Lec.1

Environment (refers to the surroundings) is the area where living organisms live. It includes all the physical, chemical and natural forces**.**

Ecosystem is the community where the biotic and abiotic elements interact with each other. is a community where the living and non-living components of the environment interact with each other. It maintains stability within the environment. Desert, forest, coral reef, savanna, taiga, tundra are a few types of ecosystem.

Biotic components: which consist of:
1-Producers (autotrophs or self-feeders): that having chlorophyll.
2-Consumers (heterotrophs): like all living organisms do not have chlorophyll.
3-Decomposers (saprotrophs):which live on the dead organic matter.

Following are the important difference between environment and ecosystem:

Environment	**Ecosystem**
It is the surrounding where organisms live.	It is the community where the biotic and abiotic components interact with each other.
It comprises physical components.	It comprises biological components.
It provides a living space for the elements	It provides interaction between the elements
It provides the condition to live.	It provides the relation between components to live.
Environment can be macro or micro.	Ecosystem can be aquatic or terrestrial.
An organism's environment changes as it moves from one place to another.	The ecosystem remains the same no matter where the organism travels.

Environmental Microbiology are most closely to the **Microbial Ecology**

The study relationship of microorganisms with one another and with their environment (The environment in this case means the soil, water, air and sediments covering the planet and can also include the animals and plants that inhabit these areas. also includes the study of microorganisms that exist in artificial environments such as bioreactors).

Detritus food chain is the type of food chain that starts with dead organic materials. The dead organic substances are decomposed by microorganisms. The organisms that feed on dead organic matter or detritus, are known as **detritivores or decomposers**. These detritivores are later eaten by **predators**. In the detritus food chain, the excreted products by one organism is utilized by another organism.

Implications of Detritus Food Chain

- Detritus food chain is not limited to single habitat, as it is found in several different locations like the bottom of lakes and oceans. These locations are too dark to carry the process of photosynthesis. Therefore, the ecosystems of the detritus food chain are rarely dependent on solar energy.
- Detritus food chain has continuous energy flow compared to other food chains. For instance, in the grazing food chain, there is a distinct transfer of energy flow between different trophic levels.
- Energy for this type of food chain is from the dead and decomposed matter known as detritus.
- This type of food chain acquires energy from detritus, utilizing the detritus to its fullest, with minimum wastage.
- Compared to other kinds of food chains, the detritus food chain has much larger energy flow in a terrestrial ecosystem.

example of a detritus food chain is when dead organic waste is consumed by microscopic organisms like bacteria or fungi. Later, these microscopic organisms are consumed by other detritivore organisms like snails, earthworms and so on.

Microbiology is the science devoted to the study of organisms that are too small to be seen by the naked eye. These microorganisms are a diverse group of living forms that exist as single cells or cell clusters. There are five field of microbiology:

(a) the study of bacteria (bacteriology)

(b) the study of viruses (virology)

(c) the study of algae (phycology)

(d) the study of fungi(mycology)

(e) the study of protozoa (protozoology)

Bacteriology

The bacteria are the smallest prokaryotic cells and the least structurally complex unicellular microorganisms. They possess the greatest metabolic flexibility. Typical shapes of common bacteria are: (a) sphere (coccus), (b) rod (bacillus) and (c) spiral (spirillum). Diameter of a typical cell is 1 µm. The cell wall contains chemical compound **peptidoglycan**, which is not found in organisms in other domains. They multiply by **binary fission** in which one cell divides in two cells, and many can move using **flagella.**

The archaea are a group of ancient organisms and subdivisions include **methanogens** (methane producing), **halobacteria** (live in high-salt environments) and **thermoacidophiles** (grow best under high temperature and high acidity). The cells of archaea are somewhat similar to bacteria in size and shape; however, they are genetically and biochemically quite different and may be the oldest form of life on Earth. They also multiply by binary fission and move by means of flagella, but archaea do not have peptidoglycan in their cell walls.

For growth, all bacteria depend on the following:

(1) Temperature: for each bacterium there is a temperature best suited to it, eg, bacteria from the gut prefer body temperature (37°C), bacteria naturally occurring in water prefer a lower temperature (20°C)

2) Food: as with any living organism, bacteria require nitrogen, phosphorus and essential minerals as well as a carbon source. Bacteria are so adaptable as to the kinds of foods on which they can grow, that they are present in nearly every habitat: in the deep ocean, in the air we breathe, on our skin, in soil, in milk and other foodstuffs, etc.

(3) Oxidizing requirement: some bacteria need oxygen (aerobes), but others can use other substances instead and live in the complete absence of oxygen (anaerobes).

(4) Lack of predators: bacteria can be killed by predators or inhibited from growing,simply by other organisms competing for their food, etc.

Virology

Viruses are a group of infective agents unique in both their size and their method of reproduction. They are the smallest independent biological particles capable of carrying all of the genetic information necessary for their own reproduction. They are normally measured in nanometres (nm). They are visible only under an electron microscope. The genetic information is carried as nucleic acid, either RNA (ribonucleic acid) or DNA(deoxyribonucleic acid), but virus particles do not carry both nucleic acids. Virus classification is based on a range of characteristics including size, shape, capsid (coat of virus particle) symmetry, and presence or absence of an envelope, genome structure, sensitivity to physical or chemical insults, and more specific properties involving lipids, carbohydrates, host range, mode of infection and pathogenicity

Phycology

The algae are a diverse group of photosynthetic. Some of them are single-celled while others are multicellular, and they come in a great range of shapes and sizes, from spherical cells to 60 m long multicellular. They all contain green pigment chlorophyll, but some of them also contain other pigments. The role of pigment is to absorb sunlight, which algae use as a source of energy. The cell walls of algae are rigid and are composed of cellulose.

Mycology

Many fungi are microscopic, while others, like mushrooms, are macroscopic. All fungi have chitin in their cell walls. Yeasts are single-celled fungi. Yeasts can be spherical, oval or cylindrical. Molds are filamentous fungi and have a mycelial structure. Long thin filaments on the mycelium are called hyphae. Some branches of mycelium may grow in the air and asexual spores (conidia) are formed on these aerial branches.

Protozoology

Protozoa are diverse groups of microscopic single-cell organisms and they are much larger (5–500 μm) than prokaryotes. Protozoa are classified into three groups based on shape: ciliates, flagellates and amoebae. They do not have a rigid cell wall and many of them have a specific shape due to cytoskeleton just beneath the outer membrane of the cell.

Lec.2

Microbial interaction

- Microorganisms interacts with each other and can be physically associated with another organisms in a variety of ways.
- One organism can be located on the surface of another organism as an **ectobiont** or located within another organism as **endobiont.**
- Microbial interaction may be **positive** such as mutualism, proto-cooperation, commensalism or may be **negative** such as parasitism, predation or competition

Types of microbial interaction

1. Positive interaction: mutualism, proto-cooperation, commensalism
2. Negative interaction: Ammensalism (antagonism), parasitism, predation, competition

I. Mutualism:

- It is defined as the relationship in which each organism in interaction gets benefits from association. It is an obligatory relationship in which mutualist and host are metabolically dependent on each other.
- Mutualistic relationship is very specific where one member of association cannot be replaced by another species.
- Mutualism require close physical contact between interacting organisms.
- Relationship of mutualism allows organisms to exist in habitat that could not occupied by either species alone.
- Mutualistic relationship between organisms allows them to act as a single organism.

Examples of mutualism:

- **i. Lichens:**
- Lichens are excellent example of mutualism.
- They are the association of specific fungi and certain genus of algae. In lichen, fungal partner is called **mycobiont** and algal partner is called
- Phycobiont is member of cycanobacteria ad green algae (*Trabauxua*).
- Because phycobionts are photoautotrophs, the fungus get its organic carbon directly from algal partner, in turn fungi protects the phycobiont from extreme conditions and also provide water and minerals to algae.

- Lichen grow very slowly but are able to colonies habitat that do not permit the growth of other organisms.
- Most lichens are resistant to high temperature and drying.
- **ii. Protozoan-termite:**
- Protozoan-termite relationship is the classical example of mutualism in which flagellated protozoan lives in the gut of termites.
- Theses flagellated protozoan feeds on diet of carbohydrates acquired as cellulose or lignin by their host termites, metabolize into acetic acid which is utilized by termites.
- **iii. Paramecium-Chlorella:**
- *Paramecium* (protozoa) can host *Chlorella* (algae) within its cytoplasm.
- The algae *Chlorella* provide the protozoan partner with organism carbon and O2, in turn protozoa provide protection, mortility, CO2 and other growth factors.
- The presence of *Chlorella* within *Paramecium* helps to survive protozoa in anaerobic condition as long as there is sufficient light.

II. Syntrophism:

- It is an association in which the growth of one organism either depends on or improved by the substrate provided by another organism.
- In syntrophism both organism in association gets benefits.
    - Compound A
        - Utilized by population 1
    - Compound B
        - Utilized by population 2
    - Compound C
        - utilized by both Population 1+2
    - Products
- In this theoretical example of syntrophism, population 1 is able to utilize and metabolize compound A, forming compound B but cannot metabolize beyond compound B without co-operation of population 2. Population 2is unable to utilize compound A but it can metabolize compound B forming compound C. Then both population 1 and 2 are able to carry out metabolic reaction which leads to formation of end product that neither population could produce alone.

Examples of syntrophism:

- **i. Methanogenic ecosystem in sludge digester**
- Methane produced by methanogenic bacteria depends upon interspecies hydrogen transfer by other fermentative bacteria.

- Anaerobic fermentative bacteria generate CO_2 and H_2 utilizing carbohydrates which is then utilized by methanogenic bacteria (*Methanobacter*) to produce methane.
- **ii. *Lactobacillus arobinosus* and *Enterococcus faecalis*:**
- In the minimal media, Lactobacillus arobinosus and Enterococcus faecalis are able to grow together but not alone.
- The synergistic relationship between E. faecalis and L. arobinosus occurs in which E. faecalis require folic acid which is produced by L. arobinosus and in turn lactobacillus require phenylalanine which is produced by Enterococcus faecalis.

III. Protocooperation:

- It is a relationship in which organism in association is mutually benefited with each other.
- This interaction is similar to mutualism but the relationships between the organisms in protocooperation is not obligatory as in mutualism.

Examples of Protocooperation:

- i. Association of *Desulfovibrio* and *Chromatium*: it is a protocooperation between carbon cycle and sulfur cycle.
- ii. Interaction between N_2-fixing bacteria and cellulolytic bacteria such as *Cellulomonas*

IV. Commensalism:

- It is a relationship in which one organism (commensal) in the association is benefited while other organism (host) of the association is neither benefited nor harmed
- It is an unidirectional association and if the commensal is separated from the host, it can survive.

Examples of commensalism:

- **i. Non-pathogenic *coli* in intestinal tract of human:**
- *E. coli* is a facultative anaerobe that uses oxygen and lower the O_2 concentration in gut which creates suitable environment for obligate anaerobes such as *Bacteroides*. *E. coli* is a host which remains unaffected by *Bacteroides*.
- **ii. *Flavobacterium* (host) and *Legionella pneumophila* (commensal):**
- *Flavobacterium* excrete cystine which is used by *Legionella pneumophila* and survive in aquatic habitat.
- Association of *Nitrosomonas* (host) and *Nitrobacter* (commensal) in Nitrification:
- *Nitrosomonas* oxidize Ammonia into Nitrite and finally *Nitrobacter* uses nitrite to obtain energy and oxidize it into Nitrate.

V. Amensalism (antagonism):

- When one microbial population produces substances that is inhibitory to other microbial population then this inter population relationship is known as Ammensalism or Antagonism.
- It is a negative relationship.
- The first population which produces inhibitory substances are unaffected or may gain a competition and survive in the habitat while other population get inhibited. This chemical inhibition is known as antibiosis.

Examples of antagonism (amensalism):

- **. Lactic acid produced by lactic acid bacteria in vaginal tract:**
- Lactic acid produced by many normal floras in vaginal tract is inhibitory to many pathogenic organisms such as *Candida albicans*.
- **ii. Skin normal flora:**
- Fatty acid produced by skin flora inhibits many pathogenic bacteria in skin
- **iii. Thiobacillus thiooxidant:**
- Thiobacillus thioxidant produces sulfuric acid by oxidation of sulfur which is responsible to lowering of pH in the culture media which inhibits the growth of most other bacteria.

VI. Competition:

- The competition represents a negative relationship between two microbial population in which both the population are adversely affected with respect to their survival and growth.
- Competition occurs when both population uses same resources such as same space or same nutrition, so, the microbial population achieve lower maximum density or growth rate.
- Microbial population competes for any growth limiting resources such as carbon source, nitrogen source, phosphorus, vitamins, growth factors etc.
- Competition inhibits both population from occupying exactly same ecological niche because one will win the competition and the other one is eliminated.

Examples of competition:

- i. Competition between *Paramecium cadatum* and *Paramecium aurelia:*
- Both species of Paramecium feeds on same bacteria population when these protozoa are placed together.
- *P. aurelia* grow at better rate than *P. caudatum* due to competition.

VII. Parasitism:

- It is a relationship in which one population (parasite) get benefited and derive its nutrition from other population (host) in the association which is harmed.
- The host-parasite relationship is characterized by a relatively a long period of contact which may be physical or metabolic.
- Some parasite lives outside host cell, known as ectoparasite while other parasite lives inside host cell, known as endoparasite.

Examples of parasitism:

- **i. Viruses:**
- Viruses are obligate intracellular parasite that exhibit great host specificity.
- There are may viruses that are parasite to bacteria (bacteriophage), fungi, algae, protozoa etc.

VIII. Predation:

- It is a wide spread phenomenon when one organism (predator) engulf or attack other organism (prey).
- The prey can be larger or smaller than predator and this normally results in death of prey.
- Normally predator-prey interaction is of short duration.

Examples of Predation:

- **i. Protozoan-bacteria in soil:**
- Many protozoans can feed on various bacterial population which helps to maintain count of soil bacteria at optimum level
- ii. *Bdellovibrio, Vamparococcus, Daptobacter* etc are examples of predator bacteria that can feed on wide range of bacterial population.

Lec.3

Aquatic microbiology

An aquatic ecosystem is an ecosystem in a body of water. The two main types of aquatic ecosystems are marine ecosystems and freshwater ecosystems. Communities of organisms that are dependent on each other and on their environment live in aquatic ecosystems.

Aquatic microbiology is the science that deals with microscopic living organisms in fresh or salt water systems. Aquatic microbiology includes all microorganisms, such as: viruses, bacteria, Actinomycetes, and fungi and their relation to other organisms in the aquatic environment. Bacteria, viruses, and fungi are widely distributed throughout aquatic environments. They can be found in fresh water rivers, lakes, and streams, in the surface waters and sediments of the world's oceans, and even in hot springs.

Importance of aquatic microorganisms

- Aquatic microorganisms play a vital role in the cycling of nutrients within their environment, and thus are a crucial part of the food chain.

- Many microorganisms obtain their nutrition by breaking down organic matter in dead plants and animals. As a result of this process of decay, nutrients are released in a form usable by plants.

- These aquatic microorganisms are especially important in the cycling of the nutrients nitrogen, phosphorus, and carbon. Without this recycling, plants would have few organic nutrients to use for growth.

The **advantages of microorganisms** in nutrient cycles and in the food web can be clarified in at least two ways:

1. In addition to breaking down organic matter and recycling it into a form of nutrients that plants can use

2. Many of the microorganisms become food themselves. There are many types of animals that graze on bacteria and fungi. For example, some deposit-feeding marine worms ingest sediments and digest numerous bacteria and fungi found there.

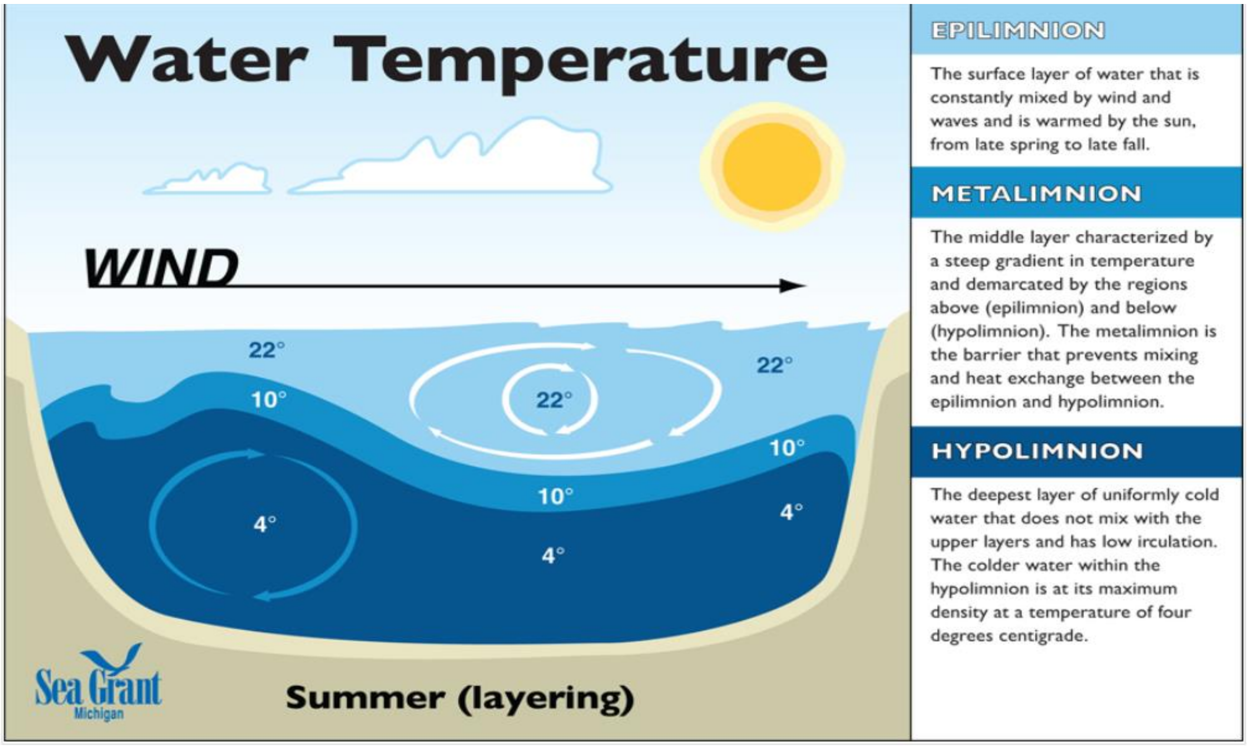
3. Humans have taken advantage of the role these microorganisms play in nutrient cycles. At sewage treatment plants, microscopic bacteria are cultured and then used to break down human wastes.

However, in addition to the beneficial uses of some aquatic microorganisms, others are pathogenic may cause problems for people because they are pathogens, which can cause serious diseases (**disadvantages** مساوىء)

1. For example, bacteria such as Salmonella typhi, S. paratyphi, and the Norwalk virus are found in water contaminated by sewage can cause illness.

2. Fecal coliform (E. coli) bacteria and Enterococcus bacteria are two types of microorganisms that are used to indicate the presence of disease causing microorganisms in aquatic environments.

Water column and temperature



A. **Water surface and Epilimnion**(22-25 °C):

Microbial flora consists of: 1. Photosynthetic bacteria, 2. Cyanobacteria, 3. Mesophilic contaminating bacteria, 4. Psychrotrophic or psychrophilic bacteria.

Microbial activity of this part of water column are: 1- Photosynthesis, 2- aerobic nitrogen fixation, 3- aerobic decomposition of organic matter

B. Thermocline ,Metalimnion (10-22°C,):

Microbial flora consist of psychrophilic facultative anaerobic bacteria. Microbial activity of this part of water column are aerobic and anaerobic decomposition.

C. Hypolimnion (4 °C): Microbial flora consist of extreme psychrophilic anaerobic bacteria. Microbial activity is: 1- Anaerobic nitrogen fixation bacteria (Clostridium pasteurianum), 2- Anaerobic decomposition of organic matter, and 3- production of CH_4, H_2S and NH_3.

D. Sediments (-5 °C): Microbial flora consist of 1- Barophilic bacteria, 2- anaerobic bacteria, H_2S, and CH_4 producing bacteria. Microbial activity is anaerobic decomposition of sediments

Table shows range of temperature that different type of bacteria tolerates

	Minimum	Optimum	Maximum
Psychrophilic	-10-5	10-20	20-30
Mesophilic	10-15	30-40	40-50
Thermophilic	25-45	50-75	75-93

Gases and Aquatic Microorganisms

• Two gases of major importance to microorganisms (oxygen and carbon dioxide).

• Other gases of importance are (nitrogen, hydrogen and methane).

Types of microorganisms according to oxygen requirements in aquatic environment:

1. Obligatory aerobes,
2. Microaerophilic organisms,
3. Facultative aerobes
4. anaerobes
5. Obligatory anaerobes

Salinity:

Water ecosystem can be divided according to salt content into two groups:

1. Freshwater habitat, salinity closed from zero
2. Marine water, salinity ranged from 33- 37g/kg.

Halophilic microorganisms, a marine organism or an organism living in a saline habitat.

a. Weakly halophilic 2- 4%

b. Moderately halophilic 5- 20%

c. Extremely halophilic 20- 30%

Lec.4

Indicators of Microbial Water Quality

To determine if a given water supply is safe, the source needs to be protected and monitored regularly. There are two broad approaches to water quality monitoring for pathogen detection:

The first approach is **direct detection of the pathogen itself**, for example, the protozoan *Cryptosporidium parvum*. While it will be more accurate and precise if specific disease-causing pathogens are detected directly for the determination of water quality, there are several problems with this approach:

1- it would be practically impossible to test for each of the wide variety of pathogens that may be present in polluted water.

2- even though most of these pathogens can now be directly detected, the methods are often difficult, relatively expensive, and time-consuming.

Instead, water monitoring for microbiological quality is primarily based on a **second approach**, which is to **test for indicator organisms** This concept of indicator organisms was introduced in 1892 and is the basis for most microbiological quality standards in water today.

Indicator Microorganism: A nonpathogenic microorganism whose presence suggests the presence of enteric pathogens. Indicator organisms are used because pathogens themselves are frequently difficult to detect in drinking water and wastewater low numbers, difficult, time consuming, or expensive to culture.

The US Environmental Protection Agency (EPA) lists the following criteria for an organism to be an ideal indicator of fecal contamination.

1. An indicator should always be present when pathogens are present

2. Indicators and pathogens should have similar persistence and growth characteristics.

3. Indicators and pathogens should occur in a constant ratio so that counts of the indicators give a good estimate of the numbers of pathogens present.

4. Indicator concentrations should far exceed pathogen concentration at the source of pollution.

5. The indicator should not be pathogenic and should be easy to quantify.

6. Tests for the indicator should be applicable to all types of water.

7. The test should detect only the indicator organisms thus not giving false positive reactions.

8. Should survive longer in the environment than the toughest enteric pathogen.

9. Should be a member of the normal intestinal microflora of warm-blooded animals.

Types of indicators

1- Coliform Organisms (Total Coliform) Coliform bacteria are metabolically defined as gram-negative, rod-shaped bacteria capable of growth in the presence of bile salts and able to ferment lactose at an optimum 35ºC. The main reason is because they are:

- easy to detect and enumerate in water - and are representative enough for determining microbial contamination of drinking water. - Besides the criteria discussed previously in regard to the choice of indicator organisms, there are numerous reasons for their use. Waterborne pathogens such as *Vibrio cholerae* and

Salmonella spp. usually die very quickly and are present in very low numbers. These characteristics make their isolation and detection difficult and impractical.

2-Thermotolerant Coliform Bacteria (FC) This group of bacteria comprises the bacteria genus *Escherichia*, and to a lesser extent, *Klebsiella, Enterobacter, and Citrobacter*. They are defined as a group of coliform organisms that are able to ferment lactose at 44 to 45ºC. Sometimes, this group is also called Fecal Coliform (FC) to specify coliforms of fecal origin. However, concentrations of thermotolerant coliforms are usually directly related to that of *E. coli* and thus can be used as a surrogate test for *Escherichia coli (E. coli)* is a specific subset of the thermotolerant coliform bacteria. They are found abundantly in human feces and warm-blooded animals. Usually, *E. coli* cannot multiply in any natural water environment and they are, therefore, used as specific indicators for fecal contamination. Both WHO Guidelines and EPA standards require zero *E. coli* to be found per 100 ml of drinking water sample.

3- **Fecal *Streptococci*** Most of the species under the genus Streptococcus are of fecal origin and can be generally regarded as specific indicators of human fecal pollution. However, certain species may be isolated from the feces of animals. Fecal streptococci seldom multiply in polluted water and they are more persistent than coliform and E. coli bacteria. Therefore, they are generally useful as additional indicators of treatment efficiency. This indicator organism is commonly tested with E. coli for evidence of recent fecal contamination. Four key points in favor of the fecal streptococci were: (1) Relatively high numbers in the excreta of humans and other warm-blooded animals. (2) Presence in wastewaters and known polluted waters. (3) Absence from pure waters, virgin soils and environments having no contact with human and animal life. (4) Persistence without multiplication in the environment

4- **Sulphite-reducing clostridia (SRC):** Gram-positive, spore-forming, non-motile, strictly anaerobic rods that reduce sulphite (SO3) to H2S. *Clostridium perfringens*: As for SRC, but also ferment lactose, sucrose and inositol with the production of gas, produce a stormy clot fermentation with milk, reduce 4 nitrate, hydrolyze gelatin and produce lecithinase and acid phosphatase. Bonde (1963) suggested that not all SRC in receiving waters are indicators of faecal pollution, hence *C. perfringens* is the appropriate indicator, spore forming and strictly anaerobes.

5- **Bacteriophages (phages)** are viruses that infect and replicate in specific bacteria. The ability to identify phages (coli phages) of E. coli, also detects fecal contamination. This is because the presence of coli phages also indicates the presence of E. coli. The significance of coli phages as indicators of sewage contamination, and their greater persistence compared to bacterial indicators make them useful as additional indicators of treatment efficiency.

6- **Heterotrophic Bacteria** are members of a large group of bacteria that use organic carbon for energy and growth. Many laboratories measure heterotrophic bacteria (*Pseudomonas, Aeromonas, Klebsiella, Flavobacterium, Enterobacter*) by the heterotrophic plate count (HPC) Varies from 1 to 104 CFU/mL, and depends on temperature, residual chlorine concentration, and availability of organic nutrients.

The presence of heterotrophic bacteria does not indicate the likelihood of pathogen presence. However, a sudden increase in HPC may suggest a problem with treatment or water disinfection. HPC > 500 CFU/mL indicates poor water quality.

Lec.5

Soil microbiology is a system that describes the numbers, fate, activity, and interactions of microorganisms present in soil, and how they are affected by their environment.

The soil microbial community is largely responsible for:

- The cycling of carbonaceous, nitrogenous, and phosphorous compounds.

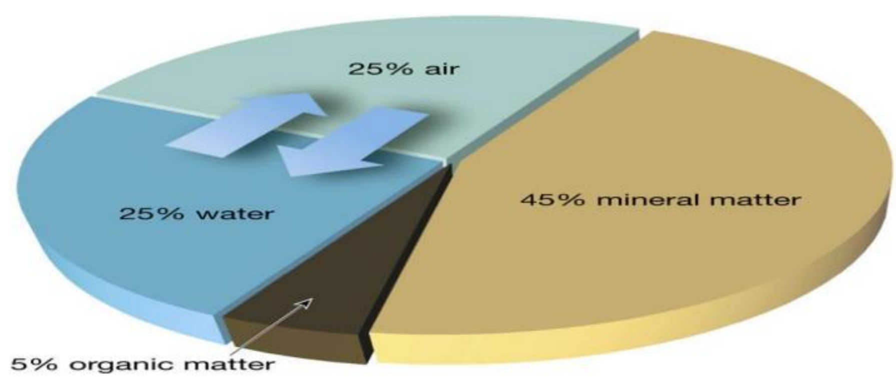
- Soil microorganisms can be involved in plant-pathogenic reactions,

- As well as in biological transformations of xenobiotic compounds added to soil.

The term **soil** refers to the outer, loose material of the earth's surface, a layer distinctly different from the underlying bedrock. A number of features characterize this region of the earth's crust. Agriculturally, it is the region supporting plant life and from which plants obtain their mechanical support and many of their nutrients. Chemically, the soil contains a multitude of organic substances not found in the underlying layers.

The soil is composed of five major components:

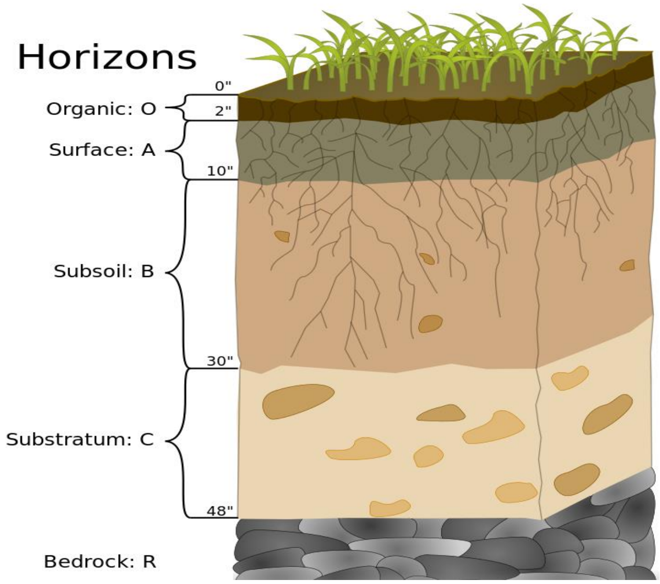
mineral matter, water, air, organic matter, and living organisms. The quantity of these constituents is not the same in all soils but varies with the locality.



The soil particles contain to:

Gravel, > 2 mm; Sand, 2 - 0.05; Silt, 0.05 – 0.002 mm and clay, < 0.002 mm.

The horizons are used in the classification of soils. major layers make up the soil profile:



Soil Living organic matter (Soil Biota or organisms)

The living part of soil organic matter includes a wide variety of organisms such as plants, insects, earthworms, animals, and microorganisms. Soil is excellent culture media for the growth of various microorganisms that contains several distinct groups, and amongst them; bacteria, fungi, actinomycetes, algae, protozoa and viruses. Microorganisms form a very small fraction of soil mass and occupy a volume of less than 1%, in the upper layer of soil (top soil up to 10 – 30 cm depth i.e. Horizon A), the microbial population is very high which decreases with depth of soil. Each organism are responsible for a specific change/ transformation in the soil. The final effect of various activities of microorganisms in the soil is to make the soil fit for growth and development of higher plants.

Living organisms present in the soil are grouped into two categories as follow:

1. Soil flora (micro flora) e.g. Bacteria, Fungi, Actinomycets, and Algae.

2. Soil fauna (micro fauna) animal like e.g. Protozoa, Nematodes, earthworms, moles, ants, rodent

Soil Microflora

1- **Bacteria**; It is the most abundant groups, and usually more numerous than others. Soil bacteria numbers vary between $10^8 – 10^9$ cell/ gm of soil, however, in an agriculture field their number goes about 3×10^9 cell/ gm of soil.

Based on its **regular presence soil bacteria are divided into two groups**:

- Soil indigenous (true resident), or **autochthonous**.
- Soil invaders or **allochthonous**.

Bacteria number and variety influenced by soil type, microenvironment, organic matter, cultivation processes.

- They are found in a high number in cultivated soil than virgin land, - in a maximum in rhizospheric space than in non – rhizospheric region, possibly due to aeration and availability of nutrients.

- The inner region aggregates contained high level of G – ve bacteria, while the outer region contains high level of G + ve bacteria, thus may be due to; polymer formations, motility, surface charge, and life cycle of bacteria.

Bacteria do not occur freely in soil solution, but are closely attached to soil particles by <u>motility apparatuses</u> (flagella and Pilli), or by <u>extracellular polysaccharides, or</u> may be <u>embedded in organic matter</u>.

Bacteria have some major **roles** in soil such as:

1 Miniralization of elements.

2- N2 – fixation from atmosphere.

3- Stabilization of mineral ions.

4- Biotransformation of chemicals.

5- Biogas formation.

Example of some soil bacteria: *Agarobacteriun, Arthobacter, Bacillus, Alcaligenes, Erwinia, Corynebacter, clostridium, Nitrosomonas, Nitrobacter, Rhizobium*

Lec 6

2-Actinomycetes in the soil:

Actinomycetes are a transitional group between the simple bacteria and the fungi.

The general characteristics of Actinomycetes

- Fungi like bacteria
- Second most numerous after bacteria
- Active degrading more resistant organic compounds (e.g. wood fiber).
- Produce antibiotics- actinomycine, streptomycin.
- Produce geosmin which give earthy smell
- Optimal growth at neutral pH
- Not pathogenic except in some species.
- The colonies of some genera developing on the agar surface may have a firm consistency and adhere tenaciously to the solidified substratum; in certain of these genera.
- The surface appears powdery and often becomes pigmented when the aerial spores are produced.
- Turbidity is not formed in stationary liquid culture; rather the cells appear at the surface in a distinctive, flaky manner. In aerated liquid media, Streptomyces growth is also not homogeneous and diffuse as with most bacteria, but typical mycelial pellets or clumps develop.
- In addition, some actinomycete genera produce no aerial mycelium, and they closely resemble Mycobacterium and the coryneform bacteria in general morphology, staining reactions, and physiology.

The relation of Actinomycetes to Fungi: Despite their placement together with the bacteria, the relation of the actinomycetes to the fungi is apparent in three properties: (a) like the fungi, many actinomycetes form an aerial mycelium as well as conidia; (b) the mycelium of the higher actinomycetes has the extensive branching characteristic of the fungi

(c) the growth of actinomycetes in liquid culture rarely results in the turbidity associated with unicellular bacteria, instead it occurs as distinct clumps or pellets. (d) On the other hand, the morphology and size of hyphae, conidia, and of the individual fragments of species whose mycelium undergoes segmentation are similar to structures found among the bacteria.

Nevertheless, there is evidence for that actinomycetes participating in the following processes:

a. Decomposition of certain of the resistant components of plant and animal.
b. Formation of humus

c. Transformations at high temperature

d. Cause of certain soil-borne diseases of plants; for example, potato scab and sweet potato pox, for which the causal agents are *Streptomyces scabie*

e. Cause of infections of humans and animals; for example, *Nocardia asteroids*

J. Possible importance in microbial antagonism and in regulating the composition of the soil community. This role in the ecosystem may be a consequence of the ability of many actinomycetes to excrete antibiotics or their capacity to produce enzymes that are responsible for lysis of fungi and bacteria. Noteworthy in this connection are observations that amendment of soil with a substance, such as chitin, that favors hyphal development of actinomycetes sometimes leads to a marked suppression of fungi causing diseases of higher plants.

3-Fungi in soil environment The fungi possess a filamentous mycelium network of individual hyphal strands. The mycelium may be subdivided into individual cells by cross walls or septa, but many fungal species are nonseptate. Individual hyphae may be vegetative or fertile, the fertile filaments producing either sexual or asexual spores.

Fungi are **heterotrophic** in nutrition, and neither sunlight nor the oxidation of inorganic substances provides these microorganisms with the energy needed for growth; fungal distribution is consequently determined by the availability of oxidizable carbonaceous substrates. The application of organic substrates alters the composition of the flora, and the relative dominance of genera such as *Penicillium, Trichoderma, Aspergillus, Fusarium, and Mucor* sp.

Some of soil fungi are: *Alternaria, Aspergillus, Cladosporium, Helimenthosporium, Humicola, Fusarium, Phytophthra, Plasmodiophora,*

Fungi in soil play variety roles and activities, some of these roles are:

- they may participate in the **microbiological balance** in soil, limiting the size and activity of the protozoan and nematode fauna.

- By the degradation of plant and animal remains, the fungi participate in the formation of **humus** from fresh organic residues. Species of *Alternaria, Aspergillus* , and others synthesize substances resembling constituents of the soil organic fraction. Some fungi can also produce substances

- **Mycorrhiza** fungi supply minerals to associated plants, likewise fungi receive benefit from plants exudation, like some carbohydrates.

- Production of fungi static products including **antibiotics**.

- Contributes in soil **aggregation** that protects soil particles from weathering.

- **Degrade** some of tough plant residues, like lignin's