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# Assessment of impact of land use types on soil organic carbon content in South West, Nigeria

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**Abstract**

The present study attempts to relate the soil organic carbon content with four different land uses (Faculty of Agriculture Teaching and Research farm, cashew plantation and Agricultural and Bioresources experimental farm and oil palm plantation) which come under South west, Nigeria. The objective of the study was to assess the effects of different land uses on soil organic carbon. The sampled soils were collected from different land uses at 0–15 cm (surface), 15 – 30 cm and 30 - 45 cm (sub-surface) depth and were analyzed for soil physical properties with standard procedures. Data were analysed using descriptive statistics and analysis of variance (ANOVA). The results indicated that the oil palm plantation land use recorded the highest mean of soil organic carbon content compared with other land use types at 0 – 15 cm soil depth (23 ±4 g kg-1), which was 1.5, 2.6 and 53.3 % more than in the Faculty of Agriculture Teaching and Research farm land, the cashew plantation land and the Agricultural and Bioresources experimental farm land. This is attributed to more inputs of litter fall and reduced decomposition of organic matter. Similarly, the lowest soil organic carbon content under Agricultural and Bioresorces engineering as compared to others was attributed to reduce of organic matter and frequent tillage which encouraged oxidation of organic matter. The finding indicated that the means of soil organic carbon were significantly different (P < 0.05) between the land use types. Conservation farming should be practiced

*Keywords*: Assessment, Land use type, soil organic carbon, soil properties, south west.



## 1.0 INTRODUCTION

Soil is a thin layer, natural entity comprises of minerals, soil organic matter (SOM), water, and air. It provides a habitat for organisms recycle waste products; serve as an engineering material and a medium for plant growth (Brady and Ray, 2017). Soil organic carbon (SOC) is a complex of organic compounds in the form of soil organic matter (SOM). It represents a key indicator for soil quality, both for agricultural functions and for environmental functions (Dungait et al., 2012, Follett et al., 2012). It components include small (fresh) plant residues, micro-organisms, decomposing (active) organic matter, and stable organic matter (humus) (Lal, 2008). It includes everything both surface and subsurface layers of the soil that undergone biological decomposition irrespective of origin or state of decomposition (Baldock and Skjemstad, 2009). It plays important roles in maintaining soil structure (Bronick and Lal, 2005), improving soil water retention, fostering healthy soil (Wilson et al., 2009), provides fertility for crops (Schmidt et al., 2011), reduces compaction, and reduces surface crusting (Blair et al., 2006a, Powlson et al., 2011). The amount of soil organic carbon (SOC) stored was influenced by several factors including slope length and gradient, climate, vegetation type and stand age, land management and soil properties such as soil type, soil depth, soil texture, pH, bulk density, clay content and current and past land use (Lal, 2002, Leifield et al., 2005, Canadell, 2007, Luyssaert et al., 2008, Smith, 2008, Egli et al., 2009, Baldock and Skjemstad, 2009, Djukic et al., 2010, Follett et al., 2012). In the soil, the rate of decomposition and accumulation of soil organic matter was determined by soil properties such as texture, pH, temperature, aeration, clay mineralogy and soil biological activities (Baldock, 2007, Kell, 2011. Farmers are the primary soil managers who have responsibility to maintain SOM for environmental benefit of the global population (Lal, 2002).

Land use changes, are known to be important drivers for soil redistribution, influencing erosion and sedimentation processes. Many researchers such as Emadi et al. (2008), Khresat et al. (2008), Ceyhum et al. (2009) and Offiong et al. (2009) reported that change of land uses such as long term cultivation, deforestation, urbanization, overgrazing, forest clearing and also conversion of natural forest and plantations caused significant variations in soil properties, terrestrial cycles, soil erosion and lead to a reduction in soil organic matter content. Land use change is the most prominent cause of SOC decline in soils (Van der Werf et al., 2009), affect soil physical and chemical properties (Braimoh and Vlek 2004, Gong et al., 2006, Gol, 2009, Geissen et al., 2009). According to Islam and Weil (2000) and Lal (2002) that SOC storage is greater in forested land than in the cropland and pastures that replace them. Land preparation such as tillage operation from agriculture breaks up the soil aggregates and makes them more susceptible to wind and water erosion and also promotes oxidation of SOC to carbondioxide (Olson et al., 2011). Rodríguez et al. (2009) highlighted that soil organic carbon content can be increased by the following factors: (i) litter production; (ii) litter quality; and physical protection through organic mineral complexes. The main objective of the study was to assess the impacts of the land use types on soil organic carbon content in the South west, Nigeria.

## 2.0 MATERIAL AND METHODS

### 2.1 Description Of The Study Areas

South west, Nigeria is tropical rainforest region and it comprises of six States including Ekiti, Lagos, Ogun, Ondo, Osun and Oyo. The study area has being used as Agricultural development progamme (ADP) for over Third years. For the purpose of this study, four land use types were chosen from ADP and they were designated as Faculty of Agriculture Teaching and Research Farm land, cashew plantation land, Agricultural and Bio Resources Experimental Farm land, and oil palm plantation land (Fig. 1).

### 2.2 The Faculty of Agriculture Teaching and Research Farm land [A]

It occupies the valley bottom of the land. There is presence of common weeds and crops like cassava, vegetables (Amaranthus, Talinum triangulare), maize, and tomatoes. Small farm implements (e.g. cutlass, hoes) used for the continuous agricultural practices were found on the site. The soils are compacted due to grazing of livestock (cattle and sheep) on the field. It fall within longitudes 05o 29.5`E and latitudes 070 48.5`N. Soil temperature around this area was around 24$^{o}$C

### 2.3 The Cashew Plantation Land [B]

It fall within longitudes 05o 29`E and latitudes 070 48`N is a plain land, located at the upper slope and it have elephant grass and termite molds. It also has a shady environment due to the canopy provided by the cashew trees; soil temperature around this area was around 24$^{o}$C

### 2.4 The Agricultural and Bio Resources Experimental Farm land [C]

It fall within longitudes 05o 29.9`E and latitudes 070 48.4`N with slightly sloppy. There are presence of worm cast, and termite molds, and concretions in some part, and weeds present include elephant grass, stubborn grass, and crops like cassava, and vegetables. Tillage Implement were used for the continuous agricultural practices were found on the site. The soils are compacted due to grazing of livestock (cattle and sheep) on the field. It doesn't have a shady environment, due to absence of trees on the farmland, and therefore soil temperature around this area was around 25$^{o}$C

### 2.5 The Oil Palm Plantation Land [D]

It fall within longitudes 05o 29.6`E and latitudes 070 48.4`N with a moderately sloppy, and there are presence of some common weeds like Elephant grass (Sida acuta) and presence of worm casts. Small farm implements (e.g. cutlass, hoes) used for agricultural practices were found on the site. The oil palm plantation land has a shady environment due to the canopy provided by the oil Palm trees; soil temperature around this area was around 22$^{O}$C

### 2.6 Soil Sampling And Laboratory Analysis

The land use types as presented above were selected and they were designated with letters (A, B, C and D). Profile pit was dug for each location. Soils sampled both disturbed and undisturbed were collected from each pit horizon. The soil was sampled from 0 – 45cm at intervals of 25 cm within each selected location. The disturbed soil samples were air dried and ground gently and passed through a 2 mm sieve for analyses of physical and chemical properties. Laboratory analyses were carried out on the samples collected soil profiles. The following properties were determined include bulk density (on the undisturbed soil cores), particle size distribution, soil organic carbon (SOC), soil organic matter (SOM) and soil porosity.

### 2.7 Soil Texture

150g of air-dried finely powered soil was put in a 500 ml of conical flask and 15ml of 0.5N sodium oxalate was added. 200 ml of distilled water was added to the mixture and shaken for 20 minutes. The content was transferred to one litre capacity measuring cylinder and made it up to one litre by adding enough water. Hydrometer (Model p10090) was dipped into the suspension after 5 minutes given direct reading of the percentage of clay and silt. Hydrometer reading after 5 hours of sedimentation gives percentage of clay directly. Hydrometer given the reading in g/l percentage of sand was determined by deducting the percentage of clay and silt from 100. Similarly percentage of Silt was determined by subtracting the hydrometer reading for Clay from clay and Silt (APHA, 2005).

### 2.8 Soil Organic Carbon (SOC) And Soil Organic Matter (SOM)

150g of sieved soils was weighed into 250ml conical flask and 15ml of 1N dipotassium dichromate pentaoxo dichromate (vii) ($K2Cr2O7$) was added, 25ml of concentrated tetraoxo sulphate (vi) acid ($H2SO4$) was also added and mixed, then allowed it to stand to cool down for 30 min and added 200 ml distilled water. The suspension was filtered and 3 drops of indicator was added.

The filtrate was titrated with 0.4 N $(NH_4) SO_4FeSO_4.6H_2O$ (APHA, 2005)

Soil organic carbon (g kg-1) $= \frac{meq of Cr2O7 - meq Fe-NH4-SO4}{weight of sample}$ x 100

Soil organic matter (g kg-1) = Organic Carbon x 1.724

### 2.9 Bulk density (g cm$^{-3}$)

Bulk density was determined by gravimetric method. The samples box was weighed empty, and later weighed with the soil. The sample box was placed in an oven at a temperature of 105°C for 24 h and allowed to cool in a desiccator. The bulk density was determined using the formula given by FAO/IIASA (2008).

Bulk density of soil (g cm$^{-3}$) $= \frac{Mass\ of\ over\ dry\ soil\ (g)}{Volume\ of\ core\ (cm^3)}$

### 2.10 Soil Porosity

Porosity was measured using the core sampler and mathematically expressed as the percentage ratio of the total pore volume to the bulk soil volume (APHA, 2005).

Porosity (%) = $\frac{Total\ pore\ volume}{Bulk\ soil\ volume}$ x100

### 2.11 Data Analysis

The experiment was repeated five (5) times on each sample and analysis of variance (ANOVA) was performed using SPSS (Version 20) where the level of significant difference was found among the experimental data at 95% (0.05) confident level, means separation was performed using Duncan New Multiple's range test (DNMRT)

## 3.0 RESULTS AND DISCUSSION

### 3.1 Soil Particle size/ Textural Class

The soil textural fractions and class is presented in Table 1. The first two highest values of sand fraction were (60.8±3.55, 48.8±2.88) and they occurred in the 15 – 30 and 30 – 45 cm soil depths under University oil palm plantation [D] (Table 1). The lowest mean sand fraction (34.8±3.88) under Department of Agricultural and Bioresources experimental farm [C] compared to other lad use types (Table 1). Similarly, Department of Agricultural and Bioresources experimental farm had the first two highest clay fraction (41.2±2.69, 45.2±3.26,) and they occurred in the 15 – 30 and 30 – 45 cm soil depths (Table 1). While the lowest mean clay fraction (29.2±3.88) under University oil palm plantation. The soil under University cashew plantation [B] has highest silt fraction (27.6±1.0) followed by faculty of agriculture teaching and research farm [A] (24.0±2.0), while University oil palm plantation has the lowest (Table 1). The soil textural fractions of sand, clay and silt ($p<0.05$) showed no significant variation with land use types in the respective soil depth (Table 1). Silty clay loam and slity clay are the most common soil textures in the study areas. Silty clay occurred in the 15 – 30 and 30 – 45 cm as the dominant textural class in all land use types except under University oil palm plantation that textural class was clay loam in the 15 – 30 cm soil depth (table 1). The result revealed that textural class varies with the soil depth. This finding collaborates with Ayoubi et al. (2010) that different land use types with the similar parent material produced variations in soil textures. .

**Table 1** Particle size analysis / textural class

| Sampling Location | Depth (cm) | Sand (%) | Clay (%) | Silt (%) | Textural Class |
|---|---|---|---|---|---|
| Faculty of Agriculture Teaching and Research [A] | 0 – 15 | 44.8 ± 2.34a | 31.2 ± 3.56a | 24 ± 2.0a | Silty Clay Loam |
| | 15 – 30 | 44.8 ± 4.25a | 39.2 ± 4.12a | 16.0 ± 2.0ab | Silty Clay |
| | 30 - 45 | 43.8 ± 3.81a | 38.2 ± 3.76a | 18. 0 ± 1.0ab | Silty Clay |
| University Cashew Plantation [B] | 0 - 15 | 42.6 ± 3.66a | 30.1 ± 3.11a | 27.6 ± 1.0a | Silty Clay Loam |
| | 15 – 30 | 45.2 ± 3.76a | 3.8.8 ± 3.55a | 16.0 ± 2.0ab | Silty Loam |
| | 30 - 45 | 46.7 ±3.88a | 35.8 ± 3.58a | 17.5 ± 2.0ab | Silty Loam |
| Department of Agricultural and Bioresources Engineering [C] | 0 – 15 | 44.8 ± 4.82a | 37.2 ± 3.71a | 18.0 ± 2.0ab | Silty Clay Loam |
| | 15 – 30 | 34.8 ± 3.88ab | 41.2 ± 2.69ab | 24.0 ± 1.0a | Silty Clay |
| | 30 - 45 | 36.8 ± 4.44ab | 45.2 ± 3.26ab | 18.0 ± 2.0ab | Silty Clay |
| University Oil Palm Plantation [D] | 0 – 15 | 42.8 ± 4.22a | 37.2 ±3.86a | 20.0 ± 1.0a | Silty Clay Loam |
| | 15 – 30 | 60.8 ± 3.55b | 29.2 ± 3.88b | 10.0 ± 1.0b | Clay Loam |
| | 30 - 45 | 48.8 ± 2.88a | 31.2 ± 3.64a | 20.0 ± 1.0ab | Silty Clay |

Results represented the mean ± standard deviation values of replicate readings. Values with the same letters are not significantly different (P< 0.05) (vertical comparisons only).

Soil organic carbon and soil organic matter concentration

SOC is directly proportional to SOM. The amount of soil organic carbon content in the particular soil is related to amount of organic matter processed. The relationship between soil organic carbon and soil organic matter and land use types were presented in Figures 1 and 2 respectively. The land use type D has the highest value of SOC concentration (23±3.89), followed by type A (22.54± 4.11) (Table 3). While the lowest SOC concentration (10.69±2.34) under land use type C. The lowest SOC concentration under land use type C could be attributed to reduced inputs of organic matter, continuous cropping, frequent tillage which encouraged oxidation of organic matter. While the highest SOC concentration that occurred under land use type D might be as results of no tillage operation and shady of environment (plant covers) as compared with other land use changes. This result agrees with a study by Rodríguez et al. (2009) that land dominated by tree plants that have providing cover to environment and the organic carbon. The SOC also significantly varied with soil depth in all land use types. This showed that the SOC contents were declined with soil depth by 11.0, 9.8, 32.2 and 9.1 % under land use types A, B, C and D respectively. Analysis of variance performed on the soil organic carbon (Table 2) revealed a significant difference ($p < 0.05$) among the land use types, and also there significant difference within land use types at the same level of significant. The mean SOC concentrations in the surface layers were significantly higher than the sub-surface layers indicative of the concentrations decreased as depth increased. The highest declined in the SOC concentration with soil depth under land use type C could be attributed to continual farm tillage practices and absence of plant covers. Practising conservation farming should be adopted in the areas.

**Table 2** Analysis of variance (ANOVA) on land use types

| Source | Sum of Square | Df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| SST | 95.03 | 3 | 31.68 | 4.72 | 0.23* |
| SSB | 275.51 | 2 | 137.76 | 20.53 | 1.00* |
| SSE | 40.27 | 6 | 6.71 | | |
| A | 992.56 | 2 | 494.28 | 73.96 | 0.10* |
| B | 1123.27 | 2 | 561.64 | 83.70 | 0.10* |
| C | 194.19 | 2 | 97.10 | 14.47 | 0.33* |
| D | 1286.14 | 2 | 643.08 | 95.84 | 0.10* |

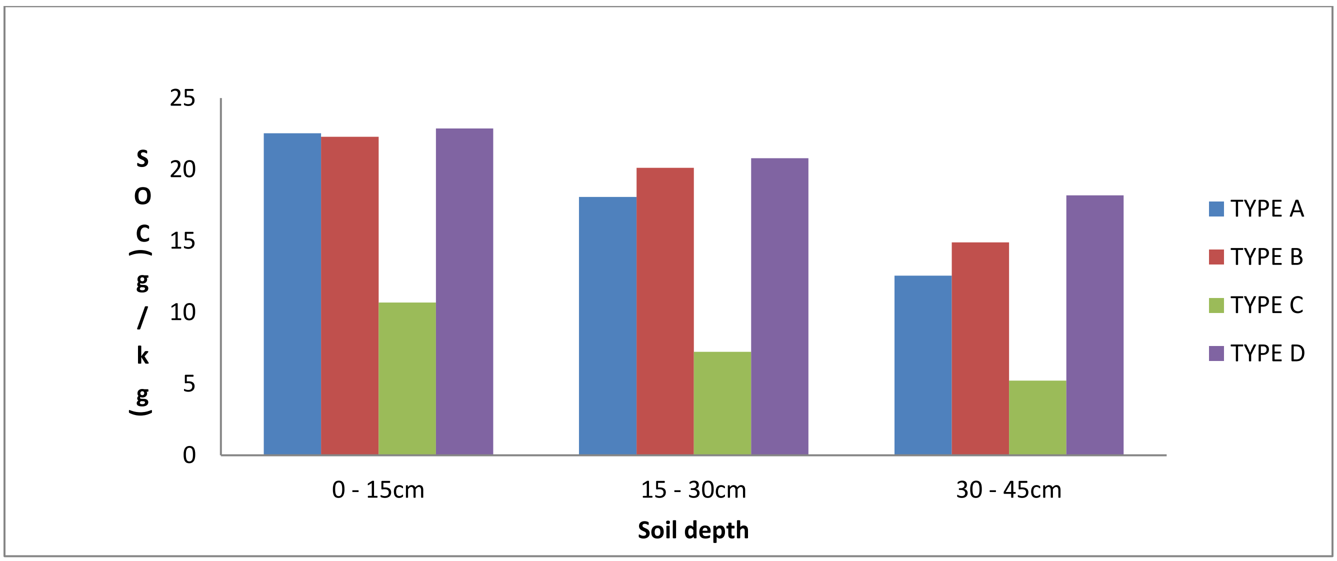


**Figure 1** Graphical representation of the relationship between soil organic carbon and land use types.

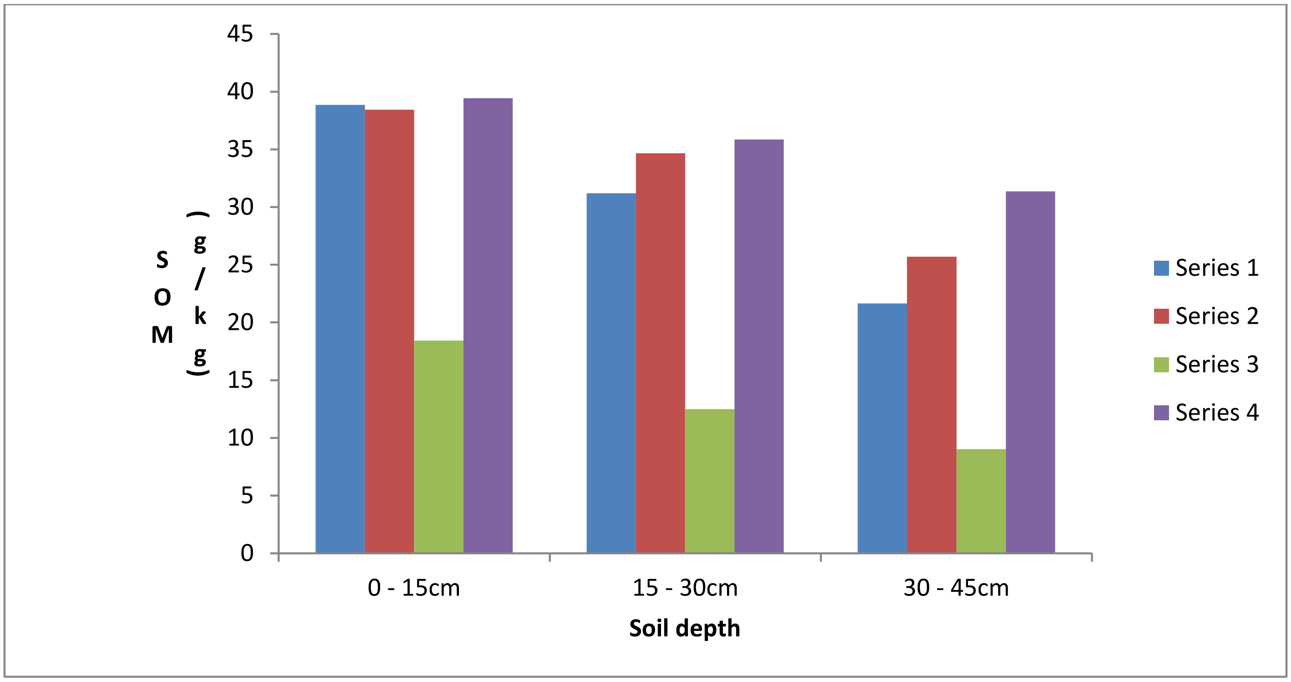


**Figure 2** Graphical representation of the relationship between soil organic matter and land use types

### 3.2 Soil Bulk Density

Figure 3 shows the relationship between soil bulk density and land use types. The highest bulk density occurred in deepest layers and with values under land use type C (1.58±0.04 g cm-3) followed by land use type A (1.56 ±0.03 gcm-3), while the least bulk density under land use type B (1.54±0.03) (Table 3). Similarly, the lowest bulk density occurred in surface layers under land use type D (1.37±0.04) followed by land use type (1.39±0.07). These results indicated that soil bulk density increases with decreases soil organic carbon and porosity (Table 3). The high soil bulk density could be attributed to tillage which resulted to disturb the soil structure, causing a compacted surface soil layer, especially in the department of Agricultural and Bioresources experimental farm (land use type C). This finding revealed that the highest clay content and bulk density occurred sub surface layer under land use type D.

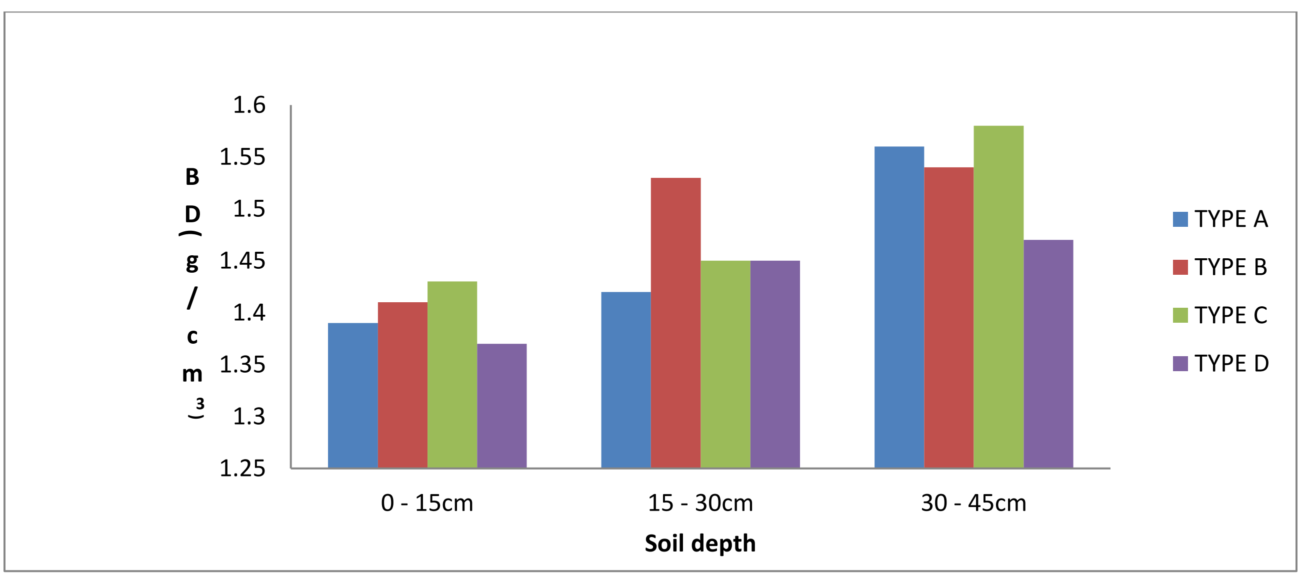


**Figure 3** Graphical representation of the relationship between bulk density and land use types

### 3.3 Soil Porosity

Figure 4 shows the relationship between soil porosity and land use types. The highest occurred in the surface layer and with values under land use type D (50±2.0) followed by land use type A (48±2.0) and the lowest was recorded in the land use type C (10±1.0) (Table 3). The soil porosity decreases with increases in soil depth (Table 3). In summary, the study revealed the effects of both tillage and agricultural practices on farm land. Hence, five indigenous farming practices should be encouraged such as Agroforestry, crop rotations, .mixed-/inter-cropping and polyculture

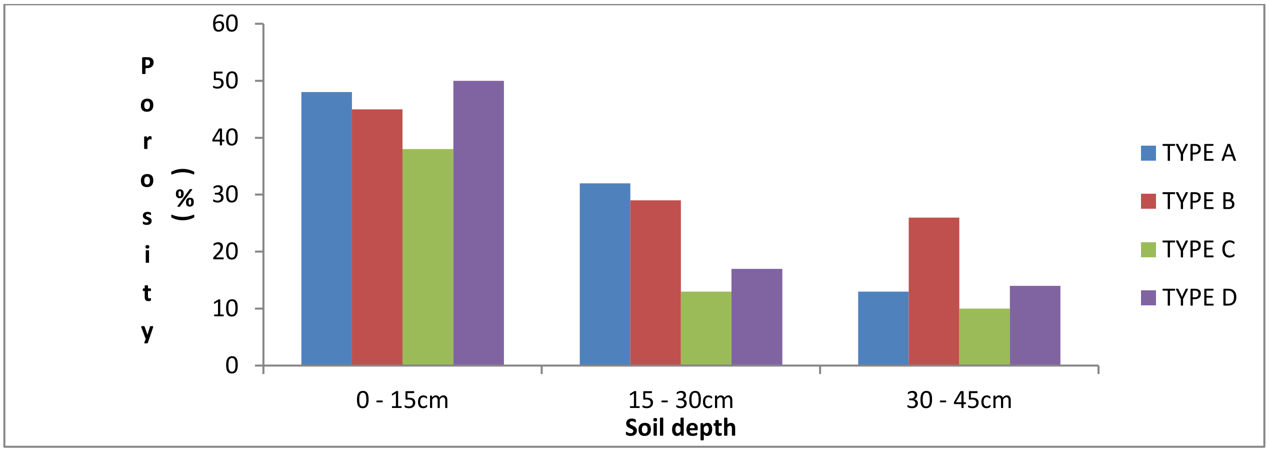


**Figure 4** Graphical representation of the relationship between bulk porosity and land use types

**Table 3** Means soil organic carbon, soil organic matter concentrations and bulk density and porosity in the study areas

| Land use Type | Depth (cm) | SOC (g $Kg^{-1}$) | SOM (g $Kg^{-1}$) | BD (g $cm^{-3}$) | P (%) |
|---|---|---|---|---|---|
| A | 0 – 15 | 23 ± 4a | 39 ± 4a | 1.4 ± 0.1ab | 48 ± 2.0a |
| | 15 – 30 | 18 ± 3a | 31 ± 4a | 1.4 ± 0.1ab | 32 ± 1.0ab |
| | 30 - 45 | 13 ± 5ab | 22 ± 6ab | 1.6 ± 0.0a | 13 ± 1.0b |
| B | 0 – 15 | 22 ± 4a | 38 ± 4a | 1.4 ± 0.1ab | 45 ± 2.0a |
| | 15 – 30 | 20 ± 4a | 35 ± 3a | 1.5 ± 0.0a | 29 ± 1.0ab |
| | 30 - 45 | 15 ± 6ab | 26 ± 3ab | 1.5 ± 0.0a | 26 ± 1.0ab |
| C | 0 – 15 | 11 ± 2ab | 18 ± 3ab | 1.4 ± 0.1ab | 38 ± 2.0ab |
| | 15 – 30 | 7 ± 3b | 13 ± 3a | 1.5 ± 0.0a | 13 ± 1.0b |
| | 30 - 45 | 5 ± 2b | 09 ± 4a | 1.6 ± 0.0a | 10 ± 1.0b |
| D | 0 – 15 | 23 ± 4a | 39 ± 5a | 1.4 ± 0.0ab | 50 ± 2.0a |
| | 15 – 30 | 21 ± 4a | 35 ± 4a | 1.5 ± 0.0a | 17 ± 1.0b |
| | 30 - 45 | 18 ± 3a | 31 ± 3a | 1.5 ± 0.0a | 14 ± 1.0b |

Results represented the mean ± standard deviation values of replicate readings. Values with the same letters are not significantly different ($P < 0.05$) (vertical comparisons only).

KEY

SOC: Soil Organic Carbon
SOM: Soil Organic Matter
BD: Bulk Density

## 6.0 CONCLUSION

The relationship between soil organic carbon and land use types were determined. There are three textural classes (silty clay loam, silty loam and clay loam) observed in the study areas. This finding shows that Land use types have influenced soil organic carbon and other soil properties in the study area. The present study's results reveal that there are variations in soil texture under different land use types with similar parent material. The result revealed that soil organic carbon and other soil properties varies with the soil depth.

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