Nitrogen and Water

water.usgs.gov/edu/nitrogen.html

The USGS Water Science School

Nutrients, such as nitrogen and phosphorus, are essential for plant and animal growth and nourishment, but the overabundance of certain nutrients in water can cause a number of adverse health and ecological effects. Nitrogen, in the forms of nitrate, nitrite, or ammonium, is a nutrient needed for plant growth. About 78% of the air that we breathe is composed of nitrogen gas, and in some areas of the United States, particularly the northeast, certain forms of nitrogen are commonly deposited in acid rain.

Sugar Creek, Indiana, has been modified to favor rapid removal of water from agricultural lands. High nitrogen levels in streams can be the result. Credit: USGS.

Of course nitrogen is used in agriculture to grow crops, and on many farms the landscape has been greatly modified in order to maximize farming output. Fields have been leveled and also modified to efficiently drain off excess water that may fall as precipitation or from irrigation practices. This pictures shows Sugar Creek in Indiana, as it has been extensively modified for human use. As commonly found in small agricultural streams, Sugar Creek has been straightened, deepened, and had tile drains installed to favor rapid removal of water from agricultural lands. If excess nitrogen is found in the crop fields, the drainage water can introduce it into streams like these, which will drain into other larger rivers and might end up in the Gulf of Mexico, where excess nitrogen can lead to hypoxic conditions (lack of oxygen).

Sources of nitrogen

Although nitrogen is abundant naturally in the environment, it is also introduced through sewage and fertilizers. Chemical fertilizers or animal manure is commonly applied to crops to add nutrients. It may be difficult or expensive to retain on site all nitrogen brought on to farms for feed or fertilizer and generated by animal manure. Unless specialized structures have been built on the farms, heavy rains can generate runoff containing these materials into nearby streams and lakes. Wastewater-treatment facilities that do not specifically remove nitrogen can also lead to excess levels of nitrogen in surface or groundwater.

Nitrate can get into water directly as the result of runoff of fertilizers containing nitrate. Some nitrate enters water from the atmosphere, which carries nitrogen-containing compounds derived from automobiles and other sources. More than 3 million tons of nitrogen are deposited in the United States each year from the atmosphere, derived either naturally from chemical reactions or from the combustion of fossil fuels, such as coal and gasoline. Nitrate can also be formed in water bodies through the oxidation of other forms of nitrogen, including nitrite, ammonia, and

organic nitrogen compounds such as amino acids. Ammonia and organic nitrogen can enter water through sewage effluent and runoff from land where manure has been applied or stored.

Problems with excess levels of nitrogen in the environment

Excess nitrogen can harm water bodies

Excess nitrogen can cause overstimulation of growth of aquatic plants and algae. Excessive growth of these organisms, in turn, can clog water intakes, use up dissolved oxygen as they decompose, and block light to deeper waters. Lake and reservoir eutrophication can occur, which produces unsightly scums of algae on the water surface, can occasionally result in fish kills, and can even "kill" a lake by depriving it of oxygen. The respiration efficiency of fish and aquatic invertebrates can occur, leading to a decrease in animal and plant diversity, and affects our use of the water for fishing, swimming, and boating.

Excess nitrogen in water can harm people

Too much nitrogen, as nitrate, in drinking water can be harmful to young infants or young livestock. Excessive nitrate can result in restriction of oxygen transport in the bloodstream. Infants under the age of 4 months lack the enzyme necessary to correct this condition ("blue baby syndrome"). In parts of Eastern Europe where groundwater is contaminated with 50-100 milligrams per liter (mg/L) of nitrate, pregnant women and children under 1 year of age are supplied with bottled water.

Variation of nitrate across the United States

The concentration of nitrate (a form of nitrogen) of water bodies vary widely across the United States. Natural and human processes determine concentration of nitrate in water. The National Atmospheric Deposition Program has developed maps showing nitrate patterns, such as the one below showing the spatial pattern of nitrate at selected sampling sites for 2002. You should be aware that this contour map was developed using the nitrate measurements at the specific sampling locations; thus, the contours and isolines were created using interpolation between data points. You should not necessarily use the map to document the nitrate of a water body at a particular map location, but rather, use the map as a general indicator of nitrate throughout the country.

Source: National Atmospheric Deposition Program (NRSP-3)/National Trends Network. (2004). NADP Program Office, Illinois State Water Survey, 2204 Griffith Dr., Champaign, IL 61820.

Risks of nitrate contamination in shallow groundwater

Much of the Nation uses groundwater at its main source of water for many needs, from drinking water and other home uses to irrigation to public uses, such as supplying water to parks. Of course, geology and the factors that affect the availability of groundwater vary greatly geographically, but many places, such as southern Georgia, have aquifers that can supply a lot of freshwater very near the land surface. Since nitrogen contamination is more of a problem in shallow aquifers, it is worthwhile to be aware of what aquifers in the United States would be more at risk for nitrogen contamination.

For a USGS study, the map below was developed to show those areas with the highest risk for contamination of shallow groundwater by nitrate. Generally, aquifer vulnerability is represented by soil-drainage characteristics—the ease with which water and chemicals can seep to groundwater—and the extent to which woodlands are interspersed with crop land. Use of the risk map to identify and prioritize contamination at a more detailed level than presented here is not advised because local variations in land use, irrigation practices, aquifer type, and rainfall can result in nitrate concentrations that do not conform to risk patterns shown at the national scale.