Nitrate in Groundwater

Gallatin Local Water Quality District

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What is nitrate?

Nitrate is made up of nitrogen and oxygen (chemical formula NO_3^-). A naturally occurring compound, it is an essential nutrient for plants. It is formed when nitrogen from ammonia or other sources combines with oxygen in water. Nitrate is tasteless, odorless and colorless.

Where does nitrate come from?

Nitrogen is a natural part of the environment. The atmosphere is 78% nitrogen (N_2) by volume. During the process of soil formation, nitrogen accumulates in the soil. Nitrogen stored in organic matter in the soil is converted into nitrate by bacteria.

Nitrate is found in plants, animal manure, human waste (septic systems and sewage sludge), manufactured fertilizers made of nitrogen and ammonium, and airborne nitrogen compounds given off by industry and automobiles deposited on the land in precipitation and dry particles. Small amounts of nitrate are naturally found in groundwater. In nature, water usually contains less than 1 milligram (mg) of nitrate-nitrogen per liter and is not considered a major source of nitrate exposure. Researchers agree that naturally-occurring nitrate-nitrogen concentrations in groundwater seldom exceed 3-4 milligrams per liter (Lamond, Powell & Devlin; 1999).

How does nitrate get into groundwater?

Nitrate dissolves easily in water. When rain, snowmelt or irrigation water travels across the land, it carries nitrate (and other contaminants) with it. As this water percolates (moves downward) through the soil, it will eventually migrate to an underlying aquifer.

In addition to being soluble in water, nitrate is very stable, meaning it rarely combines with other compounds. It also does not bind to soil particles like many water contaminants do. This means nitrate will move around with groundwater and you could find a nitrate problem miles away from a potential source or years after a farm or other source for nitrate is gone.

Most nitrate that enters the groundwater comes from human (anthropogenic) sources. The improper siting, operation or maintenance of septic systems, improper manure management practices in feedlots and barnyards, and over-application of fertilizers on agricultural crops and urban/suburban lawns contribute significantly to the loading of nitrate to groundwater.

Common sources of nitrate in groundwater:

- *Septic systems*
- *Fertilizers*
- *Manure*
- *Decaying plant material*
- *Airborne nitrogen compounds from industry and automobiles*

Why is nitrate a concern in groundwater?

High levels of nitrate in drinking water are associated with adverse health effects. Of particular concern are persons using private/domestic (non-public) wells that receive little or no water quality monitoring. Without monitoring, users may not realize they are being exposed to high nitrate levels.

High nitrate levels found in drinking water may also indicate the presence of other types of contaminants such as coliform bacteria, viruses, and other human pathogens as well as pesticides.

Nitrate levels in the Gallatin Valley

Overall, nitrate levels in the valley are below the federal MCL of 10 mg/L. There are isolated areas with levels ranging from 5-10 mg/L and a few areas where it is above the MCL standard.

Of the 282 wells sampled in the Gallatin Valley in 2010 and 2011 through the Well Educated Program, only 4 exceeded the drinking water standard for nitrate. Nitrate values ranged from 0-12.2 mg/L with an average of 2 mg/L. (MSU-Extension Water Quality Well Educated Program).

Did you know…

Groundwater wells supply most residents of Gallatin County with their drinking water. The exception is the City of Bozeman, which relies mostly on surface water, with only a small percentage of supplied by a groundwater spring.

What are the health effects from high nitrate?

Health effects and symptoms in infants:

Infants under six months of age are at risk of nitrate poisoning, called **methemoglobinemia**. Toxic effects occur when bacteria in the infant stomach convert nitrate to more toxic nitrite. When nitrite enters the bloodstream, it interferes with the body's ability to carry oxygen to the body tissues. Symptoms include shortness of breath and blueness of the skin around the eyes and mouth (blue-baby syndrome). Infants with these symptoms need
immediate medical care since the condition can lead to coma and eventually death. As an additional precaution, nursing mothers may want to avoid drinking water high in nitrate.

Health effects and symptoms in children and adults:

Children over six months old and adults are not susceptible to methemoglobinemia because they have enough stomach acid to inhibit the growth of the bacteria that cause it. In healthy adults and children, ingested nitrate is excreted rapidly in the urine.

Some scientific studies suggest a linkage between high nitrate levels in drinking water with birth defects and certain types of cancer. Further long-term scientific studies are needed to determine direct linkages. According to the EPA, long-term exposure to water with high nitrate levels can cause diuresis (excessive discharge of urine), increased starchy deposits, and hemorrhaging of the spleen. People with heart or lung disease, reduced gastric acidity, certain inherited enzyme defects (ie, methemoglobin reductase) cancer, and women who are pregnant may be more susceptible to the toxic effects of nitrate than others.

Are there standards or regulations for nitrate in groundwater?

A maximum contaminant level (MCL) of 10 mg/L (milligrams per liter) has been established by the U.S. Environmental Protection Agency for nitrate in drinking water. This is a health-based standard set because of the health risk to infants. The standard applies to all public water systems (municipalities and community water systems) and is used as an advisory for private wells. Public water supply systems are required to test for various contaminants, including nitrate, on a regular basis. There are no testing regulations for private wells.

How and where do I test for nitrate?

The only way to know if drinking water is contaminated with nitrate is to have it tested. For homes on a private well, it is the homeowner's responsibility to have their water tested. The Gallatin Local Water Quality District (GLWQD) recommends that homeowners test their wells for nitrate (and bacteria) on an annual basis at a minimum. If there are infants less than six months of age and/or pregnant women in the household, the homeowner may want to consider testing the water more frequently.

There are numerous certified laboratories in Montana that can test your drinking water for nitrate as well as other water quality parameters. For a complete listing of laboratories, to obtain the required sampling bottles, and sample collection instructions, contact the GLWQD at (406) 582-3168. You can also visit our website at www.glwqd.org to download our fact sheets on *certified laboratories* and *how to collect a water sample*.

My water is high in nitrate…now what?

If the nitrate concentration exceeds the MCL of 10 mg/L, do not give the water to any infant under six months of age, either directly or in formula. Give them water from a source that has been tested to meet the nitrate standard. Commercially bottled water is required to meet the nitrate standard and is fine for infants, but is expensive and wasteful. A point-of-use treatment system is often a better long-term option.

An alternative supply is also a possible solution, such as relocating or deepening a well.

Water Treatment Systems

Reverse osmosis, ion exchange and distillation are types of water treatment systems that can remove nitrate. Carbon adsorption filters, mechanical filters of various types, and standard water softeners do not remove nitrate.

Can I boil my water to reduce or eliminate nitrate levels to a safe amount?

NO! Boiling will actually increase the concentration of nitrates due to evaporation of the water.

Reverse Osmosis . Pressure is used to force water through a semi-permeable membrane, filtering out most impurities. According to manufacturers' literature, 85-95% of nitrate can be removed. Actual removal rates may vary, depending on the initial quality of the water, the system pressure, and water temperature.

Ion Exchange. Special anion exchange resins are used that exchange chloride ions for nitrate and sulfate ions in the water as it passes through the resin. Since most anion exchange resins have a higher selectivity for sulfate than nitrate, the level of sulfate in the water is an important factor in the efficiency of an ion exchange system for removing nitrates. **Disposable mixed-bed deionizers** is an ion-exchange process where virtually all the dissolved ions in the water can be removed. This type of system uses both anion and cation exchange resins.

Distillation. The process involves boiling the water, collecting and condensing the steam via a metal coil and removes nearly 100% of the nitrate.

To find a water treatment company, look up "Water Purification and/or Treatment" online or in the phone book and call them to discuss which treatment types will work best for you. Remember, there is no fool-proof way of knowing when any treatment system may fail. Therefore, installing a home water treatment system does not mean regular water testing can be discontinued. There are pros and cons to each type of treatment system, and no single system will correct all water quality problems.

Recommendations if nitrate level exceeds 10 mg/L:

- *Do not give the water to infants less than 6 months of age or use it to prepare baby formula.*
- *Avoid drinking the water during pregnancy.*
- *Do not boil the water for drinking; this will actually increase the nitrate level by concentrating it.*
- *Seek medical help immediately if an infant shows symptoms of methemoglobinemia.*
- *Identify the nitrate source and then remove/reduce it.*
- *Individuals with chronic health problems which increase sensitivity to nitrate should limit or stop daily intake of the water.*
- *Limit your daily intake if you are concerned about the scientific uncertainty for long-term exposure.*

Reduce the risk of nitrate contamination to your well

The risk of groundwater contamination from nitrate depends upon a couple of factors: nitrogen input to the land surface and the aquifer's vulnerability to nitrate leaching and accumulation (usually based on soil properties; i.e., well-drained soils or poorly drained soils).

Conduct an inventory of your property: Identify and remove sources of nitrate near your well. Fertilizers, animal waste and sewage systems should be located and managed so they do not contaminate the well. If a nitrate source is too close to the well and cannot be moved, then you may need to install a household water treatment system designed to remove nitrate or hire a licensed well contractor to permanently seal and abandon your existing well and have a new well drilled in a different location and/or to a deeper depth.

Proper well location: Wells should be located upgradient (uphill) and at least 100 feet away from septic systems (drainfield and tank).

Proper well construction: Make sure your well casing extends above the ground surface (18 inches is recommended). Construct an earth berm around the well to divert surface water runoff away from the wellhead. For more well tips see the GLWQD fact sheet, *Top 10 Well Maintenance Tips*.

Maintain your septic system: A failing or improperly maintained septic system is unable to properly treat human waste which can lead to higher concentrations of nitrate and other water contaminants entering an aquifer. Good septic system care includes: Having your tank pumped on a regular basis by a licensed contractor. Don't drive vehicles over your drainfield or tank. Avoid planting trees and shrubs near the drain pipes or drainfield as the roots can clog the lines. Do not dispose of chemicals or non-biodegradable materials in your toilet or drain.

Reduce your use of garden and lawn fertilizers: Use only when necessary and according to the manufacturer's application instructions. More is not better!

Factors that put your well at risk:

- *Shallow well depth (less than 100 feet deep)*
- *Well is in an area with highly porous, sandy soils*
- *Improperly constructed or maintained well*
- *Improperly maintained septic system*
- *Immediately down-gradient of an animal feedlot, barnyard, high-density septic system area, or a septic "sludge" application site.*
- *Improper/overuse of fertilizers on the property*

Groundwater moves slowly, so it can take years for nitrate to reach a well. A well that tests safe for nitrate today could show contamination in the future.

Additional Resources:
Gallatin City-County Environmental Health Department, 215 W. Mendenhall, Rm 108, Bozeman. (406) 582-3120. www.gallatin.mt.gov
EPA Safewater Page: www.epa.gov/safewater/contaminants/dw_contamfs/nitrates.html
World Health Organization: http://www.who.int/water_sanitation_health/dwq/chemicals/nitratenitrite_background.pdf
NSF International, Home Water Treatment: http://www.nsf.org/consumer/drinking_water/dw_treatment.asp?program=WaterTre

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