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# Mapping soil organic carbon-soil biodiversity variability in the ecosystem-nexus of tropical soils

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## Abstract

It is no more news that the deterioration of our mother Earth has resulted in many hardships faced in many lands of the world. Research statistics have shown that about 80% of the environmental problems faced in Asia, especially the loss of soil biodiversity result from deforestation. Africa has been intensely affected by the hazards of climate change at a rate of more than 50%, also Near East and North Africa has recorded more than 48% loss of their biodiversity in soils due to habitat alteration and loss. This list is in-exhaustive and heart-broken, presenting a view that if sustainable remediation is not taken then we will have more malnourished and sick people in years to come, our environment will be more polluted and toxic, our water system will become more and more difficult to remediate, there could be an increase in local, national and international conflict among other unforeseen unpleasant happenings. To contribute as a modality towards solving this problem this study investigated the current soil organic carbon-soil biodiversity variability in the ecosystem-nexus of soils. The study took place within the University of Abuja landmass. Spatial and temporal data were collected on earth-system properties, were analysis and simulations were done. The Area was model and interpolated to find hot spots with a grave threat. Explorative and descriptive statistics were applied in the study. Results indicated that the soils of the study area are compacted and hence unfit to support sustainable survival of the living entities within the soil system, with soil Bulk density value range at 2.1gcm$^{-3}$ – 2.71gcm$^{-3}$. Organic carbon of the area was low. Geotechnical and geomorphological evaluation and interactions revealed only two (2) points having earthworm length of 1 cm which presented a view that the soils spore is too tight to enable the sustainable flourishing of below and above ground biodiversity in the sites investigated. Hence ecological tool like the use of Vetiver Grass Technology was recommended for the study area environmental regeneration and for healing the soils impediment

Keywords: Mapping Biodiversity; Variability; Ecosystem-Nexus; Tropical Soils; Organic carbon

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## 1.0 Introduction

Ecological degradation and subsequent land pollution, fragmentation and destruction of the potential of agricultural soils have been on a global scale for years now, and its impact on food shortages, increase in marginal lands and its hunger, malnutrition including societal unrest consequences is heart-breaking, this has exacerbated many problems globally and is still counting. This then necessitates innovative research towards the sustainability of our food ecosystem and soil nexus.

It is no more news that the deterioration of our mother Earth has resulted in many hardships faced in many lands of the world. Research statistics have shown that about 80% of the environmental problems faced in Asia, especially the loss of soil biodiversity result from deforestation. Africa has been intensely affected by the hazards of climate change at a rate of more than 50%, also Near East and North Africa has recorded more than 48% loss of their biodiversity in soils due to habitat alteration and loss. This list is in-exhaustive and heart-broken, presenting a view that if sustainable remediation is not taken then we will have more malnourished and sick people in years to come, our environment will be more polluted and toxic, our water system will become more and more difficult to remediate, there could be an increase in local, national and international conflict among other unforeseen unpleasant happenings.

Soil organic carbon (SOC) is the most important component in maintaining soil quality because of its role in improving the physical, chemical, and biological properties of the soil (FAO, 2016). Changes in agricultural practices often influence both the quantity and quality of SOC and its turnover rates (FAO, 20016), as such, stagnation or decline in yields has been observed in intensive cropping systems in the latest decennia (Bhandari et al., 2002), and has been attributed to the poor quality and quantity of SOC and its impact on nutrient supply and soil biophysical wellbeing (Bhandari *et al*., 2002). The level of SOC at a point in time reflects the long-term balance between addition and losses of SOC, particularly C and N, under continuous cultivation (Manna *et al*., 2005).

Report of USDA (2016) including Hudson (1992) looks at soil mapping as being the process of delineating natural bodies of soils, classifying and grouping the delineated soils into map units, and capturing information about the Earth-system properties for interpreting and depicting soil spatial distribution on a map. Various statements including the views of USDA (2016) has indicated that for precision agriculture, soil, environmental and ecosystem wellbeing, the knowledge of soil variability at the field scale may be useful for improving site-specific management of the land which enhances the land productivity.

Rapid and accurate sensing methods for Earth-system properties determination would favorably replace labor-intensive, time-consuming and expensive traditional and conventional methods used in assessing soil-environmental-ecosystem nexus webbing. Critical Earth-system properties have been over the years been assessed as a strategy in the utilization of lands for specific purposes (USDA, 2016; FAO, 2016). Sampling and analysis used for innovative techniques of evaluating the potential of the soils have been stressed by many scholars including the report of FAO (2016) and Adiaha et al., (2020), these techniques combine models, field exploration and stimulations including estimations for studying the processes involved in environmental, soils, health including for climatic modulation. Outcome reported by FAO (2000); FAO (2016) including the research of Adiaha et al., (2020) has validated some evolutionary techniques especially in the modelling and evaluation of Earth-system properties in soil-plant-environmental and climatic nexus.

Soil biodiversity plays a major role in the continued sustainability of soils, plants, the ecosystem and soil resources nexus (FA0, 2020). The need to regenerate the world soil biodiversity especially in Africa among other red-spot has become critical in the sustainability drive of our plant soils and their resources. It is now universally accepted that earthworms are important in soil biological, chemical and physical functioning and sustainability, yet their abundance and distribution are little known. Research by Nye (1995) including the work of Madge (1996) has stressed the important role earthworm plays in soil functioning. Hauser (1994) in a field experimental studies stressed that earthworms are essential for the proper functioning of the soil physical, chemical and biological fertility under alley farming. Findings presented by FA0 (2020) indicated that more than 75-80% of the environmental problems and hazards which results in soil biodiversity depletion and loss emerge as a result of land and environment mismanagement including climatic variability, and this has left an impending threat on the sustainability of our global food system, creates increasing environmental hazards with high potential of increasing the already existing global climatic hazards.

Soil toxicity with salts and depreciation from its biodiversity biological balance has created a wide range of global problems, for instance, Nigerian soil has been mapped and reported by FAO, (2020) to be on a red list on her soil biodiversity balance, triggering problematic and compounding management issues especially for agriculture uses. Salt impediments like compacting among other physical-chemical-biological nexus problems have been reported globally to be a serious setback to the food boom and rapid spring-up of agrarian societies (USDA, 2016; Jeffrey, 2013), thus, this then triggers the need for more innovative research towards human and ecosystem sustainability in-other to create modalities towards a sustainable approach for arriving at continual maintenance of our solid, liquid and gaseous earth-system properties. Against the impending threat of global soil depreciation and degradation in physical, chemical and biological balance this study seeks to achieve the following objectives:

Map soil organic carbon-organic matter availability and distribution in Typic Plinthustalf of University of Abuja Landmass
Assess variability influence of Earth System properties on soil biodiversity
Assess the variability in Organic carbon-organic matter-Soil biodiversity in tropical soils of the University of Abuja
Predict Future Availability of Soil biodiversity with the Variability in Earth-System Properties of tropical soils of University of Abuja

## 2. 0 Materials and methods

### *2.1. Location of the Study Area*

The study was conducted during the dry season of late 2020 within the landmass of University of Abuja the Federal Capital Territory (FCT) of Nigeria as in Fig. 1.

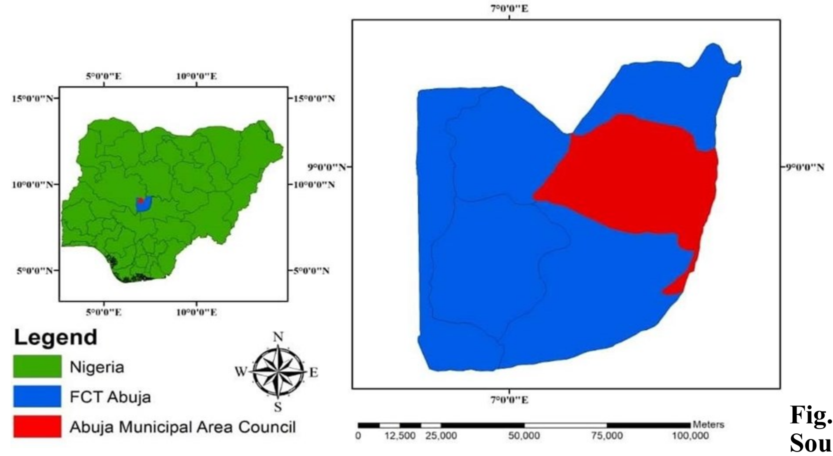


**Fig.** 1. Location of the study area
**Source**: Oku et al., (2020)

### 2.2 Background of the Study Area

The Federal Capital Territory of Nigeria falls within the Southern Guinean Savanna zone of the West Africa (Oku *et al*., 2020). The soils of Abuja are classified as Alfisols and sub order of Ustalfs with Ustic moisture regime. The area has a characteristics of the sub humid climate regime (Oku *et al*., 2020). There is a dominant occurrence of plinthite layers or continuous concretionary layers precisely within 24 cm and 39 cm and at times 150 cm depth (Oku *et al*., 2020). At the great-order group of Plinthustalfs, another sub-group as Typic Plinthustalfs exist (Lawal et al., 2012; Oku et al., 2020).

### 2.3 Characteristics of the Soils of the Study Area

The soils of Abuja are underlain predominantly by basement complex rocks dominated by granites, gneisses, migmatites, quartzites and schist (Bennett et al., 1979; Oku *et al*., 2020). The upland soils of the area which exist under the basement complex formation are generally deep, weakly to moderately structured and has sand to sandy clay in its texture with gravel and concretionary layers in the upper or beneath the surface layers (Ojanuga, 2006; Oku *et al*., 2020). Quartz is observed to be the prominent mineral constituent of the soils with high kaolinite clay content which is responsible for the relatively low plasticity of the soils (Alhassan et al., 2012; Oku *et al*., 2020).

### 2.4 Geographic information of the Study Area

Although officially in Abuja Municipal Council Area, the University of Abuja landmass falls within Gwagwalada. Gwagwalada is a suburb of the Federal Capital Territory, Nigeria. It is situated along Abuja-Lokoja road at about 55 kilometres away from FCT main town and centrally located between latitudes 8□ 55' N - 9□ 00'N and longitudes 7□ 00' E - 7□ 04' E (Ishaya, 2013). With a population of about 157,770 at the 2006 census, the region covers a total landmass of about 65 km$^2$ out of the 8,000 km2 of the total FCT landmass and is located at the centre of a very fertile area with an abundance of grasses (Ishaya, 2013). The area is bordered by Kuje area council to the East, Abaji area council to the West, Kwali area council to the south and Abuja Municipal Area Council to the Northeast and the North by Suleja Local Government Area of Niger State (Balogun, 2001).

### 2.5 Climatic and Geo-characteristics of the Study Area

The area is characterized by a warm, humid, rainy season and a scorching dry season. The research report of Oku *et al*., (2020) has indicated that the highest annual rainfall within the Territory is about 1632 mm. The area has been reported to have recorded a 20 % in its relative humidity. The area has recorded a 30% elevation with high values at the extreme south of the area.

### 2.6 Field Survey and Earth-system Property Data Collection

The University of Abuja landmass was stratified into four (4) stratum according to the catena that exists in the area. Twenty (20) experimental stations were sampled to investigate the variability that exists in the earth-system properties.

### 2.7 Geographic studies and Data collection

Field data were collected for geographic studies where each experimental stations in the four strata were georeferenced and mapped.

### 2.8 Soil Sampling and Data generation

Four (4) replicate undisturbed core samples were collected at a depth of 0–30 cm from randomly selected positions in the different strata using a cylindrical core of 30 cm in length.

### 2.9 Laboratory Investigation and Analysis

#### Particle size analysis

Particle size analysis (PSA) was done using the hydrometer method (Gee and Bauder, 1986).

#### Bulk density

Bulk density was determined by the core method (Burke et al., 1986).

#### Porosity

Porosity was calculated as the function of total volume not occupied by soil solids, assuming a particle density of 2.65 Mg m$^{-3}$ (Danielson and Sutherland, 1986).

#### Organic Carbon Determination:

Soil organic matter content of the soil was estimated from the soil organic carbon content present in the soil. This procedure was done following the equation (equation 1) as presented by van Bemmelen and used by Adiaha et al., (2020 c) which presented a value of 0.58, as a standard for converting SOC to SOM.

$$\mathit{Organic\ Matter}\ (OM)\% = \mathit{Organic\ Carbon}\ (OC)\% \times$$

#### Soil organic carbon

Soil organic carbon was determined by the wet oxidation method (Nelson and Sommers, 1982). Percentage (%) SOM = % organic carbon×1.724 (Walkley, 1934).

#### Soil salinity

Soil salinity was measured by passing an electric current between two electrodes of a salinity meter in a sample of soil solution, as described by the Government of New South Wales Department of Agriculture, NSW Agriculture (2003)

### 2.10 Laboratory Simulations and Earth-System Properties Modelling

Soil samples were immersed in water, weighed and result from the analysis fitted with % sand and % clay fraction of the experimental soil particle size analysis into soil-water characteristics model. The use of the soil-water characteristics model was prescribed by NRCS (2015) and emphasized by USDA (2013) and has been utilized widely for Earth-system properties studies: modelling and forecast.

Earth-system properties including Wilting point, Field Capacity, Saturation, Matric Bulk Density, Available water, Matric Potential, Moisture Content and Matric Osmotic count were simulated by fitting particle size analysis result, Organic matter content including soil salinity analysis result into the soil-water characteristics model of NRCS as prescribed (NRCS, 2015; USDA, 2013 and FAO 2016), this simulation procedure has yield wide experimental result and has been validated in research report presented by FAO (2016) including the work of Adiaha et al., (2020 c).

### 2.11 Soil Biodiversity Studies

Soil sample collected at each of the twenty (20) experimental stations was analyzed through viewing in a micro-morphological and geotechnical high-resolution electronic microscope. Observation of the baseline organism (earthworm) was done immediately after field soil sample collection, this following the procedure as described by Chude et al. (2020). The samples were wetted and nutrient algae added and kept at room temperature for two (2) days, after which it was reviewed in the micro-morphological and geotechnical high-resolution electronic microscope to validate the earthworm count.

### 2.12 *Data Processing and Analysis*

Descriptive statistics: CV, % analysis, Mean, STD, SE including the chi-square statistics was applied in the study

A correlation test of the Principal Component Analysis (PCA) of the exploratory statistics was applied to draw up the relationship and evaluate the performance of Earth-System properties on Soil biodiversity

In other to find the interaction that exists between the parameters, the Pearson Product Correlation (PPMC) analysis was utilized, where the coefficient of determination (R) and correlation coefficient (r) was utilized to establish the relationship. Simple Linear Regression model: Y = a + b*X was utilized to present the relating influence among the various parameters.

The chi-square statistics was applied to predict the influence of the interacting parameters and test its significance at a 0.05% probability level.

A modelling and statistical tool: Statgraphics Centurion "version 19" was utilized to run data analysis and modelling and for production of the graphics.

QGIS and ArcGIS was used for geographic mapping and modelling

### *2.13 Standardization of Laboratory Experimentation and Analysis*

All parameters determined in the study were compared with standardized ratings for tropical soils presented in Table 1 and Table 2.

*Table 1. Ratings for interpreting selected Earth System properties for tropical soils*

| Parameter | Range / Rating | | Source |
|---|---|---|---|
| Organic matter (%) | Low | < 2 | Udo et al., (2009) |
| | Moderate | 2 - 3 | |
| | High | > 3 | |
| | Very High | > 6 | |
| Porosity (%) | Poor agricultural soils | < 40 | Kachinskii, (1970) |
| | Satisfactory agricultural soil | 41 - 45 | |
| | Good agricultural soils | 46 - 50 | |
| | Best agricultural soils | > 50 | |
| Coefficient of variability (%) | Low | < 15 | Wildings, (1985) |
| | Moderate | 16 - 35 | |
| | High | > 35 | |
| Saturated hydraulic conductivity (cm/hr) | 0.8 | Very slow | FAO, (1963) |
| | 0.8 – 2 | Slow | |
| | 2.1 – 6.00 | Moderately slow | |
| | 6.1 – 8.00 | Moderately rapid | |
| | 8.1 – 12.50 | Rapid | |
| | > 12.50 | Very rapid | |
| Bulk density impact on soil biodiversity ($gcm^{-3}$) | 1.56 – 2.0 | Impaired soil biodiversity population growth | Chude et al., (2020) |
| | > 2 | Resist soil biodiversity population growth | |
| Porosity impact on soil biodiversity (%) | 1.00 | Impaired soil biodiversity population growth | Chude et al., (2020) |
| | > 2 | Resist soil biodiversity population growth | |
| Organic carbon (%) | < 1 | Low | Udo et al., 2009 |
| | 1 – 1.5 | Moderate | |
| | > 1.5 | High | |

*Table 2: Ratings and classifications for interpreting saline soils*

| Soil salinity class | EC (dS/m) | Effects on crop plants |
|---|---|---|
| Non-saline | 0 – 2 | Salinity effects negligible |
| Slightly saline | 2 – 4 | Yields of sensitive crops may be restricted |
| Moderately saline | 4 – 8 | Yields of many crops are restricted |
| Strongly saline | 8 – 16 | Only tolerant crops yield satisfactorily |
| Very strongly saline | > 16 | Only very tolerant crops yield satisfactorily |

**Source**: Jeffrey (2013)

*Table 3: General Porosity Ranking*

| Soil porosity status indicator | Rating (%) |
|---|---|
| Soil very compact | <5% |
| Soil compact | 5-10% |
| Soil moderately porous | 10-25% |
| Soil highly porous | 25-40% |
| Soil extremely porous | >40% |

Source: (Pagliai, 1988)

## 3.0 Result and Discussion

### *3.1 Mapping of soil organic carbon-organic matter availability and distribution in Plinthustalf of University of Abuja Landmass*

### *3.1.1 Variability that exists in soil organic carbon content in tropical soils of Abuja, Nigeria*

The result of the mapping of soil organic carbon (OC) indicated that the distribution of OC in the area is uneven and low in quantity as presented in Fig. 2. The area was observed to have soil organic carbon content at 8% -16% in strata 1, with Coefficient of Variation (CV %) observed at 10% which presented the strata as having low organic matter content as presented in Table 3, hence exhibiting problematic characteristics for the proper functioning and availability of the soil biodiversity in the area. A variability rate of CV=16% was recorded for Strata 2 of the area investigated which presented that strata have to have a moderate variability class of organic carbon content in the soil. These strata presented soil organic carbon content at a range of 6-10% for the five (5) experimental stations observed for this strata as presented in Table 4. Strata 3 showed a variation in organic carbon content at 6-9% with a variability class of CV=17% which indicated that the strata is moderate in the variation that exists in the organic carbon content of the strata as indicated in Table 3. The variation that exists in soil organic content in Strata 4 of the area investigated as presented in Table 6 indicated that Strata 4 has a low content of organic carbon in the area, which was observed at 10% of the variability output of the CV statistics. The strata were observed to 6-8% distribution appearance of soil organic carbon content. Views presented in this study agrees with the research of FAO (2016) including the study of IPCC (2000) which indicated variation in soil organic carbon content due to variability that exists in the soil system.

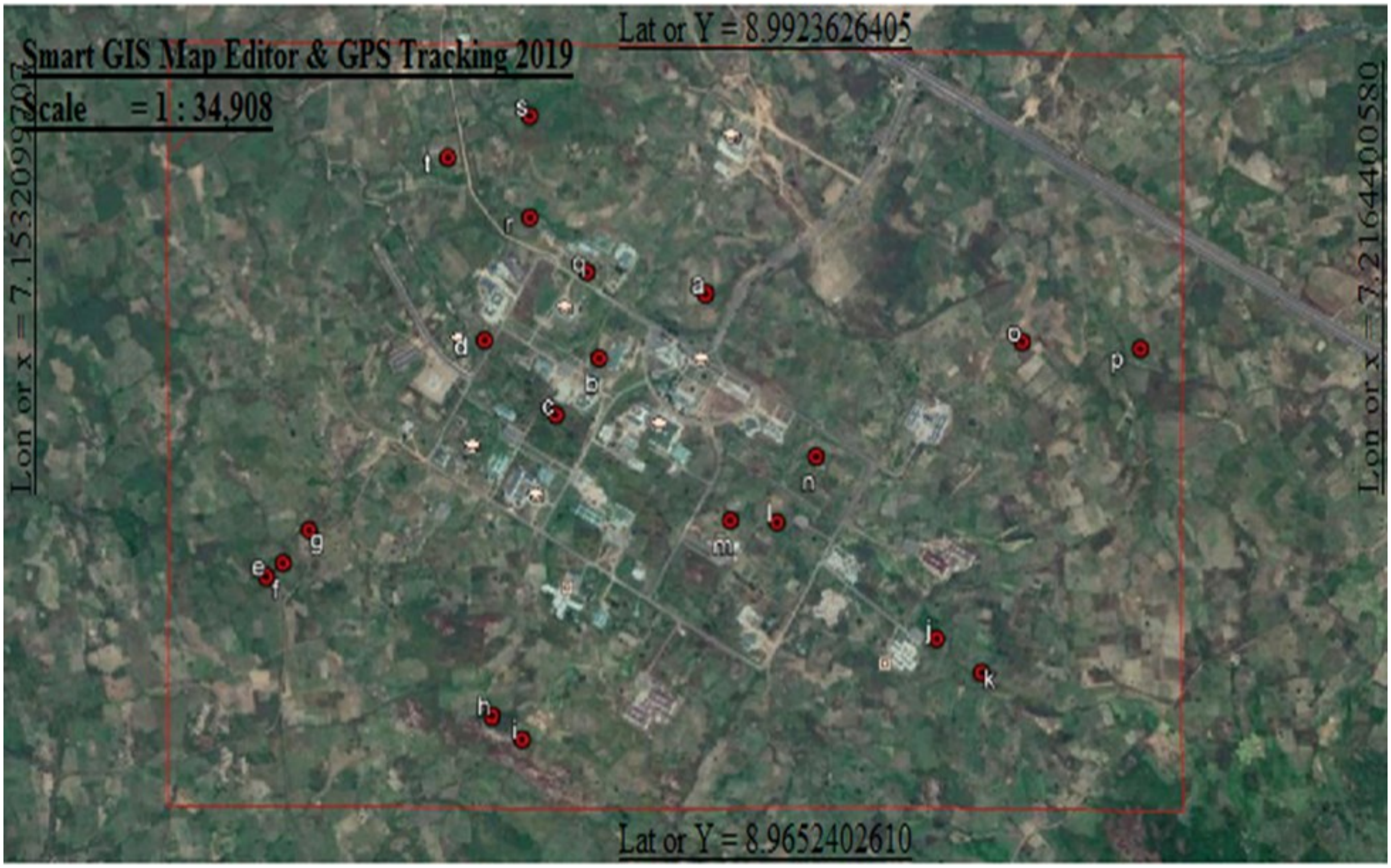


Fig. 2: Points of experimental stations investigated for the study

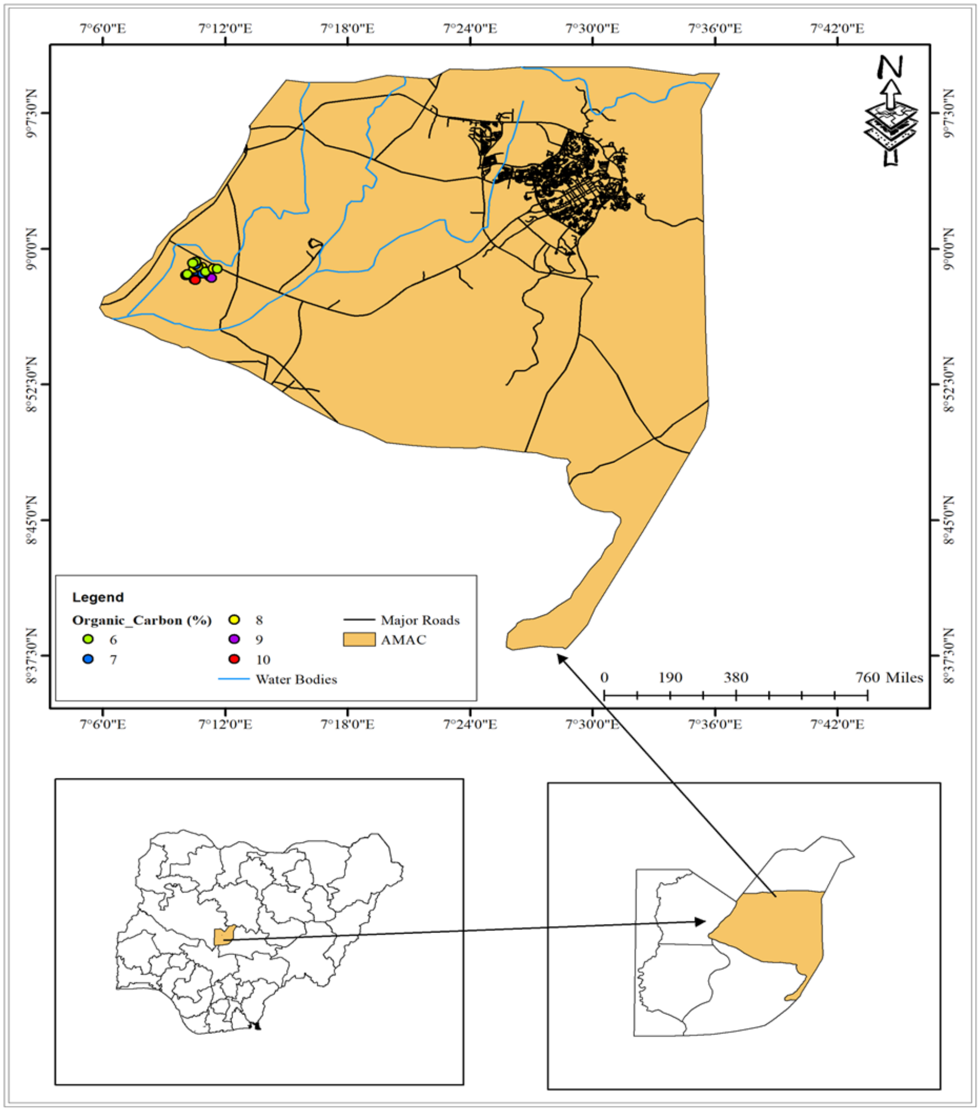


Fig. 3: Organic carbon distribution in soils of University of Abuja, Nigeria

***Table 3**: Earth-System Properties Variability with Ecosystem interaction in Tropical Soils for Strata 1*

**Strata 1**

| Lat | Long | Elevation (m) | | Wilting point (% Vol) | Field Capacity (% Vol) | Saturation (% Vol) | Available water ( cm/ cm) | Saturated Hydraulic conductivity (cm/hr) | Matric Bulk Density (g/ cm3 ) | Organic Matter (% Wt) | Organic Carbon (%) | Moisture Content (% Vol) | Matric Potential (kPa) | Matric Osmotic count ( kPa ) | Salinity (dS/ m) | Geomorphological microscopic view for Earthworm count | Geotechnical Electronic microscopic view for Earthworm count |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.983139 | 7.180917 | 284 | Station 1 | 3.3 | 10.3 | 47 | 0.07 | 12.848 | 1.4 | 14 | 8 | 13.8 | 126 | 126 | 1.3 | 0 | 0 |
| 8.981389 | 7.177806 | 264 | Station 2 | 3.4 | 11.4 | 46.8 | 0.08 | 11.917 | 1.41 | 13 | 8 | 13.9 | 31 | 31 | 2.4 | 1 | 1 |
| 8.979833 | 7.176528 | 261 | Station 3 | 4 | 12.2 | 46.5 | 0.08 | 10.704 | 1.42 | 12 | 7 | 14.8 | 32 | 32 | 3.1 | 1 | 0 |
| 8.981889 | 7.174444 | 260 | Station 4 | 6.4 | 17.4 | 45.6 | 0.11 | 6.053 | 1.44 | 13 | 8 | 13.8 | 81 | 81 | 2.9 | 0 | 0 |
| 8.975417 | 7.168 | 256 | Station 5 | 6.5 | 19.8 | 45.9 | 0.13 | 5.07 | 1.43 | 16 | 9 | 15 | 115 | 115 | 2 | 0 | 0 |
| Mean | | | | 4.72 | 14.22 | 46.36 | 0.09 | 9.32 | 1.42 | 13.60 | 7.89 | 14.26 | 77.00 | 77.00 | 2.34 | 0.40 | 0.20 |
| STD | | | | 1.43 | 3.71 | 0.53 | 0.02 | 3.16 | 0.01 | 1.36 | 0.79 | 0.53 | 40.00 | 40.00 | 0.65 | 0.49 | 0.40 |
| CV % | | | | 30 | 26 | 1 | 24 | 34 | 1 | 10 | 10 | 4 | 52 | 52 | 28 | 122 | 200 |

*Table 4: Earth-System Properties Variability with Ecosystem interaction in Tropical Soils for Strata 2*

**Strata 2**

| Lat | Long | Elevation (m) | | Wilting point (% Vol) | Field Capacity (% Vol) | Saturation (% Vol) | Available water ( cm /cm) | Saturated Hydraulic conductivity (cm/ hr) | Matric Bulk Density (g/ cm3) | Organic Matter (% Wt) | Organic Carbon (%) | Moisture Content (% Vol) | Matric Potential (kPa) | Matric Osmotic count ( kPa) | Salinity (dS /m) | Geomorphological microscopic view for Earthworm count | Geotechnical Electronic microscopic view for Earthworm count |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.975778 | 7.1685 | 252 | Station 6 | 4.6 | 14.1 | 46.2 | 0.09 | 8.904 | 1.43 | 14 | 8 | 14.9 | 36 | 36 | 2.5 | 1 | 0 |
| 8.976694 | 7.169278 | 269 | Station 7 | 5.2 | 14.5 | 45.9 | 0.09 | 8.17 | 1.43 | 11 | 6 | 28.1 | 41 | 41 | 2.3 | 1 | 1 |
| 8.971639 | 7.174667 | 275 | Station 8 | 3.4 | 11.7 | 46.8 | 0.08 | 11.733 | 1.41 | 15 | 9 | 89.3 | 31 | 31 | 2.5 | 0 | 0 |
| 8.971028 | 7.175556 | 278 | Station 9 | 7.2 | 18.8 | 45.8 | 0.12 | 5.453 | 1.44 | 18 | 10 | 79.3 | 101 | 340 | 2 | 1 | 0 |
| 8.973778 | 7.187639 | 289 | Station 10 | 5.9 | 15.3 | 45.9 | 0.09 | 7.778 | 1.43 | 12 | 7 | 83.2 | 48 | 263 | 1.8 | 1 | 0 |
| Mean | | | | 5.26 | 14.88 | 46.12 | 0.094 | 8.4076 | 1.428 | 14 | 8.12 | 58.96 | 51.4 | 142.2 | 2.22 | 0.8 | 0.2 |
| STD | | | | 1.16 | 2.10 | 0.33 | 0.01 | 1.85 | 0.01 | 2.24 | 1.30 | 28.33 | 23.21 | 120.83 | 0.25 | 0.37 | 0.37 |
| CV % | | | | 22 | 14 | 1 | 13 | 22 | 1 | 16 | 16 | 48 | 45 | 85 | 11 | 46 | 183 |

*Table 5: Earth-System Properties Variability with Ecosystem interaction in Tropical Soils for Strata 3*

**Strata 3**

| Lat | Long | Elevation (m) | | Wilting point (% Vol) | Field Capacity (% Vol) | Saturation (% Vol) | Available water ( cm/ cm) | Saturated Hydraulic conductivity (cm/hr) | Matric Bulk Density (g/ cm3) | Organic Matter (% Wt) | Organic Carbon (%) | Moisture Content (% Vol) | Matic Potential (kPa) | Matric Osmotic count ( kPa ) | Salinity (dS/ m) | Geomorphological microscopic view for Earthworm count | Geotechnical Electronic microscopic view for Earthworm count |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8.972861 | 7.188944 | 293 | Station 11 | 4.7 | 10.3 | 46.7 | 0.06 | 12.06 | 1.41 | 16 | 9 | 84 | 30 | 286 | 2.1 | 1 | 0 |
| 8.976917 | 7.183 | 283 | Station 12 | 4.3 | 11.7 | 46.7 | 0.07 | 11.733 | 1.41 | 11 | 6 | 67 | 31 | 276 | 2 | 1 | 1 |
| 8.976972 | 7.181639 | 275 | Station 13 | 5.9 | 14.5 | 45.9 | 0.09 | 8.17 | 1.43 | 12 | 7 | 61 | 41 | 268 | 1.9 | 1 | 0 |
| 8.978722 | 7.184139 | 282 | Station 14 | 5.2 | 13.8 | 46.2 | 0.09 | 9.05 | 1.43 | 10 | 6 | 52 | 34 | 226 | 1.6 | 1 | 0 |
| 8.981833 | 7.190139 | 288 | Station 15 | 5.4 | 15 | 46.1 | 0.1 | 8.33 | 1.43 | 13 | 8 | 49 | 44 | 261 | 1.8 | 1 | 0 |
| Mean | | | | 5.1 | 13.06 | 46.32 | 0.082 | 9.8686 | 1.422 | 12.4 | 7.192 | 62.6 | 36 | 263.4 | 1.88 | 1 | 0.2 |
| STD | | | | 0.55 | 1.78 | 0.32 | 0.01 | 1.69 | 0.01 | 2.06 | 1.19 | 12.47 | 5.55 | 20.47 | 0.17 | 0.00 | 0.40 |
| CV % | | | | 11 | 14 | 1 | 18 | 17 | 1 | 17 | 17 | 20 | 15 | 8 | 9 | 0 | 200 |

*Table 6: Earth-System Properties Variability with Ecosystem interaction in Tropical Soils for Strata 4*

| **Strata 4** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lat | Long | Elevation (m) | | Wilting point (% Vol) | Field Capacity (% Vol) | Saturation (% Vol) | Available water ( cm /cm) | Saturated Hydraulic conductivity (cm/ hr) | Matric Bulk Density (g/ cm3) | Organic Matter (% Wt) | Organic Carbon (%) | Moisture Content (% Vol) | Matic Potential (kPa) | Matric Osmotic count ( kPa) | Salinity (dS /m) | Geomorphological microscopic view for Earthworm count | Geotechnical Electronic microscopic view for Earthworm count |
| 8.981639 | 7.193583 | 284 | Station 16 | 5.4 | 14.1 | 46.2 | 0.09 | 8.904 | 1.43 | 11 | 6 | 48 | 36 | 277 | 2 | 1 | 0 |
| 8.983722 | 7.177444 | 272 | Station 17 | 4.7 | 11.7 | 46.6 | 0.07 | 11.038 | 1.42 | 13 | 8 | 42 | 31 | 262 | 1.9 | 0 | 0 |
| 8.985222 | 7.175778 | 277 | Station 18 | 9.3 | 24 | 46.1 | 0.15 | 3.106 | 1.43 | 12 | 7 | 51 | 270 | 486 | 1.8 | 1 | 1 |
| 8.987972 | 7.175778 | 272 | Station 19 | 5.5 | 15.5 | 46.1 | 0.1 | 8.05 | 1.43 | 10 | 6 | 71 | 48 | 277 | 1.9 | 0 | 0 |
| 8.986889 | 7.173361 | 252 | Station 20 | 7 | 17.4 | 45.6 | 0.1 | 6.05 | 1.44 | 10 | 6 | 68 | 81 | 307 | 1.9 | 0 | 0 |
| Mean | | | | 6.38 | 16.54 | 46.12 | 0.102 | 7.4296 | 1.43 | 11.2 | 6.496 | 56 | 93.2 | 321.8 | 1.9 | 0.4 | 0.2 |
| STD | | | | 1.64 | 4.17 | 0.32 | 0.03 | 2.69 | 0.01 | 1.17 | 0.68 | 11.44 | 90.10 | 83.39 | 0.06 | 0.49 | 0.40 |
| CV % | | | | 26 | 25 | 1 | 26 | 36 | 0 | 10 | 10 | 20 | 97 | 26 | 3 | 122 | 200 |

### 3.1.2 *Variability that exists in soil organic matter content in tropical soils of Abuja, Nigeria*

The variability that exists in soil organic matter observed for soils of the University of Abuja as shown in Fig. 3 indicated that the area has low organic matter content. With variability strength of 12-16% organic matter content at Strata 1 and a Coefficient of Variation of been low with CV value observed at 10% as shown in Table 3. At Strata 2 as presented in Table 4, a variability range of 11-18% content of organic matter was observed which presented a Coefficient of Variation class of the Strata as being moderate in its organic matter content in the soil, this moderate class was observed at CV=16%. The variability that exists in organic matter content in Strata 3 of the study area shows that 10-16% variation range exist in the organic matter content in the area, which was observed at a variability class of (CV=17%), which shows that the area is moderate in its organic matter content as presented in Table 5. A 10% variation (coefficient of variation) exist in the variability of organic matter content in experimental stations evaluated at the University of Abuja, this variability class was found to be low for soil sustainability and for soil biodiversity flourishing. However, the availability rate of 10-13% exists in organic matter content in soils at Strata 4 of the twenty experimental points investigated for this study. The outcome of this finding agrees with the research of Chude et., (2020) which indicated soil impediments including low organic matter been a hindrance to the sustainability of soil biodiversity and ecosystem development. The research out of FAO (2016) also validates views of this research outcome where their report presented views that soil condition like the balance in the availability of organic matter being one of the strong determinant factors for soil biodiversity regeneration and availability in an area. Views presented in the work of Adiaha et al., (2020 c) also align with the findings of this study, where their works indicated soil organic matter being an important factor in environment-ecosystem interaction for environmental sustainability and for humans to sustainably benefit from the ecosystem and for sustainable climatic modulation.

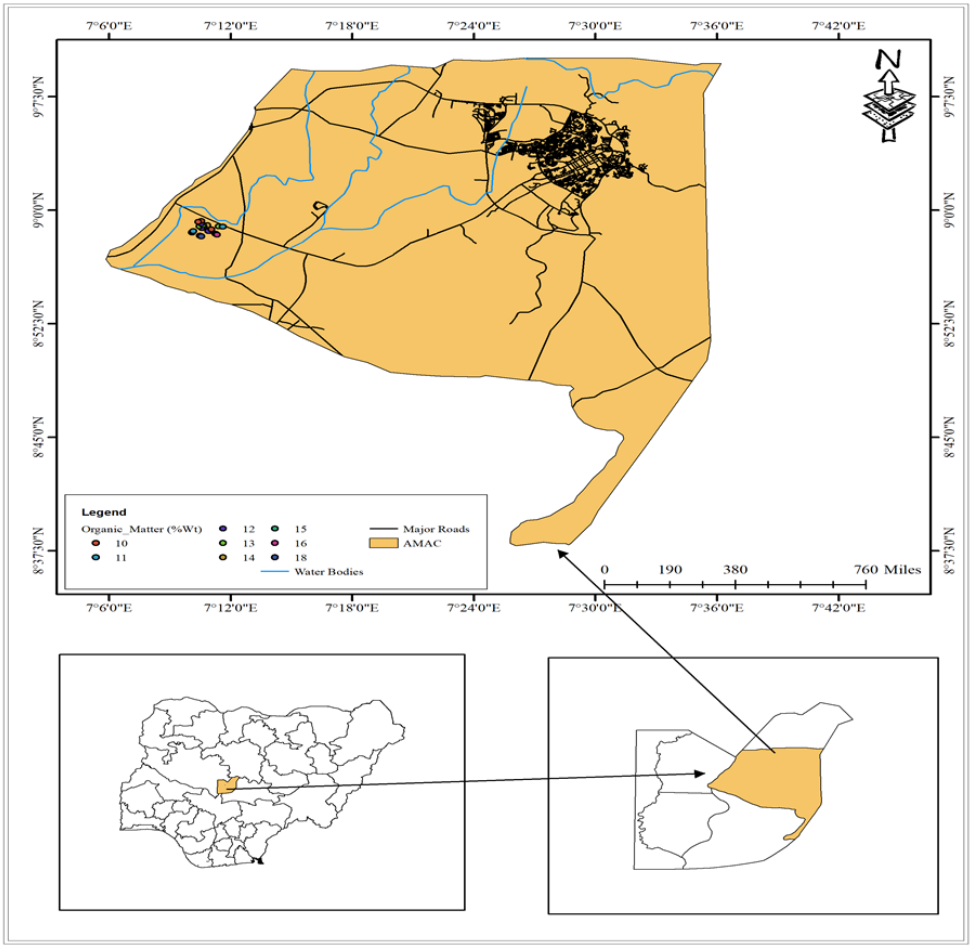


Fig. 4: Organic carbon distribution in soils of University of Abuja, Nigeria

### 3.1.3 *Implication of the observed Variability that exist in soil organic carbon-organic (OC-OM) matter content to the sustainability of in tropical soils of Nigeria*

The observed variability that exists in the whole of the four (4) stratum investigated indicated that soil organic carbon-organic matter content in the area is low, with the implication of reducing the biophysical and chemical functionality of the soil and its support for soil biodiversity flourishing. It could be stated that soil organic carbon-organic matter nexus and availability balance could either enhance or inhibit the availability of soil biodiversity. Hence, if soil organic carbon -organic matter continues to deplete then the soils of the area will be more toxic as the build-up of soil toxins and associated chemical spills will be the outcome of the experimental sites investigated. This view is consistent with the research outcome of FAO (2016); FAO (2020) and Chude et al., (2020) which stated degradation and loss of organic carbon-organic matter been a triggering factor in the depreciation of soil biodiversity.

### *3.1.4 Variability Influence of Earth-system properties on Soil Biodiversity availability in tropical soil*

*Variability Influence (VI) that exist in using geomorphological Earthworm count on Earth-system properties on Soil Biodiversity availability*

Result presented in Table 8 and Fig 5 which observed the Variability Influence (VI) that exist in using geomorphological Earthworm count indicated that Earth-System properties like wilting point had 10% influence on soil biodiversity availability in the twenty (20) sites investigated. Water at field capacity had a 46% influence on the biodiversity of the soils of the area investigated. Soil saturation had a low value of 1% influence on the soil biodiversity. Available water quantity of the area had a 70% influence on the availability of the soil biodiversity that exists in the area. Saturated Hydraulic conductivity of the soil had 30% influence on the flourishing of the soil biodiversity of the area. The matric bulk density of the area was observed to have a 2% influence on the biodiversity of the soils of the area. Organic matter influence on the soil biodiversity was observed at 4%. The moisture content of the soils of the area had 42% on the availability of the biodiversity in soils of the area. Matric potential of the area was observed to have a 93% influence on the availability of the soils of the area. Matric osmotic of the area contributed a 2% influence on the availability or non -availability of the area. The salinity of the area was observed to have contributed 11% to the variation that exists in the soil biodiversity of the area. Cases in the influence of soil salinity as presented by Jeffrey (2003) has indicated that the area had a strong salinity contribution to the biodiversity of soils of the area. Findings presented in this experiment confirms that the work of FAO (2016) indicated multiple factors including soil content. The soil has been a factor in the flourishing of the soil biodiversity of an area. Reports presented by USDA (2018) has indicated that such soils could be a hindrance to the sustainability of soil biodiversity and environmental sustainability and requires specialized treatment for its agricultural utilization.

*Table 8: Variability Influence of Earth-System Properties on Soil biodiversity Earthworm Count Availability in tropical soil*

| **Variability Influence of Earth-System Properties on Geomorphological Earthworm Count availability in tropical soil** | | | | |
|---|---|---|---|---|
| Interacting Earth-System Properties | Model | $R^2$ | r | % Variability Influence |
| Wilting point (% Vol) | -0.1316 +1.356 | 0.098 | 0.049 | 10 |
| Field Capacity (% Vol) | -0.14 +2.7046 | 0.4599 | 0.22995 | 46 |
| Saturation (% Vol) | 0.2033+8.7463 | 0.0075 | 0.00375 | 1 |
| Available water ( cm/cm) | 30.392 +3.4765 | 0.6979 | 0.34895 | 70 |
| Saturated Hydraulic conductivity(cm/hr) | 0.1538 +0.6963 | 0.3008 | 0.1504 | 30 |
| Matric Bulk Density (g/cm3) | 8.8235+13.224 | 0.0196 | 0.0098 | 2 |
| Organic Matter (% Wt) | 0.05+0.01 | 0.0444 | 0.0222 | 4 |
| Organic Carbon (%) | 0.0862+0.01 | 0.0444 | 0.0222 | 4 |
| Moisture Content (% Vol) | 0.0086+0.2381 | 0.4195 | 0.20975 | 42 |
| Matric Potential (kPa) | 0.0113+1.3793 | 0.9329 | 0.46645 | 93 |
| Matric Osmotic count ( kPa) | 0.0004+0.5755 | 0.019 | 0.0095 | 2 |
| Salinity (dS/m) | 0.4326+1.552 | 0.1106 | 0.0553 | 11 |

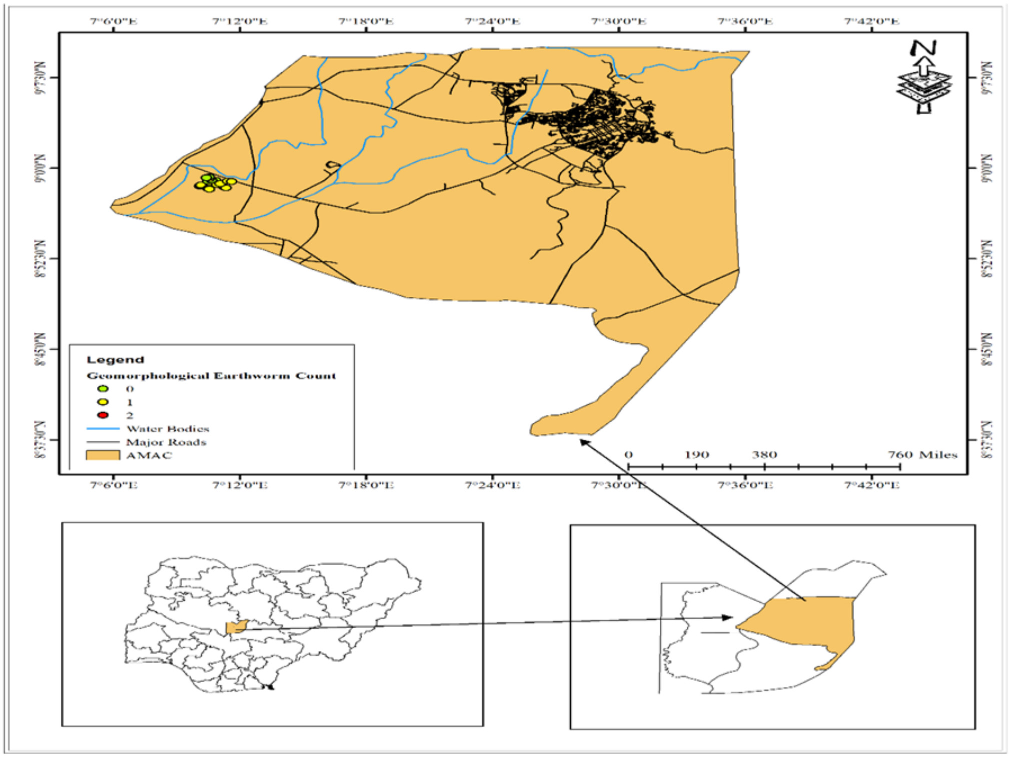


Fig. 5: Variability Influence that exists in using geomorphological Earthworm count on Earth-system properties on Soil Biodiversity availability

### *Variability Influence (VI) that exist in using Geotechnical Earthworm count on Earth-system properties on Soil Biodiversity availability*

The Variability Influence (VI) that exist in using geotechnical electronic microscopic to view Earthworm count as influence by the variability and influence of Earth-System properties in soils of the study area is presented in Table 9 and Fig 6. It was observed that Wilting point, Field Capacity, Available water had a 1% influence on the biodiversity availability in the soils of the area when view and correct with outcome obtained using a Geotechnical microscope. The soil Saturation was observed at 33% with Saturated Hydraulic conductivity giving an influence recorded at 5%. Matric bulk density was shown to have contributed an 18% at a variation impact due to the use of geotechnical observation techniques. Organic Matter (OM) and Organic carbon (OC) influence on soil biodiversity availability were shown to be 40% respectively due to the difference in instruments used for the Earthworm count. Moisture content, Matric Potential, Matric Osmotic count had a contributory variation influence on soil biodiversity at 11%, 11% and 12% respectively. The salinity impact due to change in instrumentation used was observed at 15%. However, the change that occurred in the variability influence of Earth-System properties due to changes in instrumentation could be attributed to the difference in potential and ability of the instrument in the analysis of biologically active entities.

*Table 9: Variability Influence of Earth-System Properties on Soil biodiversity Earthworm Count Availability in tropical soil*

**Variability of Earth-System Properties on Geotechnical Electronic microscopic view Earthworm Count availability in tropical soil**

| Interacting Earth-System Properties | Model | $R^2$ | r | % Variability Influence |
|---|---|---|---|---|
| Wilting point (% Vol) | 0.0069+0.1381 | 0.0096 | 0.0048 | 1 |
| Field Capacity (% Vol) | 0.0032 + 0.2225 | 0.0088 | 0.0044 | 1 |
| Saturation (% Vol) | 0.2236 - 10.161 | 0.3279 | 0.16395 | 33 |
| Available water ( cm/cm) | 0.4902+0.2206 | 0.0065 | 0.00325 | 1 |
| Saturated Hydraulic conductivity(cm/hr) | 0.0101+0.0862 | 0.0471 | 0.02355 | 5 |
| Matric Bulk Density (g/cm3) | 4.4118+6.4618 | 0.1765 | 0.08825 | 18 |
| Organic Matter (% Wt) | 0.025+0.495 | 0.4 | 0.2 | 40 |
| Organic Carbon (%) | 0.0431+0.495 | 0.4 | 0.2 | 40 |
| Moisture Content (% Vol) | 0.0007+0.2094 | 0.1052 | 0.0526 | 11 |
| Matric Potential (kPa) | 0.0007+0.1324 | 0.1147 | 0.05735 | 11 |
| Matric Osmotic count ( kPa) | 0.0002+0.1433 | 0.1239 | 0.06195 | 12 |
| Salinity (dS/m) | 0.0846+0.3515 | 0.1524 | 0.0762 | 15 |

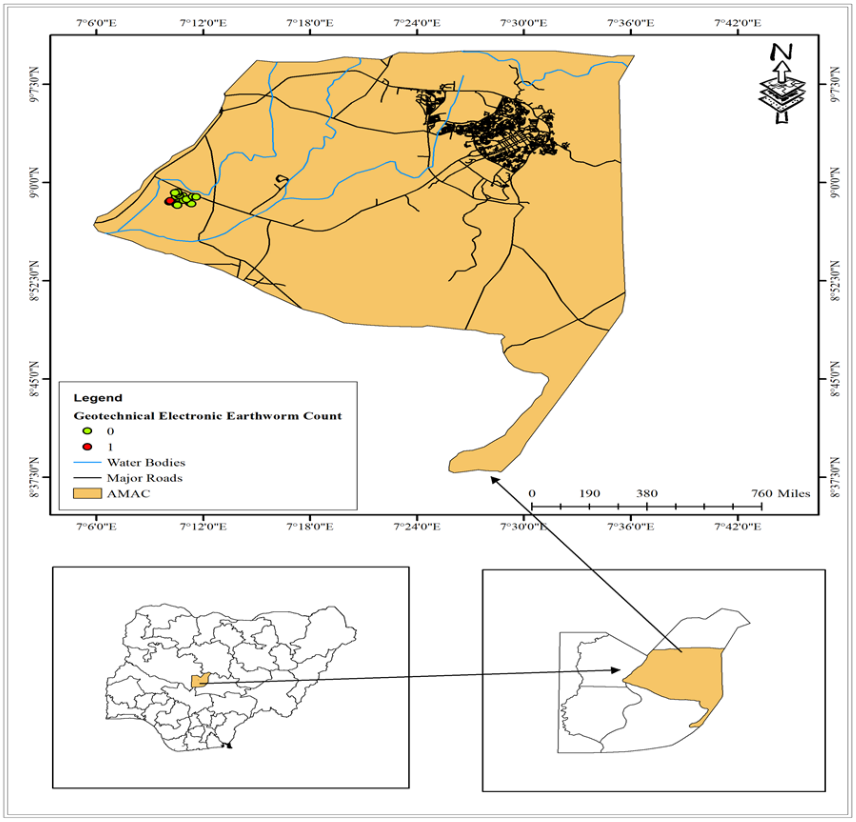
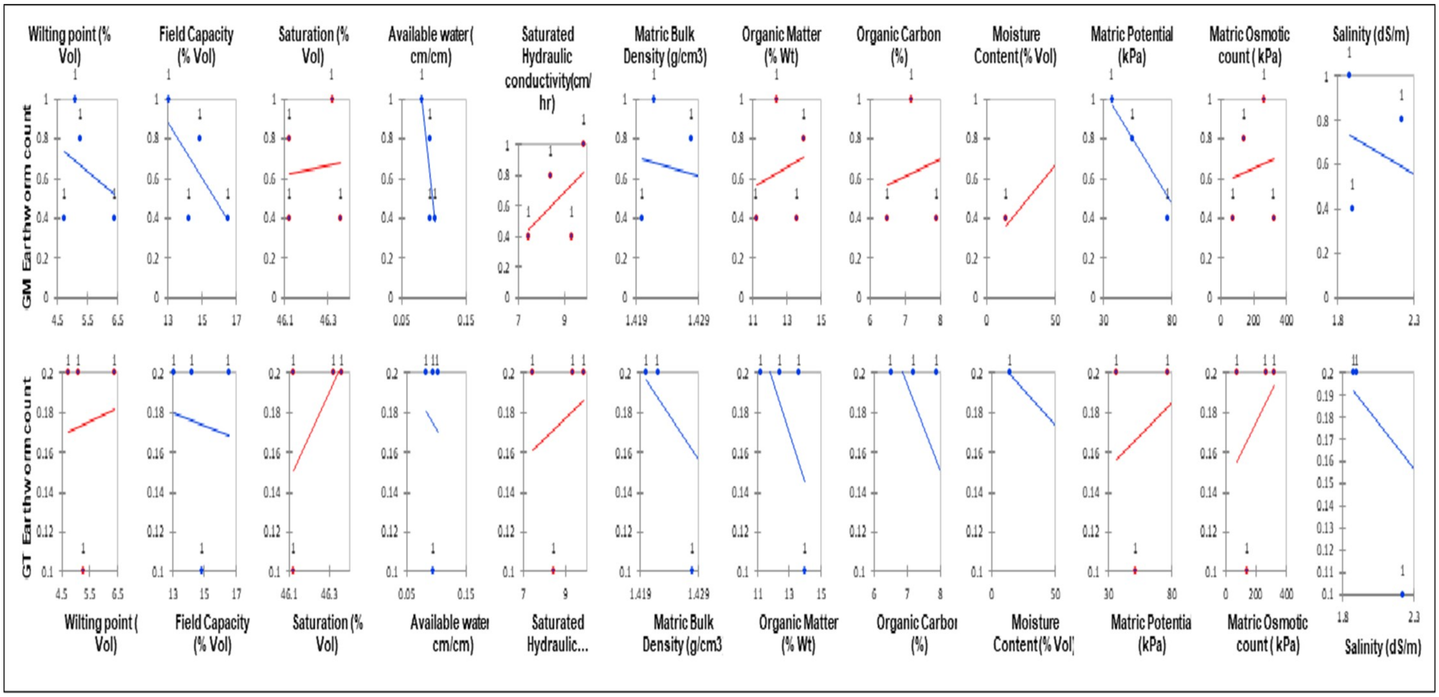
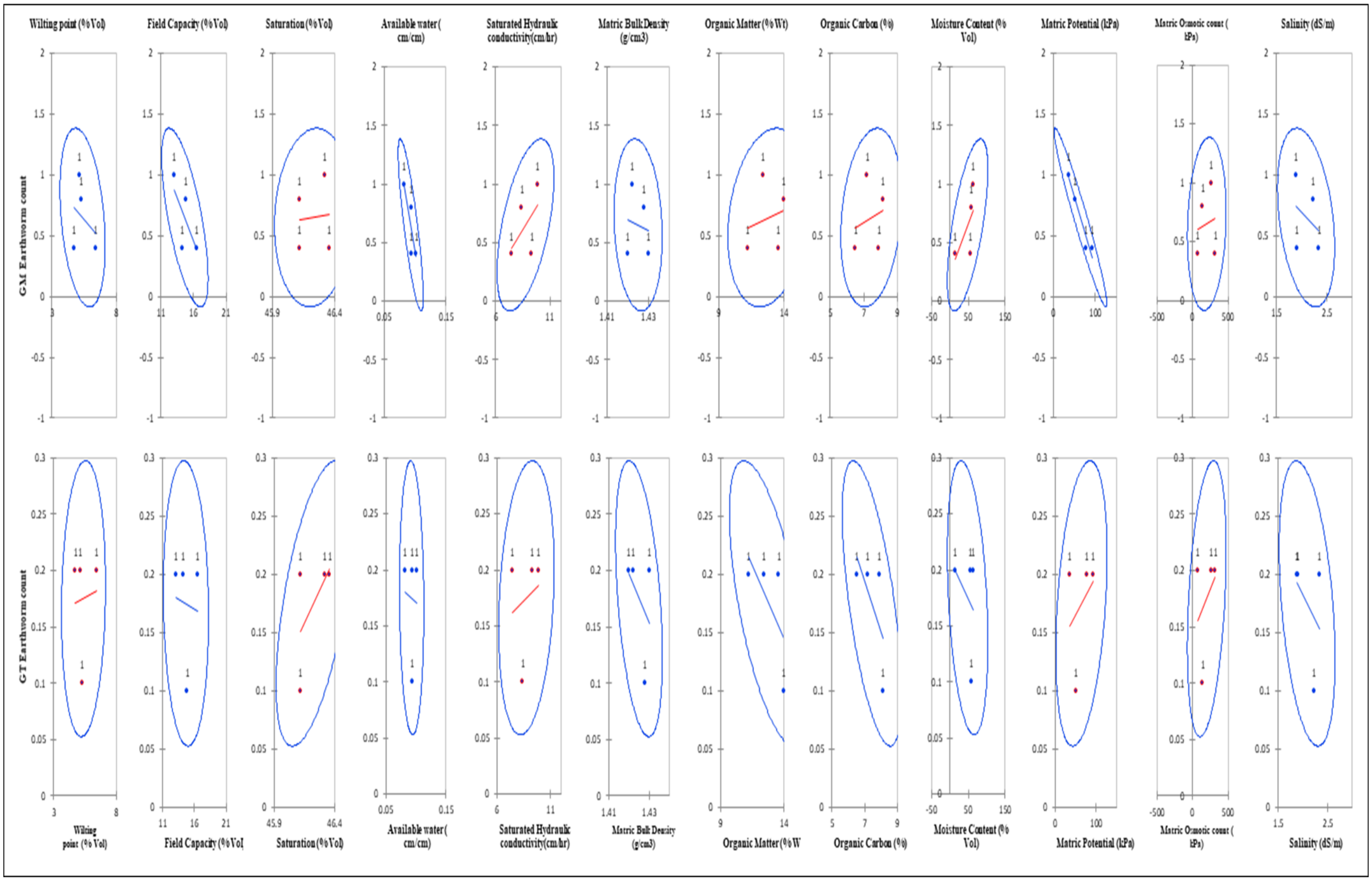


Fig. 6: Variability Influence that exists in using Geotechnical Earthworm count on Earth-system properties on Soil Biodiversity availability



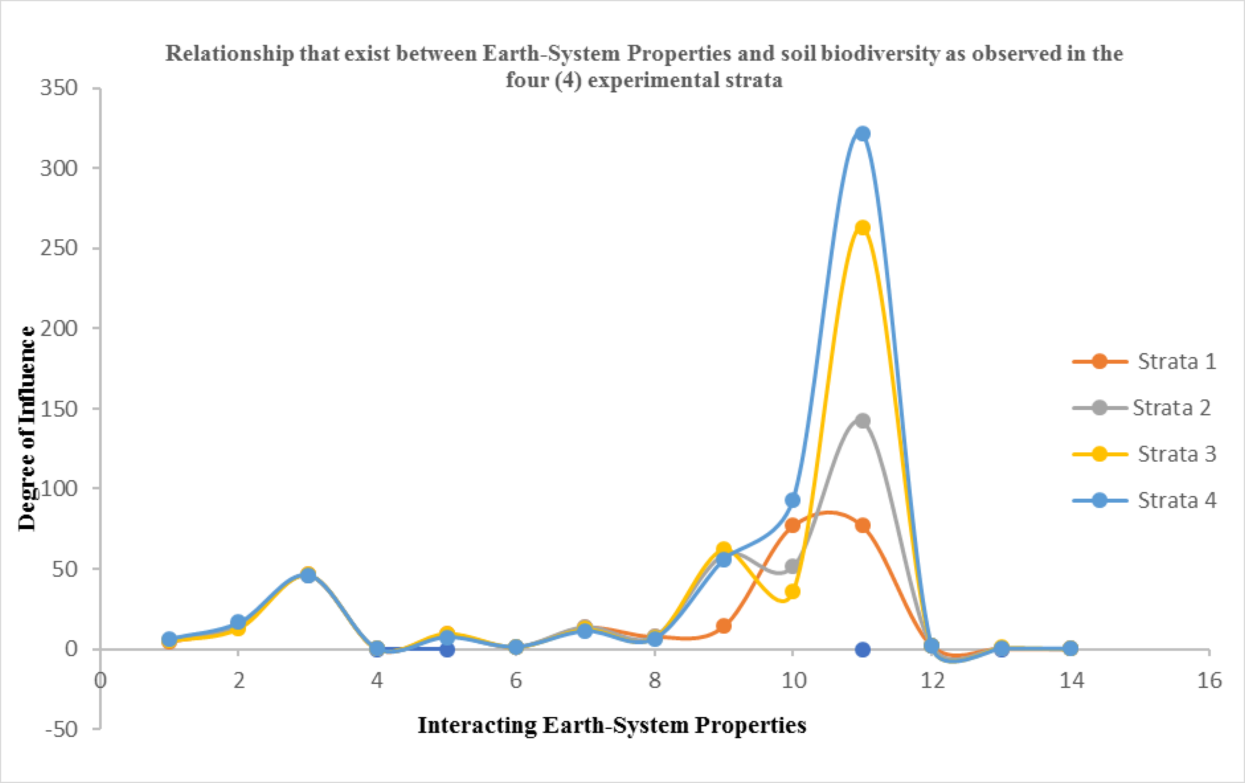
GT = Geotechnical Electronic microscopic view for Earthworm count, GM= Geomorphological microscopic view for Earthworm count
Fig. 7: Variability influence of Earth-System Properties on soil biodiverse



GT = Geotechnical Electronic microscopic view for Earthworm count, GM= Geomorphological microscopic view for Earthworm count Fig. 8: Variability influence of Earth-System Properties on soil biodiverse

*Table: 10: Strata variation that exist between Earth-System Properties and soil biodiversity*

| Mean Strata | Wilting point (% Vol) | Field Capacity (% Vol) | Saturation (% Vol) | Available water ( cm/ cm) | Saturated Hydraulic conductivity (cm/hr) | Matric Bulk Density (g/ cm3) | Organic Matter (% Wt) | Organic Carbon (%) | Moisture Content (% Vol) | Matric Potential (kPa) | Matric Osmotic count ( kPa) | Salinity (dS/ m) | Geomorphological microscopic view for Earthworm count | Geotechnical Electronic microscopic view for Earthworm count |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Strata 1 | 4.72 | 14.22 | 46.36 | 0.09 | 9.32 | 1.42 | 13.60 | 7.89 | 14.26 | 77.00 | 77.00 | 2.34 | 0.40 | 0.20 |
| Strata 2 | 5.26 | 14.88 | 46.12 | 0.09 | 8.41 | 1.43 | 14.00 | 8.12 | 58.96 | 51.40 | 142.20 | 2.22 | 0.80 | 0.10 |
| Strata 3 | 5.10 | 13.06 | 46.32 | 0.08 | 9.87 | 1.42 | 12.40 | 7.19 | 62.60 | 36.00 | 263.40 | 1.88 | 1.00 | 0.20 |
| Strata 4 | 6.38 | 16.54 | 46.12 | 0.10 | 7.43 | 1.43 | 11.20 | 6.50 | 56.00 | 93.20 | 321.80 | 1.90 | 0.40 | 0.20 |
| Mean | 5.37 | 14.68 | 46.23 | 0.09 | 8.76 | 1.43 | 12.80 | 7.42 | 47.96 | 64.40 | 201.10 | 2.09 | 0.65 | 0.18 |
| STD | 0.55 | 1.13 | 0.10 | 0.01 | 0.83 | 0.00 | 0.98 | 0.57 | 17.53 | 19.82 | 86.39 | 0.18 | 0.23 | 0.04 |
| SE | 0.28 | 0.56 | 0.05 | 0.00 | 0.41 | 0.00 | 0.49 | 0.28 | 8.76 | 9.91 | 43.20 | 0.09 | 0.12 | 0.02 |
| CV % | 10 | 8 | 0 | 7 | 9 | 0 | 8 | 8 | 37 | 31 | 43 | 9 | 36 | 22 |



**KEY**: All interacting Earth-System properties were coded as 1=WP, 2=FC, 3=Saturation, 4=A available water, 5 =$K_s$, 6=Matric Bulk density, 7=Organic matter, 8=Organic carbon, 9=Moisture content, 10=Matric potential, 11=Matric osmotic count, 12=Salinity, 13= Geomorphological Earthworm count, 14= Geotechnical Earthworm count

Fig. 9: Strata variation that exists between Earth-System Properties and soil biodiversity

### 3.1.5 Particle Size Distribution (PSD) of Typic Plinthustalf of University of Abuja, Nigeria

The result of the particle size distribution of the area as presented in Table 11 indicated that soils of the area are Loamy Sand, Sandy Loam and Loam soils, with variation impact at 15% for sand, which shows a low variability impact, 30% silt variation which contributed a high potential for the soil-biodiversity availability and variation. However, the clay content variation influence was of the soil was recorded at 53% which indicated a high contributory influence in the build-up of the few soil biodiversity observed in the strata one. At Strata 2, a 9% variation influence was observed to have been contributed by the sand content in soils of the area, which indicated a low contribution to the biodiversity availability of the area. A 16% silt variation influence was observed to have added to the availability of the soil biodiversity of the area. However, this contributory variation impact was moderate. A moderate contributory impact at a value of 31% was found for the clay content observed at Strata 2, indicating that clay particles of the soils at Strata 2 had more impact on the soil biodiversity availability. Contributory impact on soil biodiversity at the tone of CV = 9%, 24% and 27% for sand, silt and clay respectively was observed for the soils at Strata 3 indicating that sand particles in the soils had a low influence on soil biodiversity availability of the area, while silt and clay content of the soil particles contributed moderately to the biodiversity that exist in the soils of the area. Sand and silt fraction of the soil particles at Strata 4 produce a moderate contributory effect on the availability of the soil biodiversity in the strata with a CV value recorded at 19% and 28% respectively. It was observed that clay content at Strata 4 contributed the highest impact on soil biodiversity of the area with a vibration contribution of 49% which stand above all other contributory impacts in soils at Strata 1, 2, and 3 respectively. Results presented for the contribution of the Earth-System property of soil particle sizes indicated that the particles soils of the area have great potentials in the sustainability of the living entities that exist in the soil living system. The outcome of this finding agrees with the research of Chude et al., (2020) which observed soil biodiversity reduction and poor distribution due to the potentials of the soils of the tropics. This finding outcome also aligns with the work FAO (2020) which indicated the soils of the area being one of the major determinants of the biodiversity that could exist in such an area. The research of Adiaha et al., (2020 c) also agrees with the outcome of these findings where the researchers reported the soils of the area contributing to bio-availability of soil organic carbon with tress influence which mitigated carbon dioxide ($CO_2$) content of the area investigated.

*Table 11: Particle Size Distribution (PSD) of Typic Plinthustalf of University of Abuja, Nigeria*

| Experimental Station | Strata | Sand | Silt | Clay | USDA Textural Class |
|---|---|---|---|---|---|
| | | g kg$^{-1}$ | | | |
| ST1 | | 80.3 | 17.5 | 2.2 | Loamy Sand |
| ST2 | | 76 | 22.6 | 1.4 | Loamy Sand |
| ST3 | | 74.5 | 22.4 | 3.2 | Loamy Sand |
| ST4 | | 60.4 | 32.4 | 7.2 | Sandy Loam |
| ST5 | 1 | 50.5 | 42.4 | 7.2 | Loam |
| Mean | | 68 | 27 | 4 | |
| STD | | 10 | 8 | 2 | |
| CV % | | 15 | 30 | 53 | |
| | | | | | |
| ST6 | | 68.4 | 27.4 | 4.2 | Sandy Loam |
| ST7 | | 68.4 | 26.4 | 5.2 | Sandy Loam |
| ST8 | | 74.4 | 23.4 | 2.2 | Loamy Sand |
| ST9 | | 54.4 | 38.4 | 7.2 | Sandy Loam |
| ST10 | 2 | 65.5 | 29.4 | 5.2 | Sandy Loam |
| Mean | | 66 | 29 | 5 | |
| STD | | 6 | 5 | 1 | |
| CV % | | 9 | 16 | 31 | |
| | | | | | |
| ST11 | | 82.7 | 14 | 3.2 | Loamy Sand |
| ST2 | | 74.4 | 23.4 | 2.2 | Loamy Sand |
| ST13 | | 68.4 | 26.4 | 5.2 | Sandy Loam |
| ST14 | | 69.4 | 26.4 | 4.2 | Sandy Loam |
| ST15 | 3 | 64.4 | 31.4 | 4.2 | Sandy Loam |
| Mean | | 72 | 24 | 4 | |
| STD | | 6 | 6 | 1 | |
| CV % | | 9 | 24 | 27 | |
| | | | | | |
| ST16 | | 68.4 | 27.4 | 4.2 | Sandy Loam |
| ST7 | | 76.4 | 20.4 | 3.2 | Loamy Sand |
| ST18 | | 40.4 | 48.4 | 11.2 | Loam |
| ST19 | | 62.5 | 33.4 | 4.2 | Sandy Loam |
| ST20 | 4 | 60.5 | 32.4 | 7.2 | Sandy Loam |
| Mean | | 62 | 32 | 6 | |
| STD | | 12 | 9 | 3 | |
| CV % | | 19 | 28 | 49 | |

ST=Experimental station, SD = Standard deviation, CV = coefficient of variability

*Table 12: Physical Properties of Soil of University of Abuja*

| Strata | Porosity (%) |
|---|---|
| Strata 1 | |
| Station 1 | 21 |
| Station 2 | 25 |
| Station 3 | 17 |
| Station 4 | 38 |
| Station 5 | 38 |
| Strata 2 | |
| Station 6 | 14 |
| Station 7 | 9 |
| Station 8 | 18 |
| Station 9 | 22 |
| Station 10 | 15 |
| Strata 3 | |
| Station 11 | 35 |
| Station 12 | 17 |
| Station 13 | 1 |
| Station 14 | 7 |
| Station 15 | 41 |
| Strata 4 | |
| Station 16 | 18 |
| Station 17 | 2 |
| Station 18 | 13 |
| Station 19 | 12 |
| Station 20 | 14 |
| | |
| X | 18.85 |
| STD | 11.244 |
| CV (%) | 60 |

X=mean, SD = Standard deviation, CV = coefficient of variability, SE = Standard error

### *3.2. Variability in OC-OM-Soil biodiversity in tropical soils of University of Abuja*

The result presented in Fig. 10 shows the variation in the organic carbon-organic matter (OC-OM) in the soil biodiversity of the area. The result shows that the organic matter of the area had a 14% variation influence on the organic and soil biodiversity (Earthworm) in the area, and this influence was observed to have been produced at Strata 2 of the section of the study area investigated.

Organic carbon produced 8.0% influence on the occurrence of the soil biodiversity in the area, this contributory influence was observed at Strata 2, while Strata 1 contributed a close value of 7,9% to the soil biodiversity influence of organic carbon potential toward soil biodiversity flourishing in the area.

It was observed that soil biodiversity (Earthworm count) was near-highest at Strata 2 of the study area as shown in Fig. 10, while Strata 3 gave the highest Earthworm availability in the twenty (20) experimental sites investigated.

It could be stated that  Strata 3 Earthworm count > Strata 2 > Strata 1, while Strata 1 Earthworm count = Strata 2

The difference in the two (2) instruments used (Geotechnical Electronic microscopic and  Geomorphological microscopic) to capture the occurrence/availability of the Earthworm could be said to be the best or highest with the Geomorphological microscopic and hence advice to be used for soil biodiversity investigation. The outcome of this study agrees with the view presented by FAO (2020); Chude et al., (2020) including the research of FAO (2016), where their research stated variation in soil system being a factor in soil biodiversity availability. Report of USDA (2016); Hudson (1992) also align with the view presented in these findings.

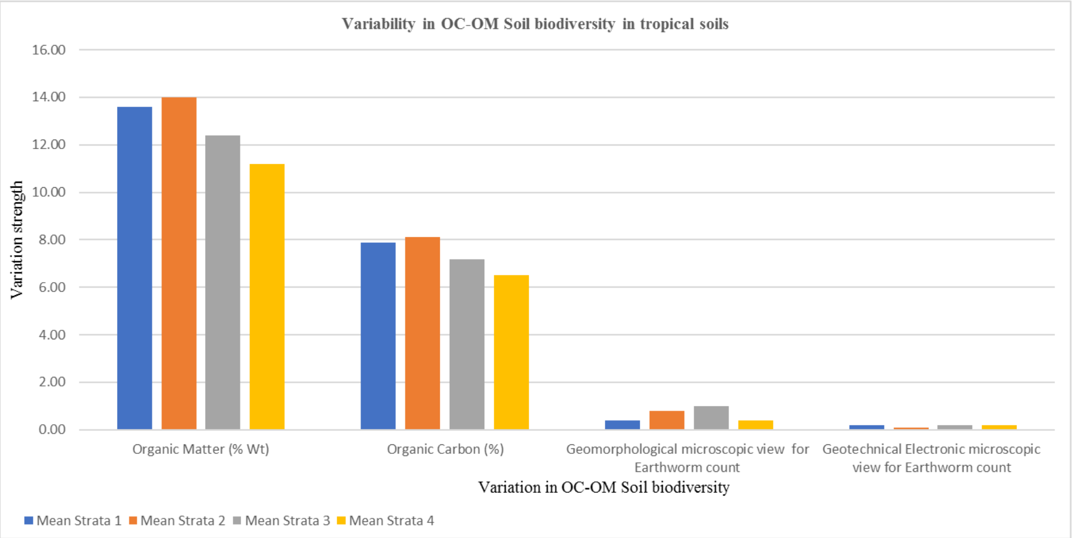


Fig. 10: Variation in OC-OM Soil biodiversity

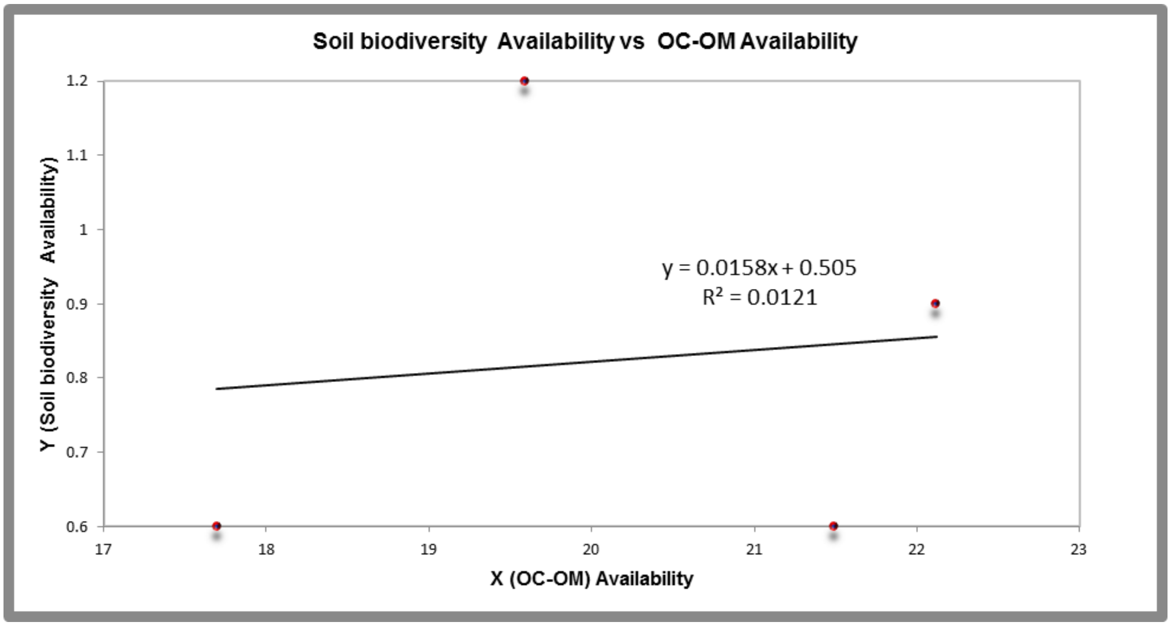


Fig. 11: Variability in OC-OM-Soil biodiversity in tropical soils of University of Abuja

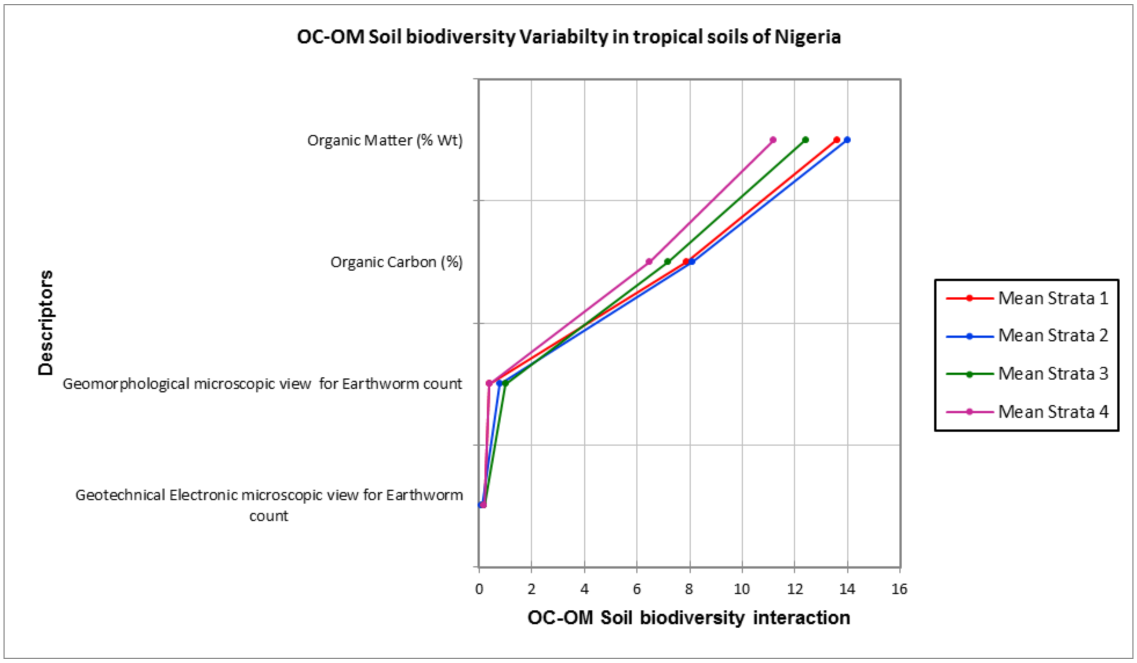


Fig. 12: Variability in OC-OM-Soil biodiversity in tropical soils of University of Abuja

### *3.3. Predicted Future Availability of Soil biodiversity with the Variability in Earth-System Properties of tropical soils of University of Abuja*

The result presented in Table 13 indicates the predicted values for Y- Soil biodiversity using the Earth-system properties. The outcome of the result indicated that there could be a 95.0% prediction intervals for new observations in the loss of soil biodiversity with her associated inhibiting status of the soil properties. A 95.0% confidence intervals exist for the mean of the observed earth properties.

*Table 13: Predicted Future availability of soil biodiversity with the variability in Earth-System Properties of tropical soils of University of Abuja*

| X | Predicted Y | Lower 95% Pred. Limit | Upper 95% Pred. Limit | Lower 95% Conf. Limit | Upper 95% Conf. Limit |
|---|---|---|---|---|---|
| 17.7 | 0.785448 | -1.2234 | 2.7943 | -0.545603 | 2.1165 |
| 22.12 | 0.854683 | -1.01851 | 2.72788 | -0.261146 | 1.97051 |

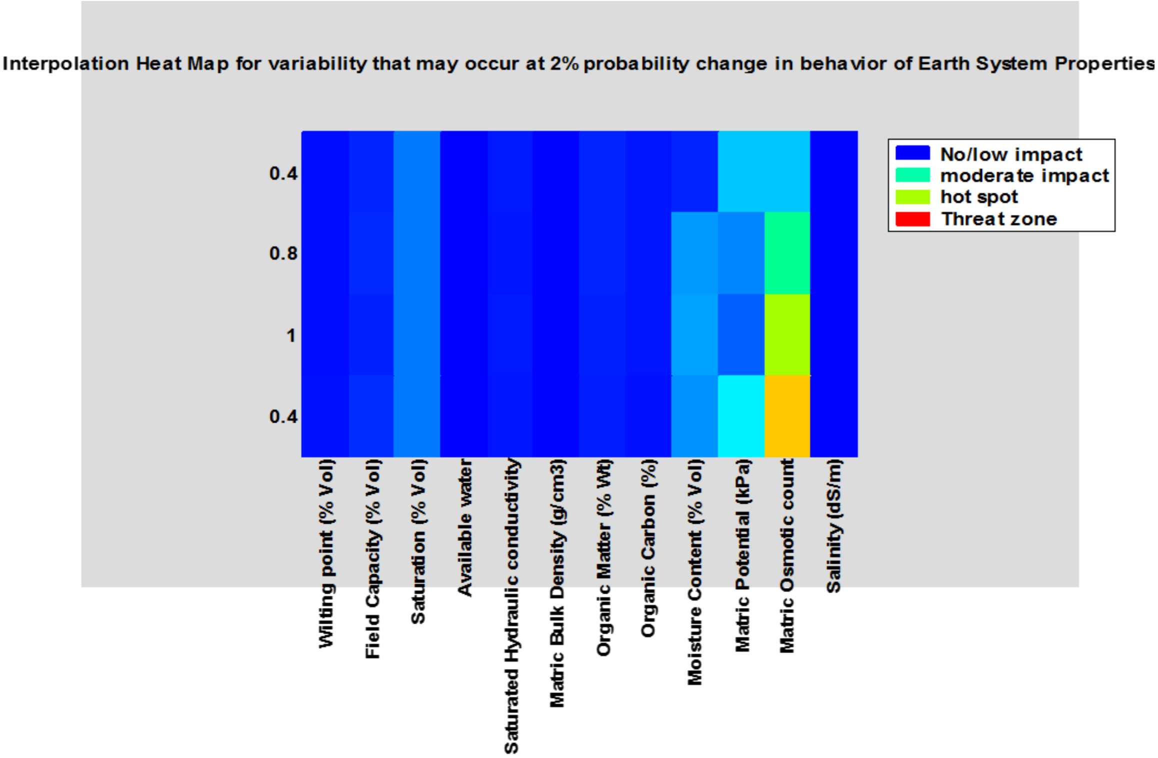


Fig. 12**:** Variability that may occur at ≥ 2% probability change in behavior of Earth System Properties

### *3.4 Variability that may exist in the Future in Soil OC-OM-Soil Biodiversity in the Area*

Result outcome presented in Table 8 indicates the hypothesis test run to determine whether or not to reject the idea that the OC-OM will influence soil biodiversity in the near future revealed that since the P-value is greater than or equal to 0.05, OC-OM and soil biodiversity are independent at the 95.0% confidence level, presenting a view that the Earth System properties: OC-OM has an independent influence on the future variability of soil biodiversity in the area, Therefore, the observed behavior calls for the maintenance of soil fertility and environmental regulation. The outcome of the findings agrees with the findings of Chude et al., (2020) which stated soil impediments including soil compaction is a drawback to the flourishing of soil biodiversity

*Table 14**:** Future Variability in Soil OC-Soil Biodiversity Availability*

| **Test** | **Statistic** | **Df** | **P-Value** |
|---|---|---|---|
| Chi-Square | 0.021 | 3 | 0.9992 |

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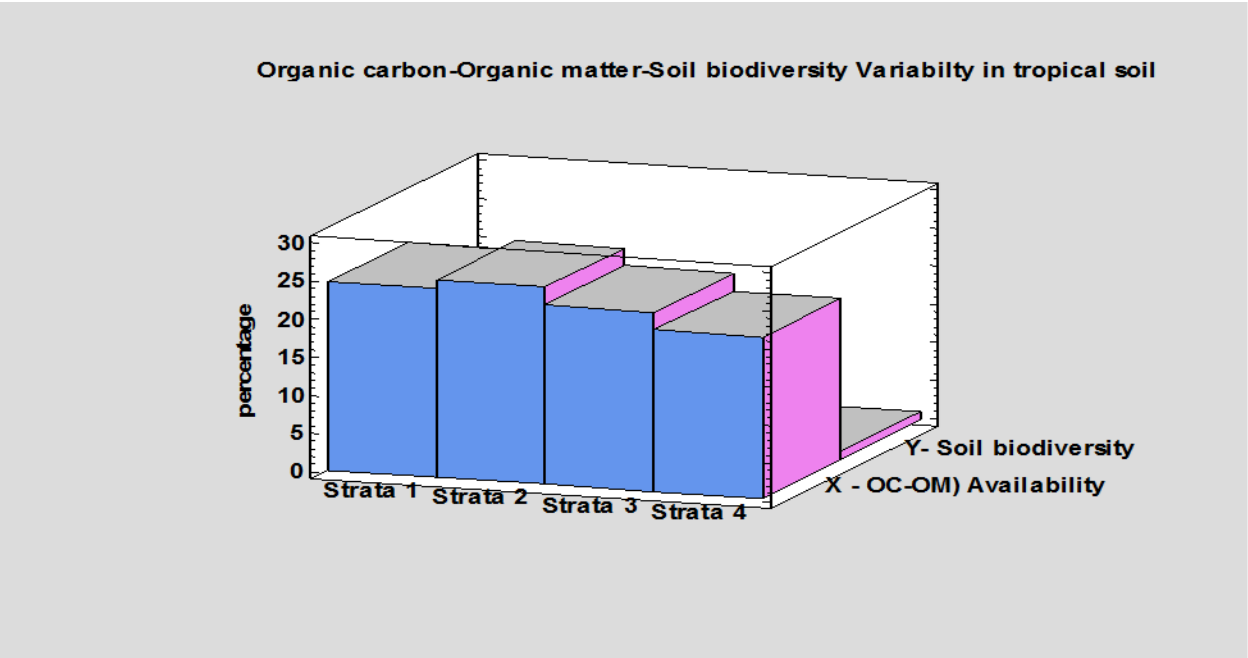

Fig. 13: Future outlook of Organic carbon-organic matter-soil biodiversity variability in tropical soil

### *3.5 Organic Carbon-organic matter-Soil Biodiversity Future Availability frequency distribution in Typic Plinthustalf of tropical soils of University of Abuja*

The result presented in Table 15 shows the observed frequency that exists in the variability of soil biodiversity as influenced by organic carbo-organic matter variation of the Typic Plinthustalf of the area studied. Percentage of variability observed in the area indicates that Strata 2 has the highest variability influence with a percentage value observed at (25.88%), while strata 4 was observed to have the lower percentage recorded at 21.18%. It could be stated that a constant value of 1.18% was observed for soil availability influence in soil biodiversity as impaired by the availability of organic matter-organic carbon nexus. The view presented in this finding agrees with the result of Adiaha et al., (2020) where the scholars reported variability in soil nutrients and its hazard on crop production, human and plant nutrition and health.

Table 15: Future outlook Frequency Distribution of Organic Carbon-Organic Matter-Soil Biodiversity Availability in Typic Plinthustalf of tropical soil

| | X – (OC-OM Availability) | Y- (Soil biodiversity Availability) | Row Total |
|---|---|---|---|
| Strata 1 | 21 | 1 | 22 |
| | 24.71% | 1.18% | 25.88% |
| Strata 2 | 22 | 1 | 23 |
| | 25.88% | 1.18% | 27.06% |
| Strata 3 | 20 | 1 | 21 |
| | 23.53% | 1.18% | 24.71% |
| Strata 4 | 18 | 1 | 19 |
| | 21.18% | 1.18% | 22.35% |
| Total | 81 | 4 | 85 |
| | 95.29% | 4.71% | 100.00% |

## 4.0 conclusion and Recommendation

Results indicated that the soils of the study area are compacted and hence unfit to support sustainable survival of the living entities within the soil system, with soil Bulk density value range at 2.1gcm-3 – 2.71gcm-3. Organic carbon of the area was low. Geotechnical and geomorphological evaluation and interactions revealed low earthworm count in the area, which presented a view that the soils spore is too tight to enable the sustainable flourishing of below and above ground biodiversity in the sites investigated. Hence ecological tool like the use of Vetiver Grass Technology is recommended for the study area environmental regeneration and for breaking compacted areas so as to healing the soils impediment.

Application of soil biodiversity regenerating materials like organic materials including fertilizers and ecological maintenance is strongly recommended as a strategy to mitigate the loss of soil carbon and facilitate the flourishing of soil biodiversity in the area and its environs.

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