service in ACTION

Colorado State University Cooperative Extension

no. .517

Nitrates in drinking water

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Quick Facts

Nitrate is a colorless, odorless, and tasteless compound that is present in some groundwater in Colorado.

Nitrate can be expressed as either NO_3 (nitrate) or NO_3-N (nitrate-nitrogen). Nitrate levels above the EPA Maximum Contaminant Level of 10mg/l NO_3- N or 45 mg/l NO_3 may cause methemoglobinemia in infants.

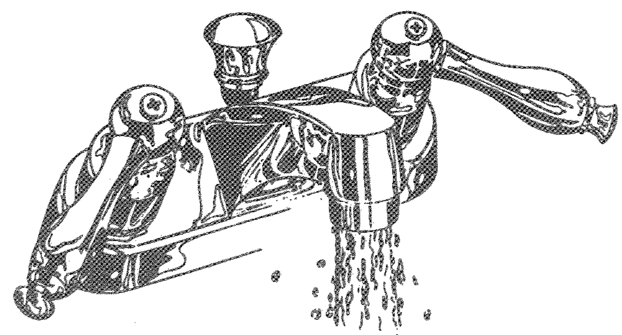
Proper management of fertilizers, manures, and other nitrogen sources can minimize contamination of drinking water supplies.

Nitrate (NO_3) is a naturally occurring form of nitrogen found in soil. Nitrogen is essential to all life, and most crop plants require large quantities to sustain high yields. The formation of nitrates 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 nitrates from the soil to satisfy nutrient requirements and may accumulate nitrate in their leaves and stems. Due to its high solubility, nitrate also can leach into groundwater. If humans or animals ingest water high in nitrate, it may cause *methemoglobinemia*, an illness especially found in infants.

Nitrates form when fertilizers, decaying plants, manures, or other organic residues are broken down by micro-organisms. Usually plants take these nitrates up, but sometimes rain or irrigation water can leach them into groundwater. Although nitrate occurs naturally in some groundwater, higher levels are thought to be the result of human activities in most cases.

Common Sources of Nitrate

- Fertilizers and manure
- Animal feedlots
- Municipal wastewater and sludge
- Septic systems
- N-fixation from atmosphere by legumes, bacteria and lightning



Health Effect of Nitrates

Humans

High nitrate levels in water can cause *methemoglobinemia* or blue baby syndrome, a condition especially found in infants under six months. The stomach acid of an infant is not as strong as older children and adults, which causes an increase in bacteria that can readily convert nitrate to nitrite (NO_2). Therefore, do not let infants consume drinking 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 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 death.

Pregnant women, adults with reduced stomach acidity, and individuals deficient in the 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 babies with the above symptoms to the

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hospital emergency room immediately. If recognized in time, methemoglobinemia is treated easily with an injection of methylene blue.

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 diet, 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. N-nitrosamine compounds have been shown to cause cancer in test animals, but studies of humans exposed to high levels of nitrate or nitrite have not provided convincing evidence of an increased risk of cancer.

Animals

Although there is no enforceable drinking water standard for livestock, do not allow animals to drink water with more than 100 mg/l NO_3-N. This is especially true of young animals that are affected by nitrates in the same manner as human babies. Older animals may tolerate levels as high as 200 mg/l NO_3-N.

Ruminant animals (cattle, sheep) are susceptible to nitrate poisoning since bacteria present in the rumen converts nitrate to nitrite. Non-ruminant animals (swine, chickens) rapidly eliminate nitrate in their urine. Horses are monogastric, but their large cecum acts much like a rumen making them more susceptible to nitrate poisoning than other monogastric animals.

It is difficult to determine the toxicity of nitrate in animals since it depends on the rate that the substance is consumed. A few hundred milligrams of nitrate may cause poisoning if consumed in a few hours. But, spread over a whole day, 1,000 mg nitrate may cause no signs of toxicity. Common symptoms include abdominal pain, diarrhea, muscular weakness, or poor coordination. Affected animals will have blood that is a chocolate-brown color. If the problem is diagnosed in time, they can fully recover with a treatment of methylene blue. Pregnant animals may abort within a few days.

Nitrate also exists in animal feeds and fodder. Drought stressed forage plants commonly have high nitrate levels. These feeds can have an additive effect when consumed with high nitrate drinking water.

The Drinking Water Standard

Reports of methemoglobinemia are extremely rare. Clinical infant methemoglobinemia was first recognized in 1945, and about 2000 cases were reported in North America and Europe by 1971. Fatality rates during that time were reported to be approximately 7 percent to 8 percent. From 1960 to 1972, however, only one death from blue baby syndrome was documented.

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

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. The MCL is the highest level of NO_3 or NO_3-N that is allowable in drinking water by the U.S. Environmental Protection Agency (EPA). These figures also may 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.

Protecting Your 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. In Colorado, nitrate contamination above the MCL occurs relatively infrequently, and mainly in agricultural areas overlying vulnerable aquifers.

Protecting your drinking water supply from contamination is important for health 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 precise crop uptake needs in order to minimize groundwater contamination.

Best Management Practices for Fertilizer Use

Careful fertilizer management can reduce nitrate leaching to groundwater. Consider the following practices in planning your fertilizer program:

1. Use soil and water analysis to determine exact nitrogen needs of crop (see Service in Action no. .500, *Soil sampling—the key to a quality fertilizer recommendation*).
2. Set a realistic yield goal for each field. Take the five-year average production of your field and add 5 percent to get an attainable yield goal.
3. Credit all sources of nitrogen available to the crop, including manures, water, organic matter, legumes, and residual subsoil nitrate.
4. Split nitrogen fertilizer into as many separate applications as feasible (see .514, *Nitrogen and irrigation management—keys to profitable yields and water quality*.)

Water Quality Analysis

Nitrate is a tasteless, colorless, and odorless compound that you cannot detect unless your water is chemically analyzed. If you drink water from a private well, get a qualified laboratory to test it yearly. The local health department or Cooperative Extension county office usually can supply the name of an approved testing laboratory in your area.

Sample water for nitrate testing at the well site or at a tap inside the house. Place samples in clean, 4 to 16-ounce plastic containers. Send the sample to a laboratory immediately. If you refrigerate the sample prior to sending, it will help the sample remain intact until it reaches a laboratory. Do not freeze the sample.

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, it is a good practice to retest your water every three to six months.

Purification of Contaminated Water

While it may be technically possible to remediate contaminated groundwater in some cases, it can be difficult, expensive and not totally effective to remove nitrates from water. For this reason, prevention is the best way to ensure clean water.

Water treatments include distillation, reverse osmosis, ion exchange, or blending. **Distillation** boils the water, catches the resulting steam, and condenses the steam on a cold surface (a condenser). Nitrates 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. Higher yield systems use water pressures of 150 psi.

Ion-exchange, takes another substance, such as chloride, and trades 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 sodium chloride solution. The backwash solution, which is high in nitrate, must be disposed of properly.

Blending is another method used to reduce nitrates in drinking water. Contaminated water can be mixed with clean water from another source to lower overall 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 nitrates from water. Boiling nitrate contaminated water does not make it safe to drink, and actually increases the concentration of nitrates. Drilling a new well to deeper water with less nitrate may be a feasible remedy in certain areas. In many cases, the most effective alternative is to utilize bottled water for drinking and cooking.

References

Additional information on water quality can be obtained from the following Service in Action sheets, published by Colorado State University Cooperative Extension:

Follett, R. H., and J. R. Self. 1989. *Domestic water quality criteria.* Service in Action .513.

Hallaway, J. 1983. *Drinking water treatment devices: filters.* Service in Action 9.728.

Hallaway, J. 1983. *Drinking water treatment devices: distillers.* Service in Action 9.729.

Kendall, P. 1991. *Drinking water quality and health.* Service in Action 9.307.

Ludwick, A. E. and P. N. Soltanpour. 1979. *Soil sampling-the key to a quality fertilizer recommendation.* Service in Action .500.

Soltanpour, P. N., I. Broner, and R. H. Follett. 1990. *Nitrogen and irrigation management-keys to profitable yields and water quality.* Service in Action .514.

Soltanpour, P. N. and W. L. Raley. *Evaluation of drinking water quality for livestock.* 1989. Service in Action 4.908.

Stanton, T. L. 1983. *Nitrate poisoning in livestock.* Service in Action 1.610.

Glossary

Blue baby syndrome: A disease that affects the oxygen carrying capacity of infant's blood, usually resulting from the consumption of high levels of NO_3. Also known as methemoglobinemia.

Contaminant: Any physical, chemical, biological, or radiological substance that degrades water quality.

Groundwater: Water that saturates subsurface formations or aquifers.

Leaching: The downward movement of dissolved or suspended minerals, fertilizers, agriculturaal chemicals, or other substances through the soil profile.

Maximum Contaminant Level (MCL): The highest amount of a specific contaminant allowed by the EPA in public drinking water supplies. These are health-based standards that by law must be set as close to the "no-risk" level as feasible.

Nitrate (NO_3): An important plant nutrient that is soluble in water and may cause health problems if consumed in large amounts.

Nitrate-nitrogen (NO_3-N): -Relates to the actual nitrogen in nitrate. Multiply NO_3-N values by 4.4 to convert to nitrate.

Non-point Source Pollution: Water contamination from diffuse sources such as agricultural fields, urban runoff, or large contruction sites.

Parts per million (ppm): A unit of proportion used to describe the concentration of a chemical in water. Equivalent to mg/l.