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LABILE AND NON LABILE FRACTIONS OF SOIL CARBON UNDER DIFFERENT LAND USES AND DEPTHS IN SOUTH KASHMIR

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ABSTRACT

Soil samples were collected from surface and sub-surface under four lands uses namely agriculture, forest, horticulture and grassland. In case of agriculture and grassland samples were collected from two depths viz. 0-15 and 15-30 cm while as in case of horticulture and forest samples were collected from three depths namely 0-15, 15-30 and 30-45 cm. Soil samples were analyzed for very labile, labile, less labile and non labile carbon.The highest mean values of TOC viz., 106.47 and 90.88 g kg^{-1} at 0-15 and 15-30 cm, respectively were recorded under forestland which were followed by grass land having value of 84.67 and 73.49 g kg^{-1}respectively. Very labile and labile carbon were highest in grassland land use with a value of 16.10 and 5.26g kg^{-1} respectively in 0-15 cm soil depth while as less labile and non labile carbon were highest in case of top layer (0-15 cm) of forest land use with mean values of 7.93 and 78.08g kg^{-1} respectively. It was observed that these forms were in the order; non labile > very labile > less labile > labile under all land uses. In general, a depth-wise decrease in content of both labile carbon fractions and non labile carbon was observed.

INTRODUCTION

Carbon (C) is the fundamental building block of all life on earth and sixth-most abundant element in the universe after hydrogen, helium, oxygen, neon, and nitrogen. Soil organic matter (SOM) and related soil properties are probably the most widely acknowledged indicators of soil quality (Wander and Drinkwater, 2000). The SOM not only affects sustainability of agricultural ecosystems, but also extremely important in maintaining overall quality of environment as soil contains a significant part of global carbon stock: 3.5% compared with up to 1.7% in atmosphere, 8.9% in fossil fuels, 1% in biota and 84.9% in oceans (Lal *et al.,* 1995). Soil organic matter is made up of different pools which vary in their turnover time or rate of decomposition. Soil labile organic C is a soil fraction with turnover time of less than a few years (even less than weeks) as compared to recalcitrant C with a turnover time of several thousand years (Parton *et al.,* 1987). Soil labile organic C as the most active fraction of soil organic C can be readily influenced by disturbance and management (Harison *et al.,* 1993). Organic manures addition increased the amount of labile carbon (Cl) by 54.5-77.3 % as compared to chemical fertilizer applied alone in soil depth 0-10 cm.Sensitivity index (SI) of labile carbon for different treatments showed positive values, which indicates positive impact of the management practices on soil organic matter content and on the soil quality (Rajeev Padbhushan *et al.,* 2015).Therefore, soil labile organic carbon oxidation drives the flux of carbon dioxide (CO_2) between soils and the atmosphere (Zou *et al.,* 2005) and makes a greater contribution to nutrient cycling than stable soil organic C (Whalen *et al.,* 2000). In general, the labile C pool has a greater turnover rate (or shorter mean residence time in soils) of several weeks to months or years compared with more recalcitrant pools (Paul *et al.,* 2001) and therefore, labile C pool is much smaller in size. Many factors, including vegetation soil, and climate, have been known to affect soil organic carbon and labile carbon (Xie *et al.,* 2004).Zhang (2010) reported that soil labile organic carbon contents follow the order: Carex lasiocarpa wetland>Calamagrostis angustifolia wetland>forest land>paddy field>dry farmland. Soil labile organic carbon in Carex lasiocarpa wetland and Calamagrostis angustifolia wetland are also higher than those in other land use types. Though the effect of land uses and soil depth on carbon pools has been studied extensively but there is very less information on a study of the impact of land uses and depth on the labile soil carbon forms. We hypothesized that different land uses and depth could have considerable impact on the labile carbon pool. To test the hypothesis, this experiment was carried out to study the effect of land uses and depth on labile and non labile fractions of carbon.

MATERIALS AND METHODS

Study Area

The study area consists of Southern part of Kashmir which included districts of Anantnag, Kulgam, Shupiyun and Pulwama. All the four districts have temperate climatic conditions with severe winter. The area is surrounded by Pir Panjal mountain range. The average temperature of the region is between -11 to 35ºC. The topography of the area is very undulating.

Soil Sampling and Analysis

Soil samples for analysis from surface and subsurface were collected from four land use systems of South Kashmir

Agriculture } Surface (0-15 cm)
and
Grasslands } Subsurface (15-30 cm)
Horticulture Surface (0-15 cm)
and
Forest Subsurface (15-30 cm and 30-45 cm)

All the soil samples collected were dried in shade, ground to pass through 2 mm sieve and stored in polyethylene bag at a dry place.

After processing soil samples, different fractions of labile carbon were estimated through a modified Walkley and Black method as described by Chan *et al*. (2001) using 12.0 N, 18.0 N and 24 N H_2SO_4 for Very labile C (VLC), labile C (LC), less labile C (LLC) respectively and non-labile C (NLC) fractions were calculated from the differences between these and total organic carbon. Total organic C was estimated by loss of ignition at 450°C (Houba *et al.,* 1995). The data generated were analyzed by using standard statistical procedure followed by Gomez and Gomez (1984).

RESULTS

Total organic carbon (TOC)

The data pertaining to total organic carbon (TOC) are presented in Table 1. The TOC content was having confidence interval of 48.53 to 65.85, 99.25 to 113.69, 48.11 to 63.04 and 75.62 to 93.71 g kg^{-1} of soil with mean values of 57.19, 106.47, 55.57 and 84.67 g kg^{-1} of soil in the surface soils under horticulture, forest, agriculture and grasslands, respectively. The Table infers that the highest mean values of TOC viz., 106.47 and 90.88 g kg^{-1} at 0-15 and 15-30 cm, respectively were recorded under forestland which were followed by grass land having value of 84.67 and 73.49 g kg^{-1} respectively.Similarly confidence interval values at both soil depths were also higher under forest land followed by grassland. At soil depth of 30-45 cm, mean values (79.97 and 72.37 & 87.57 g kg^{-1} respectively) and confidence interval values were higher under forest land than horticultural land. An overall depth wise decreasing trend was observed for total organic carbon in all the land use systems with highest mean observed in the surface soils (0-15 cm). However, for all soil depths the highest TOC was under forest soils followed by soils under grassland, whereas horticulture and agriculture had similar mean TOC.

Very labile carbon (VLC)

Data pertaining to very labile carbon (VLC) under different land uses are presented in Table 2. A decreasing trend with depth was observed for all the land use systems with highest value in the surface layer *i.e.* 0-15 cm. In the surface (0-15 cm) horticulture, forest, agriculture, and grassland soils very labile carbon (VLC) showed a confidence interval of 6.33 to 8.61, 14.54 to 17.10, 5.96 to 9.24 and 11.87 to 18.33 g $kg^{-1}$of soil, respectively. Table exhibited that the highest VLC mean values of 16.10 and 14.39 g kg^{-1} at soil depths of 0-15 and 15-30 cm

Table 1: Confidence interval (95 %) and mean values of total organic carbon (g kg^{-1}) under different land uses and depths

Land use	0-15 cm				15-30 cm				30-45 cm			
	Mean	S.E	95% C.I		Mean	S.E	95% C.I		Mean	S.E	95% C.I	
			Lower	Upper			Lower	Upper			Lower	Upper
Horticulture	57.19	4.17	48.53	65.85	47.55	4.41	38.41	56.70	40.76	4.05	32.30	49.21
Forest	106.47	3.37	99.25	113.69	90.88	3.69	83.29	98.47	79.97	3.68	72.37	87.57
Agriculture	55.57	3.62	48.11	63.04	46.31	3.14	40.01	52.62	-	-	-	-
Grassland	84.67	4.43	75.62	93.71	73.49	4.77	63.43	83.56	-	-	-	-

Table 2: Confidence interval (95 %) and mean values of very labile carbon (g kg^{-1}) under different land uses and depths

Land use	0-15 cm				15-30 cm				30-45 cm			
	Mean	S.E	95% C.I		Mean	S.E	95% C.I		Mean	S.E	95% C.I	
			Lower	Upper			Lower	Upper			Lower	Upper
Horticulture	7.47	0.57	6.33	8.61	6.29	0.53	5.22	7.37	5.14	1.82	4.09	6.19
Forest	15.10	0.84	13.44	16.78	13.39	0.52	12.35	14.43	11.77	0.50	10.72	12.81
Agriculture	7.60	0.81	5.96	9.24	6.52	0.75	5.02	8.02	-	-	-	-
Grassland	15.82	1.21	13.40	18.24	13.44	1.14	11.18	15.72	-	-	-	-

Table 3: Confidence interval (95 %) and mean values of labile carbon (g kg^{-1}) under different land uses and depths

Land use	0-15 cm		15-30 cm		30-45 cm							
	Mean	S.E	95% C.I		Mean	S.E	95% C.I		Mean	S.E	95% C.I	
			Lower	Upper			Lower	Upper			Lower	Upper
Horticulture	4.53	0.59	3.32	5.74	3.51	0.52	2.44	4.58	3.62	0.47	2.65	4.59
Forest	4.65	0.20	4.23	5.08	4.00	0.16	3.66	4.33	3.42	0.19	3.02	3.82
Agriculture	2.79	0.28	2.20	3.39	2.06	0.24	1.57	2.55	-	-	-	-
Grassland	5.26	0.49	4.25	6.27	4.45	0.40	3.64	5.26	-	-	-	-

Table 4: Confidence interval (95 %) and mean values of less labile carbon (g kg^{-1}) under different land uses and depths

Land use	0-15 cm				15-30 cm				30-45 cm			
	Mean	S.E	95% C.I		Mean	S.E	95% C.I		Mean	S.E	95% C.I	
			Lower	Upper			Lower	Upper			Lower	Upper
Horticulture	4.77	0.32	4.11	5.44	4.25	0.43	3.37	5.13	3.36	0.37	2.59	4.14
Forest	7.93	0.25	7.43	8.42	6.80	0.30	6.19	7.42	5.86	0.29	5.25	6.48
Agriculture	5.50	0.65	4.21	6.80	4.52	0.49	3.51	5.52	-	-	-	-
Grassland	6.03	0.64	4.75	7.31	5.15	0.50	4.14	6.16	-	-	-	-

Table 5: Confidence interval (95 %) and mean values of non labile carbon (g kg^{-1}) under different land uses and depths

Land use	0-15 cm				15-30 cm				30-45 cm			
	Mean	S.E	95% C.I		Mean	S.E	95% C.I		Mean	S.E	95% C.I	
			Lower	Upper			Lower	Upper			Lower	Upper
Horticulture	40.41	3.38	33.65	47.18	34.99	2.81	29.12	40.85	28.64	3.17	22.27	35.01
Forest	78.08	2.59	72.44	83.71	66.65	2.72	60.91	72.39	58.92	2.90	52.94	64.90
Agriculture	39.68	2.69	34.11	45.24	33.23	2.42	28.34	38.11	-	-	-	-
Grassland	58.27	2.38	53.48	63.06	47.10	2.96	41.16	53.04	-	-	-	-

were recorded under grassland which were closely followed by forest land use with mean values of 15.42 and 13.43 at 0-15 and 15-30 cm soil depths, respectively. The lowest mean values at 0-15 and 15-30 cm depths were recorded under agriculture land. The confidence interval values (both upper and lower) followed a similar trend as that of mean values. At 30-45 cm depth the mean values under horticulture land were higher over forest land and confidence interval also followed a similar trend.

Labile Carbon (LC)

The range for labile carbon (LC) was 3.32 to 5.74, 4.23 to 5.08, 2.20 to 3.39, and 4.25 to 6.27 g kg^{-1} of soil in horticulture, forestry, agriculture and grassland soils, respectively. A perusal of the data (Table 3) revealed that mean values of LC in grass land at 0-15 and 15-30 cm depth were 5.26 and 4.45 g kg^{-1}, respectively which were higher than other lands. The lowest mean values of LC (2.79 and 2.06 g kg^{-1}) at two depths were recorded under agriculture land. The confidence interval values of LC at 0-15 and 15-30 cm depths were higher in grassland. At 30-45 cm depth both mean and confidence interval values were higher in horticulture land compared to forest land. A decreasing trend in labile carbon content with depth was observed under all land uses with highest value observed in the surface layer.

Less labile carbon (LLC)

Table 4 indicated that mean and confidence interval values of less labile carbon (LLC) at 0-15 and 15-30 cm soil depths of forest land were higher than other lands examined under the present study. The confidence interval for horticulture, forest, agriculture and grassland were 4.11 to 5.44, 7.43 to 8.42, 4.21 to 6.80, and 4.75 to 7.31 g kg^{-1} of soil respectively. The data further revealed that at 30-45 cm soil depth, the mean value of 5.86 g kg^{-1} obtained under the forest land was higher compared to horticulture land. The confidence interval also followed a similar trend. For less labile carbon content, a decreasing trend with depth was observed in all land use systems with highest value observed for surface soils (0-15 cm).

Non labile carbon (NLC)

The data on non -labile carbon (NLC) mean values and confidence interval values of different lands at various soil depths are presented in Table 5. The confidence interval for non labile carbon (NLC) content was 33.65 to 47.18, 72.44 to 83.71, 34.11 to 45.24 and 53.48 to 63.06 g kg^{-1} of soil for horticulture, forest, agriculture and grassland land use systems respectively in the surface (0-15 cm). It was found that the highest mean values of NLC viz., 78.08 and 66.65 g kg^{-1}at 0-15 and 15-30 cm, respectively were recorded under forest land which was followed by grass land with mean values of 58.27 and 47.10 g kg^{-1} of soil respectively. Similarly confidence interval values at both soil depths were also higher under forest land.

At soil depth of 30-45 cm, mean values and confidence interval values (both lower and upper) were higher under forest land than horticulture land. A decrease in NLC from upper to sub-surface layer was observed under all land use system

DISCUSSION

As far as labile fractions are concerned, LC and VLC were highest for grassland and followed by forest, indicating that type of inputs may control the labile fractions of carbon in the soils. The labile pool which turns over relatively rapidly, results from the addition of fresh residues such as plant roots and living organisms, while resistant residues which are physically or chemically protected are slower to turn over. Similar results were also reported by Sreekanth *et al*. (2013) during the study of soil carbon alterations of selectedforests. TOC were highest in surface layer and decreased with depth High TOC in upper layers are because of addition of organic matters in form of leaf litter in forest or manures in case of agriculture soils. In general a depth-wise decrease in content of both labile fractions of carbon (viz. VLC, LLC and LC) and non labile carbon was observed. Belay-Tedla et al.(2009) observed that the labile C fractions generally declined with increase in soil depth. VLC and LLC both were dominant in the surface layers and decreased with depth. Similar results have been obtained by Xia *et al*. (2010). Wang *et al*. (2005) while working on soil organic carbon also reported depth wise decrease in labile carbon fractions.Non labile fraction of organic carbon decreased with depth. The result indicates that the decrease with depth is mainly induced by the labile fractions of carbon due to additions of fresh organic materials at the surface of soils in various forms. The results are in accordance with the results of Nierop and Verstraten (2003). Non labile fraction is the more stable fraction of organic carbon and is also termed as the recalcitrant fraction. The explanation for this trend may be that the LC fractionations are controlled by litter and root inputs from the vegetations, but NLC reflects slower turnover rate with depth in the soil profile (Cheng *et al.*, 2008).

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