Minnesota Pollution Control Agency

Nitrate in Minnesota Ground Water: A GWMAP Perspective

Ground Water/September 1998

G W M A P

Ground Water Monitoring and Assessment Program

Nitrate is probably the most widespread anthropogenic (human-made) chemical of concern in ground water. There are many anthropogenic sources of nitrate, including animal waste and fertilizer. In addition, human activities such as cultivation and combustion of fossil fuels may lead to increased nitrate in ground water. The drinking standard for nitrate is 10 parts per million (ppm). Drinking water exceeding this standard is considered unsafe for infants up to 6 months of age.

The Minnesota Pollution Control Agency's Ground Water Monitoring and Assessment Program (GWMAP) has collected ground-water quality information since 1991. Most of the GWMAP's nitrate data comes from two recently completed studies. The first, called the baseline study, was designed to assess chemical concentrations, including nitrate, in the principal aquifers of Minnesota. The second study is an on-going effort in the St. Cloud area to determine the effects of land use on ground water quality.

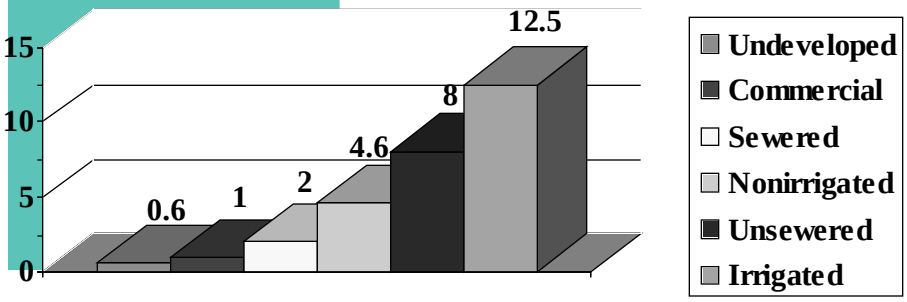
Results from these two studies were used to:

- determine background concentrations of nitrate in the state's principal aquifers and under different land uses;
- identify factors resulting in elevated concentrations of nitrate and increased risk to people using affected drinking water;
- attribute causes to these instances of increased concentration or risk.

This fact sheet contains a summary of nitrate results from the two studies. A comprehensive discussion of nitrate in Minnesota ground water, using GWMAP information, is presented in a report titled *Nitrate in Minnesota Ground Water - A GWMAP Perspective*. Information from the baseline and land-use studies may be found in *Baseline Water Quality of Minnesota's Principal Aquifers* and *Effects of Land Use on Ground Water Quality - St. Cloud Area, Minnesota,* respectively.

What are background concentrations of nitrate?

Nitrate will be converted to nitrogen gas when oxygen is absent in ground water. This process, called denitrification, usually occurs deeper in an aquifer (more than 50 feet below the top of the aquifer). Concentrations in deep ground water are very low, less than 0.1 part per million (ppm). Near the top of an aquifer, where oxygen is present, concentrations are much higher. In ground water not affected by humans, nitrate concentrations in shallow ground water will be about 0.5 to 0.7 ppm. Typical concentrations in commercial, sewered residential, nonirrigated agriculture, unsewered residential, and irrigated agricultural land uses are approximately 1.0, 2.0, 4.6, 8.0, and 12.5 ppm, respectively (see figure, left).



What factors affect nitrate concentrations in shallow ground water?

In shallow ground water, where oxygen is usually present, the primary factor affecting the concentration of nitrate in ground water is the amount of nitrogen available for leaching from

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soil. This means that nitrate concentrations differ between land uses because more nitrogen is available to be leached under certain land uses. In the land-use study, concentrations of nitrate in shallow ground water followed the pattern : irrigated agriculture > unsewered residential > nonirrigated agriculture > sewered residential = commercial > undeveloped. Bedrock aquifers, such as the Prairie du Chien, St. Peter and Jordan aquifers, are less likely to have conditions favorable for accumulation of nitrates if the depth to bedrock is great. Sand and gravel aquifers are less likely to have conditions favorable for accumulation of nitrates if there is organic carbon (food) for microbes to use. All aquifers are less likely to have conditions favorable for accumulation of nitrates if confining layers are thick.

What factors lead to the disappearance of nitrate in ground water?

The two most important causes of nitrate disappearance in ground water are dilution and biological transformation. Dilution can be an effective means of reducing nitrate concentration only if additional nitrate is not leached into ground water. Biological transformations occur once oxygen is used up by microbes. Nitrate is then used by microbes in a manner similar to oxygen. The land-use and baseline studies both indicate that nitrate decreases with depth in the upper 70 feet of an aquifer.

What are the risks from nitrate in ground water?

The Health Risk Limit for nitrate is 10 ppm. Factors which lead to a greater likelihood of exceeding this drinking criteria include:

- poor well construction, which leads to direct leaching of nitrates and oxygen-rich water;
- land use, with much greater potential risk in irrigated agricultural settings and moderate increase in potential risk in unsewered settings; and
- the type of aquifer, with shallow sand and gravel aquifers, bedrock aquifers located near the land surface (e.g. eastern portions of the Prairie du Chien aquifer), and fractured bedrock near the land surface (e.g. shallow Cretaceous or Precambrian wells) having increased likelihood of exceeding drinking criteria.

What are the implications for managing nitrates in ground water?

Shifts in land use may lead to significantly greater nitrate concentrations and potential risk to drinking water users. Ground water assessments should be conducted when the following land-use changes occur:

- nonirrigated to irrigated;
- residential development within irrigated agriculture;
- unsewered residential development;
- conversion of undeveloped land to agriculture or unsewered residential.

A ground water assessment includes three components:

- using geochemical information to assess aquifer nitrate susceptibility;
- conducting predictive modeling and assessing sensitivity of physical, chemical, and land-use factors on nitrate distribution in ground water; and
- estimating the probability of exceeding drinking water or surface water criteria.

Aquifers mapped as hydrologically sensitive should undergo geochemical sensitivity analysis. This includes determining the distribution of oxygen and carbon in the upper portion of the aquifer. Implications for management include drilling wells deeper in the aquifer (below the oxygenated zone), not drilling high capacity wells deep in the aquifer (they will mix water from upper and lower portions of the aquifer), and minimizing nitrogen inputs into oxygen-rich aquifers.

What other work is GWMAP doing?

GWMAP has begun two new studies related to nitrate distribution in ground water. The first is a study of the effects of septic systems on water quality. The second is a study of the effects of manure storage systems on ground water quality. These studies include the three aquifer assessment criteria presented above. Annual or summary reports will be prepared for each study.

Where can I get more information?

For more information about the nitrate study, contact Jennifer Maloney, hydrogeologist, GWMAP, at (651) 296-8544 or toll-free/TDD (800) 657-3864. Additional information on this study and other ground water projects is available on the MPCA's web site at <http://www.pca.state.mn.us>.

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