATER

Limescale formation

Hard water leads to the buildup of limescale, which can foul plumbing, and promote galvanic corrosion. In industrial scale water softening plants, the effluent flow from the re-generation process can precipitate scale that can interfere with sewage systems.

Soap scum

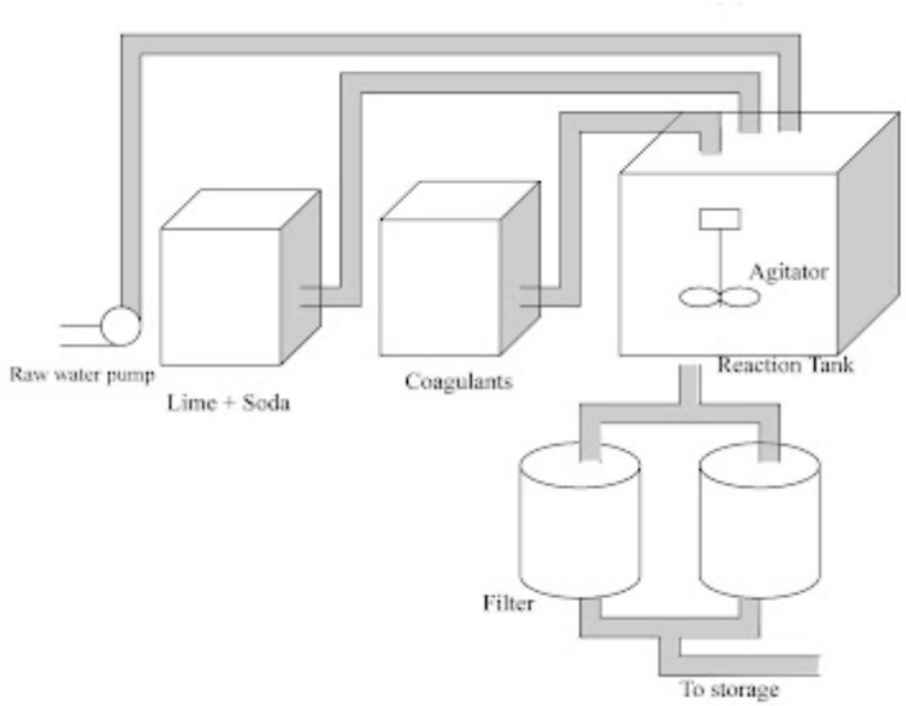
The slippery feeling experienced when using soap with soft water occurs because soaps tend to bind to fats in the surface layers of skin, making soap molecules difficult to remove by simple dilution. In contrast, in hard-water areas the rinse water contains calcium or magnesium ions which form insoluble salts, effectively removing the residual soap from the skin but potentially leaving a coating of insoluble stearates on tub and shower surfaces, commonly called soap scum. Which of these effects is considered more or less desirable varies from person to person, and those who dislike the sliminess and difficulty of washing off soap caused by soft water may harden the water by adding chemicals such as baking soda, calcium chloride or magnesium sulphate

WATER CONDITIONING

Water conditioning is the removal of calcium, magnesium, and certain other metal cations in hard water. The resulting soft water is more compatible with soap and extends the lifetime of plumbing. Water softening is usually achieved using lime softening or ion-exchange resins.

SOFTENING OF WATER

The most common means for removing water hardness rely on ion-exchange polymers or reverse osmosis. Other approaches include precipitation methods and sequestration by the addition of chelating agents. Soda lime is a process used in water treatment to remove Hardness from water. This process is now obsolete but was very useful for the treatment of large volumes of hard water. Addition of lime (CaO) and soda (Na2CO3) to the hard water precipitates calcium as the carbonate, and magnesium as its hydroxide. The amounts of the two chemicals required are easily calculated from the analysis of the water and stoichiometry of the reactions. The lime-soda uses lime, Ca (OH)2 and soda ash, Na2CO3, to precipitate hardness from solution.



Soda lime water softening process

Carbon dioxide and carbonate hardness (calcium and Magnesium bicarbonate) are complexed by lime. In this process Calcium and Magnesium ions are precipitated by the addition of lime (Ca(OH)2) and soda ash (Na2CO3).

Following are the reactions that takes place in this process:

As slacked lime is added to a water, it will react with any carbon dioxide present as follows:

$Ca(OH)2 + CO2 \rightarrow CaCO3 \downarrow + H2O....(1)$

The lime will react with carbonate hardness as follows:

$Ca(OH)2 + Ca(HCO3)2 \rightarrow 2CaCO3 \downarrow + 2H2O$.....(2)

$Ca(OH)2 + Mg(HCO3)2 \rightarrow MgCO3 + CaCO3 \downarrow + 2H2O$.....(3)

The product magnesium carbonate in equation 3 is soluble. To remove it, more lime is added:

$Ca(OH)2 + MgCO3 \rightarrow CaCO3 \downarrow + Mg(OH)2 \downarrow$.....(4)

Also, magnesium non-carbonate hardness, such as magnesium sulfate, is removed:

$Ca(OH)2 + MgSO4 \rightarrow CaSO4 + Mg(OH)2 \downarrow$.....(5)

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 non-carbonate hardness and the calcium non-carbonate hardness produced in equation 5. Soda ash is added to remove calcium non-carbonate hardness:

$Na2CO3 + CaSO4 \rightarrow Na2SO4 + CaCO3 \downarrow$.....(6)

To precipitate $CaCO3$ requires a pH of about 9.5; and to precipitate $Mg(OH)2$ requires a pH of about 10.8, therefore, an excess lime of about 1.25 meq/l is required to raise the pH.

The amount of lime required: lime (meq/l) = carbon dioxide (meq/l) + carbonate hardness (meq/l) + magnesium ion (meq/l) + 1.25 (meq/l)

The amount of soda ash required: soda ash (meq/l) = non-carbonate hardness (meq/l)

After softening, the water will have high pH and contain the excess lime and the magnesium hydroxide and the calcium carbonate that did not precipitate. Recarbonation (adding carbon dioxide) is used to stabilize the water. The excess lime and magnesium hydroxide are stabilized by adding carbon dioxide, which also reduces pH from 10.8 to 9.5 as the following:

$CO2 + Ca(OH)2 \rightarrow CaCO3 \downarrow + H2O$

$CO2 + Mg(OH)2 \rightarrow MgCO3 + H2O$

Further recarbonation, will bring the pH to about 8.5 and stablize the calcium carbonate as the following:

$CO2 + CaCO3 + H2O \rightarrow Ca(HCO3)2$

It is not possible to remove all of the hardness from water. In actual practice, about 50 to 80 mg/l will remain as a residual hardness.

<u>Limitation of Soda Lime Process:</u>

Lime soda softening cannot produce a water at completely free of hardness because of the solubility (little) 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 (because a greater hardness of magnesium forms scales on heat exchange elements).

Demineralization process is the modern industrial water softening process. By this process ,it can be possible to remove hardness as well as remove of all dissolve salts i.e;. FeCO3, CaCl2 . We can also say that demineralization or deionization is the process of removing the dissolved ionized solids from water by ion exchange. The major portions of total dissolved solids (TDS) are mineral salts, such as calcium bicarbonate, magnesium sulfate, and sodium chloride. Mineral salts are composed of cations and anions. Since deionization requires the removal of all ions, both the negatively charged anions and the positively charged cations, then materials capable of attracting both are required. These materials are known as cation and anion exchange resins.