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The sources, effects and household treatments of hardness in drinking water

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ABSTRACT

Hard water poses a serious threat to human health. It is the cause of numerous human disorders. It disrupts the industry as well. Drinking it is dangerous for both personal and household uses. Polyvalent metallic ions from sedimentary rocks, as well as seepage and runoff from soils, are what give water its hardness of magnesium and calcium. The two main ions that cause water hardness are those that are found in many sedimentary rocks. They are also typical vital mineral components found in diet. The risks of osteoporosis, nephrolithiasis, colorectal cancer, hypertension and stroke, coronary artery disease, and insulin resistance can all be elevated by excessive calcium and magnesium intake both obesity and resistance. Some epidemiological and experimental research have shown a negative link between magnesium shortage and the aetiology of hypertension. blood pressure and magnesium levels in the serum. This Hard Water containing these ions can be treated at primary level for household purposes. Point-of-entry ion exchange (water softener) devices are used in some households to remove hardness (calcium, magnesium) and iron from water.[1]

KEYWORDS

Nephrolithiasis, conditioning, seepage, hard water, polyvalent, and bathtub rings.

INTRODUCTION

Water Hardness (WHs) is the traditional measure of the capacity of water to react with soap, Hard Water (HW) requiring considerably more soap to produce lather. HW frequently causes a discernible precipitate deposit in containers, including "bathtub ring," consisting of insoluble metals, soaps, or salts[2]. It is not brought on by a single material, but rather a range of dissolved polyvalent metallic ions, with calcium and magnesium cations making up the majority of the cations but also including Aluminium, Barium, iron, Manganese, Strontium and Zinc.

The most widely used unit of measurement for water hardness is milligrammes of calcium carbonate equivalent per litre. In general, water with calcium carbonate concentrations of less than 60 mg/l is regarded as soft; between 60 and 120 mg/l, moderately hard; between 120 and 180 mg/l, hard; and over 180 mg/l, extremely hard. Hardness can be classified as carbonate (temporary) or non-carbonate (permanent), even though cations are the source of hardness.[3]

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The main natural sources of hardness in water are seepage, runoff from soils, and dissolved polyvalent metallic ions from sedimentary rocks. The two main ions, calcium and magnesium, are found in a variety of sedimentary rocks, the most popular being chalk and limestone. They are also typical vital mineral components found in diet. Other polyvalent ions like aluminium, barium, iron, manganese, strontium, and zinc also contribute slightly to the overall hardness of water, as was previously indicated. The main function of each of these primary ions is explained in more detail below.[4]

ROLE OF CALCIUM IN WATER HARDNESH

Among nutrients, calcium is special in that the body can use its store; the relationship between decreasing and increasing bone mass is linear. About 99% of the body's weight is made up of bones and teeth, weighing a total of about 1200 g. Numerous primary studies using randomised controlled trials have demonstrated that raising the amount of calcium consumed, improves bone mass throughout growth and lowers the chance of fracture and bone loss in later life, particularly in individuals who have historically consumed low amounts of calcium.[5]

The chances of osteoporosis, nephrolithiasis (kidney stones), colorectal cancer, hypertension, stroke, coronary artery disease, insulin resistance, and obesity can all be elevated by excessive calcium intake. Treatments exist for the majority of these illnesses, but not cures. In order to maximise bone mineral density, estimates of calcium demand have been based on bone health outcomes due to a dearth of strong evidence regarding the involvement of calcium as a contributing factor in relation to these disorders. One of the most common age-related illnesses is osteoporosis. Together, calcium and vitamin D help to build more bone mass.

Kidney stone incidence is lowered by dietary calcium, according to epidemiological studies. However, the findings of a sizable randomised study point to a higher risk of kidney stones in relation to calcium supplements. This could be because the supplements were used by individuals who exceeded the daily maximum intake limit of 2500 mg of calcium or because the calcium was swallowed as a bolus rather than with food. While there are many variables that contribute to hypertension, some research have linked a sufficient calcium intake to a decreased risk of high blood pressure, though not all of them. Although a specific mechanism has not been found, electrolytes most likely have a part. In randomised prospective studies and prospective studies, dairy products have been linked to lower blood pressure and a lower risk of stroke, more so than calcium alone. A calcium shortage may be more common in people who shun dairy products or do not have access to them throughout their lives.

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water would not be absorbed regardless of extremely low or high calcium concentrations in the water. However, water can be a significant source of calcium for the infants if other food sources are employed that do not provide the same amount as full-strength formula.

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When a healthy person does not have renal impairment, the extra calcium that is absorbed is eliminated by the kidneys. The main people for whom excessive calcium consumption is a concern are those who are susceptible to hypercalcaemia and milk alkali syndrome, which is the concurrent occurrence of hypercalcaemia, metabolic alkalosis, and renal insufficiency.[6]

ROLE OF MAGNESIUM IN WATER HARDNESS

Magnesium is the second most prevalent cation in intracellular fluid and the fourth most abundant cation overall in the body. About 350 cellular enzymes require it as a cofactor, many of which are involved in the metabolism of energy. It is also necessary for appropriate vascular tone, insulin sensitivity, and the synthesis of proteins and nucleic acids. The average body weight is around 25 g, of which roughly 60% is made up of bone. Because only a tiny fraction of the total body burden is in blood or other fluids and because it might vary, it is challenging to measure.[7]

Reduced magnesium levels have been linked to impaired insulin sensitivity, raised levels of C-reactive protein (a proinflammatory marker and coronary heart disease risk factor), enhanced vascular responses, and endothelial dysfunction. Type 2 diabetes, hypertension, coronary heart disease, and metabolic syndrome have all been linked to low magnesium levels.
The pathophysiology of hypertension has been linked to magnesium insufficiency, as evidenced by several experimental and epidemiological studies showing a negative association between serum magnesium levels and blood pressure. Clinical study data, however, have not proven as compelling. In controlled diet trials, postmenopausal women and patients with hypomagnesemia have been found to suffer cardiac arrhythmias of both ventricular and atrial origin. In fact, intravenous magnesium treatment is used to treat Torsade de Pointes, a dangerous heart arrhythmia.[8]

Magnesium salts have been used for many years to treat proteinuria and hypertension in pre-eclampsia, which is defined as hypertension after 20 weeks of pregnancy. A recent

magnesium sulphate experiment revealed a 50% lower chance of eclampsia. Research on animals has shown that the incidence or rate of atherosclerosis and magnesium intake are inversely (protectively) correlated. There's evidence between magnesium with coronary heart disease mortality in people in an inverse (protective) manner. It appears that magnesium may have an anti-inflammatory impact because three cross-sectional studies have now shown an inverse link between the concentration of C-reactive protein and magnesium intake and blood magnesium concentration.[9]

Numerous research works have established the role of magnesium in type 2 diabetes. Intake of magnesium has been found to have an inverse (protective) connection with as well as the chance of getting type 2 diabetes. In type 2 diabetes mellitus, oral magnesium supplementation enhances insulin sensitivity and metabolic management. Magnesium insufficiency is linked to intestinal malabsorption and alcoholism. Certain medications, including some diuretics, antibiotics, and chemotherapy therapies, can cause an increase in magnesium loss through the kidneys. As a result, patients taking these medications should consider taking magnesium supplements as part of their treatment plan.

Renal insufficiency is the main cause of hypermagnesaemia, as it is linked to a markedly reduced excretion of magnesium. Diarrhoea is a transient, adaptive change in bowel movements that can be brought on by an increased consumption of magnesium salts; in people with good renal function, hypermagnesemia is rare. High amounts of magnesium and sulphate in drinking water (above around 250 mg/l each) can have a laxative effect, however evidence indicate that people become acclimated to these levels with time. Excessive consumption of magnesium in supplement form, as opposed to magnesium in the food, has also been linked to laxative effects.[10]

OTHER HEALTH EFFECTS

It has been proposed that exposure to HW poses a danger of exacerbating eczema. Although the exact origins of atopic eczema are unknown, the environment is a significant factor in the aetiology of the condition. Eczema flare-ups have been linked to a number of things, such as wool, dust, nylon, shampoo, perspiration, and swimming. One explanation for the greater use of soap in HW is that it leaves metal or soap salt residues on the skin (or clothing) that are difficult to remove and cause irritation when in contact. There have been reports of a connection between WHs and the 1-year and lifetime prevalence of atopic eczema in elementary school students. Trends in the prevalence of eczema among students in secondary schools were not noteworthy. Further research is being conducted.[11]

OTHER FACTORS

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TASTE OF WATER

To varied degrees, dissolved minerals influence the flavour of drinking water. The flavour and familiarity of each user will typically determine how acceptable a certain water . Producers of demineralized bottled or packaged water frequently add additional minerals to enhance the flavour because demineralized water tends to have a flat taste. While some consumers find certain bottled mineral waters appealing due to their unusually high mineral concentrations, most public drinking water systems would not approve of them. Treatment or blending can be used to control consumer observable concentrations of dissolved solids, such as calcium and magnesium, in public drinking water sources.[12]

CONDITIONING

The goal of conditioning is typically to get an appropriate pH and alkalinity level as well as bicarbonate equilibrium. Other ions that may be involved include sulphate, nitrate, and chloride. corrosivity. Lime (hydrated calcium oxide) or lime soda (lime plus sodium carbonate) softening is the typical method used in central water softening treatments. These substances cause calcium and magnesium carbonate to precipitate more frequently, which lowers the treated water's calcium hardness [20]. These waters should be stabilised as needed to control corrosivity. They are balanced to minimise lime post-precipitation. Naturally soft water—such as rainwater or soft deionized water—differs significantly from water that has undergone cation exchange, in which sodium is used in place of divalent cations (such as Ca^{2+}, Mg^{2+}, etc.). Even though cation exchange-softened water has high salt and chloride concentrations, it is not always caustic. Similar stabilisation and corrosion-reduction measures must be applied before delivery to naturally soft waters.[13]

TREATMENT

HOUSEHOLD WATER TREATMENT

Some homes utilise point-of-entry ion exchange (water softener) devices to remove iron and hardness (calcium, magnesium) from their water. For example, each divalent ion in the It swaps out the water for two sodium ions. Softening will improve laundry and washing performance and reduce scaling in pipes, fixtures, and water heaters, among other aesthetically pleasing impacts within the house. However, it also raises the drinking water's salt and chloride level. Naturally, if drinking water is not softened or remineralized, consumption of calcium and magnesium in the water will decrease. Nearly all of the minerals in the input water are removed by point-of-use reverse osmosis and distillation equipment, which can also eliminate a variety of possible trace-level pollutants. As taking out mineral nutrients. The drinking water that is left after this treatment is mineral-free. Therefore, using these gadgets may cause consumers in the home to consume fewer nutrients and minerals overall.[14]

It is important to inform users of these devices about the potential changes in mineral composition and how they may affect their overall nutrient intake. For instance, individuals who install or sell these gadgets should be urged to alert users to the potential for decreased mineral consumption. One way to prevent demineralization of drinking and cooking water is to soften just the hot water line at the hot water heater's entry. This method has various advantages and lowers expenses. In order to preserve a certain amount of these minerals in the water that is actually consumed (for example, to a proper bypass of a portion of this water), the producers of these water softeners may also offer kitchen tap) or create and install a suitable remineralizing machine before the point of consumption in the water line.[15]

CONCLUSION

The mineral content of natural and treated waters varies greatly; it ranges from extremely low levels in rainwater and naturally softened water to moderate and extremely high levels in naturally hard water and waters. Waters that are processed and bottled may be soft, demineralized, or naturally mineralized. As a result, the amount of minerals in drinking and cooking water might differ significantly based on factors like geography, water source, and treatment.[16]

The level of hardness in drinking water affects customer acceptability from an aesthetic standpoint as well as operational and financial factors. For those reasons, a lot of HWs are softer.[17]

Employing a number of useful technologies, and the mineral composition will be profoundly changed. The best conditioning technology to use will depend on the specific conditions in the area (such as corrosion, piping materials, and water quality issues). There's some bending. For health reasons, changes to the amounts of calcium and magnesium in drinking water must adhere to the technical specifications for water supply. Appropriate for distribution and shouldn't jeopardise the level of disinfection[25]. Water providers and public health authorities may choose to further alter drinking water composition in light of total mineral nutrition based on local conditions and common deficits.[18]

It is important for consumers to know the mineral makeup of their water, regardless of whether it has been altered. It is important to take into account how drinking water minerals contribute to mineral nutrition. where it is suggested to alter the supply or where less common sources—like recycled water, seawater, or brackish water are processed and used to produce drinking water.[19]

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Prior to distribution, the water must be stabilised for all of those methods to work, and adding lime is a popular and affordable solution. Drinking water may help the diet contain more calcium and magnesium. This might be significant for people whose intake of calcium and magnesium is limited. When demineralized water that needs to be conditioned is added to or substituted for drinking water supplies, it is advisable to add calcium and magnesium salts to the mixture to get the concentrations closer to what the population was previously receiving from the original source. Since lime softening is a widespread procedure, adding calcium and occasionally magnesium is also common for technical reasons. In fact, adding calcium and frequently magnesium, which could be advantageous for food consumption. Similar mineralization treatments should be taken into consideration for naturally soft water, as stabilisation is frequently necessary for corrosion control.[20]

The preventive effects of hardness or magnesium on cardiovascular mortality are supported by some evidence from epidemiological research, although this evidence is controversial and does not establish causation. More research is being done. There are currently no recommended guidelines for the minimum or maximum concentrations of minerals due to a lack of data.[21]

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