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Virginia Household Water Quality Program: Iron and Manganese in Household Water

Authored by Erin James Ling, Water Quality Extension Associate, Biological Systems Engineering, Virginia Tech; Brian Benham, Associate Professor and Extension Specialist, Biological Systems Engineering, Virginia Tech, and Jen Pollard Scott, Research Assistant, Biological Systems Engineering, Virginia Tech

Private water sources, such as wells and springs, are not regulated by the U.S. Environmental Protection Agency (EPA). Although private well construction regulations exist in Virginia, private water supply owners are responsible for the maintenance of their water systems, for monitoring the quality of their drinking water, and for taking appropriate steps to address problems should they arise.

The EPA public drinking water standards are good guidelines for assessing your water quality. *Primary drinking water standards* apply to contaminants that can adversely affect health and are legally enforceable for public water systems. *Secondary drinking water standards* are non-regulatory guidelines for contaminants that may cause nuisance problems such as bad taste, foul odor, or staining.

Testing your water annually and routinely inspecting and maintaining your water supply system will help keep your water safe. For more information, visit the Virginia Household Water Quality Program website at www.wellwater.bse.vt.edu.

Introduction

Iron and manganese are naturally occurring minerals found in certain rocks and soils that can be dissolved by groundwater. Corroding iron or galvanized steel pipes may also be a source of iron in household water. Typically, neither iron nor manganese presents a health risk to humans when present in a household water supply; however, a portion of the population suffering from hemochromatosis (excess iron in the body) may be especially sensitive to iron in drinking water.

Iron and manganese are primarily associated with nuisance problems such as staining of clothes and plumbing fixtures or objectionable taste. Iron and manganese are similar chemically and therefore produce similar problems. Iron and manganese are usually either dissolved (in solution) in water or found in particulate form.

Dissolved or In-Solution

Ferrous iron (Fe^{2+}) and manganous manganese (Mn^{2+}) are present when tap water appears clear at first but develops black- or rust-colored particles that settle to the bottom of the container when the water is left standing for a while. Particles develop because the ferrous iron and manganous manganese react with air, chlorine, or other oxidants to form ferric iron or manganic manganese.

Particulate or Colloidal

Ferric iron (Fe^{3+}) and manganic manganese (M^{4+}) are present when the iron or manganese is in the oxidized form. Particles in suspension in the tap water result in water that has a brownish-black, rust, red, or yellow color.

Problems Associated With Iron and Manganese

Iron and manganese can cause a variety of nuisance problems. Both can affect the taste and color of the water and food prepared with the water. Iron and manganese may react with the tannins in tea, coffee and some alcoholic beverages to produce a black sludge, which will affect both taste and appearance. Iron will typically cause reddish-brown staining of laundry,

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porcelain, dishes, utensils and glassware. Manganese causes similar brownish-black staining. These stains are generally not easily removed by soaps and detergents; in fact, using chlorine bleach and alkaline cleaners (such as sodium and carbonate) may intensify the stains.

The presence of iron and manganese in a water supply can lead to a buildup of these contaminants in pipelines, pressure tanks, water heaters, and water softeners. This buildup is often associated with decreased water pressure and increased operating costs for water-using appliances. Another problem that may be associated with both iron and manganese is the presence of bacteria that feed on these elements. These bacteria do not pose a health risk to humans, but do produce a red-brown (iron) or black-brown (manganese) slime in toilet tanks, water troughs, or other places where water stands. The bacterial slime can eventually clog water systems if left untreated. Iron or manganese bacteria can be controlled by disinfecting the water supply system using shock chlorination (*Shock Chlorination: Disinfecting Private Household Water Supply Systems for more information,* Virginia Cooperative Extension publication 442-663). Finally, as mentioned earlier, iron in drinking water may cause health problems for a small segment of the population. If this is a concern, consult your physician.

Testing for Iron and Manganese

The Environmental Protection Agency has established secondary, or nuisance, standards for iron and manganese because they affect the water's taste, odor, or color, and can produce stains. The secondary drinking water standard for iron in drinking water is 0.3 milligrams/liter (mg/L) and 0.05 mg/L for manganese. However, water with lower concentrations of these metals may still cause staining problems. Fortunately, the treatment options for iron and manganese can be very effective, but one must know how much iron and/or manganese is present and the form(s). Measurement of iron and manganese is most accurately made by a certified laboratory. When collecting any water sample, follow the instructions for proper sample collection carefully. A list of certified laboratories maintained by the Virginia Division of Consolidated Laboratory Services is available at: www.wellwater.bse.vt.edu/resources.php.

Treatment Options

Water treatment equipment for iron and manganese should be selected and installed in coordination with other equipment that may be necessary to address other water quality problems. If your water has excessive iron and/or manganese, one of the following treatment methods may be appropriate.

Phosphate Treatment

Adding phosphates to the water supply can control dissolved iron and manganese up to a combined concentration of 3 mg/L. Phosphate compounds introduced into the water supply work by surrounding the iron and manganese, keeping the metals dissolved or in solution. To be effective, the phosphate must be added to the plumbing system at a point where the iron and manganese are in solution. It is important to remember that iron and manganese are not actually removed with this treatment option so the water may still have a metallic taste. Using too much phosphate will result in the treated water feeling "slippery" and may cause diarrhea. Furthermore, the phosphate compounds used in this treatment option are not stable at high temperatures. The phosphate compounds will break down and become ineffective if the water is heated or boiled. Phosphate compounds may contribute to excess nutrient concentrations in surface water that can lead to algal blooms and impaired water quality after being discharged from the household via the drain. Therefore, phosphate treatment for iron and manganese is not recommended in areas where phosphate is limited or banned in cleaning products, like Virginia.

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 before purchasing a unit. The resin in ion exchange treatment units must be periodically regen-

The Virginia Household Water Quality Program, offered through Virginia Cooperative Extension (VCE), periodically conducts county-based household water sampling clinics where you can learn about the quality of your water supply, proper water supply system maintenance, and, if needed, possible water treatment options. Please contact your local Extension office or visit www.wellwater.bse.vt.edu for more information.

erated by flushing the system with a brine (sodium chloride) solution. Using a softener to remove iron or manganese does reduce the softening capacity of the unit, which may require it to be recharged more frequently. Water softeners can become clogged when levels of iron or manganese in the water exceed manufacturer recommendations. Ion exchange treatment may result in lower pH, and therefore slightly more corrosive water. Additionally, a sodium-based ion exchange system will increase the level of sodium in the treated water, so if you or others in your household are on a low-sodium diet or are concerned with sodium intake, consult your physician. Water softeners may be installed to bypass the cold water faucet in the kitchen, allowing unsoftened water to be available for drinking and cooking.

Aeration Followed by Filtration

This method is effective for treating iron and manganese with a combined concentration of between 5 and 10 mg/L. Air is mixed with passing water to oxidize the iron and/or manganese, producing particles that can then be filtered out of the water. Air-saturated water then enters an aerator vessel, where the air is separated from the water. The water passes through a filter to screen out particles of iron and/or manganese. More holding time and oxygen are required for treating manganese compared to iron with this type of system. As is the case with any filter, the filter used with this treatment option must be periodically backwashed/changed to ensure proper performance. Aeration is not recommended if the water contains organic complexes of iron/manganese or iron or manganese bacteria, as they will clog the filter.

Oxidizing Filter

An oxidizing filter treatment system is effective in treating iron and manganese at combined concentrations of up to 15 mg/L. Because oxidizing filter units combine oxidation and filtration, they can be used to treat water with dissolved and/or particulate iron and manganese. An oxidizing filter typically contains a filter medium made of natural manganese greensand or manufactured zeolite coated with manganese oxide. Regular maintenance of these systems is required. The filters must be routinely backwashed to remove accumulated iron and manganese particles. Maintenance frequency depends on the amount of iron and manganese in the water and the amount of water treated.

Chemical Oxidation Followed by Filtration

This method is effective for treating combined concentrations of iron and manganese greater than 10 mg/L and is rarely used for domestic applications. Water is treated with an oxidizing chemical such as chlorine, potassium permanganate, or hydrogen peroxide and then filtered through a sand media filter to remove the oxidized iron and/or manganese particles. This method may prove to be particularly useful when iron or manganese are combined with organic matter or when iron bacteria are present (see Table 1.).

A complete water analysis for contaminants and/or the advice of a certified water treatment professional will help in selecting the specific treatment method appropriate for each application. Consumers should verify manufacturer claims before purchasing any water treatment device by contacting the National Sanitation Foundation (www.nsf.org), or the Water Quality Association at www.wqa.org/.

Additional Information

For more information on household water quality, see the Virginia Cooperative Extension publications listed here:

Virginia Household Water Quality Program website: www.wellwater.bse.vt.edu/.

Virginia Cooperative Extension website: pubs.ext.vt.edu/category/home-water-quality.html.

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Table 1. Indication, cause, and possible treatment options for iron and manganese.

Indication	Cause	Possible Treatment Options
Water is clear when drawn but red-brown or black particles appear as water stands; red-brown or black stains on fixtures and laundry	Dissolved iron and/or manganese	Phosphate compounds (<3mg/L combined concentration of iron and manganese) Water softener (<5 mg/L combined concentration) Aeration followed by filtration (5 to 10 mg/L) Chemical oxidation followed by filtration (>10 mg/L combined concentrations) Oxidizing filter (≤15 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 outlet	Particle filter (if quantity of oxidized material is high, use larger filter than inline; e.g. sand media filter)
Red-brown or black slime appears in toilet tanks or forms clogs in faucets	Iron or manganese bacteria	Kill bacteria with shock chlorination, then filter; if bacteria persist consider continuous chemical oxidation with filtering.
Water has reddish or black color that remains longer than 24 hours	Colloidal iron/manganese; organically complexed iron/manganese	Chemical oxidation followed by filtration

Source: Varner, D., S. Skipton, D. Hay, and P. Jasa. Drinking Water: Iron and Manganese (G96-1280-A) Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln (1996). Accessed online August 2011: (http://www.p2pays.org/ref/20/19707.htm)

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