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Drinking Water Treatment

Salt-Free Water "Softener" Options

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New no-salt technologies may be effective in treating hard water, but consumers should carefully investigate product claims prior to buying a specific treatment device.

Hard water is not a health risk, but many Nebraska consumers find hard water to be a nuisance because of mineral buildup on plumbing fixtures, including water heaters; unsightly film on glass and crystal wares; and poor soap and/or detergent performance. Water described as "hard" contains high amounts of dissolved calcium and magnesium, which are positively charged contaminants called cations.

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 1* shows hardness classifications. 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 1. Classification of water hardness (hardness as calcium carbonate).

Classification	mg/L	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

Contaminants Managed by Salt-free Water Softening Alternatives

In recent years, several emerging nonchemical technologies—based on a variety of physical phenomena—have entered the market to help consumers address the problems caused by hard water. Generally, these technologies do not remove most of the hardness-causing minerals from the water, but rather reduce the problems associated with the hardness. These technologies generally use electricity, but at a rate lower than most home appliances.

If actual removal of calcium and magnesium (hardness minerals) or low concentrations of iron and manganese is desired, treatment other than salt-free water softening alternatives must be used. The removal of hardness minerals from water is often termed "softening." The most common method of removing hardness minerals from water at the residential or small commercial scale is an ion exchange water softener.

Water softeners work by exchanging sodium or potassium on the surface of a resin with calcium and magnesium in the water. Thus water softening removes calcium, magnesium, and certain other metal cations out of the water, resulting in a final hardness concentration in the "soft" range (see *Table 1)*. These types of softening increase the concentration of sodium or potassium in the water.

At the municipal scale, water softening can also be achieved in a treatment plant using lime, or a combination of lime and soda ash. More information on ion exchange water softeners can be found in the NebGuide G1491, *Drinking Water Treatment: Water Softening (Ion Exchange)*. This NebGuide discusses the independent tests and certifi-

cations for water softeners that have been developed to help consumers ensure the effectiveness of a system.

In addition, two other home water treatment technologies, distillation and reverse osmosis, have been proven to remove hardness without adding other constituents to the water. These treatment methods are generally not applied to whole house treatment. They are discussed in the NebGuides *Drinking Water Treatment: Reverse Osmosis* (G1490) and *Drinking Water Treatment: Distillation* (G1493).

Contaminants Not Managed by Salt-free Water Softening Alternatives

No one piece of treatment equipment removes all contaminants. All treatment methods have limitations, and water quality situations often require a combination of treatment processes. Salt-free water softening alternatives do not manage bacteria, hydrogen sulfide, silt or sand, lead, nitrate, pesticides, and many other organic and inorganic compounds. Generally, salt-free alternatives are not designed to remove iron and manganese, requiring pretreatment of the water or the use of an appropriate ion exchange softener to remove them. Refer to the Extension Circular *Drinking Water Treatment: An Overview* (EC703) for a discussion of possible water quality problems and appropriate treatments for these contaminants.

Water Testing

Regardless of which water treatment system is considered, the water should be tested to determine the hardness concentration to be managed. Public water systems routinely monitor the quality of the water being delivered and can provide information on water hardness. Users of private drinking water wells can have their water tested for hardness. Refer to the NebGuide *Drinking Water: Testing for Quality* (G907) for testing information. Testing laboratories, some city-county health departments, and some water treatment equipment dealers can test water for hardness.

Treatment Principles

The devices being created by newer nonchemical technologies typically are designed to be installed at the point of entry, treating all water entering a residence or all water flowing to a hot water heater.

Emerging Technologies

Electrically induced precipitation uses a direct electrical current to precipitate water hardness and other compounds. The hardness precipitate forms on an electrode that must be cleaned periodically. Some studies have shown that the precipitate forms a soft sludge on surfaces such as a heating element and is easily removed by fast flowing water near the surface.

Electrochemical water treatment systems induce the removal of dissolved hardness minerals and other contaminants using electricity. The technology goes by several names: continuous electrolytic deionization, capacitive deionization, or electrically regenerated ion exchange. The system can lower the water concentration of both positively charged contaminants (cations), such as calcium, magnesium, sodium, lead, and uranium, and negatively charged contaminants (anions), such as chlorides, nitrates, nitrites, sulfates, and fluorides. The introduction of a negatively charged electrode, or cathode, into the water causes positively charged cations to move toward it. These systems utilize this property by combining the electrode with ion exchange membranes made from ion exchange resins. Unlike other types of membranes, ion exchange membranes only allow dissolved contaminants to pass. Any dissolved contaminant that is ionized is reduced in its concentration in the water. These systems have been shown to be effective at treating water to less than 5 grains per gallon of hardness, but have difficulty in achieving soft water with less than 1 grain per gallon of hardness.

Template-assisted crystallization uses surface-treated resin beads to convert (not remove) dissolved hardness ions to microscopic scale-resistant crystals. The polymeric beads are fluidized, creating agitation that releases the microscopic crystals and allows for further formation of crystals. Once these crystals are formed and released from the beads, they are insoluble particles that do not form scale on surfaces. In some cases, a fine dust may form on dishes but it can be wiped away. Template-assisted crystallization systems typically require relatively clean water as the input, and may require pretreatment if the water contains high iron and manganese concentrations or other sediment.

Magnetic water treatment, or the use of magnets and electromagnetic devices for water treatment, is a controversial method. This approach passes the hard water through a magnetic field to form microscopic precipitates that do

not form scale on water heaters, pipes, and other plumbing fixtures. A number of studies have reported on magnetic water treatment, but with varying results. There is no scientific consensus as to the effectiveness of magnetic water treatment and its removal mechanisms. Thus, magnetic water treatment, unlike the other technologies previously described, should be regarded as unproven technology without a strong scientific basis.

Selection Requirements

Some research supports the application of some of these devices on industrial levels as an anti-scaling treatment. But few conclusive studies confirm the efficiency of these devices for residential use in reducing problems from mineral buildup on plumbing fixtures. Although equipment vendors provide testimonials concerning the need for less soap and detergent when using their devices, no independent studies confirm which technologies address poor soap and detergent performance due to interactions with the hardness.

Currently, it is hard to predict which devices will work in all homes, given the high degree of variability in water quality and water use patterns. Standards and protocols for no-salt softening devices are being developed and may offer testing and certification of these household products in coming years. But until product testing for household anti-scaling products is available, consumers cannot tell for certain which products best reduce scale buildup in the home.

These no-salt technologies offer consumers some promise, but not without the kinds of problems that may occur with emerging technologies. In some cases, one of these products may be very effective, but in other cases, a product may not live up to consumers' expectations. Consumers should carefully investigate product claims prior to purchasing a specific device.

Other important guidelines for selecting specific pieces of water treatment equipment are discussed in the NebGuide *Drinking Water Treatment: What You Need to Know When Selecting Water Treatment Equipment* (G1488).

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