

How To Operate and Maintain Manganese Greensand Treatment Units



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Recently, I had the opportunity to provide onsite technical assistance to a small elementary school. On my initial visit, I encountered a sign in large, block letters saying, "DO NOT DRINK THE WATER." The 177 students and 28 faculty members were using bottled water for drinking, signs were posted everywhere warning about the water, and a local TV crew was on the way. Although the school had its own water treatment system, poor water quality forced the state health department to issue a "boil water" order. This was not a good situation, particularly for an elementary school.

This school was built outside an area served by municipal drinking water. Drilling a well and installing a greensand treatment process was the only alternative to assure a sufficient supply of safe water. The treatment process consisted of three cylindrical units, 14 inches in diameter and 65 inches in height. Each fiberglass unit contained 40 pounds of support gravel and 3.25 cubic feet of manganese greensand, which was being regenerated during backwash with potassium permanganate. A 300-gallon galvanized tank provided chlorine contact time. Soda ash for pH adjustment and calcium hypochlorite for disinfection completed the chemical treatment. At times, they were able to obtain a trace chlorine residual throughout the school. This was the exception, however, and the water was usually discolored, with an objectionable taste and odor, and had the ability to stain anything it contacted.

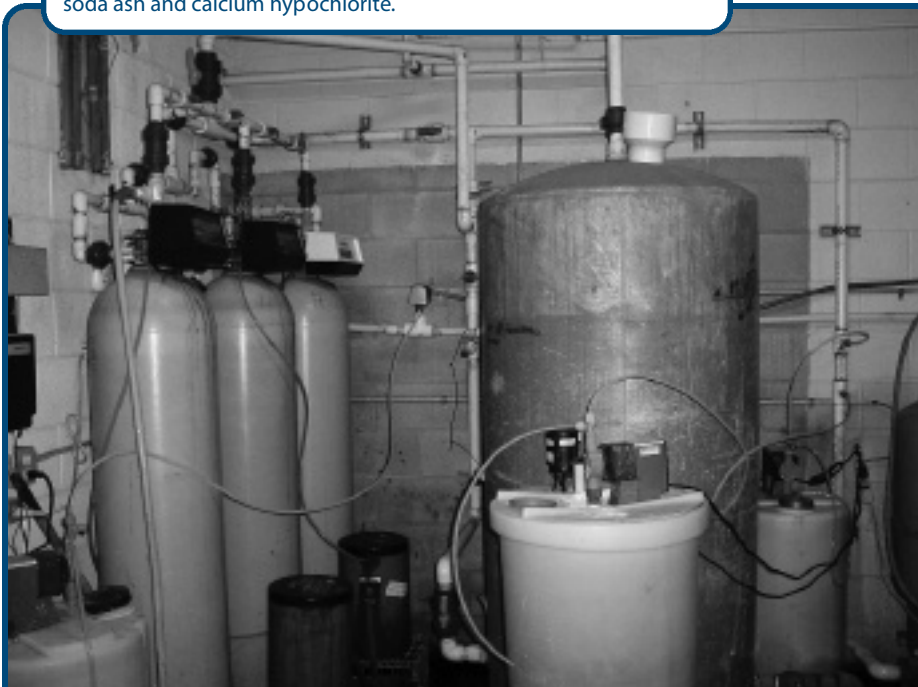
Poor Water Was One Challenge

The school's raw water quality would cause problems even for a larger, more sophisticated treatment plant. An onsite analysis showed 16.3 parts per million (ppm) of iron, 1.19 ppm manganese and a 6.5 pH. There was also a small amount of hydrogen sulfide present. Each of the

three treatment units had approximately one square foot of surface area for a total surface area of three square feet, and the pump was producing 21 gallons per minute (gpm). One unit was on stand-by, causing surface loading greater than 10 gallons per minute per square foot (gpm/sq. ft) on the other two. At some point, an attempt to convert the chlorine contact tank into a pre-treatment basin had only made the problems worse.

I will be the first to admit that, for many years, I paid little attention to these small treatment units. The size and design just did not look like serious water treatment to me. However, the more I learned about them, the more I realized they required the same operation, maintenance, water treatment knowledge, and experience as units many times their size.

The three upright cylinders on the left in this photo are the filters containing greensand and gravel. The large tank at right center is the chlorine contact tank where the filtered water is contained for a specific amount of time to allow for disinfection. The other tanks contain soda ash and calcium hypochlorite.



Manganese Greensand

The manganese greensand process has been used effectively for removing iron, manganese, and hydrogen sulfide since the 1950s in the U. S. Manganese greensand is processed from what is commonly known as “New Jersey greensand,” but is more correctly identified as glauconite. For iron and manganese removal, the naturally occurring singular grains of glauconite are washed and classified to produce a filtration media having a sieve analysis of 18 x 60 mesh with a resulting effective size of 0.3–0.35 millimeters (mm) and a uniformity coefficient of 1.60 or less, giving the media excellent filtration characteristics.

The glauconite is first stabilized then coated with manganese oxide. This coating provides the glauconite with its special chemical oxidation-reduction properties for the removal of iron and manganese, as well as small quantities of hydrogen sulfide.

The greensand process for removing iron and manganese is usually accomplished using one of two procedures: continuous regeneration (CR) or intermittent regeneration (IR), or, in some cases, both.



Three slightly larger greensand units located at Douthat State Park, Virginia.

Continuous Regeneration (CR)

CR is primarily used when iron removal is the main objective. The CR method is exactly what the name implies, continuously feeding an oxidizer, such as chlorine, potassium permanganate (KMnO_4), or a combination of the two, into the raw water prior to the filter. This process can remove 15 milligrams per liter (mg/L) or more of soluble iron. However, with high concentrations, the flow rate through the filter must be reduced to 1.5–2.5 gpm/sq. ft. At these higher concentrations, the filter runs can also be reduced to as little as four to six hours. Waters having iron concentrations in the lower range of 0.5–3.0 mg/L could expect filter runs of 18 to 36 hours at a higher flow rate of 3–5 gpm/sq. ft. If high concentrations of iron are being oxidized prior to the filter, capping the filter with anthracite to a depth of 18 inches or greater will increase run times.

Filters removing large amounts of particulate matter, such as oxidized iron, benefit greatly from the addition of several inches of anthracite as a cap. Anthracite is less dense than greensand or normal filter sand, allowing particles to penetrate deeper before being trapped. In fact, if the main consideration is removing oxidized iron, the greensand layer itself may be reduced slightly to allow for the addition of a full 18 inches of anthracite. Larger greensand units that have a trained operator present may use KMnO_4 in addition to chlorine, in the CR method.

If both iron and manganese are present, chlorine should be injected into the raw water first, followed by KMnO_4 . These feed points should be spaced to allow the chlorine—the cheaper of the two chemicals—time to oxidize



This photo shows a typical setup to feed potassium permanganate consisting of a tank, mixer and feed pump.

as much iron as possible before the KMnO_4 is injected. The KMnO_4 will then oxidize the manganese as well as any remaining soluble iron. The accepted procedure is to carry a slight excess of permanganate onto the filter. Manganese greensand will reduce the excess permanganate to manganese oxide. The manganese oxide will then precipitate on the grains of media, maintaining them in a continually regenerated state. When using this process for filter regeneration, a thin line exists between regeneration and break-through. For this reason, smaller treatment units, specifically those without full-time operators, should consider the CR process using only chlorine as the pre-oxidant.

All new greensand must be fully regenerated prior to placing it into service. This procedure is printed on each bag of greensand and consists of soaking the media for several hours in a 2–3 percent solution of KMnO_4 . The procedure that I have used for years consists of thoroughly mixing one pound of KMnO_4 to five gallons of water, applying the solution to the filter until the media is covered, then allow to “marinate” overnight. The following morning, the filter is backwashed until no permanganate remains in the wash water, then placed into service. From this point on, maintaining free chlorine residual greater than 0.5 at the filter effluent will insure the media retains the all-important manganese oxide coating. Because the school already had intermittent regeneration equipment in place, we decided to combine the CR with IR.

Intermittent Regeneration (IR)

IR is normally used when the problem is mostly manganese with lesser quantities of iron.

In this process, manganese oxidation occurs directly using the properties of the freshly regenerated manganese greensand. After treating a specific amount of water, the oxidation capacity of the media will be consumed and regeneration is required. Following a normal backwash cycle, the bed is regenerated by the down-flow passage of a dilute KMnO_4 solution through the filter bed using 1.5 ounces of KMnO_4 per cubic foot of media. This solution is allowed to remain in contact with the media for several minutes. Following regeneration, the filter will require rinsing until all the excess permanganate is gone. The rinse water containing the excess permanganate can be directed to a container for use in the next regeneration. This method minimizes permanganate disposal problems and reduces chemical costs. One drawback in the IR process is the extra time the filter is out of service for backwashing. The CR process requires approximately 15 minutes for backwashing and rinsing, rather than a complete regeneration required for the IR process (usually 75 minutes).

For operations using sodium hydroxide as a pH adjustment, along with the CR process, the pre-pH correction should not exceed 6.8–7.0 to prevent the formation of a non-filterable colloid, which sometimes occurs.



The Norton, Harding, Jimtown (West Virginia) PSD serves approximately 1,000 customers in two communities. On the right is a greensand filter and a carbon filter, used for low levels of phenols in the raw water, is on the left. This plant has two additional greensand filters that remove 3.3 mg/L iron and 0.4 mg/L manganese at a pH of 6.5.

Backwash Rates

The recommend backwash rate for manganese greensand is 12 gpm/sq. ft. of filter area at 60 degrees Fahrenheit. This rate is sufficient to expand the bed 35–40 percent. Please note that backwash rates versus filter loading rates can cause serious problems in smaller treatment units. For example, a small installation with one 12-inch inside diameter filter, will require the well pump to deliver 12 gpm to properly backwash. However, if high levels of iron are present, that same unit may only be capable of filtering 2 gpm.

Minimum Bed Depth

The minimum depth of the greensand bed is 24–30 inches when using the IR method and 18–20 inches when using the CR method. If you are removing large amounts of pre-oxidized iron, reducing the depth of the greensand will allow for a deeper cap of anthracite. Before changing the configuration of any filter bed, contact your supplier or the manufacturer.

Removing Iron and Manganese

Even with small treatment units, removing iron and manganese requires knowledge, skill, and occasional access to a few simple pieces of lab equipment—no matter what the sales representative told you. A certified laboratory must perform the initial analysis for any new water supply. If the lab determines minimal or no treatment is necessary, sending an occasional sample to the same lab will make certain that changes have not taken place.

If, on the other hand, iron, manganese, hydrogen sulfide, etc., are present, and you spend the money for a treatment unit to remove them, then protect your investment and learn to operate it properly. Simple lab tests designed for small operations on a tight budget can check levels of iron, manganese, chlorine, pH, and any number of other parameters on site.

If you are using the treatment unit in a school, restaurant, or other situation where your liability is increased, I would invest in some simple equipment. The lab equipment that I rely on more than any other when working in well supplies both large and small, is a filter flask, a hand vacuum pump, and a package of 0.22 micron filters. When analyzing samples for iron and/or manganese content, always perform two separate analyses, one before filtering and one after. Many of the less sophisticated tests used to determine iron and manganese levels measure total concentrations, both soluble and insoluble.

When measuring levels of a specific inorganic in raw water, it is important to know what amount, if any, is already insoluble so you can accurately oxidize what remains. If the finished water has objectionable levels of iron or manganese, it is important to know whether the problem is caused by incomplete oxidation or particles of oxidized material that have passed through the filter.

Pressure gauges must be installed on the raw water line before it enters the filter (influent) and on the finished water line as it leaves the filter (effluent). Following a backwash, when the filter is clean, the two gauges should have approximately the same pounds per square inch (psi) reading.

As the filter begins to collect oxidized material, you will begin to see a pressure differential between the two. The more iron and manganese in the raw water reaching the filter, the quicker this pressure differential will occur. This is

called "loss of head" and indicates the filter is becoming dirty. When the pressure difference between the two gauges reaches 8–9 psi, the filter needs backwashing.

Failure to backwash a dirty filter can force iron or manganese, either in the soluble or insoluble state, through the filter just like toothpaste being squirted from its tube. In some instances, the precipitated iron is of such a nature that it filters in depth and leaks into the effluent, even after a 2–5 psi differential pressure increase. In this case, backwashing should be initiated on a gallons-treated basis using experience.

Back to School

What happened at the elementary school that was the seed for this article? Luckily, everyone from the county board of education to the school's maintenance people was willing to do whatever it took to fix the problem.

At this school, the design required that the treatment process meet the high periodic demand for water. Because of the demand, reducing the flow rate was not an option. Instead, we installed three additional treatment units, bringing the total to six. Each unit was fitted with an orifice plate that reduced the influent rate to 2.5 gpm. This provided a combined filter capacity of 15 gpm. All six filter beds were then rebuilt using manufacturer's specifications and properly regenerated with potassium permanganate.

Because of the high levels of both iron and manganese, the decision was made to combine the manufacturer's IR process with CR using pre-chlorine only. We are attempting to maintain a free residual of 1.0 ppm at the filter effluent, which produces an acceptable residual throughout the school.

Pressure gauges were installed on both the influent and effluent lines to measure head loss. The well pump rate was adjusted, a new 300-gallon chlorine contact tank replaced the old one, and lines throughout the school were flushed. Because of the time required to complete an IR backwash cycle, the automatic controls were set to backwash two filters each night. Six weeks into the school year, bacteria samples, as well as overall water quality, has been very acceptable.

Acknowledgement

The author would like to thank Howard Schwartz, lab technician with Hungerford & Terry, Inc., for information used in this article.

Larry Rader has more than 25 years in the water industry. If you have a question for Rader, he can be reached through e-mail at lrader@meer.net.



Invest in Basic Lab Equipment

Perhaps the single factor that contributes most to poor water quality—particularly in smaller treatment facilities—is the lack of minimal basic lab equipment. No operator should be expected to solve a problem unless he or she knows what is actually causing the problem. Although most facilities (even smaller ones) are required to occasionally send samples to a certified lab, this is usually only a one-liter snapshot out of the thousands of gallons that have passed through your treatment process. If you are one of the lucky few with good quality raw water and no complaints, this snapshot may be sufficient. However, for those of us who have listened to the daily complaints, from regulators and customers alike, or have struggled through one problem after another, there is a better way. Hach, LaMotte, and other companies offer low-cost, low-tech equipment to analyze chlorine, iron, manganese, pH, etc. A complete pre-analysis filter kit, containing a hand-operated vacuum pump, filter holder, 0.22 micron filters, and complete instructions is available through Control Equipment Company in Roanoke, Virginia. Call them at (800) 572-3220 or visit their Web site at www.cec-online.com.



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