Ethiopian Journal of Environmental Studies & Management 15(1): 68 – 80, 2022
ISSN:1998-0507 doi: https://ejesm.org/doi/v15i1.7
Submitted: December 4, 2021 Accepted: February 10, 2022

# EVALUATION OF SOME SOIL PHYSICAL PROPERTIES AT IGUZAMA COMMUNITY LAND, OVIA NORTH EAST LOCAL GOVERNMENT AREA, EDO STATE, NIGERIA

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**Abstract**
*This study was carried out to evaluate some soil physical properties at Iguzama community land in Ovia North East local government area of Edo State, Nigeria. Core and routine samples were collected from existing Profiles in an already mapped 115.5 hectares land representatives of the various soil types present in the study area. Standard procedures were used in the determination of bulk density, total porosity and saturated hydraulic conductivity (Ksat). Data obtained were subjected to statistical analysis and presented graphically using bar charts. Results showed that Profiles 1,2,3 and 4 covers 19.35, 18.3, 27.5 and 50.34 hectares respectively. Generally, bulk density increased with depth: Profile 1(19.35 ha) had the lowest bulk density with a mean value of 1.37g/cm$^3$ while Profile 4(50.34 ha) had the highest bulk density with a mean value of 1.55g/cm$^3$. Total porosity decreased with depth across the profiles. Profile 3(27.5 ha) had the highest total porosity with a mean value of 41.75% while Profile 4(50.34 ha) had the lowest total porosity with a mean value of 39.25%. Saturated hydraulic conductivity(Ksat) decreased with depth across the Profiles. Profile 1(19.35 ha) had the highest Ksat with a mean value of 31.80 cm/hr while Profile 4(50.34 ha) had the lowest Ksat with a mean value of 16.20 cm/hr. Profile 1 had the best soil physical properties. In Conclusion, soil physical properties emphasized are within acceptable values for arable and perennial crops in this agroecological zone and would support crop production respecting basic agronomic practices with minimal use of machineries.*

**Key Words:** *Profile, Bulk Density, Porosity, Saturated Hydraulic conductivity (Ksat)*

## Introduction

Soil physical properties have significant influence on the behaviour of soil for Agricultural uses. These properties determine to a large extent the adaptability of the soil to cultivation and the level of biological activities that the soil can support. Das and Agrawal (2009) reported that soil texture and structure determines the total porosity and the size distribution of pores which influences water, heat and air relationships in the soil. Sandy soil, consisting of macro pores, promotes rapid exchange of gases but the reduction in the volume of macro pores upon compaction by human induced practices has led to an

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increase in carbon dioxide ($CO_2$) and decrease in oxygen ($O_2$) in soil which in turn affects the roots of plants because oxygen is required for respiration (Brady and Weil, 2002). Soil compaction which results from mechanical impedance is affected by texture, moisture content, soil depth, bulk density and tillage (Chokor, 1982). Bulk density has been reported by Busari *et al.* (2012) to increase with increasing soil depth because of influence of soil organic matter which was higher in upper horizon than lower horizons

The conversion of native forests and pasture lands to cultivation is usually accompanied by a decline in soil organic carbon, which changes the distribution and stability of soil aggregates and thereby making the soils more susceptible to erosion. When this crop land is reconverted to forest land, the amount of carbon sequestered in the soil will be increased, thereby making the soil more fertile (Brady and Weil, 2002). Excessive soil compaction is a major form of soil degradation and which reduces air space and porosity of the soil. Peterken (1974) reported that agricultural soils typically become compacted because wheels, tracks or other heavy equipment are applied to the soil surface during cultural operations and which in turns restricts the movement of air through the soil structure and impedes roots penetration and water drainage, and often reduces crop production. Early detection of these impact of compaction in respect to soil penetration would provide early detection of stress on roots growth which may affect crop productivity (Ajayi *et al.,* 2009).

Looking at the current stress on the soil as a natural resource of food security and safety, due emphasis is needed for maintaining soil physical fertility by adding organic materials such as introduction of legumes in crop rotation, adoption of conservation tillage. These would increase the fertility of the soil and cause a drastic increase in plant growth (Foth, 1990). Moreover, human activities like tractorization has been reported to increase bulk density and soil penetrometer resistance and a resulting corresponding decrease in soil moisture retention (Chokor *et al.,* 2018). These human-induced activities are widely carried out by commercial farmers on the soils at Iguzama Community land and has some impact on soil physical properties; hence this study.

## Materials and Methods

### *Study Area*

This study was carried out at Iguzama Community in Ovia North East Local Government area of Edo state, Nigeria, and covered a total land area of 115.5 hectares of land as expressed in Fig. 1. The site is located within latitudes 6.42263 and 6.43012 $^{o}$ N and longitudes 5.47731 and 5.48943$^{o}$ E. The Soil is formed from Coastal Plain sand, a derivative of sedimentary rock that has undergone intense weathering process arising from high rainfall and temperatures.

The study area is young oil palm plantation with Cassava and a portion of old fallows land to examine the effect of such land use types on the Soil physical properties. The arable land is a continuous cultivated land with cassava (*Manihot utilissima*) as the dominant crop (Fig 2). The land is used yearly by farmers. Topographic position of the study area is a flat terrain with slight height differentia.

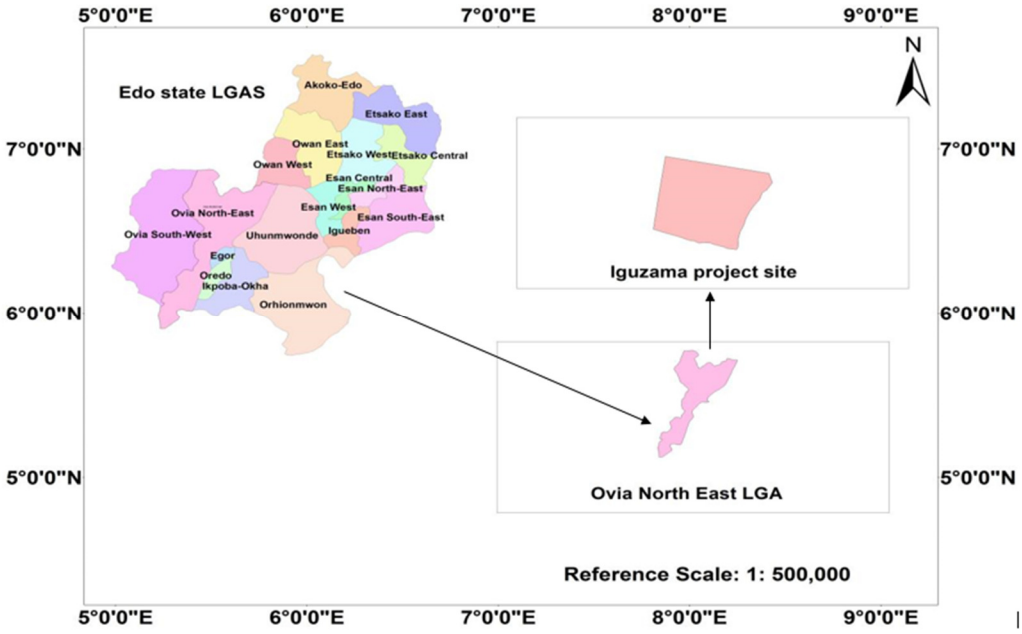


Fig. 1: Iguzama – Location map

Plate 1: Iguzama – Google map showing vegetation and land use of the study area

***Samples Collection***

The methodology involved collecting core and routine samples from existing Profiles that were representatives of the various soil types present in the community site (Table 1). Using a steel core sampler of 6cm height and 5 cm of diameter, undisturbed soil samples was collected for the determination of bulk density, total porosity and saturated hydraulic conductivity.

Table 1. Profile locations and their coordinates

| Profile | Latitude (N) | Longitude (E) | Elevation (m) | Area extent (ha) | Area coverage (%) |
|---|---|---|---|---|---|
| 1 | 06.42196° N | 005.48272° E | 91 | 19.35 | 16.75 |
| 2 | 06.42532 ° N | 005.48017 ° E | 96 | 18.35 | 15.88 |
| 3 | 06.4300 ° N | 005.47970 ° E | 99 | 27.5 | 23.8 |
| 4 | 06.42791 ° N | 005.48844 ° E | 102 | 50.34 | 43.57 |

***Sample Analysis***

The soil samples were analyzed at the Soil Science and Land Management Laboratory, Faculty of Agriculture, University of Benin. Soils samples collected from each horizon from the profile pits, were air-dried and passed through a 2 mm sieve. The sieved samples were analyzed for some Soil physical properties.

***Particle Size Distribution***

Particle size distribution were determined by hydrometer method (Bouyoucos, 1962) after the removal of organic matter content with hydrogen peroxide and dispersion with sodium hexametaphosphate (International Institute for Tropical Agriculture IITA, 1979).

***Bulk Density***

Bulk density was determined with the undisturbed core sample by the method of Black and Hartge (1986). The soil was oven dried at 105° C to a constant weight. The weight of oven dry soil was recorded and total volume calculated from the height and radius of the soil; afterward the bulk density was calculated as follows;

$$\text{Bulk density} = \frac{\text{mass of oven dried soil(g)}}{\text{volume of bulk soil (cm}^3\text{)}}$$

***Saturated Hydraulic Conductivity (Ksat)***

Saturated hydraulic conductivity (Ksat) was determined by constant head core technique (Reynolds *et al.,* 2002). Volume of water draining out was measured over time period until flow was constant, at which time; the flow rate was determined by the equation:

$$\text{Ksat} = \frac{Q}{AT} \times \frac{L}{\Delta H}$$

Permeability class was according to the soil survey staff (1993).

***Total Porosity***

Total porosity was calculated with core samples using the method of Flint and Flint (2002) as:

$$Total\ porosity = \frac{Volume\ of\ water\ at\ 0kpa}{Volume\ of\ bulk\ soil}\ x\ \frac{100}{1}$$

***Data Analysis***

Data obtained were subjected to statistical analysis and presented graphically with bar charts.

**Results and Discussion**

In evaluating some soil physical properties of 115.5 hecatares at Iguzama community in Edo state, continuous cultivation of crops, high rainfall and temperature were major problems affecting crop productivity. This is because continuous cultivation affects soil structure through retricting root growth and penetration into subsoil. High rainfall on the other hand, causes leaching of nutients that move down the soil profiles and not made available to plants. This situation leads to stunted, drought, stressed plants as a result of restricted water and nutrient uptake which results in reduced crop yields (Lal and Shukla, 2004).

Profile 4 had the highest mean value (1.55 g/cm$^3$) (Fig. 11) for bulk density across the four profiles followed by profile 2 (1.52 g/cm$^3$) (Fig. 5), profile 3

(1.42 g/cm3) (Fig. 8)and profile 1(1.37 g/cm$^3$) (Fig. 1) respectively. These bulk density values are within the range of 1.0-1.7 g/cm$^3$ by Wild (1993) as ideal for agronomic activities for most mineral soils and permit easy penetration of most adventitious roots (Amalu, 2016). In conformity with (Aban and Oriji, 2019) on morphological and physico-chemical properties of soils formed from diverse parent materials in Cross River State Nigeria. Bulk density values varied widely in all the soils studied, ranging from mean value of 1.41 g/cm$^3$ in sandstone to mean value of 1.52 g/cm$^3$ in basalitic rocks.

Profile 3 had the highest mean value (41.75%) (Fig. 9) for total porosity across the four profiles followed by profile 1 (41.25%) (Fig. 3), profile 2 (39.50%) (Fig. 6) and profile 4 (39.25%) (Fig. 12) respectively. According to Brady and Weil (2004) total porosity values varies between 30-60%. Accross the profiles, total porosity was high and is in agreement with low bulk density associated with these soils.

Profile 1 had the highest mean value (31.80 cm/hr) (Fig. 4) for Saturated hydraulic conductivity (Ksat) across the four profiles followed by profile 2 (27.63 cm/hr) (Fig. 7), profile 3 (20.68 cm/hr) (Fig. 10) and profile 4 (16.20 cm/hr) (Fig. 13) respectively. According to Soil Survey Staff (1993) Ksat is <0.025 cm/hr is extremely slow, between 0.025-0.15 cm/hr is very slow, between 0.15-0.51 cm/hr is slow, between 0.51-1.5 cm/hr is moderately slow, between 1.5- 5.1 cm/hr is moderate, between 5.1- 15.0 cm/hr moderately rapid, between 15- 51.0 cm/hr is rapid and > 51.0 cm/hr is very rapid. Across the profiles, saturated hydraulic conductivity (Ksat) is rapid. This is attributed to the high fraction of Sand content associated in this area of Study. This is in arrangement with Brady and Weil (2004) who reported that Sandy soils consist of macropores and Ksat requires macropores in conducting water (Edward, 1992).

## Conclusion

Profile 1 (19.35 ha) was considered to have the best soil physical properties because it has the lowest mean value for bulk density (1.37 g/cm$^3$), highest for Ksat (31.80 cm/hr) while 41.25% for total porosity followed by Profile 3 (27.5 ha) had the highest mean value for total porosity (41.75%), 1.42 g/cm$^3$ for bulk density (1.42 g/cm$^3$) and 20.68 cm/hr for Ksat. Profile 2 (18.35 ha) had mean value for bulk density (1.52 g/cm$^3$), 39.50% for total porosity and 27.63 cm/hr for Ksat. Profile 4 (50.34 ha) had the highest mean value for bulk density (1.55 g/cm$^3$) and lowest for total porosity (39.25%) and Ksat (16.20 cm/hr). Profile 4 (50.34 ha) has the least soil physical properties. Profile 1 has the best physical properties

## Recommendations

The following recommendations should be considered. Based on the findings of this study, Organic farming is encouraged to improve the soil physical properties of the soil. Also, areas with high saturated hydraulic conductivity (Ksat) deep rooted crops are recommended while shallow rooted crops should be cultivated on seasonal basis.

Table 2: Particle size distribution of all profiles

| Profile 1 | | | | | Profile 2 | | | | | Profile 3 | | | | | Profile 4 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Depth (cm) | Clay g/kg | Sand | Silt | TC | Depth | Clay | Sand | Silt | TC | Depth | Clay | Sand | Silt | TC | Depth | Clay | Sand | Silt | TC |
| 0-13 | 64.8 | 895.2 | 40 | S | 0-12 | 44.8 | 915.2 | 40 | S | 0-14 | 44.8 | 915.2 | 40 | S | 0-11 | 74.8 | 875.2 | 50 | S |
| 13-44 | 154.8 | 825.2 | 20 | SL | 12 – 58 | 84.8 | 895.2 | 20 | S | 14-41 | 164.8 | 815.2 | 20 | SL | 11 – 40 | 184.8 | 795.2 | 20 | SL |
| 44-80 | 194.8 | 785.2 | 20 | SL | 58-125 | 234.8 | 755.2 | 10 | SCL | 41-90 | 224.8 | 755.2 | 20 | SCL | 40-91 | 254.8 | 725.2 | 20 | SCL |
| 80-149 | 254.8 | 725.2 | 20 | SCL | 125-174 | 244.8 | 735.2 | 20 | SCL | 90-176 | 224.8 | 755.2 | 20 | SCL | 91-136 | 264.8 | 705.2 | 30 | SCL |
| Mean→ | 167.3 | 807.7 | 25 | | Mean→ | 152.3 | 825.2 | 22.5 | | Mean→ | 164.8 | 810.2 | 25 | | Mean→ | 194.8 | 775.2 | 30 | |
| SE | 398.7 | 356.8 | 05 | | SE | 512.1 | 46.55 | 06.29 | | SE | 42.43 | 37.75 | 05 | | SE | 43.78 | 38.51 | 07.07 | |
| CV | 04.77 | 008.8 | 04 | | CV | 067.3 | 01.13 | 0559 | | CV | 05.15 | 00.93 | 04 | | CV | 04.49 | 00.99 | 04.71 | |

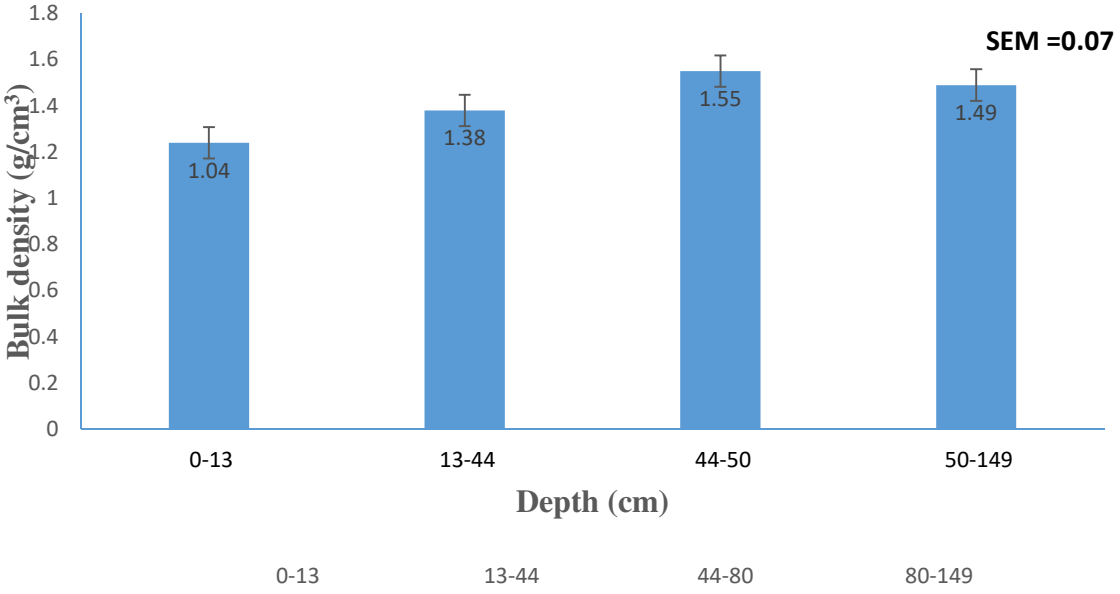


Fig. 2 : Graph Showing Bulk Density with Depths in Profile 1

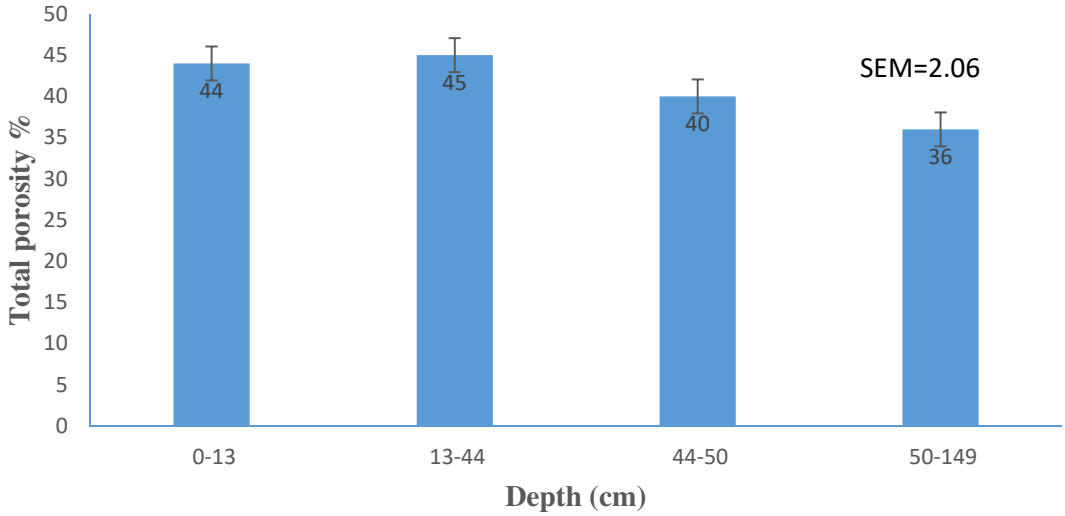


Fig 3: Graph showing total porosity with depths in Profile 1

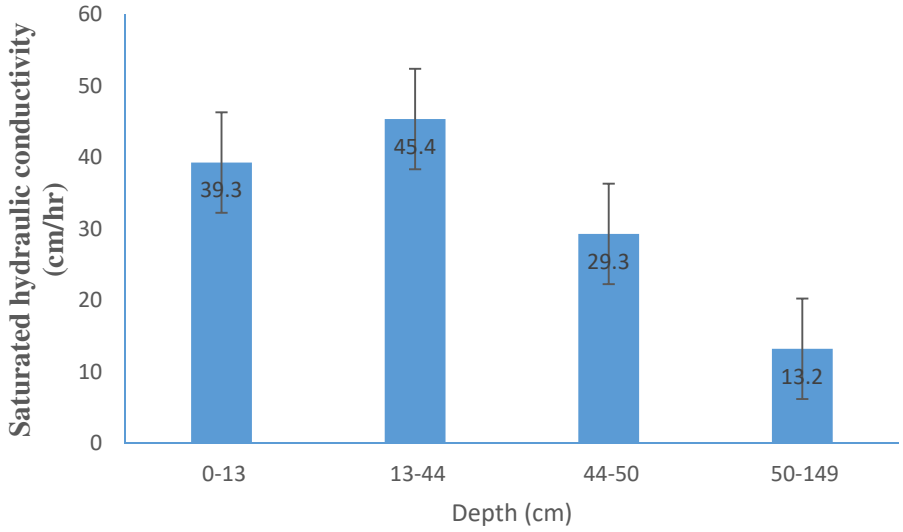


Fig 4: Graph showing Saturated hydraulic conductivity with depths in Profile 1

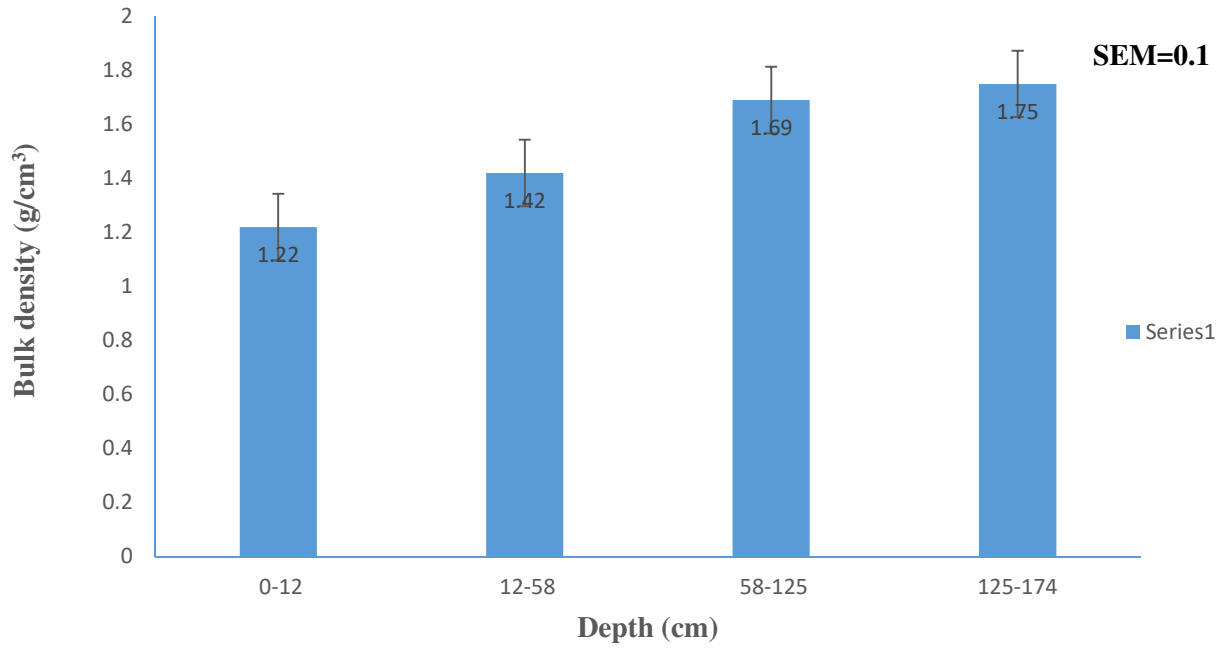


Fig. 5: Graph Showing Bulk Density with Depths in Profile 2

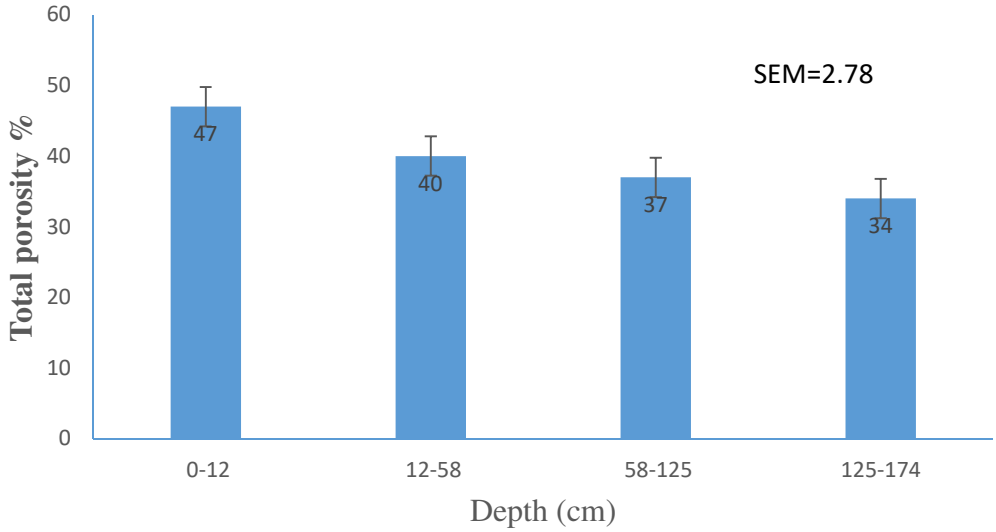


Fig 6: Graph showing total porosity with depths in Profile 2

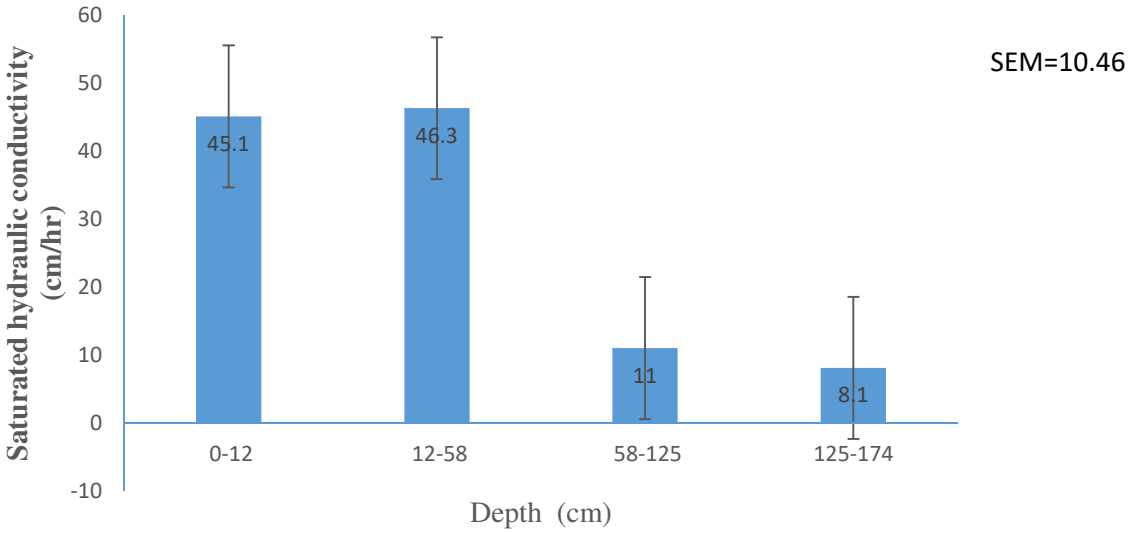


Fig 7: Graph showing Saturated hydraulic conductivity with depths in Profile 2

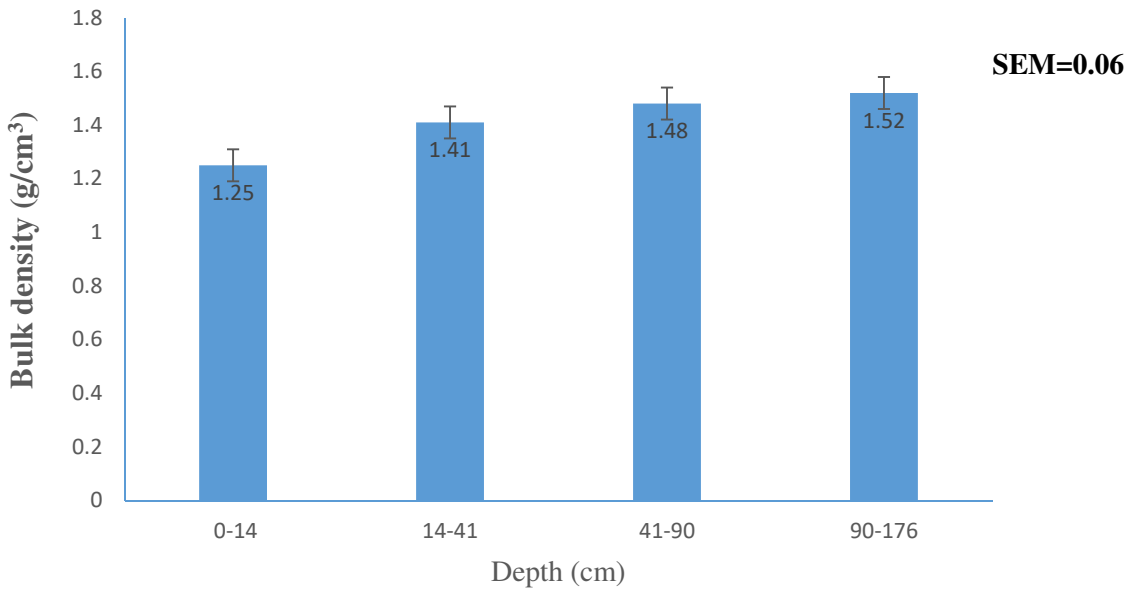


Fig. 8: Graph Showing Bulk Density with Depths in Profile 3

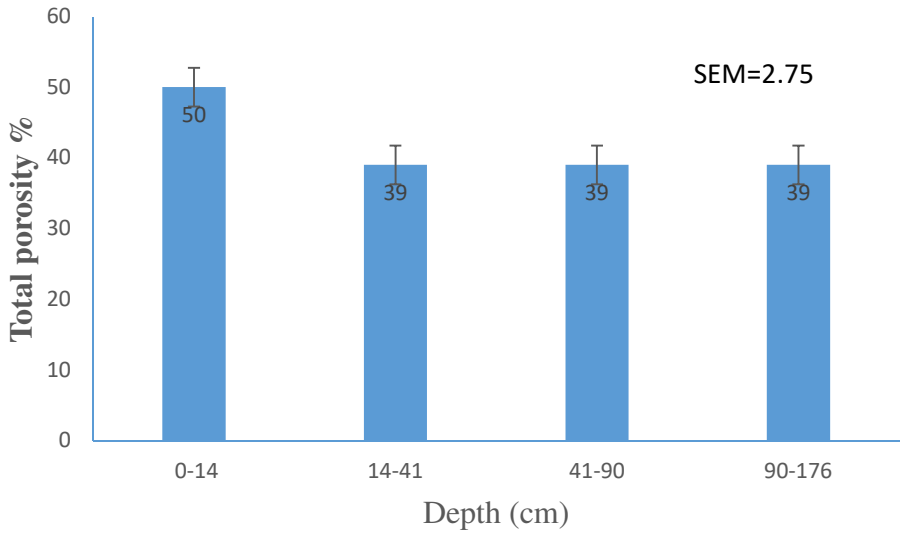


Fig 9: Graph showing total porosity with depths in Profile 3

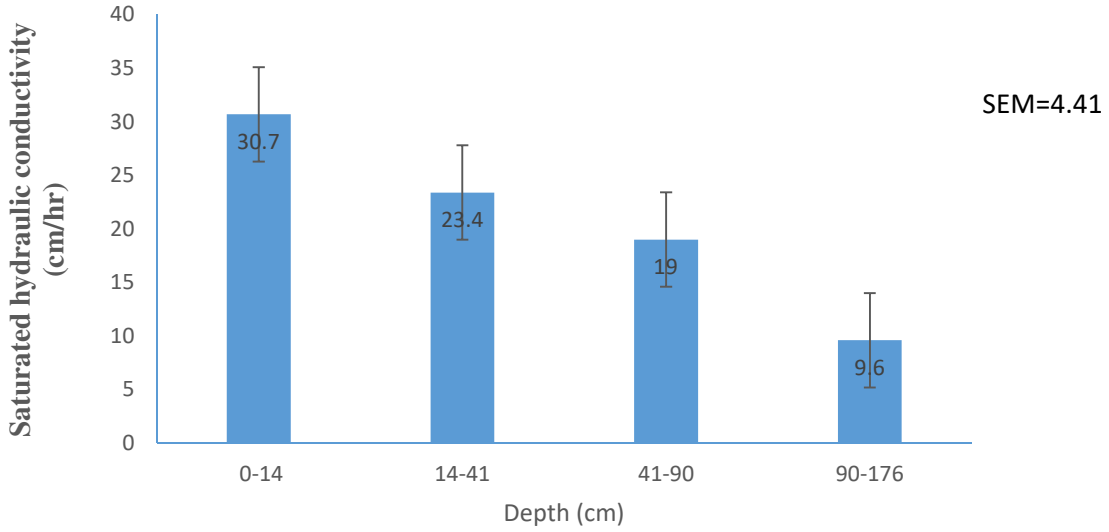


Fig 10: Graph showing Saturated hydraulic conductivity with depths in Profile 3

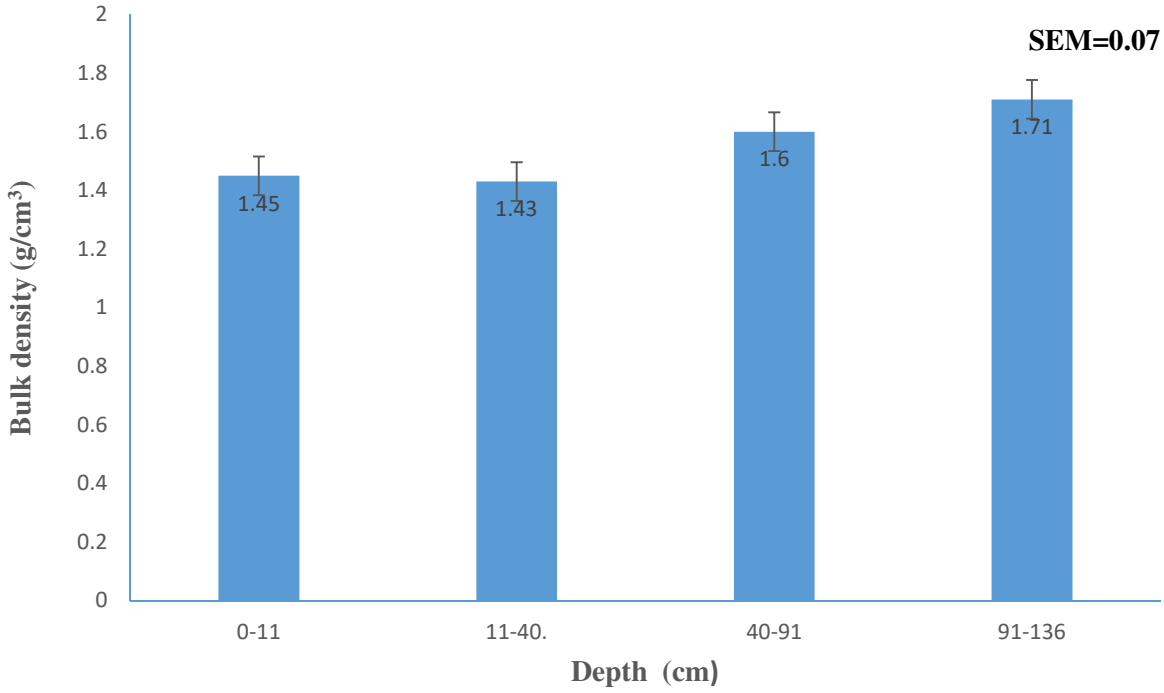


Fig.11: Graph Showing Bulk Density with Depths in Profile 4

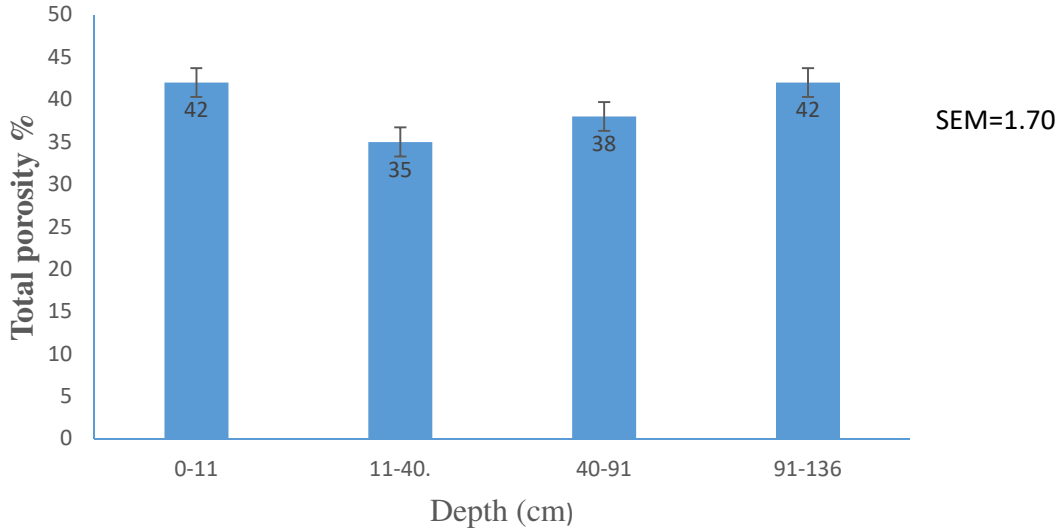


Fig 12: Graph showing Total porosity with depths in Profile 4

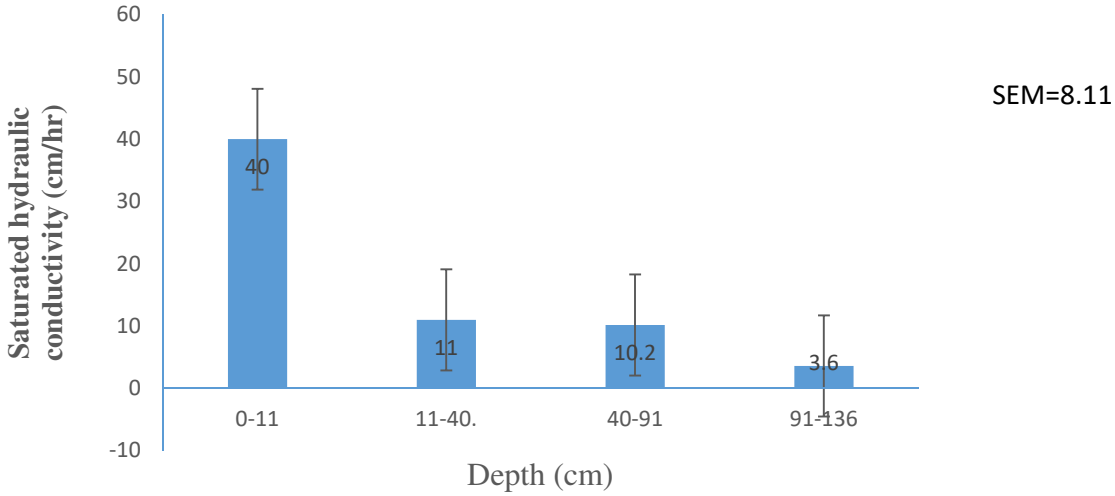


Fig 13: Graph showing Saturated hydraulic conductivity with depths in Profile 4

**References**

Ajayi, A.E., Dias Junior, M.S., Curi, N., Araujo Junior, C.F., Aladenola, O.O., Souza, T.T.T. and Inda Junior, A.V. (2009). Comparison of estimation methods of soil strength in five soils. *Revistabrasileira de ciencia do Solo,* 33(3): http:dx.dol.org/10.1590/s100-068332009000300002.

Amalu, U.C. (2016). Properties and fertility status of soils supporting pineapple (*Ananas comosus* L.Merr) in select communities of Cross River State, South-East Nigeria. *Nigeria Journal of Crop Science*. 3(1):78-91.

Black, G.R. and Hartage, K.H. (1886). Bulk Density. In: Klute, A. (Ed). Methods of soil analysis, part 1, 2nd ed. *Physical and mineralogical. Agronomy Monograph*. No.9, pp 363-375.

Bouyoucos, C.J. (1962). Hydrometer method improved for making particle size analysis of soils. *Agronomy Journal*, 54: 464 - 465.

Brady, N.C. and Weil, R. (2002). The nature and properties of soil, 13th edition; Prentice Hall. Inc; New Jersey, USA. 960pp.

Brady, N.C. and Weil, R.R. (2004). The nature and properties of soils, thirteenth edition Pearson Education, Inc. New Delhi.

Busari, M.A., Azeez, J.O. and Orelaja, O.O. (2012). Impact of long term (9 years) deposition of animal wastes on soil physical properties in Abeokuta, south western Nigeria: Implications for soil management. *The Journal of Solid Waste Technology and Management.* 38(4): 271-278.

Chokor, J., Osarobo, E. and Impens, R. (2018). Study of Soil Compaction from Mechanization and Its Effect on Soil Bulk Density, Moisture Content and Penetrometer Resistance. *Nigeria Journal of Soil Science,* 28(1): 287-294.

Das, D.K. and Agrawal, R.P. (2009). Physical properties of soils. In: Fundamental of Soil Science, *The Indian Society of Soil Science*, pp 449 – 460.

Edward, P. (1992). Soil Science and Management printed in the United States of America.

Flint, I.E. and Flint, A.I. (2002). Pore-size distribution. In: Done, J.H. and Topp, G.C. (Eds), Methods of Soil Analysis, Part 1. Physical methods. *Soil Science Society of America*, Madison WI, pp. 246-253.

Foth, H.D. (1990). Fundamentals of Soil Science, 8th edition, John Wiley and Sons, Inc; New York, USA. 360p

International Institute for Tropical Agriculture (IITA) (1979). Selected methods for tropical Agriculture .3rd edition; Dec., IITA, Ibadan. pp 34.

Lal, R. and Shukla, M.K. (2004). Principles of Soil physics, Marcel Dekker Inc. New York.

Nigeria Geological Survey Agency (2008). Regional and geology series first edition.

Wild, A. (1993). Soils and the environment: An introduction. Cambridge University press, Britain, 287pp.