The Nitrogen Cycle

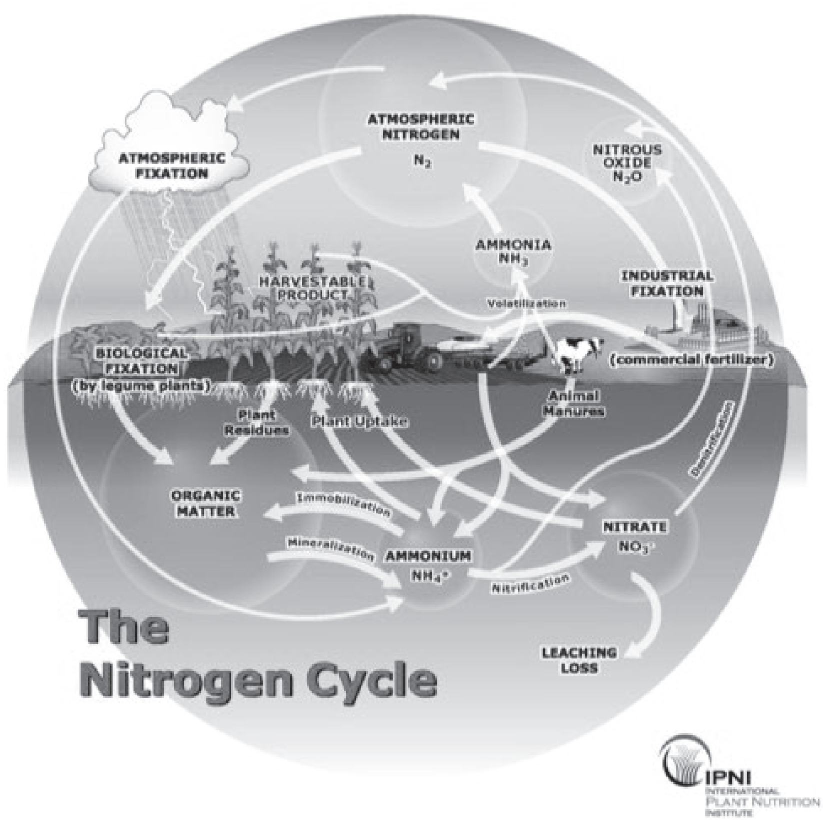
Where does the fertilizer go?

Nitrogen is necessary for plant growth, maintenance and repair. It is often added to crops to enhance plant growth, depending on the soil and the crop. Nitrogen is used in several different forms. Organic nitrogen is found in crop residue and animal wastes (manure). The crop residue from the previous season's crop may be left to mineralize (break down) in the field, a cover crop may be planted post harvest and turned under before the new crop is planted in the spring, or manure may be applied late winter, early spring or during the growing season. These forms of organic fertilizers are not readily usable by the crop and need some time to be converted by bacteria in the soil to become available.

In many crop production systems, commercial fertilizers (inorganic nitrogen) are used in the form of ammonium (NH_4), nitrates (NO_3) or urea (CH_4N_2O), and are referred to as "quick release" fertilizers. Both ammonium and nitrates are immediately available to plants, while urea is converted by a soil enzyme to ammonium. The fertilizer may be applied by broadcasting, injecting or side-dressing. Fertilizer certification is required by law in Ohio, if a grower plans to apply fertilizer (other than manure) to more than 50 acres of agricultural production grown primarily for sale. If a co-op or other custom applicator for fertilizer applications is hired, no certification is needed.

Fertilizer applications follow the 4R's of nutrient management: the right source, at the right rate, at the right time, in the right place (http://www.nutrientstewardship.com/). Crops that receive fertilizer during growth benefit from the application. If there is an immediate rain event or if there is too much fertilizer used, much of it will run off or leach below the roots within the soil and the benefit of the fertilizer will be lost resulting in a monetary loss. Growers use agronomists and their experience to maximize the benefit of fertilizer application.

Below is a diagram of how nitrogen cycles through the ecosystem. It looks quite complicated...that is because there are many forms of nitrogen and many pathways for it to follow.



After the powerpoint and discussion, draw arrows below to follow the path of nitrogen through the nitrogen cycle. Be sure to show which forms are usable by plants. Use the terms to identify the arrows describing the processes:

Nitrogen fixation

Immobilization

Nitrification

Ammonification/Mineralization

Volatilization/Denitrification

Atmospheric N_2

Plants ----> Animals

(crop residue) (waste/manure)

Ammonium

Nitrite---> Nitrate

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Nitrogen Cycle Model (I.B.ii.)

Why isn't nitrogen included in a soil test report? What happens to Nitrogen?

This activity shows how nitrogen changes forms within the earth's atmosphere and how it interacts with the lithosphere (land), biosphere (living things) and hydrosphere (water).

Assign students to one of the following bacteria and/or nitrogen compound roles (determine the number of students per role according to your class size).

- Nitrogen-fixing bacteria (free-living in soil or symbiotic, i.e. rhizobia or cyanobacteria in water)
- Nitrifying bacteria 1 (nitrosomonas)
- Nitrifying bacteria 2 (nitrobacter)
- Denitrifying bacteria
- Water
- Atmospheric nitrogen
- Ammonium (NH_4^+)
- Nitrite (NO_2)
- Nitrate (NO_3^-)
- Plant(s)

Give labels to the bacteria and equip them with cards of appropriate compounds to "transform" the nitrogen compounds' cards:

- Nitrogen-fixing bacteria (free-living in soil or symbiotic, i.e. rhizobia or cyanobacteria in water) will transform N_2 cards to NH_4^+ cards
- Nitrifying bacteria 1 (nitrosomonas) will transform NH_4^+ cards to NO_2 cards
- Nitrifying bacteria 2 (nitrobacter) will transform NO_2 cards to NO_3^- cards
- Denitrifying bacteria will transform NH_4^+, NO_2 or NO_3^- cards to N_2 cards

Each form of nitrogen will have a card of the molecule they represent. You may use different colors to represent the different forms of N. The different forms of N may travel with a water molecule, as most nutrients are adsorbed by plants within soil solution.

- Atmospheric nitrogen (N_2 cards)
- Ammonium (NH_4^+ cards)
- Nitrite (NO_2 cards)
- Nitrate (NO_3^- cards)

Choose spots around the room for locations where bacteria are stationed, spreading out different types:

1. Soil sub-surface (make multiple areas for this one)-locate N-fixing, nitrifying (both types) and denitrifying bacteria in different areas
2. Water source-locate N-fixing, nitrifying (both types), and denitrifying bacteria in different areas of the water
3. Soil surface-locate N-fixing, nitrifying (both types) and denitrifying bacteria in different areas

At each stop through the cycle, the bacteria will change the form of the nitrogen products by exchanging a nitrogen compound card.

Nitrogen compounds can move freely from one place to another. There is no formal sequence they must follow.

Plants will remove nitrogen (in the proper form) from the cycle (immobilization) if the N compound is in the company of a water molecule.

Have N move through the cycle for 5 minutes. See what amounts of each type are left at the end.

Reflection

1. How is this a realistic model of the Nitrogen cycle? What factors are not accounted for?

2. What effect may climate (rainfall, drought) have on the cycle?

3. How do the differences in the method and form of fertilizer applied affect the cycle?

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