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G1279 Drinking Water: Nitrate-Nitrogen

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Drinking Water: Nitrate-Nitrogen

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This NebGuide discusses practices recommended to manage nitrate-nitrogen in a domestic water supply.

Many Nebraskans have questions about the impact of nitrate in their drinking water. Water quality monitoring shows that nitrate is present in groundwater throughout much of Nebraska and that concentrations are increasing in some areas.

Nitrogen is essential for all living things as it is an essential component of protein. Nitrogen exists in the environment in many forms and changes forms as it moves through the nitrogen cycle. However, excessive concentrations of nitrate-nitrogen in drinking water can be hazardous to health, especially for infants and pregnant women.

Sources of Nitrate in Drinking Water

Nitrogen is the nutrient applied in the largest quantities for lawn and garden care and crop production. Feedlots, animal yards, septic systems, and other waste treatment systems are additional sources of nitrogen. Nitrogen occurs naturally in the soil in organic forms from decaying plant and animal residues.

Bacteria in the soil convert various forms of nitrogen to nitrate, a nitrogen/oxygen ion (NO_3^-). This is desirable as the majority of the nitrogen used by plants is absorbed in the nitrate form. However, nitrate is highly leachable and readily moves with water through the soil profile. If rainfall or irrigation is excessive, nitrate will be leached below the plant's root zone and may eventually reach groundwater.

Nitrate-nitrogen (NO_3^-N) in groundwater may result from point sources such as sewage disposal systems and livestock facilities, from nonpoint sources such as fertilized cropland, parks, golf courses, lawns, and gardens, or from naturally occurring sources of nitrogen. Proper site selection for the location of domestic water wells, upslope and with adequate separation distances between wells and possible contamination sources, can reduce potential nitrate contamination of drinking water. Proper well construction and maintenance also reduces potential drinking water contamination.

Indications of Nitrate

Nitrate in water is undetectable without testing because it is colorless, odorless and tasteless. A water test for nitrate is highly recommended for households with infants, pregnant women, nursing mothers or elderly people. These groups are the most susceptible to nitrate.

Nitrate-nitrogen occurs naturally in groundwater, usually at concentrations far below a level of concern for drinking water safety. An initial test of a new water supply is needed to determine the baseline nitrate concentration. In addition, if the water supply has never been tested for nitrate, it should be tested.

Activities near the well potentially can contaminate the water supply, changing the nitrate concentration. Domestic wells near potential point sources of contamination, such as livestock facilities or sewage disposal areas, should be tested at least once a year to monitor changes in nitrate concentration. Depending on the location of the well relative to areas where nitrogen fertilizer is applied, follow-up testing to monitor changes from nonpoint sources may be conducted less often. All drinking water supplies should be checked at least every two or three years to assure that significant increases in nitrate concentrations are not occurring.

If a fertilizer or manure spill occurs, the spill should be cleaned up immediately and any wells near the spill should be tested. Unfortunately, any nitrate from the spill may not move through the soil profile quickly and annual testing is recommended to monitor the effects of the spill.

Potential Health Effects

The primary health hazard from drinking water with nitrate-nitrogen occurs when bacteria in the digestive system transforms nitrate to nitrite. The nitrite oxidizes iron in the hemoglobin of red blood cells to form methemoglobin, which lacks the oxygen-carrying ability of hemoglobin. This creates the condition known as methemoglobinemia (sometimes referred to as "blue baby syndrome"), in which blood lacks the ability to carry sufficient oxygen to the individual body cells.

Most humans over one year of age have the ability to rapidly convert methemoglobin back to oxyhemoglobin; hence, the total amount of methemoglobin within red blood cells remains low in spite of relatively high levels of nitrate/nitrite uptake. However, in infants under six months of age, the digestive system has an underdeveloped capability to secrete gastric acid, thus the pH level in the digestive system may rise. At a higher pH, bacteria levels may rise, increasing the transformation of nitrate to nitrites. In addition, the enzyme systems for reducing methemoglobin to oxyhemoglobin are incompletely developed in infants under six months of age. Thus, methemoglobinemia can occur. Older persons who have a gastrointestinal system disorder producing a pH level which allows for increased bacteria growth may be at greater risk than the general population. In addition, individuals who have a genetically impaired enzyme system for metabolizing methemoglobin are at greater risk.

In 1962, the U.S. Public Health Service adopted drinking water standards and set the recommended limit for nitrate-nitrogen at 10 mg/L. This drinking water standard was established to protect the health of infants and was based on the best knowledge available.

The Environmental Protection Agency (EPA) has since adopted the 10 mg/L standard as the maximum contaminant level (MCL) for nitrate-nitrogen in public water systems. Subsequent reviews of this standard have not resulted in any changes. However, it is difficult to establish an exact level at which nitrogen concentrations in water are safe or unsafe. The intake of nitrogen from food and other sources also is important and must be considered.

Even though the MCL for nitrate-nitrogen in drinking water is 10 mg/L, there have been cases where infants have been exposed to water with nitrate-nitrogen concentrations greater than 10 mg/L without developing methemoglobinemia. Definitive guidelines for determining susceptibility to methemoglobinemia have not been developed. Therefore, if your water contains more than 10 mg/L nitrate-nitrogen, it is advisable to use an alternate source of water for infant formula and food.

In addition, because of some reports of potential birth defects when pregnant women drank high nitrate water, pregnant women should not drink water containing more than 10 mg/L NO_3^-N. It also is recommended that nursing mothers use water that has an NO_3^-N concentration below 10 mg/L since nitrate may be passed to infants in breast milk.

Older youth and adults can tolerate higher levels of nitrate-nitrogen with little or no documented adverse health effects, and may be able to drink water with nitrate-nitrogen concentrations considerably greater than the 10 mg/L level with no acute toxicity effects. However, the potential health hazard for older youth and adults depends on the individual's reaction to nitrate-nitrogen and the total ingestion of nitrate-nitrogen and nitrates from all sources. In addition, little is known about possible long-term chronic effects of drinking high nitrate water. If your water test indicates a level of nitrate-nitrogen above 10 mg/L and only adults or older children will be drinking it, consult your family physician for a medical recommendation.

A potential cancer risk from nitrate (and nitrite) in water and food has been reported. A possibility exists that nitrate can react with amines or amides in the body to form nitrosamine which is known to cause cancer. Nitrate must be converted to nitrite before nitrosamine can be formed. The magnitude of the cancer risk from nitrate in drinking water is not known.

Bacteriological contamination in water may contribute to an individual's susceptibility to the presence of nitrate. All drinking water sources also should be tested for bacteriological contamination, particularly if the nitrate-nitrogen level exceeds the 10 mg/L standard. The presence of both nitrate and bacteriological contamination may indicate poor well location or construction, and possible contamination from surface drainage, feedlots, sewage systems, or some other source.

Testing

Tests for nitrate can be performed, for a fee, by the Nebraska Health and Human Services System Laboratory, some city/county health department laboratories and some commercial laboratories.

Select a laboratory and obtain a drinking water nitrate test kit from them. The kit will contain a sterilized sample bottle, an information form, sampling instructions, and a return mailing box. A University of Nebraska–Lincoln Extension office or Natural Resources District office can assist in obtaining a kit or directing you to a laboratory.

The sample bottle for nitrate-nitrogen testing may contain a preservative to prevent any loss of nitrate-nitrogen in the sample. **This sample bottle should not be rinsed before filling and should only be used for samples intended for nitrate-nitrogen analysis. It must be used within a 90-day period to insure validity of the analysis.**

The sampling instructions provide information on how to collect the sample. Follow these instructions carefully to avoid contamination and to obtain a representative sample. Promptly mail the sample with the completed information form to the laboratory. Take the sample on a day when it can be mailed to arrive at the laboratory Monday through Thursday. Avoid weekends or holidays which may delay the mail or lab analysis.

Although field test kits are available for measuring nitrate-nitrogen concentration, they are not as accurate as laboratory procedures. Results from field test kits can be affected by the presence of certain chemicals and by temperature variation. Laboratory testing should be used to assure the most accurate and reliable results.

Interpreting Test Results

The laboratory will report the nitrate concentration as milligrams per liter (mg/L) or as parts per million (ppm), which are equivalent for the concentrations occurring in water (1 mg/L = 1 ppm).

Most laboratories report nitrate as nitrate-nitrogen (NO_3^-N), which is the amount of nitrogen in the nitrate form. Some labs may report total nitrate (NO_3^-). Be sure to check your test report for which quantity, NO_3^-N or NO_3-, is reported. Use the following to compare the two reporting systems:

10 mg/L nitrate-nitrogen (NO_3^-N) =
44.3 mg/L nitrate (NO_3^-)

The U.S. Public Health Service recommended limit of 10 mg/L NO_3^-N in drinking water is used by the EPA as the maximum contaminant level for public water systems. Public water systems are legally defined as those that have 15 or more connections or regularly serve more than 25 persons. These systems must comply with the 10 mg/L NO_3^-N standard in order to be an approved water supply.

EPA requires regular testing of public water systems for nitrate-nitrogen and these test results are available from the supplier. If a test indicates that the nitrate-nitrogen concentration of the delivered water exceeds the standard, the public must be notified and treatment must be performed. Often, the treatment may be as simple as blending the water that exceeds the standard with water that has a nitrate-nitrogen concentration less than 10 mg/L such that the average concentration of the delivered water is below the EPA standard.

The Nebraska Safe Drinking Water Act, adopted in 1986, gave the Nebraska Health and Human Services System Department of Regulation and Licensure the responsibility for implementing the federal requirements. The 10 mg/L NO_3^-N standard applies to public water supplies and other water supplies approved by them. Individual private wells are not required to meet drinking water standards, but some lending agencies may require a Nebraska Health and Human Services System Department of Regulation and Licensure approvedwater supply before making housing loans to individuals.

Options

If excessive nitrate-nitrogen is present in your water supply, you have two basic choices: obtain an alternate water supply or use some type of treatment to remove the nitrate-nitrogen.

The need for an alternate water supply or nitrate-nitrogen removal should be established before making an investment in treatment equipment or an alternate supply. Base the decision on a nitrate analysis by a reputable laboratory, and after consulting with your physician to help evaluate the level of risk.

Alternate water supply

It may be possible to obtain a satisfactory alternate water supply by drilling a new well in a different location or a deeper well in a different aquifer, especially if the nitrate contamination is from a point source such as livestock or human wastes. If the water supply with high nitrate is coming from a shallow aquifer, there may be an uncontaminated, deeper aquifer protected by a clay layer that prevents the downward movement of the nitrate-contaminated water. A new well should be constructed so surface contamination cannot enter the well. It should be located away from any potential sources of contamination, such as septic systems, feedlots or underground fuel tanks.

The Nebraska Health and Human Services System Department of Regulation and Licensure may be able to assist in determining the cause of water contamination and make recommendations to correct the problem. In addition, the Conservation and Survey Division of the University of Nebraska–Lincoln can provide general information on the possible location of a water supply with satisfactory quality. Both are based in Lincoln but have offices at several locations across the state.

Another alternate source of water is bottled water that can be purchased in stores or direct from bottling companies. This alternative especially might be considered when the primary concern is water for infant food and drinking.

The Nebraska Department of Agriculture licenses and inspects bottling companies, but does not routinely sample bottled water. You should assure yourself of the nitrate content, general quality and bacterial quality of any water purchased. In all cases, the purchased water must be handled and stored in a manner to prevent contamination.

Treatment

Nitrate can be removed from drinking water by three methods: distillation, reverse osmosis and ion exchange. Home treatment equipment using these processes is available from several manufacturers. **Carbon adsorption filters, mechanical filters of various types, and standard water softeners do not remove nitrate-nitrogen.**

The distillation process involves heating the water to boiling and collecting and condensing the steam by means of a metal coil. Nearly 100 percent of the nitrate-nitrogen can be removed by this process. **Merely boiling water will increase rather than decrease the nitrate concentration.** Water without nitrate is obtained by collecting and condensing the steam generated as the water boils.

In the reverse osmosis process, pressure is applied to water to force it through a semipermeable membrane. As the water passes through, the membrane filters out most of the impurities. According to manufacturers' literature, from 85 to 95 percent of the nitrate can be removed with reverse osmosis. Actual removal rates may vary, depending on the initial quality of the water, the system pressure, and water temperature.

Ion exchange for nitrate-nitrogen removal operates on the same principle as a household water softener. In a standard water softener, calcium and magnesium ions are exchanged for sodium ions. However, for the nitrate removal process, 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.

All of the methods described here for the removal of nitrate are relatively expensive. Consider both the initial cost and the operating costs. Operating costs include the energy needed to operate the system, additional water that may be needed for flushing the system, consumable supplies and filters, repairs, and general maintenance.

Regardless of the quality of the equipment purchased, it will not perform satisfactorily unless it is maintained in accordance with the manufacturer's recommendations. Maintenance of the equipment may include periodic cleaning and replacement of some components. Also consider any special installation requirements that may add to the equipment cost.

Reputable water conditioning equipment dealers can assist in evaluating available equipment. Equipment should be purchased only through reputable dealers and manufacturers. This helps assure that the equipment will perform the necessary task, and maintenance and repair parts will be available when needed. Check to see if the equipment has been tested or evaluated by an independent agency.

The Water Quality Association (WQA) and the National Sanitation Foundation (NSF) both operate voluntary programs to test water treatment equipment for manufacturers. Equipment listed by WQA and NSF has been evaluated, meets the test standards requirements and normally has a label identifying the WQA or NSF testing. This independent testing provides some assurance that the manufacturers' claims have been verified.

Summary

Nitrate in drinking water can be a problem, especially for infants. A water test is the only way to determine whether the nitrate-nitrogen concentration is under the acceptable standard of 10 mg/L. Proper well location and construction are key practices to avoiding nitrate contamination of drinking water. Management practices to reduce the risk of contamination from applied fertilizers and manure help keep the water supply safe.

If drinking water exceeds the acceptable nitrate-nitrogen standard, the choices are to use an alternate water supply or treat the water. An alternate supply may be bottled water for drinking, especially for infant formula, or a new well in a different location or aquifer. Water treatment options are distillation, reverse osmosis or ion exchange.

For information on current drinking water guidelines, contact the U.S. Environmental Protection Agency Safe Drinking Water Hotline in Washington D.C. at 1-800-426-4791 or the Nebraska Health and Human Services Systems Laboratory, 3701 South 14th St., P.O. Box 275S, Lincoln, NE, 68502.

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