Distribution of carbon stocks under different land use systems of Somawarpet taluk, Kodagu District, India

Abstract:

A study was conducted in Somawarpet taluk of Kodagu district in Karnataka in the aim the soil carbon stocks under different land use systems namely natural forest land use, coffee based agroforestry and paddy systems. Soil samples were collected at different depths like 0-20, 20-40, 40-60 and 60-80 cm with five replications under each land use systems. Natural Forest showed the highest mean value of Potassium Dichromate Oxidizable Carbon content of 18.06g kg^{-1}, followed by coffee system with o P otassium Dichromate Oxidizable Carbon content of 13.86 g kg^{-1} and the lowest mean value (8.23 g kg^{-1}) was found in paddy land use system. The highest mean value of bulk density (BD) was found in paddy land use system (1.33 Mg m^{-3}). In all the land use systems BD content increases with increasing soil depth. The highest soil carbon stock mean value of 4140.23 t ha^{-1} was noticed in natural forest, followed by coffee land use system (3267.38 t ha^{-1}) and lowest value of 2171.45 t ha^{-1} of carbon stock content was observed under paddy land use system. In all the land use systems Potassium Dichromate Oxidizable Carbon content and carbon stock content was decreasing with increasing soil depth.

Key words: Land use systems, Soil organic Carbon, Natural Forest, Coffee based agroforestry, carbon cycle, Pottassium dichromate oxidisable carbon.

Introduction:

One of the environmental issues that the modern world is dealing with is global warming. The most significant contributing component is determined to be carbon emissions. (Dopp, 2016. The ecosystem has experienced significant carbon emissions as a result of this development. It is commonly recognized that vegetation has a significant role in the dynamics of ecosystems. Because of this, there is a growing interest in managing our soil properly to counteract the steadily rising atmospheric CO_2 concentration. The atmosphere, oceans, fossil fuel reserves, and terrestrial systems all serve as natural carbon sinks on a global scale. Carbon is stored in terrestrial systems in the form of rocks and sediments, marshes, forests, swamps, and soils used for agriculture. The rising levels of atmospheric carbon dioxide may be countered by soil as a potential carbon sink. If soil organic carbon (SOC) breakdown rates are reduced and more crop biomass is annually returned to the soil, atmospheric CO_2 can be absorbed in agricultural soils (USDA-NRCS, 2014). Soil organic carbon status which determines nutrient availability, the biological activity, Soil aggregate stability, soil structure, bulk density, plant available water content, Soil organic carbon content required in land use planning, fertilizer recommendation, irrigation management and different crop modeling studies. Mapping of soil carbon at high resolution is of great importance for natural resources management. Since the spatial variation of soil carbon is controlled by complex interactions.

Carbon sequestration is the net removal of atmospheric carbon dioxide and its long-term (thousands of years) storage in terrestrial systems as living carbon pools. The soil has significant role in carbon cycle. The soil organic carbon stock acts as a major part of the terrestrial carbon reservoir than the atmospheric carbon (Grace, 2004) with storage of about 1500Pg to 2000Pg C (1 Pg =1015 g or 1 Pg = 1 billion tonnes) in the top 100 cm depth layer in the world soils (Wang *et al*., 2012). Since there is twice as much carbon in soil as there is in the atmosphere, changes in the soil carbon pool have a major impact on the atmosphere's chemical makeup (Feller and Bernoux, 2008). The only means to remove a significant amount of the primary greenhouse gas (CO_2) into the biological system is by absorption from the atmosphere into the physiological system and plant biomass, and then into the soil. (Ramachandran *et al*., 2007).

The term "soil carbon" describes all of the carbon present in the soil, including both inorganic and biological forms. Among the several ecosystems in India, forests have the potential to have the greatest impact on climate change through the sequestration or emission of carbon, a significant greenhouse gas; biological growth, which can raise forest stocks; or deforestation, which can raise carbon emissions.

The quantification of SOC stocks relies on understanding the spatial variability of SOC stocks in a landscape, which in turn requires identification of its controlling factors including, land use and land cover (LULC) types (Sitaula*et al*., 2004; Smith, 2008; Saha*et al*., 2011). Many studies have reported large SOC stocks under forest compared to grassland and agricultural land (Abbasi *et al.*, 2007; Yang *et al*., 2009; Saha*et al*., 2011; Dorji *et al*., 2014).

A huge amount of carbon is stored in forests (Salleh *et al*., 2001). According to FAO (2010) the total forest carbon stocks of the world is 652 Giga tonnes (161.8 t ha^{-1}). Carbon is captured in its vegetation, litter and soil. Coffee based agroforestry has emerged for potential carbon sequestration, compensating for deforestation by sequestering carbon and assisting in the fight against climate change. The amount of biomass, type of vegetation, nutrient management approaches, and other conservation strategies all affect the nutrient status of different land use systems. The large amount of biomass is produced and added to soil continuously from diverse tree species in natural forest, coffee agroforestry and Paddy land use in Somawarpet taluk of Kodagu District. This creates continuous cycle between above ground biomass and below ground root biomass by different tree species and contributing to soil organic carbon pool and its fertility status. The above mentioned land use systems has greater role in carbon sequestration to sustain the ecological safety. The above mentioned land use systems are major land use systems at Somawarpet taluk, Kodagu district. So, to know the carbon stock in these land use systems study has been conducted.

Material and methods

The study area covered Somawarpet taluk of Kodagu district in Karnataka. The latitude and longitude coordinates of Somawarpet taluk, Kodagu district are 12^{0}59' N latitude and 75^{0}84' E longitudes. Location map of study area presented in Fig. 1. The climate of this region may be broadly termed as tropical except at the higher ranges of the hills where it is sub-tropical. The annual precipitation of Somawarpet taluk is 1569.8 to 2862.71 mm with a mean of 1944.40 mm.

A study was undertaken to know the distribution pattern of soil carbon stock under three land use systems of the Somawarpet, Kodagu district as follows, Natural forest (*Hopeaponga*, *Ficus benjamina*, *Terminalia paniculata*, *Terminalia tsjeriam-cottam. syzygiumcumini etc.*,), **C**offee based agroforestry- (predominantly Robusta coffee (*Coffee acanephora*) was grown under native tree species of *Acrocarpus fraxinifolius*, *Dalbergialatifolia*, *Lagerstroemia microcarpa*and *Syzygiumcumini*), and paddy land use system (Plate 1). The 60 representative soil samples were collected from 0 **to** 20 cm, 20 **to**40 cm, 40 **to** 60 cm and 60 **to** 80 cm depth from different land use systems with five replications. The analysis of soil samples for the organic carbon content and carbon stock content was done using standard procedures.

Methods of soil analysis

Potassium Dichromate Oxidizable Carbon (PDOC)

Determination of Potassium Dichromate Oxidizable Carbon was carried out by wet oxidation method by (Walkley and Black, 1934).

Estimation of potassium dichromate oxidizable carbon was done by wet oxidation method (Walkley and Black, 1934). Weigh 0.5 g of 0.2 mm sieved soil sample in 500 ml capacity conical flask. Add 10 ml of 1N $K_2Cr_2O_7$ solution and 20 ml of concentrated

H_2SO_4 in a conical flask and gently mix and keep away for 30 minutes. After 30 minutes, add 200 ml of distilled water, 10 ml H_3PO_4, about 0.2 g of NaF and 8 to 10 drops of diphenylamine indicator to it. Contents were titrated against standard ferrous ammonium sulphate until it becomes bright green. Blank titration was run by following all the above steps without soil and calculated using the following formula,

$$\text{PDOC }((\text{g kg}^{-1}) = \frac{(Blank\ TV\ -\ Sample\ TV) x\ N.of\ FAS\ x\ 0.003\ x\ 1000}{\text{Weight of soil (g)}}$$

Bulk Density (BD)

Bulk density was determined using clod method by dipping an air dried, pre-weighed paraffin coated clod into a beaker of water, measuring the volume displacement and calculated as described by Black (1965). Bulk density was expressed as Mg m^{-3}.

Soil Organic Carbon stock

Changes in Soil Organic Carbon (SOC) generally occur over many years and it is often difficult to identify small changes. The SOC contents stock in soil (t ha^{-1}) was calculated using equation (Manjunatha*et al.*, 2012).

$$\text{Soil Carbon stock (t ha}^{-1}) = \frac{\text{Area(m}^2)\ \times \text{BD (Mg m}^{-3})\ \times \text{Depth (cm)} \times \text{PDOC (g kg}^{-1})}{1000}$$

Where,

Area: 10000 m^2

BD: Bulk Density at each depth

Depth: Depth interval considered (0-20, 20-40, 40-60 and 60-80 cm)

PDOC: Potassium Dichromate oxidisable carbon in g kg^{-1}

Results and Discussion

Among different land use systems the Potassium Dichromate Oxidisable Carbon (PDOC) value ranged from 11.43 to 23.10 g kg^{-1} in natural forest, 8.96 to 17.31 g kg^{-1} in coffee system and 3.95 to 11.11 g kg^{-1} in paddy system respectively (Table 1). Natural forest recorded higher mean PDOC value of 18.06 g kg^{-1}, followed by coffee system with mean PDOC value of 13.86 g kg^{-1} and the lowest mean value was found in paddy land use system (8.23 g kg^{-1}). In all the land use systems PDOC content was decreasing with increasing soil depth. Increase in PDOC of forest soil due to continuous addition of biomass through leaf litter and roots. Similar results reported by Geo Jose (2006). The lower mean organic carbon status (8.23 g kg^{-1}) content in paddy land might be attributed to lower vertical mixing of soils and also due to the inadequate organic substrate from the farming system. The highest potassium dichromate oxidizable organic carbon (PDOC) status is recorded in the natural forest was attributed to the long term addition of carbon over more than 25-50 years in these soils coupled with minimum physical disturbance to surface soil as compared to agriculture and horticulture land use systems. Similar results are also reported by Brij *et al*. (2012) and Yao *et al*. (2010).

The highest mean value of bulk density (BD) was found in paddy land use system (1.33 Mg m^{-3}) followed by coffee based agroforestry (1.19 Mg m^{-3}) and the lowest mean value was found in natural forest (1.16 Mg m^{-3}). In all the land use systems BD content increases with increasing soil depth (Table 1).

Influence of different land use systems on carbon stock in different land use systems were presented in Fig. 2. Highest carbon stock potential was observed in Natural forest (4140.23t ha^{-1}) followed by coffee based agroforestry (3267.38t ha^{-1}) and lowest value of carbon stock potential was observed in paddy land (2171.45 t ha^{-1}). In all the land use systems carbon stock content was decreasing with increasing soil depth.Among different land use systems the carbon stock value ranged from 2766.06 to 5035.80 g kg^{-1} in natural forest, 2257.92 to 3912.96 g kg^{-1} in coffee based agroforestry, and 1106.56 to 2822.96 g kg^{-1} in paddy land use system respectively. Indicating higher organic carbon turnover through decomposition of leaf litter and due to the quality and quantity of biomass turnover. The larger the biomass turn over higher would be the carbon stock. Roy *et al*. (2010) also found increase in organic carbon status with addition of organic matter through leaf litter in forest land use system. The larger carbon stock observed under natural forest might be due to dense vegetation and depositions of plant leaf litters with least disturbance of the natural forest such as forest fire, grazing and also anthropogenic pressure is totally restricted and less temperature fluctuations due to canopy cover. Hence the carbon stock will be more in natural forest. These results of present study are in agreement with findings of Tchienkoua and Zech (2004).

The lowest mean value of carbon stock was found in paddy land use system 2171.45t ha^{-1} of carbon due to lower soil organic carbon stock which is due to exposer of soil to light and more utilization of nutrients by the crops, a similar result was found in Lal and Puget (2005); Han *et al.* (2010).

Conclusion:

The present investigations have shown that, soil organic carbon content was highest in natural forest compared to other land use systems. Soil organic carbon significantly varies among different land use systems as well as with increase in depth and increase in soil carbon storage may be possible through proper management of land use system. It is concluded that, the highest carbon sequestration potential was observed in natural forest followed by coffee land use system.The study revealed that land use and its management influence soil organic carbon stocks by biomass accumulation and level of decomposition at high temperatures, its microclimate and control on soil erosion. Forest land-use system, associated with good ground and canopy cover, significantly increased the soil organic carbon content and stock compared to land-use systems.

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Natural Forest

Coffee Based Agroforestry

Paddy Land Use System

Plate 1: Different land use system in the study area

Table 1. List of variables in Cropping Systems

Cropping Systems	**Depth (cm)**	**PDOC (g kg^{-1})**	**BD (Mg m^{-3})**	**Carbon stock (t ha^{-1})**
	0-20	23.1	1.09	5035.80
	20-40	21.36	1.14	4869.17
	40-60	16.34	1.19	3889.87
NF	60-80	11.43	1.21	2766.06
	Range	**11.43-23.10**	**1.09-1.21**	**2766.06-5035.80**
	Mean	**18.06**	**1.16**	**4140.23**
	0-20	17.31	1.13	3912.96
	20-40	16.05	1.16	3723.6
	40-60	13.12	1.21	3175.04
CBA - I	60-80	8.96	1.26	2257.92
	Range	**8.96-17.31**	**1.13-1.26**	**2257.92-3912.96**
	Mean	**13.86**	**1.19**	**3267.38**
	0-20	11.11	1.27	2822.96
	20-40	10.06	1.31	2634.67
	40-60	7.8	1.36	2121.6
PL	60-80	3.95	1.4	1106.56
	Range	**3.95-11.11**	**1.27-1.40**	**1106.56-2822.96**
	Mean	**8.23**	**1.33**	**2171.45**

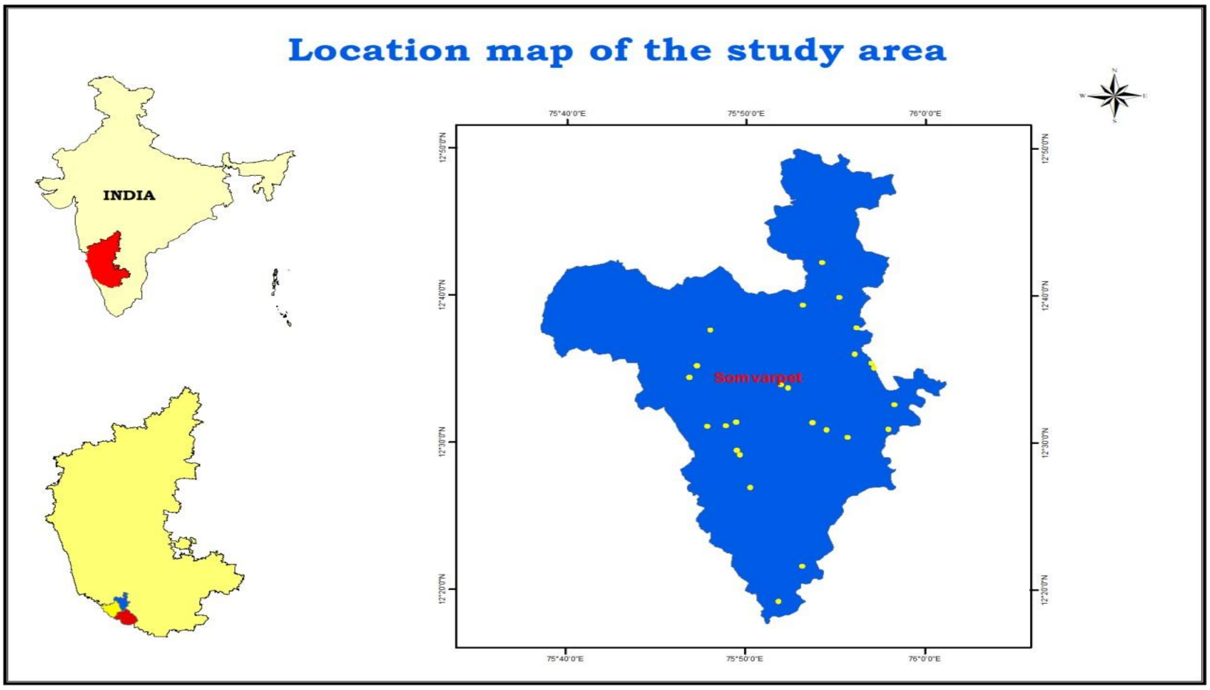

Fig.1: Location map of study area

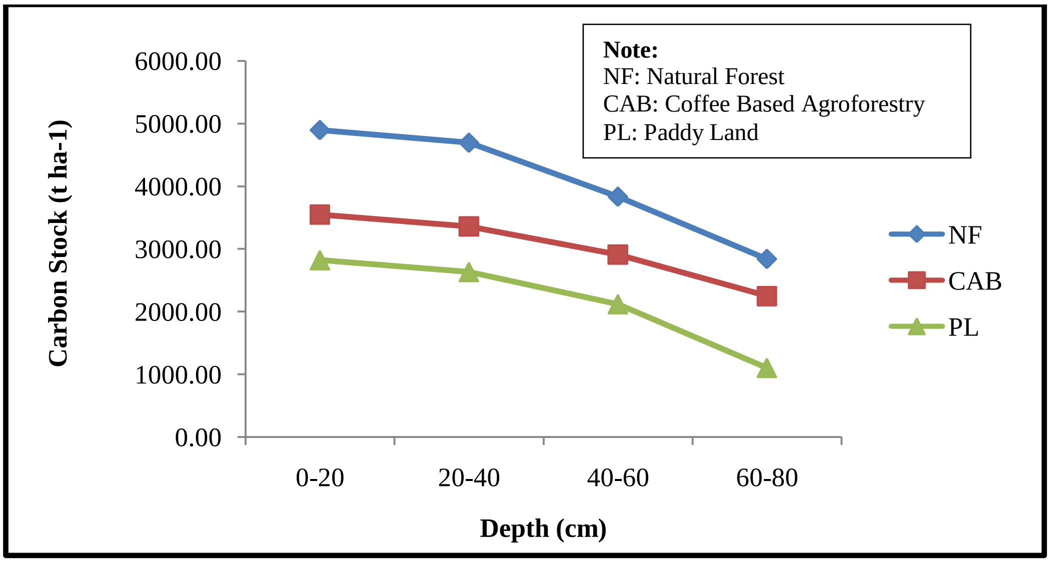

Fig. 2: Soil carbon stock content under different land use systems