Int.J.Curr.Microbiol.App.Sci (2018) *7*(12): 75-83

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 7 Number 12 (2018)**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2018.712.010

Distribution of Forms of Carbon and Carbon Stock in Different Land Management Units of Kanginhal Sub-Watershed in Northern Dry Zone of Karnataka, India

Ragini S. Patil* and P.L. Patil

Department of Soil Science and Agricultural Chemistry, College of Agriculture, Dharwad, University of Agricultural Sciences, Dharwad - 580005, Karnataka, India

**Corresponding author*

Keywords

Land management units, Organic carbon, Water soluble carbon, Active carbon, Inorganic carbon, Total carbon and carbon stock

Article Info

Accepted:
xx November 2018
Available Online:
xx December 2018

A B S T R A C T

A study was undertaken during 2017-18 to identify the distribution of forms of carbon and carbon stock in different land management units (LMUs) of Kanginhal sub-watershed in Gadag district of Karnataka. Horizon-wise soil samples were collected from each LMU and analyzed for organic carbon, water soluble carbon, active carbon, inorganic carbon and total carbon. Organic carbon, water soluble carbon and active carbon were decreased with depth in all the LMUs, whereas inorganic and total carbon did not follow any definite trend. Water soluble carbon and active carbon exhibited significant positive relationship with organic carbon, whereas inorganic and total carbon exhibited significant and positive relationship with $CaCO_3$. Organic, water soluble and active carbon were significantly and positively correlated with each other, whereas inorganic and total carbon was significantly and positively correlated with each other. Highest organic carbon stock was recorded in LMU-5, whereas highest inorganic and total carbon stocks were recorded in LMU-6. Inorganic carbon stock contribution was more to the total carbon stock compared to organic carbon stock.

Introduction

The carbon cycle is a fundamental part of life on earth. Total carbon includes both organic carbon and inorganic carbon (free $CaCO_3$). However, emphasis would be more given to the organic form of carbon because inorganic form is relatively stable and is not influenced by land management practices.

Intensive cropping leads to a decrease in soil organic matter (SOM) content, particularly in arid and semiarid conditions and leads to decline in soil fertility and subsequently soil quality. The SOM not only enhances the soil quality by improving several soil properties related to physical, chemical and biological conditions but also improves environmental quality by reducing atmospheric carbon dioxide (CO_2). Soil organic carbon (SOC) is the amount of carbon stored in the soil is a component of soil organic matter - plant and animal materials in the soil that are in various stages of decay. SOC in soil exists mainly in two pools *viz.*, active and passive pools. Active pool consists of living microorganisms and their products and has short turnover rate. It includes microbial biomass carbon, water soluble carbon, active carbon, water soluble carbohydrates *etc.* and these are sensitive to the management practices. Therefore active pool considered as a good indicator of minor changes in the SOC (Xia *et al.*, 2010). Passive pool is more stable having high turnover rate. Soil inorganic carbon (SIC) exists in soil as primary and secondary carbonates. Primary carbonates are formed from parent material, whereas secondary carbonates are formed from primary carbonates. Secondary carbonates formed when dissolved CO_2 precipitates carbonates and bicarbonates with Ca and Mg.

In rainfed, arid and semiarid regions of India, next to poor rain water management, depletion of nutrients caused by low SOC stock is an important cause of soil degradation resulting in poor soil physical quality, loss of favourable biology and occurrence of multiple nutrient deficiencies resulting in low productivity. Therefore, one of the most important determinants of the present and future condition of farmland (i.e., sustainability) is the management applied to it (Hellkamp *et al.*, 2000). As management decisions are generally made based on the combinations of land attributes, it is important to identify the levels and geographical patterns of biophysical constraints and land degradation potential of the planned area on a spatial and temporal basis. A land management unit (LMU) is defined as: "A homogeneous block of land that responds in a similar way under similar management." LMUs are best assessed using a combination of physical factors (e.g. soil type, slope, aspect), major management factors (e.g. dryland versus irrigated areas, different arable or horticultural crops, dairy effluent disposal areas, *etc.*) and history of previous use and management. Some producers will find that their property has several LMUs while others can treat their entire property as a single LMU. Knowledge about vertical distribution of nutrients in each LMU is useful to know the inherent capacity of soils to supply nutrients. As roots of most of the crop plants go beyond the surface layer and draw part of their nutrient requirements from the sub surface layers of the soil (Sangwan and Singh, 1993). Different cropping systems were followed under different LMUs. After harvesting of crops, different crops add different amount of root biomass to the soil. Therefore, it is necessary to study the amount of carbon added to the soil and carbon stock accumulated in different LMUs.

Materials and Methods

Kanginhal sub-watershed (Gadag taluk, Gadag district) was selected as study area and is located in Northern dry zone of Karnataka between 15°25′-15°30′ N latitudes and 75°41′-75°45′ E longitudes, covering an area of 3693.87 ha, bounded by Lakkundi village in the south, Neeralagi village in the north and Haralapura village in the east and Nagasamudra in the west (Fig. 1). The major parent material in the sub-watershed is weathered schist. The climate of the area is semi-arid or hot tropical and monsoonic type. The maximum temperature during summer was 38.2 °C and the minimum temperature was 14.8 °C in winter. Mean maximum temperature was 32.85 °C and mean minimum temperature was 19.18 °C. The average annual rainfall was 539.8 mm. It was well distributed with southwest monsoon (June to September) bringing 315 mm and northeast monsoon about 121 mm rain during October and November months. About 88 mm of rainfall was also received during the summer months (April-may). Entire sub-watershed is having dark grey to black colour with clay texture. The soil depth is very shallow to very deep and gradient of land was nearly level to very gently slopping. The soils come under moderately eroded and some portion of the soils comes under slight eroded class. The sub-watershed was subjected to the detail of LRI using IRS P6 LISS IV data at 1:7920 scale in Sujala-III project. Soil resources were mapped at soil phase level and identified six LMUs (Fig. 2) (Anon., 2017). From each LMU one series was selected and for each series one representative profile was selected. From each profile horizon-wise samples were collected during 2016 to study the vertical distribution of forms of carbon and carbon stock. The organic carbon content of finely ground (0.2 mm) soil samples was determined by using Walkley and Black's wet oxidation method (Sparks, 1996). The water soluble carbon was determined using the method as described by McGill *et al.,* (1986). In brief, 10 g of soil was shaken for 1 hour with 20 ml of soil, followed by centrifugation (6000 rpm), filtration and titration against standard ferrous sulphate. The 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 with 20 ml of 0.02 *M* $KMnO_4$ for 2 minutes (horizontal shaker-120 rpm), followed by centrifugation and measuring the light absorbance at 550 nm by colorimeter. The inorganic carbon (free calcium carbonate) content of soil samples was determined by rapid acid titration method as described by Piper (2002) and expressed in g kg^{-1}. Total carbon was determined by using CHNS analyzer (Vario EL cube model). Carbon stock for each LMU was calculated by using the formula:

$$C_{stock} = C_{conc} \times BD \times D \times A$$

Where,

C_{stock} → Carbon stock (Mg)
C_{conc} → Carbon content in the soil (g g^{-1})
BD → Bulk density (Mg m^{-3})
D → Depth (m)
A → Area of LMU (m^2)

The experimental results were 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 ranged from 2,300 to 9,000 mg kg^{-1} and it decreased with depth in all the LMUs (Table 1). It might be due to addition of organic materials in the surface soils through litter fall, external applications, *etc.* which generally occurs at the surface. Similar results were also observed by Majumdar (2014) in the soils of Northern transition zone of Karnataka and Sharma *et al.,* (2014) in the foothill Himalayas under different land use systems. The highest organic carbon content was observed in Ap horizon of LMU-5 due to more addition of organic matter through crop residues and roots, as legumes are the main crops and lowest in Ap horizon of LMU-1 due to very shallow depth and poor management practices.

Water soluble carbon is easily degraded by microorganisms and it plays key role in soil formation. The water soluble carbon distribution is similar to the soil organic carbon in all the LMUs. The water soluble carbon values decreased with depth in all the LMUs and it ranged from 12.3 to 54.6 mg kg^{-1} (Table 1). It may be due to decrease in organic carbon content down the depth. Similar results were also observed by Min *et al.,* (2011) in the soils of China, Majumdar (2014) in the soils of Northern transition zone of Karnataka and Sharma *et al.,* (2014) in the foothill Himalayas under different land use systems. The highest water soluble carbon content was observed in Ap horizon of LMU-5 due to the addition of higher organic inputs and lowest in Ap horizon of LMU-1 due to lack of addition of organic manures, crop residues and poor management practices.

The active carbon also called reactive carbon is readily degradable by microorganisms and used as an indicator of change produced by cropping and soil management practices that manipulates SOM content. In different LMUs, active carbon content ranged from 2,810 to 5,090 mg kg^{-1} and decreased with depth due to decrease in organic carbon content, as it is in accordance with organic carbon content.

The active carbon content was highest in Ap horizon of LMU-5 and lowest in Ap horizon of LMU-1 (Table 1).

The inorganic carbon values ranged from 4,200 to 33,960 mg kg^{-1} (Table 1). It increased with depth in LMU-3, LMU-4 and LMU-6. It was due to accumulation of displaced calcium from exchange complex from of upper layers (Barade and Gowaikar, 1965). Higher inorganic carbon in LMU-2 and LMU-3 was restricted to upper horizons. The inorganic carbon content was highest in Bssk horizon of LMU-6 and lowest in Ap horizon of LMU-3. Among the Ap horizons, it was lowest in LMU-3 (4,200 mg kg^{-1}) and highest (19,680 mg kg^{-1}) in LMU-5 and LMU-6.

The total carbon values ranged from 11,600 to 37,060 mg kg^{-1} (Table 1). The total carbon content decreased with depth in LMU-2 and LMU-5, increased in LMU-6 and did not follow any definite trend in LMU-3 and LMU-4. The highest total carbon content was observed in Bssk horizon of LMU-6 and lowest in Ap horizon of LMU-3. Among the Ap horizons, it was highest (28,680 mg kg^{-1}) in LMU-5 and lowest (11,600 mg kg^{-1}) in LMU-3. The distribution of total carbon depends on both organic and inorganic carbon; however, contribution from inorganic carbon was more.

Organic carbon stock ranged from 6 to 112 Mg ha^{-1} and 667 to 2,75,579 Mg per LMU. Inorganic carbon stock ranged from 40 to 544 Mg ha^{-1} and 4,202 to 9,63,076 Mg per LMU.

Fig.1 Location map of the study area

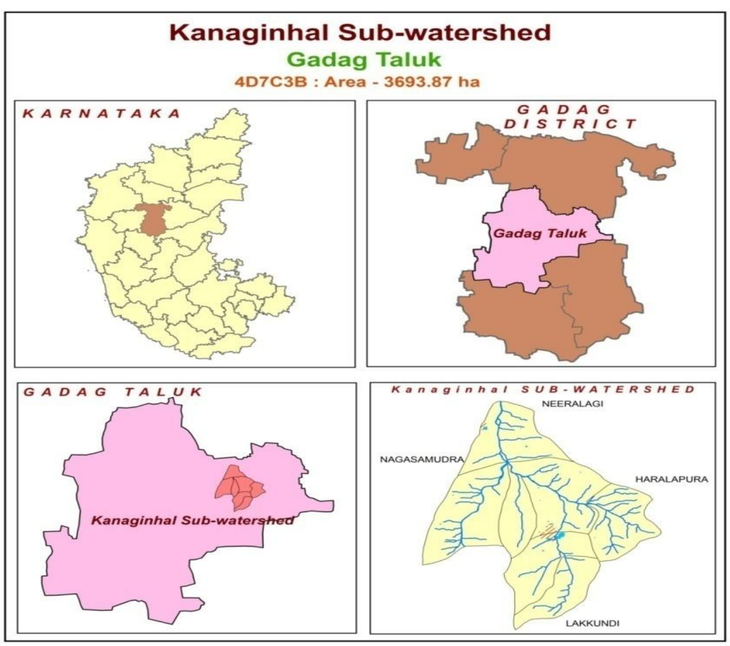

Fig.2 Land management units (LMU) of Kanginhal sub-watershed

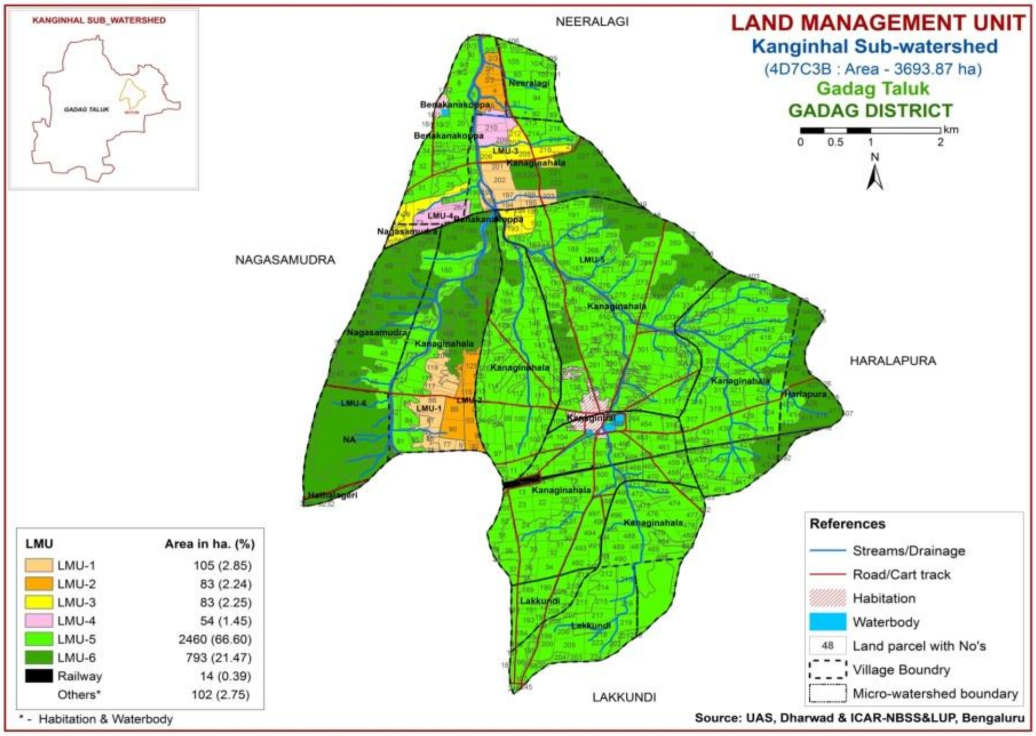

Fig.3 Carbon stock in different LMUs of Kanaginhal sub-watershed

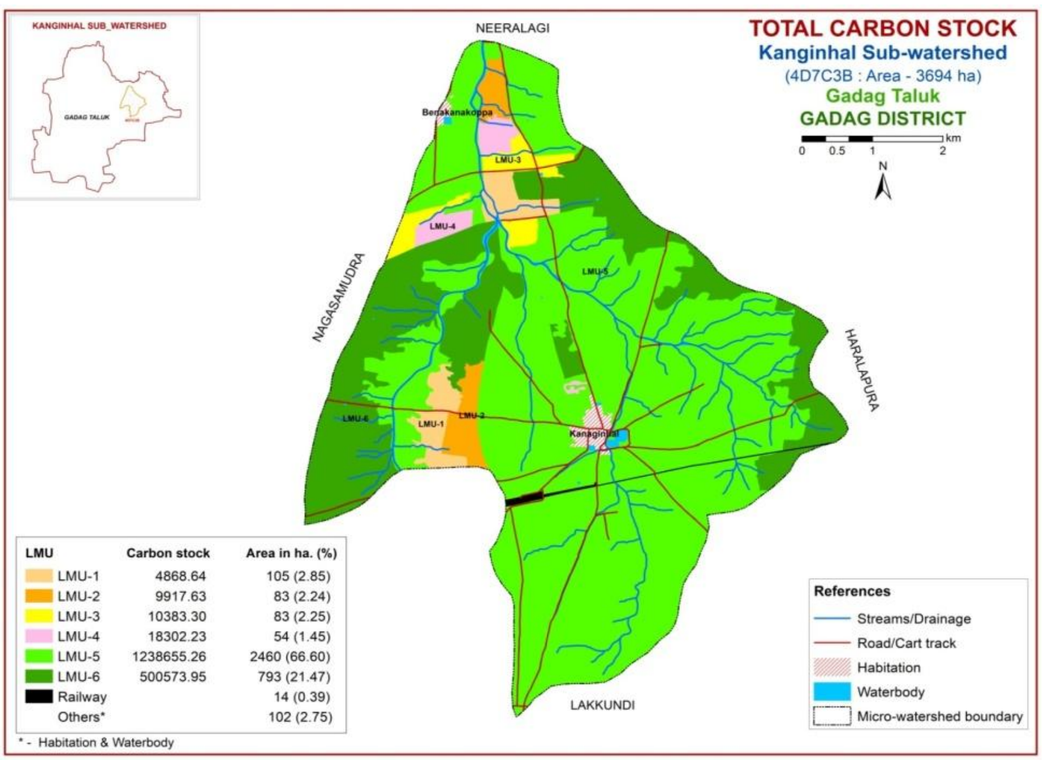

Table.1 Vertical distribution of forms of carbon in different LMUs

LMU	Series	Horizon	Depth (cm)	Organic -C	Water soluble-C	Active-C	Inorganic-C	Total-C
				(mg kg^{1})				
LMU-1	HGK	Ap	0-20	2,300	12.3	2,810	14,520	16,820
LMU-2	NPT	Ap	0-18	4,300	27.0	3,230	15,840	20,140
		Bw	18-46	3,500	20.7	3,030	15,000	18,500
LMU-3	VKP	Ap	0-14	7,400	42.9	4,000	4,200	11,600
		Bw_1	14-39	7,000	39.6	3,910	6,000	13,000
		Bw_2	39-72	6,200	37.8	3,740	6,600	12,800
LMU-4	MVD	Ap	0-19	7,800	45.6	4,210	17,040	24,840
		Bw_1	19-36	7,000	39.0	3,890	17,760	24,760
		Bw_2	36-52	5,800	35.2	3,570	18,240	24,040
		Bw_3	52-76	5,500	33.9	3,490	18,600	24,100
		BCk	76-109	4,300	26.4	3,220	19,680	23,980
LMU-5	NGT	Ap	0-22	9,000	54.6	5,090	19,680	28,680
		Bw	22-62	5,500	34.2	3,500	20,280	25,780
		Bss	62-118	4,700	30.3	3,360	19,680	24,380
		BC	118-154	4,300	27.3	3,250	16,080	20,380
LMU-6	MGR	Ap	0-17	7,400	43.2	4,090	19,680	27,080
		Bw	17-25	6,200	37.2	3,710	23,640	29,840
		Bss	25-98	4,700	30.9	3,410	26,400	31,100
		Bssk	98-152	3,100	15.6	2,900	33,960	37,060

Table.2 Carbon stock in different LMUs of Kanginhal sub-watershed

LMU	Area (ha)	Organic carbon stock	Inorganic carbon stock	Total carbon stock	Organic carbon stock	Inorganic carbon stock	Total carbon stock
		(Mg per ha)			(Mg per LMU)		
LMU-1	105	6	40	46	667	4,202	4,869
LMU-2	83	24	96	119	1,980	7,938	9,918
LMU-3	83	66	59	125	5,494	4,889	10,383
LMU-4	54	84	265	348	4,518	13,784	18,302
LMU-5	2,460	112	391	504	2,75,579	9,63,076	12,38,655
LMU-6	793	87	544	631	69,078	4,31,496	5,00,574

Table.3 Correlation between the forms of carbon and soil properties in different LMUs

	Sand	Silt	Clay	$CaCO_3$	CEC	pH	EC	OC
Organic-C	-0.385	0.154	0.383	-0.306	0.504*	-0.151	0.032	1.000**
Water soluble-C	-0.338	0.119	0.347	-0.291	0.491*	-0.163	0.027	0.988**
Active-C	-0.380	0.183	0.355	-0.235	0.375	-0.132	-0.005	0.965**
Inorganic-C	0.199	-0.540*	0.130	1.000**	0.044	0.466*	0.520*	-0.306
Total-C	0.107	-0.525*	0.239	0.967**	0.181	0.448	0.554*	-0.055

** Correlation is significant at the 0.01 level
* Correlation is significant at the 0.05 level

Table.4 Correlation amongst forms of carbon in different LMUs

	Organic-C	Water soluble-C	Active-C	Inorganic-C	Total-C
Organic-C	1	0.988**	0.965**	-0.306	-0.055
Water soluble-C		1	0.962**	-0.291	-0.042
Active-C			1	-0.235	0.010
Inorganic-C				1	0.967**
Total-C					1

** Correlation is significant at the 0.01 level
* Correlation is significant at the 0.05 level

Total carbon stock ranged from 46 to 631 Mg ha^{-1} and 4,869 to 12,38,655 Mg per LMU (Table 2) (Fig. 3). Organic carbon stock (per ha and per LMU) was lowest in LMU-1 (6 Mg ha^{-1}) and highest in LMU-5 (112 Mg ha^{-1}). Inorganic carbon stock and total carbon stock were lowest in LMU-1 and highest in LMU-6 (Fig. 2). Highest carbon stock related to high carbon content whereas, lowest carbon stock related to shallow depth of the soils (Singh *et al.*, 2007).

Organic, water soluble and active carbon recorded positive correlation with silt and clay and negative correlation with sand, $CaCO_3$ and pH. Organic and water soluble carbon showed positive correlation with EC and significant positive correlation with CEC (r = 0.504* and r = 0.491*, respectively). Active carbon showed positive correlation with CEC and negative correlation with EC (Table 3). Correlations of active carbon fraction to CEC suggest that soil organic matter contributed to increases in soil CEC (Papini *et al.*, 2011). SOC showed a relationship with texture only in the top layer. Fine-textured soil contain one to two fold more soil organic carbon (SOC) (Van Gestel *et al.*, 1991). However, the results were not consistent at different depths.

Inorganic and total carbon had significant and positive correlation with $CaCO_3$ (r = 1.000** and r = 0.967**, respectively). However, inorganic carbon had significant positive correlation with pH (r = 0.466*) whereas, total carbon had positive correlation with pH (Table 3). It clearly indicates that as pH increases $CaCO_3$ content increases.

Water soluble carbon recorded a significant positive correlation with active carbon (r = 0.962**). Similar results were also found by Majumdar and Patil (2017) in the soils of Northern transition zone of Karnataka. Organic and water soluble carbon showed negative correlation with total carbon but active carbon showed positive correlation with total carbon. Inorganic carbon showed negative correlation with organic, water soluble and active carbon and significant positive correlation with total carbon (r = 0.967**) (Table 4).

Water soluble carbon and active carbon showed significant positive relationship with organic carbon (r = 0.988** and r = 0.965**, respectively) (Table 4). It clearly indicates that increase in organic carbon content leads to the increase in water soluble carbon and active carbon content. Similar results were also reported by Sofi *et al.,* (2012) in the soils of Jammu and Kashmir and Majumdar and Patil (2017) in the soils of Northern transition zone of Karnataka.

Water soluble carbon and active carbon were derived from soil organic carbon stocks. These relationships also corroborated the good soil health under different LMUs. Similar results were also reported by Sofi *et al.,* (2012). Inorganic carbon was significantly and positively correlated with total carbon, indicates that inorganic carbon contributed more to the total carbon (Table 4).

From the present study, it can be concluded that, management practices influenced the amount of carbon fractions and carbon stock. Organic, water soluble and active carbon decreased with depth, whereas inorganic and total carbon did not follow any definite trend. Among the pools, inorganic carbon contributed more to the total carbon. Organic, water soluble and active carbon was positively and significantly correlated among themselves and were positively correlated with silt and clay.

However, inorganic and total carbon had shown significant positive correlation among them. Carbon stock was mainly related with carbon content, depth, bulk density and area of the LMU.

Acknowledgement

The study was part of the Sujala-III project funded by World Bank through Government of Karnataka. The authors duly acknowledge the support.

References

Anonymous (2017) *Land resource inventory atlas of Kanginhal sub-watershed, Sujala-III Project*, UAS, Dharwad. pp. 56-59.

Barade, N.K. and Gowaikar, A.S. (1965) Studies on soils of semi-arid regions of North Gujarat. Journal of the Indian Society of Soil Science 13, 43-52.

Blair, G.J., Lofroy, R.D.B. and Lisle, L. (1995) Soil carbon fractions based on their degree of oxidation, and the development of a carbon management index for agricultural systems. Australian Journal of Agriculture Research 46, 1459-1466.

Gomez, K.A. and Gomez, A.A. (1984) *Statistical Procedure for Agricultural Research*. 2nd Edn. John Wiley and Sons, New York. Pp. 639.

Majumdar, S. (2014) Studies on C, N, P and S dynamics under different land use systems of a microwatershed in Northern transition zone of Karnataka. *M. Sc. (Agri.) Thesis*, Univ. Agric. Sci., Dharwad, Karnataka (India).

Majumdar, S. and Patil, P.L. (2017) Carbon dynamics under different land use systems of a micro-watershed in Northern transition zone of Karnataka. Oryza 54, 414-419.

McGill, W.B., Cannon, K.R., Robertson, J.A. and Cook, F.D. (1986) Dynamics of soil microbial biomass and water soluble organic C in Breton L. after 50 years of cropping to two rotations. Canadian Journal of Soil Science 66, 1-9.

Min, Z., Xiao-Ke, Z., Wen-Ju, L., Yong, J., Guan-Hua, D., Xu-Gao, W. and Shi-Jie, H. (2011) Distribution of soil organic carbon fractions along the altitudinal gradient in Changbai mountain, China. Pedosphere 21, 615-620.

Papini, R., Valboa, G., Favilli, F. and Labate, G. (2011) Influence of land use on organic carbon pool and chemical properties of Vertic Cambisols in Central and Southern Italy. Agriculture ecosystems and environment 140, 68-79.

Piper, C.S. (2002) *Soil and Plant Analysis*, Hans Publications, Bombay, India. pp 56-64.

Sangwan, B.S. and Singh, K. (1993) Vertical distribution of Zn, Mn, Cu, and Fe in semi-arid soils of Haryana and their relationships with soil properties. Journal of the Indian Society of Soil Science 41, 463-467.

Sharma, V., Hussain, S., Sharma, K.R. and Arya, V.M. (2014) Labile carbon pools and soil organic carbon stocks in the foothill Himalayas under different land use systems. Geoderma 232, 81-87.

Singh, G. and Sharma, K.N. (2007) Characterization of inorganic soil P forms in soils representing different agro-ecological zones of Punjab. Journal of the Indian Society of Soil Science 55, 209-211.

Sofi, J. A., Rattan, R. K. and Datta, S. P., 2012, Soil organic carbon pools in the apple orchards of Shopian district of Jammu and Kashmir. Journal of the Indian Society of Soil Science 60, 187-197.

Sparks, D.L. (1996) *Methods of Soil Analysis Part-3: Chemical Methods*, Soil Science Society of America, USA. pp 961.

Van Gestel, M., Ladd, J.N. and Amato, M. (1991) Carbon and nitrogen mineralization from two soils of contrasting texture and micro aggregate stability: influence of sequential fumigation, drying and storage. Soil Biology and Biochemistry 23, 313-322.

Weil, R.W., Islam, K.R., Stine, M.A., Gruver, J.B., Susan, E. and Liebig, S. (2003) Estimating active carbon for soil quality assessment: A simplified method for laboratory and field use. American Journal of Alternative Agriculture 18, 3-17.

How to cite this article:

Ragini S. Patil and Patil, P.L. 2018. Distribution of Forms of Carbon and Carbon Stock in Different Land Management Units of Kanginhal Sub-Watershed in Northern Dry Zone of Karnataka, India. *Int.J.Curr.Microbiol.App.Sci.* 7(12): 75-83.
doi: https://doi.org/10.20546/ijcmas.2018.712.010