

# NITROGEN Cycle

Part of Paper I

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  $N_2$ ,  $NH_3$ ,  $N_2O$ ,  $NO$ ,  $NO_2$ ,  $NO_2^-$  and  $NO_3^-$ ) 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.

## (i) Atmospheric (Abiological) nitrogen fixation :->

By photochemical and electrochemical reactions, oxygen combines with nitrogen to form oxide of nitrogen. It can be summarized as under -



In the tropics where thunderstorms and lightning are common large quantities of nitrogen are converted into nitrogen.

(ii) Biological nitrogen fixation :- It involves the transformation of atmospheric  $N_2$  into nitrites and nitrates by living organisms. It is further of three types -

(a) Symbiotic nitrogen fixation -> It is brought about by certain bacteria like -

- ⇒ *Rhizobium leguminosarum* → in the root nodules of legumes.
- ⇒ *Frankia* → in the root nodules of *Alnus*, *Casuarina*.
- ⇒ *Klebsiella* → in the leaf nodules of *Sesuvium*.
- ⇒ *Nostoc* and *Anabaena* → in the coralloid roots of *Cycas*.
- ⇒ *Nostoc* in the thallus 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 legumes. Nodules contain a red colour pigment leghaemoglobin, it acts as an oxygen scavenger and keeps the level of molecular oxygen low inside the nodules which activates the enzyme nitrogenase which reduces  $N_2$  to ammonia.

(b) Asymbiotic Nitrogen Fixation → These are primitive nitrogen fixers and fix the nitrogen as ammonia actively under poor aeration by the reductonal process.

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

- ⇒ Obligatory aerobes e.g. - *Azotobacter*, *Beijerinckia*.
- ⇒ Facultative aerobes e.g. - *Bacillus*, *Klebsiella*, *Enterobacter*.
- ⇒ Photo-synthetic e.g. - *Chromatium*, *Rhodospirillum*.

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

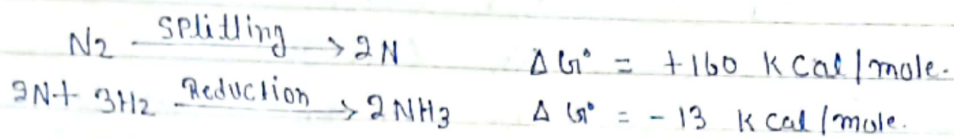
(c) Loose association Nitrogen Fixation :

Loose association nitrogen fixing bacteria is *Azospirillum lipoferum*; it lives with the roots of *Digitaria*, *Sorghum*, *Zea mays* etc.

### (a) Industrial Nitrogen fixation $\rightarrow$ :

$N_2$  and  $H_2$  combines to form  $NH_3$  industrially. It has been estimated that electrochemical and photochemical fixation result ~~estimated that~~ in an average amount of nitrate of  $7.6 \times 10^6$  metric tonnes/year while biological estimated at  $54 \times 10^6$  metric tonnes/year.

Biological nitrogen fixation involves following steps--

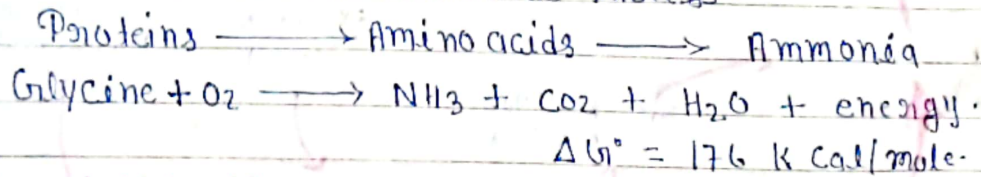


So, net energy input for nitrogen fixation is 147 kcal/mole.

### (b) Ammonification $\rightarrow$ :

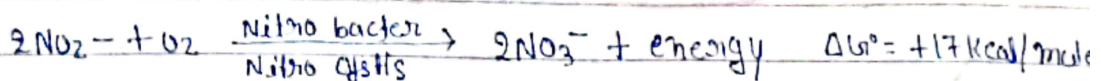
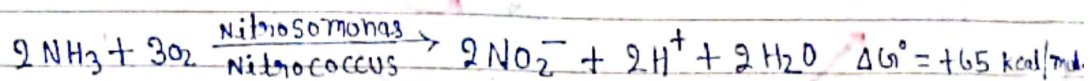
It involves the decomposition of proteins of dead plants and animals and nitrogenous wastes like urea, uric acid etc. Ammonifying bacteria also called bacteria of decay.

The common Ammonifying bacteria are *Bacillus Prazinosus*, *B. Vulgaris*, *B. mycoides*. In this process, energy is also produced, so is an exothermic process.



### (c) Nitrification $\rightarrow$ :

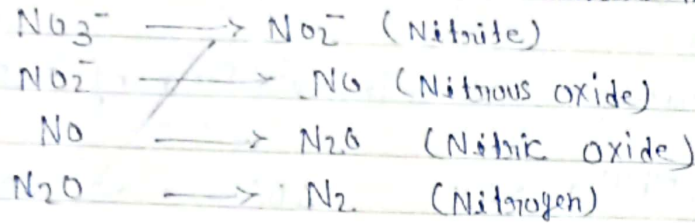
It involves the oxidation of  $NH_3$  to nitrate through nitrites in the presence of nitrifying bacteria in the following manner,



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

### (3) Denitrification :-

It is a biological process by which ammonium compounds, nitrate 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 -



So we find that N<sub>2</sub> cycle is the most complex cycle. There are different paths available for the movement of Nitrogen and each path is regular biologically or non biologically. Energy is either consumed or released in each process. (A)

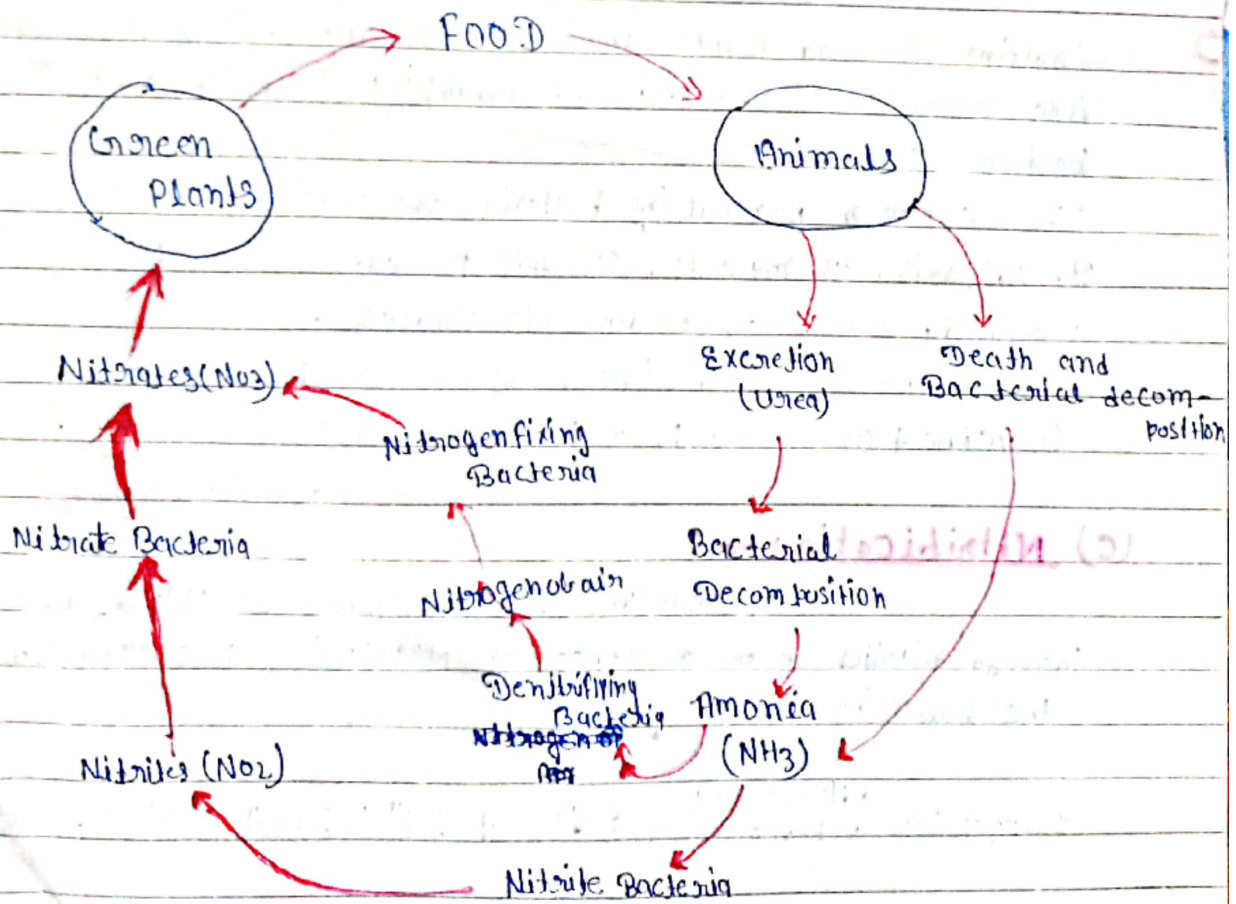


Fig :- NITROGEN CYCLE