

Soil Humus

Humus is the organic residue in the soil resulting from decomposition of plant and animal residues in soil, or it is the highly complex organic residual matter in soil which is not readily degraded by microorganism, or it is the soft brown/dark colored amorphous substance composed of residual organic matter along with dead microorganisms.

Composition of Humus: In most soil, percentage of humus ranges from 2-10 percent, whereas it is up to 90 percent in peat bog. On average humus is composed of Carbon (58 %), Nitrogen (3-6 %, Av.5%), acids -humic acid, fulvic acid, humin, apocrenic acid, and C: N ratio 10:1 to 12:1. During the course of their activities, the microorganisms synthesize number of compounds which plays important role in humus formation.

Functions/Role of Humus:

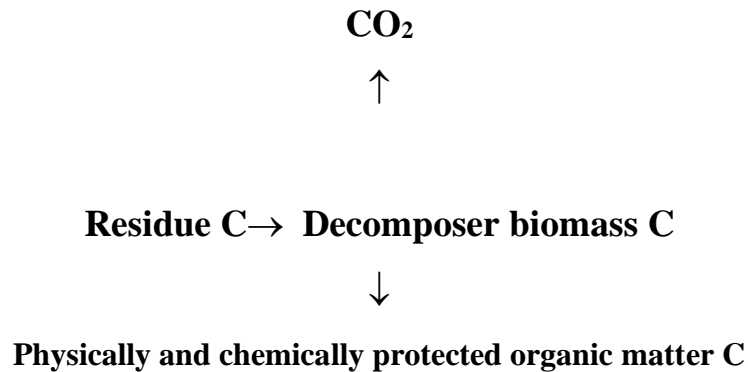
- 1) It improves physical condition of soil.
- 2) Improve water holding capacity of soil.
- 3) Serve as store house for essential plant nutrients.
- 4) Plays important role in determining fertility level of soil.
- 5) It tend to make soils more granular with better aggregation of soil particles.
- 6) Prevent leaching losses of water soluble plant nutrients.
- 7) Improve microbial/biological activity in soil and encourage better development of plant-root system in soil.
- 8) Act as buffering agent i.e. prevent sudden change in soil PH/soil reaction.
- 9) Serve as source of energy and food for the development of soil organisms.
- 10) It supplies both basic and acidic nutrients for the growth and development of higher plants.
- 11) Improves aeration and drainage by making the soil more porous

Formation of humus

Humus is a product of decomposition of organic matter. By the time plant and animal matter becomes humus, the materials is partly decomposed and chemically stabilized. In the soil microorganisms act on the dead plant and animal remains,

degrade, and decompose them into simpler organic compounds. A product of this microbial decomposition is **humus**, which is a dark colored, amorphous substance, composed of organic matter not readily decomposed by the organisms. When detrital carbon (carbon from plant, microbial and animal residues) is processed by decomposer organisms (largely microbes) in the soil, the carbon is either lost as carbon dioxide, incorporated into the cells of the decomposer organisms, or enters a carbon pool that is relatively stable either as a result of physical protection from attack by decomposers or chemical protection. It seems that **physically protected organic matter is related to the structural characteristics of the soil**, whereas **chemically protected organic matter is related to the chemical processes in the soil and referred to as soil humus**. Incomplete decomposition of detritus leads to production of humus in an ecosystem. Under less than ideal conditions for decomposition, a portion of the litter entering the soil system is not completely decomposed, but is modified into humus, which may decompose slowly and hence accumulate. **The first and most important aspect of humus formation is shredding of organic matter (detritus)**, which will be performed by **saprophagous fauna (earthworms, millipedes, snails, enchytraeids etc.)** followed by microorganisms, which will subsequently be subjected to further chemical transformations. It is found that around **90%** of the organic matter has been processed by two of these animal groups, **enchytraeids and earthworms**. The decomposition process from litter to humus has two stages. In **the first stage**, there is rapid loss of solubles (sugars, starches, proteins) followed by cellulose, but a little loss or sometimes-even gain of lignin (insoluble decay products). During this stage, carbon is relatively available and nutrients are limiting, and there is immobilization of the nutrients such as N. Once the litter reaches the **second stage**, it can be considered as humus, it has **stabilized contents and slow decomposition rate**. During the late stage of decay, there is net loss of lignin and N mineralization. **The critical determining factor** for

the rate of humus accumulation on a site is how much of the original litter mass remains at a point at which the materials gets converted to humus and decomposition slows down.



Factors controlling humification

The major factors that influence the rate of humification are(**nature of plants, animals or soil organisms, rate of decomposition, temperature , aeration and moisture**). All these factors are more or less interrelated. The participation of the plant cover in humus formation is determined by the **amount and nature of the plant residues, their mode of admission into the soil and the nature of their decomposition**. The quantum of humus formed by woody species is less than that of grass vegetation, as the roots of woods species are thick and long living. Local micro meteorological conditions are considered good predictors of decomposition rates and good relationships exist between temperature or actual evaporation and rates of litter decomposition. **Temperature** is directly proportional to the rate of humification up to a certain extent as an increase in temperature increases the rate.

Good aeration and moisture content in soil also stimulates the humification process. The **chemical nature** of litter is probably the most significant factor influencing the proportion that becomes humus. The **availability of microorganisms** and the extent of their activity influence the process of humification to a maximum extent, as these are the main drivers of the process. **The whole complex of processes by which plant residues are transformed and finally converted into humus** is the result of **combined activity of associations of microbes exhibiting diverse biochemical functions**. The humus reserve of the soil is determined by the ratio of the two processes – the new formation and decomposition of humus substances.

The amount of humus in different soils varies greatly depending on the factors as discussed above.. **It is less in arid soils and very high in humid soils**. Even in the same soil type, it varies through **different horizons of the soil profile**. In the top layer of the soil, humus quantity is greater than that in the deeper layers, as the availability of fresh or partly decayed detrital matter is higher in the top layer of the soil. In humid areas with dense forest or vegetal cover, the humus may be found in the three stages of degradation.

- The top floor is covered with dead organic parts at a low degree of decomposition that form litter
- Below the litter may be found a layer of partially decomposed organic matter, which is known as duff layer
- When the duff is decomposed, the simpler decomposition products generally called leaf moulds are accumulated below duff layer.

Sometimes under anaerobic conditions, the dead remains are not at all acted upon by microorganisms. Accumulation of such un decomposed organic remains is termed as peat

The role of disturbances

In addition to the rate of organic matter decomposition, the accumulation of humus in a site depends on the **type, frequency and intensity of disturbance**. Anthropogenic activities rather than natural disturbances are major factors that interfere in the process of humification. **Forest fire, intensive cultivation and extensive use of chemical fertilizers** are known to be major practices that interfere with the natural dynamics of humus in the soil. Even **insect outbreaks** may affect the rate of humus decomposition and accumulation **directly** by altering the quality and quantity of litter fall and **indirectly** by reducing canopy cover and changing soil moisture and temperature conditions.

Role of humus in soil

Soil organic matter (SOM) has been extensively examined because of its importance for soil fertility and productivity. Moreover, its importance for establishing favorable physical conditions and architecture in soil is well known. It contributes a lot to chemical, physical as well as biological properties of soil. Humus is known to fulfill multiple functions in soil formation and soil fertility. The humus makes the **soil fertile, provides nutrients to the plants and microorganisms, increases availability of minerals in dissolved state to plants on complete decomposition and it forms several organic acids that serve as solvents for soil materials**. Humus has got high capacity for retaining water, **because** it is porous, thus increasing the water retention capacity of soils. It acts as a **cementing agent** for binding the sand particles and **increases the** rate of nutrient

uptake by plants. Optimum humus content in soil assures an ergonomically valuable structure, a favourable water-air regime, and provides better progressive warming-up of soil. Most important physico-chemical soil indices such as high cation exchange capacity, acid-base buffering capacity of soils, etc are related to humus. Besides all these important roles, humus plays some limiting roles. humus has been regarded as “the very essence of soil fertility” .. Surface humus accumulations may also hinder seedling germination and growth. Humus can also be an energy trap because of its long residence time in the soil. In addition to agronomic as well as pedologic importance, humus is equally important ecologically. Being a part of the detritus based food chain; it plays a key role in energy as well as material circulation in the ecosystem (as detritus food chain is very important for the circulation of materials). Detritus based food chain is less dependent on direct solar energy; it depend chiefly on the influx of organic matter produced in another trophic system. Hence, availability of nutrients and energy locked up in the falling detritus to the soil depends on the rate of decomposition, and humification. As decomposition rate gets speeded up, mineralisation takes place releasing nutrients as well as energy into the soil system, which will be available for recirculation in the entire cycle.

Humus-nature and characteristics

Humus is not soluble in water. It is present in soil in the form of organic colloids. The colloidal nature and other major characteristics of humus, the important soil component, are listed below.

- It is black color distinguishing it from most other colloidal constituents in soils.

- The tiny colloidal humus particles (micelles) are composed of carbon, hydrogen and oxygen, probably in the form of modified **lignin, polyuronides** and **polysaccharides**.

- The humus colloidal particles have very **high surface area** generally exceeding that of silicate clays.

- The colloidal surfaces of humus are **negatively charged**, the sources of the charge being **phenolic (-OH)** or **carboxylic (-COOH) groups**. The extent of the negative charge is pH dependent (high at high pH).

- The **cation exchange capacity** of humus far exceeds that of most silicate clays (150-300 cmol/kg) at high pH values.

- Cation exchange reactions with humus are qualitatively similar to those occurring with silicate clays.

- Humus has a **high water holding capacity** (on a weight basis), i.e. approximately 4-5 times that of the silicate clays (humus will adsorb from a saturated atmosphere water equivalent to 80-90% of its weight).

- Humus has **low plasticity and cohesion**, which account for its very favourable effect on aggregate formation and stability.

- Humic substances show **optical characteristics** in response to light.