Utah State University
WATER QUALITY EXTENSION

Nitrogen

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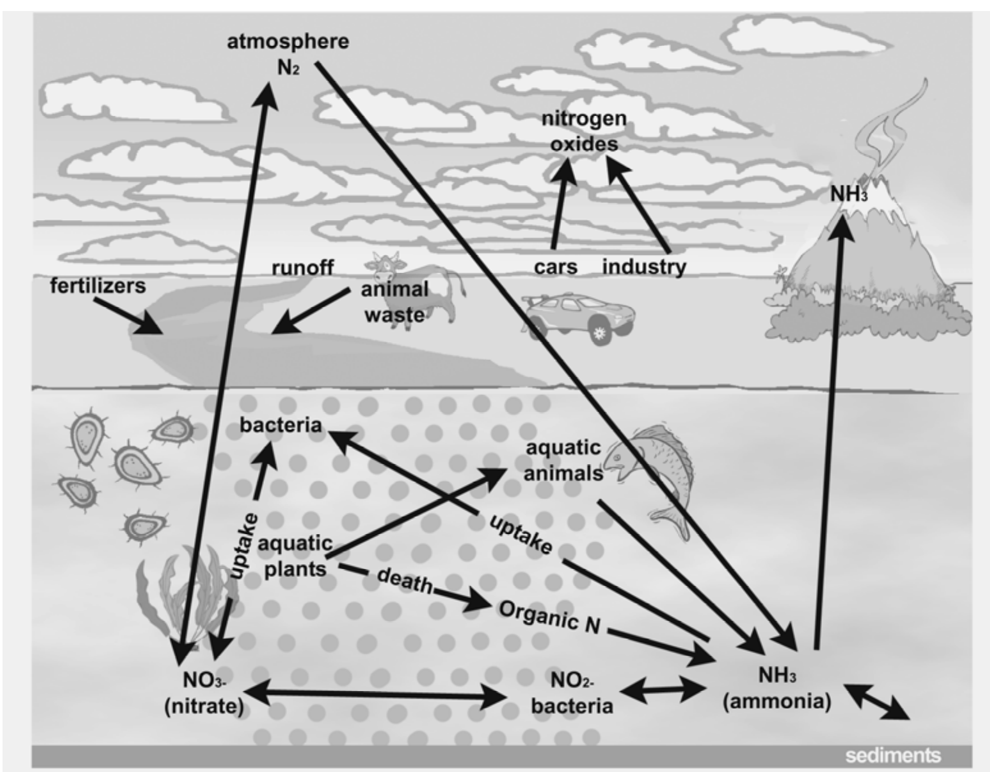
What is nitrogen?

Nitrogen is an essential nutrient for plants and animals that is used in the structure of proteins and other molecules. Nitrogen is found in a variety of forms throughout the global environment.

Even though nitrogen is abundant, only a few forms found in nature can be used directly by plants. Many forms of nitrogen are extremely soluble and move easily through soils into ground water or back to lakes and streams.

Although nitrogen gas makes up 79% of our atmosphere, this nitrogen cannot be used directly by plants. It must first be converted to a usable form through a process called *nitrogen fixation*—done by specialized bacteria in soil, certain types of microscopic algae in water, and lightning strikes.

The nitrogen cycle, shown below, shows the many ways that nitrogen moves around our earth.



Source: Gilbert Graphics

What are the common forms of nitrogen?

Three simple **inorganic forms** of nitrogen are found in water and can be taken up directly by plants and bacteria, or are easily changed to a form that is usable.

> **Nitrate (NO_3)** is the most common form of inorganic nitrogen in unpolluted waters. Nitrate moves readily through soils and into ground water, where concentrations can be much higher than in surface waters.
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> **Ammonia (NH_3)** is formed when organic nitrogen is broken down by bacteria. Plants prefer to use ammonia over nitrate, but ammonia is typically less abundant in natural waters. It is generally found at high concentrations only when dissolved oxygen concentrations are very low or when the water is polluted.
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> **Nitrite (NO_2)** is converted from ammonia by bacteria, but the nitrite is usually converted again to nitrate (NO_3) very rapidly. Because of this, nitrite is not usually found at measurable levels. Concentrations above 0.02 mg/liter (ppm) usually indicate polluted waters.

Organic forms of nitrogen include all the nitrogen that is incorporated into living plants or animals, waste products, and remains.

Why is nitrogen in water important?

Nitrogen is an important plant nutrient:

In lakes and streams, too little available nitrogen may limit the growth of aquatic plants. When excess nitrogen is added to a water body, however, it can over fertilize plants in the water. As these plants decay, they consume dissolved oxygen. Low levels of dissolved oxygen can kill fish and other aquatic life. For more information, see the fact sheet *Dissolved Oxygen*.

Health concerns:

- High concentrations of some forms of inorganic nitrogen are poisonous to humans or to aquatic organisms.
- Concentrations of nitrate in drinking water greater than 10 mg/liter can be harmful to young babies and cause blue baby syndrome (See Drinking Water Fact Sheet *Nitrate* for more information).
- Nitrite can be toxic to fish, such as rainbow trout, at concentrations of about 4 mg/liter.
- Ammonia may be toxic to fish and other aquatic animals at very low concentrations, especially when the water is somewhat basic (high pH) and at warm water temperatures (above 20 degrees C).

How do natural influences affect nitrogen?

Seasonal changes:

Nitrogen concentrations change naturally in streams throughout the season, due to changes in runoff and in plant uptake. In Utah, concentrations are often highest during the spring when snow melts over land, bringing nutrients from lawns, farms, and other areas. Concentrations of nitrate and ammonia may be very low during periods of rapid aquatic plant growth that uptake as much as is available.

In fall and winter, the main source of water to many Utah streams is groundwater, which often has naturally high concentrations of nitrate. The high concentrations come when plants die and decay, releasing much of the nitrogen in their tissues back into the water.

How do human activities affect nitrogen concentrations in a stream?

Human activities:

Human activities have had a huge impact on global nitrogen cycles. The amount of biologically available nitrogen generated by human activities now far exceeds nitrogen fixed by bacteria, algae, and lightning. Humans produce synthetic fertilizers, burn fossil fuels, grow legumes as a crop; and engage in various land clearing, burning and wetland draining activities—all of which release nitrogen in forms that plants use.

Land uses in your watershed:

Inorganic nitrogen is extremely soluble. It is easily carried in surface water and also travels easily through soils and groundwater. Thus human introduction of nitrogen to a watershed has wide-ranging effects.

Common human-influenced sources of inorganic nitrogen include:

- Fertilizers and animal manure;
- Malfunctioning septic systems;
- Discharge from sewage facilities;
- Acid precipitation from pollution.

How is nitrogen measured?

Field probes have been developed to measure ammonia and nitrate levels in a stream, generally when either is in very high concentration. More typically, water is collected from a stream or lake and transported to a laboratory for analysis. Often nitrate and nitrite levels are analyzed in one test and reported as a combined nitrogen value. In these cases, it is generally assumed that most of this nitrogen is nitrate.

Several tests will measure total nitrogen (organic and inorganic). A common analysis called the *Kjeldahl* test is sometimes mistaken for total nitrogen, but it actually measures all nitrogen in the water except nitrate. To get total nitrogen concentrations in this case, add the *Kjeldahl* nitrogen concentration and the nitrate concentration from the same water sample.

Field tests for nitrate and ammonia are available for volunteer monitoring projects. These tests are useful for educational, demonstrational, or screening purposes, but do not produce the level of quality control necessary for accurate watershed studies.

What do the results mean?

Nitrate:

Nitrate concentrations must not exceed 10 mg/liter (10 parts per million) if the water is to be used as a source of drinking water .

Utah has also established an “indicator concentration” of 4 mg / liter of nitrate. When indicator concentrations are exceeded, the state conducts additional studies to determine whether the water body is overfertilized by nitrate and to determine if fisheries or recreational uses of the water are being impacted.

Ammonia:

Ammonia can be directly toxic to fish and other aquatic life. The toxic concentration, however, changes as the pH and temperature of the water changes, and when fish are exposed for longer periods of time. Ammonia in neutral or slightly acidic water is not as toxic to fish compared to ammonia in more basic waters. This difference can be quite dramatic, resulting in a 20-fold increase in toxicity with a change in pH from 7 (neutral) to 9 (somewhat alkaline). pH changes of this magnitude are not uncommon in many natural situations.

The state of Utah has established maximum concentrations for two of the forms of nitrogen found in water. Check the Division of Water Quality’s web site for the water quality standards for the state of Utah (R317-2) to determine the toxicity of ammonia under different temperatures and pH levels.

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For more information, contact USU Water Quality Extension at 435-797-2580, or visit our website at http://extension.usu.edu/waterquality/