

Hydrogen Sulfide (Rotten Egg Odor) in Pennsylvania Groundwater Wells

F139

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Sources of Hydrogen Sulfide

Hydrogen sulfide (H_2S) is a gas that gives water a distinctive “rotten egg” odor. It occurs naturally in groundwater as a consequence of the activities of sulfur reducing bacteria. These bacteria feed on small amounts of sulfur in the water and thrive in the low oxygen environments present in groundwater wells and plumbing systems. Although sulfur-reducing bacteria can impart taste and odor in the water, they do not cause disease or health concerns for humans. In Pennsylvania, hydrogen sulfide problems are most common in wells drilled into acidic bedrock, especially shales and sandstones.

Sometimes hydrogen sulfide may be noticeable only in the hot water in the home. In this case, chemical reactions within the water heater may be the source of the rotten egg odor. Water heaters are fitted with a magnesium rod to inhibit corrosion of the heater. The magnesium rod can chemically reduce sulfates to form hydrogen sulfide.

In rare cases, the addition of water treatment equipment, like a water softener, may cause the production of hydrogen sulfide. In this case, the softener provides a favorable environment for sulfur-reducing bacteria to grow.

Effects of Hydrogen Sulfide

Hydrogen sulfide in water is an aesthetic concern that causes a disagreeable taste and odor to the water. While the gas is poisonous and flammable, the human nose can detect it well before it causes health concerns. Most people can detect hydrogen sulfide levels well below 0.5 mg/L. Hydrogen sulfide can also cause corrosion of metals in a plumbing system, and it can cause yellow or black greasy stains on fixtures or inside pipes when it forms metallic sulfides.

Standards and Water Testing

Hydrogen sulfide does not have a drinking water standard because it makes the water aesthetically undrinkable long before it reaches harmful concentrations. Testing the water to determine the concentration of hydrogen sulfide may be helpful when choosing between water treatment devices. Testing for hydrogen sulfide must be done in the home or the sample must be chemically stabilized before being sent to a commercial testing lab. Consult with local certified commercial water testing laboratories to determine if they can test for hydrogen sulfide in water. You can obtain a list of certified commercial water testing laboratories from your local Cooperative Extension office. Ask for Agricultural and Biological Engineering fact sheet number F-105 entitled *Where to Have Your Water Tested*. This list is also available on-line at <http://wqext.psu.edu/>.

Removal of Hydrogen Sulfide From Hot Water Only

In cases where the rotten egg odor occurs only in the hot water, the production of hydrogen sulfide can often be simply treated by removing the magnesium rod from the hot water heater. This rod often provides a chemical catalyst for the production of hydrogen sulfide from naturally occurring sulfates in the water. The magnesium rod is present in the hot water heater as an anti-corrosion device. Removal could cause increased corrosion and reduced life of the hot water heater and will likely void the manufacturer's warranty. Replacement of the magnesium rod with an aluminum rod should eliminate the rotten egg odor while maintaining corrosion protection for the heater.

Water Treatment to Remove Hydrogen Sulfide from Water

Hydrogen sulfide can be effectively removed from water using a number of treatment processes. The most efficient and cost-effective treatment option will depend primarily on the concentration of hydrogen sulfide. Most treatment processes are designed to treat all of the water entering the home (known as point-of-entry or POE treatment) since hydrogen sulfide is an aesthetic odor problem.

Before you purchase water treatment equipment, make sure you shop around and compare treatment units and prices among several reputable dealers that carry a variety of treatment devices. Be sure to understand the maintenance requirements for each unit and get a written warranty for any device you decide to purchase.

Continuous Chlorination and Filtration

Oxidation is the most common form of treatment used to eliminate hydrogen sulfide. In this process, a chemical is used to convert the dissolved hydrogen sulfide gas into forms of sulfur that can be easily filtered from the water. Chlorine is often used as an oxidizing chemical to convert hydrogen sulfide gas to insoluble sulfur (a yellow solid). Although often not necessary, the insoluble sulfur can be filtered mechanically with sand or aggregate. Chlorination can be used to remove any level of hydrogen sulfide but it is most often applied in cases where the hydrogen sulfide concentration exceeds 6.0 mg/L. A small chemical feed pump is used to feed the chlorine solution (usually sodium hypochlorite) into the water upstream from a mixing tank or coil of plastic pipe. The mixing tank or pipe should be sized to provide at least 20 minutes of contact time to allow for adequate oxidation of the hydrogen sulfide. An additional activated carbon filter may be necessary to remove the chlorine residual present in the treated water and to remove any small amounts of unoxidized hydrogen sulfide gas.

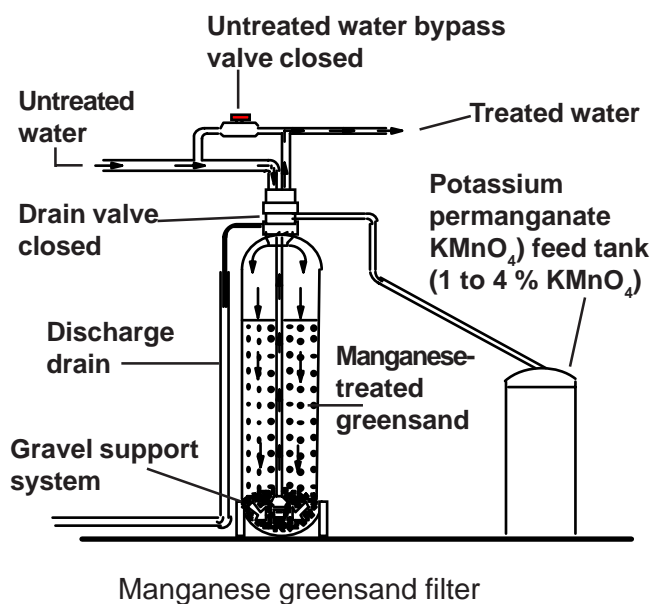
Chlorination systems require significant maintenance. Chlorine solution tanks must be routinely refilled and mechanical filters need to be backwashed to remove accumulated sulfur particles. If a carbon filter were also installed, the carbon would need to be replaced occasionally. The frequency of maintenance is primarily determined by the concentration of hydrogen sulfide and the amount of water used.

Continuous Potassium Permanganate with Filtration

Much like chlorination described above, a potassium permanganate solution can be injected into the water with a small chemical feed pump installed ahead of a holding tank that provides at least 15 minutes of contact time. The oxidized sulfur particles can then be removed using a manganese greensand or zeolite filter. The filter media also allows for polishing of unoxidized hydrogen sulfide (see Oxidizing Filters). Like chlorination, this method is excellent for high concentrations of hydrogen sulfide above 6.0 mg/L. However, the potassium permanganate solution is an irritant and poison that must be handled and stored with standard procedures.

Oxidizing Filters

Oxidizing filters both oxidize and filter hydrogen sulfide in one unit. The filter is usually comprised of manganese treated greensand although other materials such as chemically treated aluminates and silicates like zeolite can also be used. Oxidizing filters with Birm filter media are not recommended for hydrogen sulfide removal. In the case of a manganese greensand oxidizing filter, the filter media is treated with potassium permanganate to form a coating that oxidizes the hydrogen sulfide. As this chemical coating is consumed by hydrogen sulfide, the unit must be regenerated with a potassium permanganate solution. In addition to regeneration, these units require regular backwashing to remove sulfur particles. As mentioned above, the potassium permanganate solution used for regeneration must be handled and stored using accepted safety procedures.



Oxidizing filters can be used to remove up to 2-3 mg/L of hydrogen sulfide. However, the higher the concentration of hydrogen sulfide, the more frequently the unit will need regeneration and backwashing.

Other Methods

Other oxidants may be used alone or in combination with additional treatment to remove hydrogen sulfide from water. Hydrogen peroxide is an excellent oxidant for hydrogen sulfide, but its use in private individual systems has been limited. Ozonation may also be used to oxidize hydrogen sulfide as well as various aeration equipment.

A manganese greensand filter. Reproduced with permission from *Home Water Treatment*, NRAES-48, published by NRAES, Cooperative Extension, 152 Riley-Robb Hall, Ithaca, New York 14853-5701. (607) 255-7654.

Carbon Filtration

When the water contains a small concentration of hydrogen sulfide less than about 1.0 mg/L, activated carbon filtration may be effective. Activated carbon removes a variety of water contaminants, including hydrogen sulfide, by adsorbing the gas on the surface area of the carbon particles. A large unit (usually 1.0 to 1.5 cubic feet of carbon) capable of treating all of the water entering the home is required. Cost and maintenance requirements are low but the carbon needs to be replaced periodically. As previously mentioned, carbon filters are sometimes used in conjunction with other treatment systems like chlorination to “polish” the treated water to remove small amounts of residual hydrogen sulfide.

More recently, other forms of activated carbon known as “catalytic carbon” have been developed for hydrogen sulfide treatment. Catalytic carbon first adsorbs the hydrogen sulfide then oxidizes the gas much like an oxidizing filter. As a result, catalytic carbon units can be used to treat much higher hydrogen sulfide concentrations than activated carbon filters. Maintenance requirements are less than oxidizing filters because no chemicals are added but backwashing is still necessary. Catalytic carbon requires a minimum of 4.0 mg/L of dissolved oxygen in the source water. Some groundwater supplies may need pretreatment to increase the dissolved oxygen concentration.

Aeration

Since hydrogen sulfide occurs as a gas in water, it can be physically removed by injecting air into the water and allowing the gas to escape. Aeration units may work by cascading, bubbling, or stripping the gas from the water.

Aeration may be advantageous because it does not add chemicals to the water. Maintenance costs are low for aeration units but the initial purchase costs are often higher than other treatment options. Aeration is not usually efficient enough to remove all of the offensive odor at high hydrogen sulfide concentrations; thus, it is normally not used when hydrogen sulfide concentrations exceed about 2 mg/L. In some cases, aeration may form sulfur particles that must be filtered from the water. Disinfection of aerated water is recommended.

Ion Exchange (IE)

Ion exchange to remove hydrogen sulfide works much like a conventional water softener by exchanging one ion for another. In this case, hydrogen sulfide is removed from the water and chloride is added in its place. The unit must be regenerated with a sodium chloride solution and the treatment will result in an increased amount of chloride in the treated water. Suspended solids and precipitated iron can also clog the IE unit and may require pretreatment.

Shock Chlorination

Shock chlorination involves pouring a concentrated chlorine solution directly into the well to kill bacteria. This technique is commonly used as a first step in treating bacterial contamination problems in wells. Since hydrogen sulfide originates from bacterial reduction of sulfur, shock chlorination will be helpful in reducing or eliminating the offensive bacteria. You can get detailed information about how to shock chlorinate your well from Fact Sheet F-137 entitled *Shock Chlorination of Wells and Springs*.

In most cases, sulfur-reducing bacteria and hydrogen sulfide odor will return quickly after shock chlorination. If the duration of the benefit from shock chlorination treatment is inadequate, a continuous treatment device described above should be investigated.

For More Information on Treatment Options

More information and details on the methods available for removing hydrogen sulfide from water is available from the NRAES-48, *Home Water Treatment*. This 120-page publication is available for \$15 from the Penn State, College of Agricultural Sciences, Publications Distribution Center at 814-865-6713.

Other Options for Avoiding Hydrogen Sulfide

While treatment devices are available to reduce or remove hydrogen sulfide from water, other options should not be overlooked. In some cases, a municipal water supply line may be nearby. Connecting to a municipal water supply may seem expensive initially,

but it may be economically preferable given the long-term costs and attention associated with purchasing and maintaining a water treatment device. Hooking into a municipal water supply will also usually increase the real estate value of your home.

Another option may be to develop an alternate private water supply. In some cases, drilling a new well that is shallower than your existing well may produce water without hydrogen sulfide by avoiding deeper sulfur-bearing rock formations. A local consulting hydrogeologist could be hired to investigate this possibility. Other sources of water like a shallow groundwater spring or a rainwater cistern could also be developed to avoid hydrogen sulfide but they may present other water quality and quantity problems. Alternative sources of water should be thoroughly investigated along with treatment options when choosing a strategy to avoid hydrogen sulfide in water.

For more information

For further information and resources on:

- ☞ Drinking Water Quality (see fact sheet F 101 *Drinking Water Publications from the Penn State College of Agricultural Sciences*)
- ☞ Groundwater Protection
- ☞ Watershed Monitoring & Control Systems

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