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A REVIEW

Concept of soil organic carbon stock

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Abstract : Soil organic carbon (SOC) controls ecosystem and agro-ecosystem function, influencing soil fertility, water holding capacity and many other functions. The total amount of C stored in the surface soil is higher than sub surface soil area. It is estimated that the amount of C in the atmospheric pool is about 766 Pg C and about 566 Pg C in living vegetation. It is also of global importance because of its role in the global carbon cycle and therefore, the part it plays in the mitigation of atmospheric levels of greenhouse gases (GHGs). Different factors such as topography, climate, and soil physico-chemical properties also effect SOC stock in soil. Past long-term experimental studies have shown that soil organic C is highly sensitive to changes in land use, with changes from native ecosystems such as forest or grassland to agricultural systems almost always resulting in a loss of SOC. Land use change in different part of the world has also been observed to influence SOC stocks in different depth of the soil. Proper management of land use and land management practices and application of fertilizers, organic compost and manures could leads to greater C-storage in the soil, improves soil fertility and crop yield.

Key Words : Organic carbon, Ecosystem, Carbon cycle, Greenhouse gases, C-storage

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INTRODUCTION

Soils represent the largest terrestrial stock of carbon holding between 1400 x 1015 g (Post *et al.*, 1982) and 1500 x 1015 g (Batjes, 1996). Carbon present in soil is 2 times more than the amount present in the atmosphere and 3 times the amount held in terrestrial vegetation. In most soils the majority of this carbon is held in the form of soil organic carbon (SOC) (Batjes and Sombroek, 1997). SOC plays important role in ecosystem function, soil structure development, water-holding capacity, cation exchange capacity and the soils ability to form complexes with metal ions and to store nutrients (Keulen, 2001). Proper management of soils increases SOC levels can therefore increase the productivity and sustainability of agricultural systems (Cole *et al.*,1997). In agricultural systems cultivation practices, crop rotations, tillage practices, fallow periods and water management are all important factors that could either reduce or increase soil C sequestration (Saree *et al.*, 2012). Soil organic carbon includes decomposed plant, animal and microbial residues. Many organic compounds in the soil are also bound with inorganic soil particles (Post and Kwon, 2000). Carbon enters terrestrial ecosystems, including agriculture, through photosynthesis by green plants that assimilate CO_2 and fix it into organic forms (Morgan *et al*., 2010).

Status of SOC stock in different land use land cover:

The soil organic carbon stock in 1m to depth ranges from 30 t/ha in arid climates to 800 t/ha in organic soils in cold regions, and a predominant range of 50 to 150 t/ha (Lal, 2004). Yigini and Panagos (2016) concluded that in China the average SOC in 2006 was 18.5 $g \cdot kg^{-1}$, significantly higher than 17.3 $g \cdot kg^{1}$ in 1979. The changes of agricultural use to industrial or urbanized uses were the main factors influencing SOC. Duffera *et al*. (2007) reported that different experiment models has been studied to observed the changes of soil organic carbon in sol. Deng *et al*. (2016) reported that the land-use change significantly reduced soil C stock. Soil C stocks decline after land use changes from grassland to plantation (-10%), native forest to plantation (-13%), native forest to farmland (-42%) and grassland to farmland (-59%) and soil C stocks increase after land use changes from native forest to grassland (+8%), farmland to grassland (+19%), farmland to plantation (+18%) and farmland to secondary forest (+53%). Soil C stocks significantly increased after the conversion from farmland to grassland (+6.16 Mg ha^{-1}) and forest to grassland (+11.53 Mg ha^{-1}) and soil C stocks significantly declined after the conversion from grassland to farmland (-12.45 Mg ha^{-1}), forest to farmland (-21.05 Mg ha^{-1}) and forest to forest (-12.28 Mg ha^{-1}).

Factor affecting soil organic carbon:

Effects of climatic on soil organic carbon:

The climatic conditions such as precipitation, temperature and radiation are the most important factors which influence soil organic carbon (Ahmad *et al*., 2010). Oueslati *et al.* (2011) reported that the SOC content increases as mean annual precipitation increases. Climate change is among the major global issues of the 21st century. Climate change such as fossil fuel combustion, land use change, deforestation and soil degradation decrease soil organic carbon content and reduce the crop yield (Lal, 2004).

Effect of topography on soil organic carbon stock:

Topography (especially altitude and slope aspect) are largely responsible for the spatial and vertical distributions of SOC (Dorji *et al*., 2014). Topography influences soil organic carbon through its effects on geomorphological and biogeochemical processes (Creed *et al*., 2013). Webster *et al*. (2011) observed that the size of the measured soil carbon pools across all topographic features increased from the green leaves and freshly fallen leaves in the surface soil. Yohannes *et al*. (2015) reported that litter biomass carbon more in the middle slope and lower in the higher slope. The trend of leaf litter biomass carbon might be related with less accumulation of litter fall in steep slope due to canopy cover and slope character (Ahmad *et al.,* 2010). Fissore *et al*. (2017) reported that at erosion positions along the hillslope, SOC and nutrient content are typically lower and soil thickness is reduced compared to depositional positions.

Effects of land use and land use land cover (*LULC*) *change on SOC stock* :

Forests to rangelands or agricultural lands have become a important factor for environmental degradation and global climate change (Lemenih, 2004). Agricultural sector is responsible for nearly one-third of global warming and climate change that is due to the mismanagement and land use change (Tan and Lal, 2005). Carbon sequestration potential can be accelerate by proper management activities (Lal, 2004). Loss of soil organic carbon storage has a great effect on soil structure through increasing soil compaction, soil erodibility and runoff probability (Hoover, 2003). Land use changes can reduce soil health. But restoring the degraded land to the natural vegetation can develop carbon inputs to the soil through organic matter (Post and Kwon, 2000). Moreover loss of organic carbon can cause nutrient deficiency for the sustainable production of agricultural products (Jones *et al.*, 2009). Loss of soil organic carbon also held by water and wind erosion, flood and land slide (Dawson and Smith, 2007).

Effect of application of fertilizers and manures on SOC stock :

Cheng *et al*. (2010) reported that the SOC increase was higher under balanced chemical fertilizations with compound N, P and K fertilizers than unbalanced fertilizations such as N only, N plus P and N plus K. Ge *et al*. (2013) reported that the soil organic carbon and nitrogen are used as indexes of soil quality assessment and sustainable land use management.

Soil physico-chemical properties affecting soil organic carbon stock:

Clay minerals play a special role in stabilizing the organic compounds (Zeraatpishe and Khormali, 2012). Matus *et al*. (2014) reported that the positive ($P < 0.01$) relationship was observed between the SOC and the C in the silt fraction (R^2 0.80-0.97, $P < 0.01$). Zhang *et al*. (2018) shows that the average soil organic carbon content (SOC) is more in surface whereas it decreased with the soil depth.

Management of soil organic carbon:

SOC comes from biosphere that is captured by plants through the process of photosynthesis. The amount of SOC is a balance of C inputs and C losses of organic material (Burke *et al.*, 1989). In natural ecosystems, climate are primary factors determining plant biomass input and subsequent decomposition of SOC for a given soil type. In agricultural systems, SOC turnover rates and equilibrium levels are further impacted by management practices (Bhattacharyya *et al.*, 2000). Retaining crop residues generally greatly reduces soil erosion and minimizes water losses during fallow periods (Thomas *et al.*, 2007). However, crop residues retained on the surface of the field make only a small contribution to longer-term soil C stocks (Kane, 2015). In below ground root biomasses is primary contributor to SOC stocks (Jobbágy and Jackson, 2000). Roots generally decay slower than aboveground residues (Rasse *et al.*, 2006). Erosion has been a major loss mechanism for SOC from agro-ecosystems, which accounts for an estimated 20-50 per cent of historic C losses (Lal, 2004). Soil management practices such as conservation farming are designed to increase C inputs and minimize the C losses that are characteristics of traditional cultivation practices (Burke *et al.*, 1989).

Soil potential for carbon accumulation:

The amount of organic carbon stored in soil results from the net balance between the rate of soil organic carbon inputs and rate of mineralization. Schlesinger (2000) compiled data on long-term rates of soil organic carbon accumulation in Holocene age soils. He found a slow rate of carbon increase in soil even after thousands of years. This long-term increase represents accumulations of passive soil organic carbon fractions, which include charcoal and resistant compounds physically protected in organ mineral complexes. Schlesinger (2000) documented long-term rates of carbon storage from 0.2 g cm^{-2} y^{-1} in some polar deserts to greater than 10 g cm^{-2} y^{-1} in some forest ecosystems, with an average rate of 2.4 g C cm^{-2} y^{-1} over all ecosystems.

Soil organic C stock calculation:

FAO (2008) given the equation for calculation carbon stock (kg^{-1} ha^{-1}) by multiplying the concentrations of carbon in soil samples (g kg^{-1}), bulk density (g cm^{-3}) and sample soil depth (cm):

$$Cs = BD \times Cc \times D \times 10{,}000$$

Conclusion:

There are many factors and processes that determine the direction and rate of change in SOC stock content. Correct management practices like conservation tillage, crop rotation, residue management and integrated nutrient management have good potential in improving soil carbon sequestration. Efficient use of agricultural inputs would reduce greenhouse gas emissions and result in carbon sequestration. Sequestration of carbon in soil can improve soil health which will help in improving input use efficiency in agriculture Site specific technologies should be developed for improving carbon sequestration and enhancing input use efficiency. Remote sensing, GIS and Simulation model can serve as useful tools in estimation and prediction of carbon sequestration at regional scale.

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