E-CONTENT – Evs (24)

Nalanda Open University

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M.A. / M.Sc. Environmental Science,

Part – I, Examination 2020

Short description of the suggested Topics

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Short description of the suggested Topics

Theory Paper – IV

(BIODIVERSITY, ITS CONSERVATION & MICROBIOLOGY)

Lesson Prepared by – Prof. (Dr.) Rajesh Kumar

Retired Professor, University Department of Botany,

V. K. S. University, Ara

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Next part of Theory Paper – IV

5. International Biodiversity Convention

The convention on biodiversity (biological diversity) or CBD is an international treaty presented at the Rio de Janeiro Earth summit in 1992 (Brazil) which aims to establish a legislative framework to the issues of protection and exploitation of biodiversity.

This is the first international text dealing biodiversity as a fragile entity, common to all humanity and that needs to be preserved.

To date over 193 countries are signatories to CBD, although some parties have not yet ratified.

Main themes of Convention

- Protection of biodiversity

- Sustainable use of biodiversity
- The fair and equitable sharing of benefits arising from the utilization of genetic resources.

The themes mentioned above were later on discussed in different International Convention as given below:

CARTAGENA PROTOCOL

This was on Biosafety to the convention on biodiversity. It offers signatory states a legal framework for the use of biotechnologies and/or their products, offering the introduction to the precautionary principle.

It is an international agreement fitting into the framework of Convention on Biological Diversity.

ITPGREA PROTOCOL

"International Treaty on Plant Genetic Resources for Food and Agriculture" is an International agreement by the FAD which came into force in June 2004. It provides a legal framework for exchange of biological resources when food safety issues are affected.

The aim of this International Convention is to promote the safeguarding of agricultural biodiversity by supervising its sustainable recovery. It defines the way for sharing agreements of benefits arising from their use. The ITPGREA is a treaty operated in accordance with the principles of Convention on Biological Diversity.

NAGOYA PROTOCOL (Japan)

This international agreement came into force on 12th October, 2014. It refers to Access to Genetic Resources and the Fair and Equitable sharing of benefits arising from their utilization to the Convention on Biological Diversity.

The aim of this protocol is to protect ancestral and cultural knowledge as well as misappropriation of genetic resources. The Nagoya Protocol is a part of the wider framework of Convention on Biological Diversity.

Main components of International Convention on Biodiversity

i. Convention on Biological Diversity
ii. Convention on International trade in Endangered species of wild Fauna and Flora (CITES)
iii. Convention on conservation of Migratory species of wild animals.
iv. International Treaty of Plant Genetic Resources for Food and Agriculture (ITPGRFA)
v. Convention on wetlands (Ramsar convention)
vi. World Heritage Convention (WHC)
vii. International Plant Protection Convention (IPPC)
viii. International Whaling Commission (IWC)

International efforts for Protection, Promotion and Conservation of Biodiversity

Our life depends on plants and without them ecosystem would cease to function. Our survival and survival of all species are tied to plants. Global Strategy for plant protection, promotion and conservation seeks to limit the rates of plant diversity loss. It will ultimately affect other living organism (animals) for their survival.

International efforts emphasize forming an idea of having a sustainable future where living species are able to thrive and be maintained (including their protection, promotion and conservation) under supporting human activities and in turn supports the livelihood and wellbeing.

Considering the seriousness, International Organizations have taken the following steps for Protection, Preservation, Promotion and Conservation of Biodiversity:-

They have 5 goals and total 16 targets

Objective 1

Biodiversity is well understood, documented and recognized.

Target:

i. An online data on flora and fauna of all species.
ii. An assessment of conservation status of all known species to guide conservation plan.
iii. Information, Research and Associated outputs to implement the strategy developed and shared.

Objective – 2

Biodiversity is urgently and effectively conserved.

Target:

iv. 15% ecological/vegetational type must be secured.
v. 75% area of plant diversity of each ecological area must be protected for conserving plants.
vi. 75% protection of lands in each sector must be managed sustainably.
vii. At least 75% of threatened species must be conserved in-situ.
viii. At least 75% of threatened species in ex-situ collection and 20% available for recovery and restoration.
ix. 70% of Genetic Diversity of crop must be conserved.
x. Effective management plan in place to prevent new biological invasions and to manage important area for diversity that are invaded.

Objective - 3

Biodiversity is used in a sustainable and equitable manner.

Target:

xi. No species of wild flora endangered by International Trade.
xii. All wild harvested plant-based products source must be used sustainably.

xiii. Indigenous and local knowledge and practices associated with local food security and health care must be mentioned.

Objective – 4

Education and awareness, its role in sustainable livelihoods and importance of life on earth must be promoted.

Target

xiv. The importance of biodiversity and the need for its conservation must be incorporated into communication, education and public awareness programme.

Objective - 5

The capacity and public engagements are necessary to implement the strategy.

Target

xv. The number of trained people working with appropriate facilities according to national needs be engaged to achieve the target of this strategy.

xvi. Institutions, networks, partnerships for conservation be established at national, regional and international levels to achieve the target of this strategy.

6. Growth of history of Microbiology; scope and importance of Microbiology.

Microbiology is the study of microorganism (microbes) which is not visible with naked eyes and only visible with microscope.

The diverse group of organisms includes – Bacteria, Archae, Algae, Cyanobacteria, Fungi, Protozoa and Virus. Viruses are ultramicroscopic and only visible with electron microscope).

Growth history of Microbiology

History of microbes starts in the late 17th century. Credit goes to Anton Van Leeuwenhoek (Dutch) for their discovery, who is known as Father of Microbiology. He developed single lens microscope with magnification of 50x - 300x. He published a series of articles in the British Royal Society, London during mid1670's on Paramecium, Amoeba, Filamentous – fungi, Algae and Bacteria.

- Then in 1688 Francisco Reddy (Italian) carried out a series of experiments on decaying meat and explained the Theory of Biogenesis which meant that living organisms arise only from pre-existing organisms.
- As growth of history of microbiology proceeds then Louis Pasteur disproved the theory of Abiogenesis that living organisms could develop from non - living matter.
- Edward Jenner (1796) used vaccination with materials to protect people against smallpox.

- In 1835 Agostino Bassi first reported that a microorganism could cause disease (Pathogenic) silk worm disease was due to fungal infection.

1860 - 1910: Golden Age of Microbiology - Many research works were conducted by

- **Louis Pasteur (1822 – 1895),** Robert Koch (1843 – 1910) and others. Many branches of microbiology were established.
- **Joseph Lister (1867)** developed an awareness that infectious disease were caused by microorganisms, chain of transmission can be broken, Pasteurization of milk, Purification of water and control of insects.
- **Chares Chamberland (1884)** developed bacterial filter and discovery of viruses and their role in disease.
- **Dmitri Iwanowski (1892)** developed TMV (tobacco mosaic virus) the first viral pathogen.
- **Buchner (1897) -** discovered the cell free alcoholic fermentation – provided the key to chemical analysis of energy yielding process.
- **Contributions of Louis Pasteur (1822 – 1895) –** (Father of industrial microbiology) - Firstly demonstrated that air contain microbes, discovered aerobic life, established the germ theory of fermentation and about the activity of microbes like yeast and bacteria, developed various methods of sterilization, hot air oven, autoclave etc. coined the term vaccine and develop vaccine for Anthrax and Rabies.
- **F. J. Cohn -** Discovered binary fission in Bacteria and discovered Bacillus and clostridium like bacteria.
- **Robert Koch (1843 – 1910)** Father of Medical Microbiology and discovered Bacillus of Anthrax and tuberculosis and cholera vibrio. Koch's postulates explained that
  - Microorganism can be isolated and grown in pure culture.
  - Isolated microorganism is inoculated into healthy host
  - He also developed many training bacteria.
  - Developed pure culture and solid culture to grow bacteria.
- **Ernst Ruska and Max Knoll (1934)** – Known for discovery of electron microscope and tissue culture technique.
- **1929 –** is year to remember when sir Alexander Fleming discovered the antibiotic Penicillin from a fungi called *Penicillium notatum* which destroys staphylococci to cure Tuberculosis.
- **Beadle and Tatum (1941)** isolated Neurospora crassa and proposed Onegene one enzyme hypothesis.
- In later stage there was development of r-DNA technology (Gene Cloning and Genetic Engineering). Valuable pharmaceutical drugs like Human Insulin, Hormones and several vaccines were developed.

Today, Modern Microbiology is well developed discipline with established concepts and techniques.

Importance and Scope of Microbiology

It has large scope as many microbiologists focus on specific group of micro-organisms such as

- Virologists – On viruses
- Bacteriologists – On Bacteria
- Phycologists – On algae (cyanobacteria)
- Mycologists – on fungi
- Protozoologists – on Protozoa

The scope is also on different fields-

- Microbial Morphology
- Microbial Cytology
- Microbial Genetics
- Microbial Taxonomy
- Microbial Physiology
- Microbial Ecology
- Molecular Biology
- Medical Microbiology
- Food Microbiology
- Public Health Microbiology
- Dairy Microbiology
- Immunology

The scope of microbiology in modern era is more significant as they are – extremely useful as experimental materials, very simple, grow rapidly, can culture in large quantities and easy to work with materials for studying complex processes of metabolism.

Microbes can be used for synthesis of Antibiotics, Toxins, Energy production and Microbial Nitrogen Fixation.

Importance :

i. Production of Antibiotics. Eg. – Penicillin from Penicillium.
ii. Production of enzymes, vaccines, alcoholic and other pharmaceutical drugs.
iii. Diagnosis of disease and their treatment for example – ELISA, Widal Test.
iv. Treatment of industrial wastes and materials.
v. Plant growth promotion (Hormones).
vi. Sterile product preparation.
vii. Sterilization (process of killing microorganism) eg. – moist, heat sterilization etc.
viii. Steroid biotransformation. eg. – Testosterone, Progesterone.

ix. Identification of micro-organism eg. – Morphological, microscopic or cultural study.

x. Testing of pharmaceutical products and raw materials

Reference:

i. A text book of Microbiology – by Dr. C. P. Baveja

ii. Microbiology – by J. Machael and N. R. Krieg

iii. Study Material of N. O. U, Patna

7. Role of micro-organisms in fighting the pollution.

The process of using microorganisms to remove the environmental pollutants or prevent pollution is called Bioremediation. It is also called Bio-treatment, Bioreclamation and Biorestoration. The removal of organic waste by microbes for environmental cleanup is the essence of Bioremediation.

Type of Bioremediation

I. Biostimulation

II. Bioaugmentation

III. Intrinsic Bioremediation

Following are the role of microorganism in control of pollution:

i. Use of Bacteria in control of Pollution - There are so many species of Bacteria which are used to clean pollutants such as GEMs (Genetically Engineered Microorganisms) bacteria like Pseudomonas, Alcaligends and Acinetobacter. Such bacteria produce enzymes to degrade Octane and many different organic compounds from crude oil.

List of such GEMs are given below with XENOBIOTICS.

S. No.	GEMs Genetically Engineered Microorganisms (Bacteria)	XENOBIOTICS (It refers to foreign and synthetic chemicals as – Pesticide, Herbicide etc.)
01.	*Pseudomonas putida*	Mono - and - dicholo aromatic compounds
02.	p. diminuta	Parathion
03.	P. obovoranus	Alkane
04.	Acinebactor species	4 – chlorobenzene
05.	Alcaligenes species	2, 4 – dichlorophenoxy acetic acid

The other Bacteria usually Thermophillic bacteria are used to break down organic matters including most toxic substances.

ii. Use of Fungi in Bioremediation (Pollution Control) - Certain fungi play important role in cleaning pollution such as

- Candida species is a fungi which can degrade formaldehyde.
- Gibeberella species can degrade - Cyanide

- ❖ White rot fungi can degrade organic pollutants in soil, TNT even DDT can be degraded by this fungi.

iii. Environmental cleanup by microorganisms

Basically there are two methods for removal and transportation of wastes for treatment:

A. In-situ bioremediation
B. Ex-situ bioremediation

A. In - situ involves direct approach for microbial degradation of Xerobiotics at the site of pollution like (soil and water). It has been successfully applied for cleanup oil-spillages, beaches etc.
B. Ex – situ - Toxic or Waste materials are collected the bioremediation with the requisite microorganisms can be carried out at designed places.

iv. Role of microorganisms in degradation of pollutants like Hydrocarbons

Petroleum and its products are hydrocarbons. Oil constitutes a variety of hydrocarbons (Xylanes, Naphthalenos, Octanes, camphor etc.).

Such pollutants can be degraded by microorganisms like Pseudomonas, Mycobacterium, Nocardia, Anthrobacter etc.

GEMs are used to enhance such bioremediations.

Note - Creation of superbug by transfer of plasmids of Bacteria are also very helpful to clean oil spills, marine pollution, sewage city and industrial pollutants.

v. Bio – surfactants - There are chemical compounds characterized by hydrophobic and hydrophilic regions in one molecule. Bio-surfactants from Bacteria, Cyanobacteria (blue green algae), Fungi and Yeast are classified into:

a. Glycolipid
b. Lipopeptides
c. Phospholipids
d. Glycoprotein
e. Polymeic Bio-surfactants

Bio-surfactant producing GEMs - A newly produced gem called *Pseudomonas aeruginosa* can reduce the surface tension of oil water surface thus promotes biodegradation of oil.

Thus a variety of pollutants are discharged in the environment (air, soil, water) from large number of industries and mills. Such contaminated air, soil and water can be made pollution free up to certain extent with the help of microorganisms.

Conclusion:

Microorganisms can play major role in bioremediation. It is a natural process and therefore perceived by the public. It is useful for destruction of wide variety of contaminants. Instead of transferring pollutants (contaminants) to land or air or water, the complete destruction of target pollutants is possible.

These activities are supported by a set of legislative and regulatory promotional measures, such as "National Environmental Policy (2006)" Clean Technology and Control of Pollution (CP) etc. Further, Government should plan a Joint Action Committee to launch bioremediation from lab to field.

Reference:

i. A text book of Biotechnology – by R. C. Dubey

ii. Bioremediation methods and its application – by U. Sathyanarayan

iii. Study material of N. O. U, Patna

8. Introductory note on Biogeochemical Cycle; Detailed description of Hydrological Cycle, Phosphorus Cycle and Nitrogen Cycle.

Biogeochemical cycle

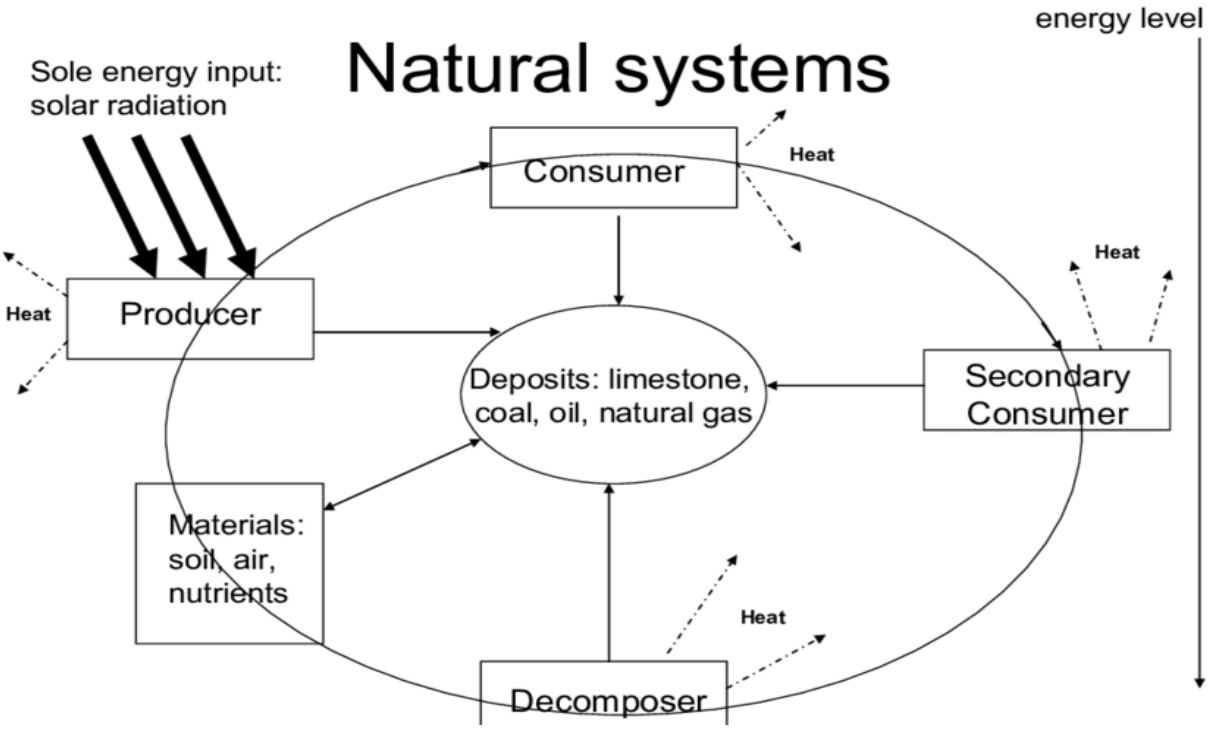
It is made up of 3 words:

Bio = life, Geo = Earth, Chemical = Elements (C, O, N, P, S etc.)

So, it can be defined as "A cycle of nutrients (water, Carbon, Oxygen, Nitrogen, Phosphorus, Sulphur) from the abiotic components of Ecosystem (water, air, soil, rock) through the biotic components (plants, animals, fungi, bacteria)

The way in which an element or compound such as water moves between its various living and nonliving forms and locations in the biosphere is called Biogeochemical Cycle.

The key point is that "energy flows through ecosystem and it dissipated as heat, but chemical elements are recycled" as shown below in the sketch:



However, the water which contains hydrogen and oxygen is essential for living organisms; that is why Hydrological Cycle or Water Cycle or H_2O Cycle is the most important of all Biogeochemical Cycles.

Hydrological or Water Cycle

Water

Water is very important for all living organisms. Our cells contain over 70 percent of water. Of the water on earth 97.5 percentage is salt water. Of the remaining water, over 99% is in the form of Underground water or Ice. Ground water is present in soil particles and in cracks of rocks. Aquifers are groundwater reservoirs. Less than 1% of freshwater is found in lakes, rivers and other available surface forms.

Hydrological Cycle is the most important process in the natural world also known as **Water Cycle or the Global H_2O Cycle**. It describes the storage and movement of water between the:

Biosphere – Atmosphere - Lithosphere – Hydrosphere

- Total amount of water remains constant; its distribution among various process changes.
- It is a cyclic form in which throughout water changes between its different states.
- Water evaporates into water vapour (gas).
- Water vapour condenses to become water (liquid).
- Water freezes into ice (solid).
- Ice melts into water.

Process and Components of Hydrological Cycle:

Evaporation; Precipitation; Infiltration; Percolation; Transpiration; Run off and Storage.

Evaporation - Evaporation occurs when water changes from liquid state to gaseous state. Maximum evaporation takes place from sea surfaces, rivers and lakes.

Condensation - Condensation is the process by which water vapour condenses to form clouds or fog or dew. Condensation takes place due to cooling of air.

Precipitation - Precipitation is the process of condensed water particles fall from the atmosphere and reach the ground. Precipitated water may fall into water bodies or on land. It can then go to stream or penetrate into soil.

Interception – Interception is the process of interrupting the movement of water in the chain of transportation events leading to streams.

Infiltration – Infiltration is the physical process involving movement of water through boundary area where atmosphere interfaces with the soil. Infiltrated water and water stored in soil, can become subsurface run off.

Percolation - Percolation is the movement of water through the soil due to gravity and by the capillary forces. All groundwater originates as subsurface water.

Transpiration – Transpiration is a physiological phenomenon in plants through which water inside plants is transferred to the atmosphere as water vapour. Only a small amount of water is retained by plants for metabolic processes.

Run off - Run off is the flow of water from a drainage to streams. It generally consists of the flow that is unaffected by artificial diversions or storage.

Storage - Three basic water storage places are

Atmosphere, Earth and the Ground.

Storage takes place in Oceans, Rivers, Glaciers etc. and underground storage occurs in soil and rocks.

Process - The process of Hydrological Cycle starts with oceans (sea) - where water gets evaporated due to heat energy (sunlight) and forms water vapour. Water vapour moves upwards forming clouds. Most of the clouds condense and precipitate in the form of rain, snow or sleet. Portion of water that reaches the ground, enters the earth's surface i.e. soil thus enhancing the water table and moisture content.

Then vegetation sends a portion of water vapour back to atmosphere through the process of transpiration. Some amount of water is retained as depression storage. The process continues by boiling of cool air over oceans, carrying water molecules, forming into water vapour then clouds getting condensed and precipitates as rainfall.

Similarly, water gets percolated into soil, increasing water table and runoff water heading toward water bodies.

Thus the cycling process continues.

Phosphorous Cycle

Phosphorous cycle is one of the Biogeochemical Cycles that describes the movement of Phosphorous through the Lithosphere, Hydrosphere and Biosphere.

Low concentration of Phosphorous in soil reduces plant growth and slows soil microbial growth.

It differs from other cycles because it does not include gas phase, although small amounts of phosphorous is present in the form of phosphoric acid (H_3PO_4) in atmosphere. The largest amount of P is present in sedimentary rock. In human body 80% of P is found in teeth and bones.

It is an important element for all forms of life. It is present in DNA, RNA and Critical component of ATP – the cellular energy carrier.

Process (Cycle)

It begins with rocks when it rains. Phosphates are removed from the rocks by weathering. They are distributed throughout both soil and water. Plant absorbs phosphate ions from the soil. Phosphates absorbed by the animal tissue eventually

returns to the soil through the excretion of urine, fecal as well as from the final decomposition of plants and animals after death.

The same process occurs within aquatic ecosystem. Phosphorous is not highly soluble, binding tightly to molecules in soil, therefore reaches water by travelling with run off soil particles. It may enter waterways through fertilizers, sewage seepage, natural mineral deposits and wastes. They are thus available for aquatic organism and travels up through successive stages of food chain.

It is beneficial for many biological processes but excessive concentration of phosphorous is considered pollutant. Humans can alter the phosphorous cycle by cutting of tropical rain forests and use of agricultural fertilizers.

Nitrogen Cycle

Nitrogen Cycle is the process by which nitrogen travels between its various chemical forms. This transformation can be carried out through both biological and physical processes.

Forms of Nitrogen

a. Nitrogen as : Ammonia (NH_4)
Nitrate (NO_3^-)
Nitrite (NO_2^-)
Nitrous oxide (NO_2)
Nitric oxide (NO)

b. Nitrogen as : Nitrogen gas (N_2)

Nitrogen cycle consists of the following steps:

I. Nitrogen fixation
II. Nitrogen Assimilation
III. Ammonification
IV. Nitrification
V. Denitrification
VI. Sedimentation

I. Nitrogen fixation

It is the conversion of free Nitrogen of atmosphere into the biologically acceptable form or Nitrogenous compounds.

There are three ways to convert N_2 into more chemically reactive forms:

a. Biological N_2 fixation
b. Physico-chemical N_2 fixation
c. Industrial N_2 fixation

a. Biological N_2 fixation

Some symbiotic bacteria, Blue green algae and some free living bacteria are able to fix Nitrogen as Organic Nitrogen.

Example - Symbiotic bacteria - Rhizobium

- Blue green algae - species of Nostoc, Anabaena etc.
- Free living bacteria such as – Azobacter, Clostridium, Rhodosprillium etc.

b. Physico-chemical N_2 fixation or Non biological N_2 fixation

In this process, atmospheric Nitrogen combines with oxygen (as Ozone) during lightning and electrical charges in the clouds and produces different Nitrogen oxides.

$$N_2 + 2\,(o) \longrightarrow 2NO$$
$$2NO + 2\,(o) \longrightarrow 2NO_2$$
$$2NO_2 + (o) \longrightarrow N_2O_5$$

Nitrogen Oxides get dissolved in rain water and on reaching earth surface they react with mineral compounds to form Nitrates and other Nitrogenous compounds.

$$N_2O_5 + H_2O \longrightarrow 2HNO_3$$
$$2HNO_3 + CaCO_3 \longrightarrow Ca(NO_3)_2 + CO_2 + H_2O$$

c. Industrial N_2 fixation

Under great pressure at a temperature of 600^0C and with the use of an Iron Catalyst, Hydrogen and atmospheric nitrogen can combined to form ammonia (NH_3) in Haber – Bosch process.

II. Nitrogen Assimilation

In this process, Inorganic Nitrogen in form of nitrates, nitrites and ammonia is absorbed by the green plants via their roots and then it is converted into nitrogenous organic compounds

Nitrates are firstly converted into Ammonia which combines with organic acids to form amino acids. It is then used in synthesis of proteins, enzymes, chlorophylls, Nucleic acid etc.

III. Ammonification

It is the process of releasing Ammonia by certain microorganisms utilising organic compounds derived from dead organic remains of plants and animals and excreta of animals.

The microorganisms involved are:

Actinomycetes and Bacillus vulgaris, Bacillus ramosus etc.

IV. Nitrification

It is the process of enzymatic oxidation of ammonia to nitrate by certain microorganisms in soil and ocean.

Nitrosomonas - ammonia to nitrites $(NO_2)^-$

Nitrobacter - oxidation of nitrites into nitrates $(NO_3)^-$

In Soil, $2NH_4^+ + 2O_2\,(o) \longrightarrow NO_2^- + 2H_2O + \text{Energy}$

In Ocean $2\,NO_2^- + O_2 \longrightarrow 2\,NO_3^- + \text{Energy}$

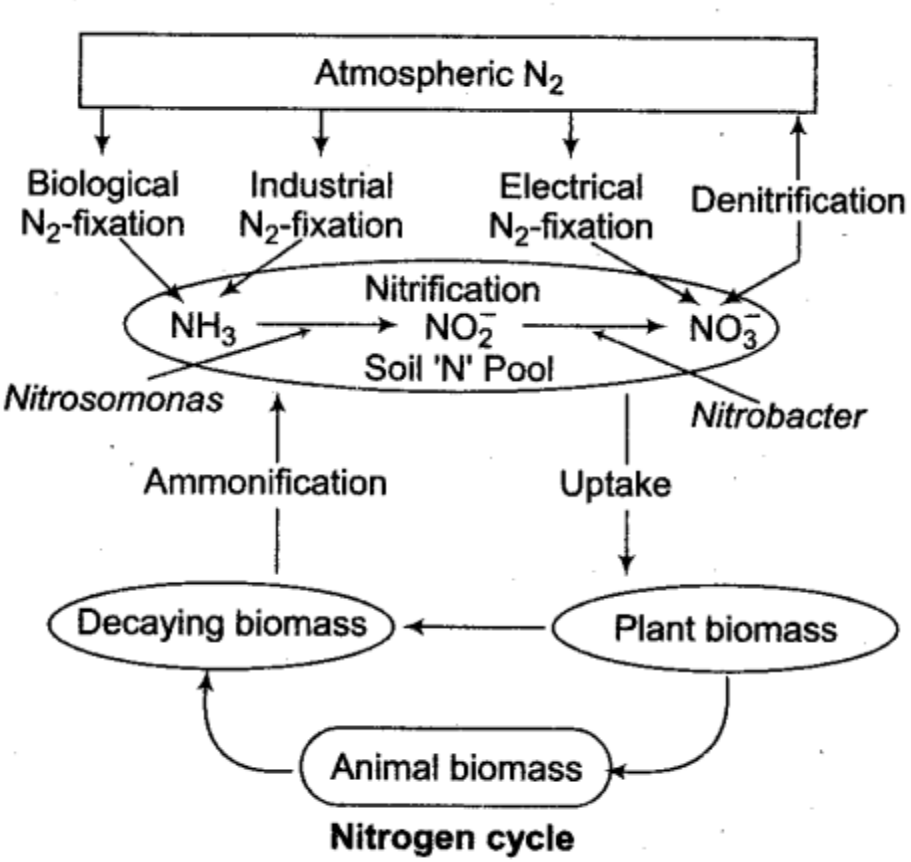
V. Denitrification

It is reduction of nitrates back into the largely inert Nitrogen gas (N_2) by denitrifying bacteria such as Pseudomonas, Micrococcus, Thiobacillus etc.

$$2\,NO_3^- \longrightarrow 2\,NO_2^- \longrightarrow 2NO \longrightarrow NO_2 \longrightarrow N_2$$

VI. Sedimentation

Sometimes, nitrates of soil are locked up in the rocks while they are washed down to sea or leached deeply into the earth along with percolating water. This phenomenon is called **Sedimentation.**



Nitrogen cycle