Chapter 25 Microbiology of Soil

OUTLINE

However dead the earth may look and be considered in our thoughtless moments, the experience of man far back beyond his written records has led him to associate trouble capable of multiplying itself as coming from dirt. Bacillus tetanus, amoebic dysentery, thermophilic spoilage, actinomycosis, and botulism are new terms, but the need of freedom of earth in wounds, in food, and in clothing is no recent discovery. The demonstration that soil, instead of being all dead, harbors millions of organisms releases that flight of imagination which pictures the soil as a sort of Lilliputian Zoo in which some magic hand has eliminated all barriers and set free every grade of minute but rapacious monster to go roaring after the next lesser grade as its lawful prey. Thus the soil is pictured to us in terms that lead us to ask what manner of thing it is.

This paragraph is from the introduction of an address entitled "A Microbiologist Digs in the Soil" given by the late Charles Thom, one of America's great mycologists and soil microbiologists.

Directly or indirectly the wastes of humans and other animals, their bodies,

and the tissues of plants are dumped onto or buried in the soil. Somehow they all disappear, transformed into the substances that make up the soil. It is the microbes that make these changes—the conversion of organic matter into simple inorganic substances that provide the nutrient material for the plant world. Thus microorganisms play a key role in maintaining life on earth as we know it.

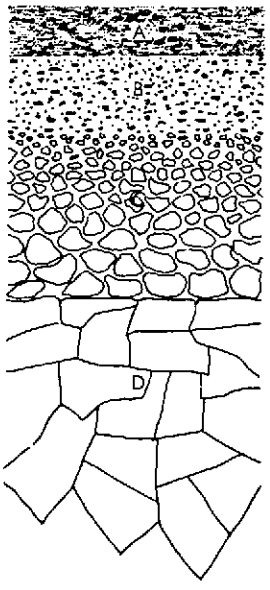
PHYSICAL CHARACTERISTICS OF SOIL

Soil has been defined as *that region on the earth's crust where geology and biology meet*. From a functional viewpoint, the soil may be considered as the land surface of the earth which provides the substratum for plant and animal life. The characteristics of the soil environment vary with locale and climate. Soils differ in depth, physical properties, chemical composition, and origin. A profile of soil is shown in Fig. 25-1.

Mineral Particles

The dominant mineral particles in most soils are compounds of silicon, aluminum, and iron, and lesser amounts of other minerals, including calcium, magnesium, potassium, titanium, manganese, sodium, nitrogen, phosphorus, and sulfur. The mineral constituents of soil range in size from small clay particles (0.002 mm or less) to large pebbles and gravel. The physical structure, aeration, water-holding capacity, and availability of nutrients are determined by the proportion of these particles, which are formed by the weathering of rock and the degradative metabolic activities of microorganisms.

Soils can be classified as **mineral soils,** which have solid matter that is largely inorganic, and **organic soils,** which have very little inorganic material. The latter are typically found in bogs and marshes. Most of the information in this chapter is concerned with mineral soils.



Horizon A: Organic debris in various stages of decomposition and minerals

Horizon B: Fine particles and minerals

Horizon C: Weathered mineral materials excluding bedrock

Horizon D: Unweathered rock, bedrock

Figure 25-1. A schematic illustration showing the profiles of soil.

Organic Residue

The plant and animal remains deposited on or in the soil contribute organic substances. Their decomposition will be described later in this chapter. In the last stages of decomposition, such material is referred to as **humus**, a dark-colored, amorphous substance composed of residual organic matter not readily decomposed by microorganisms. Indeed, the microbial population, both dead cells and living cells, is of such a large magnitude that it contributes significantly to the organic matter of soil. Certain agriculturally important properties are contributed to the soil by humus, which improves the texture and structure of the soil, contributes to its buffering capacity, and increases its water-holding capacity.

Water

The amount of water in soil depends on the amount of precipitation and other climatic conditions, drainage, soil composition, and the living population of the soil. Water is retained as free H_2O in the spaces between soil particles and adsorbed to the surfaces of particles. Various organic and inorganic components of soil are dissolved in soil water and thus are made available as nutrients for soil inhabitants.

Gases

The soil atmosphere is derived from air but differs in composition from it because of the biological processes occurring in soil. The gaseous phase of soil consists mainly of carbon dioxide, oxygen, and nitrogen. These gases exist primarily in the spaces between soil particles which are not filled with water, although a small amount of gas, especially carbon dioxide, is dissolved in water. Obviously, then, the amount of gases in the soil is related to the amount of moisture.

MICROBIAL FLORA OF SOIL

Fertile soil is inhabited by the root systems of higher plants, by many animal forms (e.g., rodents, insects and worms), and by tremendous numbers of microorganisms.

The vast differences in the composition of soils, together with differences in their physical characteristics and the agricultural practices by which they are cultivated, result in corresponding large differences in the microbial population both in total numbers and in kinds.

The conditions described earlier as influencing the growth of organisms under laboratory cultivation are equally applicable to the soil. With specific reference to soil, these conditions can be summarized as follows: (1) amount and type of nutrients, (2) available moisture, (3) degree of aeration, (4) temperature, (5) pH, (6) practices and occurrences which contribute large numbers of organisms to the soil, e.g., floods or addition of manure. The existence of roots and the extensiveness of the root system in soil also influence the numbers and kinds of microorganisms present.

Variations of climatic conditions may selectively favor certain physiological types. Interactions between and among microbial species no doubt has an important effect on the members of the population. This is an extremely complex situation. Predatory protozoa and antibiotic-producing actinomycetes may eliminate certain groups of microorganisms. Cellulolytic and proteolytic organisms, on the other hand, may provide nutrients for less versatile biochemical species.