Nitrogen in the Environment: Nitrogen Fixation

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Nitrogen can be found in many forms in our environment. Nitrogen is also very important for plants to live. The earth's atmosphere is made up of 78 percent nitrogen in the form of a colorless, odorless, nontoxic gas. The same nitrogen gas found in the atmosphere can be found in spaces between soil particles. However, plants are unable to use this form of nitrogen. Certain microorganisms found in the soil are able to convert atmospheric nitrogen into forms plants can use. This is called **biological nitrogen fixation**.

Types of nitrogen fixation

In addition to biological fixation that takes place by microorganisms in the soil, fixation can also take place chemically. An example of this is in the fertilizer industry where atmospheric nitrogen (N_2) can be combined with hydrogen (H^+) to make anhydrous ammonia (NH_3) and other nitrogen fertilizer products.

Symbiotic nitrogen fixation

One of the most interesting forms of biological nitrogen fixation is that which takes place by microorganisms living in very small nodules on the roots of certain plants such as legumes. This is called **symbiotic nitrogen fixation**. A symbiotic relationship is an association or relationship where both organisms mutually benefit. In this case, microorganisms obtain food and energy from the root of the plant while producing nitrogen the plant can use for growth and development. The form of nitrogen produced is the same form of nitrogen that is found in several types of commercial nitrogen fertilizers.

Importance of nitrogen fixation to crops

The microorganism's ability to fix atmospheric nitrogen is often discussed in terms of the plant's ability to fix nitrogen. The amount of fixation that takes place is strongly influenced by soil conditions. Factors such as moisture, temperature, oxygen supply and fertility in the soil can influence fixation. Diseases and insects can also affect the degree of nitrogen fixation.

One of the most common groups of plants that fix nitrogen are legumes. Of the total nitrogen required by legumes, generally about half is nitrogen fixed from the atmosphere, with the remainder being taken up from residual nitrate in the soil. This means that where legumes are grown, outside applications of manure or fertilizer nitrogen are not needed.

Different legumes also vary in the amount of total nitrogen they can fix. Listed below in the table are common legumes used in agriculture and the total amounts of nitrogen they fix during a growing season.

Common legume crops	Total nitrogen fixed
Alfalfa	70 to 200 pounds per acre per year
Field peas	155 to 175 pounds per acre per year
Red clover	60 to 100 pounds per acre per year
Soybeans	20 to 275 pounds per acre per year

Implications on water quality

The process of nitrogen fixation by legumes alone probably does not significantly impact water quality. This is because the ammonium (NH_4^+) produced from fixation is readily used by the legume plant for growth and development, and is not further converted to nitrate (NO_3^-). Although nitrogen exists in many forms in the soil, it is the nitrate form that primarily affects water quality.

When the legume plant dies, nitrates are produced. This happens because the legume plant residues are easily broken down by microorganisms in the soil, resulting in the production of nitrates. However, this usually takes place at a time when a subsequent crop is growing, taking advantage of the nitrates produced.

The presence of nitrate in the soil is desirable because it is required by plants for growth and development. However, nitrate is highly mobile and easily moves with water. The results of a heavy rain can move nitrates downward in the soil, below the root zone of plants. Whether nitrates continue to move downward, and into groundwater, depends on underlying soil and/or bedrock conditions, as well as depth to groundwater. If depth to groundwater is shallow and the underlying soil is sandy, the potential for nitrates to enter groundwater is relatively high. However, if depth to groundwater is deep and the underlying soil is heavy clay, groundwater contamination from nitrates is not likely.

Once nitrates get into the groundwater, the greatest concerns are for infants less than one year old and for young or pregnant animals. High levels of nitrates can be toxic to newborns, causing **anoxia**, or internal suffocation. Seek alternative water sources if nitrate levels exceed the health standard of 10 ppm nitrate-N. Do **not** boil water to eliminate nitrates. It **increases** nitrate levels rather than decreasing them. The most common symptom of nitrate poisoning in babies is a bluish color to the skin, particularly around the baby's eyes and mouth. These symptoms of nitrate toxicity are commonly referred to as the "blue-baby" syndrome.

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