Minnesota Pollution Control Agency

Nitrates in Minnesota's Ground Water

Ground Water/August 1998

G W M A P

Ground Water Monitoring and Assessment Program

What is nitrate?

Nitrogen is a common element in air, water and soil. Nitrogen combined with three atoms of oxygen forms nitrate. Nitrate is the primary form of oxidized nitrogen in ground water. It is soluble (dissolves in) ground water and may be found in high concentrations, if there is a nearby source of nitrate and oxygen is present. If there is no oxygen, bacteria in the soil use the nitrate as a food source, releasing nitrogen gas.

What are sources of nitrate in ground water?

The main source of nitrogen in soil is through interaction with the atmosphere, which is about 78 percent nitrogen by volume. Small amounts of nitrate occur naturally in ground water as a result of atmospheric nitrogen contained in precipitation and minerals found in soils and rock. Most nitrate which enters ground water comes from anthropogenic (human-derived) sources such as atmospheric deposition of nitrous oxides associated with the combustion of coal and gas, land application of animal manure at farms, and application of fertilizers to agricultural crops and urban yards. Over-application of fertilizer, improper manure management practices, and improper operation and maintenance of septic systems can contribute significantly to the loading of nitrate to ground water.

What forms of nitrate are present in ground water?

Because most ground water contains oxygen, various forms of nitrogen such as nitrogen gas, ammonia and nitrite are usually converted to nitrate. However, in the absence of oxygen (reducing conditions), ammonia can be a concern if there are direct sources of ammonia available to ground water. Nitrate and ammonia can occur together in reducing waters when a source of nitrogen is nearby, such as a leaking waste lagoon, a poorly-managed feedlot, or a failed septic system.

What is considered a safe level of nitrate in ground water?

The Minnesota Department of Health has established a Health Risk Limit (HRL) of 10 milligrams per liter (parts per million, or ppm) of nitrate nitrogen in ground water. An HRL is the concentration of a contaminant in ground water that is safe to ingest daily over a lifetime. The primary concern for ingesting ground water high in nitrates is with infants under six months old. The toxic effects of nitrates in infants occur when bacteria in the stomach convert nitrate to more toxic nitrite, which reduces the capability of the blood to carry oxygen to the tissues, resulting in “blue baby syndrome” (methemoglobinemia). Most children over six months old and adults have enough stomach acid to inhibit growth of the bacteria which can cause the disease. For more information on health concerns associated with nitrate and treatment of water supplies to reduce nitrate concentrations, see the Minnesota Department of Health fact sheet, *Nitrate in Drinking Water*.

Minnesota Pollution Control Agency, 520 Lafayette Road North, St. Paul, MN 55155-4194
(651) 296-6300, toll-free (800) 657-3864, TDD (651) 282-5332

How is nitrate distributed in Minnesota ground water?

Nitrate exceeded the HRL of 10 ppm in just over three percent of wells sampled in GWMAP's statewide baseline network of 954 wells. Aquifers with over five percent exceedances include the Prairie du Chien (5.6 percent), the surficial drift (5.7 percent), and the Cretaceous (7.7 percent). None of the exceedance rates was greater than ten percent and nearly all wells which exceeded the HRL were determined to be sensitive to nitrate contamination. The overall median value for samples from wells determined to be nitrate stable was 0.51 ppm. Nitrate concentrations were greatest in the water table aquifer and lowest in the Devonian aquifer. Background concentrations of nitrate in oxygenated aquifers range from less than 0.5 to about 1.5 ppm for most aquifers; in oxygen-deficient aquifers, nitrate averages less than 0.1 ppm.

Which aquifers are most sensitive to nitrate contamination?

Oxygenated aquifers in which there is a nitrogen source are sensitive to contamination with nitrate. This is because bacteria which use nitrate to metabolize (eat) organic matter die when oxygen is present in ground water. Once oxygen is gone, bacteria use nitrate and its concentration in ground water decreases rapidly. Aquifers most likely to be oxygenated, and therefore sensitive to nitrate contamination, include surficial sand and gravel aquifers, karst (limestone) aquifers, and fractured bedrock aquifers close to the surface.

The following general guidelines can be used in assessing aquifer sensitivity to nitrate contamination:

- High sensitivity: a source of nitrogen, presence of oxygen, low iron and manganese concentrations.
- Low sensitivity: no source of nitrogen, absence of oxygen, high iron and manganese concentrations.
- Transition: a source of nitrogen, absence of oxygen; sensitivity of these aquifers will depend on the quantity of nitrogen inputs.

What are some management strategies for reducing risks from nitrate?

There are two primary management strategies for reducing nitrate risk. The first is to minimize inputs of nitrogen into shallow ground water. This is accomplished by implementing best management practices (BMPs). Some BMPs include:

- applying fertilizer at recommended rates;
- accounting for nitrogen credits associated with manure; and
- sound planning and zoning to minimize nitrogen inputs from unsewered developments.

The second management strategy is aquifer protection, which includes identifying sensitivity of an aquifer throughout its vertical extent. If portions of an aquifer are not sensitive to contamination by nitrate, they should be protected by preventing activities which may make them more sensitive, such as installing high capacity wells or having poorly designed or constructed wells drilled into these portions of the aquifer. Drinking water wells should be completed in these non-sensitive portions of the aquifer to prevent exposure to nitrates. This may mean that the well will have a higher iron or manganese content than if the well were completed in a sensitive portion of the aquifer. Long-term monitoring networks can be established to check for iron and other chemical parameters to help ensure that these portions of the aquifer remain non-sensitive.

For more information about nitrate in Minnesota ground water, or to request other fact sheets in this series, contact:

GWMAP

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Minnesota Pollution Control Agency
520 Lafayette Road N.
St. Paul, MN 55155-4194
toll-free/TDD (800) 657-2864

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