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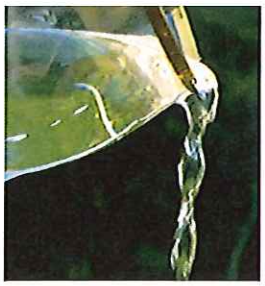

DRINKING WATER

Iron in Drinking Water

Alex Colter and R. L. Mahler

Note: This is the first in a series of publications on drinking water contaminants and treatments for them. Treatment costs are approximate, and subject to change.

Iron is a harmless, though sometimes annoying, element present in public and private water supplies.
High concentrations of dissolved iron can result in poor tasting, unattractive water that stains both plumbing fixtures and clothing. When iron-rich waters mix with tea, coffee, or alcoholic beverages, they assume a black, inky appearance with an unpleasant taste. Vegetables cooked in iron-rich waters will also become dark and unappetizing. Concentrations of iron as low as 0.3 milligrams per liter (mg/L) will deposit reddish-brown stains on fixtures, utensils, and clothing, all of which can be difficult to remove (See Additional References section on page 4).

Ferric iron deposits within corroded pipes can break free and generate rusty tap water. Iron bacteria gives water a disagreeable taste and causes yellow stains on laundry. This bacterium can also clog water systems, plug filters, or envelop pump screens, resulting in expensive repairs.

EPA considers iron an aesthetic problem

The Environmental Protection Agency (EPA) drinking water standards fall under primary and secondary standards. Primary standards based on health considerations are designed to protect people from three classes of pollutants: pathogens, radioactive elements, and toxic chemicals.

Secondary standards involve aesthetic issues, such as taste, odor, color, corrosivity, and the foaming and staining properties of water. Iron is regulated under the Secondary Maximum Contaminant Level (SMCL) standard. The SMCL for iron in drinking water is 0.3 milligrams per liter (mg/L), or 0.3 parts per million (ppm). Water with less than these concentrations should not exhibit any of the previously mentioned side effects.

Quick Facts about Iron

Type Inorganic

Source Naturally occurring in groundwater and corroded water system pipes

EPA MCL Secondary Maximum Containment Level of 0.3 milligrams per liter (mg/L) is considered safe for drinking.

Health Issues No known health concerns in concentrations usually found in drinking water

Indications Unpleasant taste, smell, and staining of plumbing fixtures and laundry

Health considerations

At concentrations most commonly found in drinking water, the presence of iron is not considered a health problem. Iron in drinking water can even provide a health benefit. Small concentrations are essential to human health, because iron helps transport oxygen in the blood. The majority of water supplies in the United States provide approximately 5 percent of the daily dietary requirement for iron.

First step—test water for iron

When faced with possible iron contamination in the household water supply, the initial step is to verify the cause of contamination. Whether the source of iron is from natural processes or water pipe corrosion, a laboratory analysis of the water, costing about $25, can verify the scope of the problem and help determine the best treatment. Obtain a water sample kit from a certified laboratory. (See a telephone book's yellow pages for a certified testing laboratory; it may be listed under Laboratories—Testing). In addition, iron-testing kits are available for about $30 at local hardware stores and are quite simple to use. Typically, laboratory tests are needed to more accurately quantify the extent of iron contamination. If the source of water is a public or municipal system, it is essential to contact the water department to verify whether any quality issue is linked to the public system or to the individual home's plumbing or piping.

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Four types of iron in water

Remediation methods should be customized to the type of iron discovered in the water system. Without knowledge of the form of iron causing the contamination, treatment may be ineffective.

Iron can be present in water in four forms. None are considered a health hazard. Identifying the form of iron present as well as the concentration level is important when deciding on the best treatment. The four forms are:

Ferrous (clear-water) iron. This is the most common form and results in the most complaints by water users. When oxygen content is low, as in deep wells or aquifers, iron is dissolved and water remains clear and colorless. Tap water may remain clear, but if allowed to sit for a period of time it will precipitate and rust colored particles will begin to form and settle to the bottom.

Ferric (red-water) iron. When exposed to the atmosphere, ferrous iron begins to oxidize and reddish-brown-to-black particles begin to form. This "rusty" sediment is the ferric form of iron. Ferric iron is insoluble in water.

Iron bacteria are nonpathogenic and occur in soil, groundwater, and surface waters. They may also thrive on the metal parts of plumbing fixtures or water systems and are most commonly seen when removing the lid from the toilet tank. Iron bacteria usually appear as a gelatinous or slimy substance suspended in water and may be colored brown, red, or white.

Organic iron can combine with different naturally occurring organic materials and exist as an organic complex. This form of iron can be found in shallow wells and surface water and is usually yellow or brown.

Seven Treatment Options

When faced with an iron contamination problem, consider one of these seven water treatment alternatives. With the exception of well reconstruction, all treatment methods discussed here can be installed to filter the entire home or business or, smaller versions can be installed to designated water lines such as the kitchen or shower faucet, or the water and ice dispenser in your refrigerator.

Due to the destructive nature of iron contamination in the kitchen, bathroom, and laundry room, most water quality specialists recommend that an entire home filtration system be used. Filtration systems can be purchased from specialized water filtration stores (see yellow pages), the internet or, off the shelf from larger hardware stores, such as Home Depot or Lowes Hardware. The actual cost of these systems can be extremely variable. Such variables include; the type of iron contamination, choice of process, brand, and how much filtered water is needed on a daily basis (measured in gallons per minute). Depending on the type and size of the system, filtrations units can range from $20.00 to $5,000.00 dollars. A skilled homeowner can install a filtration system, but it may be wisest to enlist the help of a certified plumber or water filtration specialist.

Option 1. Faucet attachments—$20 to $100.
Screw-on faucet type water filters like Brita or Pur are the least expensive treatment options and can remove small quantities of iron from drinking water. But in cases where larger amounts of iron deposits are present, the filters will clog rapidly and the unit will cease to be cost effective. These filtration units cannot prevent iron from reaching other areas in your house.

Option 2. Aeration with filtration—$200 and up
This method is effective with iron concentrations that do not exceed 25 mg/L. Aeration mixes oxygen-rich air with untreated water and converts soluble iron to its insoluble form, which is then filtered. This method is not effective on organic iron or iron bacteria, which can clog filters and screens. This method also requires continuous backwashing to remove the accumulated iron. Ozonation is a specialized form of aeration using ozone to convert soluble iron. This process can be very expensive, starting at around $1000.00. Catalytic Filtration ("BIRM") is a granular filter medium that enhances the reaction between oxygen and iron and then filters the insoluble iron. Catalytic filtration starts at around $500.00.

Option 3. Ion exchange/water softeners —$200 and up
A water-softening system can be efficient in removing low concentrations of dissolved iron of less than 5 mg/L. This is simply a process of exchanging iron particles with sodium or potassium ions. Because water softeners add sodium to the water, it is not a practical water treatment option for those who are concerned with sodium intake. Also, this process is not effective on organic iron.

Option 4. Phosphate treatments—$300 and up
The phosphate process is an inexpensive treatment that can be used to treat iron concentrations up to 3 mg/L. Phosphate compounds encircle iron minerals and prevent them from falling out of solution. The dissolved iron will always be present in the water; therefore drinking water will still have a metallic taste. Phosphate compounds also increase the amount of nutrient levels in surface waters.

Option 5. Chemical oxidation with filtration—$500 and up
This process effectively treats iron concentrations up to 10 mg/L and involves the use of chemicals such as chlorine, potassium permanganate, or hydrogen perox-

ide to oxidize the dissolved iron. Filters are then used to remove the particles from the treated water. Chemical oxidation does require that chemicals are transported, handled, and stored with care.

Option 6. Oxidizing filters (manganese greensand)—$500 and up
This type of treatment system is ideal for lower flow-rate systems and is effective in treating dissolved iron at concentrations up to 15 mg/L. These high levels of iron can be treated with an ion exchange sand material such as manganese greensand, which is capable of removing 99 percent of the iron. After the iron is trapped on the greensand it is then washed off. Although chemical regeneration is often needed, this method works well when concentrations are less than 15 mg/L with pH levels greater than 7.5.

Option 7. Well reconstruction—can be thousands of dollars
One alternative in solving an iron problem may be to construct a new water well, or to extend the well screen deeper into the groundwater. While this may be an expensive alternative costing several thousands of dollars, the long-term cost could be lower than continuous water treatment. Refer to local yellow pages for a licensed and bonded well-drilling specialist.

Background—how iron gets into drinking water

Rainwater percolating through soil and rock dissolves minerals containing iron and hold them in solution. The water's hardness and acidity influence the amount of iron that will dissolve during the percolation process. These iron-rich waters recharge surface waters and aquifers that inevitably serve as drinking water sources. Although present in most drinking water at some level, iron is hardly ever found at concentrations greater than 10 parts per million. Often, corrosion also can be a source of iron in drinking water. Iron contamination as a result of corroded pipes is a common occurrence in many cities that have very old water systems.

Iron (Fe) is a metallic element that makes up about 5 percent of the Earth's crust. The only elements more plentiful are oxygen at 47 percent, silicon at 28 percent, and aluminum at 8 percent. In its pure form, iron is a dark-gray metal, but it is exclusively found in combination with other elements called ores. The most common iron-containing ores are hematite, magnetite, and taconite. When in the presence of oxygen, iron is a reactive element that oxidizes (rusts) very easily. The red, orange, and yellow colors visible in many soils and rocks all over the world are usually iron-oxides.

Table 1: Identify iron-in-water problem before seeking the best solution.

Problem	Cause	Treatment Options
Water is clear when exiting the tap but if allowed to sit, reddish brown particles begin to form and settle to the bottom.	Dissolved ferrous iron	For iron concentrations of less than 3mg/L, use phosphate compounds. Options 4,7 For iron concentrations less than 5 mg/L, use water softeners. Option 3,7
Red, brown, or black stains on laundry and/or plumbing fixtures.	Can be the result of any of the four different types of iron found in drinking water.	For concentrations up to 10 mg/L, use chemical oxidation with potassium permanganate or chlorine followed by filtration. Options 5,7 For concentrations less than 15 mg/L, use an oxidizing filter, such as manganese greensand. Options 6,7 For concentrations less than 25 mg/L, use pressure aeration. Options 2,7
Water contains red, brown, or black particles directly out of the tap.	Corrosion of plumbing system pipes. Or, ferrous iron that has been exposed to the atmosphere prior to exiting the tap.	Use a neutralizing filter, particle filter, or sand filter and increase the pH. Options 2 to 7
Reddish-brown or black sludge in toilet tanks or faucets.	Iron bacteria.	Shock treatment with chlorine, continuous feed of chlorine, followed by filtration. Options 5,7
Reddish-brown, black, or yellow color that does not settle out after a period of 24 hours.	Organic iron.	Chemical oxidation with chlorine followed by filtration. Options 5,7

Summary

Iron is present in drinking water as a result of natural earth processes or corroded pipes. It is considered a secondary household water contaminant with no known health related issues at concentrations normally found in household drinking water. Indications of iron in drinking water include the staining of plumbing fixtures and clothing, as well as an unpleasant taste and odor. Iron can be present in drinking water in several different forms; therefore, testing of the water supply is essential before choosing water treatment equipment. No treatment methods will work on all four forms of iron. Treating water that has been contaminated with iron can be an expensive process, so it is important to get help from a certified professional.

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20 Iron Facts

In nature

1. When in the presence of oxygen, iron is a reactive element that oxidizes (rusts) very easily.
2. The reds, oranges and yellows that we see in many soils and rocks all over the world are usually iron oxides.

In water supplies

3. Rainwater percolating through soil and rock can dissolve minerals containing iron, ultimately contaminating all drinking water supplies.
4. Iron contamination from corroded pipes is a common occurrence in many North American cities, especially where aging water systems are more than 100 years old.
5. Iron is found in four different forms: ferric, ferrous, bacterial, and organic.
6. Ferrous ("clear-water") iron is the most common form and results in the most complaints by water users.
7. When insoluble ferric ("red-water") iron is poured into a glass, it appears rusty or has a red or yellow color.
8. Water's hardness and acidity largely determine how much iron dissolves in it.
9. Iron bacteria can clog water systems, plug filters, or envelop pump screens, which can result in large repair bills.

Amounts

10. The present EPA Maximum Contaminant Level for iron in water, 0.3 mg/L (ppm), is based on taste and appearance rather than on any detrimental health effect.
11. When iron in water exceeds the 0.3 mg/L limit, red, brown, or yellow staining of laundry, glassware, dishes, and plumbing fixtures occurs.
12. Although present in most drinking water, iron is hardly ever found at concentrations greater than 10 parts per million.

Health

13. Iron is not known to be hazardous to health. It is considered a secondary—or aesthetic— contaminant.
14. Small concentrations of iron are vital to human health. It helps transport oxygen in the blood.
15. Most water systems in the United States supply approximately 5 percent of the dietary requirement for iron.

Aesthetics

16. Hydrogen sulfide gas, a frequent derivative of iron bacteria, gives water a distinct rotten egg odor.
17. Iron stains on laundry can be exaggerated with the addition of alkaline cleaners or chlorine bleach.
18. When iron blends with tea, coffee, or alcoholic beverages, it takes on a black appearance with an unpleasant taste.
19. Vegetables cooked in iron-contaminated water will turn dark and unappealing.

Best treatments

20. A common mistake made by homeowners is selecting the wrong type of treatment. No one treatment method will work on all four forms of iron.

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