Hard Water

In many parts of the United States, significant concentration of CaCO3(s) [calcium carbonate solid found in limestone] and MgCO3(s) [magnesium carbonate solid] dissolve into rainwater runoff as it flows through soils rich in these compounds.1

H2O(ℓ)

For example: CaCO3(s) 🡪 Ca+2(aq) + CO3-2(aq)

Water containing dissolved calcium and magnesium ions (Ca+2 and Mg+2) is known as hard water. Hard water is not a health hazard because both calcium and magnesium are part of a healthy diet. However, the presence of these ions in water can be a nuisance. Due to their relatively low solubility (inability to dissolve in water to a great extent), the water becomes saturated with CaCO3 and MgCO3 as it evaporates. If evaporation continues, some dissolved ions pprecipitate our as salts. These precipitates show up as scaly depositis on faucets, sinks, or cookware. Washing cars or dishes with hard water leaves spots of CaCO3 and MgCO3(s).1 Washing clothes in hard water can form complex precipitates which, over time tear at and weaken fabrics.

Water can be softened with water softeners. These devices replace the Ca+2 and Mg+2ions present in hard water with ions of K+1 or Na+1. Since potassium and sodium salts are soluble, they do not form scaly deposits in the way that calcium ions and magnesium ions do. However, when sodium ion containing compounds are used to soften drinking water, the resulting water is high in sodium content, a disadvantage to those who must control their sodium intake due to high blood pressure.1

Most of these compounds found in hard water, such as CaCO3 and MgCO3 are weak bases (That is they are weakly alkaline). Cleaning with some white vinegar, which contains the weak acid acetic acid (also called ethanoic acid), HCH3CO2 or CH3COOH, can cause a chemical reaction with the calcium carbonate and magnesium carbonate, removing the unsightly solids. This chemical reaction between an acid and a base is called neutralization.

A spritz of white vinegar on a window spotted with calcium carbonate can neutralize the weak base and give you a cleaner, clearer window. Use of some white vinegar warmed in a stainless steel pan, can help to remove some stains that can form.

CaCO3(s) + 2 CH3COOH(aq) 🡪 CO2(g) + H2O(ℓ) + Ca(CH3COO)2(aq)

Conversely, water lacking ions of calcium and magnesium may be classified as soft water. You may know of soft water, as it gives you a feel of unending soapiness. In the absence of the ions of calcium and magnesium if may feel as though you cannot rinse out shampoo or there is a consistent level of suds-formation which occurs.

Some find soft water and bothersome as hard water. As with most issues, a balance is the nicest thing of all.

1 Tro, Nivaldo J (2014) Chemistry A Molecular Approach Pearson p.785