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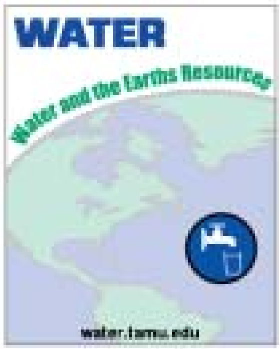

Drinking Water Problems: Iron and Manganese

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Iron and manganese are two similar elements that can be a nuisance in a drinking water supply. Iron is more common than manganese, but they often occur together. They are not hazardous to health.

What problems do iron and manganese cause?

Iron and manganese can give water an unpleasant taste, odor and color. Iron causes reddish-brown stains on laundry, porcelain, dishes, utensils, glassware, sinks, fixtures and concrete. Manganese causes brownish-black stains on the same materials. Detergents do not remove these stains. Chlorine bleach and alkaline builders (such as sodium and carbonate) may even intensify the stains.

Iron and manganese deposits build up in pipelines, pressure tanks, water heaters and water softening equipment. These deposits restrict the flow of water and reduce water pressure. More energy is required to pump water through clogged pipes and to heat water if heating rods are coated with mineral deposits. This raises energy and water costs.

Water contaminated with iron and manganese often contains iron or manganese bacteria. These bacteria feed on the minerals in the water. They do not cause health problems, but do form a reddish-brown (iron) or brownish-black (manganese) slime in toilet tanks and can clog water systems.

How do iron and manganese enter drinking water?

Iron and manganese are common elements in the earth's crust. As water percolates through soil and rock it can dissolve these minerals and carry them into groundwater. Also, iron pipes can corrode and leach iron into a household water supply.

How do I know if my water contains iron or manganese?

The appearance and/or taste of water can indicate the presence of iron and manganese. For example, reddish-brown (iron) or black (manganese) particles may be visible when water is drawn from the tap. These particles of iron and/or manganese may come from corroded pipes or from the water supply itself. The particles form because oxygen in the plumbing system is oxidizing and precipitating the iron and manganese.

If water is clear when it comes from the tap but particles form and settle out after the water has sat for a while, the iron and/or manganese is in the water supply itself. It is dissolved in the water and remains invisible until it oxidizes and precipitates.

Sometimes water from the tap is a reddish color. This is caused by colloidal iron—iron that does not form particles large enough to precipitate. Manganese usually is dissolved in water, although some shallow wells contain colloidal manganese that gives water a black tint.

Reddish-brown or black slime in toilet tanks or faucets is a sign of iron and manganese bacteria.

Water containing high concentrations of iron and manganese may have an unpleasant metallic flavor. The water may react with tannins in coffee, tea and other beverages to produce a black sludge. You may also notice that the water is staining clothing and other items.

While these symptoms can indicate that your water contains iron and manganese, you will need to have the water tested to measure how much it contains.

How is testing done and what do the results mean?

Unlike public water suppliers, owners of private wells are not required to have their water tested for iron and manganese. However, it is important to have a laboratory test to measure how much of these substances is in the water, and to measure for other conditions and substances (pH, oxygen, hardness and sulfur) that can determine the most suitable treatment method.

To find a water testing laboratory in your area, contact your county Extension office, local utility or health department. Ask the laboratory to send you a test kit for iron and manganese. A kit usually contains a sample bottle, an information form, a box for mailing the sample, and instructions. Follow instructions carefully when collecting the water sample. Mail the sample promptly and be sure to include the information form. Take the sample on a day when it can be mailed to arrive at the laboratory Monday through Thursday. Avoid weekends and holidays that might delay the analysis.

The laboratory may ask you to sample for iron or manganese bacteria inside the plumbing system. The inside of the toilet tank is a good place to take this sample.

Your test results probably will be reported as mg/L (milligrams per liter). The U.S. Environmental Protection Agency has set Secondary Maximum Contaminant Levels (SMCL) for iron and manganese at 0.3 mg/L and 0.05 mg/L, respectively. SMCLs are standards for substances that are not health hazards. Water that contains less than 0.3 mg/L of iron and 0.05 mg/L of manganese should not have an unpleasant odor, taste or appearance and should not require treatment.

How do I eliminate iron and manganese from drinking water?

If the test shows that your water does contain undesirable levels of iron and/or manganese you have two options: 1) obtain a different water supply; or 2) treat the water to remove the impurities.

You might be able to drill a new well in a different location, or complete the existing well in a different water-bearing formation. Ask your well driller for advice on these options.

If you decide to treat the water, there are several effective methods to choose from. These are summarized in Table 1. The most appropriate method depends on factors such as the concentration of iron and manganese in the water, whether bacteria are present, and the amount of water you need to treat.

Phosphate treatment

Low levels of dissolved iron and manganese (combined concentrations up to 3 mg/L) can be remedied by injecting phosphate compounds into the water system. Phosphate prevents the minerals from oxidizing and thus keeps them in solution. The phosphate compounds must be introduced into the water at a point where the iron is still dissolved in order to keep the water clear and prevent staining. Injection should occur before the pressure tank and as close to the well discharge point as possible.

Phosphate compound treatment is relatively inexpensive, but there can be disadvantages to this method. Phosphate compounds do not actually remove iron, so treated water retains a metallic taste. Adding too much phosphate can make the water feel slippery. Phosphate compounds are not stable at high temperatures, which means that if treated water is heated (in a water heater or when cooking) the iron and manganese will be released, react with oxygen and precipitate. Finally, the use of phosphate products is banned in some areas because of environmental concerns.

Ion exchange water softener

Low to moderate levels of iron and manganese (a combined concentration of up to 5 mg/L) usually can be removed by an ion exchange water softener. Before you buy one, be sure the concentration of iron in your water does not exceed the maximum iron removal level of the equipment. Not all water softeners can remove iron from water, so check the manufacturer's specifications carefully. Excessive amounts of dissolved iron can plug a softener.

An ion exchange softener works by exchanging the iron in the untreated water with sodium on the ion exchange medium. Backwashing flushes iron from the softener medium, forcing sodium-rich water back through the device. This process adds sodium to the resin medium while the iron is carried away in the waste water.

Because iron reduces the unit's capacity to soften water, it will have to be recharged more often. Follow the manufacturer's recommendations concerning the appropriate material to use for a partic-

Table 1. Treatments for iron and manganese in drinking water.

Cause	Indication	Treatment
Dissolved iron or manganese	Water clear when drawn but reddish or blackish particles appear as water stands Reddish-brown or black stains on fixtures or laundry	Phosphate compounds (use for < 3 mg/L iron) Water softener (use for <5 mg/L combined concentrations of iron and manganese) Oxidizing filter—manganese greensand or zeolite (use with <15 mg/L combined concentrations of iron and manganese) Aeration/filtration (use with <25 mg/L combined concentrations of iron and manganese) Chemical oxidation and filtration (use with >10 mg/L combined concentrations of iron and manganese)
Dissolved (colloidal) iron or manganese (organic complexes of these minerals)	Water is reddish or blackish color from the tap and color remains longer than 24 hours (no particles precipitate)	Chemical oxidation and filtration
Oxidized iron in the water supply	Water from the tap contains reddish-brown particles that settle out as water stands	Particle filter
Corrosion of pipes and equipment	Water from the tap contains reddish-brown particles that settle out as water stands	Raise water pH and use a particle filter
Iron or manganese bacteria	Reddish-brown or black slime in toilet tanks and sink and tub drains	Shock treatment and filtration

ular concentration of iron. Some manufacturers suggest adding a "bed cleaning" chemical with each backwashing to prevent clogging.

Water softeners add sodium to water, which can cause health problems for people on sodium-restricted diets. In such cases, install a reverse osmosis unit to provide unsoftened water for cooking and drinking, or use a potassium salt water softener.

Oxidizing filter

Moderate levels of iron and manganese (a combined concentration of up to 15 mg/L) can be treated with an oxidizing filter. The filter is usually natural manganese greensand or manufactured zeolite coated with manganese oxide. These substances adsorb dissolved iron and manganese. Synthetic zeolite requires less backwash water and softens water as it removes impurities. The amount of dissolved oxygen in your water (which can be determined by field test kits, water treatment companies or water testing laboratories) determines the correct oxidizing filter to use.

Aeration/filtration

High concentrations of iron and manganese can be treated with an aeration/filtration system. In this system, air is pulled in and mixed with the passing stream of water. The air-saturated water then enters a precipitator/aerator vessel where air separates from the water. The water then flows through a filter where various filter media screen out oxidized particles of iron, manganese, and some carbonate or sulfate.

Pressure-type aerators are commonly used in household water systems. Backwashing the filter periodically is a very important maintenance step. Aeration is not recommended for water containing iron/manganese bacteria or colloidal (organic complexes of) iron/manganese because they can clog the aspirator and filter.

Chemical oxidation

High levels of dissolved or oxidized iron and manganese (combined concentrations of up to 25 mg/L) can be treated by chemical oxidation. This method is particularly helpful when iron is combined with organic matter or when iron/manganese bacteria are present.

The system consists of a small pump that puts an oxidizing chemical into the water while it is still in the well or just before it enters a storage tank. This pump operates whenever the well pump operates. The oxidizing chemical may be chlorine, potassium permanganate or hydrogen peroxide. The chemical must be in the water for at least 20 minutes for oxidation to take place, longer if the water contains colloidal iron/manganese. After solid particles have formed they are filtered, often with a sand filter. Adding aluminum sulfate (alum) improves filtration by causing larger particles to form.

When chlorine is used as the oxidizing agent, excess chlorine remains in the treated water. If the particle filter is made of calcite, sand, anthracite or aluminum silicate, a minimum amount of chlorine should be used to avoid the unpleasant taste that results from excess chlorine. An activated carbon filter will remove excess chlorine, as well as small quantities of iron/manganese particles. Chlorine oxidizes iron best at a pH of 6.5 to 7.5. Chlorine should not be used for high levels of manganese because manganese requires a pH higher than 9.5 for complete oxidation.

Potassium permanganate is more effective than chlorine for oxidizing manganese at pH levels higher than 7.5. Potassium permanganate is poisonous and a skin irritant. There must be no excess potassium permanganate in treated water and the concentrated chemical must be stored in its original container away from children and animals. Using this chemical requires careful calibration, maintenance and monitoring.

Raising pH and particle filtration

If corroded pipes are the source of iron/manganese particles in the water, raising the water's pH and using a sediment filter is the simplest solution to the problem.

Shock treatment and filtration

Shock treatment is the most common method of killing bacteria and chlorine is the chemical most often used in this process. (See L-5441, "Shock Chlorination of Wells," Texas Cooperative Extension.) It is almost impossible to kill all the iron and manganese bacteria in a system, so be prepared to repeat the shock chlorination treatment when the bacteria grow back. If repeated treatments become too time consuming, it can be more efficient to install a continuous application system that injects low levels of liquid chlorine or drops chlorine pellets into the well automatically.

Chlorine rapidly changes dissolved iron to solid iron that will precipitate. Therefore, a filter may be needed to remove particles if a continuous chlorination system is used.

Multistage treatment

If water has high levels of iron and manganese in both the dissolved and solid forms, a multistage treatment operation is necessary. The first stage is chlorination to oxidize dissolved iron and kill bacteria. The water can then be filtered through a mechanical device to remove particles. This can be followed by filtering with activated carbon to remove excess chlorine and, finally, softening to control hardness and remove any residual dissolved minerals.

Summary

Although iron and manganese in a household water supply are not hazardous to health, they can be a nuisance and damage laundry and other items. The treatment method for these impurities depends on the form and concentration in which they occur in the water.

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