

Water Treatment NOTES

Cornell Cooperative Extension, College of Human Ecology

Hydrogen Sulfide in Household Drinking Water

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Sources

Water containing hydrogen sulfide, commonly called sulfur water, has a distinctive "rotten egg" or swampy odor. Hydrogen sulfide is a gas formed by the decay of organic matter such as plant material. It is typically found in groundwater containing low levels of dissolved oxygen and a pH less than 6.0. If the pH range of the water is higher (7.0-12.0), the water may contain other forms of sulfur (sulfide or bisulfide). Sulfur problems occur less frequently in surface waters because flowing water is aerated naturally so that the hydrogen sulfide reacts with oxygen and escapes as a gas or settles as a solid.

Sulfur bacteria are also found in many drinking water wells and household distribution systems. These harmless bacteria use natural sulfur compounds in water as a food source, thereby producing hydrogen sulfide. Although sulfur bacteria pose no health risk to humans, their presence in drinking water may cause objectionable tastes and odors.

A water heater may also produce a sulfur odor. The magnesium rod present in many water heaters can chemically change naturally occurring sulfates in water to hydrogen sulfide. If this occurs, the magnesium rod can be replaced with an aluminum rod or simply removed, although removing the rod may nullify the warranty on the water heater.

Drinking water standards and testing

Many impurities are regulated by drinking water standards set by the U.S. Environmental Protection Agency (EPA). Hydrogen sulfide is not regulated, however, because it is considered a nuisance chemical and does not pose a health risk at concentrations typically present in household water.

Concentrations high enough to be a health risk also make the water unpalatable. Conversely, concentrations as low as 0.5 milligrams per liter (mg/L) can add objectionable taste and a rotten egg odor to drinking water.

Since hydrogen sulfide is a gas that can easily evaporate when dissolved in water, the water sample must be stabilized before a laboratory analysis for the chemical can be done. Sample bottles containing a stabilizing chemical should be obtained from a laboratory certified by the New York State Department of Health (contact your local health department or Cooperative Extension office for a list of certified labs or look online at <http://www.wadsworth.org/labcert/elap/comm.html>). Stabilized water samples cannot be analyzed for other contaminants. Finally, if laboratory tests show the absence of hydrogen sulfide in drinking water that has a characteristic sulfur odor, the water should be tested for sulfur bacteria.

Water treatment options

It is important to know the origin of hydrogen sulfide so the problem can be treated properly. To determine if the water heater is involved, run cold water, such as from the shower, inside the house. If no odor is detected, turn off the cold water and run the hot water. The presence of sulfur in hot but not cold water indicates that the problem is most likely caused by bacterial activity. In many areas, sulfur water is prevalent in groundwater at certain well depths or because an old dug or abandoned well provides a food source for sulfur bacteria. In these situations, it may be necessary to locate a new water supply or install a home water treatment system.

Most methods for treating sulfur water rely on the oxidation of hydrogen sulfide gas into elemental sulfur, a solid. Oxidation is the process by which soluble or dissolved contaminants are converted to soluble byproducts or insoluble products that can be filtered. This process changes the chemical and physical properties of the reactants. Hydrogen sulfide can be oxidized by several methods. If concentrations exceed 6.0 mg/l, chemical oxidation such as chlorination is recommended. If concentrations do not exceed 6.0 mg/l and water pH is above 6.8, an oxidizing filter such as manganese greensand can be used.

Regardless of the method, good initial design and maintenance of the treatment system are important. For example, sulfur bacteria produce slime that may cause clogging problems. Shock chlorination of the entire water system, including storage tanks, hot water tanks, and distribution lines, may be necessary to kill the bacteria (see *Water Treatment Notes 5: Chlorination of Drinking Water*). Chlorine should remain in the system for several hours, preferably overnight. If the problem persists, continuous chlorination may be required.

Chlorination

Continuous chlorination is a very common and effective method for oxidizing hydrogen sulfide, especially if the water pH is 6.0-8.0. Chlorine has the secondary advantage of being lethal to bacteria so it typically follows other treatment options to maintain a chlorine residual and prevent bacterial activity. Chlorine is usually administered as sodium hypochlorite, which reacts with sulfide, hydrogen sulfide, and bisulfide to form compounds that do not cause foul taste or odors in drinking water.

Although the amount of hypochlorite to be administered depends on the concentration of hydrogen sulfide in the water supply, a recommended dosage is 2.0 mg/l chlorine for every 1.0 mg/l hydrogen sulfide. Chlorine should be added before the water reaches the mixing tank, and sufficient storage must be provided so that the water is in contact with the chemical for twenty minutes. Treated water may have lingering tastes or odors caused by the formation of certain harmless by-products or residual chlorine. After the required contact time, therefore, the water should be passed through a depth filter or activated carbon filter to remove final suspended sulfur or excess chlorine.

Chlorination systems are available as a pellet-drop unit or a liquid-chemical feed, both of which include an activated carbon filter to remove excess chlorine. The pellet-drop system automatically dispenses a

measured amount of chlorine down the well casing or into the retention tank during the pumping cycle. The chemical feed system features a liquid feeder connected to the well pump. Some disadvantages of chlorination systems include the complexity of chemical reactions and maintenance of the system. Chlorination systems can be difficult and expensive to operate because they require continuous addition of chemicals.

Manganese greensand

Manganese greensand is another common treatment method that has been used successfully for more than fifty years to remove sulfur in drinking water. It is usually recommended for water that contains less than 5.0 mg/l hydrogen sulfide. A manganese greensand filter has a special coating that oxidizes hydrogen sulfide gas to solid sulfur particles, which are filtered. When all of the manganese oxide is consumed, the greensand is regenerated, or recoated, with potassium permanganate. Potassium permanganate is a purple oxidizing chemical that is added to the untreated water to maintain the manganese greensand filter. Concentrated potassium permanganate is poisonous and a skin irritant that should be stored in its original container away from children and animals.

Hydrogen sulfide consumes a disproportionate amount of manganese greensand filtering capacity. To work properly, the greensand must be regenerated at periodic intervals based on water usage and contaminant concentration. When greensand is used to treat high concentrations of hydrogen sulfide, more frequent regeneration with potassium permanganate is required. The consumer must buy the potassium permanganate and load it into the feeder or solution tank, which typically dispenses the chemical automatically at predefined intervals. Unlike chlorine, there should be no excess potassium permanganate in the treated water (a faint pink tinge is evident if potassium permanganate is present in the water).

Although hydrogen sulfide can be effectively oxidized by manganese greensand, a pre-chlorination step is recommended to oxidize most of the hydrogen sulfide and lengthen the life span of the manganese greensand filter. Otherwise, the filter may become clogged by the solid sulfur particles and it will need more frequent replacement or regeneration. Manganese greensand is available in both natural and synthetic forms. The synthetic gel removes as much contaminant as does the natural greensand, but the synthetic requires less backwash water and also softens the water while it removes the hydrogen sulfide.

Aeration

Another common treatment for sulfur water is aeration. Hydrogen sulfide is physically removed by agitating the water via bubbling or cascading and then separating or "stripping" the hydrogen sulfide in a container. The undesired hydrogen sulfide is removed as a volatile gas by venting it into a waste pipe or to the outdoors.

Aeration is most effective when hydrogen sulfide concentrations are lower than 2.0 mg/l. At higher concentrations, this method may not remove all of the offensive odor unless the air is used to oxidize hydrogen sulfide chemically into solid sulfur, which is then filtered.

In a typical aeration system, ambient air is introduced into the water using an air compressor or blower. Well-designed aeration tanks maintain a pocket of air in the upper third or upper half of the tank. If the tank does not maintain an air pocket, sulfur odor may return. Most household water supplies contain less than 10 mg/l of sulfur, in which case an aeration tank about the same size as the filter tank (10" x 54") works fine. When sulfur levels exceed 10 mg/l, larger aeration tanks, repressurization systems, chlorination systems, or a combination may be needed.

Aeration has many advantages for removing hydrogen sulfide, including its effectiveness at low levels and lack of chemical additives. Also, maintaining a properly designed aeration system is less costly than many chemical-based treatment systems. But the introduction of oxygen to the water may cause problems if some hydrogen sulfide is oxidized to sulfide, bisulfide, or solid sulfur particles, all of which are not air-strippable and need to be filtered from the treated water. In addition, aeration tanks, spray nozzles, and trays can accumulate bacterial slime and other substances that must be removed periodically.

Aeration is not always practical for home water treatment, especially if hydrogen sulfide concentrations exceed 10 mg/l, because it requires very acidic conditions (pH 4.0-5.0), long contact times for the air and water to mix, and usually large space requirements. In addition, treated water may need to be repressurized for distribution within the house and objectionable odors must be removed by venting the gas outside. Aeration can actually accentuate bacterial sulfur problems if the bacteria are not removed first. Some water treatment specialists prefer to install chlorinators -to kill bacteria and lower extreme sulfur levels before aeration. Aeration systems may be installed following a water softener when there are low sulfur levels.

Ozone

Ozone is a powerful oxidant that chemically converts sulfides to solid sulfur, breaks down the slime produced by sulfur bacteria, and rapidly degrades to oxygen. Ozone is generated electrically on site using an electrode system and ambient air or pure oxygen as an oxygen source.

Relatively small ozonator systems that fit in spaces equivalent to those used by other water treatment equipment can handle high sulfide levels rapidly and efficiently. As with aeration systems, ventilation is required to remove hydrogen sulfide gas. Pre-filtration is recommended to remove solids and slimes that may coat the ozone generator. Post-filtration may be needed to remove oxidized solids. As is true of any home water treatment system, good initial design and regular maintenance are important to prevent problems.

Catalytic carbon

Although several methods have always been available to treat hydrogen sulfide in drinking water, advancements in catalytic carbon now provide another alternative to chemical treatment. Essentially, catalytic carbon is activated carbon with a modified carbon surface. Activated carbon is typically associated with adsorption, a physical process in which dissolved molecules adhere to the surface of the carbon filter. When used alone, activated carbon filtration removes very small amounts of hydrogen sulfide, generally concentrations below 0.3 mg/l. Activated carbon, however, has a limited capacity to adsorb hydrogen sulfide. Once the filter is saturated, the activated carbon must be replaced, not regenerated. As a result, activated carbon is not effective for removing moderate or high concentrations of hydrogen sulfide in drinking water.

Catalytic carbon retains all of the adsorptive properties of conventional activated carbon, but it combines them with the ability to promote or catalyze chemical reactions. During the treatment process, catalytic carbon first adsorbs sulfides onto the carbon surface. Then, in the presence of dissolved oxygen, it oxidizes the sulfides and converts them to no objectionable compounds. In this capacity, catalytic carbon is similar to manganese greensand and chlorination systems that remove sulfides through oxidation. It differs in that it maintains consistent catalytic activity (oxidation) that can be controlled and enhanced to treat sulfur water without use of chemical additives.

Several design considerations affect the performance of catalytic carbon, including empty bed contact

time (the amount of time it takes for water to travel from the top of the carbon bed to the bottom, typically three to five minutes), backwash capability (as with manganese greensand, backwashing with treated water is recommended to remove any solid or filtered material such as elemental sulfur), and the concentrations of hydrogen sulfide and dissolved oxygen in water. A minimum dissolved oxygen level of 4.0 mg/l is necessary for complete oxidation of hydrogen sulfide to elemental sulfur, which is filtered. In water containing less than 4.0 mg/l dissolved oxygen, levels can be increased by aeration or the addition of chemical oxidants. Higher levels of dissolved oxygen are required to remove higher concentrations of hydrogen sulfide. Overall, catalytic carbon systems are relatively easy to operate, and they have lower space and maintenance requirements than other systems.

Ion exchange

Ion exchange is a treatment process in which a chemical or contaminant is exchanged on a resin column for another, less objectionable one. In general, two types of ion exchange units are available: cation exchange water softeners and anion exchange units. Water softeners remove cations (positively charged constituents such as the hardness minerals calcium and magnesium) and replace them with sodium or potassium. Anion exchange units remove anions (negatively charged constituents such as nitrate and sulfate) and replace them with chloride. Some mixed media ion exchange units remove both cations and anions. Hydrogen sulfide can interfere with the effectiveness of cation exchange water softeners, especially if the water contains iron or manganese. Anion exchange units, however, are effective for treating sulfur water. To remove hydrogen sulfide, the anion exchange resin column is usually recharged with sodium chloride, and the chloride replaces sulfide in the treated water.

Disadvantages of ion exchange include a low rate of water flow through the treatment system and treated water containing elevated levels of chloride. In addition, anion exchange units lower the pH of the treated water, which makes it corrosive to household plumbing.

Summary

Hydrogen sulfide in household drinking water is a common nuisance contaminant. Although it is not hazardous to human health, the offensive odor of sulfur water makes treatment desirable. Fortunately, various physical and chemical treatment options are available. Often, the treatment for hydrogen sulfide is the same for iron and manganese so that all three contaminants can be removed in one process.

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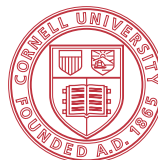
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