NITRIFICATION - DENITRIFICATION

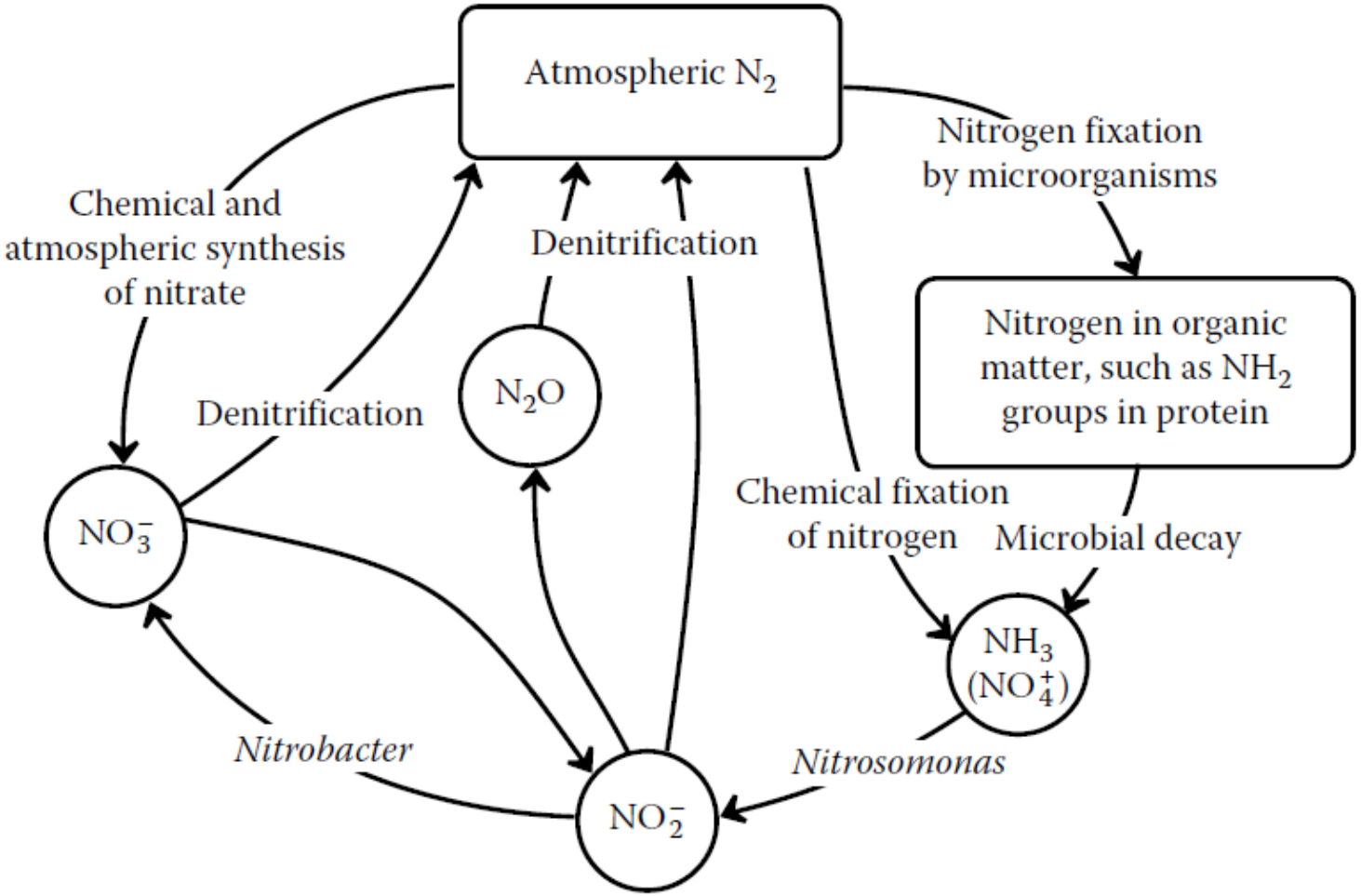
- Carbon and nitrogen are the major pollution sources that contribute to environmental quality problems.

- Problems which are associated with carbon and nitrogen are:

1. Imbalance of natural ecological systems
2. Depletion of dissolved oxygen in surface waters
3. Odor problems
4. Contaminants that complicate water treatment
5. Increase risks to human health

- Nitrogen is one of the primary nutrients critical for the survival of all living organisms.
- It is a necessary component of many biomolecules, including proteins, DNA, and chlorophyll.
- Although nitrogen is very abundant in the atmosphere as dinitrogen gas (N_2), it is largely inaccessible in this form to most organisms, making nitrogen a scarce resource and often limiting primary productivity in many ecosystems. Only when nitrogen is converted from dinitrogen gas into ammonia (NH_3) does it become available to primary producers, such as plants.

THE NITROGEN CYCLE



Ammonification:

The majority of the organic nitrogen contained in raw sewage is converted to ammonia through a process of decomposition by heterotrophic bacteria, known as ammoniafication. Ammonia nitrogen may exist in aqueous solution as either ammonium ion or unionized ammonia. The relationship between the two forms is pH and temperature dependent and may be expressed in accordance with the following equation:

$$NH_3 + H_2O \rightarrow NH_4^+ + OH^-$$

Nitrification:

- Nitrification is an essential process in the nitrogen cycle of soils, natural waters, and wastewater treatment systems.
- Nitrification is the biological process and actually the net result of two distinct processes: the oxidation of ammonia (NH_3) or ammonium (NH_4^+) to nitrite (NO_2^-) by ammonia-oxidizing bacteria (*Nitrosomonas*) and the oxidation of nitrite (NO_2^-) to nitrate (NO_3^-) by the nitrite-oxidizing bacteria (*Nitrobacter*).

The stoichiometry of nitrification is:

$$2NH_4^+ + 3O_2 \rightarrow 2NO_2^- + 2H_2O + 4H^+$$

$$2NO_2^- + O_2 \rightarrow 2NO_3^-$$

The overall reaction is as follows:

$$NH_4^+ + 2O_2 \rightarrow NO_3^- + 2H^+ + H_2O$$

Factors Affecting Nitrification

- Several environmental factors that might control nitrification in various ecosystems.

i. Temperature
ii. Salinity
iii. Light
iv. Organic Matter Concentrations
v. Substrate (Ammonium and Nitrite) Concentrations
vi. pH
vii. Oxygen Concentration

Denitrification:

- Denitrification is a natural soil microbial process by which certain species of bacteria under anoxic conditions reduce nitrate nitrogen to the gaseous end-products of N_2, NO_2^- or N_2O which can then escape from solution to the atmosphere.
- Denitrification occurs when soil bacteria use nitrate for their respiration in the place of oxygen in the air.

- Denitrification is a two-step process and, using methanol as the electron donor, may be represented by the following equations:

$$2CH_3OH + 6NO_3^- \rightarrow 6NO_2^- + 2CO_2 + 4H_2O$$

$$3CH_3OH + 6NO_2^- \rightarrow 3O_2 + 3CO_2 + 3N_2 + 3\,H_2O + 6OH^-$$

- The overall reaction using methanol may be expressed as:

$$5CH_3OH + 6NO_3^- + 6O_2 \rightarrow 5\,CO_2 + 3N_2 + 7H_20 + 6OH^-$$

Factors Affecting Denitrification

1. Presence of Nitrate
2. Temperature
3. Soil wetness
4. Presence of dissolved carbon

Nitrogen Forms

- Nitrogen exists in several forms. The principal nitrogen types of concern to wastewater treatment are:

1. Total Nitrogen
2. Total Kjeldahl Nitrogen (TKN)
3. Ammonia
4. Organic Nitrogen
5. Nitrate and Nitrite

Roles of Nitrification-Denitrification

1) Agricultural and Terrestrial Systems

2) Wastewater Treatment

3) The Marine Environment