Mineralization is the process whereby organic matter, organic fertilizers, and some slow-release fertilizers are broken down or transformed by soil microorganisms to supply plants with available ammonium and nitrate. Mineralization is a three-step process involving *aminization, ammonification,* and *nitrification.* Aminization and ammonification are stages of the mineralization process in which proteins, amines, and amino acids (usually from organic matter or humus) are converted to ammonium, a source of nitrogen utilized by plants. Mineralization is described in the following equation:

Mineralization

$$\underset{\text{organic nitrogen}}{R\text{-}NH_2} + H_2O \xrightarrow{\text{microorganisms}} \underset{\text{ammonium nitrogen}}{NH_4^+} + R\text{-}OH + \text{energy}$$

Following mineralization, ammonium nitrogen (NH_4^+) is absorbed by plants or undergoes further transformation to become nitrate (NO_3^-). Ammonium nitrogen is the preferred nitrogen source because additional energy is required to transform nitrate into usable forms by plants and because ammonium nitrogen is less vulnerable to leaching and denitrification losses. Transformation of ammonium nitrogen to nitrate nitrogen, referred to as *nitrification,* is described as follows:

Nitrification

$$\underset{\text{ammonium nitrogen}}{NH_4^+} + O_2 \xrightarrow[\text{warm temperatures}]{\text{Nitrosomonas bacteria}} \underset{\text{nitrate nitrogen}}{NO_2^-} + 2H^+ \xrightarrow{\text{Nitrobacteria}} \underset{\text{nitrate nitrogen}}{NO_3^-} + H_2O$$

Nitrification depends on environmental conditions that favor soil microbiological activity. Warm temperatures, adequate soil moisture, and soil oxygen are necessary for this activity. However, nitrification does not readily occur in extreme temperatures (e.g., below freezing or above 105°F), in saturated or poorly aerated soil, in excessively dry soil, or in soil with a low pH (<4.8). Under such unfavorable conditions, microorganisms do not perform nitrification and ammonium may accumulate. Ammonium nitrogen also may become toxic to turfgrasses when they are grown under cool, low-light conditions that minimize nitrification.

Nitrate nitrogen is readily soluble in water and may be repelled by negatively charged exchange ions of soil components. Therefore, unless grasses rapidly utilize this form, it may be lost through leaching if excessive moisture is applied. This may be especially true during the winter, when grass is not actively growing. In addition to nitrate and water, hydrogen ions (H^+) are produced during nitrification; a reduction in soil pH may be observed when this occurs. This reduction is especially acute when a high rate of nitrogen is applied to sandy soils low in calcium. These soils are poorly buffered against changes in pH induced by the acidifying effect of nitrification.

Besides leaching and crop removal, nitrogen can be lost through *denitrification* and *volatilization.* Denitrification, the conversion of nitrate nitrogen to gaseous nitrogen under anaerobic conditions, can result in the loss of nitrogen into the atmosphere. Certain anaerobic soil organisms can obtain oxygen from nitrates. They also can obtain oxygen from nitrites in waterlogged soils, subsequently releasing nitrous oxide and nitrogen gas. Low soil oxygen levels and/or high soil moisture, alkaline (high-pH) soils, and high temperatures favor denitrification. Applied nitrogen can be lost through denitrification at the rate of 10% to 30% in compacted, waterlogged soils that have an especially high pH level (>7.5).