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Soil Carbon Fractionation: Tool of Agricultural sustainability

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ABSTRACT

Soil is the largest terrestrial pool of organic carbon. Thus small changes in the soil carbon stock could result in significant impacts on the atmospheric carbon concentration. This fluctuation in soil carbon often occurs in response to environmental conditions (like interaction between abiotic and biotic factors, decomposition processes and associated rates of nutrient cycling) or by anthropogenic activities. Agricultural productivity can be enhanced by increasing Carbon inputs into the soil by using various management practices like addition of manure, fertilizer and by crop rotation. Soil carbon is the major determinant of soil quality and agronomic sustainability because of its impact on other physical, chemical and biological indicators of soil quality. Carbon fractionation is a useful tool for observing the changes in different pool of labile, recalcitrant and total pool of soil carbon. This is often described in terms of the Soil Organic Matter (SOM) pool sizes, chemical properties, and turnover rates. Fractionation procedures include mainly physical and chemical methods and their combinations. The former is based on physical separation of SOM into aggregate, particle size, and density fractions and fractions according to their magnetic susceptibility, and or combination of the two, and the latter on the various wet chemical procedures that fractionate SOM according to solubility, hydrolysability, and resistance to oxidation or by destruction of the mineral phase. The fractionation procedure can be used to determine the state and rate of change in soil Carbon of agricultural and natural systems. Soil Carbon fractionation is helpful for assessing trace gas emissions and in prediction of changes in ecosystem services of soils in response to climate change. Land use and soil management affects soil organic carbon pools. Strategies for increasing the different soil carbon pool is needed to mitigate Carbon di oxide emissions and for improvement of soil quality and economic crop production. Management and improvement of the world's soil resource is imperative for a regular availability of sufficient food and fibre to a growing population.

INTRODUCTION

Soil organic carbon (SOC) is the carbon conserved within soil. In soil carbon occurs in two forms inorganic and organic. Inorganic form devises from parent rock material or from carbonates. Naturally-occurring organic carbon forms are resulting from the decay of plants and animals. Soil organic matter (SOM) is composed of decaying plant and animal matter. In soils, a wide variety of organic carbon forms are present and range from freshly deposited litter to highly decomposed forms such as humus. Soil organic carbon (SOC) is highly affected by climate and land use management. Soil carbon plays an important role in cycling plant nutrients, increasing grain yield and improving the physical, chemical and biological properties of soils.

Soil Carbon fractionation is separation of Soil Organic Matter (SOM) into different pools based on their microbial decomposability, strength and turnover times [1,2]. Soil carbon fractionation provides an outline of soil function with a property of controlling crop productivity. Major fractions of soil organic carbon are crop residues, humus (decomposed materials) and recalcitrant organic carbon (biologically stable). Each fraction has different functions due to the comparative stability and biological obtainability of the carbon. Factors such as water availability, soil type and management practices can influence the carbon storing capacity of the different fractions. The different types of soil carbon pool not only vary in quantity but are also formed of different materials with different chemical and physical properties and different decomposition times. Soil Carbon composition and turnover is influenced by land management and inherent soil quality of decomposition and nutrient cycling.

SOIL CARBON FRACTIONATION IN DIFFERENT SOIL STRUCTURES

Soil aggregates are stable clumps of material that stabilize and store carbon. The stability comes from the action of microorganisms, which produce an adhesive secretion that sticks the soil particles to each other. The association among soil biotic activity, soil organic matter (SOM) decay and maintenance, and soil aggregate dynamics was first described as specific location of clay and quartz particles by Emerson [3].Next, Edwards and Bremner [4] suggested a model of microaggregate by solid-phase reaction between clay minerals, polyvalent cations and SOM. Based on this concept, Tisdall and Oades [5] coined the term, macroaggregate, which is the combination of microaggregates. Oades [6] proposed, the formation of microaggregates within macroaggregates. Microaggregates and macroaggregates both are involved in the fortification of SOM in the long term; and their stabilization is a fundamental process inducing the turnover of SOM. Recent studies on aggregate construction and SOM stabilization broadly verify this modification and practices it as the foundation for forthcoming knowledge of SOM dynamics. Soil aggregation is mainly influenced by soil flora, fauna, microclimate and inorganic binding agents.

The ranks of aggregate size dispersal and associated carbon (C) and nitrogen (N) pools are influenced by the aggregate separation method. Soil aggregate size distribution and C pools in aggregates vary between dry and wet sieving methods depending on soil properties and cropping systems.[7] .Dry sieving of moist soil is helpful in determining microbial biomass, active and slow C pools, soil aggregation and activities that include water-soluble C in aggregates. Dry sieving causes less destruction to the physical habitat of microbial communities in comparison of wet sieving [8]. Dry sieving method causes rupture of weak aggregates [8,9,10]; increased disruption of physical habitat of microbial communities [11,12]; and underestimation of C and N pools in aggregates. The wet sieving method is widely used to determine size dispersal and firmness of aggregates caused by water droplets impact on dry soil causing slaking and surface crusting [13,8]. Wet-sieving soil aggregates is most useful to examine long-term changes in soil organic matter and microbial activity between soil types.

SOIL CARBON EFFECT ON CARBON SEQUESTRATION

Carbon sequestration is the process of eliminating CO_2 from the atmosphere and storing it in C pools of having variable turnover rate. The capability of land to store C has certain importance now because, under Article 3.4 of the Kyoto Protocol of the United Nations Framework Convention on Climate Change, countries can count this sequestration as a support to sinking greenhouse gas emissions [14,15].

Carbon sequestration can be determined by quantifying fluctuations in C pools. Management practices, climate and preeminent CO_2 strongly effect C dynamics and their influence on future C stocks in soils. A major prospective to proliferate C sequestration in soil systems is by adopting appropriate management, but global warming may disaffirm any storage stimulated by changed management and elevated CO_2, although there is increasing evidence that the reverse could be the case. While the practises of C sequestration are eventually controlled at the micro level, management practices, climate and atmospheric CO2 concentration can greatly affect the way in which terrestrial ecosystems store C. The significant stocks of carbon sequestered in any biomes are found mainly underneath the soil. Organic C in the soil is placed in definite isolated pools, with different properties. Human activities are disturbing the C cycle to a substantial amount and the result is an alteration in microclimate which could have momentous damaging influences on terrestrial ecosystems [15]. Terrestrial pools have up to 98% of the total C stock which found stored below ground [16]. About two-thirds of global C is below ground and this pool generally has much slower turnover rates than aboveground C [17].

A major quantity of SOM is substantially protected from decomposition through obstruction by clay minerals and enclosing within soil structures. A huge quantity of this SOM comprises a pool having an intermediate (10–15 year) shelf life, but this decays more rapidly on disturbance. More active organic matter, consisting of microbial biomass and plant litter, changes more rapidly but makes up only 3 –5% of total organic matter[18,19]. At the other extreme is very old material that is physically or biochemically protected in a passive obstinate form with a residence time of hundreds to thousands of years [20,21,22]. In their conceptual model,[23] Six *et al*. (2002) differentiate the SOM that is secured either physically or biochemically against decomposition from that which is unprotected. They identified some quantifiable pools as unprotected (light fraction and the particulate organic matter fraction) and protected (biochemically, silt- and clay and aggregate protected) C pool [23]. Protected SOM is stabilized by three main mechanisms. First, chemical steadiness is the effect of chemical bonding between soil minerals (clay and silt particles) and SOM. Second, biochemical stabilization is caused by the chemical processes between substrates such as lignins and polyphenols and soil aggregates. Soil aggregates form structural barriers between microbes and enzymes and their substrates. Carbon from vegetation move in the soil in the form of either above-ground litter or root material or animal excretion [24]. Soil microaggregates and macroaggregates are formed around the light fractions through a process of biochemical processes between C and soil mineral particles to form the heavy fraction of organic C [21].

CONCLUSIONS

Soil has the capacity to transform and store matter and energy. Agroecosystem efficiency depends on productivity. SOM supports ecosystem function in terrestrial systems. Materials with longer residence times typically comprise the largest reservoirs in soils. SOC has the ability to regulate water and air movement. SOC is closely associated with soil's biological and physical status. Physicochemical reactivity of soil is also influenced by the SOC. Soils are vulnerable to carbon losses and results in release of greenhouse gases to the atmosphere as a consequence of accelerated degradation due to land use change or unsustainable management practices. Soil carbon plays a vital role in regulating ecosystem services. Managing soils to obtain multiple economic, societal and environmental benefits requires integrated policies and incentives that maintain and enhance soil carbon. Decisive action needs to be taken to limit soil carbon loss due to erosion and emissions of carbon dioxide and other greenhouse gases to the atmosphere.

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