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Nitrate in Private Water Wells

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Nitrate (NO_3) is a naturally-occurring form of nitrogen found in soil, is very water soluble, and is not retained in the soil. Nitrogen is necessary for all forms of life, and many crops require large quantities to sustain high yields. Nitrate forms when microorganisms break down fertilizers, decaying plants, manures, or other organic materials. Plants take up the nitrate, but sometimes rain or irrigation water can leach them directly into groundwater. Although nitrate occurs naturally in some groundwater, in many cases higher levels are associated with human activities. Nitrate is one of the most common groundwater contaminants in rural areas.

- Nitrate is a colorless, odorless, and tasteless compound that is present in some groundwater in Arizona.
- Nitrate can be expressed as either NO_3(nitrate) or NO_3-N (nitrate-nitrogen).
- Nitrate levels above the U.S. Environmental Protection Agency (EPA) maximum contaminant level (MCL) of 10 mg/L NO_3-N or 45 mg/L NO_3 may cause methemoglobinemia (blue baby syndrome) in infants.
- Nitrate can be naturally occurring or as a result of human sources.
- Proper management of fertilizers, manures, septic systems, and other nitrogen sources can minimize contamination of drinking water supplies.

Is nitrate a natural part of the environment?

The formation of nitrate is an integral part of the nitrogen cycle in our environment. In moderate amounts, nitrate is a harmless constituent of food and water. Plants use nitrate and other forms of nitrogen from the soil to satisfy nutrient requirements and may accumulate nitrate in their leaves and stems. Due to its high mobility, nitrate also can leach into groundwater.

What are common sources of nitrate?

- fertilizers and manure,
- animal feedlots,
- municipal wastewater and sludge,
- septic systems, and
- N-fixation from atmosphere by legumes, bacteria, and lightning.

What are the health effects of nitrate?

Healthy adults can consume fairly large amounts of nitrate with few known health effects. In fact, most of the nitrate we consume is from our diets, particularly from raw or cooked vegetables. This nitrate is readily absorbed and excreted in the urine. However, prolonged intake of high levels of nitrate are linked to gastric problems due to the formations of nitrosamines. Nitrosamines are a compound formed by the combination of amines and nitrates or nitrites. This conversion can occur in an acid environment such as the stomach. Nitrosamines have been found to be carcinogenic in laboratory animals.

High nitrate levels in water can cause methemoglobinemia or blue baby syndrome, a condition found especially in infants under six months. The stomach acid of an infant is not as strong as in older children and adults. This causes an increase in bacteria that can readily convert nitrate to nitrite (NO_2). Do not let infants drink water that exceeds 10 mg/L NO_3 -N. This includes formula preparation.

Nitrite is absorbed in the blood, and hemoglobin (the oxygen-carrying component of blood) is converted to methemoglobin. Methemoglobin does not carry oxygen efficiently. This results in a reduced oxygen supply to vital tissues such as the brain. Methemoglobin in infant blood cannot change back to hemoglobin, which normally occurs in adults. Severe methemoglobinemia can result in brain damage and/or death.

Pregnant women, adults with reduced stomach acidity, and people deficient in an enzyme that changes methemoglobin back to normal hemoglobin are all susceptible to nitrite-

induced methemoglobinemia. The most obvious symptom of methemoglobinemia is a bluish color of the skin, particularly around the eyes and mouth. Other symptoms include headache, dizziness, weakness, or difficulty in breathing. Take infants exhibiting the above symptoms to the hospital emergency room immediately. If recognized in time, methemoglobinemia is treated easily with an injection of methylene blue.

Reports of methemoglobinemia are extremely rare. Clinical infant methemoglobinemia was first recognized in 1945. About 2,000 cases were reported in North America and Europe by 1971. Fatality rates were reported to be approximately 7 to 8 percent. From 1960 to 1972, however, only one death from blue baby syndrome was documented.

Methemoglobinemia has not been reported where water contains less than 10 mg/L of NO_3-N. This level has been adopted by the EPA as the standard in the Primary Drinking Water Regulations, chiefly to protect young infants.

What is the drinking water standard for nitrate?

Nitrate values are commonly reported as either nitrate (NO_3) or as nitrate-nitrogen (NO_3-N). The maximum contaminant level (MCL) in drinking water as nitrate (NO_3) is 45 mg/L, whereas the MCL as NO_3-N is 10 mg/L. An MCL is the highest level of a contaminant that is allowable in public drinking water supplies by the EPA. Nitrate values may also be reported in ppm (parts per million), which is equivalent to mg/L. Be sure you know which value is reported for your water sample.

How do I know if there is nitrate in my drinking water?

Because nitrate is odorless and colorless, the only way to determine if you have nitrate in your private well water is to have it tested. Well water should be tested every year for nitrate. Contact a state certified laboratory before you collect your water sample; they will have specific instructions on how to collect, store, and transport the sample. A test will cost approximately $12-$20. Use a laboratory certified by the Arizona Department of Health Services, Bureau of State Laboratory Services [contact information: 3443 N. Central Avenue, Suite 810, Phoenix, AZ 85012-2208; (602) 255-3454; (602) 255-3463 FAX; **http://azdhs.gov/lab/index.htm].** Refer to fact sheet *Well Water Testing and Understanding the Results* for more information.

Laboratory results will be compared to the MCL, and recommendations for treatment should be considered if nitrate levels exceed 10 mg/L NO_3-N. Be aware that nitrate levels in groundwater may vary seasonally. If your water tests high or borderline high, retest your water every three to six months.

How do I treat nitrate-contaminated drinking water?

If a water test indicates the presence of elevated nitrate or nitrate-nitrogen levels, you have several choices: obtain an alternate water supply, connect to a public water supply if available, or use a home treatment method to remove or reduce the contaminant.

You should determine if any practices in and around the home or property could be contributing to the elevated contaminant levels in groundwater. These include: lawn and garden fertilizer use, location of animal pens and waste, compost piles, septic system operation and maintenance, cesspools, or leaky sewer pipes. Take necessary steps to address these potential sources.

• Alternate Water Supply

It may be possible to obtain an alternate water supply by installing a new well in a different location or a deeper well in a different aquifer (water-bearing, saturated zone beneath the earth's surface). If the nitrate-contaminated water supply is coming from a shallow groundwater source, there may be an uncontaminated, deeper aquifer protected by an impervious layer that prevents the downward movement of the contaminated water. A new well should be constructed to allow surface water to drain away from it, preventing surface water from entering and potentially contaminating the well. Locate the new well up-slope and at an adequate distance away from any potential sources of contamination, such as septic systems, feedlots, animal pens, or underground fuel tanks.

Purchasing bottled water for cooking and drinking is another option for an alternative source of drinking water. This source may be expensive over the long-term, and you will need to weigh the cost of this versus installing a new well or a treatment system.

• Home Treatment Methods

Three home water treatment systems can remove or reduce nitrate from drinking water: distillation, reverse osmosis, or ion exchange.

- **Distillation** boils the water, catches the resulting steam, and condenses the steam on a cold surface (a condenser). Nitrate and other minerals remain behind in the boiling tank.
- **Reverse osmosis** forces water under pressure through a membrane that filters out minerals and nitrate. One-half to two-thirds of the water remains behind the membrane as rejected water. Higheryield systems can use water pressures in excess of 150 psi.
- **Ion-exchange** uses another substance, such as chloride, to trade places with nitrate. An ion exchange unit is filled with special resin beads that are charged with chloride. As water passes over the beads, the resin takes up nitrate in exchange for chloride. As more water passes over the resin, all the chloride is exchanged for nitrate. The resin is recharged by backwashing with a sodium chloride solution. The backwash solution, which is high in nitrate, must be properly disposed of.

Blending is another method to reduce nitrate in drinking water. Mix water high in nitrate with nitrate-free water or water with low nitrate levels from another source to lower the final nitrate concentration. Blended water is not safe for infants but is acceptable for livestock and healthy adults.

Charcoal filters and water softeners do not adequately remove nitrate from water. Boiling nitratecontaminated water does not

make it safe to drink and actually increases the concentration of nitrate. Refer to fact sheet *Water Facts: Home Water Treatment Options* (AZ1498) for more information.

How do I protect my drinking water?

The 1990 EPA National Survey of Drinking Water Wells found that approximately 57 percent of the private wells tested contained detectable levels of nitrates. However, only 2.4 percent exceeded the EPA maximum contaminant level.

Protecting your drinking water supply from contamination is important for health reasons and to protect property values and minimize potential liability. High nitrate levels often are associated with poorly constructed or improperly located wells. Locate new wells uphill and at least 100 feet away from feedlots, septic systems, barnyards, and chemical storage facilities. Properly seal or cap abandoned wells.

Manage non-point sources of water pollution (fields, lawns) to limit the loss of excess water and plant nutrients. Match fertilizer and irrigation applications to crop needs in order to minimize groundwater contamination.

Summary

You can protect your private well by paying careful attention to what you do in and around your home and property (as well as your neighbor's activities near your well). Regular testing and adopting practices to prevent contamination can help ensure that your well supplies you and your family with good quality drinking water. For more information on well protection, see the fact sheet *Private Well Protection* (AZ1486e).

Sampling for Nitrate

A sample is meant to represent the entire volume of water from which it is drawn. It is important to collect, store, and transport a sample properly to avoid changing the contents in a way that alters the outcome of analysis. Before collecting a sample, be sure to contact a laboratory that is certified to analyze drinking water samples and that has experience with carrying out the analysis. It is best to obtain a sample container and instructions for how to collect the sample from the laboratory prior to collecting and submitting a sample. The laboratory can offer guidance about the best place to collect the sample in your home and should give instructions about how much water is needed and how to store the sample until it can be delivered to the laboratory. Be sure to follow instructions carefully, because a sample that is collected, stored, or delivered incorrectly could lead to misinformation about the quality of your water supply.

For Additional Information

Arizona Well Owner's Guide to Water Supply (AZ1485)

Arizona Cooperative Extension (ACE) bulletins contain a variety of information about water, water quality, safe drinking water, and private wells. They are available through your county Extension office or from CALSmart Distribution Center, located in Tucson, at 4101 N. Campbell Avenue; (877) 763-531; (520) 795-8508 FAX; or visit http://cals.arizona.edu/pubs/

References

Kendall, P. 1992. Drinking water quality. Colorado State University Extension Fact Sheet 9.307. Available at **http://www.ext.colostate.edu/pubs/foodnut/09307.html.** Accessed 27 June 2008.

Self, J.R. 1998. Domestic water quality criteria. Colorado State University Extension Fact Sheet 0.513. Available at http://**www.ext.colostate.edu/PUBS/crops/00513.html.** Accessed 27 June 2008.

Self, J.R. and R.M. Waskom. Nitrates in your drinking water. Colorado State University Extension Fact Sheet, 0.517. Available at **http://www.ext.colostate.edu/PUBS/crops/00517.html.** Accessed 27 June 2008.

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This information has been reviewed by University faculty.
cals.arizona.edu/pubs/water/az1486i.pdf

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