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Hardness in Drinking Water[1]

DEFINITION OF HARDNESS

Hardness in drinking water is defined as those minerals, which dissolve in water, that have a divalent (positive two) electrical charge. Minerals are composed of either atoms or molecules. An atom or molecule that has dissolved in water is called an "ion".

The primary components of hardness are calcium (Ca^{++}) and magnesium (Mg^{++}) ions. Dissolved iron (Fe^{++}) and manganese (Mn^{++}) also satisfy the definition of hardness but typically make up only a very small fraction of total hardness. Positively charged ions are called cations.

HEALTH EFFECTS OF HARDNESS

The presence or absence of conventional hardness in drinking water is not known to pose a health risk to users. Hardness is normally considered an aesthetic water quality factor. The presence of some dissolved mineral material in drinking water is typically what gives the water its characteristic and pleasant "taste". At higher concentrations however, hardness creates the following consumer problems:

- produces soap scum; most noticeable on tubs and showers;
- produces white mineral deposits on dishes; more noticeable on clear glassware; and
- reduces the efficiency of devices that heat water. As hardness deposits build in thickness, they act like insulation, reducing the efficiency of heat transfer.

EXPRESSING THE AMOUNT OF HARDNESS IN WATER

There are two numbering systems which are used by drinking water professionals to identify the concentration of hardness in drinking water. They are:

milligrams per liter, abbreviated as mg/L; and
grains per gallon, abbreviated as gpg.

To convert one hardness concentration to the other, use the following formula: 1/17.2 x (the concentration in milligrams per liter) = (the concentration in grains per gallon); or (the concentration in grains per gallon) x 17.2 = (the concentration in milligrams per liter).

CATEGORIZING HARDNESS

Water supply professionals do not fully agree on the descriptive terminology that should be used when categorizing the concentration of hardness in water nor what lower threshold justifies the investment in a water softener. Shown below are the two common severity scales used to categorize hardness.

1. The material contained in this fact sheet was excerpted from the New Hampshire Department of Environmental Services web site (http://www.des.state.nh.us/ws.htm).

Categorizing Hardness

Worded Description	Sanitary Engineers		Water Conditioning Industry	
soft water	0-75 mg/L as CaC03		0-50 mg/L as CaCO3	
somewhat hard water	76 to 150	"	51-100	"
hard water	151 to 300	"	101-151	"
very hard water	301 and up	"	151 and up	"

THE WATER SOFTENING PROCESS

A private home water softener typically has two tanks. The taller tank contains the purifying media called a cation ion exchange "resin", while the smaller tank contains the sodium or potassium salt used to regenerate the resin media. During normal operations, raw water passes through the ion exchange resin media in the tall tank. The calcium (Ca++), magnesium (Mn++), iron (Fe++) or manganese (Mn++) ions in the water are "exchanged" for sodium (Na+) or potassium (K+) ions which have been temporarily stored in the "pores" of the resin.

As the softener removes hardness minerals from the water supply, sodium or potassium will be given back proportionally. Shown below is the concentration of either sodium or potassium, that would be added to the existing raw water concentration, if 10 mg/L of hardness is removed. To determine the increase for your situation, divide your total hardness by 10 and then multiple that result by the appropriate number in the right hand column.

Hardness Removed	Na+ or K+ Added		
10 mg/L	Sodium (Na+) added	=	4.6 mg/L
10 mg/L	Potassium (K+) added	=	7.6 mg/L

Eventually the removal capacity of the resin media becomes exhausted and the resin will need to be regenerated. The regeneration process begins by a rapid backwashing of the resin to remove fine particulate material, which originates in the well or piping. The process continues at a slower rate by backwashing the resin with a strong brine (salt) solution. The sodium or potassium from the brine enters the resin "pores" and displaces the previously removed hardness ions. After a period of time (approximately 20 minutes), the remaining brine, along with the concentrated displaced hardness ions are flushed out of the device and disposed of into an approved dry well, septic tank or sewer.

Studies by the Water Quality Association (WQA), indicate that waste brine and purged contaminant s does not injure leach fields or septic tanks.

Advantages Of Water Softening

- Softener resin can be regenerated and re-used.
- Ion exchange can consistently remove hardness from water to extremely low levels.
- Softening removes dissolved iron and manganese. Other water quality factors such as pH, alkalinity and dissolved oxygen are not critical to removing iron and manganese.
- Conventional softening also removes dissolved radium.

Disadvantages Of Water Softening

- Softening adds sodium or potassium to your drinking water depending on which "salt" you use. For those concerned with elevated sodium levels in their drinking water, potassium chloride (KCl) can be substituted in place of sodium chloride (NaCl). The process is equally as efficient however the cost of potassium chloride is higher than sodium chloride
- Softening will not operate satisfactorily if iron bacteria, clay particles, rusty colored water etc. exists, even occasionally. If any solids are present, a particle (sediment) filter must be installed before the ion exchange media tank.
- Water softeners require a location to disposal of waste brine. If you do not have sewer service, disposal of the waste brine will likely be into the ground. This creates the potential of contaminating the groundwater and subsequently your own well or those wells of your neighbors down hill. If potassium chloride is used the potassium is also a soil nutrient being one of the three components of typical fertilizer.

REDUCTION OF SALT USAGE

Salt brine can contaminate the general groundwater and possibly your well. Consequently reducing salt usage while maintaining system effectiveness is important. In areas without sewers, the more reduction of salt, the more appropriate is water-softening treatment. Three methods to reduce salt usage are described below.

1. **Method of Initiating the Regeneration Cycle**

   Older water softeners used a time clock to initiate the regeneration of the resin media. Modern softeners however, regenerate by either of the following methods;

   a. probe(s) that measure the water's electrical conductivity and its change; or
   b. a meter that measures the volume of water already treated during that production cycle.

   In either case, regeneration will be triggered based on actual need (called demand regeneration), rather than a time clock. A time clock backwashes a softener whether it needs regeneration or not, such as during a vacation period. This excessive backwashing needlessly increases salt use and the generation of waste brine.

   Demand regeneration can occur during the day when water is being actively used. When this happens the unit goes into a bypass mode and untreated water must be used within the home. This, although a disadvantage, is of short duration. From an environmental viewpoint, we recommend demand based regeneration of the resin media where softening is used.

2. **Strength of Brine Used to Regenerate**

   The regeneration of a water softener can be carried out using different strengths of the brine solution. From an environmental view point, those devices with a higher efficiency of contaminants removed per pound of salt used, (known as weaker brine regeneration) are, in our opinion, the more appropriate to use.

The following summarizes the choice you need to make relative to the strength of brine versus the size of the treatment device.

The weak brine regeneration alternative, which is recommended. This uses approximately 6 pounds of salt to regenerate each cubic foot of softener resin media. Advantage: provides a higher efficiency of contaminate removal per pound of salt. (Approximate 7 percent efficiency compared to the 2 percent achieved with the strong brine alternative.)

Disadvantage: results in lower percent regeneration of resin and thus generally requires some enlarging of the size of the softener if rejuvenation cycle times are going to be comparable.

The strong brine regeneration alternative, which is not recommended. This uses approximately 12 pounds of salt to regenerate each cubic foot of softener resin media. Disadvantage: lower efficiency of contaminant removal per pound of salt. (approximately 2 percent efficiency compared to the 7 percent achieved with weak brine alt.);

Advantage: results in higher percentage of regeneration of resin media and thus allows the installation of a minimum sized softener.

Partial Treatment (Split Flow)

In cases where there is little iron or manganese, “by-passing” a certain percentage of the raw water around the treatment device can reduce sodium usage even further. This typically requires throttling valves and meters on both the treatment and the "by-pass" lines. A hardness target concentration could be approximately 50-75 mg/L in the blended treated water.

TESTING YOUR WATER

EAI Analytical Labs will provide you with your free water testing kit containing: sample bottles, detailed sampling instructions and a tracking form. Bacteria samples bottles are distributed pre-sterilized and all sample bottles contain their necessary preservatives. Kits are available for pickup or they can be mailed to you. If you are interested or have any questions regarding the analysis of your water, please give us a call.