The Nitrogen Cycle

Real World Ecosystems Backgrounder

The element nitrogen is absolutely essential to life on Earth if for no other reason than because it is a key component of the chlorophyll that allows producers to utilize sunlight in **photosynthesis** (The chemical process during which green plants convert light energy, carbon dioxide and water in the presence of chlorophyll into carbohydrates. Oxygen is produced as a by-product). Nitrogen is actually the fourth most common atom found in living tissues and is a crucial element in forming **amino acids** (Nitrogen-containing molecules that join to form protein molecules) to build proteins and the genetic materials found in all cells. Until the introduction of agriculture, possibly some twelve thousand years ago, nitrogen was one of the major factors limiting the functioning of many ecosystems.

Although nitrogen gas forms 78 per cent of the Earth's atmosphere, without human activities nitrogen is actually available to most plants and animals in very limited amounts. Nitrogen gas is very stable and does not easily react with any other substance. For living organisms to make use of nitrogen, it must first be "**fixed**" into a usable form, either ammonium ($NH3^{+}$) or nitrate ($NO3^{-}$) ions. Lightning produces a very small amount of nitrate ions that will be carried to the ground by rainfall, but the vast majority of nitrogen used by plants is fixed by a very few **species** bacteria and blue-green algae. Many of these bacteria exist in the soil, but several species of plants have "**nitrogen-fixing**" bacteria living within their root tissues.

The nitrates produced by bacterial action are actually formed in several steps. First, nitrogen-fixing bacteria take in nitrogen gas from the atmosphere and convert it to ammonia (NH3). Then, **nitrate-forming** bacteria reacts the ammonia with oxygen to produce nitrite ($NO2^{-}$) ions. Finally, the nitrite ions are converted to nitrate ions ($NO3^{-}$) by a third type of bacteria, the **nitrate-forming** bacteria. Nitrate ions may be absorbed by plant roots and when taken into plant cells are converted to ammonium ($NH4^{+}$) ions, which are then used to make amino acids. Plants can make all of the amino acids they need from nitrate that they absorb through their roots, but animals rely on the transfer of amino acids through normal food chains and food webs.

The action of **decomposers** on dead plant, animal tissue, and animal waste products returns nitrogen to the soil in the form of ammonia. This ammonia may once again be acted on by nitrite and nitrate-forming bacteria for uptake by plants. Interestingly enough, plants actually compete with yet other soil bacteria for nitrates. **Denitrifying bacteria** in waterlogged soils will break down nitrates to nitrogen gas or nitrous oxide gas as a part of their normal metabolism to return nitrogen into the atmosphere.

The agricultural practice of applying nitrogen fertilizers adds ammonia, ammonium and nitrates to the environment in amounts far in excess of any process normally found. One concern is the issue of the amount of fertilizer found in runoff water.

Excessive nitrogen in aquatic systems may result in "**algal blooms**" in which algae grows into dense mats, covering water surfaces and leading to low oxygen levels. Such conditions are hazardous to aquatic organisms. Another concern is that application of nitrogen fertilizers may stimulate the growth of denitrifying bacteria, resulting in the over-production of nitrous oxide gas. This gas, better known as "laughing gas," is used by dentists as an anesthetic but is also a greenhouse gas that is hundreds of times more effective than carbon dioxide. No laughing matter! As if that is not bad enough, nitrous oxide gas is also involved in the ground level production of ozone, which is not only toxic but is yet another greenhouse gas. Finally, the technological process of producing synthetic fertilizers requires high temperatures and pressures. This requires the burning of large amounts of fossil fuels to produce the needed energy, and you have already seen how this is an issue regarding global warming.

Did You Know?

Look into your fish tank to see the nitrogen cycle at work! Did you know that fish tanks have an awesome nitrogen cycle? Fish waste is nitrogenous, and will break down into ammonia (NH_3). Unfortunately, ammonia is very toxic to fish. That is why you need nitrogen-fixing bacteria to convert the ammonia into a nitrite and finally a nitrate! New fish tanks often suffer from "new tank syndrome" because there are very little nitrogen-fixing bacteria to convert the toxic ammonia to a nitrate.

Attack of the insect-eating plant! Did you know that there are plants that actually "eat" mosquitoes? Scientists have found that a water plant called bladder-wort actually eats mosquito larvae. It does this by having small bladders that are submerged in water. These bladders have a "one way" trap door. Small crustaceans and other things such as mosquito larvae are trapped in the bladder and are a source of nitrogen for the plant!

Use worms to get rid of waste… naturally! A vermicomposter is a great way to compost indoors. Indoor composters use a plastic container with some organic soil and red wigglers worms. These worms will eat five times their weight every day. The wrigglers like anything organic such as tea bags, coffee grinds, banana peels. But be careful not to add cheese or meat products, this will soil your composter. Approximately every 4-6 months you can harvest your soil, and leave the worms, then add more soil to your composter. The soil you harvested can be put om top of your indoor plants. The nutrient rich soil will help your plants grow.