NebGuide

University of Nebraska–Lincoln Extension, Institute of Agriculture and Natural Resources

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Drinking Water: Hard Water (Calcium and Magnesium)

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Hard water isn't a health hazard but can be a nuisance within the home. Learn how to test water, interpret the results, and choose a treatment.

Water described as "hard" contains high amounts of dissolved calcium and magnesium. Hard water is not a health risk but is a nuisance because of mineral buildup on plumbing fixtures and poor soap and/or detergent performance.

Sources of Hardness Minerals

Water is a good solvent and picks up impurities easily. As water moves through soil and rock, it dissolves very small amounts of minerals and holds them in solution. Dissolved calcium and magnesium are the two most common minerals that make water "hard." The degree of hardness becomes greater as the calcium and magnesium content increases.

Indications of Hard Water

Hard water interferes with almost every cleaning task, from laundering and dishwashing to bathing and personal grooming.

The amount of hardness minerals in water affects the amount of soap and detergent necessary for cleaning. Soap used in hard water combines with the minerals to form a sticky soap curd. Some synthetic detergents are less effective in hard water because the active ingredient is partially inactivated by hardness, even though it stays dissolved.

Bathing with soap in hard water leaves a film of sticky soap curd on the skin. The film may prevent soil and bacteria from being removed. Soap curd interferes with the return of skin to its normal, slightly acid condition, and may lead to irritation. Soap curd on hair may make it dull, lifeless, and difficult to manage.

When doing laundry in hard water, soap curds lodge in fabric during washing to make fabric stiff and rough. Incomplete soil removal from laundry causes graying of white fabric and the loss of brightness in colors. A sour odor can develop in clothes. Continuous laundering in hard water can shorten the life of clothes.

In addition, soap curds can deposit on dishes, bathtubs and showers, and all water and plumbing fixtures. Hard water also contributes to inefficient and costly operation of water-using appliances. Heated hard water forms a scale of calcium and magnesium minerals that can contribute to the inefficient operation or failure of water-using appliances. Pipes can become clogged with scale that reduces water flow and ultimately requires pipe replacement.

Potential Health Effects

Hard water is not a health hazard. In fact, the National Research Council (National Academy of Sciences) states that hard drinking water generally contributes a small amount toward the total calcium and magnesium needed in the human diet. The Council further states that in some instances, where dissolved calcium and magnesium are very high, water could be a major contributor of calcium and magnesium to the diet.

Much research has been done on the relationship between water hardness and cardiovascular disease mortality. While numerous studies suggest a correlation between hard water and lower cardiovascular disease mortality, no firm conclusions have been drawn. The National Research Council has recommended further studies be conducted. The World Health Organization (WHO) is attempting to coordinate a worldwide study on the effect on cardiovascular disease before and after changes in water supply hardness.

Hard water treated with an ion exchange water softener has sodium added. According to the Water Quality Association (WQA) the ion exchange softening process adds sodium at the rate of about 8 mg/liter for each grain of hardness removed per gallon of water.

For example, if water has a hardness of 10 grains per gallon, it will contain about 80 mg/liter of sodium after being softened with an ion exchange softener if all hardness minerals are removed. As a result of the sodium content of

softened water and potential benefits of drinking hard water, some individuals may be advised by their physician not to install water softeners, to soften only hot water, or to bypass the water softener with a cold water line (usually to a separate faucet at the kitchen sink) to provide unsoftened water for drinking and cooking.

Testing

Testing Public Water Supplies

Public water system operators are required to provide annual water quality reports, referred to as consumer confidence reports (CCRs). The CCR may include information about the hardness level of the water delivered. You can also contact the water supplier and ask for this information.

Testing Private Water Supplies

If you have a private water supply, you can have the water tested for hardness. Most water testing laboratories offer hardness tests for a fee, including the Nebraska Department of Health and Human Services (DHHS) Laboratory.

In addition, a variety of water hardness test kits and dip strips are available for purchase. They are generally easy to use, relatively inexpensive, and can provide a good estimate of hardness. Laboratory tests should be considered if more accurate measurements are needed.

Many companies that sell water treatment equipment offer hardness tests. When using these water tests, be certain you understand the nature of the test, the water condition being measured, and the significance of the test results.

Interpreting Test Results

Public Water Supply Test Results

The Environmental Protection Agency (EPA) establishes standards for drinking water which are designed to protect your health and ensure that your public water supply is of good quality. Standards fall into two categories: Primary Standards and Secondary Standards.

Primary Standards are based on health considerations and Secondary Standards are based on taste, odor, color, corrosivity, foaming, and staining properties of water. There is no Primary or Secondary standard for water hardness.

The Nebraska DHHS, which administers drinking water standards in the state, does not regulate water hardness in public water supplies. Therefore, water hardness is not regulated in Nebraska public water supplies by federal or state statutes.

Private Water Supply Test Results

Water hardness often is expressed as grains of hardness per gallon of water (gpg) or milligrams of hardness per liter of water (mg/L). *Table I*, adapted from the WQA shows hardness classifications. Hardness ions are typically combined with sulfate, chloride, carbonate, or bicarbonate ions. For consistency, concentrations are generally converted to the equivalent concentration as calcium carbonate ($CaCO_3$) and expressed in terms of hardness as calcium carbonate.

Water hardness is classified by the U.S. Department of Interior and the Water Quality Association as follows:

Table I. Classification of water hardness (hardness as calcium carbonate).

Classification	*mg/l or ppm*	*grains/gal*
Soft	0 - 17.1	0 - 1
Slightly hard	17.1 - 60	1 - 3.5
Moderately hard	60 - 120	3.5 - 7.0
Hard	120 - 180	7.0 - 10.5
Very hard	180 and over	10.5 and over

Options

Options for Public Water Supplies

Public water suppliers are not required to manage hardness in the water provided. However, some public water suppliers may voluntarily manage hardness. In some cases, management of other water quality parameters may result in water hardness being reduced.

Options for Private Water Supplies

Some private water supply users may prefer using hard water. Others may choose to manage or reduce water hardness. Three commercially available options for managing water hardness will be discussed below.

Powdered or liquid chemicals:

Powdered or liquid water softeners are chemicals that can be added to a batch of water to help control water hardness. Products may form an insoluble precipitate with calcium and magnesium ions that make water cloudy and can build up on surfaces.

Ion exchange water softening units:

Ion exchange water softening units can be permanently installed into the plumbing system to continuously remove calcium and magnesium.

The ion exchange process involves water passing through a media bed, usually sulfonated polystyrene beads, which are supersaturated with sodium. The ion exchange process takes place as hard water passes through the softening material. The hardness minerals attach themselves to the resin beads while sodium on the resin beads is released simultaneously into the water. When the resin becomes saturated with calcium and magnesium, it must be recharged. The recharging is done by passing a salt (brine) solution through the resin. The sodium replaces the calcium and magnesium which are discharged in the waste water.

Although not commonly used, potassium chloride can be used to create the salt brine. In that case potassium rather than sodium is exchanged with calcium and magnesium.

For additional information on water softeners, including information on how a water softener works, maintenance requirements of water softeners, and difference in softener salt, see NebGuide G1491, *Drinking Water Treatment: Water Softening (Ion Exchange)*.

Physical water treatment:

There are a variety of devices that claim to manage hard water scale using primarily magnetic or electrical technology. Manufacturers generally claim the devices utilize energy to alter the behavior of compounds or elements within the water. They do not claim water chemistry is altered. In fact, the hardness of the water before and after treatment is not changed. This complicates assessment of their performance. While protocol has been established to assess the effectiveness of ion exchange water softeners (NSF/ANSI 44), at this time, no recognized agency in the U.S. has established protocol to assess the effectiveness of physical water treatment devices. Therefore, questions remain as to their effectiveness.

Summary

Hard water is not a health hazard, but dealing with hard water in the home can be a nuisance. The hardness (calcium and magnesium concentration) of water can be approximated with a home-use water testing kit, or can be measured more accurately with laboratory water analysis. Water hardness can be managed by adding powdered or liquid water softeners to a batch of water. Ion exchange softening units can effectively reduce water hardness. The effectiveness of physical water treatment devices to control scale or otherwise manage hardness has not been scientifically assessed.

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