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Review on Causes of Water Hardness and Its Removal Methods

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Abstract: ***This Chapter aim to engage in the main aspects related to Hardness content in drinking water and its effects on human health. It also focuses on the Ion exchanges techniques. It also focuses on the removal of hardness content with the help of ion exchange method by using commercial resin. this Chapter show various Previous Research work Carried out by researcher on role of Hardness in Human health. There are various Procedures that may be used, each having bene- fits and drawbacks. Physical Method, Chemical Method, Adsorption method And Ion exchange method Are the Four most Often method for Hardness removal. Also, this chapter focuses on the problem causes by hardness and diseases.***
This literature review Emphasize on the importance of the Hardness content in the Drinking Water and Effect on Human health, Methods to remove the hardness content in Drinking water, Standard Method to examine the hardness content in water and type of hardness.
Keywords: Water Hardness, Types, Causes, Ion Exchange Method, Removal of hardness.

I. INTRODUCTION

The health of the residents in the cities, township, etc is very Important. It is very essential that health risk assessment in term of the quality of drinking water should be properly carried out. Water is an essential component for life on the earth which contains minerals extremely important in human health Supply of fresh and clean drinking water is the basic need for all human beings on earth. The contamination of soil, ground water and surface water by heavy metal or metalloids has becomes a major environmental and public health hazard and major constraint to sustainable development in many countries of Ashi and Pacific. Along with the depletion of water levels the pollution of water bodies is becoming a matter of serious concern and attention is needed. For developing sustainability both quality and quantity of water resources need to be monitored and preventive and mitigative measures need to be taken.

II. LITERATURE REVIEW

A. Need

Water is essential for hydration and therefore, for life. It is also very important in food preparation and cooking, sanitation and hygiene, and a wide range of other uses. The drinking water supply has a primary objective of protecting human health, including ensuring access to adequate quantities of safe water. It is estimated that approximately 17% of the world's population uses water from the unprotected and remote sources, 32% from some form of protected sources and 51% from centralized (piped) system to the dwelling or a plot. Of the latter, a small but increasing proportion applies some form of treatment within the home. Individual water consumption occurs both at home and elsewhere, such as at schools and workplaces. Drinking-water is consumed not only as water *per se* but also in beverages and incorporated in food- stuffs. In response to increasing global and local water scarcity, there is an increasing use of sources such as recovered/recycled water, harvested rainwater, and desalinated water. 884 mil- lion people lack access to safe water supplies; approximately one in eight people. [**1**]

B. Sources of Exposure to Hardness

Knowing the hardness of water is important when evaluating its use as a domestic or industrial water supply. Hard water interferes with laundering, washing, bathing and personal grooming. Several studies have indicated a link between hardness concentrations (particularly calcium and magnesium) and cardiovascular diseases, Alzheimer's disease, and atopic eczema. However, the link is tenuous, and many confounding variables exist in the studies [**2**]. Hard water is mainly caused by calcium and magnesium cations and to a lesser extent aluminum, iron and other cations. Calcium and magnesium are the two major cations responsible for hard-ness in natural water. Therefore, for most waters, the total hardness is caused by major cations and associated anions as shown in

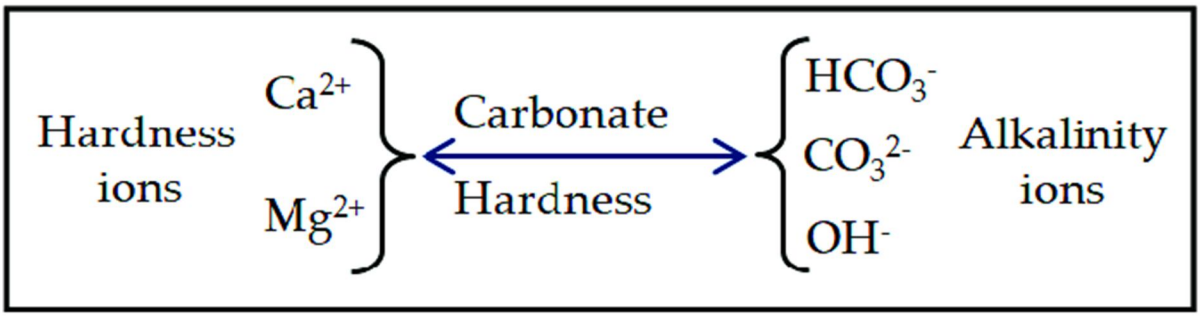

Figure 2.1 -Major cations and associated anions in water

C. Hardness

Hard water is usually defined as water, which contains a high concentration of calcium and magnesium ions. However, hardness can be caused by several other dissolved metals; those forms divalent or multivalent cations, including aluminum, barium, strontium, iron, zinc, andmanganese. Normally, monovalent ions such as sodium and potassium do not cause hardness.These divalent cations have a propensity to come together with anions in the water to form stable salts. The type of anion found in these salts distinguishes between the two types of hard-ness - carbonate and non-carbonate hardness (**Table 1**).

Hardness generally enters groundwater as the water percolates through minerals contain- ing calcium or magnesium. The most common sources of hardness are limestone (which intro-duces calcium into the water) and dolomite (which introduces magnesium.) Since, hardness enters the water in this manner groundwater generally has a greater hardness than surface water.[**3**]

Carbonate hardness compounds	Non-carbonate hardness compounds
Calcium carbonate (CaCO3)	Calcium sulphate ($CaSO_4$)
Magnesium carbonate (MgCO3)	Magnesium sulphate (Mg SO_4)
Calcium bicarbonate [Ca (HCO3)2]	Calcium chloride (Ca Cl_2)
Magnesium bicarbonate [Mg (HCO3)2]	Magnesium chloride (Mg Cl_2)

Table 1 - Carbonate and non-carbonate hardness compounds

Definition of "Hardness".

1) According to world Encyclopaedia 2005, water hardness is a measure the amount of calciumand magnesium salts in water.

2) The hardness of water is defined as the quality of water which is due to the presence of bicarbonate of calcium and Magnesium, Sulphates, Chlorides and Nitrates of Calcium and Magnesium [4].

D. Problems Caused by Hardness

Hard water has no known adverse health effect, WHO says at its Geneva Conference. In addition, hard water, particularly very hard water, could provide an important supplementarycontribution to total calcium and magnesium intake. The health effects of hard water are mainlydue to the effects of the salts dissolved in it, primarily calcium and magnesium. On the other hand, the major cause of hypermagnesemia is renal insufficiency associated with a significantlydecreased ability to excrete magnesium.[**5**]

1) Cardiovascular Disease

In most large-scale studies, an inverse relationship between the hardness of drinking- water and cardiovascular disease has been reported. However, no such association has been found in some other studies, particularly in those involving small geographical areas a clear association is often not found. The extent to which confounding variables, such as climatic, socioeconomic, or major risk factors, may account for the inverse relationship is unclear. Nev- ertheless, in a number of studies, a weak inverse relationship was reported after allowance wasmade for climatic and socioeconomic factors [**6**]

2) Cerebrovascular Mortality

Some reports suggest there is a significant protective effect of magnesium intake from the drinking water on the risk of cerebrovascular disease. Despite their inherent limitations, studies on the ecological correlation between mortality and environmental exposures have beenused widely to generate or discredit epidemiological hypotheses.

Dietary calcium is the main source of calcium intake. Epidemiological studies have shown that dietary calcium is inverselyassociated with the blood pressure. However, controlling for magnesium levels eliminates the perceived effect of calcium levels on cerebrovascular mortality. In the general population, the major proportion of magnesium intake is through food, and a smaller proportion is through drinking water. For individuals with the borderline magnesium deficiency, waterborne magnesium can make an important contribution to their total intake.[**9**]

3) Malformations of Central Nervous System

There is good evidence that environmental influences must play some part, possibly a major part, in the etiologic of neural tube malformations in the human embryo. Almost all that evidence, however, relates to non-specific and uncertain markers of as yet unidentified specific teratogens. For example, the frequency of malformations of the central nervous system varies greatly from country to country. He concluded that because mortality from cardiovascular dis-ease in the county boroughs of England and Wales has been shown to be strongly an associatedwith softness of their water supplies water factor might be responsible for the regional variations of mortality from the central nervous system malformations [**10**].

4) Diabetes

Hard water is indicative of the presence of higher levels of magnesium. In certain areas, drinking water actually contains 100% or more of the recommended daily allowance about magnesium, which is around 300-400 mg daily with levels varying according to gender and age. Because, all kinases and other ATP-related enzymes and channels regulating insulin action are dependent on magnesium, it is not surprising that serum magnesium concentrations have been found to be decreased in non-diabetic subjects with metabolic syndrome and that hypo- magnesaemia is a common feature in subjects with type-2 diabetes. his should include measuresof glycosylated haemoglobin, an indicator of glycaemic control that has been found to respondto oral magnesium supplementation and to correlate negatively with serum ionized magnesiumor serum total magnesium in type 2 diabetics.[**12**]

5) Kidney Stones

The hardness of water is due to the presence of carbonate and sulphate salts of calciumand magnesium. More than 3/4th of kidney stones is generally composed of calcium salt and usually occur as calcium oxalate and less commonly as calcium phosphate. The remaining 20%of stones are composed of uric acid, struvite and cystine stone. Stones form in urine that is supersaturated and this saturation is dependent on chemical free ion activity, which makes theurine under-saturated. In this situation, the stone will not grow and may even dissolve. In- creased urinary ion excretion and decreased urine volume will both an increase free ion activityand Favor stone formation and growth. Formation of kidney stones (nephrolithiasis) is based on genetic, metabolic, nutritional and environmental factors. Some studies suggest that in the preventive approach to calcium nephrolithiasis, intake of soft water has been preferable to hardwater since it is associated with a lower risk for recurrence of calcium stones.[**13**]

E. Methods of Removal of Hardness

The existence of Ca^{2+} and Mg^{2+} ions in water causes hardness. A water supply with a hardness level of 100 parts per million (100 ppm) contains the equivalent of 100 g of $CaCO_3$ in one litter of water. The total hardness is equal to the sum of magnesium hard-ness and calcium hardness.

1) Physical Method

Temporary hardness present in the water can be removed by using the following methods:

By heating Salts like calcium bicarbonate and magnesium bicarbonate, when dissolved in water causes temporary hardness. While heating, soluble salts of calcium and magnesium (bicarbonates) change into insoluble salts. the chemical equations are as follows:

Calcium bicarbonate → Calcium carbonate Carbon dioxide + Water

$C(HCO_3)_2 \rightarrow CaCO_3 + CO_2 + H_2O$

Magnesium bicarbonate → Magnesium carbonate + Carbon dioxide + Water

Mg (HCO)→ MgCO3 + CO2 + H_2O [**17**]

2) Chemical Method

Removing harness using chemical method involves the use of chemical water softenersThese are of two types those which lead to precipitation and those which do not precipitate

Calcium hydroxide, Ca (OH)2

Addition of calculated amount of Ca (OH), will remove only temporary hardness fromwater. Ca (OH), precipitates the insoluble trioxocarbonate

Example, Ca (OH)2(5) + Ca (HCO_2)2(aq) → 2Ca CO) (s)+2H_2O

Note: Ca (OH)2 is slightly soluble, Ca (HCO) is soluble, CaCO3 is insoluble

Also, notice that excess of Ca ($OH_{)2}$ could cause hardness, hence the amount added ismeasured [**37]**

3) Adsorption

Adsorption is defined as the deposition of molecular species onto the surface. The molecular species that gets adsorbed on the surface is known as adsorbate and the surface on which adsorption occurs is known as adsorbent. Common examples of adsorbents are clay, silica gel, colloids, metals etc. Various advanced technologies like nanofiltration, electro-dialysis, chemical precipitation, reverse osmosis, lime soda process and ion exchange process are used to soften water [**19**]. But these methods are restricted by high operating cost . In ion exchange method, compounds enriched with harmless ions which replaces thehardness causing ions in water. Challenges of conventional technique and ease of handling made adsorption technique popular in researches. The adsorption technique is proved to bemore effective since it doesn't eject any ions into the treated water [**20**].

4) Ion Exchange Method

Calcium (Ca) and magnesium (Mg) ions that cause water hardness can be re- moved easily by using an ion exchange procedure. Standard water softeners are cation exchange devices. Cations refer to positively charged ions dissolved in the water. Cat ion exchange involves the replacement of the hardness ions with a non-hardness ion.

From the chemical point of view, they are polyacids, polybasic or both polyacids and polybasic (polyampholyte, amphoteric ion exchangers). Those which exchange cat- ions are called *cation exchangers* and those which exchange anions are called *anion exchangers*. Generally, those exchanging ions are called *ion exchangers*. Some ion ex-changers prepared by modification of various types of substances, particularly natural ones, besides capability of exchanging ions exhibit distinct sorption properties. [**22**]

III. CONCLUDING REMARK ON REVIEW

The Different investigations on the techniques for determining the hardness Concentration of water have been conducted while reviewing all the literature reviews that were mentioned. It is also noticed that People are like to applying ion exchanges method to softening the water. These purification process treat hardness content as a pollutant and remove it from water, regardless of the hardness content. Additionally, research show that hardness content I.e. Mg^{++} and Ca^{++} is a beneficial ion for human health and those deficiencies or overdoses of hard water can result in health issues. Due to its significant contribution to the mineralization of bones and hair. hardness in a water is a crucial component for maintaining human health. It is also observed that ion exchange method removes hardness content to unacceptable levels.

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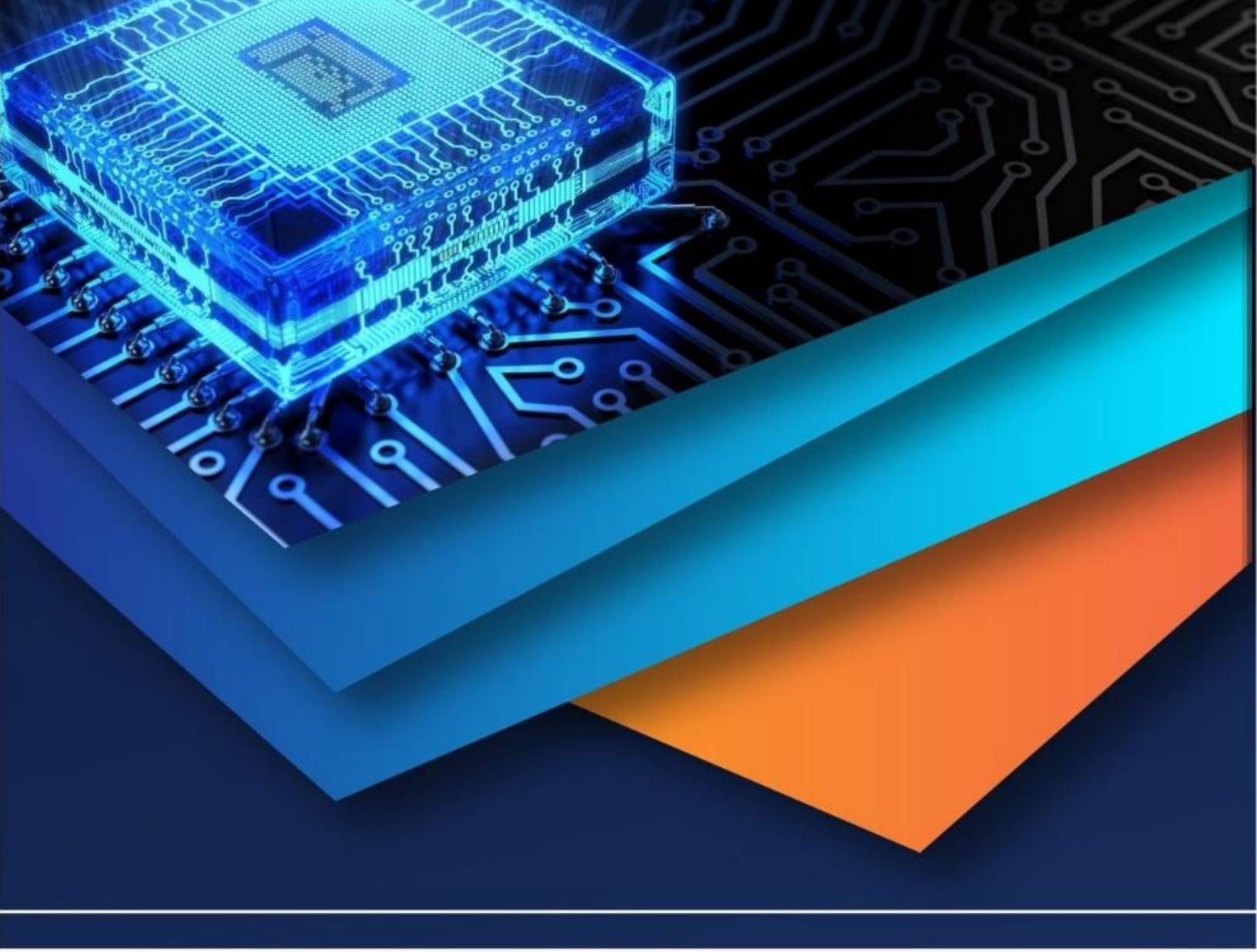

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