INCREASING SOIL ORGANIC CARBON POOL AS A MEANS TO REGULATE GLOBAL WARMING

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Abstract: Under suitable conditions and appropriate management practices, the soil can be a good reservoir for terrestrial carbon. If the carbon-retention capacity of soil can be improved it will lead to a corresponding reduction of carbon in the atmosphere and will improve the situation arising from release of carbon to the atmosphere and subsequent global warming. However, agricultural practices, if not properly managed, can result in release of a large amount of carbon stored in soil to the atmosphere aggravating the situation. In this work, various factors that contribute to improving the soil carbon storage have been described on the basis of existing literature.

Keywords: SOM; SOC; decomposition; agriculture; nutrients

1. Introduction:

Soil Organic Matter (SOM) includes all the constituents of soil, less than 2 mm in size, which is of biological origin and is at various stages of decomposition. Undecomposed materials on the surface of the soil usually of more than 2 mm size are not included under SOM. The three basic forms of carbon present in soil and sediments are (i) elemental, (ii) inorganic and (iii) organic. Elemental carbons are the incomplete combustion products of different organic matter. Inorganic carbons are mainly found in the form of carbonates. Organic carbon forms are derived from decomposition of plants and animals. SOC forms the part of the natural carbon cycle. Soil organic carbon (SOC) in undisturbed soil is lost through agriculture contributing to rise of CO_2 in the atmosphere. SOC is a renewable resource and can be put back, through proper soil management practices. Loss of 'natural land', including tropical forests to agriculture, grazing, logging and urbanization, has resulted in environmental stress. Use of nitrogenous fertilizer has contributed to increasing N_2O emissions. Rising temperatures will help microorganisms in soil to decompose organic matter rapidly, releasing more carbon dioxide (CO_2). In oxygen deficient areas, such as peat bogs, rice fields and stomachs of ruminants, methane (CH_4) continues to be produced.

Soils of the agro-ecosystems (croplands, grazing lands, rangelands) are depleted of soil organic carbon (SOC) pool by 25–75% depending on climate, soil type, and historic management. The magnitude of loss may be 10 to 50 tons C/ha. Technical potential of carbon sequestration in soils of the agro-ecosystems is 1.2 to 3.1 billion tons C/yr. Improvement in soil quality by increase in the SOC pool of 1ton C/ha/yr in the root zone, can increase annual food production in developing countries by 24–32 million tons and 6–10 million tons of roots and tubers. Carbon sequestration rates vary by tree species, soil type, regional climate, topography and management practices. Soil organic carbon (SOC) sequestration has large potential to provide a sink for atmospheric carbon.

2. Importance of soil organic carbon:

Soil organic carbons act as the source and sink for the nutrients and play a very important role in maintaining soil fertility. In work done in the agro-economic ecosystem of West Africa, the soil organic carbon is found to be low. The carbon contents and status of soil is related to the clay and silt present in soil. The type of clay present in soil has influence in stabilization of the organic content. Soil organic carbon is regarded as an index of sustainable land management but no minimum level has been prescribed that could help nitrogen and phosphorous mineralization. In comparison to forest land, the cultivated land has been found to have low organic carbon due to the surface disturbances [1]. In another study done in a selected region of Hindukush-Himalayan region and Nepal, the soils under degraded forest and grazing land and red soils were reported to have less than 1% soil organic carbon (SOC). On the other hand, well managed forests have considerably higher organic contents of more than 4% SOC. The soil organic carbon losses are found to be site specific [2].

3. Retention of carbon by the soil: influence of various factors:

The large number of reports available in literature point out that carbon retention by the soil depends on the level of disturbance such as cultivation and also on the particular composition of the soil. It is therefore important to know the state of occurrence of a particular soil type and its various physical and chemical properties to draw certain conclusions regarding SOC retention and release. It may be noted that the soil as a whole is a huge reservoir of carbon and SOC retention and release is likely to disturb the world carbon dynamics. If under certain physicochemical regime, the soil can retain more carbon, this will definitely lead to easing of the situation arising from carbon accumulation in the atmosphere, i.e. climate change and related effects. Not much work has been done in India on these important aspects.

Decomposition of soil organic matter releases a range of plant nutrients into soil that include nitrogen and phosphorous compounds. The decomposition products improve soil physical properties by promoting soil structure. They also act as a buffer against toxic and harmful substances like heavy metals, pesticides, etc., and being a part of soil food web, the decomposition products are important in different biological activities like nutrient cycling and availability, assisting root growth and plant nutrient uptake, creating burrows and even suppressing crop diseases [3]. In the process, the cation exchange capacity (CEC) of soil may be improved along with soil aggregation and water retention capacities supporting the biological activities of soil [4]. These processes, although not directly related to plant growth, are of fundamental importance in maintaining the soil fertility. Degradation of soil is found to have correlation with the depletion of soil organic carbon [5].

Approximately two- or three-fold more SOC is stored in the upper 100 cm of soil than the carbon stored in either the atmosphere or terrestrial vegetation and therefore, a slight reduction in SOC could significantly increase atmospheric CO_2 concentrations [6]. Generally, in agro-ecosystems, the SOC levels are found to be low because of different soil degradation processes like erosion, salinization, nutrient loss, etc. Ways to improve SOC contents of the agricultural soil could convert the soil into an excellent C sink [7] influencing the global carbon balance. For estimating the carbon stock, the spatial distribution of carbon stock is thus an important consideration.

The studies of SOC are typically done on the upper 10-20 cm of soil but there is the possibility that accumulation in sub soil layers may also be improved. It has been found that the soil texture (relative proportions of sand, clay and silt) has important effects on SOC storage. The SOC is found to have positive correlation with mean annual precipitation and the clay content of the soil and is negatively correlated to mean annual temperature [8].

The Sudano-Sahelian zone of West Africa is found to be highly unsustainable for crop production intensification. The main type of clay present there is kaolinite and the cation exchange capacity of the soil has been found to be often less than 1 cmol kg^{-1} soil, depending largely on the organic carbon content. The organic carbon content of the topsoil is found to be in the range of 1 to 8 g kg^{-1} in most of the sites [9] and it has been observed that the soil texture plays an important role in the stabilization of organic compounds. In a survey of West African soils, it was found that cation exchange capacity (CEC) depended directly on SOC ($r = 0.86$) than the soil clay content ($r = 0.46$) and it is observed that a difference of 1 g kg^{-1} in SOC results in a difference of 0.25 cmol kg^{-1} of the soil CEC [8].

The total system carbon is found to depend on the vegetation types and land used in cultivation. In the Senegal River valley, it was found to be 115 ton ha^{-1} in the forest zone and only 18 ton ha^{-1} in thecultivated area. Thus, the cultivated area has reduced carbon content due to less tree cover and increased mineralization due to cultivation. The SOC for the equatorial forest, Guinea savanna and Sudan savanna, has been observed to be 24.5, 11.7, and 3.3 g kg^{-1}, respectively and have positive correlation with both N and P (8). In an earlier study, a strong correlation between SOC and total nitrogen ($r=0.97$) has been found [10], indicating that in the predominant agro-pastoral systems without application of mineral N, the nutrition of crops largely depends on the maintenance of SOC levels. In another study, SOC and total soil nitrogen (TSN) stocks in planted forest catchment have been found to decrease with soil depth from the surficial layers to deeper layers [11].

4. Conclusion:

In recent years the knowledge of SOC and SOC dynamics growing considerably based on the current database including on the potential of soil to the contribution of climate change mitigation, ecological approaches to agriculture and many others. The major changes in the SOC reservoir could themselves have potential impact on the global climate and at the same time climate change can affect the SOC size of the reservoir through changes in biomass production and rate of decomposition of organic matter.

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