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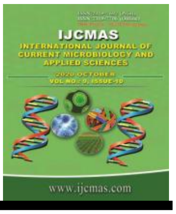

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Carbon Dynamics under Different Land-Use Systems of Nandipura Mini-Watershed of Chikkamagaluru District, Karnataka, India

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ABSTRACT

Keywords

Carbon fractions, Carbon stock, Land-use systems, Mini-watershed, Soil depth

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Assessment of carbon fraction was undertaken in Nandipura mini-watershed area under different land-use systems. Eight land-use systems were selected viz; agricultural system (maize, ragi and groundnut), horticulture system (arecanut, coconut and pomegranate), fallow land and scrubby land for the study of dynamics of carbon. Among the different land-use systems, horticultural land use systems recorded significantly higher potassium dichromate oxidizable carbon (PDOC), potassium permanganate oxidizable carbon (PPOC), Cold water extractable carbon (CWEC), soil microbial biomass carbon (SMBC), Total organic carbon (TOC), Total inorganic carbon (TIC) and Total Carbon (TC) at three depths of soil (0-20 cm, 20-40 cm and 40-60 cm) followed by agricultural land-use system. Significantly higher carbon stock was recoded under arecanut land-use system (30.95 t C ha^{-1}) at surface depth and least carbon stock was recorded under maize land-use system (17.29 t C ha^{-1}). Similar trend was observed at subsurface layers.

Introduction

Soil organic matter (SOM) is of fundamental importance in maintaining soil fertility. A good farming practice can decrease CO_2 evolution into the atmosphere and enhance soil fertility and productivity. It is more important in tropical and subtropical regions where soils are inherently low in organic carbon content and the production system is fragile. Following the unprecedented expansion and intensification of agriculture in India, there are clear evidence of the decline in the soil organic carbon (SOC) contents in many soils on one hand, while on the other hand good farming practices such as balanced fertilization and addition of crop residues either maintain or result in build-up or depletion of soil organic carbon (SOC) stock (Swarup *et al.*, 2000). The restoration of SOC in arable lands represents a potential sink for atmospheric CO_2. The soil has a significant role in the carbon cycle. The carbon pools are components of the ecosystem that can either accumulate or release carbon.

Cultivation reduces soil carbon content and changes the distribution and stability of soil aggregates. Different land-use systems influence soil aggregation, aggregate stability and overall soil health. Land-use changes have a great influence on many soil physical and chemical properties, mostly soil organic matter affecting its quality attributes and fertility. Organic matter is a key factor in improving the overall productivity of the cropping system.

Materials and Methods

Nandipura mini-watershed comes under Mugli sub-watershed of Tarikere taluk, Chikkamagaluru district. The mini-watershed is 40 km away from Chikkamgaluru district. Soil samples were collected under different land-use systems viz., an agricultural system which includes maize, groundnut and ragi land-use systems, the horticultural system which include coconut, arecanut and pomegranate land-use systems, scrubby land and currently fallow land use from different depths (0-20 cm, 20-40 cm and 40-60 cm). these soil samples were analysed for different carbon fractions.

Results and Discussion

At surface layer significantly higher mean of PDOC content was observed in arecanut land-use system (14.20 g kg^{-1}) which is followed by coconut land-use system (13.10 g kg^{-1}) and lowest organic carbon content of 7.07 g kg^{-1} was observed in maize land-use system (Table 1). At 20 to 40 cm and 40 to 60 cm, arecanut land-use system recorded a significantly higher mean of PDOC content of 13.47 g kg $^{-1}$ and 12.83 g kg^{-1}, respectively. Lowest mean PDOC content was recorded under maize land-use system with 6.67 g kg^{-1} at 20 to 40 cm and 6.03 g kg $^{-1}$ at 40 to 60 cm. The higher PDOC content under horticultural crops can be associated with the large annual addition of organic matter in the form of leaf litter, longer residue time in the soil due to less soil disturbances, which consequently ends up in the accumulation of higher PDOC in these soils (Ashura, 2016). Similar result was reported by Brij *et al* (2012).

Arecanut land-use systems recorded significantly higher mean of PPOC content of 427.44 mg kg^{-1}, 421.84 mg kg^{-1} and 414.58 mg kg^{-1} at 0 to 20 cm, 20 to 40 cm and 40 to 60 cm, respectively, which is followed by coconut land-use system (418.70 mg kg^{-1} at 0-20 cm, 412.51 mg kg^{-1} at 20-40 cm and 405.37 mg kg^{-1} at 40-60 cm) (Table 1). Significantly lower PPOC content of 348.89 mg kg^{-1}, 342.25 mg kg^{-1} and 335.13 mg kg^{-1} at 0 to 20 cm, 20 to 40 cm and 40 to 60 cm, respectively was observed under maize land-use system. PPOC content in the surface layer was higher as compared to the subsurface layer. Generally, PPOC is decreased with increase in depth in all the land-use systems. The difference in PPOC content among land-use systems might be due to changes management practices that have a detrimental effect on soil carbon. A low concentration of PPOC in agricultural land-use systems can be attributed to tillage practices. The cultivation period has a negative effect on labile carbon (Sharma *et al.,* 2014).

The CWEC recorded significantly higher mean value under arecanut land-use system (43.29 mg kg^{-1} at 0-20 cm, 41.69 mg kg^{-1} at 20-40 cm and 39.73 mg kg^{-1} at 40-60 cm) which is followed by coconut land-use system (36.73 mg kg^{-1} at 0-20 cm, 35.31 mg kg^{-1} at 20-40 cm and 33.68 mg kg^{-1} at 40-60 cm) and the lowest mean value recorded under maize land-use system (16.60 mg kg^{-1} at 0-20 cm, 15.28 mg kg^{-1} at 20-40 cm and 14.26 mg kg^{-1} at 40-60 cm) (Table 2). The CWEC content in the surface soil layer was higher and decreased with a decrease in depth. The lower per cent of CWEC in arable land due to high evapotranspiration of soil moisture. These results are in line with the findings of Zaimenko *et al.,* (2014).

Table.1 Potassium dichromate oxidizable carbon and Potassium permanganate oxidizable carbon content of soils under different land-use systems of Nandipura mini-watershed of Tarikere taluk, Chikkamagaluru District

Land use system	Potassium dichromate oxidizable carbon (PDOC)(g kg^{-1})			Potassium permanganate oxidizable carbon (PPOC) (mg kg^{-1})		
	0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm
Arecanut	14.20	13.47	12.83	427.44	421.84	414.58
Coconut	13.10	12.50	11.83	418.70	412.51	405.37
Pomegranate	9.87	9.30	8.57	405.68	397.79	396.41
Maize	7.07	6.67	6.03	348.89	342.25	335.13
Groundnut	8.97	8.13	7.80	371.21	364.42	357.34
Ragi	7.43	7.03	6.43	359.34	351.80	347.71
Scrubby land	11.10	10.73	10.07	383.03	373.93	367.91
Fallow land	11.87	11.20	10.80	395.94	385.23	377.84
S. Em±	**0.27**	**0.19**	**0.24**	**4.50**	**3.64**	**4.08**
CD at 5%	**0.82**	**0.57**	**0.73**	**13.48**	**10.90**	**12.23**

Table.2 Coldwater extractable carbon and Soil microbial biomass carbon content of soils under different land-use systems of Nandipura mini-watershed of Tarikere taluk, Chikkamagaluru District

Land use system	Cold water extractable carbon (CWEC) (mg kg^{-1})			Soil microbial biomass carbon (SMBC) (mg kg^{-1})		
	0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm
Arecanut	43.29	41.69	39.73	398.67	372.33	356.67
Coconut	36.73	35.31	33.68	373.00	353.33	329.67
Pomegranate	27.38	26.03	24.56	277.00	260.33	244.67
Maize	16.60	15.28	14.26	206.00	194.33	176.33
Groundnut	23.05	22.21	21.27	237.67	222.33	212.00
Ragi	20.05	19.20	17.76	220.67	209.33	193.67
Scrubby land	29.89	29.05	27.31	315.33	295.67	276.00
Fallow land	34.01	31.42	30.51	349.67	321.33	296.67
S. Em±	**0.84**	**0.71**	**0.67**	**12.69**	**15.38**	**18.94**
CD at 5%	**2.53**	**2.14**	**2.02**	**38.06**	**46.12**	**56.78**

Table.3 Total organic carbon, total inorganic carbon content and total carbon content of soils under different land-use systems of Nandipura mini-watershed of Tarikere taluk, Chikkamagaluru District

Land use system	Total organic carbon (TOC) (g kg^{-1})			Total inorganic carbon (TIC) (g kg^{-1})			Total carbon (TC) (g kg^{-1})		
	0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm	0-20 cm	20-40 cm	40-60 cm
Arecanut	13.09	12.04	10.86	0.40	0.37	0.35	13.49	12.41	11.23
Coconut	10.91	10.27	9.28	0.38	0.36	0.33	11.29	10.63	9.61
Pomegranate	5.70	5.46	5.03	0.34	0.31	0.29	6.04	5.77	5.34
Maize	2.11	1.84	1.31	0.18	0.18	0.15	2.29	3.15	1.46
Groundnut	4.31	3.79	3.26	0.27	0.24	0.25	4.58	4.03	3.51
Ragi	2.86	2.45	2.08	0.24	0.21	0.19	3.10	2.66	2.27
Scrubby land	7.89	7.53	7.18	0.29	0.26	0.21	8.18	7.79	7.39
Fallow land	9.15	8.42	7.90	0.32	0.29	0.25	9.47	8.71	8.14
S. Em±	**0.27**	**0.29**	**0.49**	**0.01**	**0.02**	**0.02**	**0.26**	**0.32**	**0.48**
CD at 5%	**0.80**	**0.87**	**1.47**	**0.04**	**0.05**	**0.06**	**0.78**	**0.96**	**1.45**

Table.4 Carbon stock of soils under different land-use systems of Nandipura mini-watershed of Tarikere taluk, Chikkamagaluru District

Land use system	Carbon stock (t C ha^{-1})		
	0-20 cm	20-40 cm	40-60 cm
Arecanut	30.95	29.71	28.66
Coconut	29.26	28.34	27.14
Pomegranate	22.50	21.52	20.05
Maize	17.29	16.49	15.16
Groundnut	21.28	19.58	19.13
Ragi	17.99	17.26	16.00
Scrubby land	25.96	25.39	24.01
Fallow land	27.53	26.44	25.78
S. Em±	0.61	0.45	0.56
CD at 5%	1.82	1.34	1.68

At surface layer, SMBC recorded significantly higher mean value under arecanut land-use system (398.67 mg kg^{-1}) which is followed by coconut land-use system (373.00 mg kg^{-1}) and maize land-use system was lowest which recorded a value of 206.00 mg kg^{-1}(Table 2). At 20 to 40 cm and 40 to 60 cm, arecanut land-use system recorded significantly higher mean SMBC content of 372.33 mg kg^{-1} and 356.67 mg kg^{-1}, respectively. Lowest mean SMBC content was recorded under maize land-use system with 194.33 mg kg^{-1} at 20 to 40 cm and 176.33 mg kg^{-1} at 40 to 60 cm. SMBC was decreased with increase in depth in all the land-use systems studied in the Nandipura mini-watershed. The application of manure had a positive effect on soil organic matter content, which in turn decides the SMBC (Asha, 2016). These findings are consistent with previous studies by Pramod *et al.*, (2012), who reported higher MBC content in soils under forests (430.7 µg g^{-1}) followed by a horticulture system (355.5 µg g^{-1}) and agriculture land use (257.8 µg g^{-1}).

Significantly higher mean value of TOC was recorded in the soil under arecanut land-use system (13.09 g kg^{-1} at 0-20 cm, 12.04 g kg^{-1} at 20-40 cm and 10.86 g kg^{-1} at 40-60 cm) which is followed by coconut land-use system (10.91 g kg^{-1} at 0-20 cm, 10.27 g kg^{-1} at 20-40 cm and 9.28 g kg^{-1} at 40-60 cm) and the lowest mean value of TOC content was recorded under maize land-use system (2.11 g kg^{-1} at 0-20 cm, 1.84 g kg^{-1} at 20-40 cm and 1.31 g kg^{-1} at 40-60 cm) (Table 3). The TOC content in the surface layer was higher and decreased with a decrease in depth. The variation of TOC content is due to intensive cultivation of crops which has caused 47 per cent of soil organic carbon losses in the surface layer because of the rapid decomposition of native soil organic matter (Seema, 2019).

At surface layer, TIC was significantly higher in arecanut land-use system (0.40 g kg^{-1}) which is followed by coconut land-use system (0.38 g kg^{-1}) and lowest in maize land-use system (0.18 gkg $^{-1}$) (Table 3). At 20 to 40 cm and 40 to 60 cm, arecanut land-use system recorded significantly higher mean TIC content of 0.37 g kg^{-1} and 0.35 g kg^{-1}, respectively. Lowest mean TIC content was recorded under maize land-use system with 0.18 g kg^{-1} at 20 to 40 cm and 0.15 g kg $^{-1}$ at 40 to 60 cm. TIC content decreased with increase in depth. Significantly higher TIC values were observed under the horticultural land-use system (arecanut, pomegranate and coconut). The soil pH is also slightly neutral under horticultural systems. And hence, soil having a small amount of calcium and magnesium carbonates. These results are similar to the findings of Venkanna *et al.*, (2014) and Pradeepa *et al.*, (2018).

Significantly higher mean value of TC was recorded under arecanut land-use system (13.49 g kg^{-1} at 0-20 cm, 12.41 g kg^{-1} at 20-40 cm and 11.23 g kg^{-1} at 40-60 cm) which is followed by coconut land-use system (11.29 g kg^{-1} at 0-20 cm, 10.63 g kg^{-1} at 20-40 cm and 9.61 g kg^{-1} at 40-60 cm) and the lowest mean value of TC content was recorded under maize land-use system (2.29 g kg^{-1} at 0-20 cm, 3.15 g kg^{-1} at 20-40 cm and 1.46 g kg^{-1} at 40-60 cm) (Table 3). The TC content in the surface layer was higher and decreased with a decrease in depth. The higher TC content in this system might be due to higher biomass turn over as a result of the higher leaf shedding and diversity of tree species (Seema, 2019). These results are in line with the findings of Syed (2010).

At surface layer, carbon stock potential significantly higher in arecanut land-use system (30.95 t C ha^{-1}) which is followed by coconut land-use system (29.71 t C ha^{-1}) and least was observed in maize land-use system

(17.29 t C ha^{-1}) (Table 4). At subsurface soil layer carbon stock potential under all land-use systems was found to be lower when compared to surface soil depth. At 20 to 40 cm and 40 to 60 cm, arecanut land-use system recorded significantly higher mean carbon stock potential of 29.71 t C ha^{-1} and 28.66 t C ha^{-1}, respectively. Lowest mean carbon stock potential was recorded under maize land-use system with 16.49 t C ha^{-1} at 20 to 40 cm and 15.16 t C ha^{-1} at 40 to 60 cm. Higher carbon stocks under plantation trees indicate higher organic carbon turnover through the decomposition of leaf litter (Asha, 2016). Roy *et al.*, (2010) also found an increase in organic carbon status with the addition of organic matter through leaf litter in the forest land-use system.

In conclusion the significantly higher carbon fractions were recorded in horticultural land-use systems (arecanut land-use system) and lower carbon fractions was recorded under agricultural land-use systems (maize land-use system). Horticultural land-use systems increased carbon in the soil followed by agricultural land-use systems.

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