Chemical properties of Soil

Paper: Environmental Microbiology

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The chemical properties of soils are important factors for microorganisms (Alexander 1977)

Organic Matter

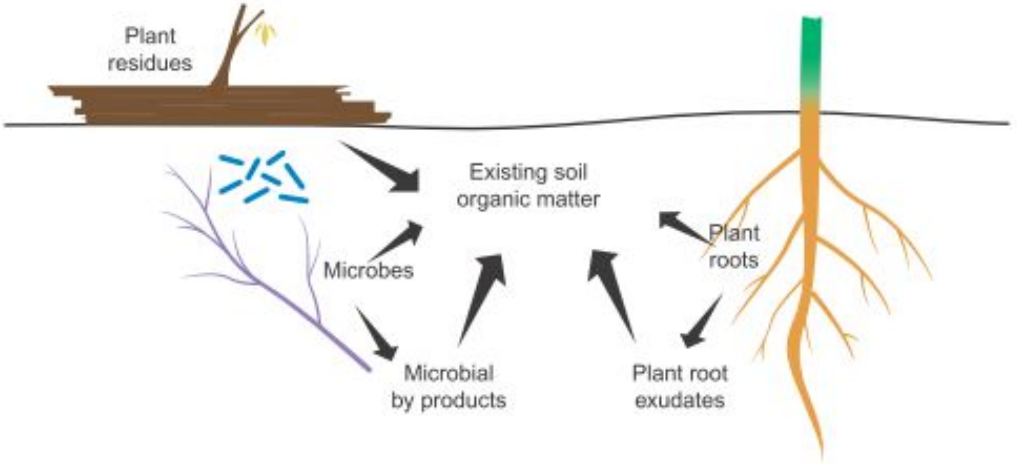

FIGURE 4.13 Schematic representation of the formation of soil organic matter.

Organic matter in soil is defined as a combination of:

1. Live biomass, including animals, microbes and plant roots (Bear 1964);
2. Recognizable dead and decaying biological matter; and
3. Humic substances, which are heterogeneous polymers formed during the process of decay and degradation of plant, animal and microbial biomass

Distribution of organic matter

Soil organic matter (SOM) contents range from less than 1% in hot arid climates that have low plant residue inputs, to 5% in cooler more humid areas with large plant inputs. In contrast, subsurface environments usually contain only very small amounts of organic matter, ,0.1%.

SOM contributes to both water holding capacity (WHC) and IEC, but it is not considered in terms of texture classification.

It is prime importance to microbial life in soil. SOM makes soil less sticky and contributes to good soil drainage and aeration. Hence, maintaining soil matter desirable

Mineral Soils: derived from the weathering of rock and other inorganic material

Humic fraction of OM

- Humic substances are those portions of the soil organic matter that have undergone sufficient transformation to render the parent material (unrecognizable).
- Humic material present in mineral soils typically constitute less than 10% by weight of the soil
- The genesis of humic material is a two-step process
  - Microbial degradation of organic polymers to monomeric constituents such as phenols, quinones, amino acids,
  - Subsequent polymerization of these by spontaneous chemical reactions (**Autooxidation** and **oxidation catalyze**d by **microbial enzymes**)

Laccases, Polyphenoloxidases, peroxidases

The humic fraction of organic matter is a stable nutrient base that serves as a slow release source of carbon and energy for the autochthonous (indigenous), slow-growing microorganisms in soil.

Humic substances have extremely complex structures that reflect the complexity and diversity of organic materials produced in a typical soil.

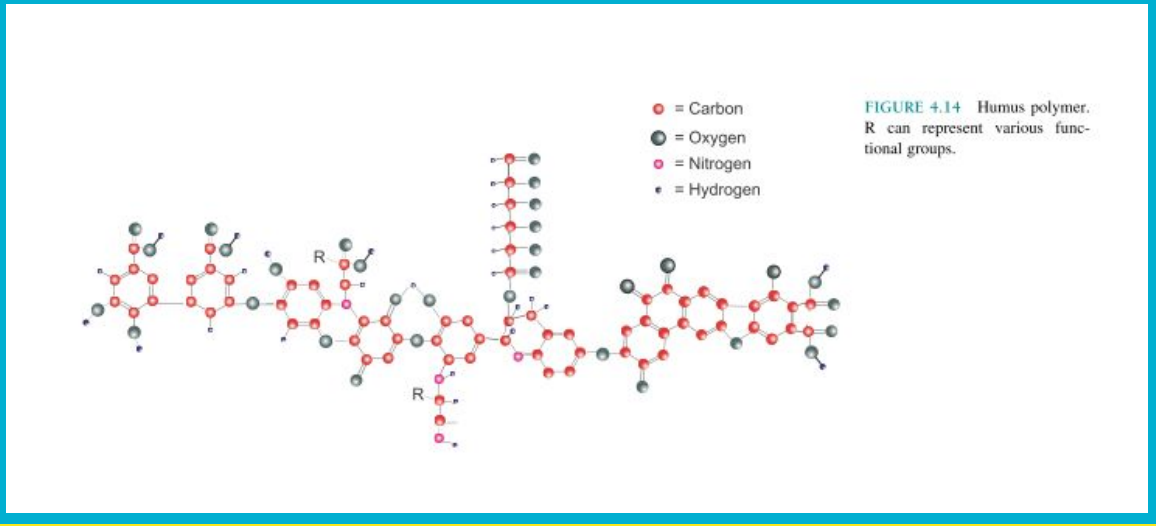

FIGURE 4.14 Humus polymer. R can represent various functional groups.

Overall, humus has a three-dimensional, spongelike structure that contains both hydrophobic (water-hating) and hydrophilic (water-loving) regions.

...what is next?

Cation Exchange Capacity

Isomorphic substitution:

Clay particles exist as inorganic lattices composed of silicon and aluminum oxides. Substitution of a divalent magnesium cation (Mg2+) for a trivalent aluminum cation (Al3+) can result in the loss of one positive charge, which is equivalent to a gain of one negative charge. Other substitutions can also lead to increases in negative charge. **therefore known as pH-dependent charge**

The many functional groups of organic matter, such as carboxyl moieties, are also subject to ionization, and can contribute to the total pH-dependent charge.
The clay and organic particles that participate in creating CEC are generally very small, .1 µm in diameter, and due to their small size are referred to as soil colloids.

How does the process of cation exchange work?

2. Ionization:

Hydroxyl groups (OH) at the edge of the lattice can ionize, resulting in the formation of negative charge:

Al 2- OH = AlO- + H+

These are also known as broken-edge bonds. Ionizations such as these usually increase as the pH increases, and are

Soil pH

Important factor that affect nutrient solubility, microbial activity and plant growth

Nutrients in mineral soil

(Brady 1984)

- Organic matter
- Nitrogen
- Phosphorus
- Potassium
- Calcium
- Magnesium
- Sulfur

Concentration of CO_2 and O_2

Affected by gas diffusion and microbial respiration

If CO_2 ⇧ Then O_2 ⇩ with depth in the soil profile

In oxygen deficient soil, other gases, including CH_4 from methanogenesis, and H_2S from anaerobic sulfate reduction in high concentration

Soil as a Microbial Habitat

Numbers of microorganisms in soil habitats are much higher than those found in freshwater or marine water (Mishustin 1975).

If the concentration of organic matter is relatively high than which type of microorganism will grow there?

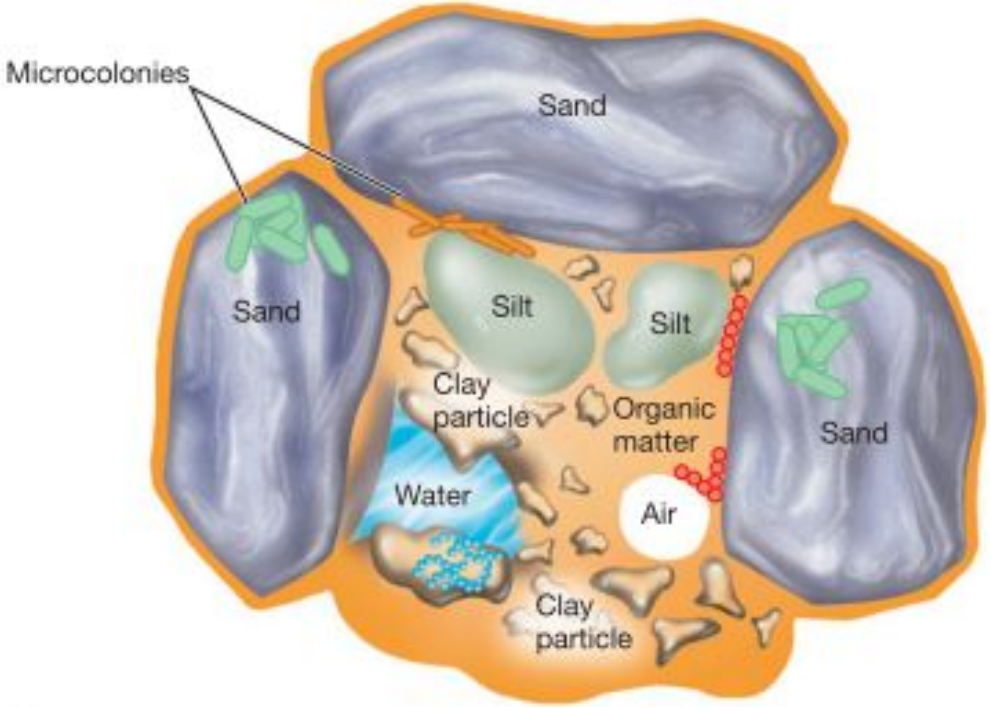

Figure 23.11 A soil microbial habitat. Very few microorganisms are free in the soil solution; most of them reside in microcolonies attached to the soil particles. Note the relative size differences among sand, clay, and silt particles.

Extensive microbial growth takes place on the surfaces of soil particles

Factors affecting microbial activity in soil

Biotic Stresses

"Autochthonous" microbes are in competition with one another, results in biotic stress. 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.

For example, protozoa graze on bacteria, and viruses infect both bacteria and fungi. Because of biotic stress, nonindigenous organisms that are introduced into a soil environment often survive for very short periods of time (days to several weeks) unless there is a specific selective niche. This effect has important consequences for survival of pathogens and for other organisms introduced to aid biodegradation or for biological control.

Abiotic Stresses

- Light
- Soil Moisture
- Soil Temperature
- Soil pH
- Soil Texture
- Soil Nutrients
- Redox Potential

Types of Microbes in Soil

- Bacteria
- Actinomycetes (10-33%)
- Cyanobacteria
- Fungi
- Yeast

Gray and Perkinson 1968

Brevibacterium, arthrobactor, agrobacterium, bacillus, alcaligenes, Clostridium, Caulobactor, Cellulomonas Micrococcus, Corynebacterium, Mycobacterium, Streptococcus, and Xanothomonas , Flavobacterium, psudomonas

Actinomycetes: Streptomyces , Nocardia

Micromonospora, Actinomyces

Fungi: Aspergillus, Geotrichum, Penicillium, trichoderma