Commonly Found Substances in Drinking Water

And Available Treatment

Illinois Department of Public Health

Introduction

This pamphlet discusses common constituents – hardness, sulfates, iron, chlorides, pH (acidity and alkalinity), total dissolved solids and hydrogen sulfide – of drinking water. Separate pamphlets on lead, nitrate, bacteria and parasites in drinking water are available from the –

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Hardness

The hardness of water is a measure of the amount of minerals, primarily calcium and magnesium, it contains. Water softening, which removes these minerals from the water, may be desirable if –

- Large quantities of detergent are needed to produce a lather when doing laundry, or
- Scale is present on the interior of piping or water tanks, laundry sinks or cooking utensils.

Water that contains more than 200 mg/l (milligrams/liter) or 200 ppm (parts per million) as calcium carbonate ($CaCo_3$), or 12 grains per gallon, is considered to be hard and may cause plumbing and laundry staining problems. (Three grains per gallon equals approximately 50 ppm.) Methods used to soften hard water for home use are zeolite softening and reverse osmosis.

The following is a measure of hardness (expressed in mg/l as $CaCo_3$):

0 - 100	Soft
100 - 200	Moderate
200 - 300	Hard
300 - 500	Very hard
500 - 1,000	Extremely hard

Zeolite softening (ion exchange) depends on the ability of granular materials, called zeolites, to exchange ions present in their structure for ions present in the water. As the hard water percolates through the zeolite bed, the calcium and magnesium ions in the water are exchanged for sodium ions in the bed, making the water soft. The calcium and magnesium ions are left attached to the zeolite grains. When the exchange capacity of the zeolite is exhausted, it can be regenerated by passing a strong salt (sodium chloride) solution through it. The excess sodium in this solution causes the zeolite to give up the calcium and magnesium ions and take up a new supply of sodium ions. The wash water is then flushed out and the unit is ready to resume the softening process.

The softening-regeneration cycle can be repeated almost indefinitely over many years of service. Zeolite softeners usually consist of two tanks: one containing the zeolite and another, called the brine tank, containing a strong salt solution. Most of these tank type softeners use a timer or a sensing device to start the regenerating process automatically. The only maintenance required of the homeowner is to add salt and water to the brine tank.

Advantages

- Maintenance is low, requiring only the periodic addition of salt water to the brine tank.
- Zeolite softeners produce softened water faster than reverse osmosis units.
- If properly maintained, zeolite softeners can be used almost indefinitely.

Disadvantages

- Only calcium, magnesium and small amounts of iron will be removed from the water.
- People on salt-restricted diets (for example, persons with high blood pressure) may not be able to drink or cook with this water. Persons on such diets should not use a zeolite softener or should consult their doctor before doing so.

Reverse osmosis units remove water hardness through a straining action. The hard water enters the unit under normal tap pressure and passes through a special membrane. The membrane allows water molecules and only trace levels of contaminants to pass through it. Hardness ions and other contaminants remain on the pressure side of the membrane and are eventually flushed away as waste. Most of these units are equipped with an activated carbon filter that removes chlorine and generally improves the taste of the water. Reverse osmosis units require very little maintenance. The membrane will need to be changed every one to three years and the activated carbon filter will need to be replaced about once a year.

Water treated by reverse osmosis is generally supplied only to bathroom and kitchen sinks and to laundry areas.

Advantages

- The process removes most dissolved minerals from water as well as reduces hardness and certain types of bacteria.
- Water treated by reverse osmosis does not adversely affect people on sodium restricted diets.

Disadvantages

- Reverse osmosis units are slow and produce more waste water. A little more than one gallon of potable water is produced every six hours. Four to six gallons of waste water are generated in that time.
- High pressure (and the associated electrical energy costs) is required to operate the unit.

Sulfates

Sulfates in groundwater are caused by natural deposits of magnesium sulfate, calcium sulfate or sodium sulfate. Concentrations should be below 250 ppm. Higher concentrations are undesirable because of their laxative effects. Sulfates cannot be economically removed from drinking water.

The following levels of sulfates (SO_4^{-2}) are expressed in mg/l:

0 - 250	Acceptable
250 - 500	Can be tolerated
500 - 1,000	Undesirable
Over 1,000	Unsatisfactory

Iron

Iron in drinking water can be objectionable because it can give a rusty color to laundered clothes and may affect taste. Frequently found in water due to large deposits in the earth's surface, iron can also be introduced into drinking water from iron pipes in the water distribution system. In the presence of hydrogen sulfide, iron causes a sediment to form that may give the water a blackish color. The Illinois Environmental Protection Agency (IEPA) has established a maximum concentration for iron in drinking water of 1.0 mg/l.

The following levels of iron (Fe) are expressed in mg/l:

0 - 0.3	Acceptable
0.3 - 1.0	Satisfactory (however, may cause staining and objectionable taste)
Over 1.0	Unsatisfactory

Iron as it exists in natural groundwater is in the soluble (ferrous) state but, when exposed to oxygen, is converted into the insoluble (ferric) state with its characteristic reddish brown or rusty color. If allowed to stand long enough, this rusty sediment will usually settle to the bottom of a container; however, it is difficult to use this type of settling to remove the iron.

There are four options available to the homeowner for removing iron from potable water. The option you choose depends on the concentration of iron in your drinking water, whether it is dissolved or suspended, and if iron bacteria are also present.

Option 1

For dissolved iron in concentrations up to 2.0 mg/l, food-grade phosphate can be added to the water through a phosphate feeder. The phosphate "sequesters" the dissolved iron, which means that it keeps the iron in solution rather than drawing it out. There are a number of commercial phosphate feeders and chemicals on the market that are safe to use. The phosphate must be fed into the water prior to the pressure tank or any other place where contact with air is possible, since contact with air will cause the iron to precipitate (or form) iron particles. If this occurs, the addition of phosphate will not work.

If the water is also hard and in need of softening, the phosphate feeder is used in conjunction with a zeolite softener and helps prevent clogging of the softener. The phosphate feeder generally requires recharging once every 30 days. One pound of phosphate can treat up to 60,000 gallons of water.

Option 2

Zeolite softening can remove up to 10 mg/l of dissolved iron. If the iron is exposed to air prior to the softener, it will form iron particles that will eventually accumulate and work their way through the zeolite bed and into the water system.

Option 3

A manganese (potassium permanganate)-treated green sand filter can remove up to 10 mg/l of iron and will remove dissolved as well as particulate iron. The permanganate provides oxygen to oxidize and precipitate any dissolved iron, and the sand filter traps the particulates.

The filter must be backwashed about once a week to remove the iron particles. After backwashing, the filter is recharged with potassium permanganate. Depending on how much iron is in the water, the recharging may only be necessary every third or fourth time the filter is backwashed.

Option 4

Adding liquid bleach (chlorine solution) followed by sand filtration may be used for any quantity of iron, whether dissolved or not, and it will also kill iron bacteria. This method involves adding liquid chlorine bleach solution followed by filtration to remove the particulate iron formed by the oxidation caused by the chlorine. The filter will require periodic backwashing to flush the iron particulates.

Chlorides

Chlorides in groundwater can be naturally occurring in deep aquifers or caused by pollution from sea water, brine, or industrial or domestic wastes. Chloride concentration above 250 mg/l can produce a distinct taste in drinking water. Where chloride content is known to be low, a noticeable increase in chloride concentrations may indicate pollution from sewage sources.

The following levels of chlorides are expressed in mg/l:

0 - 250	Acceptable
250 - 500	Less than desirable
500 - 1,000	Undesirable
Over 1,000	Unsatisfactory

pH

A measure of the acid or alkaline content of water, pH values range from 0 to 14. The lower the pH value the more acidic the water, and the higher the pH value the more alkaline the water. The pH of drinking water normally ranges from 5.5 to 9.0. At pH levels of less than 7.0, corrosion of water pipes may occur, releasing metals into the drinking water. This is undesirable and can cause other concerns if concentrations of such metals exceed recommended limits.

Total Dissolved Solids

The total dissolved solids test measures the total amount of dissolved minerals in water. The solids can be iron, chlorides, sulfates, calcium or other minerals found on the earth's surface. The dissolved minerals can produce an unpleasant taste or appearance and can contribute to scale deposits on pipe walls.

The following levels of total dissolved solids are expressed in mg/l:

Less than 500	Satisfactory
500 - 1,000	Less than desirable
1,000 - 1,500	Undesirable
Over 1,500	Unsatisfactory

The only effective means of reducing total dissolved solids is by using reverse osmosis; however, removal is not economical.

Alkalinity

Alkalinity is a measure of the presence of bicarbonate, carbonate or hydroxide constituents. Concentrations less than 100 ppm are desirable for domestic water supplies. The recommended range for drinking water is 30 to 400 ppm. A minimum level of alkalinity is desirable because it is considered a “buffer” that prevents large variations in pH.

Alkalinity is not detrimental to humans. Moderately alkaline water (less than 350 mg/l), in combination with hardness, forms a layer of calcium or magnesium carbonate that tends to inhibit corrosion of metal piping. Many public water utilities employ this practice to reduce pipe corrosion and to increase the useful life of the water distribution system.

High alkalinity (above 500 mg/l) is usually associated with high pH values, hardness and high dissolved solids and has adverse effects on plumbing systems, especially on hot water systems (water heaters, boilers, heat exchangers, etc.) where excessive scale reduces the transfer of heat to the water, thereby resulting in greater power consumption and increased costs.

Water with low alkalinity (less than 75 mg/l), especially some surface waters and rainfall, is subject to changes in pH due to dissolved gasses that may be corrosive to metallic fittings.

Hydrogen Sulfide

Tastes and odors in water may be caused by hydrogen sulfide (H_2S). Hydrogen sulfide, when dissolved in water, produces an offensive odor resembling that of rotten eggs. The presence of hydrogen sulfide in deep well water is due to the reduction of sulfate (SO_4^{-2}). The acceptable level of hydrogen sulfide is 0.05 mg/l or less.

Hydrogen sulfide can be removed through oxidation or by aeration or chlorination. The precipitated sulfur should be removed by filtration to prevent it from reverting back to hydrogen sulfide through the action of certain microorganisms.

The oxidation of hydrogen sulfide by chlorine may be advantageous in cases where it is otherwise unnecessary to repump the water (which is normally required with aeration) because chlorine can be applied directly into the system. Enough chlorine must be used to maintain a distinct chlorine residual.