Krishi Netra

Soil Organic Carbon- Importance And Management

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Soil organic carbon (SOC) is an indicatorof soil quality and is correlated with biodiversity, erosion, water infiltration and soil texture. Likewise, soilorganic matter (SOM), is primarily made up of complex organic compounds in several stages of decomposition, being closely related to soilquality. The composition and quantity of SOMdepends on inputs and subsequent degradation processes regulated bymicroorganisms. Inaccessibility of SOM for microorganisms as mediatedby organo-mineral interactions and occlusion in aggregates are generally seen as key factors for the latter. Whilethe intrinsic recalcitrance of SOM due to its molecular composition isincreasingly dismissed as a main determinant of SOM stabilization,molecular composition does play an important indirect role through itseffects on sorption processes and aggregation.

SOC is an important component in soil that maintains soil fertility, productivity, aswell as overall sustainability. Low SOC content in tropical soils, particularly thoseunder the influence of arid, semiarid, and subhumid climates, is a major factor contributing to their poor productivity. Maintaining or improvingorganic C levels in tropical soils is more difficult because of rapid oxidation oforganic matter under the prevailing high temperature and thus have poor structure,low water retention capacity, and low fertility.Poor agriculture management and climate extremes have significantly contributedtoward the land degradation and deterioration of soil quality in these regions.However, improving soil organic matter (SOM) is a prerequisite to ensure soil quality, productivity, and sustainability.

Soil organic carbon and soil organic matter are sometimes used synonymously. This is so because the bulk of organic matter is composed of carbon. It is estimated by researchers that 58% of soil organic matter is carbon.

Organic Matter Formation

The addition of organic materials to the soil, such as composts and manures, or wastes like leaves and roots, gives the soil an active organic matter source that the soil organisms need for development and metabolism. This process results in a decrease in the mass of the residue, growth-promoting soil organisms, and atmospheric respiration of carbon dioxide (CO2).

Nutrients that are used by microorganisms and plants are released throughout the decomposition and biomass turnover processes. Organic debris can adhere to soil particles and become trapped in aggregates, which is known as occlusion. While stabilized forms of organic matter have longer turnover durations (decades), fresh residues will break down in a short amount of time (days, months, or years).

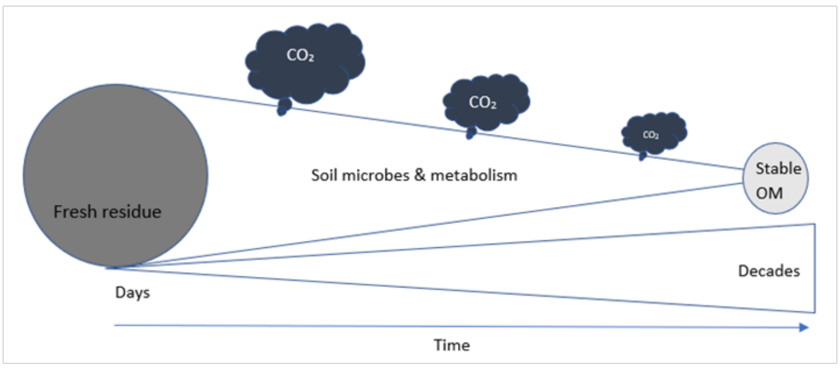

Fig: Formation of stable organic matter from fresh residue

Benefits of Organic Matter

Water Management:A soil's capacity to absorb and retain more water is increased by soil organic matter. Like a sponge, the particle organic matter in soil acts as a low-density, lightweight bulking agent. This substance aids in the formation and upkeep of both big and small pore pores in the soil, which let water seep through and drain, and retain water. Furthermore, spongy and absorbent plant wastes have the ability to swell and hold onto water.

The soil's surface is shielded from the sun, rain, and wind by residues on the surface. By reducing the rate at which water and air flow across the surface, they can shield it from the formation of a hard crust and lower the danger of erosion.

Better aeration — Both soil microbes and plant roots require oxygen! The soil community can remain active and healthy and significant chemical processes that affect fertility can take place by encouraging air exchange with the environment.

Better friability or tilth — This indicates that the soil is not firm and compacted, but rather crumbly. The soil's crumbling quality will facilitate the application of fertilizer and seed, as well as provide the perfect rooting substrate for plants.

Less crusting — A well-aggregated soil will crust less frequently. Crusting stops air and water from penetrating the soil. Additionally, it might hinder the emergence of seedlings and encourage water runoff.

Better infiltration, drainage and water storage — Because aggregated soils provide a network of pores and channels throughout the soil profile, water can enter and drain into the soil. There is variation in the sizes and shapes of pores in well-aggregated soil. Certain holes will empty completely and fill with fresh air following a wetting event, while others are small enough to retain the water, making it available for plant uptake. During protracted periods of saturation or drought, this structure aids the soil's ability to act as a buffer against abrupt changes in water content.

Nutrient Cycling and Retention—Nutrients are readily available and fresh in active organic materials. The nutrients will be ingested by the soil organisms and released into the soil solution as they decompose and breakdown the organic matter in the soil. There, it can be readily absorbed by plants and other living things or evaporated by volatilization or leaching. Active organic matter will continue to supply nutrients into the soil solution gradually and steadily as long as it is breaking down (mineralization).

Cation Exchange Capacity (CEC)

The majority of nutrients are supplied to plants as ions, which are charged atoms or molecules. A positively charged ion is referred to as a cation, and a negatively charged ion is referred to as an anion. The charge of an ion affects how it functions in soil.

Many of the nutrients in the soil are cations, and the cation exchange capacity (CEC) of the soil gauges its capability to temporarily hold onto certain cations. Because of its net negative charge, soil in the northern Great Plains can retain positively charged ions like calcium (Ca^{++}), magnesium (Mg^{++}), zinc (Zn^{++}), potassium (K^+), and ammonium (NH_4^+). However, anions like nitrate (NO_3^-) and sulfate ($SO_4^=$) are difficult for the soil to cling onto.

In mineral soils, soil organic matter contributes 20% to 80% of the CEC. The amount of sand, silt, or clay in the soil as well as the type of organic matter all affect a soil's net CEC, although the stable pool of organic matter is primarily responsible for this function. Generally speaking, the soil's CEC and likelihood of retaining nutrients increase with the amount of organic matter present.

The exchange of hydrogen ions, which controls the pH of the soil solution, is another advantage of CEC. A greater CEC preserves nutrient availability and plant health in the soil by making the pH of the soil more resilient to sudden, drastic fluctuations.

Microbial Diversity and Resiliency- Many soil organisms primarily obtain their nourishment from organic materials. It should come as no surprise that an active and diversified community of microorganisms would be supported by a consistent flow of active organic matter into the soil. We depend on the actions of soil microorganisms to make fertilizers available for plant absorption and to provide nutritious crops because they are crucial for regulating nutrient cycles and affecting the availability of nutrients to the plant body.

Because different species can carry out the same task, like turning organic matter into nutrients that plants can consume, microbial diversity is significant. Another species that can withstand the unfavorable circumstances of the soil may be able to fill in and complete the task if the original species is unable. We refer to this as "functional redundancy." Because of their renowned ability to support a vast array of constantly shifting environmental circumstances, soils are known for their high level of microbial diversity.
Crop Yield:Application of organics to soil makes favourable micro climate for crop growth, which helps to increase crop yields.

Management strategies for soil carbon sequestration

- Conservation/reduced tillage helps in reduced soil disturbance
- Crop rotations with legumes improves soil microbes and helps to maintain microbial biodiversity
- Cover crops protects soil from direct sun light and rain drops protects it from erosion and loss of organic carbon
- Organic farming practices improves soil organic matter as in this system huge quantities of organics applied in soil every year
- Balanced combined applications of chemical fertilizer and manure helps in plant biomass which will further incorporated in soil
- Planting perennials in degraded soils helps in less soil disturbance and improves soil microbial biodiversity
- Adding compost/biochar improves soil carbon directly
- Adopting improved varieties of species with greater yield and/or biomass