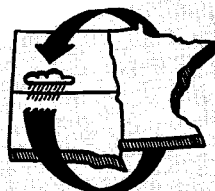


# CLEAN WATER

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## Treatment Systems for Household Water Supplies: Softening

by Russell Derickson, Bruce Seelig, and Fred Bergsrud

### What problems are caused by hard water?

Hard water interferes with all types of cleaning tasks. Cleaning problems arise when cleaning agents do not fully remove dirt. Over time, clothes washed in hard water may look dingy and feel harsh and scratchy. White clothing continually washed in hard water will gradually show a grayish tinge. Dishes and glassware washed in dishwashers using hard water may be spotted when dry. Glass shower doors, walls and bathtub surfaces will become filmy. 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. For example, when heated, calcium carbonate and magnesium carbonate are removed from the water and produce a scale buildup in the hot water heater. A large buildup of scale slows the heating process and requires more energy to heat water; water heaters with large accumulations of mineral buildup have a

shorter life span. Scale deposits also corrode and plug plumbing fixtures and accumulate in other appliances, thus affecting their performance.

Hard water is considered a nuisance water problem. Hardness removal is not a necessity to protect your health. Water softening is popular because most people prefer softened water for bathing, cleaning and washing.

### What makes water "hard"?

Groundwater contains dissolved rocks and minerals. Dissolved calcium and magnesium ions cause water to be hard. These dissolved minerals, together with other impurities, create hard water.

### How is hardness measured?

Water hardness is expressed in grains of hardness per gallon (gpg) of water. Water impurities can also be measured in either parts per million (ppm) or milligrams per liter (mg/l). One gpg is equal to 17 ppm (or mg/l). Figure 1 shows how hardness is classified.

Figure 1. How Hardness Is Classified

Concentration of Hardness Minerals in 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	Slightly 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

## How to test water for hardness

Before buying any water treatment equipment, you should know what impurities are found in the water supply. Types and amounts of impurities in your water can be determined by a certified laboratory. The results of the water test will help determine if softening is needed. The water testing may reveal whether or not other water treatment is required.

If you obtain water from a private water supply, water testing is your responsibility. Water testing should be done on a regular basis. If you suspect a problem, 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.

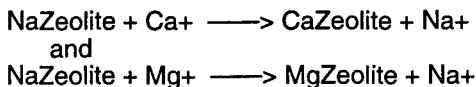
## How water softeners work: exchanging ions

The calcium (Ca+) and magnesium (Mg+) ions that cause water hardness can be removed fairly easily by using an ion exchange procedure. Water softeners are called cation exchange devices. Cations refer to positively charged ions. Cation exchange involves the replacement of the hardness ions with non-hardness ions.

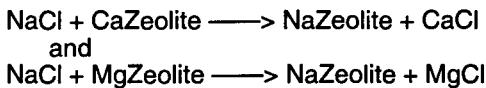
Water softeners usually use sodium (Na+) as the exchange ion. Sodium ions are supplied from dissolved sodium chloride salt, also called brine. In the ion exchange process, sodium ions are used to coat a resin bead that is present in the softener. The exchange media can be natural "zeolites" or synthetic resin beads that resemble wet sand.

Figure 2. The Ion Exchange Process

### During Softening



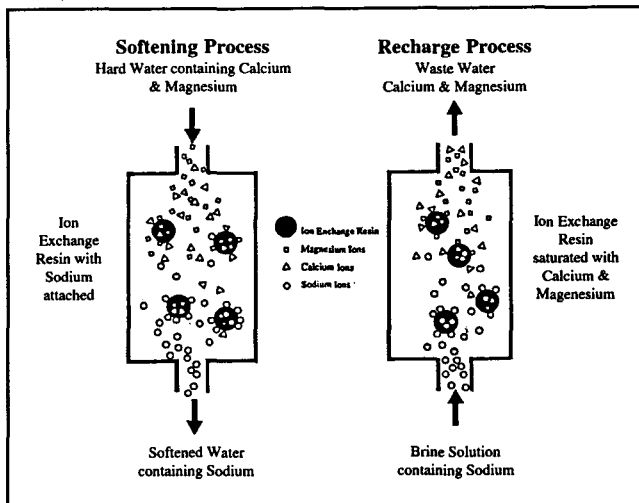
### During Recharging



As hard water passes through a softener, the calcium and magnesium trade places with sodium ions (see Figures 2 and 3). Sodium ions are held loosely and exchange easily with calcium and magnesium ions because they 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 (see Figure 3.) The time

Figure 3. The Softening and Recharging Process



between recharging cycles depends upon 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.

## What impurities will softeners remove?

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

## What types of water softening equipment are available?

Water softeners are classified in five different categories:

- 1. Manual:** There are several types of manual softeners. The operator opens and closes valves to control the frequency, rate and length of time involved in backflushing or recharging.
- 2. Semi-automatic:** The operator initiates only the recharging cycle. The operator pushes a button when the softener needs recharging; the unit will control and complete the recharging process.
- 3. Automatic:** The automatic softener is usually equipped with a timer that automatically initiates the recharging cycle as well as every step in the process. The operator sets the timer and adds salt when needed. This is the most popular type of softener used.
- 4. 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.
- 5. Off-site Regeneration (generally rental units):** The used softening tank is physically replaced with a recharged tank. Spent softening tanks are then recharged at a central location.

Basic softener units and installation of the water softener are illustrated in Figure 4.

## How to operate and maintain water softening equipment

Maintenance of water units is largely confined to restocking the salt supply for the brine solution. With manual and semiautomatic models, the owner must also start the recharging cycle. Salt can be purchased in the form of pellets, granulars 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 should also be checked and cleaned as often as needed.

The presence of excess iron or hydrogen sulfide can inhibit the effectiveness of a water softening unit. Installation of the proper presoftening treatment equipment may be required. (See the Iron and Manganese circular in this series.) Water test results will help in making that determination. More frequent backwashing or reversing the normal flow of water through the treatment unit may be required to remove iron buildup.

## What are the advantages of water softeners?

Softeners offer: 1) cleaner, softer clothes, 2) longer appliance life for washing machines, dishwashers and water heaters 3) less use of household cleaning products, such as detergents, as well as personal cleanliness products, like shampoo and 4) less water spotting.

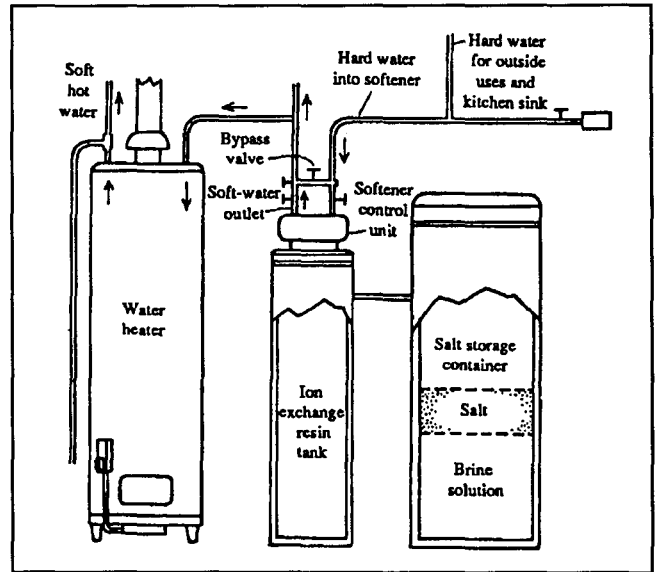
## What are the disadvantages of water softeners?

Disadvantages include: 1) softened water is not recommended for watering house plants, lawns and gardens due to its sodium content; 2) water used in recharging a water softener may overload or reduce the effectiveness of small septic or sewer systems; 3) health risks associated with sodium intake (see "What Health Risks Are Associated with Softened Water?" below); 4) 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.

## What health risks are 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. People on restricted sodium intake diets should take the increased levels of sodium in softened water into account. Consult your family physician. Sodium intake from softened water can be avoided by leaving one kitchen tap unsoftened for drinking and cooking.

Figure 4. Typical Installation of a Water Softener



## What do water softeners and supplies cost?

Retail prices for home water softeners 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 \$5-\$7 per 40 pound bag depending on the form of salt purchased.

## What are alternatives to using ion exchange units?

Water softening additives can be reduced by using detergents that include water softening chemicals in their formulation.

Some types of chemicals can be added to hard water to reduce the negative effect from calcium and magnesium. Chemical treatment for household water softening is recommended for low levels of hardness. There are two forms of water softening additives: precipitating and non-precipitating.

1. **Precipitating** water softening additives (Sal Soda, Borax) combine with calcium and magnesium to form solid particles. These particles settle out with particles of dirt during washing. Washing machine action keeps the solid particles in suspension. The water becomes cloudy and solid particles may cling to fabrics.
2. **Non-precipitating** water softening additives (Calgon, blu white) combine with calcium and magnesium to form compounds that stay in solution. Use of non-precipitating additives causes a negative environmental effect due to 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." \* Thus, the effectiveness of magnetic water conditioning devices is questionable.

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

## What to consider when purchasing an ion exchange water softener

Test your water to determine the hardness and identify other impurities that may need to be removed.

### Determine the following:

- How much softened water will your household need per day, 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?
- Will by-products of a softener overload your septic or sewer system?
- When buying or renting, are the installation costs included in the price?

### Additional recommendations:

- Investigate equipment before purchasing or renting; don't rush a purchase.
- Know that the purchase price does not directly indicate the quality of a softener's performance. A moderately-priced unit might work as well as an expensive unit.
- Don't buy 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 may be too good to be true.
- Equipment should carry UL and NSF or AWQA approval.

## Who to contact for further information

For further information contact your local county Extension Office or state health department. Additional information can be found in other publications in this series:

### Treatment Systems For Household Water Supplies:

- Activated Carbon
- Chlorination
- Filtration
- Distillation
- Iron and Manganese Removal
- Reverse Osmosis

## References

- MWPS-14 *Private Water Systems, Midwest Plan Service*
- MF-848 *Hard Water: To Soften Or Not to Soften, Kansas*
- 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*



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Russell Derickson, Extension Associate in Water and Natural Resources, South Dakota Extension Service; Bruce Seelig, Water Quality Specialist, North Dakota Extension Service; Fred Bergsrud, Water Quality Coordinator, Minnesota Extension Service.

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