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Carbon dynamics under different land use systems of a micro-watershed in Northern Transition Zone of Karnataka

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ABSTRACT

An investigation was undertaken during 2013-14 in northern transition zone of Karnataka to study the forms and distribution of carbon of Shinganhalli-Bogur micro-watershed. Three land use systems [agriculture (paddy land and non-paddy land), forest and horticulture] were selected for the study. From each land use system, fifteen surface (0-20 cm) soil samples were collected randomly. Water soluble carbon and active carbon were recorded highest under forest land use system. Among agriculture land use system, paddy land improved the carbon fractions over non-paddy land. Significant and positive correlations were registered between the carbon pools.

***Key words:** Land use systems, soil organic carbon, active carbon, water soluble carbon, carbon dynamics*

INTRODUCTION

Soil organic matter (SOM) plays an important role in maintaining soil quality and ecosystem functionality. Land use and agricultural practices, such as tillage, irrigation and fertilization, all influence the storage of soil organic carbon (SOC) (Paustian et al., 1997). The accumulation and turnover of soil organic matter (SOM) is a major factor in soil fertility and ecosystem functioning and determines whether soils act as sinks or sources of carbon in the global carbon cycle (Post and Kwon, 2000). Carbon dynamics is important for sustainability of production systems while at the same time contributing significantly to global carbon cycling (Chen et al., 2004). The nature and type of land use systems directly impacts the dynamics of the terrestrial carbon pools. Understanding SOC dynamics is also important for maintaining carbon stocks to sustain and improve crop yields (Sharma et al., 2014).

Assessment of carbon dynamics in different climatic regions can help to draw meaningful conclusions about their contribution (either source or sink) towards global carbon stocks (Banger et al., 2010). Different land use in such situations can have a pronounced impact on soil carbon storage, one through the usual addition of carbon as well as by protecting the soil from erosion (Sharma et al., 2014).

Land use systems play an important role in nutrient availability and transformation. Change in land use affects soil properties, which may alter the availability and forms of nutrients in soil. Besides parent material, climatic factors and natural vegetation, land use pattern plays a vital role in governing the nutrient dynamics and fertility of soils (Chavan et al., 1995). Different land uses influence soil degradation or aggradation process and consequential availability of plant nutrients. Soil quality mainly depends on the response of soil to different land use systems and management practices, which may often modify the soil properties and hence the soil productivity.

Organic materials are intrinsic and essential components of all soils. Moreover, SOC exists in two pools *viz.,* active pool and passive pool. The active pool consists of living microbes and their products besides soil organic matter. The active pool has a short turnover time and includes soil microbial biomass carbon, active carbon, water soluble carbon, water soluble carbohydrates etc. and is dependent on agro-ecosystem and management. Soil active carbon pools are good indicators of minor changes occurring in the SOC (Xia et al., 2010). Soil carbon fractions that are more sensitive to land use changes than the total carbon may serve as early indicators of changes in soil carbon dynamics (Six et al., 2002). Labile and/or active carbon pools form a small part of total carbon, but play a major role in soil health through nutrient availability and microbial transformations (Haubensak et al., 2002). It has a greater turnover rate compared to recalcitrant fractions. The passive pool is comparatively more stable than active pool and is slowly decomposable having a larger turnover time.

The distribution of SOC within different pools is an important consideration for understanding soil carbon dynamics and diverse role in ecosystems (Jenkinson, 1990). Changes in active fractions of soil carbon pools due to variation in land use and agricultural practices have been studied in cool temperate regions of the world (Sherrod et al., 2005; Wu et al., 2003), with few studies conducted in tropical and sub-tropical regions, particularly comparing different land use systems *viz.,* agriculture, horticulture and forestry. Hence, keeping these aspects in view, the present study was undertaken to assess the carbon dynamics influenced by different land use systems as well as the relationship between different forms of carbon.

MATERIAL AND METHODS

The selected Singhanhalli-Bogur micro-watershed in northern transition zone of Karnataka (Fig. 1) lies between 15°31'30.30" and 15°34'49.45" N latitude and 74°50'47.46" and 74°53'35.67" E longitude. Singhanhalli-Bogur micro-watershed belongs to Dharwad taluk of Dharwad district. The area is represented by semi-arid climate with annual precipitation of 755.2 mm distributed over May to October. The watershed covers an area of 760.64 hectare (ha). Three land use systems [agriculture (paddy land and non-paddy land), forest and horticulture] were selected for the study. From each land use system, fifteen surface (0-20 cm) soil samples were collected randomly. The organic carbon content

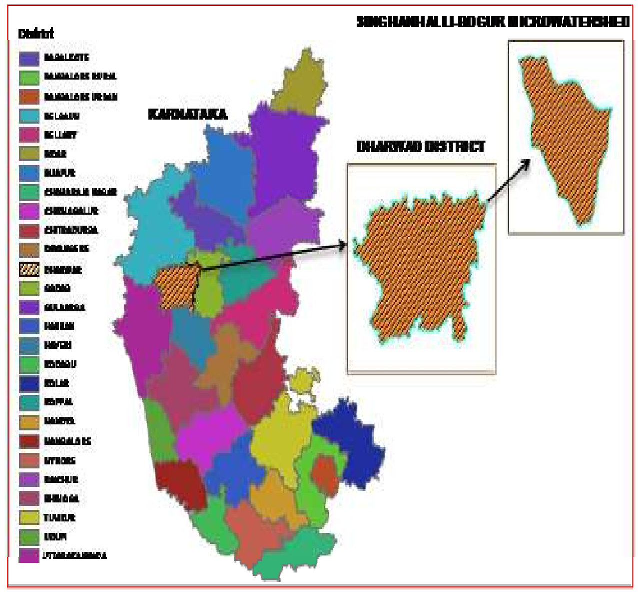

Fig. 1. Location of the study area

of finely ground (0.2 mm) soil samples were determined by Walkley and Black's wet oxidation method as described by sparks (1996). The water soluble carbon was determined using the method as described by McGill et al. (1986). In brief, the water soluble carbon was determined by mixing 10 g of soil with 20 ml distilled water and shaken for one hour. This was followed by centrifugation for 5 minutes at 6000 rpm, filtration and titrimetric determination. Active carbon was determined by the modified method of Blair et al. (1995) as outlined by Weil et al. (2003). In brief, active carbon was determined by shaking 5 g air dried soil in 20 ml of 0.02M $KMnO_4$ for 2 minutes (horizontal shaker-120 rpm), followed by centrifugation to clear the supernatant and measuring the light absorbance at 550 nm by colorimeter. The experimental data obtained was subjected to statistical analysis adopting Fisher's method of analysis of variance as outlined by Gomez and Gomez (1984). Testing of significance was done by SPSS 16.0 version and values are given at 5 per cent and 1 per cent level of significance.

RESULTS AND DISCUSSION

The organic carbon content (Table 1) of the soils in the study area ranged from 5.1 to 23.7 g kg^{-1} under different land use systems. The SOC content was relatively higher in all the land use except non-paddy land use system. The soil organic carbon content in forest land

Table 1. Soil organic carbon, water soluble carbon and active carbon of surface soil samples under different land use systems (n=15).

Sl. No.	Land use system	Statistical parameter	Soil organic carbon (g/kg)	Water soluble carbon (mg/kg)	Active carbon (mg/kg)
1	Agriculture				
a)	Paddy land	Range	5.1-15.9	30.10-68.67	420.00-684.32
		Mean	9.8	54.00	611.33
		SD	2.7	10.58	73.41
b)	Non-paddy land	Range	5.1-15.3	27.70-56.12	450.00-640.10
		Mean	7.0	36.59	447.60
		SD	3.2	8.64	63.52
2	Horticulture (Mango orchard)	Range	6.0-13.2	33.3-66.20	325.0-670.0
		Mean	9.2	51.52	565.97
		SD	2.0	9.78	117.05
3	Reserved forest	Range	8.4-23.7	36.40-106.90	820.60-1820.00
		Mean	15.9	68.49	1420.69
		SD	4.0	14.96	229.42

use system recorded the highest. The increase in SOC content under forest land use system could be attributed to greater turnover of above and below ground biomass through leaf litter and fine root biomass. Another possible reason could be the recalcitrance to litter and root biomass of forest trees, which prevented the microbial decomposition of residue biomass. Similar results were reported by Jha et al. (2010) for soils under the forest land use of the semi-arid eco system. The mean SOC content of 15.9 g kg^{-1} could be possible in forest land use of vertisol because these soils contain appreciable amount of silt and clay, which is the major determinant of soil carbon saturation limit and stabilization of SOM (Steward et al., 2007), provided there is an opportunity for substrate availability. Besides this turnover, turnover from below and above ground portion (Park and Matzner, 2003), their quality and decomposition rate (Sariyildiz and Anderson, 2003), might also have affected the carbon content of soil.

The horticulture system recorded lower organic carbon content as compared to agriculture (paddy land) system. This was attributed to the young age of the system as horticulture plantation was done only four years earlier. Hence the organic matter addition through leaf fall, root exudates and root activity was poor. The increase in SOC content in the paddy land use can be a result of continuous fertilization, incorporation of plant residue and addition of green manure. Among all the land uses, the minimum organic carbon was recorded under non-paddy land which might be due to higher physical disturbance and low organic carbon input. The results obtained in the present study are similar with those reported by Balloli et al. (2007), Somasundaram et al. (2009), Lakaria et al. (2012a), Sofi et al. (2012) and Jha et al. (2012).

Labile pool of carbon is the fraction of SOC that has the most rapid turnover rates (Verma et al., 2010) and therefore, its oxidation drives the flux of carbon dioxide from soils to atmosphere. Also, the labile carbon pool is one which is readily decomposable, easily oxidizable and susceptible to microbial attack and is sensitive to management induced changes in soil organic carbon. This pool is very important as it fuels the soil food web and greatly influences the nutrient cycling for maintaining the quality of soil and its productivity (Majumdar, 2006). The water soluble carbon content in soil represents the easily oxidizable carbon as well as the fraction that is most susceptible for microbial decomposition.

The results corroborated that land use greatly affected the water-soluble carbon content of the soil. The trend of water soluble carbon (Table 1) under different land uses was similar to that of soil organic carbon. The highest water soluble carbonwas recorded under forest land use system due to high level of organic carbon input as a result of higher biomass addition over a long period of time. The lower water soluble carbon content under non-paddy land use system might be attributed to the poor management practices such as lack of addition of crop residues and organic manures. Intensive cropping is also one of the reasons for low water soluble carbon content in non-paddy land. Similar results were also reported by Geetakumari et al. (2011),

Table 2. Correlation amongst carbon fractions under different land use systems.

	Paddy land use system	
Carbon fractions	Water soluble carbon	Active carbon
Soil organic carbon (SOC)	0.943**	0.862**
Water soluble carbon (WSC)	1	0.970**
Non-paddy land use system		
Carbon fractions	Water soluble carbon	Active carbon
Soil organic carbon (SOC)	0.982**	0.913**
Water soluble carbon (WSC)	1	0.951**
Horticulture land use system		
Carbon fractions	Water soluble carbon	Active carbon
Soil organic carbon (SOC)	0.969**	0.844**
Water soluble carbon (WSC)	1	0.939**
Forest land use system		
Carbon fractions	Water soluble carbon	Active carbon
Soil organic carbon (SOC)	0.912**	0.941**
Water soluble carbon (WSC)	1	0.938**

** Correlation is significant at the 0.01 level.

Lakaria et al. (2012a), Lakaria et al. (2012b), Jha et al. (2012) and Baljit Singh and Sharma (2012).

The perusal of the data indicated that land use significantly affected the active carbon content of the soil. Active carbonunder the different land use ranged from 325.00 to 1820.00 mg kg^{-1} (Table 1). Active carbon which is an excellent indicator of soil quality was found to be in direct proportion of SOC. A high value of active carbon under the forest land use is an indication of good soil health. Mishra et al. (2002) also reported lower active carbon in agriculture land uses as compared to the natural vegetation with higher intensity management. The present findings are also in line with those of Sofi et al. (2012), Lakaria et al. (2012a), Lakaria et al. (2012b) and Jha et al. (2012).

Significant and positive correlations was found between the various soil organic carbon pools, under different land use systems (Table 2), suggesting that the water soluble carbon and active carbon were derived from soil organic carbon stocks. This finding is in accordance with Sofi et al. (2012).

CONCLUSION

The present study revealed that different land use systems influenced the soil organic carbon and its labile pools. Soil organic carbon, water soluble carbon and active carbon were significantly increased under forest land use system. The amount of different forms of carbon present in different land use systems had shown significant positive correlation among themselves, whereby indicating dynamic equilibrium among different forms.

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