University of Idaho
College of Agriculture

Cooperative Extension System
Agricultural Experiment Station

Current Information Series No. 872

Quality Water for Idaho

Nitrate and Groundwater

Robert L. Mahler, Ernestine Porter and Roy Taylor

Nearly 95 percent of Idahoans rely on groundwater as their source of drinking water. Nationally, groundwater provides about 50 percent of drinking water. Thus, protection of groundwater from contamination by any substance that might cause health problems is a serious concern.

One potential groundwater contaminant is nitrate (NO_3). In general, recent surveys in Idaho have found very few rural water wells with nitrate levels higher than the National Public Health Service drinking water standard.

Health Concerns

Human — Humans ingest nitrate in food and water. In older children and adults, nitrate is ingested, absorbed from the digestive tract and excreted rapidly in the urine. Healthy human adults can consume fairly large amounts of nitrate with little if any known short-term adverse effects. The health effects of chronic, long-term consumption of high levels of nitrate are uncertain. They are the subject of several current research studies.

Infants younger than 6 months are believed to be susceptible to nitrate poisoning. Bacteria present in their digestive systems at birth can change nitrate to toxic nitrite (NO_2). Newborn infants have little acid in their digestive tracts, and they depend on these bacteria to help digest food. Generally, by the time infants reach 6 months, hydrochloric acid levels increase in their stomachs and kill most of the bacteria that convert nitrate to nitrite.

Once formed, the nitrite is absorbed and enters the bloodstream. There it reacts with the oxygen-carrying hemoglobin to form a new compound called methemoglobin. This compound interferes with the blood's ability to carry oxygen. As oxygen levels decrease, babies may show signs of suffocation. This condition is called "methemoglobinemia."

The major symptom of methemoglobinemia is bluish skin color, most noticeably around the eyes and mouth. Death can occur when 70 percent of the hemoglobin has been converted to methemoglobin. Treatment must begin quickly.

Infant deaths from methemoglobinemia, sometimes called "blue baby syndrome," are rare. Some documented deaths have been linked to high levels of nitrate in well water. Doctors now recommend using bottled water to make formula when nitrate levels exceed the U.S. Public Health Service drinking water standard of 10 parts per million (ppm NO_3-N).

Nitrate may also interact with organic compounds (secondary amines) to form N-nitrosamines, which are known to cause cancer. Many organic compounds could link with nitrate to form N-nitrosamines, including some pesticides. This may be important because wells with high nitrate levels are often vulnerable to pesticide contamination. Neither the immediate nor the chronic health effects of N-nitrosamines in humans are well understood.

Livestock — Nitrate poisoning is most likely to occur in ruminant animals such as cattle and sheep. Bacteria in the rumen convert nitrate to toxic nitrite. Monogastric animals such as swine and chickens have no rumen. Most nitrate is rapidly eliminated in their urine.

Although some plants naturally contain potentially harmful levels of nitrate, water rarely does. High-nitrate water is generally a health hazard to animals only when used with high-nitrate feeds.

Symptoms of methemoglobinemia in animals include lack of coordination, labored breathing, blue coloring of mucous

Guidelines for use of water with known nitrate content.

Nitrate-Nitrogen (NO_3-N)	Nitrate (NO_3)	Interpretation*
(ppm)	(ppm)	
0 to 10	0 to 44	Safe for humans and livestock.
11 to 20	45 to 88	Generally safe for human adults and livestock. Do not use for human infants.
21 to 40	89 to 176	Short-term use acceptable for human adults and all livestock unless food or feed sources are very high in nitrate. Long-term use could be risky. Do not use for human infants.
41 to 100	177 to 440	Moderate to high risk for human adults and young livestock. Probably acceptable for mature livestock if feed is low in nitrate. Do not use for human infants.
over 100	over 440	Do not use.

*Interpretations are primarily based on short-term effects. Chronic, long-term risks are not fully understood.

22

membranes, vomiting and abortions. Dairy cows may produce less milk without showing any physical symptoms. If animals show signs of nitrate poisoning or a problem is suspected, consult a veterinarian to determine if nitrate is the problem and, if necessary, to administer an antidote.

Water Testing

If nitrate is suspected in drinking water of humans or livestock, begin a routine water sampling and testing program to monitor nitrate levels. Nitrate is detectable in water only by chemical testing. It is colorless, odorless and tasteless. In Idaho, the Department of Health and Welfare, the University of Idaho and several private testing laboratories can test for nitrate.

Most laboratories usually report nitrate content in parts per million (ppm) of nitrate-nitrogen (NO_3-N). Occasionally a lab will report results in ppm NO_3. To interpret the results, you must know the form in which they are reported. To convert NO_3-N to NO_3, multiply by 4.4. For example, 10 ppm NO_3-N equals 44 ppm NO_3.

Nitrates in Groundwater

Even though naturally occurring and introduced nitrate is a common groundwater contaminant in the United States, the severity of nitrate contamination is hard to assess. Researchers agree that nitrate concentrations in unpolluted groundwater seldom exceed the National Public Health Service 10 ppm NO_3-N standard. Recent United States Geological Survey data show that almost every state has areas where nitrate levels exceed the standard. However, a recent Environmental Protection Agency study found that only 2.7 percent of rural wells exceeded the standard. Several recent studies in the Great Plains and Midwest have found localized areas where nitrate concentrations in groundwater have been increasing.

Sources of Nitrate in Groundwater

Cultivated soil usually contains between 1,500 and 4,000 pounds of organically bound nitrogen per acre. Plants are unable to use organic nitrogen directly. But as organic matter decomposes, it releases nitrogen in forms plants can use, primarily as nitrate (NO_3). This conversion of organic nitrogen into inorganic, plant-available forms occurs in natural ecosystems (forest or grassland, for example) as well as in agriculture.

The forms of organic nitrogen fertilizers used in agriculture include animal manures, human wastes, composts, sewage sludge, legume crops and green manure crops. Chemical nitrogen fertilizers contain inorganic nitrogen, usually as nitrate and/or ammonium (NH_4).

Plants do not necessarily use all the nitrate in chemical fertilizers or all the nitrate produced when organic matter decomposes. When the nitrogen supply is greater than the amount plants use, nitrate can accumulate in the soil and be lost from the system. In today's agriculture, with greater nitrogen inputs for higher crop yields, efficiencies of nitrogen use may be lower and the potential for losses may increase.

In some natural ecosystems, nitrogen is almost always in short supply, and little is lost from the system. But in other natural ecosystems, nitrogen is abundant and the potential for loss is high.

Nitrate can be lost from the system in a variety of ways. From the standpoint of groundwater quality, leaching into groundwater is the only concern. Leaching is the downward movement of water and nitrate through the soil. The potential for nitrate leaching varies with soil type and amount of water in precipitation or irrigation. For example, sandy soils under high precipitation or irrigation have a high leaching potential.

Because the downward movement of nitrate through soils was taking place even before the presence of humans, it is unrealistic to expect to stop it entirely. However, careless use of fertilizer and improper management of other nitrogen sources can increase the rate of movement and the magnitude of loss. They must be avoided.

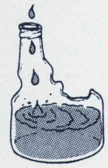
Summary

Both nature and people can be responsible for nitrate found in groundwater. Of the human activities that contribute nitrate, agriculture, garbage disposal and human waste disposal are by far the largest sources. Society's alteration of the environment to produce food and to dispose of wastes has likely resulted in increased rates of nitrate movement in soil and in greater nitrate losses to groundwater. Farmers and other individuals can use management practices to minimize the leaching of nitrate from soils without severe economic consequences.

Whatever the source of nitrate, we need to be concerned about minimizing its movement into our groundwater. Although we do not have a complete picture of groundwater contamination by nitrate, we do know the problem is growing.

The Authors — Robert L. Mahler is soil scientist and Extension water quality coordinator, Ernestine Porter is Extension textiles and clothing specialist and Roy Taylor is Extension agricultural engineer, all in the University of Idaho College of Agriculture, Moscow.

Adapted from Kansas State University Cooperative Extension Service Bulletin MF-857.



This publication is one of a series on water quality issues produced by the University of Idaho Cooperative Extension System for the people of Idaho. The material is based upon work supported by the U.S. Department of Agriculture, Extension Service, under special project number 90-EWQUI-1-9216.

Issued in furtherance of cooperative extension work in agriculture and home economics, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, LeRoy D. Luft, Director of Cooperative Extension System, University of Idaho, Moscow, Idaho 83843. We offer our programs and facilities to all people without regard to race, creed, color, sex, handicap or national origin.

8,000, September 1990

Printed with special grant funds from USDA