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Treatment Systems for Household Water Supplies: Softening

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FS 877S

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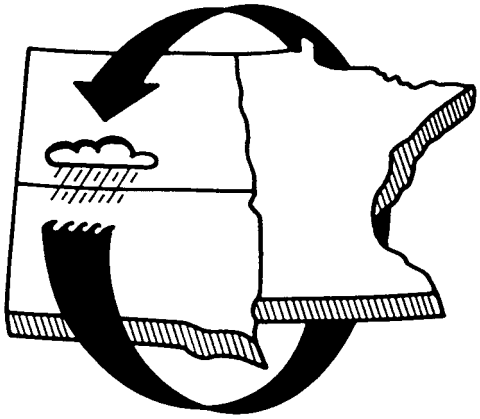
Softening

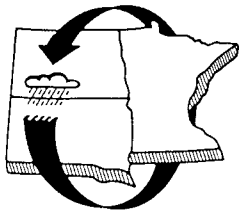


A Three-State
Water Quality Effort

Cooperative Extension Service
South Dakota State University
U.S. Department of Agriculture

Treatment Systems for Household Water Supplies

Softening



by Russell Derickson, SDSU Extension associate in water & natural resources; Bruce Seelig, NDSU water quality specialist, North Dakota Extension Service; and Fred Bergsrud, UM Extension agricultural engineer and water quality coordinator, Minnesota Extension Service

What Impurities Will Softeners Remove?

Water softeners will remove calcium and magnesium from the water during the softening process. Softeners can remove up to 10 ppm of iron and magnesium. Water supplies with high levels of iron and manganese (greater than 10 ppm) may need pretreatment to prolong the life span of a water softener.

What Makes Water "Hard?"

Groundwater contains dissolved rocks and minerals. Dissolved calcium and manganese ions cause water to be hard. These dissolved minerals together with other impurities give hard water its characteristics.

How Is Hardness Measured?

Water hardness ordinarily is expressed in grains of hardness per gallon (gpg) of water. Water impurities also can be measured either in parts per million (ppm) or in milligrams per liter (mg/l). One gpg is equal to 17 ppm (or mg/l).

Figure 1. Classifications of water hardness according to concentration of hardness minerals.

Mineral grains per gallon (gpg)*	Level of hardness	Milligrams per liter (mg/l) or parts per million (ppm
below 1.0	soft	less than 17
1.0 to 3.5	sightly hard	17 to 60
3.5 to 7.0	moderately hard	61 to 120
7.0 to 10.5	hard	121 to 180
above 10.5	very hard	more than 180

* ASAE rating scale

Problems Caused By Hard Water

Hard water interferes with all types of cleaning tasks. Problems arise when the cleaning agents do not fully remove dirt and grime. Over time, clothes washed in hard water may look dingy and feel harsh and scratchy. White clothing continually washed in hard water gradually will show a grayish tinge. Dishes and glassware washed in dishwashers using hard water may be spotted when dry. Hard water causes films on glass shower doors, walls, and bathtubs. Hair washed in hard water may feel sticky and look dull.

Regular soaps used in hard water combine with the hardness minerals to form soap curds or soap scum. Soap scum is difficult to remove from sinks and appliances.

Household appliance performance may be affected by hard water use. When water is heated, calcium carbonate and magnesium carbonate are removed from the water and produce a scale buildup in the hot water heater. A large scale buildup slows the heating process and requires more energy to heat water. Water heaters with large accumulations of mineral buildup will have shorter life spans. Scale deposits also corrode and plug plumbing fixtures and accumulate in other appliances and affect their performance.

Newer cleaning products and detergents contain softening compounds that reduce the negative cleaning effects of hard water.

The Ion Exchange Process

Calcium and magnesium ions that cause water hardness can be removed easily by using an ion exchange procedure. Water softeners are cation exchange devices that replace the positively charged Ca^{++} and Mg^{++} with a non-hardness ion. Water softeners usually use sodium (Na^{+}) as the exchange cation. Sodium ions are supplied from dissolved sodium chloride salt, also called brine.

Figure 2.

During Softening:

$NaZeolite + Ca^{++}$	$CaZeolite + Na^{+}$
and	
$NaZeolite + Mg^{++}$	$MgZeolite + Na^{+}$

During Recharging:

$NaCl + CaZeolite$	$NaZeolite + CaCl$
and	
$NaCl + MgZeolite$	$NaZeolite + MgCl$

In the cation exchange process, sodium ions are used to coat thousands of resin beads that are inside the softener. The exchange media can be natural "zeolites" or synthetic resin beads that resemble wet sand.

As hard water passes through a softener, the calcium and magnesium trade places with sodium ions (Figures 2 and 3). Sodium ions are held loosely and exchange easily with calcium and magnesium ions which have a stronger attraction to the exchange media. During this process free sodium ions are released to the water.

After softening a large quantity of hard water, the exchange media becomes coated with calcium and magnesium ions. When this occurs, the exchange media must be recharged or regenerated. To recharge the softener with sodium ions, a softener is backflushed with a salt brine solution. During a backflush the brine solution replaces the calcium and magnesium ions on the exchange media with sodium ions from the salt solution (Figure 2).

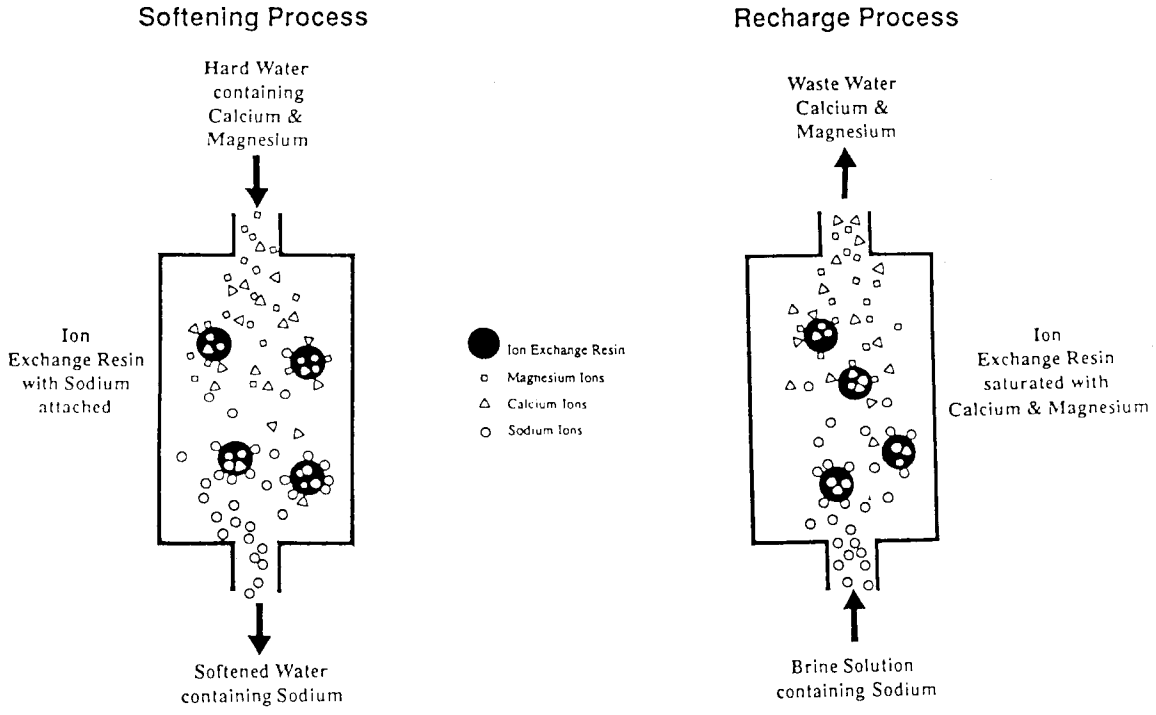
The time between recharging cycles depends on the hardness of the water, the amount of water used, the size of the unit, and the capacity of the exchange media to remove hardness.

Water Testing

Hardness is considered a nuisance water problem. Removing hardness is not necessary to protect your health, but water softening is popular because most people prefer soft water for bathing, cleaning, and washing.

Before buying any type of water softening or water treatment equipment, find out what impurities are in your water supply. A certified laboratory can determine the types and amounts of impurities in your water.

Figure 3. Resin beads with sodium, calcium, and magnesium.



The water test will help you determine if softening is needed. It also may reveal if any other contaminant is present at a level that may harm health and requires that the water be treated.

If you obtain water from a private water supply, water testing is your responsibility. Test water for nitrates and bacteria on a yearly basis. Test for hardness every 3 years. If a water quality problem is suspected, test more often.

Community water supplies are monitored and treated to protect users from health threatening water impurities. Ask your supplier for a copy of the latest water test results.

Health Risks Associated with Softened Water

During the softening process, sodium is released from the exchange media into the output water. For every grain of hardness removed from water, 8 mg/l (ppm) of sodium is added.

If you are on a restricted sodium intake diet, take the increased levels of sodium in softened water into account, and consult your physician. You can avoid sodium intake from softened water by leaving one kitchen tap unsoftened for drinking and cooking.

Types of Water Softening Equipment Available

There are five categories of water softeners: manual, semi-automatic, automatic, demand-initiated regeneration, and off-site regeneration.

Manual -- There are several types. The operator opens and closes valves to control the frequency, rate, and time length of backflushing or recharging.

Semi-automatic -- The operator initiates only the recharging cycle. A button is pushed when the softener needs recharging, and the unit will control and complete the recharging process.

Automatic -- The automatic softener usually is equipped with a timer that automatically initiates the recharging cycle and every step in the process. The operator needs only to set the timer and add salt when needed. It is the most popular softener used.

Demand-initiated Regeneration (DIR) -- All operations are initiated and performed automatically in response to the water-use demand for softened water. DIR systems generally have two softening tanks and a brine tank. While one tank is softening the other tank is recharging.

Off-site regeneration -- These generally are rental units. A used softening tank is physically replaced with a recharged tank. Spent softening tanks are then recharged at a central location.

The automatic softener or demand-initiated regeneration softener probably are the best two choices for household use. DIR softeners do not require electricity for operation but cost more because of the two softening tanks used.

The basic softener unit and the installation of the water softener is illustrated in Figure 4.

Operation and maintenance

Maintenance of water softening units is largely confined to restocking the salt supply for the brine solution. With manual and semiautomatic models, the owner will have to start the recharging cycle. Salt can be purchased in the form of pellets, granules, or blocks.

The brine tank may require periodic cleaning. The frequency of cleaning depends on the amount and purity of the salt used in the softening process. The brine valve and float assembly need to be checked and cleaned periodically.

The presence of excess iron, magnesium, or hydrogen sulfide can inhibit the effectiveness of a water softening unit. Proper presoftening treatment equipment may be required. (See FS 877IM *Treatment Systems for Household Water Supplies: Iron and Manganese Removal.*) Water test results can help you make that determination. More frequent backflushing or reversing the normal flow of water through the treatment unit may be required to remove iron and/or magnesium buildup.

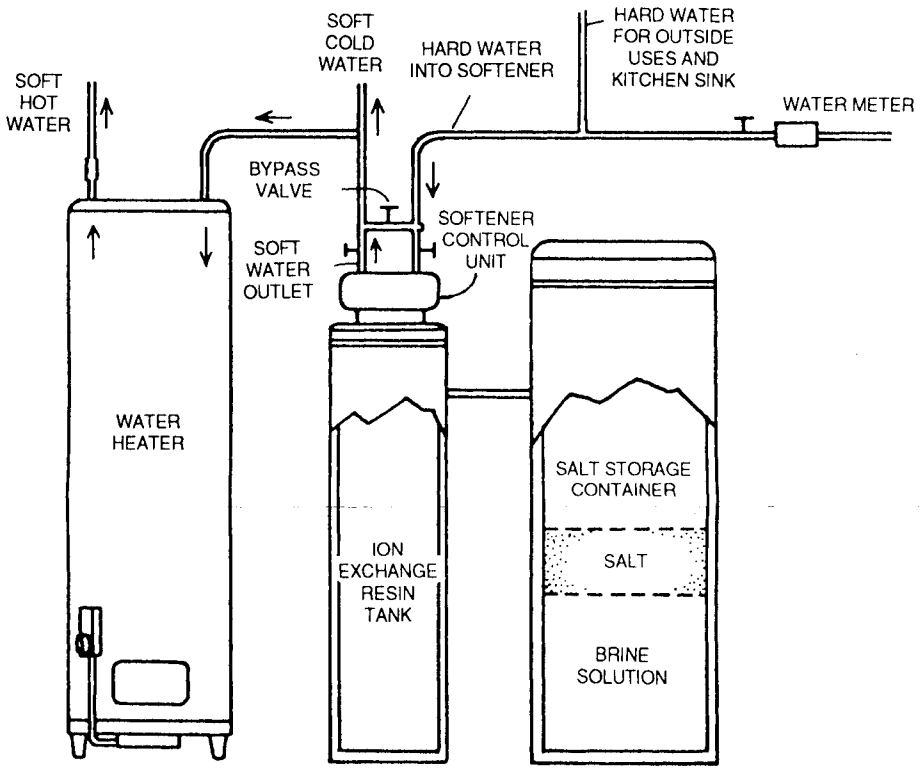
Disconnecting the power to the softener will save electricity and salt costs when leaving home for extended time periods, like vacations.

Cost of Water Softeners and Supplies

Retail prices for home water softeners may range from approximately $400 to $1200 depending on the size and type of softener. Softeners are rated by the total number of grains the unit can remove before being recharged.

Cost of salt is approximately $3-7 per 40 or 50 pound bag depending on the form of salt purchased.

Figure 4. Typical installation of a water softener.



Advantages of Water Softeners

Water treated through a softener offers cleaner, softer-feeling clothes. It also extends the life of appliances including washing machines, dishwashers, and water heaters. You are likely to use less of household cleaning products, such as detergents, and personal cleanliness products, like shampoo. Softened water reduces water spotting.

Disadvantages of Water Softeners

Softened water is not recommended for watering house plants, lawns, and gardens because of its sodium content.

There may be health risks from sodium intake.

Softened water is not recommended for steam irons or evaporative coolers; the best choice for such appliances is distilled water or water from a reverse osmosis unit.

When water used in recharging a water softener is discharged into a small septic system, the drain field may experience hydraulic overload and the surface may become soggy.

Alternatives to Ion Exchange Units

Additives

Hard water problems can be reduced by using detergents that include water softening chemicals in their formulation.

Chemicals can be added to hard water to reduce the negative effect from calcium and magnesium, but chemical treatment for household water softening is recommended only for low levels of hardness.

There are two forms of water softening additives, precipitating and non-precipitating.

Precipitating types (Sal Soda, Borax) combine with calcium and magnesium to form solid particles. These particles settle out with dirt during washing. Washing machine action keeps the solid particles in suspension, the water becomes cloudy, and solid particles may cling to fabrics.

Non-precipitating types (Calgon, blu white) combine with calcium and magnesium and form compounds that stay in solution. These additives have a negative environmental effect, however, because of their high phosphate content.

Magnetic Conditioning

Permanent magnetic water conditioning devices have been marketed based on a variety of claims regarding their effect on water hardness and related scale formation. Tests conducted at Purdue University and reported by the Water Quality Association* found ". . . no significant, beneficial variations in the physical or chemical water quality parameters measured."

Considerations When Purchasing an Ion Exchange Water Softener

- Test your water to determine the hardness and identify other impurities that may need to be removed.
- How much softened water will your household need per day and per year?
- What type and size of softener will fit your situation?
- How easy is the softener to clean and/or repair?
- Will the dealer provide service?
- What type of convenience level should a softener offer (manual or automatic operation)?
- Will pretreatment be needed for iron and manganese?
- Will sodium intake be a health problem?
- Investigate equipment before purchasing or renting. Don't rush a purchase.
- Purchase price does not directly indicate a softener's performance. A moderately priced unit might work as well as an expensive unit.
- When buying or renting, are the installation costs included in the price?
- Don't by more equipment than you need. Other removal systems might be better suited for the removal of certain impurities.
- Choose a reputable dealer. Get guarantees in writing and read them thoroughly.
- Beware of manufacturer's advertising that is too good to be true.
- Equipment should carry UL and NSF or AWQA approval.

*Research reports -- *Quantitative Assessment of the Effectiveness of Permanent Magnetic Water Conditioning Devices.* Water Quality Association. 1985.

Further Information

Contact your county Extension Office, the state water resources department, the state health department, or a commercial water treatment equipment dealer. Additional information can be found in other fact sheets in the *Treatment Systems for Household Water Supplies* series:

FS 877A Activated Carbon Filtration
FS 877C Chlorination
FS 877D Distillation
FS 877IM Iron and Manganese Removal
FS 877RO Reverse Osmosis
FS 877P Identifying and Correcting Water Problems

References

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WQFS-22. *Ion Exchange*(water softening). New Hampshire.

WR-19. *Using Ion Exchange Units to Soften Your Well Water.* Maryland.

G89-946. *Water Treatment Equipment: Water Softeners.* Nebraska.

WQFS-33. *Questions to Ask When Purchasing Water Treatment Equipment.* New Hampshire.