Well water pollutants

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Common well water contaminants

- The most common contaminants in well water include **iron, Manganese, lead**, **arsenic**, **bacteria**, **volatile organic compounds (VOCs)**, **nitrates**, and **fluoride**. Some of these contaminants are more concerning than others

Iron

Iron is one of the most common contaminants found in well water. It enters groundwater by seeping through the earth's **crust and into soil**, where it can **be dissolved by rainwater**. Iron is also the most common element in the earth's crust, making it particularly troublesome for well owners.

Signs of iron in well water

- **Iron gives water a dark color, foul odor**, and harsh **metallic taste**. It can also leave **red, brown, and orange stains** on appliances and **fixtures, clog pipes**, and **discolor skin, hair, dishes, cookware, and laundry.** The EPA regulates iron as a secondary contaminant. This category refers to contamination that does not **affect a person's health,** but rather the **aesthetic qualities** of water. The EPA standard for iron in drinking water is **0.3 parts per million**, or 300 parts per billion.

Symptoms of iron in well water

- Drinking iron at **extremely high concentrations** can cause side effects, but most levels of iron consumption are **not harmful to the body**. Symptoms of excessive iron consumption include:
- Nausea
- Vomiting
- Diarrhea
- Stomach pain

How to treat iron in well water

- There are three types of iron found in water: **ferric, ferrous, and bacterial iron**. Each of these types requires different treatment, so you will need to **discover which type of iron is contaminating your well before deciding** on a treatment option.

How to treat iron in well water

- **Ferric iron** is iron that is **not completely dissolved in water**. It makes water **appear red or brown** when it comes out of your faucet. This type of iron can be **reduced by a sediment filter or a reverse osmosis (RO) system**. RO systems contain a sediment filter that **eliminates iron before it can damage the RO membrane**, making RO an excellent treatment option for ferric iron.
- **Ferrous iron** is completely **dissolved in water**, It does not change the appearance of running water, but it will turn water a **red or brown color after standing**. The most effective way to remove ferrous iron is with a **water softener**. Water softeners are often **paired with reverse osmosis systems to remove** as much contamination as possible, particularly in well water systems.

How to treat iron in well water

- Bacterial iron is not harmful in itself, but it can create an environment for harmful bacteria to grow. It is normally yellow or brown, but sometimes it does not alter the color of water. The most effective way to remove bacterial iron, as well as any other bacteria, from your well is shock chlorination. This involves adding chlorine to your well to kill any bacteria. This is similar to the process used by city water treatment plants to make water microbiologically safe.

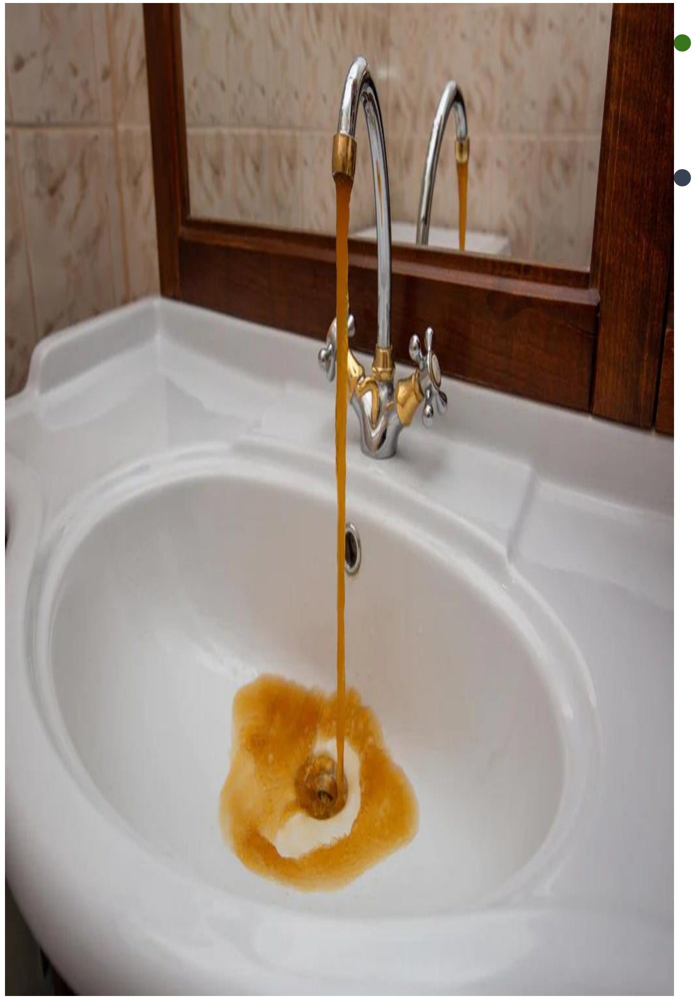
How to treat iron in well water

- Iron primarily enters into your well water **by seeping in from the earth's crust**. Iron is the most abundant mineral in the earth's crust, Heavy rainfall percolating through the soil will dissolve iron, ushering iron **deposits into the underground aquifers**. Making up over 5% of the earth's crust, iron is one of the earth's most common and widespread natural resources

How to treat iron in well water

- Iron can also enter your well water supply from exposure to **rusty, corroded plumbing**. Aged iron pipes and corroded iron fixtures will **leave brown-colored flecks in your water and orange stains on your drains**. Iron casings within your well will begin to rust over time. When iron is exposed to oxygen and water, the iron begins to oxidize and deteriorate. This is because prolonged exposure to the elements causes **iron to break down and convert into rust**. This can be remedied by replacing the pipes running from your well. If your well is old and in disrepair, **drilling a new well altogether can alleviate your iron woes.**

How does iron in water damage your home?



- **Stained appliances**
- Any appliance that is plumbed to your well will become **discolored from exposure to water rich in iron**. **orange streaks will appear in your toilet bowl**. Bright red and yellow trails will appear around the **rim of your sinks and surrounding the drains**. Bathtubs and showers will bear the bright discoloration from iron concentrations in water. Even your dishes and laundry aren’t safe from unsightly **brown and red staining after being washed in water with iron**.

How does iron in water damage your home?

Metallic and discolored water

- Iron leaves water with a bitter **metallic aftertaste** and will **turn water unappetizing colors even in very low concentrations**. Iron also gives water an **unpleasant, sharp odor**. An iron-laden well means the refreshing glass of water you pour from your **kitchen sink may come out brown, orange, red, or yellow**. Furthermore, any beverage made with water (like **tea, espresso, and coffee) will also bear that harsh, metallic aftertaste**. From boiling pasta to steaming vegetables, **any foods cooked in iron-contaminated water will darken and be left with a residual dirty**, earthy flavor. Iron also gives water an **unpleasant, sharp odor**.

How does iron in water damage your home?

Clogged pipes

- As iron residue flows through your pipes, **it can accumulate inside your plumbing and begin to restrict water flow** throughout the house. This will **reduce your home's overall water pressure**, cause your **sinks and toilets to clog**, and diminish performance from your household appliances. **Your showerhead pressure will drop**, leading to an unsatisfying flow of water. **Bacterial iron is particularly nasty and can cause the most serious clogging problems**. **Bacterial iron leaves behind thick brown slime that collects in pipes and can cause erratic water pressure**

How does iron in water damage your home?

Stained skin and hair

- Just like it can leave **stains on your sinks and dishware**, iron's staining properties also **apply to the human body**. Showering in water with high **concentrations of iron will turn your hair orange**, Bathing **in water high in iron can give your skin a reddish tint**.

Manganese greensand

- One of the most popular and effective ways to **eliminate ferrous iron is to convert it to ferric iron and then remove it from the water**. Water treatment systems that use **this tactic are called oxidizing filters**. Manganese greensand is a **powerful oxidizer**. When iron and manganese make contact with the media, they are oxidized out of a dissolved form and turned into **solid particulate matter**. The precipitate ferric iron is **then pulled out of the water by the manganese greensand media** and does not continue on into the house. **Periodically, this media needs to be back-washed by a purple powder called potassium permanganate**. Potassium permanganate both flushes the collected iron flecks down the drain and regenerates the greensand media, restoring its oxidizing capacity. Like any powerful chemical agent, **potassium permanganate can cause skin and eye irritation** and should be handled conscientiously. Manganese greensand is capable of **removing up to 15ppm of iron out of well water.**

Birm

- Birm is another type of oxidizing media used to extract dissolved iron out of well water supplies. Unlike manganese greensand, birm does not require a chemical oxidizing agent to remove the iron. However, birm only works in water **with elevated pH levels**. Therefore, most systems utilizing birm **will combine it with calcite**. Calcite is a **media that elevates the water's pH**, and, in this application, enables the birm media to **effectively oxidize the ferrous iron and remove it from the water**

How do I remove bacterial iron from my well?

- Removing bacterial iron from your well is **a labor-intensive process**, but **one that is well worth it to remove the slimy**, **Shock chlorination introduces an intense concentration of chlorine (around 200ppm)** to a well to thoroughly disinfect both **the water and the physical well itself**. In order to achieve satisfactory results, **the entire depth of the well needs to be exposed to the shock chlorination**. This includes the entire depth of the **well, the walls, the well pump, and the pressure and distribution systems**. Shocking the well eradicates the bacteria binding the iron, allowing you to catch the remaining iron with a softener, oxidizer, or sediment filter. If shocking your well does not adequately eliminate the bacterially bound iron, **then a constant chlorination system may need to be installed after your retention tank**.

Lead

- Lead can make **water appear darker**, or it may not change its appearance at all. Lead-contaminated water may also contain **small particles visible to the naked eye.** Most of the time, however, lead cannot be detected by sight, smell, or taste, so the only way to know if your water **contains lead is by testing**.

Symptoms of lead in well water

- Lead consumption at any level can produce some nasty side effects, including:
- High blood pressure
- Joint and muscle pain
- Headaches
- Birth defects and miscarriage
- Abdominal pain
- Altered brain development in children

How to treat lead in well water

- Lead can be removed from water with either a **reverse osmosis system** or certain types of **activated carbon filters**. If you need to remove lead from your water, ensure that the **activated carbon filter you purchase is certified to remove lead**. These filters are specifically designed to treat lead, and other carbon filters will not reduce lead levels in your water.

Arsenic

- Arsenic is famous for its poisonous reputation, so its presence in water should not be taken lightly. **Arsenic occurs naturally in groundwater and soil** , the likelihood of arsenic levels exceeding the EPA-recommended **10 parts per billion (ppb)** is significant. Arsenic levels below **10 ppb can still cause symptoms over prolonged exposure**, **so all wells should be tested for arsenic contamination at least once**.

Signs of arsenic in well water

- You **cannot see, smell, or taste arsenic in water**. Symptoms often result from exposure to arsenic over a long period of time, so checking your well for arsenic is crucial in preventing these side effects. Vigilantly monitoring your water composition with well **water testing kits** can provide insight into contaminants like arsenic that otherwise may remain undetected.

Symptoms of arsenic consumption

- Arsenic can produce undesirable side effects if consumed in high concentrations or even low concentrations over time. These symptoms include:
- Increased cancer risk
- Thickening and discoloration of the skin
- Nausea
- Vomiting
- Diarrhea
- Blindness

How to treat arsenic in well water

- The best treatment option for removing arsenic before it enters your home is a **reverse osmosis (RO) filtration system.** In addition to reducing arsenic levels in water, RO systems significantly decrease essentially all other contaminants as well.

Bacteria

- Bacteria are the most **important contaminant to remove from your well water because of their immediate effect on the body after consumption**. Not only do they impact the body immediately, **but they can also cause severe symptoms in old and young**
- The most common type of bacteria found in well water is **coliform bacteria**, which can be broken down into the categories **total coliform and fecal coliform**. Total coliform is not dangerous in itself, but its presence may mean that **fecal coliform has contaminated your water supply.** Fecal coliform, whose main species is E. coli, can enter a water supply from **yards, farms, and any other location where animal waste deposits into the ground**. Fecal **coliform can also be introduced by creatures entering the well or a leaking septic system**.

Signs of bacteria in well water

- Bacteria are **often not detectable in water because they are colorless and microscopic**. In most situations, you will not notice bacteria in your water until you get it tested or suffer the side effects of bacteria consumption. To combat bacterial infestation, have your well **checked every six months for the presence of bacteria**. However, due to their exposure to organic material and the elements, most wells require some form of bacteria pretreatment, **like a UV purification system**. This ensures that no matter the conditions, the water you **bring into your home is safe to consume and free from pathogens, viruses, and other harmful bacteria**.

Symptoms of bacteria in well water

- If bacteria reside in your well water, you will likely become ill a few hours to a few days after consuming it. Waterborne illnesses often stem from drinking contaminated well water. The symptoms of these illnesses include:
- Nausea
- Vomiting
- Diarrhea
- Abdominal cramps
- Fever
- Fatigue
- Headaches

How to treat bacteria in well water

- Bacteria in a well can be treated as it **enters your home or in the well itself**. Some filtration systems **deactivate the bacteria, and others remove them from the water entirely.**
- To reduce the levels of bacteria in the water, use an **ultrafiltration or reverse osmosis system**. These should be used as an additional step after **UV purification**
- To treat the well itself, you will need to perform a process **called shock chlorination**. It involves adding chlorine to the water and pumping it **through the system to eliminate the presence of bacteria.**

Volatile organic compounds

- Volatile organic compounds (VOCs) are a common industrial groundwater contaminant . **VOCs reach groundwater through industrial waste, leaks, spills, or improper disposal of items containing these chemicals**. **VOCs easily evaporate into a gas and are dangerous to inhale after they vaporize**.

Signs of VOCs in well water

- **VOCs dissolve in water** and oftentimes **do not alter its color, smell, or taste.** As a result, the only way to discover the presence of VOCs is to have **your well tested**. **A well should be tested for VOCs once every three to five years**, but consider testing more often **if you live near a landfill**. Landfills contain products with VOCs **that can leak these chemicals into groundwater in high concentrations**. If your well water is contaminated with VOCs, **do not cook or drink with the water until the VOCs are treated**. Because they vaporize in the air, **VOCs are particularly harmful when water is boiled and the chemicals are inhaled**

Symptoms of VOC consumption

- Exposure to VOCs can lead to some adverse symptoms, including:
- Damage to the nervous system, liver, and kidneys
- Eye, nose, and throat irritation
- Headaches
- Fatigue
- Vertigo
- Nausea

How to treat VOCs in well water

- **<u>Carbon filters</u> are the most effective treatment option** for removing VOCs from water. However, be sure to check that the carbon filter you are **installing is rated and tested to remove VOCs,** as not all carbon filters are engineered for such purposes. **Reverse osmosis systems with a carbon pre-filter or postfilter will remove VOCs and an abundance of other contaminants as well**. A whole-house reverse osmosis system will protect your water from VOCs, most bacteria, metals, arsenic, and many other contaminants.

Nitrates

- Nitrates are a groundwater contaminant most commonly caused by **agricultural waste. Fertilizer and animal manure are the leading contributors to nitrate contamination**, meaning it is often a more rural issue than an urban one. **Septic system leaks and industrial waste are also contributing factors to nitrate contamination**. The EPA standard for nitrate levels in drinking water is 10 parts per million (ppm), and a well should be tested at least once a year for this contaminant.

Signs of nitrates in well water

- **Nitrate cannot be detected in water by smell, sight, or taste**. Healthy adults oftentimes do not experience side effects from nitrate consumption, so testing your water can protect those vulnerable to the adverse side effects of nitrate contamination.

Symptoms of nitrate consumption

- Nitrates affect **how the blood carries oxygen around the body**. As a result, nitrate consumption is **particularly harmful to young children**, **pregnant women, and the elderly.** The symptoms of drinking water with nitrate contamination include:
- Blue baby syndrome
- Birth defects
- Increased cancer risk
- High heart rate
- Fatigue
- Weakness
- Vertigo

How to treat nitrates in well water

- **Reverse osmosis and ion exchange are the two most effective ways to reduce nitrate levels** . The most common ion exchange systems are water softeners, and they are **often used in conjunction with a reverse osmosis system**. A reverse osmosis system will reduce nitrate levels in your water by about **83 to 92 percent**.

Fluoride

- Fluoride has long been **naturally occurring contaminant in wells.** Fluoride is added to municipal water supplies to **aid oral health**, and it is beneficial when the optimal amount is consumed. **The EPA safe level for fluoride in drinking water is 4 ppm**. Consuming water with more than 4 ppm of fluoride can lead to undesirable symptoms.

Signs of fluoride in well water

- **Fluoride does not affect the taste, smell, or color of water.** This makes it a suitable additive to water at safe levels, **but it also makes it undetectable by the senses at high concentrations.** fluoride levels should be checked **in a well about once every two years**.

Symptoms of fluoride consumption

- While fluoride is good for your oral health, consuming too much can lead to tooth problems and other ill side effects. Symptoms of consuming too much fluoride include:
- Tooth discoloration and decay
- Neurological problems
- High blood pressure
- Skin irritation
- Weakness in the joints
- Increased risk of bone fractures

How to treat fluoride in well water

- The most effective treatment option for removing fluoride is a **reverse osmosis system.** Some other common filtration options, such as **ultrafiltration systems and activated carbon filters, do not remove fluoride.**

Hardness

- Hardness is generally the **amount of dissolved calcium and magnesium in the water**, but it can include other **particles such as iron or manganese**. it can **cause a scale to form that clogs pipes and can make it difficult for soap to lather**. Surrounding geology largely affects water hardness,

Organic materials

- Organic materials are **substances left from once-living organisms.** If wells are left **open, materials like leaves can fall in and affect taste and color.** When **organic materials decompose, they can form a gas called hydrogen sulfide.** This gas **smells like rotten eggs and may stain or corrode pipes and fixtures**.

Manganese

- Manganese is a chemical element that **occurs naturally in soil**. It can dissolve in groundwater and contaminate it. All **living organisms need a small amount of manganese**. Though drinking water sometimes contains manganese, it is mostly found in foods.
- **Change the taste and color of water**
- **Stain clothing and household** appliances washed with the water

Health risks

- Some studies show that manganese may have effects on the **neurological development of children**. However, these studies concern children exposed to water with a concentration of manganese that is a lot higher than **0.02 mg/L**.

Iron and Manganese Removal

What is the chemistry of iron and manganese in water systems?

- Iron (Fe) and manganese (Mn) can be present in water in one of three basic forms:
- 1. Dissolved: ferrous (Fe^{2+}) and manganous (Mn^{2+})
- 2. Particulate: ferric (Fe^{3+}) and manganic (Mn^{4+}) states
- 3. Colloidal: very small particles (difficult to settle and filter).

What is the chemistry of iron and manganese in water systems?

- **The predominance of one form over another is dependent on the pH, and temperature of the water**. Knowledge of the forms or states of iron and manganese can help finetune a given treatment practice for these metals

What are the most common treatment processes?

- The majority of iron and manganese treatment systems employ the **processes of oxidation/ filtration**. The oxidant chemically **oxidizes the iron or manganese (forming a particle**),
- The filter then removes the iron or manganese particles. **Oxidation followed by filtration is a relatively simple process.**
- The source water **must be monitored to determine proper oxidant dosage,** and the treated water should be monitored to determine if the oxidation process was successful

What are the most common treatment processes?

Oxidation

- Before iron and manganese can be filtered, **they need to be oxidized to a state in which they can form insoluble** complexes. Oxidation involves the transfer of electrons from the **iron, manganese, or other chemicals being treated to the oxidizing agent**. Ferrous iron (Fe^{2+}) is oxidized to ferric iron (Fe^{3+}), which readily forms the insoluble iron hydroxide complex $Fe(OH)_3$. Reduced manganese (Mn^{2+}) is oxidized to (Mn^{4+}), which forms insoluble (MnO_2).

What are the most common treatment processes?

- The most common chemical oxidants in water treatment are **chlorine, chlorine dioxide, potassium permanganate, and ozone**. Oxidation using chlorine or **potassium permanganate is frequently applied in small groundwater systems**. The dosing is relatively easy, requires simple equipment, and is fairly inexpensive.
- Chlorination is widely used for oxidation **of divalent iron and manganese**. However, the f**ormation of trihalomethanes (THMs) in highly colored waters may be a problem**. Chlorine **feed rates and contact time requirements can be determined by simple jar tests**.

What are the most common treatment processes?

- As an oxidant, potassium permanganate **($KMnO_4$) is normally more expensive than chlorine and ozone**, but **for iron and manganese removal, it has been reported to be as efficient and it requires considerably less equipment** and capital investment. The dose of potassium permanganate, however, must be carefully controlled. **Too little permanganate will not oxidize all the iron and manganese, and too much will allow permanganate to enter the distribution system and cause a pink color**

What are the most common treatment processes?

Permanganate can also **form precipitates that cause mudball formations on filters**. These are difficult to remove and compromise filter performance

What are the most common treatment processes?

- **Ozone may be used for iron and manganese oxidation**. Ozone may not be **effective for oxidation in the presence of humic or fulvic materials**. If not dosed carefully, ozone can oxidize **reduced manganese to permanganate and result in pink water formation** as well. Manganese dioxide particles, also formed by oxidation of reduced manganese, must be carefully coagulated to ensure their removal.

What are the most common treatment processes?

- A low-cost method of providing oxidation is to **use the oxygen in air as the oxidizing** agent **in a tray aerator**. Water is simply passed down a series of porous trays to provide **contact between air and water**. No chemical dosing is required, which allows for unattended operation. **This method is not effective for water in which the iron is complexed with humic materials or other large organic molecules**. Oxygen is not a strong enough **oxidizing agent to break the strong complexes formed between iron and manganese and large organic molecules**. Furthermore, the **rate of reaction between oxygen and manganese is very slow below pH values of 9.5**. The presence of other oxidizable species in water hinders **oxidation of the desired reduced compounds**. Volatile organic chemicals, **other organic compounds, or taste- and odor-causing compounds may result in an oxidant demand**. This additional oxidant demand must be accounted for when dosing the oxidant. The expense of operation derives from the chemical use in most cases, and therefore is directly related to the source water quality.

What are the most common treatment processes?

- Filtration In general, **manganese oxidation is more difficult than iron oxidation because the reaction rate is slower.** A longer detention time **(10 to 30 minutes) following chemical addition is needed prior to filtration to allow the reaction to take place.** There are different filtration media for the removal of iron and manganese, including **manganese greensand, anthra/sand or ironman sand, electromedia, and ceramic.**

What are the most common treatment processes?

- **Manganese greensand is by far the most common medium in** use for removal of iron **and manganese through pressure filtration**. Greensand is a processed material consisting of nodular grains of the zeolite mineral glauconite. **The material is coated with manganese oxide**. **The ion exchange properties of the glauconite facilitates the bonding of the coating**. This treatment gives the media a **catalytic effect in the chemical oxidation reduction reactions necessary for iron and manganese remova**l. This coating is **maintained through either continuous or intermittent feed of potassium permanganate**.

What are the most common treatment processes?

- Anthra/sand (also iron-man sand) are other types of **media available for removal of iron and manganese**. They consist of select anthracite and sand with a chemically bonded **manganese oxide coating.** Unlike manganese greensand, these **media are conditioned in the filter after media installation**

What are the most common treatment processes?

- Ion Exchange Ion exchange should be considered only for the removal of **small quantities of iron and manganese** because there is a risk of rapid clogging. **Ion exchange involves the use of synthetic resins where a pre-saturant ion on the solid phase** (the “adsorbent,” usually sodium) is **exchanged for the unwanted ions in the water** .

What are the most common treatment processes?

How can iron and manganese problems be minimized in distribution mains?

Problems due to iron and manganese in distribution mains may be minimized by:

- prior removal by appropriate treatment,
- protecting iron/steel mains with bituminous linings, or using noncorrosive materials,
- avoiding dead-end mains,
- avoiding disturbances in the water flow, and
- flushing periodically

Iron and Manganese Removal by Manganese Greensand

- **Intermittent Regeneration (IR) process and the manganese greensand Continuous Regeneration (CR) process**)
- The advantages of the **manganese greensand process over aeration and filtration are single pumping** (as the process generally employs pressure filtration), **reliability, flexibility, a high quality effluent and ease of operation**
- In general, iron and manganese removal with manganese greensand is **cost-effective when the iron and manganese concentrations are relatively low and the plant flow rates high**

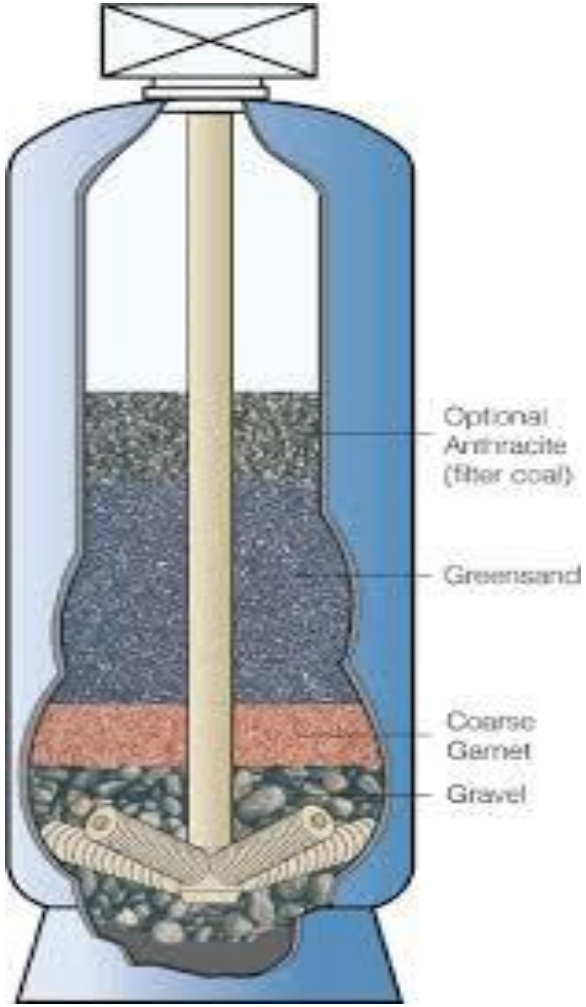
Iron and Manganese Removal by Manganese Greensand

- aeration followed by direct filtration **process, the filter run length will decrease as the iron concentration increases** due to the increased loading on the filter.
- Normally, high concentrations of **iron (10-15 ppm) coupled with high flow rates require coagulation.**
- The mechanism for iron and manganese removal by manganese greensand in both the **CR and IR** method is **oxidation followed by physical removal of the resulting precipitates by filtration** using a **manganese greensand or manganese greensand-anthracite bed.**

Iron and Manganese Removal by Manganese Greensand

- Generally the continuous regeneration or **CR process is recommended for waters where iron predominates with only small amounts of manganese. The IR process is used for water where manganese removal with or without the presence of iron is required.**

Continuous Regeneration (CR) Process



- The manganese greensand CR process, as previously mentioned, is applicable on well waters where iron removal is the main objective with or without the presence of manganese
- This process can **remove iron from water in concentrations up to 15 mg/L or more**. However, with such high **concentrations the run length between backwashing would be as little as 4-6 hours**
- Waters having iron concentrations in the lower range of **0.5-3 mg/L would have run lengths of 18-36 hours** at a more acceptable design flow rate.

Continuous Regeneration (CR) Process

- The CR process involves the **feeding of an oxidant or combination of oxidants such as potassium permanganate and chlorine to the raw water prior to contact with the manganese greensand bed.**
- Chlorine, which is recommended, **should be fed prior to the permanganate injection point**.
- **The chlorine will oxidize the bulk of the iron**.
- Potassium permanganate will then **complete the oxidation of trace amounts of iron and soluble manganese**.
- Since permanganate is a strong oxidant, manganese can be completely oxidized even at the minimum **recommended pH of 6.2**.

Continuous Regeneration (CR) Process

- The manganese greensand bed performs a **dual function to complete the removal of iron and manganese.**
- First, correct operation of a CR filter requires that a slight excess of permanganate, indicated by the influent water having a slight pink color, will **insure that the oxidant demand, whether using permanganate alone or in combination with chlorine, has been met**.
- The excess **permanganate will be reduced to a manganese oxide by the manganese greensand.**
- The **manganese oxides will then precipitate on the grains, maintaining them in a continually regenerated state**

Continuous Regeneration (CR) Process

- Second, it is a well-known fact that in iron and manganese removal by oxidation, the presence of **manganese oxide will act as a catalyst** whether oxidizing agent be **oxygen, chlorine, ozone, or permanganate, insuring that the reaction goes rapidly to completion.**

Reactions involved in iron and manganese removal by potassium permanganate and manganese greensand include the oxidation of iron by chlorine (if used) and permanganate:

Continuous Regeneration (CR) Process

$$2Fe^{2+} + Cl_2 \rightarrow 2Fe^{3+} + 2Cl$$

$$3Fe(HCO_3)_2 + KMnO_4 + 7H_2O \rightarrow MnO_2 + 3Fe(OH)_3 + KHCO_3 + 5H_2CO_3$$

the oxidation of manganese by permanganate:

$$3Mn(HCO_3)_2 + 2KMnO_4 + 2H_2O \rightarrow 5MnO_2 + 2KHCO_3 + 4H_2CO_3$$

and the reduction of any excess potassium permanganate by the manganese greensand (where Z represents manganese greensand "zeolite") to manganese dioxide:

$$3Z\bullet MnO + 2KMnO_4 + H_2O \rightarrow 3Z\bullet MnO_2 + 2KOH + 2MnO_2$$

Conversely, the oxidation of soluble iron or manganese by the manganese greensand when the oxidant demand on the raw water has not been fully met:

$$Z\bullet MnO_2 + \begin{matrix} Fe^{2+} \\ Mn^{2+} \end{matrix} \rightarrow Z\bullet Mn_2O_3 + \begin{matrix} Fe^{3+} \\ Mn^{3+} \\ Mn^{4+} \end{matrix}$$

Continuous Regeneration (CR) Process

- The media must therefore remain in a **continually regenerated form at all times**. This is easily accomplished by a visual check for the "just-pink" color in the filter influent.
- **The closed pressure filter normally contains a gravel support bed for the proper distribution of backwash waters, a manganese greensand bed and an anthracite bed.**
- As a run **progresses pressure drop increases as the filter bed becomes contaminated with the insoluble products of oxidation**. After either a predetermined number of liters, or when the head loss **reaches10 psi, the bed must be backwashed to remove the filtered particulates**

Continuous Regeneration (CR) Process

- In addition it is also beneficial (although not necessary) to provide some means of **air washing on a weekly basis to thoroughly clean the manganese greensand grains to thoroughly clean the manganese greensand grains**

Continuous Regeneration (CR) Process

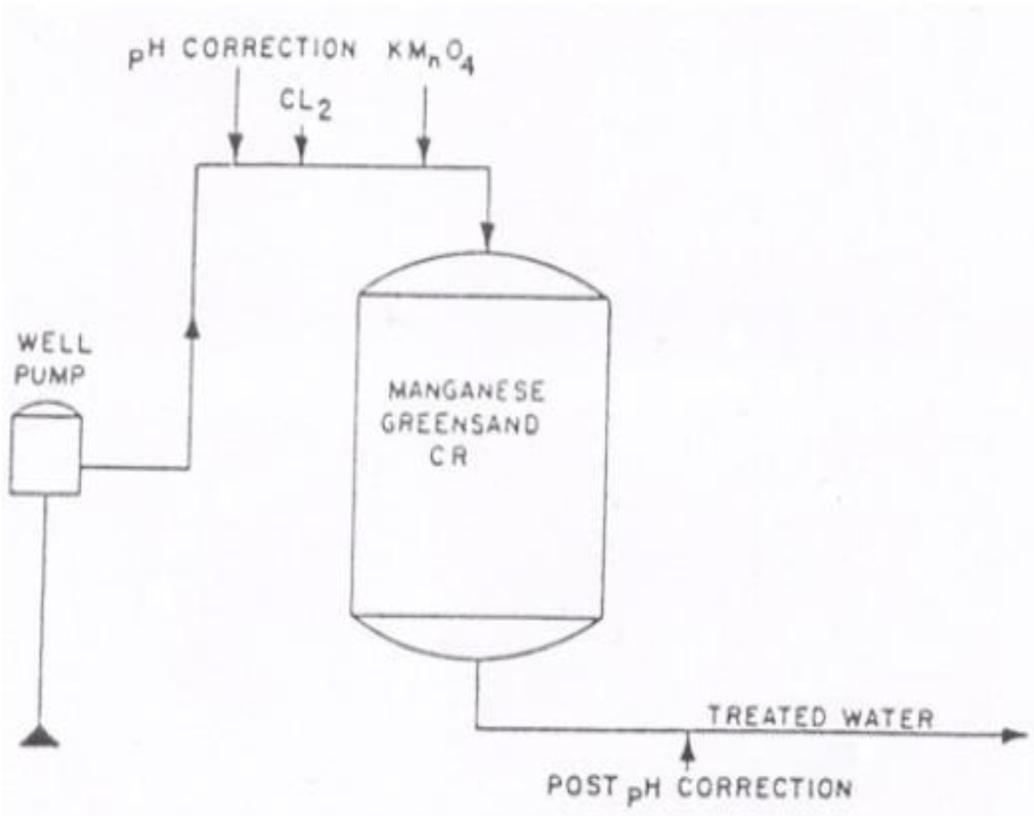


Fig 5 – Manganese Greensand CR Process

- **no regeneration of the media is required prior** to placing the unit back in service due to the continuous regeneration during service.