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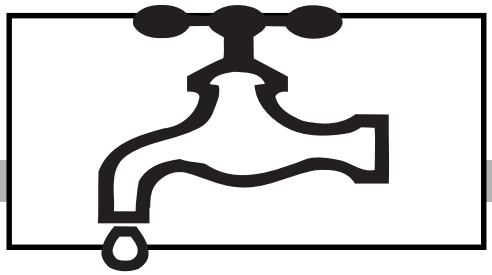

Household Water Quality

Iron and Manganese in Household Water

*Amber Wilson, Kathleen Parrott and Blake Ross**

Iron and manganese are metallic elements that are found in the earth's crust. These elements usually do not present a health hazard when they are present in the household water supply; however, they can cause nuisance problems, such as staining and objectionable taste. Iron and manganese are similar chemically and, therefore, cause similar problems. Iron is the more common of these two elements and can be found in a water source without the presence of manganese; however, manganese is rarely found alone in a water source.

Sources of Iron and Manganese in Household Water

When ground water percolates through soil and rock, minerals containing iron and manganese are sometimes dissolved by and held in the water. It is also possible for corroding iron or galvanized steel pipes to be a source of iron in household water. Iron can be found in the following two forms:

- *Ferrous iron* - this form creates a clear solution when it is dissolved in water and, as a result, is often referred to as clear water iron. This type of iron is generally present when tap water appears clear but develops black or rust colored particles that settle to the bottom of the container when the water is allowed to stand. These particles develop because the ferrous iron reacts with air, chlorine, or other oxidants to form ferric iron.
- *Ferric iron* - ferric iron is insoluble in water. Therefore, ferric iron is commonly present when the tap water appears rusty or has a red or yellow color to it (colloidal iron).

Common Problems Associated with Iron and Manganese

Iron and manganese cause a variety of different nuisance problems. Iron and manganese can affect the flavor and color of food and water. In fact, they may react with the tannins in tea, coffee, and some alcoholic beverages to produce a black sludge, which will affect both the taste and appearance. Iron will typically cause reddish-brown staining of laundry, porcelain, dishes, utensils, and glassware. Manganese causes a similar problem, resulting in a brownish-black stain. These stains are not removed by soaps and detergents; in fact, using chlorine bleach and alkaline cleaners (such as sodium and carbonate) will intensify the stains.

Furthermore, the presence of iron and manganese in the water supply will lead to build up in pipelines, pressure tanks, water heaters, and water softeners. This buildup is associated with a decrease in the amount and pressure of available water and an increase in the cost of operating water-using appliances. Iron and manganese buildup can become expensive when it results in the replacement or repair of plumbing or water softening equipment.

Yet another problem that is associated with iron and manganese in the water is iron or manganese bacteria. These bacteria do not pose a health threat; however, they do produce a red-brown (iron) or black-brown (manganese) slime in toilet tanks and can clog water systems. Iron bacteria feed on the iron or manganese present in the water and can grow in either light or dark conditions. Iron or manganese bacteria can be controlled through some type of disinfection process such as chlorination.

Testing for Iron and Manganese

Fortunately, treatment for iron and manganese can be very effective, but the most important factor in achieving effective treatment is identifying what kind of iron, and how much, is present. Likewise, it is important to

* Extension Associate, Management, Housing and Consumer Education; Extension Specialist, Housing; Extension Specialist, Biological Systems Engineering, respectively, Virginia Tech

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determine the hardness of the water, temperature variations, and the water's pH (acidity or alkalinity) level. With that in mind, it is recommended that thorough water analysis be completed before selecting a treatment method. Furthermore, water treatment equipment should be selected and installed in coordination with additional water treatment equipment that may be necessary to address other existing water quality problems. Individuals interested in having their water tested can contact their local health department for a list of state certified water-testing laboratories in their area.

Understanding Test Results

The Environmental Protection Agency has established two categories for drinking water standards: Primary Standards and Secondary Standards. Primary standards are based on health considerations and Secondary Standards are based on taste, odor, color, corrosivity, foaming and staining properties of water. Iron and manganese are classified under the Secondary Standards. The Secondary Maximum Contaminant Level (SMCL) for iron in drinking water is 0.3 milligrams per liter (mg/l), sometimes expressed as 0.3 parts per million (ppm), and .05 mg/l (ppm) for manganese. However, water with less than these amounts of iron and manganese may still cause staining problems.

Choosing a Water Treatment

If the water has excessive iron and/or manganese, one of the following five treatment methods can be used: (1) phosphate compounds; (2) ion exchange water softeners; (3) oxidizing filters; (4) aeration (pressure type) followed by filtration; and (5) chemical oxidation followed by filtration. Except for the phosphate method, these

Indication	**Cause**	**Treatment**
Water is clear when drawn but red-brown or black particles appear as water stands; red-brown or black stains on fixtures or laundry	Dissolved iron and/or manganese	• Phosphate compounds (*< 3 mg/l combined concentration of iron and manganese*) • Water softener (*<5 mg/l combined concentrations*) • Chemical oxidation with potassium permanganate or chlorine; followed with filtration (*< 10 mg/l combined concentrations*) • Oxidizing filter (manganese greensand or zeolite or manganese oxide) (*<15 mg/l combined concentrations*) • Aeration (pressure) (*<25 mg/l combined concentrations*)
Water contains red-brown or black particles when drawn; particles settle out as water stands	Iron particles from corrosion of pipes and equipment OR Oxidized iron/manganese due to exposure of water to air prior to tap	Raise pH with neutralizing filter OR Particle filter (if quantity of oxidized material is high, use larger filter than inline; e.g., sand filter)
Red-brown or black slime appears in toilet tanks or forms clogs in faucets	Iron or manganese bacteria	Kill bacteria masses by shock treatment with chlorine or potassium permanganate, then filter; bacteria may originate in well, so it may require continuous feed of chlorine or potassium permanganate, then filter
Reddish or black color that remains longer than 24 hours	Colloidal iron/manganese; organically complexed iron/manganese	Chemical oxidation with chlorine or potassium permanganate; followed by filtration

Source: "Drinking Water: Iron and Manganese" (G96-1280-A) Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln (1996).

treatment methods are most effective when used in a water supply that has an almost neutral pH (approximately 7.0). All of the methods will remove both iron and manganese. The table outlines appropriate treatment for iron and manganese problems.

Description of Treatment Methods

- **Phosphate treatment**

  A phosphate compound treatment can be used to control dissolved iron and manganese with a combined concentration of up to *3 mg/l.* Phosphate compounds work by surrounding the minerals and keeping them suspended in the solution. In order for the phosphate compounds to work, they must be introduced in the water at a point where the iron is still dissolved to preserve water clarity and prevent possible iron staining.

  Although phosphate is an inexpensive treatment method for low levels of iron and manganese, it is important to remember that the iron and manganese is not actually removed from the water and the water may still have a metallic taste. Using too much phosphate compound will result in water that will feel slippery. Furthermore, phosphate compounds are not stable at high temperatures, and if the water is heated or boiled, the phosphate compounds will break down and become ineffective. Also important to note is that phosphate compounds do contribute to excess nutrient levels in surface water. Therefore, phosphate treatment is not recommended in areas where phosphate is limited in cleaning products, as in Virginia. Reducing phosphates in surface water is an important concern in Virginia's Chesapeake Bay watershed.

- **Ion exchange water softener**

  Iron and manganese present in combined concentrations of *5 mg/l* or less can usually be removed by using an ion exchange water softener. It is important to check the manufacturer's maximum iron removal level recommendations, which typically range from 1 to 5 mg/l, before purchasing a unit. Softeners become clogged when levels of oxidized or dissolved iron exceed the manufacturer's level recommendations.

  When using this method, the iron in the water is exchanged with sodium, or occasionally potassium, ions. The iron is then flushed from the softener by backwashing (forcing sodium-rich water back through the device) and then the iron is carried away through the wastewater.

  Iron removal does reduce the softening capacity of the unit; therefore, it may have to be recharged frequently. Furthermore, not all water softeners are capable of removing iron, so be sure to check the manufacturer's specifications.

  Water softeners do add sodium to the water; therefore, if you are concerned about your sodium intake, you should consult with your doctor. Water softeners can be installed to bypass the cold water in the kitchen, allowing untreated water to be available for drinking and cooking.

- **Chemical oxidation followed by filtration**

  This method is effective for treating combined concentrations of iron and manganese less than *10 mg/l.* When this method is used, the water is treated with an oxidizing chemical such as chlorine, potassium permanganate, or hydrogen peroxide, then filtered through a sand trap filter to remove the precipitated particles. This method may prove to be particularly useful when iron is combined with organic matter or when iron bacteria is present.

  With this type of treatment system, a small feed pump is used to add the oxidizing chemical to the water supply. The process requires a retention time of at least 20 minutes to ensure that the oxidation takes place. Next the particles must be filtered. If large amounts of iron are present, a flushing sand filter may be needed. Any type of filtration material that is used requires regular backwashing or replacement to eliminate the solid iron/manganese particles.

  When organic-complexed or colloidal iron/manganese is present in the water supply, higher concentrations of chemicals and a longer retention time may be required for proper oxidation to take place. It may be helpful to add aluminum sulfate to the water because it improves filtration by causing larger iron/manganese particles to form.

  If you use chlorine as the oxidizing agent, it is important to note that any excess chlorine will stay in the water. While chlorine is an effective disinfecting agent, unpleasant taste results from too much chlorine. Using an activated carbon filter is an effective way to remove excess chlorine and improve taste.

  The pH of the water supply should be considered when choosing an oxidizing agent. If the pH of the water is less than 6.5, a neutralizing treatment is needed before chemical oxidation. Chlorine bleach is the most effective for oxidizing iron if the pH level is 6.5 to 7.5. Consequently, chlorination is not recommended for treatment of high levels of manganese because a pH level of 9.5 or greater is required for complete

manganese oxidation. Potassium permanganate can oxidize manganese at pH levels of 7.5 or higher and is also an effective method of oxidizing organic iron.

However, caution must be exercised with potassium permanganate because it is both a poison and a skin irritant. Furthermore, it is very important that no excess potassium permanganate be present in the water supply. In addition, caution must be exercised when storing the concentrated potassium permanganate to ensure that it is kept where children and animals cannot access it. If potassium permanganate is used, careful calibration, maintenance, and monitoring of your water treatment equipment is necessary.

- **Oxidizing filter**

An oxidizing filter treatment system is effective in treating dissolved iron and manganese at combined concentrations of up to *15 mg/l*. With this type of treatment, the dissolved iron and manganese are absorbed by the filter, which is normally made of natural manganese greensand or manufactured zeolite coated with manganese oxide. Filters made with synthetic zeolite require less backwash water and soften the water as it removes the iron and manganese. It is important to note that this type of system must be selected and operated based on the amount of dissolved oxygen that is present in the water supply. The amount of dissolved oxygen can be determined by using a field test kit or sending samples to a water testing laboratory.

- **Aeration followed by filtration**

This method is effective for treating iron and manganese with combined concentrations of up to *25 mg/l.* This type of treatment method uses a process in which air is mixed with the passing stream of water to oxidize the iron into particles. Next the air-saturated water enters the precipitator/aerator vessel, usually a pressure-type aerator for domestic use, in which the air is separated from the water. Then the water flows through a filter which uses various filter media to screen out oxidized particles of iron, manganese, and some carbonate or sulfate. More time and oxygen are required for treating manganese than iron with this type of system.

It is important that the filter be backwashed from time to time to ensure proper performance. Furthermore, aeration is not recommended if the water contains organic complexes of iron/manganese or iron/ manganese bacteria that will clog the filter or aspirator.

Selecting Water Treatment Equipment

Consumers are encouraged to talk to a Water Quality Association Certified Water Quality Specialist before purchasing water treatment equipment. Certified Water Quality Specialists are individuals that work in the water quality improvement industry and have passed the Water Quality Association certification examinations. Water Quality Association member dealers can be located by looking under "Water Treatment Companies" in the yellow pages of your telephone directory.

Another helpful tip is to look for the Water Quality Association Gold Seal on the product. This seal assures consumers that the equipment has been tested against industry standards and validated for performance capabilities. Likewise, consumers can look for the NSF, National Sanitation Foundation, certification mark to ensure that they are purchasing quality products. Another helpful tip for consumers is to pay careful attention to the reputation of the manufacturer and warranty offered. Last, consumers can check with the Better Business Bureau for references and complaints.

If further assistance is needed, please contact your local Virginia Cooperative Extension office to obtain a copy of one of the following publications or visit our website at **http://www.ext.vt.edu**

- Home Water Quality Problems - Causes and Treatments VCE Publication 356-482
- Household Water Testing -VCE Publication 356-485
- Household Water Treatment -VCE Publication 356-481
- Interpreting Your Water Test Report - VCE Publication 356-489
- Questions to Ask When Purchasing Water Treatment Equipment -VCE Publication 356-480

References

Varner, D., Skipton, S., Hay, D., & Jasa, P. (1996). Drinking Water: Iron and Manganese. (G96-1280-A) Lincoln, NE: Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln.

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