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## EDAPHIC FACTORS AND SOIL ORGANIC CARBON STORAGE POTENTIALS UNDER DIFFERENT LAND USE TYPES IN OMO BIOSPHERE RESERVES NIGERIA

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### ABSTRACT

*The regulatory functions of the soil are getting attention among scientists and Soil Organic Carbon (SOC) is an important indicator of soil health. A study was carried out to investigate the SOC storage potentials under different land use types (Tectona grandis, Gmelina arborea, Acacia siamea, Pinus carribea, and Natural forest) in Omo Biosphere Reserves Nigeria. The impact of the five important land use types on SOC and other soil properties were analyzed. Soil core samples were taken at two depths (0-10 and 10-30cm) to observe the changes in soil properties with depth. Laboratory analyses were carried out to determine the bulk density, soil pH, soil moisture, and soil organic carbon. The data obtained were analyzed using the Analysis of variance (ANOVA) and Duncan Multiple Range Test (DMRT) was used to separate the means while Principal Component Analysis (PCA) was used to examine the relationship between the soil parameters. Correlation analysis was carried out to examine if a relationship exists between soil depth and different land use on soil organic content and all other soil properties. The result showed that at both depths there is no significant difference between depths in pH, soil organic carbon, and soil moisture except for bulk density. Total Soil Organic Carbon stored in soil was highest in Teak plantation (3.1), followed by Acacia (2.17), and Natural forest (0.92), and at depth SOC was high in 0-10cm depth. The maximum value of bulk density ( $\text{gcm}^3$ ) was found high in 0-10cm at depth and was found high in Teak plantation (1.68) followed by Pinus plantation (1.67) and Acacia plantation (1.53). The distribution of moisture content showed no significant difference but the highest moisture was stored in Natural forest plantation (39.04), followed by Teak plantation (34) and Gmelina plantation (20), and the lowest in Pinus carribea plantation (10). Moisture content across depth showed that 0-10cm depth stored the highest but the 10-30cm depth had the highest pH. Among the land use types, Teak plantation (5.84) had the highest pH, followed by Gmelina plantation (5.4) and Natural forest plantation (5.23). Results showed that SOC storage in soils can be influenced by different land use systems.*

**Keywords:** Soil Organic Carbon, land use, edaphic, plantations, natural forest

### 1.0 INTRODUCTION

Soil Organic Carbon (SOC) is the major terrestrial pool of carbon due to soils carbon storage potential which is generally greater than that of vegetation (Post and Kwon, 2000). Soil Organic Carbon content plays a crucial role in sustaining soil quality, crop production, and environmental quality (Bauer and Black, 1994; Robinson *et al.*, 1994) due to its effects on soil's physical, chemical, and biological properties (Sbih *et al.*, 2012). Cultivation

practices disturb soil's physical properties and release physically protected soil organic matter resulting in the oxidation of soil organic matter and organic carbon content (Christensen, 2001).

According to Milne (2009) Soil Organic Carbon content refers to the carbon component of the soil organic matter. Soil organic matter is all of the organic matter that is found in the soil; by definition all organic material contains carbon. Examples of soil organic matter

include microbial biomass and the decomposing litter layer. Louw (2011) explains that SOC content is measured because it is a convenient way of demining the amount of organic matter found in a particular soil. Soil Organic Carbon is the basis of soil fertility, it releases nutrients for plant growth, promotes the structure, and biological and physical health of the soil, and is a buffer against harmful substances.

In contemporary times, the influence of humans and the agricultural system have been the most significant human activities that have caused massive losses of Soil Organic Carbon although exact quantities are difficult to measure. First was the use of fire which removes soil cover and leads to immediate and continuing losses of soil organic carbon. Eventually, Soil Organic Carbon can be lost as CO<sub>2</sub> or CH<sub>4</sub> emitted back into the atmosphere, eroded with soil material, or dissolved organic carbon washed into rivers and oceans.

Land use affects soil properties, Soil Organic Carbon inclusive and this may either make or mar the productive capacity of the soil and the possibility of retaining organic carbon content. Soil can be a sink or source of atmospheric carbon dioxide depending on land use management with significant losses occurring when native ecosystems are converted for other land uses such as plantation establishment, and agricultural lands (Davidson and Ackerman, 1993). There is therefore, the need to ascertain the effect of different land use types defined by planted forest species on Soil Organic Carbon hence, this study. The objective of this study is to assess Soil Organic Carbon storage potentials and its effect on selected soil properties in *Acacia siamea*, *Gmelina arborea*, *Tectona grandis*, *Pinus caribaea* and natural forest.

## MATERIALS AND METHODS

The study was carried out in Area J4, Ijebu-Ode which is located within Omo Biosphere Reserve, Ogun State. The Reserve is located between latitudes 6°35' to 7°05'N and longitudes 4°19' to 4°40'E in the South-west of Nigeria and covers an area of about 130,500 hectares (Ojo, 2004). The study was carried out on five different land use *Pinus caribaea*,

*Nauclea diderrichii*, *Gmelina arborea*, *Acacia siamea* plantations, and Natural Forest.

## Soil Sample Collection and Analysis

A total of thirty (three replicates/ per soil depth/land-use) soil samples were collected at two different soil depths namely 0-10cm and 10-30cm. with the aid of soil auger. Dry soil bulk density (gcm<sup>3</sup>) at 105°C was estimated by wet oxidation method. Soil pH was measured in 1M KCL suspension of 1:5(soil: liquid) using a pen type digital pH meter. Soil moisture was calculated on dry weight basis and soil temperature for each depth was measured using soil thermometer. Soil analysis was done separately for each sample at each soil depth. The Soil Organic Carbon was calculated

$$\text{Soc} = \text{B} - \text{S} \times 1.995 \dots \text{Eqn (1)}$$

Where

Soc = soil organic carbon

B = blank

S = sample

## Data Analysis

The statistical analysis of the data was conducted using Analysis of Variance (ANOVA) on the General Linear Model of SAS software. Duncan Multiple Range Test (DMRT) was further used to separate the means that were significantly different. Principal Component Analysis was used to examine the relationship between the soil parameters and Correlation analysis was carried out to examine the relationship between soil depth and different land use on Soil Organic Carbon content and all other soil properties.

## RESULTS

Table 1 shows the effect of depth on soil parameters. It shows that at the depths of 0-10 and 10-30cm considered, there is no significant difference between and soil pH (5.25 and 5.27), Soil Organic Carbon (1.74 and 1.09), Moisture content (22 and 15.71), however, bulk density of 1.38 at 0-10cm depth was significantly higher than 1.25 obtained at 10-30cm depth. In the two depths, pH increases from 5.25 at surface (0-10 cm) top to 5.27 at lower 10-30 cm layer) which showed

no significant difference between them. Soil Organic Carbon decreases from top to lower layer and Moisture content decreases with depth from top to lower layer and maximum change was noticed when we compare 0-10cm

**Table 1: Effect of soil depth on soil parameters**

LANDUSE	pH (H <sub>2</sub> O)	SOC/%	MC/%	BD/gcm <sup>3</sup>
	1:2			
0-10cm	5.25	1.74	22.00	1.38
10-30cm	5.27a	1.09a	15.71a	1.25b

Means with the same letter are not significantly different.

BD = Bulk density, SOC = Soil Organic Carbon, MC= Moisture Content

Table 2 shows the effect of land use on soil parameters. There was no significant difference among the various land uses in soil pH, except for *Pinus carribea* (4.57), and the highest was recorded in *Tectona grandis* plantation, followed by *Gmelina arborea*

**Table 2: Effect of land use on soil parameters**

SPP	pH (H <sub>2</sub> O)		SOC/%	MC/%
	1:2	BD/gcm <sup>3</sup>		
<i>Tectona grandis</i>	5.84a	1.68a	3.10a	34a
<i>Gmelina arborea</i>	5.40a	0.73c	0.63b	20a
<i>Acacia siamea</i>	5.30a	1.53a	2.17a	14a
NF	5.23a	0.98b	0.92b	39.04a
<i>Pinus carribea</i>	4.57b	1.67a	0.30b	10a

Means with the same letter are not significantly different.

BD = Bulk density, SOC = Soil Organic Carbon, MC= Moisture Content, NF= Natural forest

Table 3 shows the correlation matrix among the variables. A positive relationship exists between pH and Soil Organic Carbon ( $r = 0.371$ ) but it is not correlated. pH and moisture content ( $-0.05793$ ) negative correlation relationship between them and it is not significant. pH and Bulk density ( $-0.11161$ ), no correlation relationship between them and it is not significant. Soil Organic Carbon and Moisture content ( $-0.08406$ ), no correlation relationship between them and it is not significant. Soil Organic Carbon and Bulk Density ( $0.22749$ ), no correlation relationship between them and it is not significant.

and 10-30cm depth. Moisture content decreases from 22.00 to 15.71 and it showed no significant difference between them. Bulk density increases were significantly higher in 0-10cm depth (1.38) than in 10-30cm (1.25).

(5.4), *Acacia siamea* (5.3), Natural Forest (5.23). The distribution of Moisture Content in the various land uses showed no significant difference among the various land use but was found high in NF (39.04), followed by Teak (34) and *Gmelina* (20). It was found to be lowest in *Pinus carribea*, For Bulk density, there was no significant difference between the various land use types but was highest in Teak (1.68) and was found relatively low in *Gmelina arborea* (0.73). The distribution of Soil Organic Carbon among the various land use showed no significant difference between them but was highest in Teak (3.1) and was lowest in *Pinus carribea* (0.3).

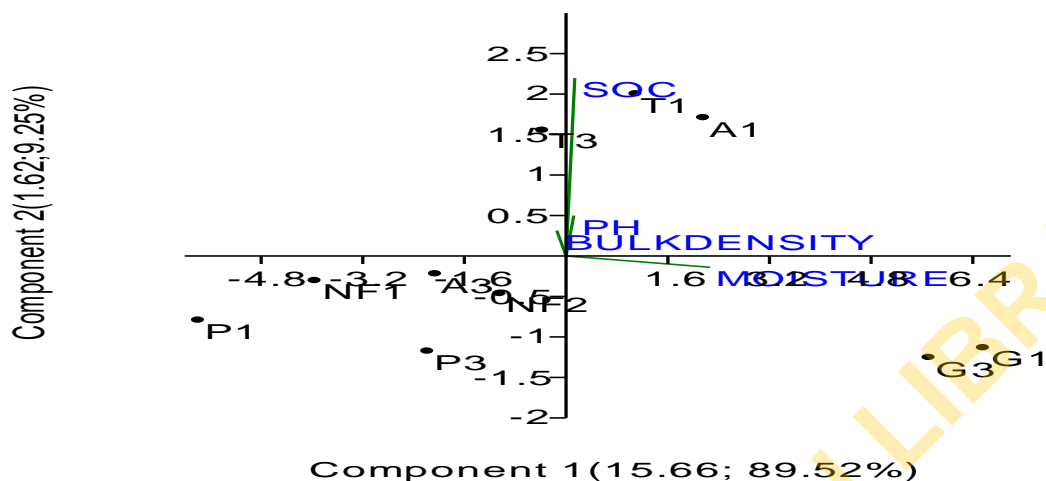
Moisture Content and Bulk Density ( $-0.2305$ ), no correlation relationship between them and it is not significant.

**Table 3: Correlation analysis among soil parameter**

VARIABLES	pH	SOC	MC	BULK
PH	1			
SOC	0.37	1		
MC	-0.02	-0.080	1	
BD	-	-	-	1

**Table 3: Correlation analysis among soil parameter**

PCA generated an eigen value of 15.66 with 89.52% variation for axis 1 and 1.62 with variation of 9.25% for axis 2. PCA recorded a significant variation of some edaphic factors in different depth and the various land use, where *Gmelina arborea* showed maximum moisture content in all the depth. Soil Organic Carbon was found maximum in *Teak* and *Acacia* at 0-10cm depth. The location of *Pinus1* and *Pinus3* in the third quadrat of the component showed low value of Soil Organic Carbon in the two depths.



Principal Component Analysis based on some edaphic factors (Moisture, pH, Soil Organic Carbon and Bulk density) along different depths (0-10cm and 10-30cm) under five land use systems (Natural forest, *Gmelina arborea*, *Pinus carribea*, *Tectona grandis*, *Acacia siamea* in Area j4, Ogun state. P1-pinus 1, P2-pinus 2, G1-Gmelina1, G2- Gmelina2, A1-Acacia1, T1-Teak1.

## DISCUSSION

Soil Organic Carbon shows significant differences among the five land-use systems, and it was highest in the Teak plantation and least quantity was stored in *Pinus carribea* plantation. This reflects the abundance or presence of decomposing liter, significant differences recorded can also be adduced to variations in soil moisture and temperature contents. The low quantity of C stored in *Pinus carribea* plantation could be as a result of continuous cropping or may be the specie are allelopathic in nature. Similarly, Bationo *et al.*, (2007) in a study Soil Organic Carbon dynamics, functions, and management in West African agro-ecosystems reported a rapid decline of SOC levels with continuous cultivation. Similarly, low value of SOC observed in the *Pinus carribea* plantation could

be as a result of the inability of organic manures to act as net carbon sink in forest lands in line with the observation of Schlesinger, (2000).

Water also influences SOC storage through several processes. Since well-aerated, moist soils are optimal for microbial activity, decomposition rates decrease as soils become drier. In contrast, organic matter decay rates are decreased in flooded soils due to restricted aeration, often yielding soils with very high amounts of SOC (e.g., peat and muck soils) (FAO and ITPS, 2015). In these water-saturated soils, other abiotic properties, namely physical properties such as peat depth and bulk density also influence the biological processing of C cycling.

Variation in soil bulk density values (Table 2) could be as a result of compaction resulting from a combination of factors such as; human and animal trafficking, raindrop impacts, and wetting and drying cycles in soil (Anikwe *et al.*, 2003).

According to (Hunt and gikes, 1992) compaction increases bulk density and reduces crop yields and the vegetative cover available to protect soil from erosion. Soils with a higher bulk density than 1.6g/cm<sup>3</sup> tend to restrict root growth. Sandy soils are more prone to high bulk density. It is generally desirable to have soil with a low bulk

density ( $\leq 1.5\text{g/cm}^3$ ) for optimum movement of air and water through the soil. The critical value of bulk density for restricting root growth varies with soil type.

According to (NLWRA 2001; Cresswell and Hamilton, 2002). Bulk density increases with compaction at depth and very compact subsoils or strongly indurated horizons may exceed  $2.0\text{g/cm}^3$ . Bulk density increases with soil depth since subsurface layers are more compacted and less organic matter, less aggregation and less root penetration compared to surface layers, therefore containing less pore spaces. Bulk density values are important for calculating the total quantities of carbon stored at a particular time and soil depth. High bulk density is an indication of low soil porosity resulting from soil compaction.

The percentage of pH in the five land use appears to be strongly acidic except for Teak which is moderately acidic according to the USDA (1993).

According to Paul and Skyl (2012) the accumulation of alkalinity in soil occurs when there is insufficient water flowing through the soils to leach soluble salts. This may be due to arid conditions, or poor internal soil drainage; in these situations, most of the water that enters the soil is transpired or evaporates rather than flowing through the soil. pH increases when the total alkalinity increases. Its influences plant growth by its effect on the activity of beneficial microorganisms. Soil pH is considered a master variable in soils as it affects many chemical processes. It specifically affects plants' nutrient availability by controlling the chemical forms of the different nutrients and influencing the chemical reactions they undergo. The pH of a soil depends on the mineral composition of the parent material of the soil and the weathering reactions undergone by that parent material according to USDA-NRCS (2017). Studies carried out by Van Breemen *et al.*, 1984 and Sparks, Donald (2003) Showed that some factors are responsible for the acidity of the soil. Some of these causes are rainfall, acid rain, fertilizer

use, oxidative weathering, and plant growth. The increase in pH may be due to one of these factors majorly high rainfall.

PCA Analysis suggested that Axis -1 showed that maximum variation and eigen value due to different land use types. A significant difference in edaphic factors along the two soil depths was also controlled by PCA. When pH, BD, SOC, are mainly in quadrat 1 and moisture in quadrat 4 along the positive axis. Moisture content was relatively in G1 and G3. SOC was high in TI, AI and T3. Soil pH and SOC are however in the same direction on this axis. This possibly indicates the influence of soil pH on SOC by regulating microbial activities. (Motavalli *et al.*, 1995, Balkrishan *et al.*, 2016).

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