الجامعة المستنصرية

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المرحلة الثالثة /فرع الاحياء المجهرية/

Lec (4): Earth Environments

Soil :is the thin veneer of material that covers much of Earth’ s surface. This fragile part of Earth’ s skin is frequently less than a meter thick, yet is absolutely vital for human life. It has a rich texture and fragrance and teems with plants, insects, and microorganisms. Scientists described it as “ the most complicated biomaterial on the planet. ” .

The complexity of soil is driven by two components:

1. The abiotic soil architecture
2. The biotic diversity, which is driven and supported by large amounts of energy from the sun through photosynthesis.

Integrated together these components result in amazing physical, chemical, and biological heterogeneity among soils globally.

Beneath the soil layer is a region known as the subsurface that includes the unsaturated or vadose zone, and the saturated zone including aquifers (show Figure down). The subsurface contains microorganisms, but microbial communities are lower in number and less diverse than in surface soils.

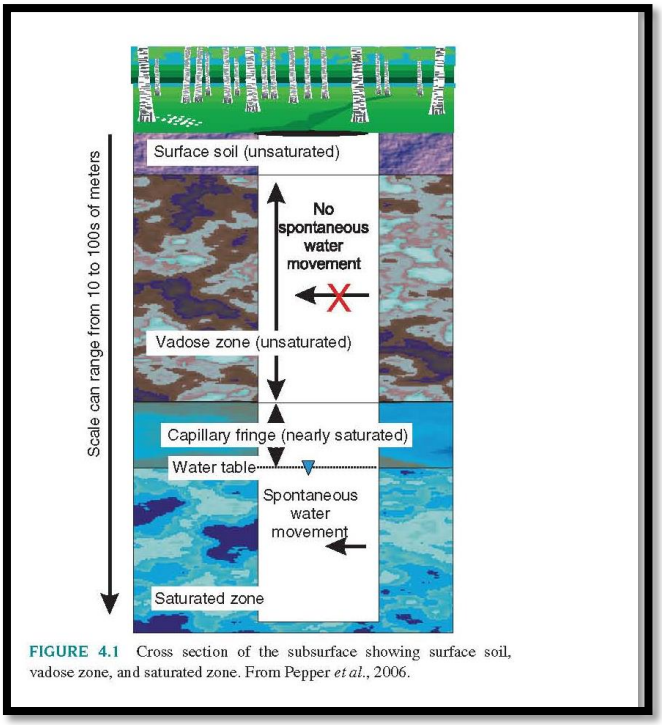

FIGURE 4.1 Cross section of the subsurface showing surface soil, vadose zone, and saturated zone. From Pepper *et al.*, 2006.

SOIL AS A MICROBIAL ENVIRONMENT

Microorganisms that are best adapted to the stresses of the soil environment.The stresses found are both biotic, including competition from other microbes, and abiotic, including the physical and chemical characteristics of the environment.

Biotic Stresses: Since indigenous soil microbes are in competition with one another, the presence of large numbers of organisms results in biotic stress factors.

- Competition can be for substrate, water, or growth factors.
- In addition, microbes can secrete allelopathic substances (inhibitory or toxic), including antibiotics, that harm neighboring organisms.
- Finally, many organisms are predatory or parasitic on neighboring microbes.

Abiotic Stresses : At the surface of the soil, however, such physical parameters as temperature and moisture fluctuate significantly throughout the day and also seasonally.

Light : Sunlight does not penetrate beyond the top few centimeters of the soil surface. Phototrophic microorganisms are therefore limited to the top few centimeters of soil.

Soil moisture: The availability of water is critical for microbial activity. As a group, the fungi are most desiccation resistant, followed by actinomycetes and then the bacteria.

Soil temperature: Soil temperatures vary widely, particularly near the soil surface. Most soil populations are resistant to wide fluctuations in soil temperature, Most soil organisms are mesophilic : although soil communities can be psychrophilic (prefer < 20 ° C), mesophilic (prefer 20–45° C), thermophilic (45–90 ° C), or hyperthermophilic (> 90 ° C) depending on the geographic location of the soil.

Soil pH: soils usually have pH values within the range of 6–8, and most soil organisms have pH optima within this range.

Soil texture: soils with a mixture of sand, silt, and clay particles offer a more favorable habitat for organisms because **they hold more nutrients and provide for better water and air flow** .

Soil nutrients: Carbon and nitrogen are generally the most important limiting nutrients that are found in soils.

Redox potential: Redox potential is the measurement of the tendency of an environment to oxidize or reduce substrates.

MICROORGANISMS IN SURFACE SOILS :

Surface soils are occupied by indigenous populations of archaea, bacteria (including actinomycetes), fungi, algae, and protozoa . In general, as the size of these organisms increases from bacteria to protozoa, the number present decreases.

In addition to these indigenous populations, specific microbes can be introduced into soil by human or animal activity include

1. The deliberate direct introduction of bacteria as biological control agents or as biodegradative agents.
2. Microbes are also introduced indirectly as a result of application of sewage sludge to agricultural fields .
3. Animals introduce microbes through bird droppings and animal excrement.

(A):Bacteria :Bacteria are the most abundant organisms found in surface soils in terms of numbers . Culturable numbers vary depending on specific environmental conditions, particularly soil moisture and temperature. Culturable bacteria can be as numerous as 10^7 to 10^8 cells per gram of soil .Anaerobic populations increase with increasing soil depth.

Soil bacteria can be classified on the basis of their growth characteristics and affinity for carbon substrates to

- oligotrophs
- copiotrophs.

The oligotrophs metabolize slowly in soil, utilizing slowly released soil organic matter as a substrate. The copiotrophs are adapted to intervals of dormancy and rapid growth, depending on substrate availability.

Bacteria are also classified according to diversity or the different types present. That has been determined using culture techniques, but more recently, estimates of diversity have been made based on DNA sequencing .

(B): Actinomycetes: Actinomycetes are procaryotic organisms that are classified as bacteria but are unique enough to be discussed as an individual group. Morphologically, actinomycetes resemble fungi because of their elongated cells that branch into filaments or hyphae. These hyphae can be distinguished from fungal hyphae on the basis of size, with actinomycete hyphae being onehalf to one-fifth the size of fungal hyphae .

Characteristics and unique functions of actinomycetes

Characteristics	
Structure	Procaryotic
Size	1–2 μm diameter
Morphology	Filamentous lengths of cocci
Gram stain	Gram positive
Respiration	Mostly aerobic, can be anaerobic
Habitat	Soil or marine
Abundance, marine isolates	5–40 CFU/ml
Abundance, soils	10^6–10^8/g

Functions

- Source of natural products and antibiotics, e.g., streptomycin
- Produce geosmin, the compound which gives soil and water a characteristic earthy odor
- Capable of degradation of complex organic molecules
- Capable of biological nitrogen fixation with species of the non-legume-associated *Frankia*

(C): Fungi: Fungi other than yeasts are aerobic and are abundant in most surface soils. Numbers of fungi usually range from 10^5 to 10^6 per gram of soil. Despite their lower numbers compared with bacteria, fungi usually contribute a higher proportion of the total soil microbial biomass . This is due to their comparatively large size than bacteria ; a fungal hypha can range from 2 to 10 µm in diameter. Yeasts can metabolize anaerobically (fermentation) and are less numerous than aerobic mycelium-forming fungi. Generally, soil fungi are normally found associated with soil particles or within plant rhizospheres.

Fungi are important components of the soil with respect to

1. Nutrient cycling and especially decomposition of organic matter, both simple (sugars) and complex (polymers such as cellulose and lignin). The role of fungi in decomposition is increasingly important as the soil pH declines because fungi tend to be more acid tolerant than bacteria Some of the common genera of soil fungi involved in nutrient cycling are Penicillium and Aspergillus .
2. Also important in the development of soil structure because they physically entrap soil particles with fungal hyphae .
3. Degradation of complex plant polymers such as cellulose and lignin, some fungi can also degrade a variety of pollutant molecules. The best-known example of such a fungus is the white-rot fungus Phanerochaete chrysosporium
4. Other fungi, such as Fusarium spp., Pythium spp., and Rhizoctonia spp., are important plant pathogens.
5. Others cause disease; for example, Coccidioides immitis causes a chronic human pulmonary disease known as " valley fever " .

(D): Algae: A lgae are typically phototrophic and thus would be expected to survive and metabolize in the presence of a source of light for energy and CO_2 for carbon. Therefore, one would expect to find algal cells predominantly in areas where sunlight can penetrate. One can actually find algae to a depth of 1 m because some algae, including the green algae and diatoms, can grow heterotrophically as well as photoautotrophically. In general, though, algal populations are highest in the surface 10 c m of soil. Typical algal populations close to the soil surface can range from 5000 to 10,000 per gram of soil.

Algae are often the first to colonize surfaces in soils that are devoid of preformed organic matter. Algal metabolism is critical to soil formation in two ways:

1. Algae provide a carbon input through photosynthesis, and as they metabolize, they produce and release carbonic acid, which aids in weathering the surrounding mineral particles.
2. Algae produce large amounts of extracellular polysaccharides, which also aid in soil formation by causing aggregation of soil particles.

Four major groups of algae are found in soil.

- The green algae or the Chlorophyta, for example, Chlamydomonas, are the most common algae found in acidic soils.
- Diatoms such as Navicula , diatoms are found primarily in neutral and alkaline soils.
- Less numerous are the yellow-green algae such as Botrydiopsis .
- The red algae (, e.g., Porphyridium) .

In addition to these algal groups, there are the cyanobacteria (e.g., Nostoc and Anabaena) , which are actually classified as bacteria but have many characteristics in common with algae. The cyanobacteria participate in the soil forming process some cyanobacteria also have the capacity to fix nitrogen.

In temperate soils the relative abundance of the major algal groups follows the order green algae > diatoms > cyanobacteria > yellow-green algae. In tropical soils the cyanobacteria predominate.

(D): Protozoa: Protozoa are unicellular, eucaryotic organisms that range up to 5.5 mm in length. Most protozoa are heterotrophic and survive by consuming bacteria, yeast, fungi, and algae. Because of their large size and requirement for large numbers of smaller microbes as a food source, protozoa are found mainly in the top 15 to 20 cm of the soil. There are three major categories of protozoa: the flagellates, the amoebae, and the ciliates . The flagellates are the smallest of the protozoa and move by means of one to several flagella. The amoebae, also called rhizopods, move by protoplasmic flow, either with extensions called pseudopodia or by whole body flow. Amoebae are usually the most numerous type of protozoan found in a given soil environment. Ciliates are protozoa that move by beating short cilia that cover the surface of the cell. Numbers of protozoa range from 30,000 per gram of soil from a nonagricultural temperate soil to 350,000 per gram of soil from a maize field .