Sem. II
CC-5 Unit I

NITROGEN Cycle

Nitrogen is an essential constituent of Protoplasm. It is the component of amino acids, Proteins, enzymes, nucleotides, nucleic acids.

Sources of Nitrogen :- Like all other major and minor elements, it flows in nature in a cyclic manner. Nitrogen is picked up as inorganic compound and is changed into organic form by plants. Though atmosphere contains 78.62% of nitrogen. It is present both in inorganic (as N_2, NH_3, N_2O, NO, NO_2, NO_3^- and NO_2^-) and organic form. The nitrogen cycle can be conveniently discussed under the following 4 heads.

(A) Nitrogen fixation
(B) Ammonification
(C) Nitrification
(D) Denitrification

(A) **Nitrogen fixation** :- According to Pratt (1977) the total supply of nitrogen is about 237 million metric tonnes / year. Of this, about 149 m.m.t is made available through biological nitrogen fixation.

(1) **Atmospheric (Abiological) nitrogen fixation** :→

By Photochemical and electro chemical reactions, O₂ combines with nitrogen to form oxide of nitrogen. It can be summarized as under —

$$N_2 + O_2 \rightarrow 2NO$$
$$2NO + O_2 \rightarrow 2NO_2$$
$$2NO_2 + H_2O \rightarrow HNO_2 + HNO_3$$
$$3NO_2 + H_2O \rightarrow 2HNO_3 + NO$$

In the tropics where thunderstorms and lightning are common large quantities of nitrogen are converted in to Nitrogen.

(2) **Biological nitrogen fixation** :- It involves the transformation of atmospheric N_2 in to nitrites and nitrates by living organisms. It is further of three types —

(a) **Symbiotic nitrogen fixation** :- It is brough about by certain bacteria like —

⇒ Rhizobium leguminosarum → in the root nodules of legumes.
⇒ Frankia → in the root nodules of Alnus, Casuarina.
⇒ Kerbsiella → in the leafs nodules of Gloscorea
⇒ Nostoc and Anabena → in the coralloids roots of cycas
⇒ Nastoc in the thalus of Anthoceros.

Rhizobia are gram negative, non sporous, aerobic, bacilli bacteria. These shows species specific symbiotic relationship. Phytoagglutinins are considered as recognition chemical substances between the two symbionts. It is believed that Rhizobium has a nitrogen fixing gene which controls the synthesis of nitrogenase. These bacteria form the nodules on the secondary roots of the leguines. Nodues contain a red colour pigment leghaemoglobin, it acts as an oxygen scavenger and keeps the level of molecular oxygen low in side the nodules which activates the enzyme nitrogenase which reduces N_2 to ammonia.

(b) Asymbiotic Nitrogen fixation → These are Primitive nitrogen fixer and fix the nitrogen as ammonia actively under poor aeration by the reductional Process.

Blue green alga account for one fourth of nitrogen input to the world's ocean. These include —

⇒ Obligatory aerobes e.g. - Azotobactor, Beijerinkia.
⇒ Facultative aerobes e.g. Bacillus, Klebsiella, Enterobactor.
⇒ Photo-synthetic e.g. Chromatium, Rhodosprillium.

It is estimated that when Azotobactor is grown along with other crops lead to higher yield and reduce the nitrogen requirement by 10-25 kg/ hectore.

(c). Loose association Nitrogen Fixation :-

Loose association Nitrogen fixing bacteria is Azosprillium liporerum; it lives with the roots of digitaria, sorghum, zea maize etc.

(3). Industrial Nitrogen fixation :

N_2 and H_2 combines to form NH_3 industrialy. It has been estimated that electro chemical and Photochemical fixation result ~~[illegible]~~ in an average amount of nitrate of 7.6×10^6 metric tonnes/year while biological estimated of 54×10^6 metric tonnes / year.

Biological nitrogen fixation involves following steps-

$N_2 \xrightarrow{\text{Splitting}} 2N$ $\quad \Delta G^\circ = +160$ K cal/mole

$2N + 3H_2 \xrightarrow{\text{Reduction}} 2NH_3$ $\quad \Delta G^\circ = -13$ K cal/mole

So, net energy input for nitrogen fixation is 147 K cal/mole.

(B) Ammonification →:

It involves the decomposition of Proteins of dead plants and animals and nitrogenous wastes like Urea, Uric acid etc. Ammonifying bacteria also called bacteria of decay.

The common Ammonifying bacteria are Bacillus Pzainosus B. vulgaris, B. mycoids. In this process, energy is also produced, so is an exothermic process.

Proteins → Amino acids → Ammonia

$$\text{Glycine} + O_2 \longrightarrow NH_3 + CO_2 + H_2O + \text{energy}.$$

$\Delta G^\circ = 176$ K cal/mole.

(C) Nitrification →:

It involves the oxidation of NH_3 to nitrate through nitrites in the Presence of Nitrifying bacteria in the following manner,

$$2NH_3 + 3O_2 \xrightarrow[\text{Nitrococcus}]{\text{Nitrosomonas}} 2NO_2^- + 2H^+ + 2H_2O \quad \Delta G^\circ = +65 \text{ kcal/mol}$$

$$2NO_2^- + O_2 \xrightarrow[\text{Nitro ojstis}]{\text{Nitro bacter}} 2NO_3^- + \text{energy} \quad \Delta G^\circ = +17 \text{ kcal}$$

It is pH dependent Process and occurs slowly in acidic cond.

Denitrification :-

It is a biological process by which ammonium compounds, nitrates and nitrites are reduced to molecular nitrogen in the presence of denitrifying bacteria like Thiobacillus denitrificans, Bacillus Subtilis, Pseudomonas etc. So it reduces the soil fertility and is stimulated by waterlogging, poor drainage, lack of aeration and accumulation of organic matter. It involves the following steps -

$NO_3^- \longrightarrow NO_2^-$ (Nitrite)

$NO_2^- \longrightarrow NO$ (Nitrous oxide)

$NO \longrightarrow N_2O$ (Nitric oxide)

$N_2O \longrightarrow N_2$ (Nitrogen)

So we find that N_2 cycle is the most complex cycle. There are different path available for the movement of Nitrogen and each path is regular biologically or non biologically. Energy is either consumed or released in each process.

fig : NITROGEN CYCLE