

Aquatic Microbiology:

Nutrient Cycles- Carbon, Nitrogen, Sulphur

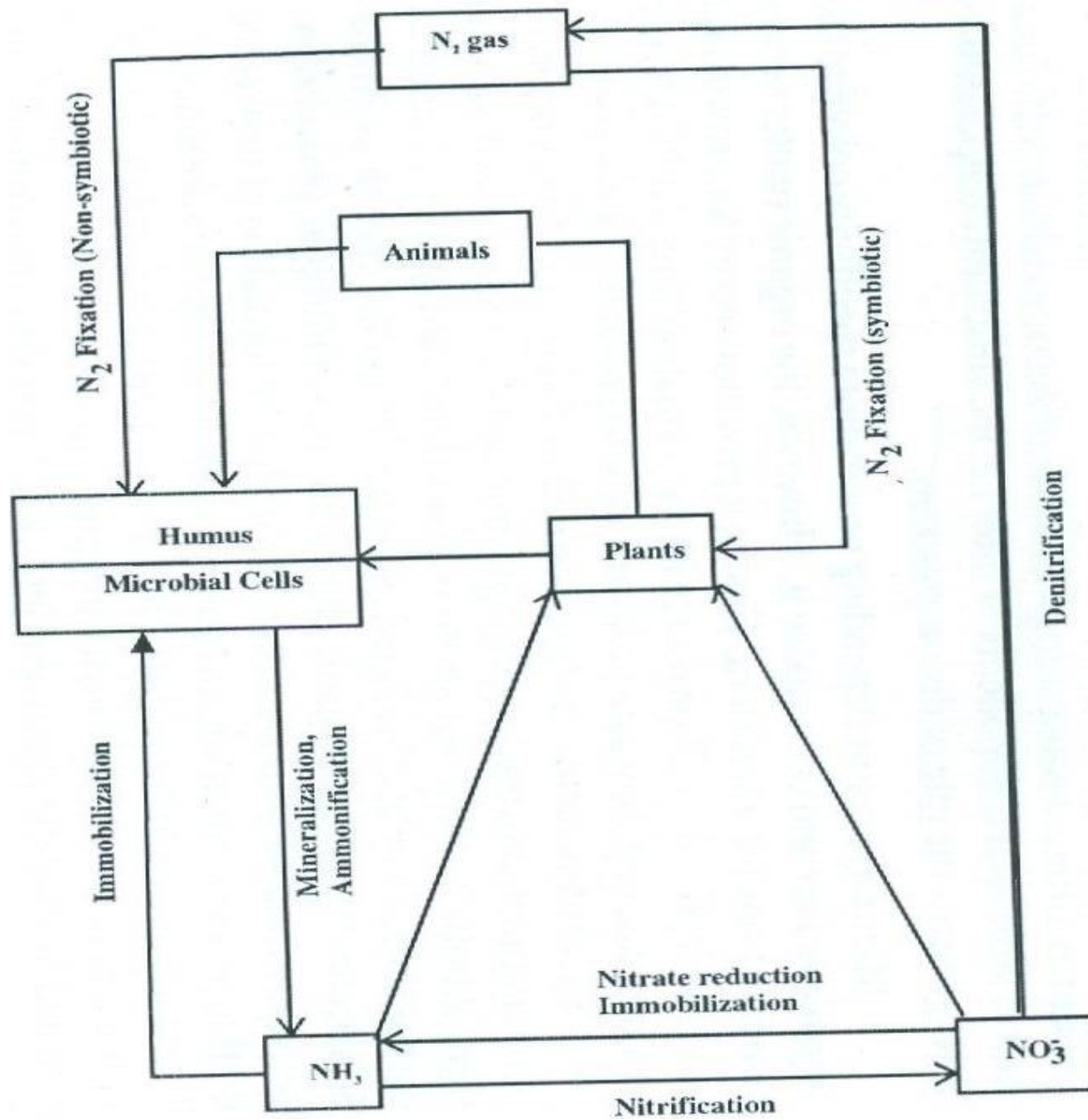
- A **nutrient cycle** (or ecological recycling) is the movement and exchange of organic and inorganic matter back into the production of matter.
- Energy flow is a unidirectional and noncyclic pathway, whereas the movement of mineral **nutrients** is cyclic.
- Mineral cycles include the carbon cycle, sulfur cycle, nitrogen cycle, water cycle, phosphorus cycle, oxygen cycle, among others that continually recycle along with other mineral nutrients into productive ecological nutrition.

Biogeochemical cycle

- Biogeochemical cycling associated with microorganisms is very important for the maintenance of soil fertility.

Nitrogen cycle:

- Nitrogen has the highest concentration in the atmosphere.
- Essential constituent of proteins and chlorophyll
- Key processes of cycling of nitrogen: nitrogen fixation, ammonification, nitrification and denitrification.



Nitrogen fixation

- Conversion of molecular nitrogen into a nitrogenous compound is known as nitrogen fixation.
- Nitrogen fixing microorganisms are called diazotrophs.
- Could be free living and symbiotic.

Ammonification

- Ammonification - organic nitrogen is converted to ammonia.
- Aerobic conditions:
- amino groups are removed from amino acids with the liberation of ammonia.

Nitrification

- Ammonia is oxidized to nitrate.
- First step, ammonia is oxidized to nitrite
Nitrosification.



Nitrosomonas and *Nitrosococcus*.

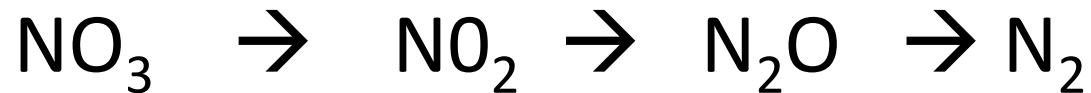
- Second step: The nitrite is oxidized to nitrate



Nitrobacter.

Denitrification

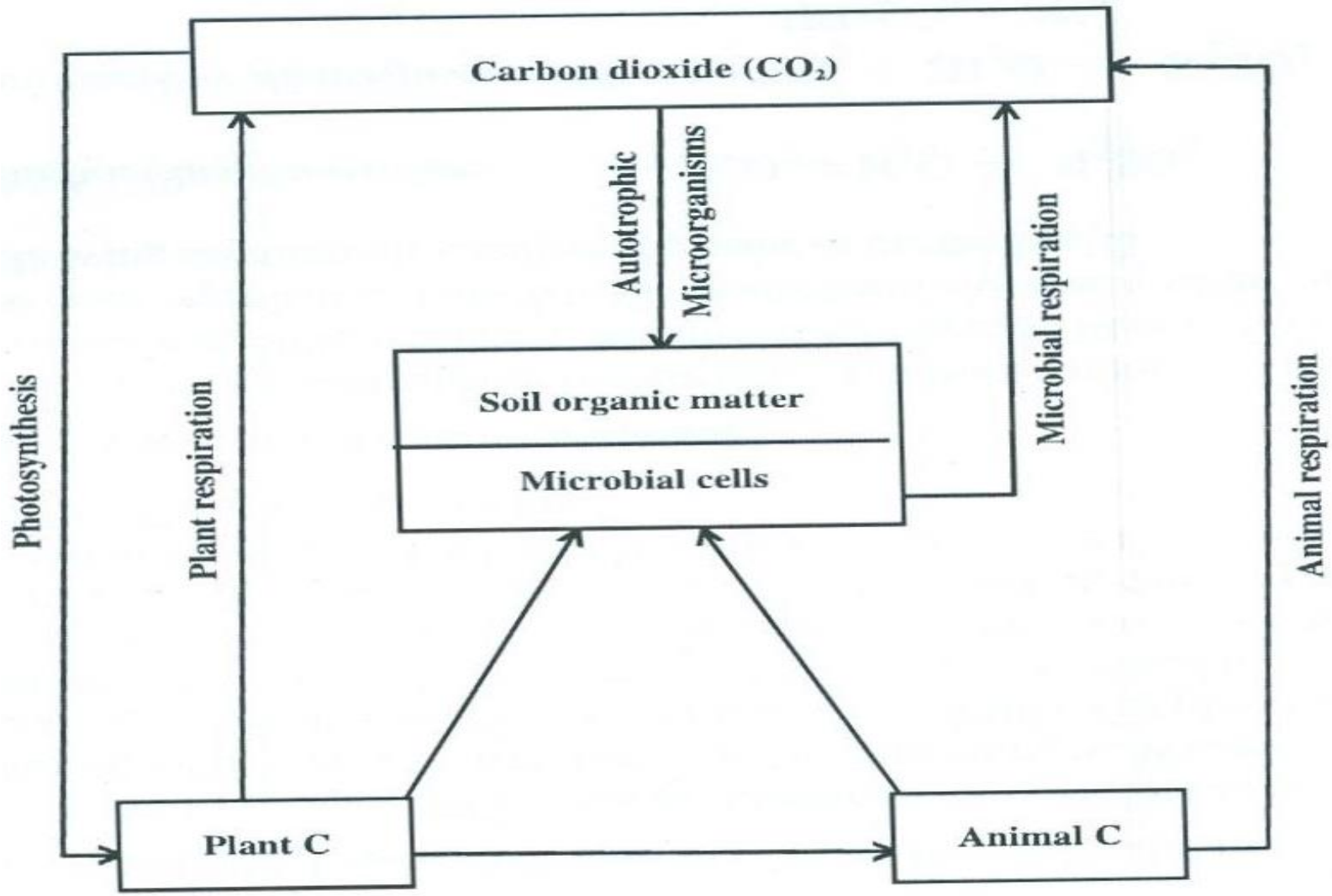
- Denitrification : Nitrates are reduced to nitrites to gaseous nitrogen



- Denitrification occurs under anaerobic conditions
- *Thiobacillus denitrificans*, *Micrococcus denitrificans* and *Clostridium* sp. etc are involved

Carbon cycle

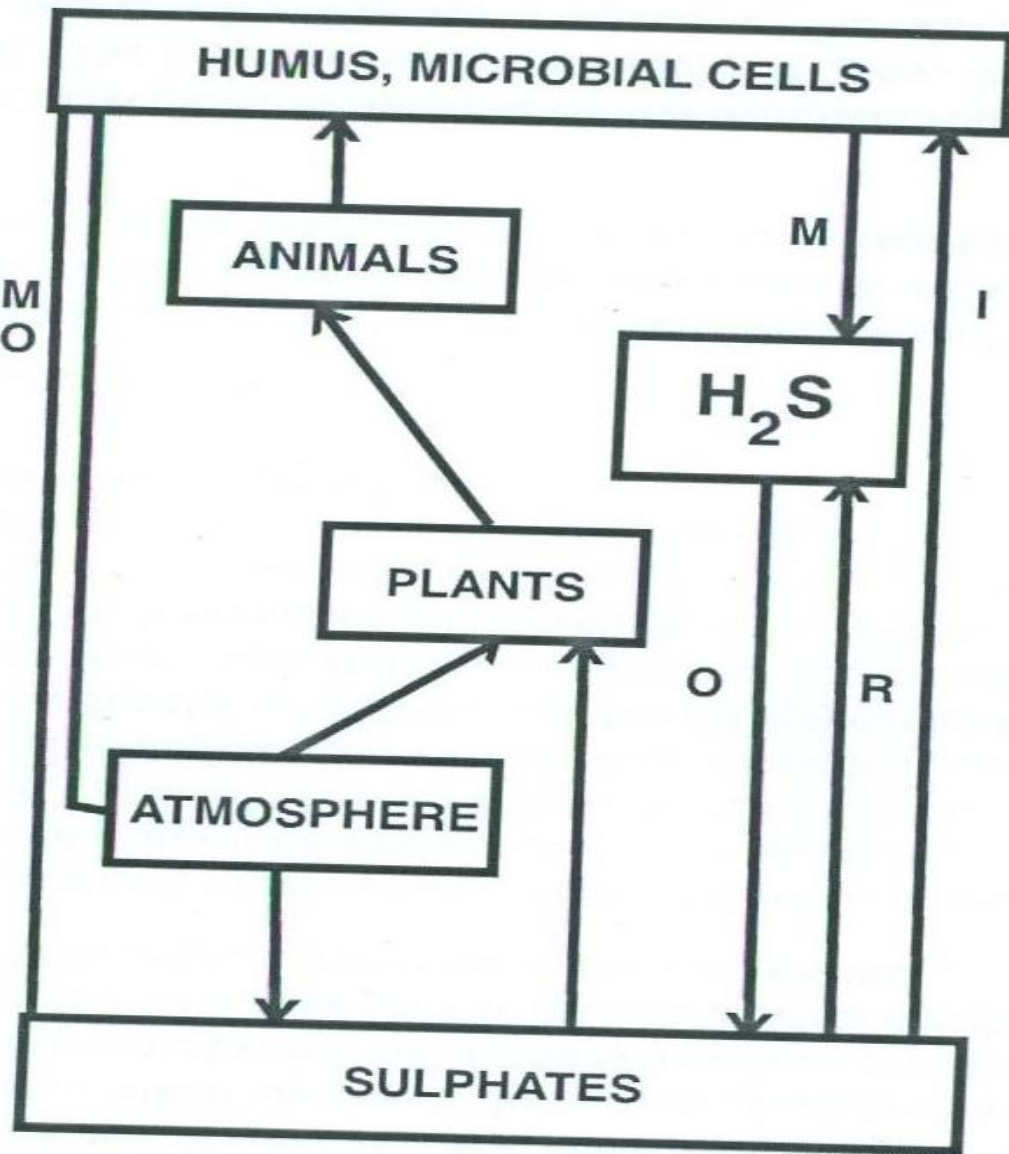
- Carbon exists in inorganic and complex organic compounds.
- In atmosphere of CO_2 is only 0.032 per cent .
- CO_2 returns back into the atmosphere through the process of respiration.
- Carbon degradation of organic matter by micro organisms.



The carbon cycle

Sulfur cycle

- Cyclic movements of sulfur between the living organisms and the environment sulfur cycle.
- Sulfur is an essential for all organisms
- Microbial proteins, aminoacids – cystine and methionine contain sulphur.
- In soil, it occurs both in inorganic form
- Four distinct transformations are recognised;
 - (i) decomposition of larger organic sulfur compounds to smaller units
 - (ii) microbial immobilization
 - (iii) oxidation of organic sulphides, thiosulphates and sulfur
 - (iv) reduction of sulphates to sulphides.



The sulphur cycle
 Mineralization I - Immobilization, O - Oxidation, R - Reduction

Decomposition of sulfur compounds

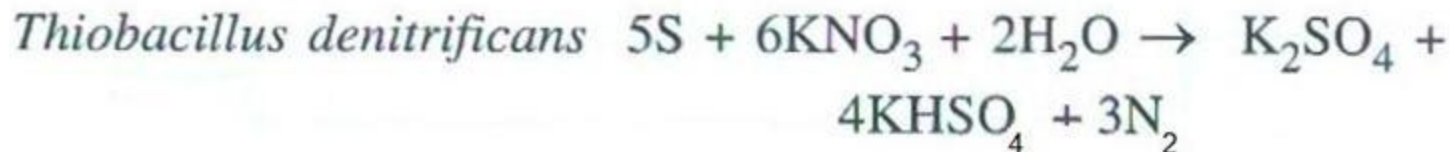
- Plants obtain their sulfur from sulfur compounds, animals feeding on plant materials sulfur is found mostly as a component of sulfur containing amino acids such
- Dead organic matter contains large molecules.
- Decomposers excrete digestive enzymes.
- Enzymes convert large molecules into small ones.
- Sulfur to inorganic compounds H_2S and NH_3

Microbial associated assimilation or immobilization

- Sulfur in soluble form, mostly as SO_4 , is absorbed through plant roots.
- Incorporated into amino acids and then to proteins.

Oxidation of sulfur compounds

- Some microorganisms oxidize reduced sulfur compounds.
- Sulfur oxidizers
- *Thiobacillus* catalysed by some of the thiobacilli.



- Heterotrophic bacteria, actinomycetes, and fungi are also able to oxidize sulphur compounds.

Reduction of sulfur compounds

- Anaerobic conditions is reduced to H₂S by sulfate reducing bacteria.
- *Desulfovibrio desulfuricans* seems to be the most important.
- Mechanism involves conversion of sulphate to sulphite, needs ATP.
- Sulphite is reduced to H₂S.
- $SO_4 \rightarrow SO_3 \rightarrow S_2O_3 \rightarrow S$