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Study of Water Softening Process

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Abstract: Water softening 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.The presence of certain metal ions like calcium and magnesium principally as bicarbonates, chlorides, and sulfates in water causes a variety of problems.

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.

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.

Keywords: Hardness, Scale formation

Introduction

In this article we can see the details about variety of methods which is use to remove hardness,and from that we can compare which method will easy to apply or execute. Every method is based on different mechanisms such as exchanging ions , producing precipitations or may applying pressure.

Theory

Hard water is simply water that contains a lot of minerals in it. These minerals are mostly magnesium carbonate, calcium, and manganese.These minerals occur naturally, and they are not harmful to your health, but they bring along many problems, some of which are mentioned above as evidence of hard water. They affect the functioning of your electrical appliances like water heater and bring a pale appearance to your dishes, clothes, skin and even hair.Hard water usually comes from wells and other underground sources where minerals from rocks dissolve in the water. These minerals are responsible for giving water the undesirable characteristic called 'hardness.'

Following are some common methods which are generally use to remove hardness of water-

1) Ion-exchange resin devices

Conventional water-softening appliances intended for household use depend on an ion-exchange resin in which "hardness ions" - mainly Ca^{2+} and Mg^{2+} - are exchanged for sodium ions.As described by NSF/ANSI Standard 44,ion-exchange devices reduce the hardness by replacing magnesium and calcium (Mg^{2+} and Ca^{2+}) with sodium or potassium ions (Na^{+} and K^{+})."

Ion exchange resins are organic polymers containing anionic functional groups to which the divalent cations (Ca^{++}) bind more strongly than monovalent cations (Na^{+}). Inorganic materials called zeolites also exhibit ion-exchange properties. These minerals are widely used in laundry detergents. Resins are also available to remove carbonate, bi-carbonate and sulphate ions which are absorbed and hydroxide ions released from the resin.

When all the available Na^{+} ions have been replaced with calcium or magnesium ions, the resin must be re-charged by eluting the Ca^{2+} and Mg^{2+} ions using a solution of sodium chloride or sodium hydroxide depending on the type of resin used. For anionic resins, regeneration typically uses a solution of sodium hydroxide (lye) or potassium hydroxide. The waste waters eluted from the ion-exchange column containing the unwanted calcium and magnesium salts are typically discharged to the sewage system.

2) Lime softening

Lime softening is the process in which lime is added to hard water to make it softer. It has several advantages over the ion-exchange method but requires full-time, trained personnel to run the equipment.

As lime in the form of limewater is added to raw water, the pH is raised and the equilibrium of carbonate species in the water is shifted. Dissolved carbon dioxide (CO_2) is changed into bicarbonate (HCO^{-3}) and then carbonate (CO_2^{-3}). This action causes calcium carbonate to precipitate due to exceeding the solubility product. Additionally, magnesium can be precipitated as magnesium hydroxide in a double displacement reaction.

In the process both the calcium (and to an extent magnesium) in the raw water as well as the calcium added with the lime are precipitated. This is in contrast to ion exchange softening where sodium is exchanged for calcium and magnesium ions. In lime softening, there is a substantial reduction in total dissolved solids (TDS) whereas in ion exchange softening (sometimes referred to as zeolite softening), there is no significant change in the level of TDS.

Lime softening can also be used to remove iron, manganese, radium and arsenic from water.

3) Chelating agents

Chelators are used in chemical analysis, as water softeners, and are ingredients in many commercial products such as shampoos and food preservatives. Citric acid is used to soften water in soaps and laundry detergents. A commonly used synthetic chelator is ethylenediaminetetraacetic acid (EDTA).

4) Distillation and rain water

Since Ca^{2+} and Mg^{2+} exist as nonvolatile salts, they can be removed by distilling the water. Distillation is too expensive in most cases. Rainwater is soft because it is naturally distilled during the water cycle of evaporation, condensation and precipitation.

5) Reverse osmosis

Reverse osmosis (RO) takes advantage of hydrostatic pressure gradients across a special membrane. The membrane has pores large enough to admit water molecules for passage; hardness ions such as Ca^{2+} and Mg^{2+} remain behind and are flushed away by excess water into a drain. The resulting soft water supply is free of hardness ions without any other ions being added. Membranes have a limited capacity, requiring regular replacement.

B. Health effects

The CDC recommends limiting daily total sodium intake to 2,300 mg per day, though the average American consumes 3,500 mg per day. Because the amount of sodium present in drinking water—even after softening—does not represent a significant percentage of a person's daily sodium intake, the EPA considers sodium in drinking water to be unlikely to cause adverse health effects.For those who are on sodium-restricted diets, the use of a reverse osmosis system for drinking water and cooking water will remove sodium along with any other impurities which may be present. Potassium chloride can also be used as a regenerant instead of sodium chloride, although it is more costly. For people with impaired kidney function, however, elevated potassium levels, or hyperkalemia, can lead to complications such as cardiac arrhythmia.

Compared to reverse osmosis and distilled methods of producing soft water, hard water conveys some benefits to health by reducing the solubility of potentially toxic metal ionssuch as lead and copper, which are more soluble in soft water than in hard water.

Advantage

a) Softener resin can be regenerated and re-used.
b) Ion exchange can consistently remove hardness from water to extremely low levels.
c) Softening removes dissolved iron and manganese (*i.e.* colorless). Other water quality factors, such as pH and alkalinity, are not critical to removing iron and manganese.
d) Conventional softening can also remove other health related contaminants.

Conclusion

From above comparative study we observe that the use of lime is simple to apply andeconomical water softening method as compare to other methods.

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