Iron and Manganese

Iron is a highly objectionable constituent of water supplies for wither domestic or industrial use. Manganese is similar in it adverse effects. In concentrations normally found in ground water, iron and manganese are not considered to be health risks but the metals create significant economic and aesthetic problems in high concentrations. Iron is seldom found in levels above 1 mg/l in surface waters; however, ground waters and acid surface drainage may contain considerable more iron. "Standard Methods" notes that under reducing conditions, iron exists in the ferrous state. In the absence of complex-forming ions, ferric iron is not significantly soluble unless the pH of the water is low. Upon exposure to air or addition of oxidants, ferrous iron is oxidized to the ferric state and may hydrolyze to form insoluble hydrated ferric acid. It should be note that this is the predominant form of iron found in most laboratory samples unless the samples are collected under anoxic conditions to avoid oxidation. The form of iron can also be altered by bacterial growth. Iron may be in true solution in a colloidal state, in inorganic or organic iron complexes or relatively coarse suspended particles. It may be either ferrous or ferric and suspended or filterable. Iron oxide particles are sometimes collected in the water sample as a result of rust in the distribution system. Iron may come from the metal cap of a glass sample bottle. It is important that any sampling or analysis of iron be conducted in accordance with standard procedures.

Iron may impart brownish staining to laundry and, in high concentration, it has a bitter taste and may adversely affect the taste of beverages made from iron laden water. Adverse impact is, therefore, aesthetic and economic. The U.S. Public Health Service and EPA have recommended a limit of 0.3 mg/l for treated water which is delivered to the consumer. While this is an arbitrary level and complaints may be received regarding lower levels, the above limit seems to have been useful in practice. Iron can be removed by the conventional sodium ion exchange process and also by oxidation processes followed by filtration. Iron from corrosion of iron or steel piping can be controlled. The removal of iron is complicated by other chemicals in ground water and is especially difficult to treat effectively in ground waters containing manganese or chelated by tannin and other organic compounds.

While low levels of iron are fairly easily treated, the higher levels are difficult to treat and care must be taken in generalizing with the complexity of ground water chemistry affecting iron removal processes. With higher concentrations of iron or manganese, approval must include requirements for complete disclosure, including concentration, effect, impact, and treatment. Treatment needs to be proven by bench tests and cost analysis to show feasibility and economics.

Manganese is much less abundant in rocks than iron, and oxidation reactions are much slower than with iron. Consequently, the concentration of manganese in natural waters is generally less than that of iron. The recommended limit is 0.05 mg/l.

Manganese occurs in more than one oxidation state and the oxidation states to be expected are divalent and quadrivalent. It also occurs in more highly oxidized states, but not normally in natural waters. Under reducing conditions in water containing carbon dioxide, it goes into solution as manganous ion. Total manganese and dissolved manganese are reported separately and the difference between the two is less significant than for iron, but the same problem remains with determining actual aquifer conditions. Toal manganese values are better determinations. Magnanese does not have adverse health effects in the concentrations naturally found in ground water. In fact, there is evidence that a limited amount of manganese is required in the diet.

Manganese, like iron, produces discoloration in laundry and impairs taste in drinking water and beverages. Literature also notes that household bleaches can oxidize iron and manganese to insoluble states to aggravate the staining problems in laundry.

There is very little data available on treatment which would be suitable for individual small water systems or how it is affected by variations in ground water chemistry. Polyphosphates or silicates also are applied to sequester low concentrations of maganese, similar to iron. Limitations are the same as for iron.

Manganese problems can be aggravated and treatment can be inhibited with formation of complexes with tannins or by interference from manganese bacteria. Manganese can usually be removed from water by the same processes used for iron.

At higher concentrations of manganese, special means of removal are often necessary for treatment such as chemical precipitation, pH adjustment, aeration, superchlorination, and the use of special ion exchange materials. At lower levels, it is frequently claimed that softeners will remove small amounts of iron and manganese along with hardness. The iron, manganese and hardness are disposed of by wasting the water when the softener is regenerated. The softener will also filter some manganese precipitate; however, it gradually plugs the bed. Low level fouling is supposedly retarded in the media with special cleaning chemicals. Softeners and oxidation filters are not effective if iron or manganese are bound into organic matters, if iron or manganese bacteria are present, or at higher concentrations.

As with iron, water supply approval should require disclosure of quality, concentration, effect, impact, and treatment. Treatment claims need to be supported by sampling and analysis, bench tests, and cost analysis for economic feasibility.

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Quality (1)	Concentration (2)	Effect* (3)	Significance (4)	Treatment** (5)	Disclosure
Good	Fe < 0.3 mg/l and Mn <0.05 mg/l	Below recommended limits of 0.3 mg/l and 0.05 mg/l	None	Treatment may be desirable, depending on individual tolerance	1, 2, 3
Marginal	Fe + Mn 0.3 to 3 mg/l and/or Mn > 0.05 mg/l	Above recommended limit. Red, brown, or black staining of pipes, fixtures, laundry and any contact surfaces. Color, turbidity, taste and odor problems may occur. Pipe plugging is possible in higher part of range.	Not a public health problem Considered aesthetically objectionable and a nuisance problem, if not reduced to acceptable levels by treatment. Affects appearance of food, plumbing, fixtures, and laundry. Is an economic problem because of treatment costs and/or plumbing system maintenance costs.	Treatment is normally necessary for aesthetic purposes. Treatment is possible and economically feasible at the low end of the range. At the high end of the range or if tannins are present, special treatment measures may be required which may not be economically feasible for private water system. Requires sampling, treatment demonstration, and cost analysis of treatment.	1, 2, 3, 4, 5
Poor	Fe + Mn > mg/l and/or Mn > 0.1 mg/l	Above recommended limit. Severe brown to black staining of pipes, fixtures, laundry, and any contact surfaces. Severe color, taste, and odor problems.	Not a public health problem Aesthetically objectionable and a severe nuisance problem. Can have adverse effects on plumbing, fixtures, food and laundry if not reduced to acceptable levels by treatment. Water is generally not usable without costly treatment.	Treatment is ESSENTIAL for most household uses, but may not be effective or economically feasible on private water systems. Requires sampling and demonstration of effectiveness by bench test and treatment cost analysis. Presence of tannin requires unusual treatment measures.	1, 2, 3, 4, 5

*Concentrations of iron and manganese normally found in ground water are not a health hazard, but may be aesthetically objectionable and may cause economic problems because of plumbing deterioration and/or treatment needed.

**Variations in ground water chemistry are complex and other constituents can drastically affect treatment. Efficacy of treatment must be demonstrated by scientific methods in accordance with standard procedures for analysis and bench tests.