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SOIL- A Solid Phase of Minerals and Organic Matter

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Soil, also commonly referred to as **earth** or **dirt**, is a mixture of organic matter, minerals, gases, liquids, and organisms that together support life. Some scientific definitions distinguish *dirt* from *soil* by restricting the former term specifically to displaced soil.

Soil consists of a solid phase of minerals and organic matter (the soil matrix), as well as a porous phase that holds gases (the soil atmosphere) and water (the soil solution). Accordingly, soil is a three-state system of solids, liquids, and gases. Soil is a product of several factors: the influence of climate, relief (elevation, orientation, and slope of terrain), organisms, and the soil's parent materials (original minerals) interacting over time. It continually undergoes development by way of numerous physical, chemical and biological processes, which include weathering with associated erosion. Given its complexity and strong internal connectedness, soil ecologists regard soil as an ecosystem.

Most soils have a dry bulk density (density of soil taking into account voids when dry) between 1.1 and 1.6 g/cm^3, though the soil particle density is much higher, in the range of 2.6 to 2.7 g/cm^3. Little of the soil of planet Earth is older than the Pleistocene and none is older than the Cenozoic, although fossilized soils are preserved from as far back as the Archean.

The pedosphere interfaces with the lithosphere, the hydrosphere, the atmosphere, and the biosphere. Collectively, Earth's body of soil, called the pedosphere, has four important functions:

- as a medium for plant growth
- as a means of water storage, supply and purification
- as a modifier of Earth's atmosphere
- as a habitat for organisms

All of these functions, in their turn, modify the soil and its properties.

Soil science has two basic branches of study: edaphology and pedology. *Edaphology* studies the influence of soils on living things. *Pedology* focuses on the formation, description (morphology), and classification of soils in their natural environment. In engineering terms, soil is included in the broader concept of regolith, which also includes other loose material that lies above the bedrock, as can be found on the Moon and other celestial objects.

PROCESSES

Soil is a major component of the Earth's ecosystem. The world's ecosystems are impacted in far-reaching ways by the processes carried out in the soil, with effects ranging from ozone depletion and global warming to rainforest destruction and water pollution. With respect to Earth's carbon cycle, soil acts as an important carbon reservoir, and it is potentially one of the most reactive to human disturbance and climate change. As the planet warms, it has been predicted that soils will add carbon dioxide to the atmosphere due to increased biological activity at higher temperatures, a positive feedback (amplification). This prediction has, however, been questioned on consideration of more recent knowledge on soil carbon turnover.

Soil acts as an engineering medium, a habitat for soil organisms, a recycling system for nutrients and organic wastes, a regulator of water quality, a modifier of atmospheric composition, and a medium for plant growth, making it a critically important provider of ecosystem services. Since soil has a tremendous range of available niches and habitats, it contains a prominent part of the Earth's genetic diversity. A gram of soil can contain billions of organisms, belonging to thousands of species, mostly microbial and largely still unexplored. Soil has a mean prokaryotic density of roughly 108 organisms per gram, whereas the ocean has no more than 107 prokaryotic organisms per milliliter (gram) of seawater. Organic carbon held in soil is eventually returned to the atmosphere through the process of respiration carried out by heterotrophic organisms, but a substantial part is retained in the soil in the form of soil organic matter; tillage usually increases the rate of soil respiration, leading to the depletion of soil organic matter. Since plant roots need oxygen, aeration is an important characteristic of soil. This ventilation can be accomplished via networks of interconnected soil pores, which also absorb and hold rainwater making it readily available for uptake by plants. Since plants require a nearly continuous supply of water, but most regions receive sporadic rainfall, the water-holding capacity of soils is vital for plant survival.

Soils can effectively remove impurities, kill disease agents, and degrade contaminants, this latter property being called natural attenuation. Typically, soils maintain a net absorption of oxygen and methane and undergo a net release of carbon dioxide and nitrous oxide. Soils offer plants physical support, air, water, temperature moderation, nutrients, and protection from toxins. Soils provide readily available nutrients to plants and animals by converting dead organic matter into various nutrient forms.

PHYSICAL PROPERTIES

The physical properties of soils, in order of decreasing importance for ecosystem services such as crop production, are texture, structure, bulk density, porosity, consistency, temperature, colour and resistivity. Soil texture is determined by the relative proportion of the three kinds of soil mineral particles, called soil separates: sand, silt, and clay. At the next larger scale, soil structures called peds or more commonly soil aggregates are created from the soil separates when iron oxides, carbonates, clay, silica and humus, coat particles and cause them to adhere into larger, relatively stable secondary structures. Soil bulk density, when determined at standardized moisture conditions, is an estimate of soil compaction. Soil porosity consists of the void part of the soil volume and is occupied by gases or water. Soil consistency is the ability of soil materials to stick together. Soil temperature and colour are self-defining. Resistivity refers to the resistance to conduction of electric currents and affects the rate of corrosion of metal and concrete structures which are buried in soil. These properties vary through the depth of a soil profile, i.e. through soil horizons. Most of these properties determine the aeration of the soil and the ability of water to infiltrate and to be held within the soil.

SOIL MOISTURE

Soil water content can be measured as volume or weight. Soil moisture levels, in order of decreasing water content, are saturation, field capacity, wilting point, air dry, and oven dry. Field capacity describes a drained wet soil at the point water content reaches equilibrium with gravity. Irrigating soil above field capacity risks percolation losses. Wilting point describes the dry limit for growing plants.

Available water capacity is the amount of water held in a soil profile available to plants. As water content drops, plants have to work against increasing forces of adhesion and sorptivity to withdraw water. Irrigation scheduling avoids moisture stress by replenishing depleted water before stress is induced.

Capillary action is responsible for moving groundwater from wet regions of the soil to dry areas. Subirrigation designs (e.g., wicking beds, sub-irrigated planters) rely on capillarity to supply water to plant roots. Capillary action can result in an evaporative concentration of salts, causing land degradation through salination.

Soil moisture measurement — measuring the water content of the soil, as can be expressed in terms of volume or weight — can be based on in situ probes (e.g., capacitance probes, neutron probes), or remote sensing methods.

SOIL GAS

The atmosphere of soil, or soil gas, is very different from the atmosphere above. The consumption of oxygen by microbes and plant roots, and their release of carbon dioxide, decreases oxygen and increases carbon dioxide concentration. Atmospheric CO_2 concentration is 0.04%, but in the soil pore space it may range from 10 to 100 times that level, thus potentially contributing to the inhibition of root respiration. Calcareous soils regulate CO_2 concentration by carbonate buffering, contrary to acid soils in which all CO_2 respired accumulates in the soil pore system.

Humans can get some idea of the soil atmosphere through the well-known 'after-the-rain' scent, when infiltering rainwater flushes out the whole soil atmosphere after a drought period, or when soil is excavated, a bulk property attributed in a reductionist manner to particular biochemical compounds such as petrichor or geosmin.

USES

Soil is used in agriculture, where it serves as the anchor and primary nutrient base for plants. The types of soil and available moisture determine the species of plants that can be cultivated. Agricultural soil science was the primeval domain of soil knowledge, long time before the advent of pedology in the 19th century. However, as demonstrated by aeroponics, aquaponics and hydroponics, soil material is not an absolute essential for agriculture, and soilless cropping systems have been claimed as the future of agriculture for an endless growing mankind.