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Sequestration of Soil Organic Carbon Pool under Different Natural Forest Vegetation Covers in Achanakmar, Chhattisgarh

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ABSTRACT:

A study was conducted to estimate SOC pools under different different natural forest vegetation covers in Bilaspur District of Achanakmar. SOC pool estimation was studied in soils under five major vegetation covers viz- Sal, Teak, Bamboo, Mixed, Open and Scrub Forests. Soil sampling was carried out randomly in different forest ranges of Bilaspur District of Achanakmar. SOC pool was estimated upto 100 cm depth of soil. Maximum SOC pool (118.18 t ha$^{-1)}$ was found in the soils under mixed forests, followed by soils under Teak forest (76.64 t ha$^{-1)}$, Bamboo forest (67.21 t ha$^{-1)}$, Sal forest (64.28 t ha$^{-1)}$ and least SOC pool under soils of Open and Scrub forest (48.72 t ha$^{-1)}$. The total percentage share of SOC pool occupied on per hectare basis in Bilaspur District of Achanakmar was found highest under Mixed forest, 31.51%, followed by Teak, 20.43%, Bamboo, 17.92%, Sal, 17.14% and least SOC pool, 12.99% under Open and Scrub forest.

***Key Words**: Soil organic carbon pool, Natural forest, Vegetation cover, AABR.*

INTRODUCTION:

The predicted increase of the mean temperature until the end of the 21st century is associated with rising global atmospheric concentrations of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) (IPCC, 2007). From these, CO_2 is the most important one of the anthropogenic greenhouse gases (GHGs), affecting and controlling the earth system globally in a significant way (Heimann & Reichstein, 2008). Changing environmental conditions will strongly influence plant and animal species and may affect the structure of terrestrial ecosystems on earth (Foley *et al.*, 2003). The feedback between the carbon (C) cycle and climate change has recently received much attention whereas knowledge on a better understanding of how soils will respond to changing environmental conditions is needed (Powlson *et al.*, 2010). Hence, it is important to consider that terrestrial ecosystems are able to change and regulate the amount of CO_2 in the atmosphere by sequestration of C in soils and releasing C from soils through respiration. It is assumed that the terrestrial biosphere is a CO_2 sink that counteracts the increasing anthropogenic emissions to some extent. However, there is a calculated imbalance, which suggests that the soils store the supposedly "missing" CO_2. (Schimel, 1995). The uppermost meter of the global SOC pool contains approximately 1500 Pg C; the uppermost two meters contain roughly 2500 Pg C, which is twice the amount stored in the atmosphere and three times the amount stored in vegetation (Jobbagy & Jackson, 2000; Batjes, 2002).

To sustain the quality and productivity information on SOC in terms of its amount and quality is essential. The first comprehensive study on SOC status in Indian soils was conducted by Jenny and Raychaudhri (1960). Further studies in estimating SOC stock was made by Gupta and Roa (1994) who reported SOC stock of 24. 3 Pg ranging from surface to an average depth of 44 to 186 cm using data from 48 soil series. Velayutham *et al*., (2000) made estimates of SOC stocks in soils to varying depths using India wide data sets. Based on average global or regional soil carbon densities estimated in Indian forest soils, it has been calculated that our soil organic carbon pool ranges from 5.4 to 6.7 Pg (Ravindernath *et al.*, 1997; Dadhwal *et al*., 1998). While Chhabra *et al.*, 2003 had estimated that the total soil organic pool in Indian forests in the top 50 cm and top 1 m soil depth were 4.13 and 6.81 Pg, respectively.

Soils can act as either sinks or sources of CO_2 depending on different land use, vegetation cover and management. The accumulation potential of C in soils depends on the size, composition and turnover of its functional soil organic matter associated with different vegetation cover. Consequently, when studying the dynamics of SOC, it is necessary to consider different vegetation covers to estimate SOC pool, their distribution, bioavailability and the mechanisms by which they are stabilized. The present study was undertaken to estimate SOC pool under different natural forest vegetation covers in Bilaspur District of Achankmar, Chhattisgarh.

MATERIAL AND METHODS

Study Area*:*

Achanakmar Amarkantak Biosphere Reserve (AABR) is one of the premium Biosphere reserves of India, located in states of Madhya Pradesh and Chhattisgarh. The AABR is comprised of three districts namely Bilaspur, Annupur and Dindori Districts. The present study was carried out in the part of Bilaspur District. The area Bilaspur District of Achanakmar lies in between 81° to 48' & 82° 24' E longitude and 22° 8' & 23° 7' North latitude. The reserve covers a huge area of 3835.51 sq. km. and it falls in almost northern part of Bio-geographic zone. About 68.10% out of the total area of this reserve lies in the Bilaspur district of Achanakmar Amarkantak Biosphere Reserve. The reserve has the varied topography and climatic conditions which provide congenial habitat for the unique diversity of vegetation. The vegetation of the forest area of the reserve represents tropical deciduous and can be further 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 has typical monsoon climate with three distinctly defined seasons and a short post rainy season. The mean daily maximum temperature ranges from 24^0C to 39^0C and mean daily minimum temperature ranges from 10^0**C** to 25^0**C** depending upon season. A few showers of rain generally occur in every season throughout the year. The average rainfall is 1322 mm to 1624 mm.

***Soil Sampling*:**

Soil sampling was carried out randomly in four different forest ranges (Achanakmar, Chhapparwa, Lamni and Surhi) of Bilaspur forest district in Achanakmar and a total of 75 (5 replicates x 3 soil depths x 5 vegetation covers) soil samples were collected for the estimation of soil organic carbon, bulk density. The soil samples were collected from 0-20 cm, 20-50 cm and 50-100 cm depths by excavating pits of 30cm x 30cm wide and 100cm depth. It was ensured that sampling sites typically represent the whole study area. Latitude, Longitude, and altitude were also recorded at each soil sampling site by GPS (*Garmin etrex 30*).

Laboratory Analysis:

The soil samples were air dried, sieved through 2 mm sieve and the fraction smaller than 2 mm size was used for estimation. For organic carbon estimation the soil was passed through 100 mesh round hole sieve and soil organic carbon was estimated by standard (Walkley and Black, 1934) method. Amount of coarse fragments were estimated in each sample collected from different vegetation covers and deducted from the soil weight to get an accurate soil weight on hectare basis for soil organic carbon calculation. Bulk density at each site was estimated by standard core method (Wilde *et al.*, 1964).All the methods in this study are in accordance with Ravindranath and Ostwald (2008).

Soc pool Estimation*:*

The data for SOC pool was calculated by using the equation as suggested by IPCC (2003) in good practice guidance for LULUCF.

RESULTS AND DISCUSSION:

The SOC Pool under natural forests was estimated and data has been presented in Table1. Maximum SOC pool, 118.18 t ha^{-1} was found in the soils under mixed forests, followed by soils under Teak forest, 76.64 t ha^{-1}, followed by soils under Bamboo forest, 67.21 t ha^{-1}, followed by soils under Sal forest, 64.28 t ha^{-1} and minimum SOC pool under soils of Open and Scrub forest, 48.72 t ha^{-1}. Subset for alpha = 0.05 indicates that the SOC pool under Open and Scrub forests placed in subset‘d’ was not statistically at par with the Sal, Teak, Bamboo, and Mixed forests, except Sal and Bamboo forests represents statistically at par group stands alone in subset ‘a’ whereas Teak and Mixed forests can be placed separately in subset ‘b’ and ‘c’ respectively. (Table 1).

Among the total SOC pool estimated per hectare basis under different forest vegetation covers, Mixed forest has higher SOC pool with 31.51%, followed by Teak, 20.43%, Bamboo, 17.92%, by Sal 17.14% and least SOC pool, 12.99% under Open and Scrub forest.
Results of one-way ANOVA indicate that SOC pool between the different forest vegetation covers was significantly different among a, b, c, and d subsets at 0.05 level (Variance ratio, F = 11.356; P< 0.05). SOC pool under soils of mixed forests and Open and Scrub forests was significantly different from the SOC pool under Sal, Teak, and Bamboo forests. However the SOC pools in the soils under Sal, Teak, and Bamboo were not significantly different from each other. (Table 2).

Mitigation potential was also worked out for soils under different forest covers with respect to Open and Scrub forests which contained the minimum SOC pool among all the forest covers. Maximum mitigation potential was of Mixed (2.43), followed by Teak (1.58), Bamboo (1.38), Sal (1.32), and Open and Scrub (1.0) forest vegetation covers. It indicates that Mixed forest vegetation cover has almost double mitigation and storage potential than other forest vegetation covers in the study area.

SOC pool was higher under Mixed forests as compared to other forest covers .This may be due to the different amount of litter production, litter decomposition, return rate and their rate of decomposition as compared to monocropping systems. The lower SOC pool was found under Open and Scrub forests. This may be due to low litter production in these forests. Thus, higher litter production and higher decomposition rate have an important role in maintaining the SOC pool of the soils.

Table 1. Soil Organic Carbon Pool under Different Natural Forest Vegetation Covers in AABR of Bilaspur Forest Division, Chhattisgarh (Upto 100 cm soil depth)

Serial No.	Vegetation Cover	SOC pool ($t\ ha^{-1}$)	SD	Mitigation Potential (Vegetation Cover wise)	SE
01	Sal	64.28[a]	±39.62	1.32	2.95
02	Teak	76.64[b]	±43.64	1.58	3.50
03	Bamboo	67.21[a]	±57.14	1.38	3.42
04	Mixed Forest	118.18[c]	±46.62	2.43	4.06
05	Open and Scrub	48.72[d]	±32.90	1.00	4.98

Same alphabets represent statistically at par group

Table 2. Statistical Mean Difference on the Basis of CD (LSD)

Serial No.	Vegetation	Mean Difference	p value
01	Sal Vs Teak	12.36*	0.005
02	Sal Vs Bamboo	2.93*	0.004
03	Mixed Forest Vs Sal	53.9*	0.000
04	Sal Vs Open and Scrub	15.56*	0.000
05	Teak Vs Bamboo	9.43*	0.003
06	Mixed Forest Vs Teak	41.54*	0.000
07	Teak Vs Open and Scrub	27.92*	0.000
08	Mixed Forest Vs Bamboo	50.97*	0.000
09	Mixed Forest Vs Open and Scrub	69.46*	0.000

*Mean Difference is significant at the 0.05 level.

CONCLUSION:

The highest SOC sequestration rate was found under soils of Mixed forest (2.43), followed by Teak forest (1.58), Bamboo forest (1.38), Sal forest (1.32), followed by Open and Scrub (1.0) vegetation covers. Thus, Mixed forest vegetation cover has a greater role in sequestration of SOC pool than monocroping system of forest vegetation covers in Achanakmar. SOC pool was found higher under Mixed forests as compared to other forest covers. This may be due to the different amount of litter production and litter as compared to monocropping systems. The lower SOC pool was found under Open and Scrub forests. This may be due to low litter production in these forests. Thus, it has been found that higher litter production and higher decomposition rate have an important role in maintaining the SOC pool of the soils in Achnakmar.

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