

Appendix C. The Nitrogen Cycle

Forms of Nitrogen

Although nitrogen is the major pollutant of concern for the Neuse River Estuary, it is also a nutrient that is essential for life. The majority of nitrogen on the planet exists as N₂ gas in the atmosphere. In fact, 78% of the volume of the air we breathe is nitrogen. Nitrogen is not a natural constituent of rocks or minerals.

$\text{N} \equiv \text{N}$ The N₂ molecule has a triple bond, which is the most stable bond known to science. Plants obtain all of the oxygen and carbon they need from the air. However, it is very difficult for a plant to obtain nitrogen from the atmosphere because N₂ gas is so non-reactive.

Very special circumstances are required to break the triple bond in N₂ gas and to convert the nitrogen into forms that most plants can use, as described in the next section. The majority of plants obtain nitrogen from the soil as either nitrate (NO₃) or ammonium (NH₄).

Once in the plant, ammonium can be used directly but nitrate is transformed to the ammonium form using energy derived from photosynthesis. The plant uses nitrogen to form proteins that act primarily to control plant growth processes. A good supply of nitrogen is associated with vigorous growth and a deep green color. Plants deficient in nitrogen become stunted and yellow in appearance.

Nitrogen in plant-available forms is generally scarce under natural conditions. In other words, under natural conditions, nitrogen is a limiting growth factor. Only recently have humans upset the balance by the addition of nitrogen fertilizers and NO_x emissions and by artificially concentrating nitrogen sources such as human and livestock wastes.

Nitrogen is classified as either inorganic or organic nitrogen. At any given time, most of the nitrogen in the soil is in the organic form. Inorganic nitrogen compounds are unstable and nitrogen is constantly returning to the atmosphere in gaseous forms.

Inorganic Forms of Nitrogen

- N₂: Inert nitrogen gas found in the atmosphere
- NO₂: Nitrous oxides, is found in the atmosphere and is a component of automobile exhaust and industrial processes
- NH₃: Ammonia is a volatile gas and often is lost from soil applied ammonium fertilizer and animal manure into the atmosphere
- NH₄⁺: Ammonium, is a positively charge cation found in the soil
- NO₂⁻: Nitrite, is a negatively charge anion found in the soil

NO₃⁻: Nitrate, is a negatively charge anion found in the soil and at times in the atmosphere

Organic Forms of Nitrogen

Organic sources of nitrogen include proteins and other complex compounds found in living, dead, or decomposing plants and animals.

The Nitrogen Cycle

The conversion of N₂ to N compounds and from nitrogen compounds back to N₂ is the nitrogen cycle. It has been estimated that it takes from 44 to 220 million years for all nitrogen to pass through the cycle. In 1982, it was estimated that human activities have caused an imbalance in the nitrogen cycle that causes an accumulation of nine million metric tons per year. This accumulated nitrogen can cause pollution problems.

Figure C1 shows a simplified nitrogen cycle in an undisturbed, forested area. In an urban area, human activities add sources of nitrogen other than the ones shown here. Modified nitrogen cycles are shown in Chapter 4 for each of the appropriate nitrogen sources.

Losses of Nitrogen

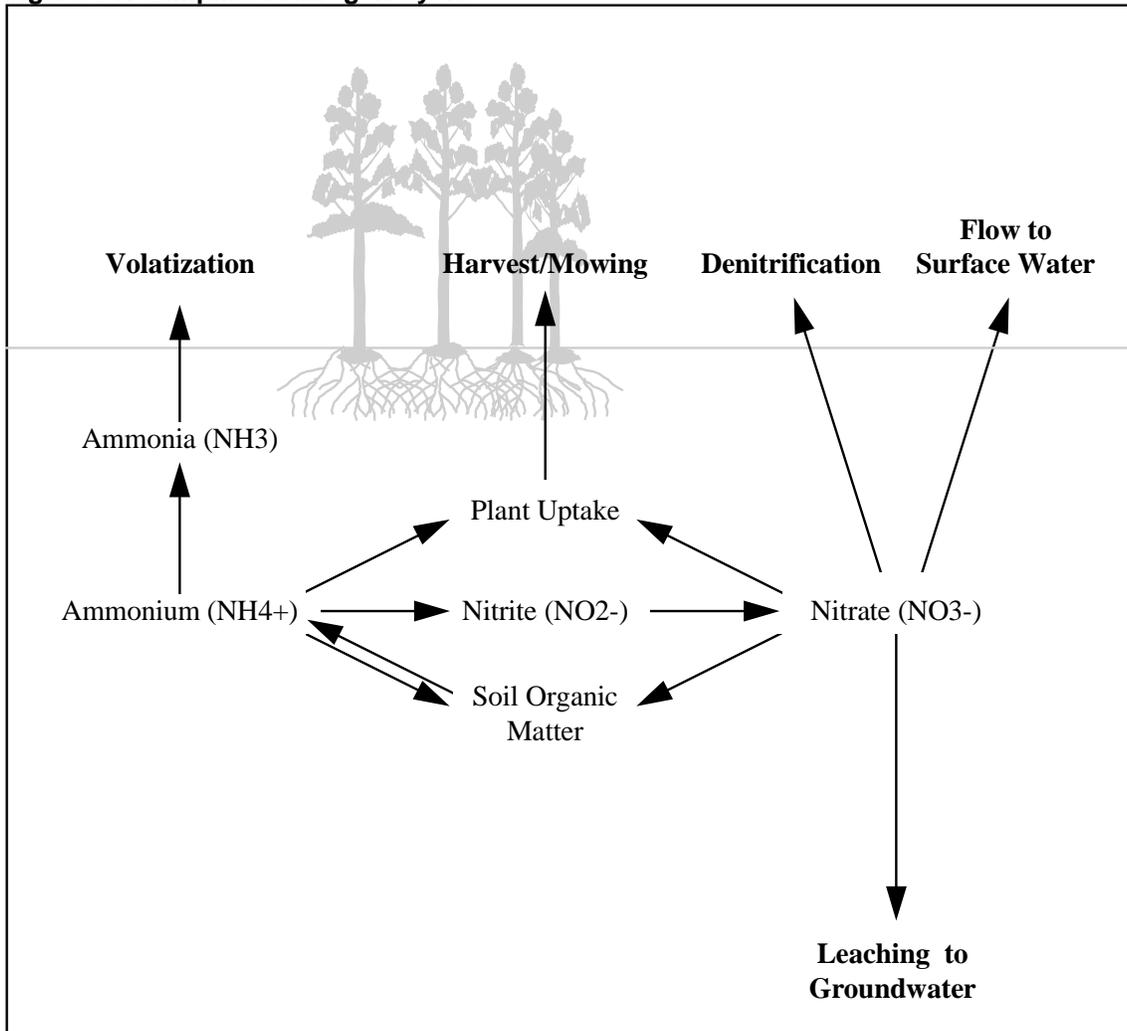
Nitrogen can be easily lost into the environment by various pathways. Those pathways include volatilization, leaching and runoff, and crop removal.

Volatilization, or the gaseous loss of ammonia, may occur under certain conditions with ammonia fertilizers. In situations where the soil is pH alkaline, or where limestone has recently been applied on acid soils, applications of ammonium fertilizer may result in the transformation of ammonium (NH₄) to ammonia (NH₃) which may be lost to the atmosphere. Urea fertilizers are particularly likely to volatilize. This situation can be avoided by incorporating these fertilizers into the soil in the case of soils with alkaline pH or waiting at least one month after limestone applications to surface apply ammonium fertilizers.

Leaching and Runoff are other important sources of nitrogen loss. Leaching occurs when inorganic forms of nitrogen, particularly nitrite (NO₂) and nitrate (NO₃) are solubilized and carried with water through the soil profile or with surface waters. Factors that contribute to nitrite and nitrate leaching or runoff include the following:

- Heavy, one-time applications of N fertilizers on sandy textured soils.
- Over applications of manure or sludge to land.
- Improperly timed applications of N fertilizer.
- Poorly designed or nonexistent soil conservation measures.
- Periods of exceptionally heavy rain.

Figure C1. Simplified Nitrogen Cycle



Harvest and Mowing are very important ways that nitrogen is lost. If crops are harvested and removed, there is a net loss to the farm's balance sheet for nitrogen. However, if crop residues or lawn clippings are saved and returned to the soil, some of the nitrogen will be recycled.

References

- National Research Council. 1993. Soil and Water Quality: An Agenda for Agriculture. National Academy Press. Washington, DC.
- NC Cooperative Extension Service. NCSU Nutrient Management Manual. Chapter 3. Raleigh, NC.