Sequestration of Soil Organic Carbon Pool under Different Land uses in Bilaspur District of Achanakmar, Chhattisgarh

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Abstract: ***Quality of soil depends on the management practices in response to the different land use systems which may often modify the soil properties and hence improve soil productivity through storage of various nutrients mostly, the soil organic carbon. Appropriate management of soils based on the adequate knowledge of SOC pools is necessary and would help to increase SOC levels for enhanced productivity and sustainability of different land uses. The present study was carried out to estimate soil organic carbon pool under four different land use systems viz. Forest land, Agriculture land, Grassland and Wasteland at three soil depths viz. 0–20, 20–50 and 50-100 cm in Bilaspur District of Achanakmar to know the sequestration potential of SOC pool. The SOC pool generally showed a negative trend with increasing soil depths within and among all land uses. The highest soil organic carbon pool was found in Forestland (166.88 t/ha), followed by Grassland (95.54 t/ha), Agricultural land (75.70 t/ha), and least was recorded in the Wasteland (57.05 t/ha). The overall percentage share of total SOC pools occupied under different land uses found in Achanakmar were: forest land, both dense and open (81%), agricultural land (17%), grassland (01%), and wasteland (01%). The present study reveals that forest land use has a maximum potential in sequestration of soil organic carbon pool compared to other land uses in Achanakmar.***

Keywords: Carbon Sequestration, SOC pool, Land use systems, Achanakmar

1. Introduction

Carbon management through carbon sequestration and its long term storage is a matter of concern and is one of the most important issues of 21st century in India with regard to facing the problems of climate change. Today one of the biggest problem faced by humans beings is climate change associated with higher emission of green house gases like CO_2, CH_4, N_2O, CFC's, HC's causing global warming. Of these gases, CO_2 alone accounts for 60 percent share. One of the most important practical method for sequestration of excess CO_2 from atmosphere and its long term storage is possible by storing it in to a biological system like plant biomass and finally into the soil. In the present scenario there is a growing need and interest in stabilizing the atmospheric CO_2 by developing sustainable management practices of different terrestrial land use systems for reducing the CO_2 emissions or on increasing the carbon sink of different land use systems. According to the IPCC, among the different carbon sinks, soil acts as one of the best option for reducing the atmospheric CO_2 and has recognized soil organic carbon pool as one of the five major carbon pools for the Land Use, Land Use Change in Forestry (LULUCF) (paragraph 21, the annex to draft decision 16/CMP.1) [1]. Soil plays a major role in Global carbon cycle as it is an important pool of active carbon [2,3]. Each ton of soil organic matter build removes about 3.667 tons of CO_2 from the atmosphere [4]. Maximum SOC sequestration in soils of different land use systems is an effective strategy for reducing and removal of atmospheric CO_2 and improving the quality of soil [5, 6].

Among different terrestrial land use system, forest land use system has been recognized as one of the efficient means for reducing the CO_2 emissions as well as enhancing long term storage of carbon in forest soils. Forests are the largest sink of carbon and its role in carbon cycle is well recognized [7,8,9]. Various landuse management practices such as afforestation, reforestation, and natural regeneration of forests, silvicultural systems and agroforestry has gained importance in preserving and restoring the carbon storage [10, 11]. Practice of combined land use system is needed especially under agricultural lands for integrated food production for the large number of people who depend on land for their livelihoods and other environmental services [12,13,14].

The importance of different land uses in mitigating the climate change globally has been highlighted through climate change negotiations. About 10-12% of the total global anthropogenic emissions of GHGs with an estimated non-CO_2 GHG emission of 5120-6116 Mt CO_2 eq/yr in 2005 are accounted alone from agricultural sector [15]. Most often the intensively managed agricultural lands offer many opportunities to improve agronomic practices, nutrient and water management, land use practices to fit the land manager's objectives of carbon sequestration. The global croplands sequester about 0.75-1Pg C/yr and accounts about 50% of the 1.6-1.8 Pg C/yr lost due to deforestation and other agricultural activities [16].

The emphasis should be given to the land use systems which have the higher potential of carbon storage than existing plant community or land use. Significant increase in carbon storage can be achieved by moving from lower biomass land uses to tree based systems such as forests, plantation forests and agroforestry [17]. Combined land use system provides best option to meet the objectives of climate change adaptaion and mitigation.

Knowledge of soils related to SOC pool sequestration and their sustainable management on priority basis is needed to increase the SOC levels for their productivity and sustainability and also to study the likely impact of climate change on soils in the future [18]. In this paper, we set up a study and highlighted the SOC sequestration potential of different land use systems in Bilaspur District of Achanakmar.

2. Material and Methods

Study Area: The study was conducted in Bilaspur District of Achanakmar Amarkantak Biosphere Reserve (AABR). It lies between East longitudes 81°29'02" & 82°27'44" and North latitudes 21°42'40" & 23°06'58" **(Figure 1).** The whole AABR covers an area of 3835.51 sq. km, of which Bilaspur District covers an area of 2476.78 sq. km which is about 68.10% out of the total area. The biosphere reserve provides a very congenial habitat to the diversified vegetation owing to the varied climatic and topographic conditions. The vegetation of the AABR has been classified into Northern Tropical Moist Deciduous and Southern Dry Mixed Deciduous forests. In Northern Tropical Moist Deciduous Forests, Sal is the dominant species followed by mixed forest, teak and Bamboo forest. The BR receives a good rainfall due to typical monsoonal climate with three distinct seasons followed by short post rainy season. The mean daily maximum temperature ranges from 24^0C to 39^0C and mean daily minimum temperature ranges from 10^0C to 25^0C depending upon season. The average annual rainfall varies between 1322 to 1624 mm. A few showers of rain generally occur in every season throughout the year.

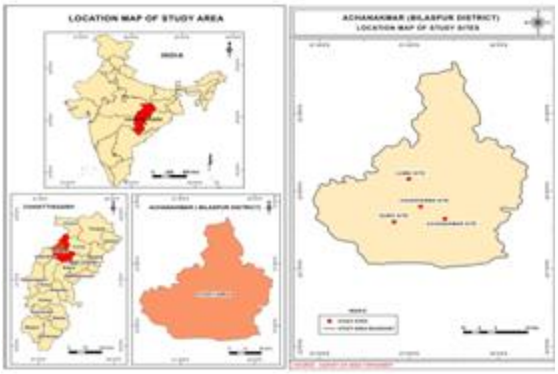


Figure 1: Location Map of Study area and Study sites

For the present study the four different land uses viz. Forest land, Agriculture land, Grassland and Wasteland were selected for the estimation of SOC pools. Soil sampling was carried out at 4 selected sites: Achanakmar, Chhapparwa, Lamni and Surhi shown in **Figure 1**. At each sampling site, 10 soil sampling points (30 x 30cm quardrat) in randomly manner were selected to collect soil samples at three different soil depths of 0-20, 20-50 and 50-100 cm by using a stainless steel cylinder. Roots, stones, and debris removed before sampling. The samples were packed in zip locked polythene bags and were tagged with the geo-morphological information (location of site, elevation, latitude, longitude) using GPS *(Garmin etrex-30).* Each separate soil sample weighing about 1kg collected in the field was returned to the laboratory which was air dried for three to four days. During the analysis of soil samples, a total of 150 soil samples were used for the estimation of SOC and 45 soil samples were used for bulk density estimation of soil. The collected soil samples were air dried for three to four days. Sieving of soil samples was done using the 2mm sized sieve and the fraction smaller than 2 mm size was used for the estimation of SOC. Standard Walkley and Black method [19] was used to determine organic carbon content in soil .The SOC content was calculated as:

% of SOC in soil = (B-S) x 0.003x 1.33x 100/W

Where,

B: Volume of ferrous sulphate solution for blank titration (ml)

S: Volume of ferrous sulphate solution for sample titration (ml)

W: Weight of soil sample (g)

0.003: Milli equivalent wt. of carbon

1.33: Correction factor (100/77)

Bulk density at each site was estimated by standard core method [20] at different soil depths viz. 0-20, 20-50 and 50-100 cm under each land use system. The collected soil samples from the field were brought to the laboratory and oven dried at 60^{o}C till constant weight. The weight of oven dried soil samples was taken and recorded. The weight of oven dried soil samples was divided by its volume to estimate the value of soil bulk density.

The total organic carbon stock (ton/ha) was calculated by following formula;

SOC stock (ton/ha) = soil depth (cm) x bulk density (g cm^{-3}) x C conc. (%) x CFst (1-% stone + % gravel/100).

For determining the total SOC pool under different land use system, the total SOC pool was calculated by multiplying the mean SOC stock in each unit area (ton/ha) by the total area covered by them. Summation of SOC stock in each depth gave the total SOC pool (tons) in each land use system.

3. Results and Discussion

The present study was set up to estimate and compare the SOC pools under different land uses viz. Forest land, Agriculture land, Grassland, and Wasteland in Bilaspur District of Achanakmar. Among different land uses in Achanakmar the dominant land use was found under dense forests which comprises (61%), followed by agricultural land (21%), open and scrub forest vegetation land (10%), grassland (01%), wasteland (01%) and others (06%) **(Figure 2).** Depth wise bulk densities of different land uses were carried out to estimate the SOC pool density variation among different soil depths. The mean bulk density values of dense forest land (0.98, 1.12 and 1.24 g cm^{-3}), Open and Scrub forest (1.01, 1.15 and 1.25), Agricultural land (1.11, 1.19, 1.28 g cm^{-3}), Grassland (1.15, 1.24, and 1.30 g cm^{-3}), Waste land (1.21, 1.28, 1.37 g cm^{-3}) were observed in 0-20, 20-50, 50-100 cm soil depths respectively **(Figure 3).** It shows that bulk density values increased with the increasing depths among all land uses. Generally speaking it was observed that wasteland had a higher bulk density followed by grass land, agricultural land and least bulk density values were found in forest land use systems. This is because the percentage of sand and silt was found higher in the soils of wasteland and grassland as compared to the forest and agricultural lands and lack of organic matter (litter) in the wastelands compared to the forest land.

Based on the findings, a negative trend of SOC was observed with increasing soil depths among all four land uses. The maximum SOC percent was found in top surface layer of 0-20 cm under soils of dense forest land use (2.52%) followed by grassland (1.72%), agricultural land (1.43%), wasteland (0.98%) and least was observed in open and scrub forest land (0.86%). In the middle layer of 20-50 cm it was observed that higher carbon content was exhibited by dense forest land (1.18%) followed by grassland (0.89%), agricultural land (0.73%), open and scrub forest land (0.53%) and wasteland (0.51%). Similarly in the lower, 50-100 cm layer higher carbon content was exhibited by dense forest land (0.51%) followed by grassland (0.39%), agricultural land (0.31%), open and scrub forest land use (0.25%) and wasteland (0.22%) **(Figure 4)**. The highest mean SOC stock found in dense forest land was 49.18, 39.24, and 29.72 (t/ha) followed by grassland having mean SOC stocks of 38.90, 32.66, and 23.98 (t/ha), agricultural land having SOC stock of 31.19, 25.66 and 18.85 (t/ha), wasteland having mean SOC stock of 23.43, 19.12, and 14.50 (t/ha) and least was observed in Open and Scrub forest land use system (18.14, 16.78, and 13.82 (t/ha) at three different soil depths of 0-20, 20-50 and 50-100 cm respectively**.** It shows that higher carbon stock was found at the top surface layer i.e. (0-20 cm depth) followed by decreasing trend at middle depths (20-50cm) and least SOC stock was found at lower depths (50-100 cm) among all land uses **(Figure 5).** The total SOC pool upto 100 cm depth of forest land (both dense and open forest) was highest (166.88 t/ha), followed by Grassland (95.54 t/ha), agricultural land (75.70 t/ha) and least was found in wasteland (57.05 t/ha) **(Figure 6)**. Data revealed that highest SOC stock was found in upper 0-20 cm soil depth, followed by 20-50 cm soil depth and least in 50-100 cm among all land uses. This shows a general trend of decreasing SOC stock from upper to lower soil depths. Similarly, the total SOC pool in tons observed under land use systems were: Forest land, both dense and open forests (1,90,76,556.3 tons), Agricultural land (38,97,157.08), Grassland (1,88,872.7 tons), and Wasteland (2,07,796.73 tons) **(Figure 7).** The findings of the analysis are given in **Table 1**. The overall percentage share of SOC pool exhibited under different land use systems found in Achanakmar were: forestland (81%), agricultural land (17%), grassland (1%) and wasteland (1%) **(Figure 8).**

The soil organic carbon stocks at three different depths under forest land use was much higher as compared to the other land uses, this is because of the highest litter fall and plant residues associated with microbial activities was observed in the forests which shows the interlinkage of forest ecosystems in storage or sequestration of SOC pools compared to other land uses. Since no such past study has been found in that area, our present study is having the relevance to some Indian studies e.g. Venkanna *et al.*, estimated SOC pools in semi-arid tropical region of southern India and found that forest land use system contain highest (87.29 Mg/ha) followed by grassland (60.03 Mg/ha), agricultural land (52.12 Mg/ha to 57.12 Mg/ha), and wasteland (44.81 Mg/ha) [21]. Choudhury *et al.*, estimated SOC pool in soils of North East India and found that forest land contains highest SOC pool followed by grassland, agriculture crop land and wasteland [22].Thus, results of our study are similar and almost in the same trend under different land uses as estimated by these researchers.

4. Conclusion

The present study lead to the conclusion that soils of forest land use has a maximum carbon sequestration potential compared to other land use systems and provide significant mitigation options by managing the forest land use systems on priority basis for increased storage of carbon pool in forest soils.

Table 1: Status of Soil Organic Carbon pool under different land uses

Land Use	Area (ha)	Soil Depth (cm)	SOC (%)	B. D (g cm^{-3})	SOC (ton/ha)	SOC Pool (Tons)
Dense forest	151109	0-20	2.52	0.98	49.18	74,31,540.62
		20-50	1.18	1.12	39.24	59,29,517.15
		50-100	0.51	1.24	29.72	44,90,203.94
Total		0-100			118.14	1,78,51,261.71
Open and Scrub forest	25083	0-20	0.86	1.01	18.14	4,57,880.21
		20-50	0.53	1.15	16.78	4,20,767.33
		50-100	0.25	1.25	13.82	3,46,647.06
Total		0-100			48.74	12,25,294.6
Agriculture/ Cropland	51485	0-20	1.43	1.11	31.19	16,05,817.15
		20-50	0.73	1.19	25.66	13,21,105.1
		50-100	0.31	1.28	18.85	9,70,234.83
Total		0-100			75.70	38,97,157.08
Grassland	1977	0-20	1.72	1.15	38.90	76,905.3
		20-50	0.89	1.24	32.66	64,568.82
		50-100	0.39	1.30	23.98	47,398.58
Total		0-100			95.54	1,88,872.7
Wasteland	3643	0-20	0.98	1.21	23.43	85,355.49
		20-50	0.51	1.28	19.12	69,635.95
		50-100	0.22	1.37	14.50	52,805.29
Total		0-100			57.05	2,07,796.73
Others	14381	-	-		-	-
Overall	2,47,678	-	-	-	-	2,33,70,382.82

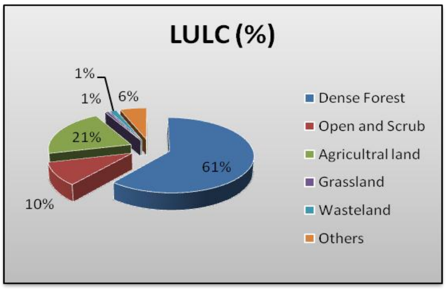


Figure 2: Land use (Study Area) in Percent

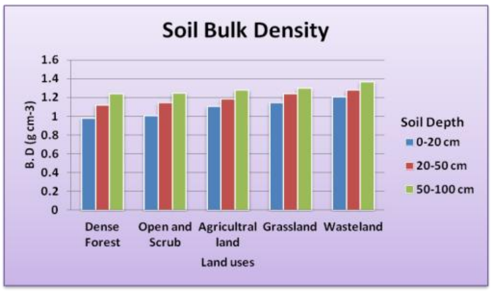
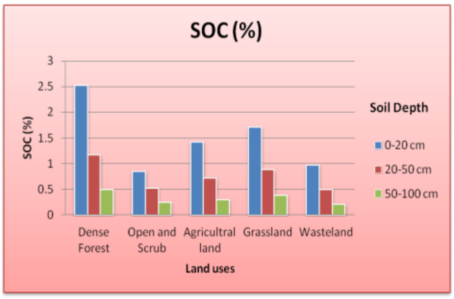


Figure 3: Values of Soil bulk density (g cm^{-3}).



Figuire 4: Values of SOC in Percent.

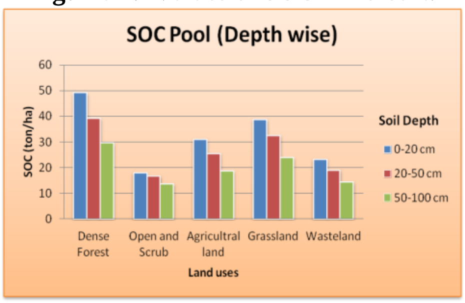


Figure 5: Depth wise SOC Pool (ton/ha)

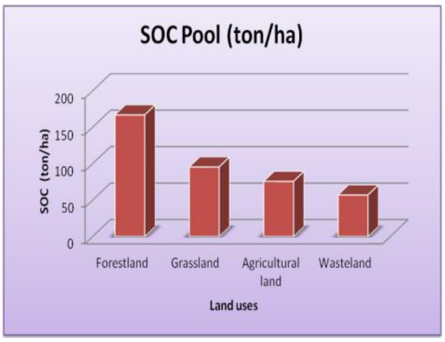


Figure 6: SOC Pool (ton/ha) in land uses.

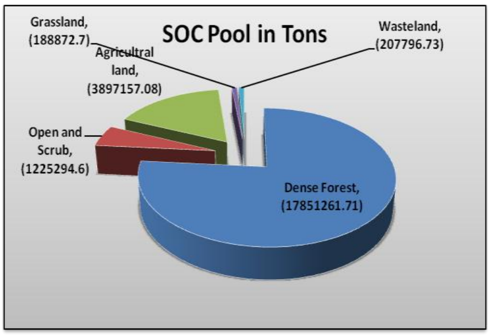


Figure 7: Total SOC Pool (tons) in land uses

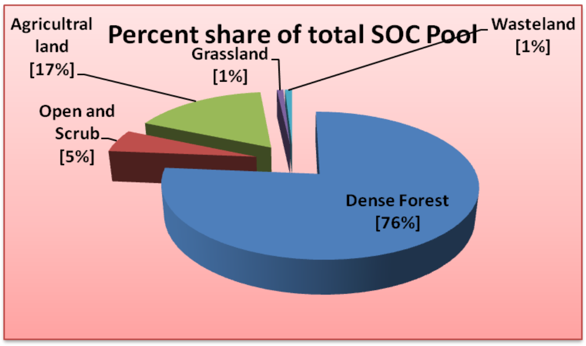


Figure 8: Percent share of total SOC Pool in land uses.

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