Iron and Manganese in Private Water Systems

Iron and manganese cause stains and tastes in water. They can be removed with several treatment processes described in this article.

Sources of Iron and Manganese

Natural sources of iron and manganese are more common in deeper wells where the water has been in contact with rock for a longer time. In coal mining regions of the state, these metals may also occur from both deep and surface mining activities. Iron and manganese often occur together in groundwater but manganese usually occurs in much lower concentrations than iron.

Both iron and manganese are readily apparent in drinking water supplies. Both impart a strong metallic taste to the water and both cause staining. Water coming from wells and springs with high iron and/or manganese may appear colorless initially but orange-brown (iron) or black (manganese) stains or particles quickly appear as the water is exposed to oxygen (see Water Testing).

Although iron and manganese can occur in wells and springs throughout Pennsylvania, they are most common in northern and western counties. A survey by Penn State found excessive iron concentrations in 17% of the private water supplies sampled in the state.

Drinking Water Standards

Iron and manganese are not health concerns in drinking water. Instead, they both have secondary or recommended drinking water standards because they cause aesthetic problems that make the water undesirable to use in the home and a bitter metallic taste that can make the water unpleasant to drink for both humans and farm animals.

Iron can also cause an orange or brown stain in sinks and in the laundry. Manganese often results in a dense black stain or solid. For these reasons, it is recommended that drinking water have no more than 0.3 mg/L (or 0.3 parts per million) of iron and less than 0.05 mg/L of manganese.

The U.S. Environmental Protection Agency has also set a Health Advisory for manganese of 0.3 mg/L. A Health Advisory is a non-enforceable drinking water standard which is meant to alert consumers to possible health effects from a drinking water constituent. The 0.3 mg/L Health Advisory for manganese was created due to concerns about various neurological health effects from regularly consuming water above 0.3 mg/L.

Remember that private water systems serving individual homes are not subject to state or federal drinking water standards. Thus, these standards only provide guidelines for the proper management of these types of water supplies.

Water Testing

The presence of stains, particulates, and metallic taste often make it obvious that iron and manganese are present in a water supply even without water testing. Still, it is a good idea to have your water tested to determine the exact concentration of each of these metals. The concentration will determine the most practical and economical water treatment options to solve the problem.

In addition to the concentration, it is also important to determine the form of the iron and manganese. If water collected from the well or spring is initially clear but then forms orange-brown or black solid particles over time, the iron and manganese are dissolved in the water. This is known as the "reduced" form of these metals. Dissolved or reduced iron and manganese are most common in groundwater with a pH less than 7.0.

Sometimes, solid particles of iron and manganese will be apparent immediately in water from the well or spring. In this case, the metals are already in the oxidized form. This is more common in higher pH water supplies or where oxygen is readily available to the water, such as a shallow spring.

If you notice orange-brown or black stains with your water or a metallic taste, you should arrange to have your water tested for iron and/or manganese. Iron and manganese are common water pollutants that can be tested by many commercial laboratories in Pennsylvania. Have your water thoroughly tested at a DEP-accredited lab to make an overall treatment plan; see Water Testing for more information.

Removing Iron and Manganese from Water

Iron and manganese can be effectively removed from water using a number of treatment processes depending on both the form and concentration of the metals. Since iron and manganese are aesthetic problems that affect all potential uses of the water, they must be removed from all water entering the home using Point-of-Entry (POE) treatment devices.

When multiple treatment processes are applicable to your problem, make sure you shop around and compare treatment units and prices among several reputable dealers that carry a variety of treatment devices. Be sure to understand the maintenance requirements for each unit and get a written warranty for any device you decide to purchase. See Tips for Buying Water Treatment Equipment for more guidance.

Water Softening (Ion Exchange)

Conventional water softeners are sometimes effective for removing iron and small amounts of manganese. Water softeners are typically used to remove calcium and magnesium hardness in water by an exchange process. The calcium and magnesium are removed from the water and sodium is added in their place. Iron and manganese removal is accomplished in the same way by exchanging the iron and manganese for sodium. The iron and manganese are then removed from the softener resin bed through backwashing and regeneration.

Removal efficiencies by softeners will vary depending on the iron concentration, water hardness and pH. Softeners are generally only recommended when the water pH is greater than 6.7, the water hardness is between 3 and 20 grains per gallon (50- 350 mg/L) and the dissolved iron concentration is less than 5 mg/L.

Oxidized forms of iron and manganese will foul the softener resin. Thus, it is critical that the raw water not come in contact with any oxidizing agents like air or chlorine before entering the softener. Using the softener resin bed as a mechanical filter for oxidized iron and manganese is generally not recommended. This could damage the resin bed and require much more frequent backwashing. If oxidized iron and/or manganese are present in the raw water, filtration should be used for removal.

Additional information about softeners and their maintenance is available in the article on Water Softening.

Polyphosphate Addition

Water containing dissolved iron concentrations less than 2 mg/L may be treated using polyphosphate addition. Phosphate addition is generally ineffective in treating manganese. The phosphate is fed into the water using a chemical feed pump that often requires trial and error dose adjustments. In this case, the iron is surrounded or "sequestered" by the phosphate and is not actually removed from the water.

There are some major drawbacks to this process. Although the sequestered iron will not cause objectionable stains, it will still give the water a metallic taste. In addition, if too much phosphate is added to the water, it will give the water a slippery feeling and it may also cause diarrhea. The polyphosphate may also be degraded in a water heater resulting in release of sequestered iron.

Oxidizing Filters

Oxidizing filters both oxidize and filter iron and manganese in one unit. The filter is usually comprised of manganese treated greensand although other materials such as birm can also be used. In the case of a manganese greensand filter, the filter media is treated with potassium permanganate to form a coating that oxidizes the dissolved iron and manganese and then filters them out of the water. Because these units combine oxidation and filtration, they can be used to treat raw water with dissolved and/or oxidized iron and manganese.

Manganese greensand filters require significant maintenance including frequent regeneration with a potassium permanganate solution as it is consumed during oxidation of the dissolved metals. In addition, these units require regular backwashing to remove the oxidized iron and manganese particles. The potassium permanganate solution used for regeneration is toxic and must be handled and stored carefully using specific safety measures.

When properly maintained manganese greensand filters are extremely efficient for moderate levels of both dissolved and oxidized iron and manganese. They are generally recommended when the combined iron and manganese concentration is in the range of 3 to 10 mg/L. Keep in mind that the frequency of maintenance (backwashing and regeneration) will increase as the metals concentration increases.

Birm filters are similar to manganese greensand but they do not require regeneration because they utilize oxygen present in the raw water to oxidize the metals. As a result, the raw water must contain a certain amount of dissolved oxygen and the pH should be at least 6.8 for iron removal and 7.5 for manganese removal. Even under ideal conditions, manganese removal efficiency is highly variable with birm filters. Birm filters do require backwashing to remove accumulated oxidized metal particles.

Oxidation Followed by Filtration

When combined levels of iron and manganese exceed 10 mg/L, the most effective treatment involves oxidation followed by filtration. In this process, a chemical is added to convert any dissolved iron and manganese into the solid, oxidized forms that can then be easily filtered from the water. Chlorine is most commonly used as the oxidant although potassium permanganate and hydrogen peroxide can also be used. A small chemical feed pump is used to feed the chlorine (usually sodium hypochlorite) solution into the water upstream from a mixing tank or coil of plastic pipe. The mixing tank or pipe coil is necessary to provide contact time for the iron and manganese precipitates to form. It may be necessary to install an activated carbon filter to remove the objectionable taste and odor from the residual chlorine. Chlorine is not recommended as an oxidant for very high manganese levels because a very high pH is necessary to completely oxidize the manganese.

Significant system maintenance is required with these units. Solution tanks must be routinely refilled and mechanical filters need to be backwashed to remove accumulated iron and manganese particles. If a carbon filter is also installed, the carbon would need to be replaced occasionally as it becomes exhausted. The frequency of maintenance is primarily determined by the concentration of the metals in the raw water and the amount of water used.

Other Treatment Methods

The methods described above are the most common processes for removing iron and manganese but others like aeration, ozonation, and catalytic carbon may also be effective. While these units may successfully treat iron and/or manganese, their cost should be carefully compared with more traditional treatment methods and, as always, you should obtain a written guarantee of their effectiveness.

Aeration units may work by cascading, bubbling, or stripping the gas from the water. Aeration may be advantageous because it does not add chemicals to the water. Maintenance costs are low for aeration units but the initial purchase costs are often higher than other treatment options. Aeration units also require a filter for removal of the oxidized iron and manganese which must be backwashed. The water should also be disinfected to keep bacteria from colonizing the aerator.

Catalytic carbon adsorbs then oxidizes and filters dissolved iron in one unit. It is effective for concentrations of dissolved iron less then 1.0 mg/L. Maintenance requirements are less than oxidizing filters because no chemicals are added, but backwashing is still necessary. Catalytic carbon requires a minimum of 4.0 mg/L of dissolved oxygen in the source water. Some groundwater supplies may need pretreatment to increase the dissolved oxygen concentration.

In recent years, ozonation has received more attention as a method for treating numerous water quality problems. Like chlorine, ozone is a strong oxidant but it is a much more unstable gas that must be generated on-site using electricity. Once the ozone is produced, it is injected into the water where it oxides dissolved metals which must then be filtered. Ozone units are usually more expensive than other more conventional treatment options but they may be useful where multiple water quality problems must be treated (i.e. bacteria and metals).

Other Options for Avoiding Iron and Manganese

While treatment devices are available to reduce iron and manganese from water, other options should not be overlooked. In some cases, a municipal water supply line may be nearby. Hooking into a municipal water supply may seem expensive initially but it may be economically preferable given the long-term costs and hassles associated with purchasing and maintaining a water treatment device. Hooking into a municipal water supply will also usually increase the real estate value of your home.

Another option may be to develop an alternate private water supply. Other sources of water like a shallow groundwater spring or a rainwater cistern could be developed to avoid iron and manganese but they may both present other water quality and quantity problems. Alternative sources of water should be thoroughly investigated along with treatment options when choosing a strategy to avoid iron and manganese in water.

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