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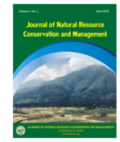

Dynamics of carbon fractions under different land-use systems of Rangapura micro-watershed in Chikkamagaluru district of Karnataka

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ABSTRACT

A study on carbon fractions was undertaken in Rangapura micro watershed area under different land-use systems. Five land-use systems were selected *viz,* maize, ragi, arecanut, coconut, and fallow land for studying the dynamics of carbon. Among the different land-use systems, horticultural (Arecanut, coconut) land-use systems recorded significantly higher potassium permanganate oxidizable carbon (PPOC), cold water extractable carbon (CWEC), soil microbial biomass carbon (SMBC), Total organic carbon (TOC), Total Carbon (TC), Humic acid (HA) and Fulvic acid (FA) at different depths followed by agricultural land-use systems (Maize, Ragi). The highest carbon stock mean values were recorded in the arecanut system (19.92 t c ha^{-1}) followed by coconut system (16.27t c ha^{-1}). The lowest was recorded in the ragi land-use system (7.68t c ha^{-1}).

Keywords: Carbon fractions, carbon stock, land-use systems, micro-watershed

INTRODUCTION

Organic matter is an intrinsic and essential component of all soils. Most of the soil organic carbon is associated with organic matter and plays an important role in crop production, through positive beneficial influence on nutrients availability in soil (Sharma *et al.* 1980). There is a strong linkage between soil organic carbon (SOC) and nitrogen contents and thus soil organic matter is a major source of nitrogen in soils. The climate and soil of a region have a great bearing on sources, availability, and degree of decomposition of organic materials in the soil, while the land use pattern significantly influences the SOC content (Sharma and Aggarwal, 1984; Bhagat et al., 2003). The land-use changes, especially the conversion of native forest vegetation to cropland and plantations in the tropical region, can alter soil carbon (Chen *et al.* 2003). Therefore, soil organic carbon concentrations reflect soil and ecosystem processes as well as the past management practices for both agricultural and non-agricultural soils (Collins *et al.* 2000).

Soil organic carbon 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 passive pool is comparatively more stable than the active pool and is slowly decomposable having a larger turnover time. The active pool has a short turnover time and includes soil microbial biomass carbon, water-soluble carbon, water-soluble carbohydrates, etc., and is dependent on agro-ecosystem and management. Land use has a direct bearing on the soil's organic carbon content. Changes in land-use patterns severely reduce the sink capacity of soils. The impact of natural vegetation is sufficiently large on soil organic carbon content indicating their sink capacity (Bhattacharyya *et al.* 2008). The non-labile or residual SOC fraction constitutes the largest percentage of SOC under integrated applications of manures and fertilizers; thus it has the potential to significantly increase SOC in agricultural soils (Ghosh*et al.*, 2009). The distribution of SOC within different pools is an important consideration for understanding its dynamics and diverse role in ecosystems (Jenkinson, 1990).

MATERIAL AND METHODS

Rangapura micro-watershed (4D3E4C2a) comes under Haralahalli subwatershed located in Tarikeretaluk, Chikkamangalore district, Karnataka. The soil samples were collected from five representative pedons to study the vertical distribution of carbon fractions in different land-use systems. The selected land-use systems were ragi, maize, coconut, arecanut, and fallow land in the micro-watershed and these soil samples were analyzed for different carbon fractions.

RESULTS AND DISCUSSION

The highest mean PPOC content was observed under arecanut land-use system (290.76 mg kg^{-1}) which is followed by coconut (241.08 mg kg^{-1}), maize (203.41 mg kg^{-1}), and ragi land-use system (190.70 mg kg^{-1}) respectively. The lowest mean value was observed in the fallow land-use system (159.27 mg kg^{-1}). Significantly higher PPOC content is observed in horticultural land-use systems (Arecanut and Coconut) and least is observed in agricultural land use system (Maize and Ragi). The low concentration of PPOC in agricultural land-use systems can be attributed to tillage practices. The difference in PPOC content among land-use systems might be due to changes in management practices which have

Table 1. Active carbon fractions under different land uses systems of Rangapuramicro watershed

Land use systems	Depth (cm)	Horizons	PPOC (mg kg^{-1})	CWEC (mg kg^{-1})	SMBC (mg kg^{-1})
Maize	0-18	Ap	214.36	347.16	476.93
	18-29	Bt_1	208.13	312.71	456.68
	29-53	Bt_2	203.18	255.74	306.80
	53-74	Bt_3	199.04	232.67	265.18
	74-95	Bc	192.36	216.25	252.21
		Range	192.36-214.36	216.25-347.16	252.21-476.93
		Mean	203.41	272.91	351.37
Ragi	0-12	Ap	201.70	317.61	468.19
	12-37	Bt_1	195.47	297.16	362.19
	37- 58	Bt_2	190.52	232.84	301.55
	58-79	Bt_3	186.12	215.15	255.25
	79-106	Bc	179.70	207.95	213.34
		Range	179.70-201.70	207.95-317.61	213.34-468.19
		Mean	190.70	254.14	320.10
Coconut	0-18	Ap	247.02	394.57	506.49
	18-33	Bt_1	245.21	305.21	467.68
	33-57	Bt_2	238.98	267.12	316.40
	57-78	Bt_3	237.98	256.36	280.50
	78-87	Bc	236.20	224.15	260.04
		Range	236.20-247.02	224.15-394.57	260.04-506.49
		Mean	241.08	289.48	366.22
Areca nut	0-19	Ap	302.26	408.32	512.61
	19-53	Bt_1	296.03	359.78	422.38
	53-84	Bt_2	291.08	267.94	348.21
	84-103	Bt_3	284.16	256.89	325.14
	103-140	Bt_4	280.26	219.86	293.62
		Range	280.26-302.26	219.86-408.32	293.62-512.61
		Mean	290.76	302.56	380.39
Fallow	0-21	Ap	168.73	301.87	380.16
	21-44	Bt_1	164.40	274.96	355.68
	44-68	Bt_2	159.44	212.46	316.20
	68-82	Bt_3	155.14	202.16	299.34
	82-108	Bc	148.62	199.47	231.63
		Range	148.62-168.73	199.47-301.87	231.63-380.16
		Mean	159.27	238.18	316.60

Note: PPOC- potassium permanganate oxidisable carbon, CWEC- cold water extractable carbon, SMBC- soil microbial biomass carbon a detrimental effect on soil carbon. The cultivation period has a negative effect on labile carbon (Sharma *et al.*, 2014). The agricultural practices like lack of biomass addition to soil, crop residue removal, and conventional tillage practices in agricultural production systems enhance carbon losses from the soil (Seema, 2019; Bhardwaj et al., 2019) reported that PPOC status is significantly affected by nutrient management treatment within the short period under tropical environment.

The highest mean CWEC content was observed under arecanut land use system (302.56 mg kg^{-1}) which is followed by coconut land-use system (289.48 mg kg^{-1}), maize land-use system (272.91 mg kg^{-1}), ragi land-use system (254.14 mg kg^{-1}), and lowest mean value was in the fallow land-use system (238.18 mg kg^{-1}). The higher values of CWEC under the horticultural land-use system (coconut, arecanut) might be due to higher build-up of soil organic carbon, water-soluble carbon and labile carbon on surface soil depth under the horticultural crops might be attributed to the accumulation of litterfall of tree species on the soil surface. The mobilization of organic components and their redistribution in soil determine the quantitative and qualitative characteristics of soil organic matter. The subsequent decomposition and incorporation of litter into the soil would have helped in raising the soil organic carbon pool status of soil (Gill *et al.,* 1987). The lower percent of CWEC in arable land could be due to the high evapotranspiration of soil moisture (Zaimenko *et al.,* 2014)

Table 2. Distribution of Total carbon fractions under different land-use systems of Rangapura micro watershed

Land-use systems	Depth (cm)	Horizons	TOC (g kg^{-1})	TIC (g kg^{-1})	TC (g kg^{-1})
Maize	0-18	Ap	22.17	0.72	22.89
	18-29	Bt_1	19.19	0.53	19.72
	29-53	Bt_2	16.09	0.47	16.56
	53-74	Bt_3	14.34	0.36	14.73
	74-95	Bc	13.98	0.20	14.18
		Range	13.98-22.17	0.20-0.72	14.18-22.89
		Mean	17.15	0.46	17.17
Ragi	0-12	Ap	20.36	0.50	20.86
	12-37	Bt_1	20.62	0.43	21.05
	37- 58	Bt_2	18.41	0.48	18.89
	58-79	Bt_3	14.44	0.28	14.72
	79-106	Bc	12.82	0.15	13.02
		Range	12.82-20.62	0.15-0.50	13.02-21.05
		Mean	17.33	0.37	17.71
Coconut	0-18	Ap	27.83	0.62	28.45
	18-33	Bt_1	26.47	0.59	27.06
	33-57	Bt_2	18.31	0.40	18.71
	57-78	Bt_3	17.83	0.38	18.22
	78-87	Bc	16.56	0.27	16.83
		Range	16.56-27.83	0.27-0.62	16.83-28.45
		Mean	21.40	0.45	21.85
Areca nut	0-19	Ap	30.01	0.57	30.58
	19-53	Bt_1	22.30	0.65	22.95
	53-84	Bt_2	27.03	0.44	27.47
	84-103	Bt_3	24.95	0.40	25.35
	103-140	Bt_4	21.92	0.33	22.25
		Range	21.92-30.01	0.33-0.57	22.25-30.58
		Mean	25.24	0.48	25.72
Fallow	0-21	Ap	20.06	0.23	20.29
	21-44	Bt_1	18.02	0.24	18.26
	44-68	Bt_2	17.10	0.20	17.30
	68-82	Bt_3	15.99	0.21	16.20
	82-108	Bc	14.82	0.10	14.92
		Range	14.82-20.06	0.10-0.23	14.92-20.29
		Mean	17.20	0.19	17.39

The highest mean SMBC content was observed under the arecanut land use system (380.39 mg kg^{-1}) which is followed by coconut land-use system (366.22 mg kg^{-1}), maize land-use system (357.56 mg kg^{-1}), ragi land-use system (320.10 mg kg^{-1}), and lowest mean value in fallow land-use system (316.60 mg kg^{-1}). The variations in soil microbial biomass carbon among different land-use systems may be attributed to variation in soil organic matter content consequently the microbial activity. Further, the variation in soil organic matter may be attributed to variation in residue returned to the soil and the addition of manure. The addition of manure had a positive effect on soil organic matter content which in turn influences the SMBC (Asha, 2016). The higher MBC content in soils under forests (430.7 µg g^{-1}) followed by horticulture system (355.5 µg g^{-1}) and agriculture land use (257.8 µg g^{-1}) (Pramod *et al.,* 2012).

The highest mean value of TOC was observed in arecanut land-use system (25.24 g kg^{-1}) followed by coconut land-use system (21.40 g kg^{-1}) and the lowest value is in the maize land-use system (17.15 g kg^{-1}). In all land-use systems, TOC content decreased with an increase in depth. Among the different land-use systems lower mean total organic carbon was observed under the agricultural land use system (ragi and maize), this might be due to the variation of TOC content due to the continuous cropping and soil cultivation which has caused 47 percent of soil

Table 3. Aliphaticity and Aromaticity of Humic acid (HA) and Fulvic acid (FA) in soils under different land-use systems of rangapura micro watershe

Land use systems	Depth (cm)	Horizons	Humic acid	Fulvic acid	HA/FA
Maize	0-18	Ap	4.84	5.67	0.87
	18-29	Bt_1	4.67	5.36	0.85
	29-53	Bt_2	4.48	5.14	0.85
	53-74	Bt_3	4.26	5.04	0.84
	74-95	Bc	4.16	4.95	0.84
		Range	4.16-4.84	4.95-5.67	0.84-0.87
		Mean	4.48	5.23	0.85
Ragi	0-12	Ap	4.55	5.41	0.84
	12-37	Bt_1	4.41	5.07	0.87
	37- 58	Bt_2	4.20	5.08	0.83
	58-79	Bt_3	4.00	5.04	0.79
	79-106	Bc	3.88	4.95	0.78
		Range	3.88-4.55	4.95-5.41	0.78-0.84
		Mean	4.21	5.11	0.82
Coconut	0-18	Ap	5.03	5.57	0.90
	18-33	Bt_1	4.86	5.42	0.87
	33-57	Bt_2	4.66	5.25	0.86
	57-78	Bt_3	4.67	5.26	0.88
	78-87	Bc	4.32	4.57	0.87
		Range	4.32-5.03	4.57-5.57	0.86-0.90
		Mean	4.71	5.21	0.87
Areca nut	0-19	Ap	5.23	5.84	0.89
	19-53	Bt_1	4.95	5.57	0.89
	53-84	Bt_2	4.76	5.39	0.88
	84-103	Bt_3	4.69	5.29	0.88
	103-140	Bt_4	4.53	5.14	0.89
		Range	4.53-5.23	5.14-5.84	0.88-0.89
		Mean	4.83	5.45	0.88
Fallow	0-21	Ap	4.26	5.08	0.84
	21-44	Bt_1	4.17	4.99	0.84
	44-68	Bt_2	3.96	4.87	0.81
	68-82	Bt_3	3.65	4.50	0.81
	82-108	Bc	3.66	4.55	0.81
		Range	3.65-4.26	4.50-5.08	0.81-0.84
		Mean	3.94	4.79	0.82

Table 4. Influence of different land-use systems on soil organic carbon stock of Rangapura micro watershed

Land-use systems	Depth (cm)	Horizons	Carbon stock (t c ha^{-1})
Maize	0-18	Ap	10.75
	18-29	Bt_1	7.58
	29-53	Bt_2	10.39
	53-74	Bt_3	9.50
	74-95	Bc	9.41
		Range	9.41-10.75
		Mean	9.53
Ragi	0-12	Ap	8.50
	12-37	Bt_1	8.49
	37- 58	Bt_2	7.17
	58-79	Bt_3	7.17
	79-106	Bc	7.10
		Range	7.10-8.50
		Mean	7.68
Coconut	0-18	Ap	18.93
	18-33	Bt_1	16.30
	33-57	Bt_2	18.51
	57-78	Bt_3	17.66
	78-87	Bc	9.97
		Range	9.97-18.93
		Mean	16.27
Areca nut	0-19	Ap	22.68
	19-53	Bt_1	21.90
	53-84	Bt_2	21.34
	84-103	Bt_3	13.56
	103-140	Bt_4	20.13
		Range	13.56-22.68
		Mean	19.92
Fallow	0-21	Ap	15.65
	21-44	Bt_1	15.57
	44-68	Bt_2	15.80
	68-82	Bt_3	9.83
	82-108	Bc	9.65
		Range	9.65-15.80
		Mean	13.30

organic carbon losses in the surface layer because of rapid decomposition of native soil organic matter (Seema, 2019). The highest mean TOC values in horticultural land-use systems (arecanut and coconut) compared to other land-use systems might be due to the large amount addition of organic matter in the form of manure, longer residue time in the soil due to fewer soil disturbances, which consequently ends up in the accumulation of higher organic carbon in these soils (Ashura, 2016). The results of the present study corroborate with Manna *et al.,* (2006).

The highest mean value of TIC was observed in maize land-use system (0.72 g kg^{-1}) which is followed by coconut land-use system (0.62 g kg^{-1}) and the lowest value was in fallow land-use system (0.23 g kg^{-1}). In all land-use systems, TIC content decreased with an increase in depth. Among the different land-use systems agricultural land-use recorded significantly higher TIC values when compared to other land-use systems may be due to the presence of inorganic carbon mainly in the form of $CaCO_3$ (Seema, 2019).

The highest mean value of TC was observed in arecanut land-use system (25.72 g kg^{-1}) which is followed by coconut land-use system (21.85 g kg^{-1}) and the lowest value was in maize land-use system (17.17 g kg^{-1}). In all land-use systems TC content is decreased with an increase in depth. The lower TC values were observed under agricultural land use system (ragi, maize) due to the rapid decomposition of native soil organic matter. A similar observation was made by Sainepo *et al.* (2018). The higher TC content in the horticulture system might be due to higher biomass turnover as a result of the higher leaf shedding and diversity of tree species (Seema, 2019). These results are supported by the findings of Syed (2010). Due to the combined effect of leaf biomass and regular application of organic amendments and fertilizer the highest TC was observed under the horticultural system compared to the agricultural system.

The highest mean value of HA content is observed in the areca nut land-use system (4.83) followed by coconut (4.71) and the lowest mean value is observed in fallow land-use system (3.94). Whereas the highest mean value of FA content is recorded in arecanut (5.45) followed by maize (5.23) and the lowest mean value is observed in the fallow land-use system (4.79) respectively. The highest mean value of HA and FA was noticed under the horticultural system and less in the agricultural land use system. Narrower HA: FA ratio of less than one in all the land-use systems suggest that the fulvic acid was relatively more than humic acid. These results suggest that the HA: FA ratio is regulated by the quality of organic matter added (Asha, 2016). Amongst the most labile fractions, fulvic acid predominated, resulting in a HA:FA ratio < 1 for all land uses. The predominance of a higher percentage of fulvic acids, as compared to humic acids, indicated either a slow rate of soil organic matter decomposition or frequent inputs of fresh organic residues. Fulvic acid was effective in discriminating changes in land use, due to its characteristic liability (Guimaraes *et al.,* 2013).

The soil organic carbon of soils varied widely among the different land-use systems the highest mean value of carbon stock potential is observed in the areca nut land use system (19.92 t c ha^{-1}) which is followed by coconut (16.27 t c ha^{-1}) and the lowest mean value was observed in the ragi land-use system (7.68 t c ha^{-1}). The highest carbon stock was recorded at the surface as compared to sub-surface soil depths. Lower carbon stocks under field crops were due to lower soil organic carbon stock which is due to exposure to light and more utilization of nutrients by the crops (Lal and Puget, 2005). The 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 forest land-use systems. Hence, the highest carbon stocks recorded in the horticultural systems compared to the agricultural system.

CONCLUSIONS

The highest carbon sequestration potential was recorded in horticultural land-use systems (areca nut, coconut) as compared to agricultural systems (maize, ragi). These differences were consistent for all fractions of carbon (potassium permanganate oxidizable, cold water extractable, soil microbial biomass, total, Humic acid, and Fulvic acid) and at different depths. Horticultural systems had almost double the amounts of different carbon fractions compared to agricultural systems, hence horticultural land-use systems could be favoured to expedite soil carbon sequestration.

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