

Nitrogen cycle

The **nitrogen cycle** represents one of the most important nutrient cycles found in ecosystems. (Figure 1). Nitrogen is a required nutrient for all living organisms to produce a number of complex organic molecules like amino acids, the building blocks of proteins, and nucleic acids, including DNA and RNA. The ultimate store of nitrogen is in the atmosphere, where it exists as nitrogen gas (N_2). This store is about one million times larger than the total nitrogen contained in living organisms. Other major stores of nitrogen include organic matter in soil and the oceans. Despite its abundance in the atmosphere, nitrogen is often the most limiting nutrient for plant growth. This problem occurs because N_2 gas is not biochemically usable by plants. Plants can only take up nitrogen in the form of ammonium ion (NH_4^+), nitrate ion (NO_3^-), or, less common, as amino acids. Animals receive the nitrogen they need for metabolism, growth, and reproduction by the consumption of living or dead organic matter containing molecules composed partially of nitrogen.

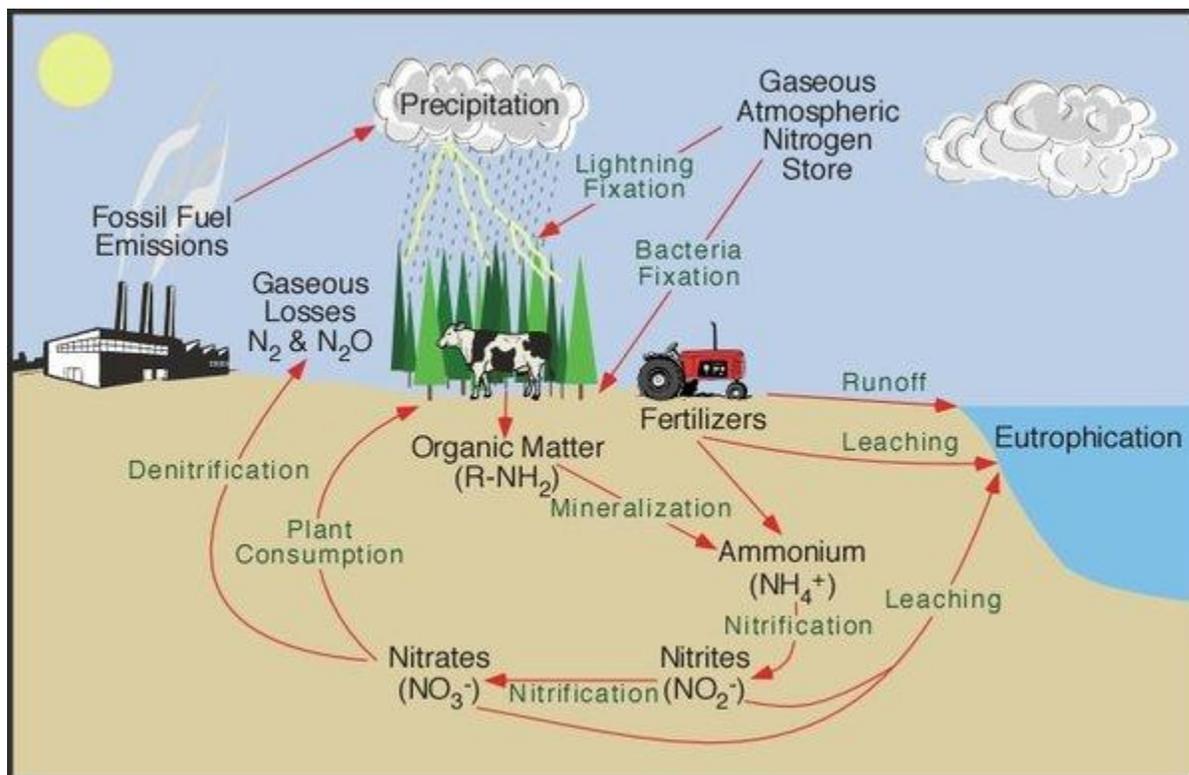


Figure 1: Nitrogen cycle. (Source: PhysicalGeography.net)

In most ecosystems nitrogen is primarily stored in living and dead organic matter. This organic nitrogen is converted into inorganic forms when it re-enters the biogeochemical cycle via decomposition. Decomposers chemically modify the nitrogen found in organic matter to ammonium ion (NH_4^+). This process is known as mineralization and it is carried out by a variety of bacteria and fungi.

Nitrogen in the form of ammonium can be absorbed onto the surfaces of clay particles in the soil. The ammonium ion has a positive molecular charge and is normally held by negatively charged soil colloids. This process is sometimes called micelle fixation (see Figure 1). Ammonium is released from the colloids by way of cation exchange. When released, most of the ammonium is often chemically altered by a specific type of autotrophic bacteria (bacteria that belong to the genus *Nitrosomonas*) into nitrite (NO_2^-). Further modification by another type of bacteria (belonging to the genus *Nitrobacter*) converts the nitrite to nitrate (NO_3^-). Both of these processes involve chemical oxidation and are known collectively as nitrification. Unlike ammonium, nitrate is negatively charged and therefore does not absorb onto negatively charged clay surface. Consequently, nitrate is very mobile in soil and it is easily leached. Some of this leached nitrate flows through the hydrologic system until it reaches the oceans where it can be returned to the atmosphere by denitrification. Denitrification is also common in anaerobic soils and is carried out by heterotrophic bacteria. The process of denitrification involves the

metabolic reduction of nitrate (NO_3^-) into nitrogen (N_2) or nitrous oxide (N_2O) gas. Both of these gases then diffuse into the atmosphere, thus removing nitrogen from the soil, accounting for the name, denitrification.

Almost all of the nitrogen found in any ecosystem originally came from the atmosphere. Significant amounts enter the soil in rainfall or through the effects of lightning. The majority, however, is biochemically fixed in ecosystems by specialized micro-organisms, all of which are bacteria of various types, including a variety of Gram-positive and Gram-negative bacteria, actinomycetes, and cyanobacteria. Members of the bean family (legumes) and some other kinds of plants form mutualistic symbiotic relationships with certain types of nitrogen-fixing bacteria. In exchange for some nitrogen, the bacteria receive from the plants carbohydrates and special structures (nodules) in the roots where they can exist in a protected environment. Scientists estimate that biological fixation globally adds approximately 140 million metric tons of nitrogen to ecosystems every year.

Humans now fix approximately as much nitrogen industrially as does natural nitrogen fixation, thus dramatically altering the nitrogen cycle. Some of the major processes involved in this alteration include:

- The application of nitrogen fertilizers to crops has caused increased rates of denitrification and leaching of nitrate into groundwater. The additional nitrogen entering the groundwater system eventually flows into streams, rivers, lakes, and estuaries. In these systems, the added nitrogen can lead to eutrophication and associated hypoxia.
- Increased deposition of nitrogen from atmospheric sources because of fossil fuel combustion and forest burning. Both of these processes release a variety of solid forms of nitrogen through combustion and contribute to acid rain.
- Livestock ranching. Livestock release a large amount of ammonia into the environment from their wastes. This nitrogen enters the soil system and then the hydrologic system through leaching, groundwater flow, and runoff.
- Sewage waste and septic tank leaching.

Further Reading

- PhysicalGeography.net
- VisionLearning - The Nitrogen Cycle: Of Microbes and Men
- NASA Soil Science Education Page - The Nitrogen Cycle
- Ecological Society of America, Issues in Ecology - Human Alteration of the Global Nitrogen Cycle: Causes and Consequences

Source: <http://www.eoearth.org/view/article/154864/>