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DEPARTMENT OF HEALTH

Methane in Minnesota Well Water

Methane gas is occasionally found in Minnesota groundwater and wells. It is not known to be a health hazard when ingested with water. However, if methane concentrates in the air of a confined space, it can be flammable and explosive, and it can displace oxygen, resulting in asphyxiation. Methane can also cause problems with the operation of the well pump and water system. Methane from the well, water storage tanks, water heaters, and any treatment devices should be vented to the atmosphere, outside of enclosed spaces such as well houses or homes. Removal of methane from water commonly involves aeration.

Methane

Methane (CH_4) is a simple hydrocarbon of one carbon atom and four hydrogen atoms. Methane gas is colorless, tasteless, and odorless. Methane is the main component of natural gas, which typically contains 50 percent to 90 percent methane. The sulfur-like smell associated with natural gas is not caused by methane or other hydrocarbons, but is due to an odorant called “mercaptan,” purposively added to help identify this commercial product. Methane is only slightly soluble in water, and will be released from solution at temperatures above 58 degrees Fahrenheit (F). Groundwater is typically in the range of 42 to 48 degrees F. Methane will be released as groundwater is pumped to the surface and the temperature rises. Methane is lighter than air, so it will rise to the ceiling if released inside a building or other enclosed space.

Methane is primarily formed by the bacterial decomposition of organic materials. “Swamp gas” is largely comprised of methane formed by bacterial decomposition of vegetation. “Sewer gas” is often partly methane. Methane may also be formed “thermogenically” by geologic processes such as volcanic action. Most methane in Minnesota groundwater is “natural,” that is, it occurs in the groundwater due to decomposition of vegetation or other organic material mixed in with sediments, thousands or even millions of years ago. However, methane can result from the decomposition of wastes under anaerobic (no oxygen) conditions from sources such as landfills, sewage, manure, or other organics. In other parts of the country, methane is associated with coal deposits or oil and natural gas operations. Economic quantities of naturally occurring methane (natural gas) have not been found in Minnesota.

Occurrence in Wells

Most wells in Minnesota do not contain methane. Those that do, likely less than 1 percent, are primarily wells drilled into glacial sediments. Well contractors often report encountering wood, reduced (black or brown) sediments, or other organic materials in the drill cuttings of glacial wells that produce methane. Methane less frequently occurs in other geologic formations including Cretaceous deposits in western Minnesota, and metasedimentary formations in northeastern Minnesota. Except for an area in central Renville County, methane occurrence is generally sporadic – the presence of methane in one well is generally not a predictor that it will occur in other nearby wells. Even though the methane in a well may have been created by the same processes that produce modern "swamp gas," the presence of a nearby swamp is not a predictor that methane will occur in a well, nor is the modern swamp the likely methane source. Some methane has been isotopically dated, and can be surprisingly old.

Methane does not frequently occur in Minnesota wells completed in sedimentary bedrock such as limestone or sandstone, and rarely occurs in igneous formations such as granite. Also, water table or "unconfined" wells rarely produce methane since a confining layer or "cap" is usually needed to trap the methane.

Health and Safety

Studies have not linked ingestion of water containing methane to any short term (acute) or long term (chronic) health effects, however very little research has been done. While most methane in well water is not caused by an active contamination source, a small possibility exists that methane may indicate sewage, solid waste, manure, petroleum, or other sources containing health related contaminants. For those reasons, it is recommended that methane-producing wells be tested for coliform bacteria and nitrate nitrogen.

Methane has an explosive limit between 5 percent and 14 percent. That means that if the methane concentration in air is between those numbers, it can ignite and explode. Methane concentrations in water of as little as 1 milligram per liter (mg/L) can lead to explosive levels if the gas is allowed to accumulate in a poorly ventilated confined space. Levels much higher than 1 mg/L have been measured in Minnesota wells. A spark from a control switch in a well house, or a flame from a water heater in a basement could ignite the methane, with disastrous results.

Methane is lighter than air, so it can rise to the ceiling of a building, and displace oxygen. Oxygen comprises approximately 21 percent of the air we breathe. If the oxygen content should fall below 19 percent, and a person enters the space, unconsciousness and death can occur. Therefore, it is important to vent methane outside of any building or enclosed space.

Methane and Wells

Methane can be dissolved in groundwater much like the bubbles (carbon dioxide) in soda. When the water containing methane is pumped to the surface, the temperature rises, and the pressure drops, which causes the methane to be released from the water, just as the bubbles in soda are released when the container is opened. Heating the water will speed the release of methane. That is why a methane (or other dissolved gas) problem is often worse at a hot water faucet.

Testing for Methane

A “sputtering” or “spitting” faucet, a gurgling noise from the well, or “water hammer” (banging of water pipes) may indicate methane or other dissolved gases. Gases such as nitrogen or carbon dioxide, or other hydrocarbons such as ethane or butane, may occur separately or combined with methane.

The presence of visible gas bubbles in a water sample may also be a clue that methane is present. The water may appear clear with bubbles, milky, frothy, or have a bluish tint. If the bubbles rise in a container of water, and the water clears from the bottom to the top, it is likely that a dissolved gas is present.

However, the presence of gas bubbles or a sputtering faucet may not be due to methane, but may be due to other dissolved gasses, or air entering the water system due to a failing air volume control; bleeder valve; leak in the well, plumbing, or water conditioning equipment; faucet aerator; or a pump malfunction, such as a submersible pump that is breaking suction.

Some water testing laboratories can test water for methane. This involves a specialized sample collection and analysis process. To avoid degassing the methane, the sample should not be aerated, and may involve inverting a sample bottle under water. Laboratories are listed in the telephone directory under “Laboratories – Testing.”

Portable gas detectors can determine methane concentrations in air.

A simple test, that requires some caution, can also detect methane gas. Fill a small plastic bottle (do not use glass or other materials) with water, leaving a small unfilled space, and quickly cap the bottle. Take the bottle outside, shake the bottle, remove the cap, hold the bottle away from yourself or anything flammable, and carefully, but rapidly, pass a small flame over the opening. If methane is present, a brief flame or “pop” will occur as the methane ignites.

Venting

Minnesota rules require new wells to have a vented cap or cover to release gas such as methane or hydrogen sulfide. However, many older wells are not vented. A variety of well caps are available which have a built-in vent on the underside of the cap. Separate down-turned vents are also available. It is important to install these caps and vents correctly to properly vent the well, and to prevent flood water, contaminants, or insects and small animals from entering the well. Wells in well houses, well pits, and basements are especially problematic because methane can accumulate in an enclosed space if not vented to the outside.

Water storage tanks, water heaters, and water treatment tanks should also be vented. Vents should extend above the ground surface and away from any building or source of ignition.

Methane Removal and Treatment

Methane will not be removed by common water treatment devices such as sediment filters, water softeners, or carbon filters. Most removal or treatment techniques involve aeration. A gas shroud, attached to the submersible pump in the well, may provide relief in some circumstances. Fittings that drain back or aerate a portion of the water into the well have been used, but may not be approved or effective, and may cause other problems.

Aeration

Aeration is the process of mixing air with the water, and venting the mixture of air and methane to the atmosphere. Aeration, sometimes referred to as “air stripping,” can remove methane as well as other gasses such as hydrogen sulfide.

Treatment devices range from the simple to the complex, and can range in cost from 10's of dollars for an aerator, 100's of dollars for a pressure or storage tank, to 1,000's of dollars for large treatment systems.

The simplest treatment system is to use a pressure tank without a bladder or diaphragm, often referred to as a “galvanized” tank. An air release valve, vented to the atmosphere, releases the methane. This passive system is relatively simple and inexpensive, and does not require a second pump or tank, but is relatively inefficient at treating large volumes of water or removing large quantities of methane.

A more effective system is to add an aspirator or aerator and air release valve to the pressure tank. With each pump cycle, air is injected into the tank. An air pump or compressor can be added to increase methane removal. These systems are moderately priced, relatively easy to install, take up little space, but add maintenance. It is important to vent the tank outside.

Waterfall, diffusion, or mechanical aerators are devices that more effectively mix air with the water, resulting in more rapid and efficient removal, but increase cost and maintenance. Some systems involve a storage/treatment tank system with spray aerators enclosed in the tank. The water is injected in the top of the tank and falls through an air column. Some systems use a stone or bubble diffuser at the bottom of the tank to mix air into the water. Some systems use both a spray or waterfall aerator and a diffusion aerator.

Use of an unpressurized aeration tank will require two pumps and two tanks – a well pump and a repressurizing pump, and a treatment tank and a pressure tank. Retention times of several minutes are typically needed to allow release of the methane. A rule of thumb is that the treatment tank should hold a volume of water at least twice the flow rate. For example, a 10 gallon per minute pump should have a minimum 20 gallon tank.

It is recommended that methane removal systems that use exhaust fans or other electrical components be explosion proof or “intrinsically safe,” to avoid ignition of the methane.

Air separators, similar to devices used on hot water heating systems to remove air, have also been used to remove methane.

Ideally, aeration units should be placed in a separate building, so that the methane is removed before the water enters a residence. Installing these devices in a basement, with a vent leading outside, is a less desirable alternative.

Aeration may also oxidize other materials in the water. This may be beneficial for things like hydrogen sulfide (rotten egg smell), but may not be desirable when iron is oxidized (turns red), or the gases that give water some of its taste are removed and the resultant water is “flat” tasting.

Vents, air release valves, and other mechanical parts can fail or freeze if not properly designed, installed, and maintained. Systems that use a nonpressurized tank may be subject to airborne contamination of the water supply if not carefully installed and maintained. All systems should be designed to be sanitary, and to avoid cross connections.

Gas Shroud

In some cases, well contractors have reduced or eliminated methane or other gas problems in the well by installing a gas "shroud" on a submersible pump. This involves placing a pipe or tube, often a thin-walled plastic pipe, from the top of the submersible pump motor, a distance of 10 or more feet above the pump. The shroud is sealed to the top of the submersible pump motor below the pump intake. The top of the shroud is open and set below the pumping water level. Methane rises through the water column in the well, leaving methane-reduced water in the shroud. This method only works on a 5-inch or larger casing, or on a 4-inch casing with a 3-inch submersible pump, and on wells that pump relatively small quantities of water at one time. Another limitation is motor cooling, that may be reduced by the shroud.

Pumping Problems

The presence of methane, or other gases, may cause pump problems including gas locking, or cavitation that can lead to poor water delivery, or pump corrosion and failure. Some manufacturers have developed modifications to submersible pumps for gaseous wells. Drilling holes in the submersible pump diffusers may allow pumping gaseous water, but may void the warranty. Moving the check valve from the top of the pump to a point higher in the drop pipe may help. Jet subs, higher speed pumps, rotor-type pumps, and piston or cylinder pumps may pump a gaseous water more efficiently than a submersible pump.

Methane and Chlorine Caution

Methane presents a problem for water supplies that continuously inject chlorine. Methane reacts with chlorine to create chloroform. Methane should be removed from the water before chlorine treatment.

Additional Information

Contact a licensed well contractor at Licensed Well and Boring Contractor Directory (www.health.state.mn.us/lwcsearch).

Minnesota Department of Health (MDH), Well Management Section staff at one of the following locations.

MDH Offices

625 North Robert Street
P.O. Box 64975
St. Paul, Minnesota 55164-0975
651-201-4600 or 800-383-9808

705 Fifth Street Northwest
Bemidji, Minnesota 56601
218-308-2100

1505 Pebble Lake Road
Fergus Falls, Minnesota 56537
218-332-5150

3333 West Division Street
Cloud, Minnesota 56301
320-223-7300

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Marshall, Minnesota 56258
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18 Wood Lake Drive Southeast
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