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Scope and Importance of Soil Microbiology

Living organisms both plant and animal types constitute an important component of soil. Though these organisms form only a fraction (less than one percent) of the total soil mass, but they play important role in supporting plant communities on the earth surface. While studying the scope and importance of soil microbiology, soil-plant-animal ecosystem as such must be taken into account. Therefore, the scope and importance of soil microbiology, can be understood in better way by studying aspects like.

1. Soil as a living system. **2**. Soil microbes and plant growth.

3. Soil microorganisms and soil structure. **4**. Organic matter decomposition.

5. Humus formation. **6.** Biogeochemical cycling of elements.

7.Soil microorganisms as bio-control agents. **8**. Soil microbes and seed germination,

9. Biological N2 fixation, **10**. Degradation of pesticides in soil.

1. Soil as a living system

Soil inhabit diverse group of living organisms, both micro flora (fungi, bacteria, algae and actinomycetes) and micro-fauna (protozoa, nematodes, earthworms, moles, ants). The density of living organisms in soil is very high i.e. as much as billions / gm. of soil, usually density of organisms is less in cultivated soil than uncultivated / virgin land and population decreases with soil acidity. Top soil, the surface layer contains greater number of microorganisms because it is well supplied with Oxygen and nutrients. Lower layer / subsoil is depleted with Oxygen and nutrients hence it contains fewer organisms. Soil ecosystem comprises of organisms which are both, autotrophs (Algae, BOA) and heterotrophs (fungi, bacteria).Autotrophs use inorganic carbon from CO2 and are "primary producers" of organic matter, whereas heterotrophs use organic carbon and are decomposers/consumers.

2. Soil microbes and plant growth:

Microorganisms being minute and microscopic, they are universally present in soil, water and air. Besides supporting the growth of various biological systems, soil and soil microbes serve as a best medium for plant growth. Soil fauna & flora

convert complex organic nutrients into simpler inorganic forms which are readily absorbed by the plant for growth. Further, they produce variety of substances like IAA, gibberellins ,antibiotics etc. which directly or indirectly promote the plant growth

3. Soil microbes and soil structure:

Soil structure is dependent on stable aggregates of soil particles-Soil organisms play important role in soil aggregation. Constituents of soil are viz. organic matter, polysaccharides, lignins and gums, synthesized by soil microbes plays important role in cementing / binding of soil particles. Further, cells and mycelia strands of fungi and actinomycetes, Vormicasts from earthworm is also found to play important role in soil aggregation. Different soil microorganisms, having soil aggregation / soil binding properties are graded in the order as fungi > actinomycetes > gum producing bacteria > yeasts. Examples are: Fungi like*Rhizopus, Mucor, Chaetomium, Fusarium, Cladosporium, Rhizoctonia, Aspergillus, Trichoderma* and Bacteria like *Azotobacter, Rhizobium ,Bacillus* and *Xanthomonas.*

4. Soil microbes and organic matter decomposition:

The organic matter serves not only as a source of food for microorganisms but also supplies energy for the vital processes of metabolism that are characteristics of living beings. Microorganisms such as fungi, actinomycetes, bacteria, protozoa etc. and macro organisms such as earthworms, termites, insects etc. plays important role in the process of decomposition of organic matter and release of plant nutrients in soil. Thus, organic matter added to the soil is converted by oxidative decomposition to simpler nutrients /substances for plant growth and the residue is transformed into humus. Organic matter /substances include cellulose, lignins and proteins (in cell wall of plants), glycogen (animal tissues), proteins and fats (plants, animals). Cellulose is degraded by bacteria, especially those of genus *Cytophaga* and other genera*(Bacillus, Pseudomonas, Cellulomonas, and Vibrio Achromobacter)* and fungal genera *(Aspergillus, Penicilliun, Trichoderma, Chactomium,Curvularia).* Lignins and proteins are partially digested by fungi, protozoa and nematodes. Proteins are degraded to individual amino acids mainly by fungi, *actinomycetes* and *Clostridium.*

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Under unaerobic conditions of waterlogged soils, methane are main carboncontaining product which is produced by the bacterial genera (strict anaerobes) *Methanococcus, Methanobacterium* and *Methanosardna*.

5. Soil microbes and humus formation:

Humus is the organic residue in the soil resulting from decomposition of plant and animal residues in soil, or it is the highly complex organic residual matter in soil which is not readily degraded by microorganism, or it is the soft brown/dark coloured amorphous substance composed of residual organic matter along with dead microorganisms.

6. Soil microbes and cycling of elements:

Life on earth is dependent on cycling of elements from their organic / elemental state to inorganic compounds, then to organic compounds and back to their elemental states. The biogeochemical process through which organic compounds are broken down to inorganic compounds or their constituent elements is known “Mineralization”, or microbial conversion of complex organic compounds into simple inorganic compounds & their constituent elements is known as mineralization .Soil microbes plays important role in the biochemical cycling of elements in the biosphere where the essential elements (C, P, S, N & Iron etc.) undergo chemical transformations. Through the process of mineralization organic carbon, nitrogen, phosphorus, Sulphur, Iron etc. are made available for reuse by plants.

7. Soil microbes and biological N2 fixation:

Conversion of atmospheric nitrogen in to ammonia and nitrate by microorganisms is known as biological nitrogen fixation. Fixation of atmospheric nitrogen is essential because of the reasons:

1.Fixed nitrogen is lost through the process of nitrogen cycle through denitrification.

2.Demand for fixed nitrogen by the biosphere always exceeds its availability.

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3.The amount of nitrogen fixed chemically and lightning process is very less (i.e. 0.5%) as compared to biologically fixed nitrogen.

4. Nitrogenous fertilizers contribute only 25% of the total world requirement while biological nitrogen fixation contributes about 60% of the earth's fixed nitrogen.

5.Manufacture of nitrogenous fertilizers by "Haber" process is costly and time consuming.

The numbers of soil microorganisms carry out the process of biological nitrogen fixation at normal atmospheric pressure (1 atmosphere) and temp (around 20 °C).Two groups of microorganisms are involved in the process of BNF.

A. Non-symbiotic (free living) and

B. Symbiotic (Associative)

Non-symbiotic (free living): Depending upon the presence or absence of oxygen, non symbiotic N2 fixation prokaryotic organisms may be aerobic heterotrophs (*Azotobacter, Pseudomonas, Achromobacter)* or aerobic autotrophs *(Nostoc, Anabena, Calothrix, BGA)* and anaerobic heterotrophs *(Clostridium, Kelbsiella. Desulfovibrio)* or anaerobic Autotrophs *(Chlorobium,Chromnatium, Rhodospirillum, Methanobacterium etc)*

Symbiotic (Associative): The organisms involved are *Rhizobium, Bratfyrhizobium* in legumes(aerobic): *Azospirillum* (grasses), Actinonycetes frantic(with *Casuarinas,* Alder).

8. Soil microbes as biocontrol agents:

Several ecofriendly bioformulations of microbial originate used in agriculture for the effective management of plant diseases, insect pests, weeds etc. eg: *Trichoderma* sp and *Gleocladium* sp are used for biological control of seed and soil bornediseases. Fungal genera *Entomophthora, Beauveria, Metarrhizium* and protozoa *Maltesia grandis. Malameba locustiae* etc are used in the management of insect pests. Nuclear polyhydrosis virus (NPV) is used for the control of *Heliothis /* American boll worm. Bacteria like *Bacillus thuringiensis, Pseudomonas* are used in cotton against Angular leaf spot and bollworms.

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9 . Degradation of pesticides in soil by microorganisms:

Soil receives different toxic chemicalsin various forms and causes adverse effects on beneficial soil micro flora / micro fauna, plants, animals and human beings. Various microbes present in soil act as the scavengers of these harmful chemicals in soil. The pesticides/chemicals reaching the soil are acted upon by several physical, chemical and biological forces exerted by microbes in the soil and they are degraded into non-toxic substances and thereby minimize the damage caused by the pesticides to the ecosystem. For example, bacterial genera like *Pseudomonas, Clostridium, Bacillus, Thiobacillus, Achromobacter etc. and* fungal genera like *Trichoderma, Penicillium, Aspergillus, Rhizopus, and Fusarium* are playing important role in the degradation of the toxic chemicals / pesticides in soil.

10. Biodegradation of hydrocarbons:

Natural hydrocarbons in soil like waxes, paraffin‟s, oils etc are degraded by fungi, bacteria and actinomycetes. E.g. ethane *(C2*H6) a paraffin hydrocarbon is metabolized and degraded by *Mycobacteria, Nocardia Streptomyces ,Pseudomonas, Flavobacterium* and several fungi.