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Estimation of SOC Concentration under Different Land use

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Abstract—*Soil organic carbon (SOC) is an important factor determining soil quality. 1115 to 2200 Pg of organic C is stored in terrestrial soils. SOC content varies with soil texture, climate and land use practices. Conversion of forest area to agricultural land use led to an estimated loss of 36 Pg C between 1860 and 1960. The present paper, however, establishes that in the red sandy soil region of India, cultivated land area has higher SOC content, especially in the plough layer, than areas under natural vegetation and/or Eucalyptus plantation. Soil samples were collected from the plough layer of plots under various land use conditions, viz. natural vegetation, cultivation, plantation and barren, in the Irga watershed in Giridih, Jharkhand. SOC was estimated with the help Walkley and Black wet combustion method. ANOVA analysis show significant means difference between cultivated land and other land use types at the 0.05 level. Level of SOC content was found to be similar in plots under Eucalyptus plantation and barren land.*

Keywords*: Land use, soil organic carbon, Walkley and Black method*

1. INTRODUCTION

Soil organic carbon (SOC) comprises a major pool in the global carbon (C) cycle; 1115 to 2200 Pg of organic C is stored in terrestrial soils [1]. Globally, variations in SOC content is brought about by soil texture, climate and land use (LU) practices. It is estimated that conversion of forest area to agricultural land use had led to a loss of 36 Pg C between 1860 and 1960 [2]. However under natural conditions, the red sandy soils of the Eastern plateau and hill region of India are a poor reservoir of SOC [3]. It, therefore, requires an assessment of the impact of varied uses of land on SOC in the tropical areas in particular.

LU brings about changes in the SOC stock mainly in the top 10 to 20 cm of the soil profile [4] or the plough layer, which has a high concentration of SOC due to – high SOM content [5] and low density of SOC [6] in general, and is mostly influenced by tillage operations [7] in cultivated areas. The objective of this paper is, therefore, to estimate SOC content in the plough layer of the red sandy soils under different LU conditions in Irga watershed in Jharkhand, India.

2. STUDY AREA

The Irga watershed is a sub-watershed in the upstream area of the Barakar River basin in the Giridih District of the Jharkhand State, India (Fig. 1). It lies in the tropical sub-humid dry bioclimatic zone experiencing average annual rainfall of 1350 mm with peaks observed in the summer monsoon months of June to September. Average annual temperature is 25^{0}C. It is a part of the Eastern plateau and hill physiographic region of India; maximum and minimum elevations are 382 m and 260 m, respectively. Topography is flat to undulating with 0 to 7.5 percent slope. Soil in the area, broadly classified as Alfisols, is sandy in texture.

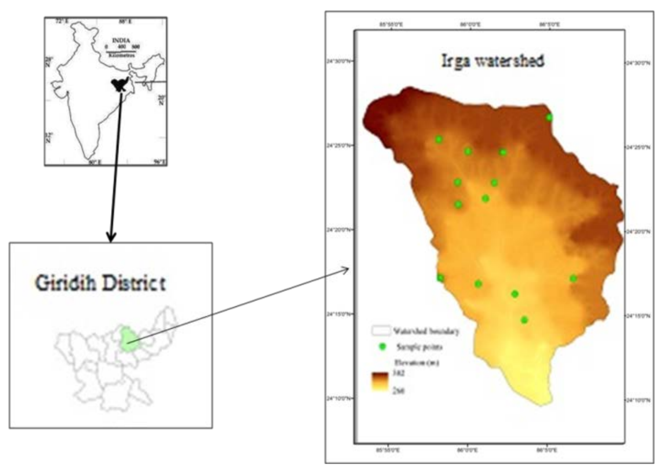

Fig. 1: Location map of Irga watershed, Jharkhand

LU in the area consists of about 37 percent cultivated land, 26 percent forest area, 12 percent area under plantation, and 18 percent barren land (Fig. 2). The agricultural practices primarily include rainfed crop production with traditional plough-based method of seedbed preparation; annual crop of *Aman* paddy is produced and fallow rotation system is practiced; manure from livestock and composting is mainly used with an additional use of chemical fertilizer. In some plots a winter crop, wheat/ maize/ *maruwa*/ vegetables are also grown. Little crop residue is left in the field so as to meet the alternative demands for fodder and fuel for domestic purposes.

3. MATERIALS AND METHOD

Survey of India topographical maps 72 H/15, L/3 and L/4 on a scale of 1:50,000 and Resourcesat-2 LISS III image of 28 December, 2012 for path 105 and row 55 (downloaded from http://bhuvan-noeda.nrsc.gov.in/download/download/download.php) and ground truth data collected during field trips were used for the generation of LULC map of the study area (Fig. 2).

Four broad LU classes were identified as representative of the study area: (1) native vegetation (NV) of the deciduous type – (a) open mixed jungle, (b) *Palash* forest (c) *Sal* forest and (d) mango garden; (2) *Eucalyptus* plantation (PL); (3) cultivated land (CL) – (a) mono-cropped and (b) double-cropped; and (4) barren land (BL). All the sites had a predominant slope of 0 to 2 percent. Triplicate soil samples were collected from 0-20 cm depth of the selected plots during the non-growing phase, i.e. over summer, so as to minimize the influence of plant type and growth stage on SOC.

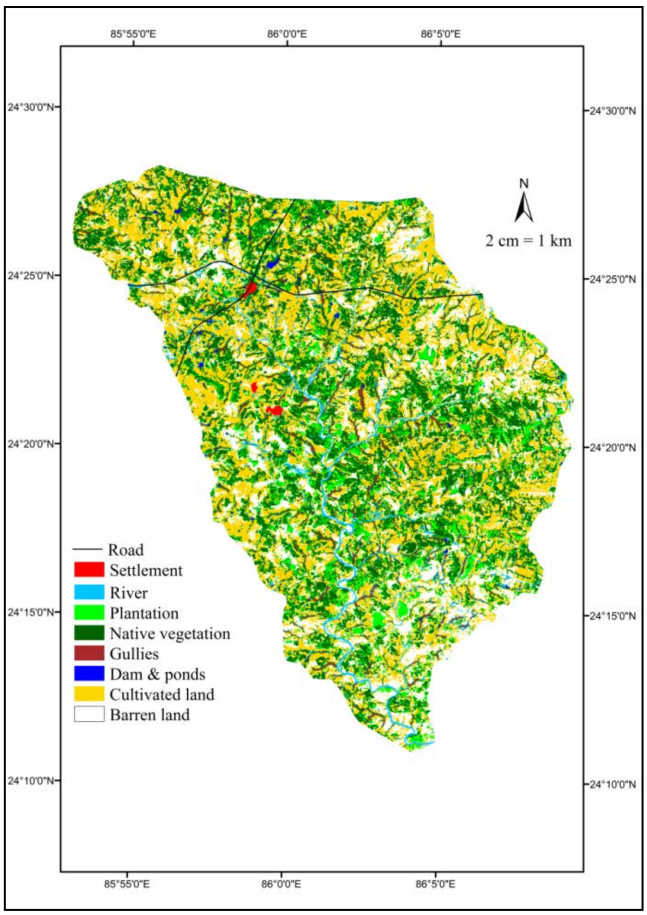

Fig. 2: Land use map of Irga watershed

SOC of the samples were determined by the Walkley and Black (1934) method [8, 9]. SOC content of each sample was calculated using the equation:

$$SOC \text{ (g } 100\text{g}^{-1}) = (V \times (B - S) \times 0.003 \times 100) / (B \times W)$$

where, *SOC* is the content of organic carbon in the soil, V = volume of 1*N* $K_2Cr_2O_7$ solution added, B = blank titre, i.e. volume of 0.5*N* $NH_4.FeSO_4$ used for titration of the volume of 1*N* $K_2Cr_2O_7$ solution, S = sample titre, i.e. volume of 0.5*N* $NH_4.FeSO_4$ used for titration of soil sample + volume of 1*N* $K_2Cr_2O_7$ solution, W = weight of soil sample used for the analysis.

All statistical analyses were done in Origin 8 software.

4. RESULTS

Results of descriptive analysis demonstrated substantial variation in SOC concentration under different LU types in the watershed (Table 1).

Table 1: Descriptive statistics

Land use type	Sample size	Mean	Standard Deviation	SE of Mean
PL	20	0.29	0.05	0.01
NV	20	0.53	0.23	0.05
CL	20	0.72	0.12	0.02
BL	20	0.37	0.13	0.03

Mean SOC content was highest in CL areas (0.72 g $100g^{-1}$) than in the soils under NV (0.53 g $100g^{-1}$), followed by BL (0.37 g $100g^{-1}$); and least in areas under PL (0.29 g $100g^{-1}$) (Fig. 3).

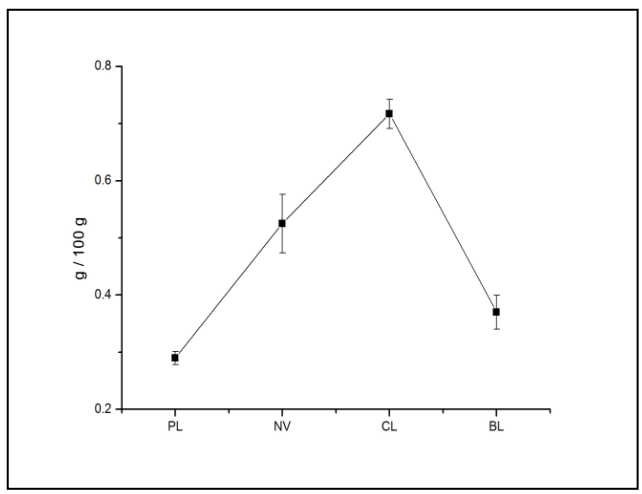

Fig. 3: Mean SOC plot across LU (SE as error)

One-way ANOVA results showed significant difference of population means at the 0.05 level. The Levene's test of homogeneity of variance further showed that population variances are significantly different at 0.05 level.

Turkey's test of means comparison reflected non-significant difference in average SOC content between BL and PL at 0.05

level (Fig. 4). Significant differences were noticeable between CL on one hand and BL, PL and NV on the other. SOC content were significantly different between NV and BL, and NV and PL.

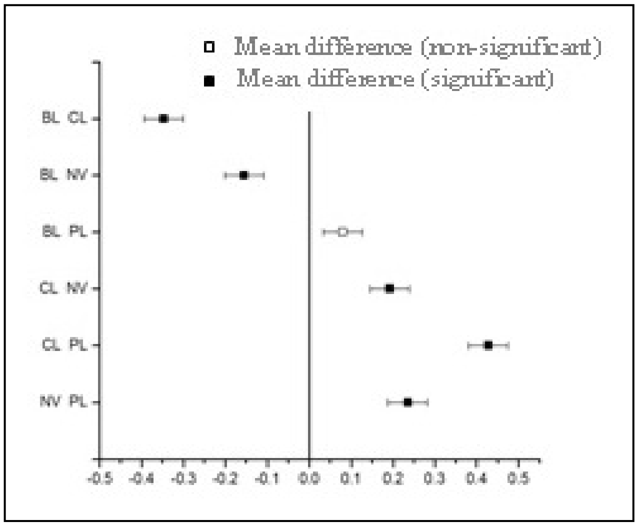

Fig. 4: Means comparison plot

5. DISCUSSION

5.1. SOC Distribution

SOC content in the plough layer of CL areas was higher than in NV area. The forests being a repository of the naturally developed sandy soils in the watershed, recorded lower SOC content.

The higher SOC content in CL was due to the sandy clay loam texture that has been an effect of land [10]; the high concentration of SOC in sand fractions due to the presence of residue-derived particulate organic matter [10-12]; as well as the application of fertilizer [7, 12], especially cow-dung and farmyard manure, and to the poor drainage conditions that are necessarily associated with paddy fields [13]. Moreover, the practice of monoculture in most of the cultivable plots (cultivation of paddy in the monsoons) and keeping the fields fallow with little crop residues after harvesting the monsoon paddy, allowed the soil to retain and regain its fertility. The occasional rainfall in the winter and pre-monsoon seasons allowed the growth of light grass cover in the fallows that added to the SOM and was a source of nutrients, when tilled, to the next year crop.

The areas under *Eucalyptus* plantation recorded the least amount of SOC content; this can be attributed to the lack of adequate surface cover and hence lower incorporation of plant residues to the soil. On the other hand, the presence of permanent grass cover led to a higher SOC content in the mango orchard. Moreover, partial grazing in the orchard area, allowed the incorporation of animal excreta that acts as a bio-fertilizer to the soil.

5.2. Best Practice

The higher SOC content in CL thus show that native SOC levels do not necessarily represent an upper limit of soil C content; C levels in CL exceeded those under native conditions due to fertilization. Moreover, cultivated crops often return more C than virgin vegetation, despite the removal of harvested C [14].

Although CL had a higher SOC content in the plough layer than NV, it is to be noted that SOC concentration will be higher in the latter at greater soil depths: trees have intermediate and shrubs have the deepest root profiles [15]. Of the NV plots, however, mango garden had a high SOC content in the plough layer equivalent to CL. Maintenance of native forests and mango garden should, therefore, a priority in this watershed.

The non-significant difference in SOC content of BL and PL implies that bringing marginal and wastelands under *Eucalyptus* plantation is not at all a good practice in increasing the SOC content and thereby improving the soil quality in the Irga watershed. PL areas, in fact, in some plots have SOC content lower than BL, especially when the latter has a slight grass cover. SOC content can, therefore, be increased by converting BL to permanent pasture and/or planting of trees like mango, than bringing them under *Eucalyptus* plantation. The grass cover will help in reducing soil loss by water erosion unlike the areas under *Eucalyptus* plantation which are devoid of adequate surface cover. It will also provide the required fodder; this will reduce the dependency on crop residues which can, therefore, be left in the cultivated fields as surface cover that will reduce erosion losses and enhance C storage.

6. CONCLUSION

The practice of paddy-fallow rotation and the application of manure have led to an increase in the SOC content in the plough layer of cultured soils in the SOC-poor red sandy soil area of the Irga watershed. For increased food productivity and C sequestration to go hand-in-hand in the sub-humid dry tropical red soils with low SOC content, it is necessary to adopt an integrated watershed development program that includes proper cropping techniques through appropriate soil nutrient management, use of animal manure, proper crop selection, adequate irrigation, leaving post-harvest crop residues in the field, reducing soil erosion through the conversion of barren and degraded land to permanent pastures and planting of trees, like mango, which have economic value and will also provide fodder and fuel to the locals.

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