

IRON (MANGANESE) AND SULFUR BACTERIA

IN YOUR WELL WATER

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Presence of bacteria in your drinking water supply does not necessarily pose a health hazard. Certain types of bacteria in household water are more of a nuisance issue. The generally recommended bacteria tests for drinking water measures the populations of two indicator bacteria: total coliform and *E. coli*. The indicator bacteria test results indirectly suggest whether your water is free from or contaminated with one or more of the numerous potentially water-borne disease causing microorganisms. However, information about other non-pathogenic bacterial contamination cannot be determined from such test results.

Your water may test negative for coliform and *E. coli*, but it may still contain other bacteria, typically nuisance bacteria. The two most common types of nuisance bacteria are iron (manganese) and sulfur bacteria. Iron (manganese) bacteria are generally more common than sulfur bacteria because large amounts of iron can be present in ground water. Iron and sulfur bacteria can live together in a household water supply system, so it can be very difficult to determine whether the problem is from one or the other, or both.

NOTE

For easy reading of this publication, the "iron (manganese) bacteria" will be referred to as just "iron bacteria" from this point forward.

Iron Bacteria

If growing conditions are favorable, iron bacteria can grow rapidly. As a result, **BACTERIAL SLIME CAN CLOG THE ENTIRE WELL SYSTEM,** rendering it useless in just a few months.

Iron bacteria derive the energy required for their growth from oxidation of dissolved iron or manganese in groundwater. *Gallionella* spp. and *Lepothrix* spp. are the two common bacterial species involved in iron and manganese oxidation. Iron bacteria produce a bacterial slime that can cause:

- unpleasant tastes and/or odors;
- corrosion of plumbing equipment and fixtures; and/or
- clogging of well screens and pipes.

The corrosion and clogging effects are not typically seen until the growth of iron bacteria is very intense. However, they more commonly produce unpleasant tastes and/or odors in the water, which are often described as:

- swampy
- oily or petroleum
- cucumber
- sewage
- rotten vegetation
- musty



- ❖ Sometimes the unpleasant taste and/or odor will only be noticeable or more intense in the morning or after extended periods of non-use. It should be noted that iron bacteria do not produce a “rotten egg” smell.
- ❖ Iron bacteria can also cause yellow, orange, red, or brown stains and rust/reddish-orange colored water.
- ❖ Iron bacteria can produce sticky slime deposits on the inner walls of toilet tanks, which are typically rusty in color, but may be yellow, brown, or grey.
- ❖ It is sometimes possible to see a brown/black gelatinous or fluffy mass and/or a rainbow-colored, oily sheen on the water’s surface in the toilet tanks. *(If any disinfectant is used in the toilet tank, this sign of iron bacteria may not show-up.)*

Growing Conditions for Iron Bacteria

Most water well systems provide favorable conditions for growth of iron bacteria. These conditions include:

- a low oxygen environment with dissolved oxygen levels of 0.5 to 4 mg/L (this amount of dissolved oxygen may be provided in a well by agitation during pumping);
- dissolved iron concentration as low as 0.01 mg/L; and
- a temperature range of 41 to 59 degrees Fahrenheit

Origin of Iron Bacteria in the Well Systems

Although a small population of iron bacteria can naturally occur in groundwater, bacteria typically exist on top of the ground. The most common way iron bacteria end up in wells happens when the bacteria enters from the ground surface during well drilling, submersible pump installation, or any other construction, maintenance, or pump servicing.

- ❖ During installation or repairs of a well, if the pipes or pumps are laid on the ground, soil containing iron bacteria can enter into the groundwater.
- ❖ If unchlorinated surface water is used as drilling water, it may contain iron bacteria and can introduce the bacteria into the groundwater.
- ❖ Driller’s equipment contaminated with iron bacteria can spread bacteria from well to well.
- ❖ Iron bacteria can enter a poorly constructed or maintained well from flooding surface water, septic systems, and other sources *(these sources can also result in serious disease-causing microorganisms in drinking water wells)*.

Testing for Iron Bacteria

Very few water laboratories test for iron bacteria. Moreover in a given household water system, the population of iron bacteria can change often because slime deposits of iron bacteria are periodically shed from pipes and fixtures. There are no drinking water standards for iron bacteria since there are no health implications. Thus, water tests looking for the presence of iron bacteria are seldom recommended and are generally not required. Instead, *the confirmation of the presence of iron bacteria is usually based on visual inspection*. A simple visual test is described below:

- Remove the screen or faucet-mounted filter from the faucet (if present).
- Fill a clean, sealable, clear glass container with water from a faucet, preferably one that’s been unused for several hours (for example, early in the morning before any other household water use).
- Leave the sample intact in the container, letting it sit undisturbed for approximately 24 hours.
- If the water remains clear, there is neither precipitates of oxidized iron and manganese (formed through oxidation of dissolved iron and manganese in water) nor iron bacteria (picture A).

- If the sediment at the bottom appears as a thin layer of a rusty flour-like substance, it is likely just precipitates of oxidized iron or very few (if any) iron bacteria in the water (picture B).
- If the sediment settled at the bottom consists of rust-colored fluffy strands/clumps with three-dimensional appearances (like strands of stained cotton), there is probably a substantial amount of iron bacteria present (picture C).



- No oxidized iron and manganese precipitates
- No iron bacteria

- Oxidized iron and manganese precipitates
- Presence of iron bacteria is unlikely

- Oxidized iron and manganese precipitates
- Iron bacteria are present

Sulfur Bacteria

Two separate groups of sulfur bacteria may exist in household water supply systems—sulfur oxidizers and sulfate reducers, with sulfate-reducing bacteria being more common.

Sulfur-oxidizing bacteria convert sulfide into sulfate, producing a dark slime that can clog plumbing. Sulfate-reducing bacteria convert sulfate to sulfide and produce hydrogen sulfide gas in the process. The unmistakable “rotten egg” odor of hydrogen sulfide gas is the most obvious sign of a sulfur bacteria problem. In addition to its offensive smell, hydrogen sulfide is also highly corrosive. As with odors caused by iron bacteria, the rotten-egg smell may only be apparent when the water hasn’t been used for several hours. *If the odor is present only when hot water is run, sulfate-reducing bacteria could be building up in the water heater. Further information about it can be found in the section “Water Heater Treatment” at the end of this publication.*

Identifying whether water issues are due to iron or sulfur bacteria is often difficult because the symptoms/signs are so similar. Moreover, iron and sulfur bacteria often coexist in household water system. Fortunately, they can be controlled by the same set of treatment methods described as follows.

Dealing with Iron and Sulfur Bacteria Problems in Household Water Supply Systems

Prevention

Once iron bacteria are well established in a household water supply system, their complete elimination is extremely difficult or even impossible. Preventive measures are more critical and effective than corrective actions. To prevent introducing any bacteria into a well, the drilling process, the installation of the submersible pump assembly, and any repair and maintenance activities must be kept clean. The following are some simple preventive measures.

1. Unsanitary well drilling can often introduce bacteria into a clean water supply. Therefore, when drilling a new well or repairing an existing well, drill bits, tools, submersible pump assemblies, casing pipes, screen, gravel pack material, and other materials entering the well should be decontaminated with a strong chlorine-bleach solution (for example, a 200 mg/L free chlorine concentration: approximately 1 cup household laundry bleach mixed with 10 gallons of water).

Note: The well contractor should make every effort to prevent introduction of iron bacteria into a well during drilling and repair.

2. The water used during drilling (drilling fluid) should also be chlorinated to achieve a free chlorine concentration of 50 mg/L (approximately 1/4 cup household laundry bleach mixed with 10 gallons of water).

Note: Chlorinated water from public water supplies contains no more than 4 mg/L free chlorine.

3. Any equipment for well drilling or repair should not be laid on the ground where it could easily pick up soil with iron bacteria or organic material that can nourish the bacteria.
4. Surface water from lakes, streams or rivers may contain iron and other bacteria and, therefore, should not be used in drilling.
5. Entrance of surface water into the well should be prevented by ensuring adequate wellhead protection measures.
6. Well casing should extend a foot or more above ground and should be capped with a sanitary well cap.
7. After construction, the well must be test pumped, disinfected by shock-chlorination, and flushed (as described below). The well must also be shock-chlorinated at the completion of any maintenance, repair, or pump work. When an existing inactive well will be used again, it must be shock-chlorinated. All active wells should also be shock-chlorinated at least one to two times a year as part of well maintenance.
8. A water test for coliform bacteria after shock-chlorination should be conducted. If the sample result is negative, the water is considered bacteriologically safe to drink. A negative result is a good indication that proper well construction and pump installation procedures were used. It also means that an infestation of iron bacteria is less likely to be a problem in the water system.

Control

If you (the well owner) live in an area where slime producing iron and sulfur bacteria are a problem, you might have heard your neighbors talking about it, and it is important that you remain alert for the early signs of the presence of iron and sulfur bacteria. Control of these bacteria is much easier early on, before the problem becomes severe. In the early stages of the infestation, shock chlorination every six months can be effective to keep this problem under control. It is not only difficult to treat heavily infected wells, but it is also expensive and only partially successful. The recommended treatment techniques for removing or reducing iron bacteria include:

- chemical treatment;
- physical removal; and
- pasteurization.

Chemical Treatment

The chemicals most commonly used for iron bacteria treatment include disinfectants and acids. Guidance for using these chemicals are given as follows.

Disinfecting your well by shock chlorination

If pipelines are less than 20 percent plugged, and if the well is shock chlorinated properly, the counts of bacteria will be comparative to a normal aquifer. Eventually the pipeline will clean itself through regular pumping and water use.

Shock chlorination involves adding chlorine from household laundry bleach to water primarily to disinfect the water. Chlorine is a common disinfectant used in water systems and is highly toxic to coliform and similar types of bacteria. Iron and sulfur bacteria are more resistant to the killing action of chlorine because iron and sulfur bacteria occur in thick layers and are protected by the slime they secrete. In the case of iron bacteria, iron dissolved in the water may also absorb/consume some chlorine before it reaches the bacteria. For these reasons, a higher chlorine concentration of *500 ppm* (as compared to 200 ppm used in standard shock chlorination) is recommended for shock chlorination to address iron and sulfur bacteria problems.

Safe and successful disinfection of iron bacteria from a well by shock chlorination requires some basic knowledge and experience. *We recommend you hire a licensed well driller or pump installer to disinfect your well.* However, you may decide to do it yourself; in such a case, follow all safety precautions and conduct the procedure as described here:

1. Using Table 1 (located on the following page), calculate the required volume of water and household laundry bleach or high test calcium hypochlorite pellet (tablet) or powder to be mixed in a clean container to prepare the chlorine solution.

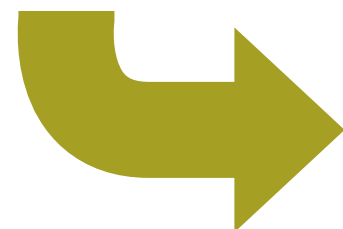


Table 1. Amount of water and bleach required to obtain a chlorine concentration of 500 ppm for various types of wells.

Casing Diameter (inches)	Storage of Water per 1 Foot Casing (gal)	Water and Bleach/Chlorine Pellet Needed per 1 Foot of Water Storage in the Well Casing ¹			
		Water (gal) ²	5.25% Laundry Bleach (quart) ³	10% Concentrated Laundry Bleach (quart) ³	High Test Calcium Hypochlorite Pellet (Tablet) or Powder ⁴ (ounce)
2	0.16	0.26	0.010	0.0052	0.026
3	0.37	0.59	0.024	0.0118	0.059
4	0.65	1.04	0.042	0.0208	0.104
5	1.02	1.63	0.065	0.0326	0.163
6	1.47	2.35	0.094	0.0470	0.235
7	2.00	3.20	0.128	0.0640	0.320
8	2.61	4.18	0.167	0.0836	0.418
9	3.30	5.28	0.211	0.1056	0.528
10	4.08	6.53	0.261	0.1306	0.653
12	5.88	9.41	0.376	0.1882	0.941
16	10.5	16.8	0.672	0.3360	1.680
20	16.3	26.1	1.044	0.5220	2.610
24	23.5	37.6	1.504	0.7520	3.760
28	32.0	51.2	2.048	1.024	5.120
32	41.8	66.9	2.676	1.338	6.690
36	52.9	84.6	3.384	1.692	8.460

¹Multiply with the depth (feet) of water storage (the length of the standing water column) in your well to get the actual amount of water and bleach required to be mixed.

²The volume exceeds the volume of water standing within the well; this will help ensure the chlorination will disinfect the entire water column, the well, and the geologic formation surrounding the source water underground.

³Liquid bleach can deteriorate by 20 to 25 percent per month in storage, especially after opening the container. Always use fresh, newly purchased household bleach. Due to the short shelf life of these products, it is not a good idea purchase more than you are immediately going to use.

⁴Containing 65-75 percent calcium hypochlorite (Ca(OCl)₂). 1 ounce = 28 grams; 1 cup pellets = 0.5 pound = 8.1 ounces; 1 pound = 454 grams.

To calculate the depth of water in the well, refer to the water well driller's report/log. Subtract the "static water level" (depth to the water in the well) from the "total depth of the well." If this information is not available, use a water well depth sounder (available in a drilling supply store or with a well drilling company) to find the static water level. Always disinfect the well sounder before and after use.

Example: Drilling records indicate the well is 350 feet deep, and the static water level is 200 feet deep. The depth of water is 150 feet (350 – 200). If your casing is 4 inches in diameter, you need to pump 1.04 gallons of chlorinated water for every foot of water in the well into your storage container. Since you have 150 feet of water in the well, you will pump $1.04 \text{ gal/ft} \times 150 \text{ ft} = 156$ gallons of water into the clean water storage container.

If the depth of the water in the well is unknown, and therefore, the total volume of water in the well is unknown, 150 gallons, for a 4-inch-diameter well, is a reasonably good estimate in most cases. The required amount of 5.25 percent and 10 percent bleach to mix with 150 gallons of water will be 6 quarts (1.5 gal) and 3 quarts (0.75 gal), respectively.

2. In a clean container, prepare the chlorine solution by mixing the amount of water and bleach calculated in **Step 1**. A clean galvanized stock tank, multiple trash cans (most can hold about 30 gallons), or a pick-up truck bed lined with a thick plastic sheet is suitable. The chlorine product must be free of additives, such as "fresh scent." Thoroughly mix the bleach with the water to make the solution. *(Be careful not to breathe the bleach fumes. Also, never combine bleach and ammonia products because doing so will create toxic chlorine gas).*
3. **Turn off the electrical power to the pump** and remove the well cap or seal. Siphon the entire amount of the chlorine solution prepared in Step 2 down the well. **Avoid pouring the solution onto the electrical pump wires.**
4. Keeping the electrical power off, drain and flush the pressure tank and water heater.
5. Turn the electrical power to the pump back on and refill both the pressure tank and water heater with chlorinated water.
6. Turn the water heater back on, and increase the temperature setting up to 160 degrees Fahrenheit, but only if the heater has a working pressure relief valve. **Caution: Use hot water carefully at this high temperature setting.**
7. Attach a clean garden hose to the outdoor faucet nearest the well and place the end of the hose inside the well. Let the water run, and recirculate the chlorinated solution back down the well (for about 30 minutes) until you smell chlorine coming out of the hose. Using the hose, wash down the interior of the well casing and the exposed pump piping for about 15 minutes, and then shut off the outdoor faucet.
8. Allow the solution to circulate throughout the system. Open each faucet, first outside, then inside the house (both hot and cold), one at a time, and let the water run. Close each faucet after a strong chlorine odor is detected. Flush the toilets one at a time. If a strong chlorine odor cannot be detected at each faucet and toilet, pour an additional 3 pints of bleach into the well and try again. This will disinfect the entire plumbing system. *It is a good idea to bypass your water softener or any other water treatment unit by closing the valve preceding it. The water softener can be disinfected by adding a 1/4 to 1/2 cup of bleach into the fill tube of the salt brine tank and activating a manual recharge. Please check with your treatment equipment dealer for their advice in this regard.*

9. **Turn off the electrical power to the pump**, return the well cap, and keep the well head covered. Allow the chlorine solution to remain in the well and water system for *at least 24 hours*.
10. Turn the pump back on. Rid the system of the remaining chlorine by turning on outside faucets, one at a time, and letting them run until you no longer smell chlorine. Run the indoor faucets (both hot and cold), one at a time, until water is clear and the chlorine smell is gone. Flush each toilet. Drain the chlorine solution out of the water heater and pressure tank, refill them with fresh water, and reduce the temperature setting back down to a safe setting of 110 to 120 degrees Fahrenheit.
11. Since the chlorine solution can disrupt a septic system, do not run more than 100 gallons of chlorinated water into your septic system. Also, do not allow the chlorinated water to drain into a stream, pond, or lake through a drainage ditch **because it may kill fish and other aquatic life**. Instead, using the hose, discharge the solution to a location outdoors, away from grass and shrubs. To conserve the water, you may run it into a storage tank and use it to water vegetation after the chlorine dissipates.
12. Properly reinstall your well cap. If it is a vermin proof cap, make sure it is installed onto the casing in a watertight manner (except for the well vent). If you have an older overlapping well cap, it is a good idea to install a new vermin proof cap. Doing so will prevent insects, spiders and bacteria from entering your well head and contaminating your drinking water.
13. You may need to repeat this disinfection process. If indications of iron bacteria persist after repeating this process, a more aggressive cleaning and disinfection procedure should be considered. See the section below describing methods for treating more severe iron bacterial infestations.

Note: The procedure described above generally does not completely eradicate iron bacteria from the household water system, but will keep bacteria levels under control. However, the procedure should be repeated each spring and fall as a part of well maintenance in order to prevent the regrowth of iron bacteria. If a well has never been shock chlorinated or shock chlorination has not been done for few years, a significant improvement can be noticed after two or three treatments.

CAUTION

Do not flush more than 100 gallons of chlorinated water from the system into the septic system.

- **Avoid draining heavily chlorinated water to lawns, and do not allow puddles to form.**
- **Do not chlorinate carbon or charcoal filters because this will deplete their capacity.**

Shock chlorination in areas with arsenic in some well waters

Although shock chlorination will sanitize wells, it may temporarily increase the arsenic levels of water in areas where aquifer sediments contain high levels of arsenic (WDNR, 2008). Arsenic occurs naturally in some bedrock and aquifer sediments in the Southern Coastal Plain (SCP) region of Georgia, and arsenic has been found in drinking water from some private wells in this region. When the water table is lowered due to the pumping of groundwater, the sediments in groundwater are exposed to oxygen. Oxygen helps in dissolving some of the arsenic contained in sediments. Similarly, because chlorine is a strong oxidant, it could dissolve arsenic from sediments and release it into the groundwater. If well owners have detectable levels of arsenic in water, the following steps may be useful:

1. Chlorine solutions are most effective against bacteria at a pH between 6 and 7. Do not use either acidic or alkaline bleach solution. Chlorine products can quickly raise the pH of the water, especially in hard water, to a level where the chlorine solution becomes ineffective. To counteract this effect, the pH may be adjusted with an acid product. A licensed well driller or pump installer should administer these acid products.
2. Do not leave chlorine solutions inside well casings for longer times than prescribed (24 hours).
3. Well casings, holding tanks, and pipes should be flushed thoroughly until no residual levels of chlorine are found.
4. Well water used for drinking should be tested for arsenic after shock chlorination to make sure the arsenic concentration is at a safe level (less than 10 ppb).

Acid Treatment

For severe cases, treatment with an acid and salt solution in combination with physical removal following thorough shock chlorination may be required. The acid solution (*commercial hydrochloric acid, commonly known as muriatic acid or an organic acid like vinegar*) may be able to penetrate thick incrustations of bacteria that the chlorine solution was unable to penetrate and kill. This procedure should only be performed by a licensed well contractor.

Physical Removal

Shock chlorination described above is usually effective against minor to moderate iron bacteria infestation. However, it is only partially effective against thick iron bacteria biofilms caused by severe infestation. Slime coatings in the inner surfaces of the well casing and plumbing makes it difficult for chlorine to reach and kill the bacteria living within the slime. Following shock chlorination, there may be an initial suppression of iron bacteria, but in several months they tend to build up again. *Therefore, physical removal is required as a first step in a heavily infected well with its pipeline more than 20 percent plugged with slimy bacterial growth.*

All well components (such as the pump, cable, etc.) must be removed and thoroughly cleaned before placing them back in the well, and the entire inner wall of the well casing should then be scrubbed by brushes or other tools to break and remove thick slimy growth. *These processes require special equipment, materials, and skills to carry out the work in a safe manner. So this should be done by an experienced licensed well driller or pump installer.* After physical cleaning, the well should be subsequently flushed in a manner that raises bacterial debris up and out of the well rather than forcing it out into the surrounding geological formation. During the flushing process, thick masses of rust-colored slime may come out of the well; this means the process is working, so do not get alarmed. After the well is cleaned and flushed, it should be shock chlorinated as previously described.

This aggressive approach of cleaning and disinfection is the best way to prevent the iron and sulfur bacteria problems from recurring. You can also help prevent their recurrence by installing a pellet-chlorination treatment unit on your well. These units are designed to periodically inject a solid chlorine pellet down into the well. This helps prevent bacteria from regaining a foothold. If you install a pellet chlorinator, you may want to include a carbon filter on the water service line to remove any residual chlorine from the water you use.

Pasteurization

This can be used for controlling infestation. Inject hot water or steam into the well, maintaining a water temperature in the well of approximately 160 degrees Fahrenheit for 30 minutes to kill the bacteria. This process is effective but can be expensive when treating large diameter wells.

Water Heater Treatment

A rotten-egg smell only during hot water use indicates that sulfur-reducing bacteria are thriving in the water heater. Water heaters contain a “sacrificial anode,” usually a magnesium rod that helps protect the water heater tank lining by corroding itself. Electrons released during corrosion of this magnesium rod nourish sulfur-reducing bacteria. The problem can be eliminated or minimized by replacing the magnesium rod with one made of aluminum or zinc, preferably by a licensed plumber. As an alternative, setting the water heater on “high” will raise the water temperature to approximately 160 degrees Fahrenheit and kill any sulfur-reducing bacteria in the tank. After about eight hours, the tank can be drained, and the temperature setting returned to normal. *However, you can do this only if the water tank has a pressure relief valve and everyone in the house is warned, to prevent scalding.*

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