WQ1030 (Revised May 2019)

Iron and Manganese Removal

Drinking water doesn't need to contain much iron or manganese to affect the taste or become an aesthetic problem in your home.

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As rainwater infiltrates soil and the rocks below, it dissolves minerals and small quantities of iron and manganese. This rainwater eventually becomes ground water.

Ground water containing dissolved iron and manganese is common in North Dakota. The concentration of iron and manganese in ground water can vary greatly, depending on local geology and the makeup of materials carried by the glaciers during the last ice age.

How Can You Recognize an Iron or Manganese Problem?

Raw Water Problem	Cause
Tap water comes out clear but then develops black or rust-colored particles after standing.	Ferrous iron (Fe2+) or manganous manganese (Mn2+)
Tap water has a reddish hue when first drawn, and on standing, clears within 24 hours.	Significant particulate iron in the water. Likely sources are rusted galvanized iron pipes or connections, a rusted pressure tank and rust from the well casing or pump.
Tap water varies from a blackish hue to almost black when first drawn but clears after standing for 24 hours.	Significant amount of dissolved manganese in the water.
Water has a metallic taste, stains appear on clothing, particulates are in the water.	Metal in the water.

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Test Your Water

Having the water tested before installing any water treatment system is important. The test will identify the bacteria and level of minerals that are present. Interpretation of the test results will help determine whether treatment is needed and what type of system or systems to consider. The intended use of the water (drinking only, drinking and cooking, laundry or all household uses) also will help determine the extent of treatment needed and the type of system to select.

The water test analysis and interpretation will provide information about naturally occurring substances and those resulting from human activity. The treatment of contaminated water supplies should be considered only as a temporary solution. The best solution is to remove the source(s) of contamination and/or obtain a new water supply.

Water Testing for Iron and Manganese

Private water systems are not subject to state or federal drinking water standards nor are they tested by anyone but the well owner. Having your household water tested on an annual basis will give you the information necessary to make good decisions on water treatment. The secondary drinking water standard set by the U.S. Environmental Protection Agency (EPA) for iron and manganese is 0.3 mg/l and 0.05 mg/l, respectively.

The need to test for iron and manganese in water is not as critical as it is for other types of contaminants that can cause health problems. In fact, low levels of both elements are important to maintain your health.

Iron and manganese are not a problem in household water until they become detectable by the senses. Laboratory analyses for iron and manganese are needed to quantify the problem.

Before sampling for iron and manganese, a certified laboratory should be consulted. A current list of certified laboratories is available in NDSU publication WQ1341, "Drinking Water Quality: Testing and Interpreting Your Results," available at *www.ag.ndsu.edu/publications/environment-natural-resources/drinking-water-quality-testing-and-interpreting-your-results*.

Lab staff will recommend a sampling procedure that will provide an accurate estimate of dissolved iron and manganese in the source water.

The water sample should be taken from a faucet close to or directly from the well. Allow the water to run for 15 minutes prior to sampling to ensure that you are pulling water from the aquifer. If your house has metal pipes or a galvanized pressure tank, an additional sample from within the house should be submitted.

Understanding Drinking Water Standards

mg (milligram) = one-thousandth of a gram

mg/L (milligram per liter) = part per million (ppm)

µg (microgram) = one-millionth of a gram

µg/L (microgram per liter) = part per billion (ppb)

Problems Caused by Iron and Manganese in Household Water

Neither iron nor manganese in drinking water presents a health hazard to the general population. However, a small percentage of the population may be affected if they suffer from an excess of iron in the body (hemochromatosis).

Iron and manganese at very low levels may contribute to disagreeable taste, staining and mineral buildup in home water systems **(Photo 1)**. Visible problems can be seen when the amount of dissolved iron exceeds about 0.2 milligram per liter (same as parts per million) and when dissolved manganese exceeds about 0.05 milligram per liter.

Usually iron and manganese concentrations in well water do not exceed 10 mg/l and 2 mg/l, respectively. Higher concentrations of iron and manganese are rare.

Photo 1. Iron stains in toilet tank.

(Thomas Scherer, NDSU)

Because iron and manganese are chemically similar, they cause similar problems. Iron will cause reddish-brown staining of laundry, sinks, toilets, tubs, dishes, utensils and even glassware. Manganese acts in a similar way but causes a brownish-black stain. Soaps and detergents do not remove these stains, and the use of chlorine bleach and alkaline builders (such as sodium carbonate) can intensify the stains.

Iron and manganese deposits will build up in pipelines, pressure tanks, water heaters and water softeners. This reduces the available quantity and pressure of the water supply. Iron and manganese accumulations become an economic problem when water supply or softening equipment must be replaced. These accumulations also result in associated increased energy costs, such as for pumping water through constricted pipes or heating water with heating rods coated with iron or manganese minerals.

Sources of Iron and Manganese

Iron and manganese are concentrated in water by contact with certain rocks and minerals, and occasionally man-made materials such as iron and steel pipes. The longer the contact times with the rocks and minerals, the higher the level of concentration. Ground water supplies usually are what require treatment for high levels of iron and manganese.

When exposed to air, iron and manganese are very reactive and break down rapidly. For this reason, you will not find them in streams or rivers; they react with oxygen to form particles and fall (precipitate out) to the bottom of the stream.

Ground water reacts with oxygen when brought to the surface of a well and will, at that point, convert to visible red/brown/black particles and move through the pipes of your home.

Frequently, hydrogen sulfide (indicated by a rotten egg smell) also is present in water that contains iron and manganese. When hydrogen sulfide is present in small quantities, it often will be detected after it goes through a chemical change in the hot water heater.

Iron Bacteria

Some types of bacteria derive their energy from feeding on dissolved forms of iron and manganese in water. While these bacteria do not cause health issues for humans, they do produce a brown (iron) or black-brown (manganese) slimy material in water tanks, toilet tanks or other places where water stands. In addition to a "foul" odor, the gelatinous material can clog plumbing and water treatment equipment, and staining is more pronounced because of its concentration.

If you notice iron bacteria in any water fixtures in the house, then it probably also is present in the well. Shock chlorination of the well and piping system in the house is needed to kill it and remove it from the piping and water fixtures. The basic procedure is to add a quantity of bleach to the well, then pump the chlorinated water into the house, opening faucets until chlorine is smelled. Then let the chlorinated water sit in the pipes for eight to 12 hours so it has enough contact time to kill the bacteria.

Water System Pipelines

An additional source for dissolved iron may be the pipelines, pressure tanks and other water fixtures. Many older homes have galvanized iron water pipes and fixtures. Water with high acidity from dissolved carbon dioxide or other acids can be corrosive to metal pipes and fixtures. To establish equilibrium, iron and other metals will be dissolved from the pipelines.

The acidity of water (pH less than 7) can be reduced by injecting an alkaline mineral such as sodium carbonate or by running the water through a filter impregnated with an alkaline material.

Because different metals are more or less corrodible, a solution to the problem may be to use a more resistant metal or plastic pipe. A plumber should be consulted regarding materials that are best suited to local water conditions.

Water Treatment Methods for Iron and Manganese Removal

Sequestering Agents: Polyphosphate Treatment

Many products are marketed as "sequestering" agents. All these products use some form of polyphosphate. These products are a relatively inexpensive way to treat water for low levels of iron and manganese.

Polyphosphates are a blend of phosphoric acid and other compounds that surround iron, keeping it "sequestered" or trapped; therefore, it's unavailable to react with oxygen and become a problem. This treatment will not remove the metallic taste often associated with excessive iron levels because the iron is not removed. It should not be used for water containing dissolved iron concentrations in excess of 2 mg/l or a combination of iron and manganese of more than 3 mg/l.

Polyphosphate usually is introduced into the water system using a chemical injection pump. Injection should occur as close to the well discharge point as possible and before the pressure tank or hot water heater. Determining the amount of phosphate needed to lower your iron and manganese level may take a little trial and error. The water will have a slippery feel if too much is added.

In addition, heat from cooking will release the iron and manganese and allow it to react with oxygen and form particles. Be aware that polyphosphates are derived from phosphorus and may contribute to a depletion of available oxygen in nearby water bodies.

Ion Exchange

Dissolved iron and manganese in water can be exchanged for sodium on an exchange resin or zeolite. This process of iron and manganese removal is the same ion exchange process that removes hardness or calcium and magnesium, Refer to NDSU publication WQ1031, "Water Softening (Ion Exchange)," available at *www.ag.ndsu.edu/publications/home-farm/water-softening-ion-exchange*.

Iron and manganese are removed during normal operation of the water softener. They, along with calcium and magnesium, later are removed from the exchange medium during regeneration and backwashing.

Some water softeners are capable of adequately treating water having iron up to 5 mg/l. However, others are limited to treating water with iron no greater than 2 mg/l. For higher levels of iron in the water, some softeners require a special blend of salt that contains additives to help remove the iron from the resin. If you want to remove iron and manganese in addition to hardness, check the manufacturer's recommendations.

One of the disadvantages of depending on ion exchange for iron and manganese removal is precipitation by oxygen. If iron bacteria are present, the problem is even worse. If you have problems with iron bacteria, they can be controlled by using chlorine or some other oxidizing agent.

Chlorination followed by filtration occurs before the water reaches the softener. Also, if suspended particles of insoluble forms of iron or manganese are present in the water prior to softening, they will be filtered out on the resin and cause plugging. Check with the manufacturer to determine the level of iron and manganese your equipment will remove. If iron and manganese levels are higher than recommended by the manufacturer, iron and manganese removal with a prefilter will be necessary prior to softening.

As long as levels of iron and manganese in the water do not exceed the manufacturer's recommendations, clogging of the softener resin should not be a significant problem. A clogged water softener can be cleaned by acid regeneration if the unit is made to withstand acid corrosion. Consult the manufacturer before attempting this.

Greensand (Adsorptive/ Oxidative) Filtration

One of the first types of filters to be used to treat water containing iron and manganese was the "greensand" filter **(Figure 1)**. The active material in "greensand" is glauconite. Glauconite is a green clay mineral that contains iron and has ion exchange properties. Glauconite often occurs mixed with other material as small pellets, thus the name "greensand." The glauconite is mined, washed, screened and treated with various chemicals to produce a durable greenish-black product with properties that allow it to adsorb soluble iron and manganese.

As water passes through the greensand filter, soluble iron and manganese are pulled from the solution and later react to form insoluble iron and manganese. Regular backwashing, as recommended by the manufacturer, is required to remove the insoluble forms of iron and manganese. In addition, the greensand filter must be regenerated periodically with a potassium permanganate solution. Follow the manufacturer's recommendations for this procedure.

Most greensand filters are rated to be effective treating water with iron concentrations up to 10 mg/l. If the pH of the water is lower than 6.8, the greensand probably will not filter out the iron and manganese adequately. The pH can be raised above 7.0 by running the water through calcite pretreatment.

An automated cleaning process called backwashing is used to remove particles collected in the filter. Regular backwashing is essential for effective filter performance and requires flow rates that are often three to four times the normal household usage rate. A backwash rate of about 8 gallons per minute/square foot of filter bed is recommended. If the household system cannot support the needed flow rate for adequate backwashing, poor filter performance and failure are likely.

Chlorination (Oxidation) Plus Filtration

Chemical oxidation followed by filtration is the accepted method of iron and manganese removal when concentrations are greater than 10 mg/l. Home water treatment for high levels of iron often uses chlorine or some other oxidant such as hydrogen peroxide.

A chlorine solution is injected with a chemical feed pump ahead of a sand filter. Soluble iron and manganese begin to settle out almost immediately after contact with the chlorine solution. However, approximately 20 minutes of contact time is needed to form particles that can be filtered.

Often the standard 42-gallon pressure tank used on many household systems will provide the needed contact time if water is forced through the tank. A simple T-connection from the pipeline to the pressure tank will not work because much of the water bypasses the tank. Additional contact time can be provided by connecting another tank in series or using a plastic pipe coil.

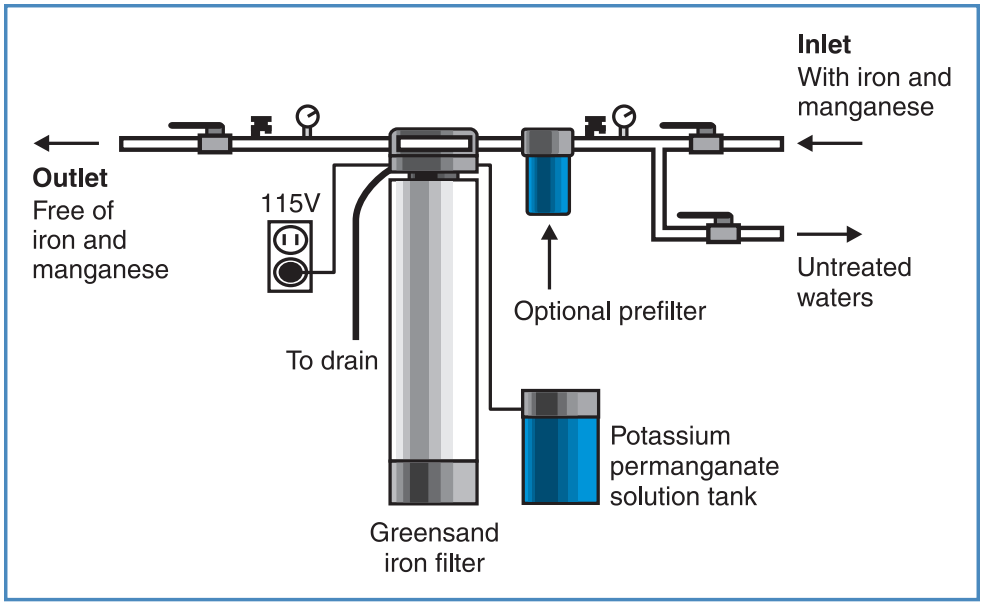

Figure 1. Greensand filter.

(Adapted from Excel Water Technologies, Inc.)

Standard Removal Rates

Treatment Method	Range of Soluble Iron/Manganese Removed	Optimal Removal at These pH Levels
	(mg/l)	
Polyphosphate	Up to 3	
Ion exchange (softener)	Up to 5	
Greensand filter	Up to 10	> 6.8
Chlorination and filter	>10	8.0 (Fe), 8.5 (Mn)

> means greater than

This type of system will remove soluble and suspended particles of insoluble iron and manganese from the source water. Backwashing the sand filter to remove precipitated iron and manganese is an important part of continued filtration. As with the greensand filter, the system flow rate should be checked to make sure it can provide the needed rates for backwashing.

An additional advantage of using the chlorination system is its bactericidal effect. Iron and manganese bacteria, along with other bacteria, are destroyed. Potential clogging problems in the sand filter are eliminated.

Chlorination does produce trihalomethanes (THM) when organic matter is present in the water. THMs are considered to be carcinogenic (maximum contaminant level permissible in public water systems is 0.1 part per million) and, if necessary, can be filtered out with an activated charcoal filter (refer to NDSU publication WQ1029, Filtration, available at *www.ag.ndsu.edu/publications/environment-natural-resources/filtration-sediment-activated-carbon-and-mixed-media*).

The optimum rate of oxidation of iron and manganese by chlorination is at a pH of about 8.0 and 8.5, respectively. Soda ash (sodium carbonate) injected with the chlorine will increase the pH to optimum levels. Adjusting the pH to alkaline levels also reduces the corrosivity of the water to pipes and plumbing.

Further Information

For further information, contact a local water treatment professional or water treatment company.

Additional home water treatment information can be found in other publications at www.ag.ndsu.edu.publications

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For related information, visit:

www.ag.ndsu.edu/publications

WQ1029 “Filtration”

WQ1031 “Softening”

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