SOIL MICRO AND MACROORGANISMS

The free living components of soil biota are bacteria, actinomycetes, fungi, algae as well as the micro and macrofauna. Additionally, there is viruses which grow only within the living cells of other organisms.

Viruses

Viruses consist of RNA and DNA molecules within protein coats. Viral particles are metabolically inert and do not carry out respiratory or biosynthetic functions. They multiply only within the host and induce a living host cell to produce the necessary viral components, after assembly, the replicatedviruses escape from the cell with the capability of attacking new cells.

Importance of viruses

1. Their ability to interact with host genetic material can make viruses very difficult to control.

2. This is also the reason why they are useful as genetic transfer agents in genetic engineering because they can serve as transfer agents a wide diversity of cells.

3. Viruses are distinguished by their ability to pass through filters capable of holding all known bacterial types.

4. They have capability for self-reproduction and ability to cause many plant and animal diseases. Viruses infect all categories of animals and plants from humans to microbes.

5. Viruses that infect soil organisms can persist in soil as dormant units that retain parasitic capability.

6. The ability of viral particles pathogenic to plants and animals to survive in soil and move into the water table is a major concern.

7. Viruses have promising prospect in biological control of weeds and obnoxious insects.

Bacteria

Bacteria are the most numerous of the microorganisms in soil. Indeed they are the most common of all the living organisms on the face of the earth. They lack nuclear membranes therefore they are termed prokaryotic cells. Their cell walls are composed principally of peptidoglycans and reproduction is by binary fission. Genetic transfer is accomplished by conjugation and transduction.Energy source and carbon source are useful for describing physiological differences among bacteria and other organisms. The majority of known bacterial species is chemoorganotrophic and is commonly referred to as heterotrophs and a few species are chemolitotrophs. The obligate chemolitotrophs used the same physiological pathway i.e Calvin cycle. Their inability use any known external source of organic carbon is linked to lack of permeases to move organic molecules across cell membranes. Therefore organic molecules must be manufactured within the cell.

The following are some bacteria which are prominently encountered in the soil taking part in soil processes.

Arthrobacter:

Numbers of the genus are numerically prominent in soil constituting up to 40 % of the total plate count population. They are reported to utilize 85-180 compounds. They are slow growing

and poor competitors in the early stages of decomposition when easily decomposable materials are rapidly attacked by other genera.

Pseudomonads:

They are aerobic except for denitrifying species that use nitrate as an alternative electron acceptor. Most species are organotrophs, a few are facultative litothrophs using H_2 or CO as an energy source. They also occur in marine waters, some species cause plant disease, and many nonpathogens are closely associated with plants. They attack a wide variety of organic substrate including sugars, amino acids, alcohol and aldose sugars, hydrocarbons, oils, humic acids and many of the synthetic pesticides.

Xanthomonas:

This is closely related to *Pseudomonas*, it embraces similar properties ecept that molecular oxygen is the only electron acceptor and nitrates are not reduced. They are pathogenic to many plants.

Sporulating Bacilli:

These members of the genus Bacillus produce heat resistant endospores and sporulation is not repressed by exposure to air. They are mostly vigorous organotrophs and their metabolism is strictly respiratory, strictly fermentative or both. There is great diversity within the genus as shown by the array of products formed by different species during the course of glucose fermentation, products include; glycerol, 2,3-butanediol, ethanol, hydrogen, acetone and formic, acetic, lactic and succinic acids. Some species are facultative litotrophs that use H_2 as an

energy source in the absence of organic carbon. *Bacillus polymyxa* is able to fix nitrogen. Several species produce lytic enzymes and antibiotic that are destructive to other bacteria eg *Bacillus thuringiensis* produce toxin which is pathogenic to insect lavae. *Bacillus mercerans* is used for retting flax, *Bacillus anthracis* is a highly animal pathogen.

Clostridium:

This is a sporogenic genus, most are strict anaerobes. The genus is of economic importance used commercially for the production of alcohols and commercial solvents. Several species such as *C butyrichum* and *C pasterianum* fix nitrogen. They are widely distributed in soils, marine and freshwater sediments, manures and animal intestinal tract. Some species are pathogenic to animals, eg *C tetani* and *C butilinum*.

Azotobacter:

This is an aerobic organotrophic bacterium capable of fixing nitrogen asymbiotically. Other genera fixing nitrogen asymbiotically are Azomonas, Beijerinkia, Dexia and Azospirillum. And Rhizobium are known to fix nitrogen symbiotically. A related genus Agrobacterium induces galls on hairy root but does not fix nitrogen. *Nitrosomonas* and *Nitrobacter* are chemolithotrophic genera. *Nitrosomonas* convert NH_4^+ to NO_2^- and *Nitrobacter* convert NO_2^- to NO_3^-.

Lactobacillus:

This is a fermentative organotrophic bacterium; it is commonly associated with plant herbage. Its lactic acid production is exploited in silages, butter, milk and local dairy products.

Enterobacter is also fermentative found in animal feces and sewage; some species are widely distributed in soil.

ACTINOMYCETES

About 90 % of the actinomycetes isolated from soil belong to the genus Streptomyces. Its members produce a well-developed, compact branched mycelium and compact colonies on agar plates. Reproduction is by production of aerial spores and by mycelial fragmentation. They are intolerant of waterlogged soil, less tolerant of dessication than fungi and generally intolerant of acidity. Thus causal organism of potato scab *S scabis* is controlled in poorly buffered soils such as sand by sulphur and ammonium amendment which result in lowered soil pH.

Many Streptomyces produce antibiotics, antibacterial, antifungi, antialgal, antiviral, antiprotozoal, or antitumor. Streptomyces also produce geosmin which is responsible for the musty smell of freshly plowed soil and partly responsible for the musty smell of earthen cellers and old straw piles. It appears that Streptomyces is mainly responsible for the maintenance of soil biological balance.

FUNGI

These are the eukaryotic organisms variously referred to as mold, mildews, rusts, smuts, yeasts, mushrooms and puffballs. Fungi are the organotrophs primarily responsible for decomposition of organic residues even though they are always outnumbered by bacteria. Important classes encountered in soil include;

Aerasiomycetes:

These are unicellular; the unit of structure is the uninucleate amoeba that feeds by engulfing bacteria. Single cells characteristically aggregate into pseudoplasmodium in which the cell does not fuse but behave as a mobile communal unit, this later change into a fruiting structure called sporocarp which bears the asexual spores.

Myxomycetes:

These are true slime forming asexual creeping plasmodium, they are animal like in their feeding but fungus like in their reproductive structure and spore formation. They are widely distributed especially in association with decaying vegetation in cool moist locations.

Oomycetes:

They are found in water and soil, they are highly destructive to plant, and they produce biflagellate asexual motile spores called zoospores. *Pythium* and *Phythophthora* are commonly encountered in soil.

Chytridiomycetes:

They are prevalent in aquatic habitat, but also commonly encountered in soil, some members are parasitic on algae, higher plants or insect lavae.

Zygomycetes:

They ferment different carbohydrate substrates. They are mostly saprobic, but some are phytopathogenic, some parasite on other fungi, some produce animal trapping mechanisms.

The mucorales which are the largest order are important economically as they are used for commercial production of alcohol and organic acids.

Ascomycetes:

Ascomycetes and Basidiomycetes are called the higher fungi. The ascomycetes are distinguished by the formations of ascus within which are ascospores following sexual reproduction. Many of them are saprophytic having a range of impacts eg plant pathogenicity, some are destructive on materials. Others are beneficial eg the fermenting activities of yeast which has long been exploited in beer, wine and bakeries.

Basidiomycetes:

This include a wide selection of fungi, they differ from other fungi by the production of specialized structure called basidium. Many of them are plant parasite thus causing heavy losses of crop and tree plants. Some are beneficial eg mycorrhizal-forming relationship with plants; mushroom has commercial importance as edible food. They are vigorous decomposers of woody materials.

Deuteromycetes:

This embraces fungi with septate hyphae but reproduce only by means of conidia, they do not have a sexual reproductive phase, and they are called fungi imperfecti. They are mostly saprobic in soil, some may be parasiticon other fungi, higher plants, humans and other animals eg species of *Aspergillus*, *Penicillium*, *Trichoderma*, *Fusarium*.

ALGAE

Blue green algae

Cyanobacteria are the blue green algae they possess photosystem II and carry out oxygenic photosynthesis. They contain chlorophyl A and phycobiliprotein pigments such as phycocyanin. They exist in unicellular, colonial and filamentous forms. They have single cells, reproductive cells or units and filamentous forms enclosed in rigid sheaths and they often show gliding motility. They are widely distributed occurring in saline and fresh waters, in soil, on bare rocks and sand. They also occur within the plant bodies of some liverworts, water ferns and angiosperms. In some ecosystems cyanobacteria are of great significance because of their ability to fix nitrogen.

Green algae

These are the eukaryotic algae they are the simplest forms of the chlorophyllus eukaryotes distinguished from other green plants by sexual characteristics. Some green algae are unicellular and some are multicellular. The algae are the most widely distributed of all green plants. They are predominantly aquatic found in fresh, brackish and salt waters. Terrestrial forms occur on rocks, mud and sand, snowfields and buildings and attached to plants and animals. Subsurface soil samples kept moist and under illumination commonly develop algae blooms. Most algal units found below ground are dormant forms some are however known to be facultative organotrophs.

SOIL MICROFAUNA

These are the microfauna (less than 0.1 mm), mesofauna (0.1-10 mm) and macrofauna (greater than 10 mm)

Microfauna

This is typified by the protozoans, they are unicellular most of which are microscopic in size but some attain macroscopic dimensions. The group is greatly diverse in morphology and feeding habit. All require water envelopment for metabolic activity. Five main groups are commonly recognized; Flagellates, ciliates, naked and testate amoeba and sporozoa. Sporozoans are wholly parasitic. Free living protozoa in soil feed on dissolved organic substances and other organism. Many feed by grazing and predation, the soil ciliates depend primarily on bacteria for food, some feed additionally on yeasts and other protozoa and even on small metazoan such as rotifers. The soil an effect on the structure and functioning of microbial communities, the rise in bacteria numbers following addition of fresh residues to soil is always followed by a rise in protozoan numbers. Selective feesding by protozoa may alter the mix of bacterial genera. Protozoa may accelerate nutrient cycling and their active motility in the soil water help to provide bacteria with dissolved oxygen and nutrients.

Meso and Microfauna

These are also called metazoan, they include; the soil dwelling nematodes, millipedes, centipedes, rotifers, mites, annelids, spiders and insects. The small members exemplified by nematodes are able to move through existing soil pores without disturbing the soil particles. The nematodes are also called are the most numerous of the soil metazoan, their numbers may reach several million per square meter. The free living forms in soil are voracious feeders on

both microflora and other fauna. Earthworms constitute the major portion of the invertebrate biomass in soil and when present are active in processing litter distributing organic matter throughout the soil. The importance of the mesofauna in soil lies in its effect on soil and litters and on the structure of microbial communities.

SOIL ENZYMES

Life is composed of a series of enzyme reactions and most of the reactions in the nutrient cycle are catalyzed by enzymes. Some enzymes are constitutive and are routinely produced by cells eg. Urease, others are adaptive or induced formed only in the presence of susceptible substrate or other initiator eg. cellulase is produced in the presence of cellulose. Dehydrogenase is constitutive and found only in living systems. Soil enzymes are protein and are often entrapped in soil organic and inorganic colloids. Soil aggregates and their constituent clays are influenced the interaction of enzymes with their substrate. The clay particle with its large external and internal surface areas is capable of adsorbing enzymes such as urease and protease. Enzymes adsorbed to clay or intertwined with humate constituents are protected from hydrolysis. Adsorption also makes the catalytic site less available. A small molecule such as urea can diffuse readily to a urease site and there undergo decomposition. Whereas a large molecule such as protein would not diffuse as readily to a protease site and would be consequently broken down at a much slower rate than urea.

Soil has a large background of extra cellular enzymes not directly associated with the microbial biomass, such enzymes include catalase, dehydrogenase, glucose oxidase, peroxidase, transaminase, cellulose, deaminase, lipase, nucleotidase, phosphatase, phytase, protease,

urease etc. Many enzymes however that have utmost significance in soil processes originate from microorganisms eg nitrogenase, nitrate reductase, nitrite reductase etc.