



AN INVESTIGATIVE STUDY OF SOIL PHYSICAL PROPERTIES AT SELECTED FARMLANDS IN KWALI AREA COUNCIL, FEDERAL CAPITAL TERRITORY, ABUJA

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Abstract

This study assessed soil physical properties across various farmlands in Kwali Area Council, Abuja, aiming to shed light on sustainable land management practices. Soil physical properties play significant role in the determination of soil suitability for agricultural use, and other purposes. The physical properties of soils influence processes such as nutrient cycling, biological activity, infiltration, and erosion. Both primary and secondary data types and sources were employed in this study. Soil samples were collected from four different crop farmlands with use of soil auger. The farmlands were those of maize, cassava, groundnut, and potato. The collected soil samples were prepared, labeled and taken to laboratory for analysis. Analysis of Variance (ANOVA) statistical tool was used to test for significance difference. The results revealed that maize farmlands were light gray in color, those of cassava farmlands were light brown in color; groundnut farmlands were light grey in color and those of potato farmlands were light brown in color. The highest sand content (61.2g/kg) was recorded on groundnut farmland and the lowest (22.2g/kg) was recorded on potato farmland. The highest silt content (11.2g/kg) was recorded on groundnut farmland and the lowest (9.2g/kg) was recorded on maize farmland. The highest clay content (28.6g/kg) was recorded on cassava farmland and the lowest (16.3g/kg) was recorded on potato farmland. The highest bulk density content (2.5g/kg) was recorded on maize farmland and the lowest (1.1g/kg) was recorded on potato farmland. The highest moisture content (23.4g/kg) was recorded on cassava farmland and the lowest (12.8g/kg) was recorded on potato farmland. The cassava and potato farmlands have no significant variation in soil physical properties at $p > 0.05$. The study recommends that the physical properties of the soil in the study area should be properly managed to protect the soil texture and structure required for agricultural production, likewise the application of agricultural techniques and processing techniques to expand the longstanding efficiency of the soil.

Keywords: Soil, Physical Properties, Farmlands, Land uses, Sustainability, FCT Abuja.

Introduction

Nigeria is an agrarian nation, and majority of the people depend on agriculture in one way or the other for their livelihood. Changes in land use, deforestation, soil erosion, and loss of soil productivity have been brought on by the fast growth of human settlements, industrialization, and agricultural methods (Amusan and Olayiwola, 2019). Due to the changing soil qualities brought on by these land use changes, crop yields, soil fertility, and environmental degradation have all declined. Millions of Nigerians' food security and way of life

are seriously threatened by the decline in soil fertility and productivity (Onwuka *et al.*, 2018).

In order to support life, soil has a variety of components, including organic material, minerals, gases, and liquids. Soil degradation is the term for the physical, chemical, and biological decline of soil quality. It could result from erosion, harmful shifts in salinity, acidity, or alkalinity, hazardous chemicals, pollutants, or excessive flooding, as well as from loss of organic matter, falling soil fertility, deteriorating structural condition, unfavorable flora changes, or acidic or alkaline conditions. Soil physiochemical

properties give the fundamentals for assessing soil quality for a variety of land uses, which is an essential step toward sustainable agriculture and land management (Garandi *et al.*, 2021).

The main factors influencing soil characteristics at regional and continental sizes are climate and geological history. However, the shift of land use types may be the primary driver altering soil characteristics at small watershed areas (Doetterl *et al.*, 2022; Gashaw *et al.*, 2023). Land use and soil management practices affect soil nutrients and related soil processes like erosion, mineralization, and leaching (Abad, *et al.*, 2014). There are numerous types of land use, including built-up, forest/vegetation, agricultural, and others. Land use and management practices have a big impact on natural resources. Some of the more recent and significant effects of land use include desertification, urban sprawl, soil erosion, and degradation (Garandi *et al.*, 2021).

Soil deterioration is one of the largest issues facing civilization right now. More serious than ever, its scale and consequences on the environment and the wellbeing of people worldwide. Political and social unrest are a result of soil degradation because of its profound impacts. It is associated with increased runoff and erosion, increased runoff and deforestation, increased runoff and river pollution, and increased runoff and greenhouse gas emissions.

The essential natural resource for agricultural production, environmental sustainability, and human well-being is soil (Food and Agricultural Organization, 2015). In Nigeria, human activities such as land use change, deforestation, urbanization and industrialization have led to decrease in production as well as soil degradation (Oyewole and Olajide, 2017). As a result of these changes in land use, soil qualities like pH, organic matter content, nutritional status, and water holding capacity have changed (Onwuka *et al.*, 2018). The effects of these modifications on soil fertility, plant development, and productivity eventually have an impact on food security and the way of life for millions of Nigerians (Adewopo and Oyedele, 2019). Due to the soils' use for agricultural production, pasture/range, forestry, and other uses and benefits, they frequently underwent various sorts of degradation (Garandi *et al.*, 2021). There has been substantial land

degradation as a result of widespread land use for all purposes at the expense of its fitness (Ahukaemere *et al.*, 2012). Numerous environmental problems, such as eutrophication, acidification, desertification, and climate change, as well as biodiversity loss and the greenhouse effect, are said to be put at risk by indiscriminate changes in land use (Paul *et al.*, 2019). Therefore, this study assessed the soil physical characteristics under different land uses in Kwali Area Council of the Federal Capital Territory, Abuja with a view to understand the impact of human activities on soil properties, and to proffer ways for sustainable land management practices in the study area.

Materials and Methods

Study Area

Kwali is one of the Area Councils in the Federal Capital Territory, Abuja. It is located between Latitude 8°53'0.46" and Longitude 7°1'6.89" as shown in Fig 1. Kwali Area Council is bounded on the North by Gwagwalada Area Council, the West by Abaji Area Council and to the East by Kuje Area Council. It consists of ten political wards namely Ashara, Dafa, Gumbo, Kilankwa, Kundu, Kwali, Pai, Wako, Yangoji, and Yebu wards (Bello and Akpu, 2022). Its average yearly temperature ranges from 22.8°C to 34.7°C. Due to the heavy cloud cover, the maximum temperature is lower during the rainy season. The daily range is likewise significantly less, rarely exceeding 8 degrees Celsius in July and August. 20% during the dry season and 95% during the wet season are the relative humidity ranges. A dry season from November to March and a wet season from April to October define the research area's climate.

Zonal Tropical Ferruginous soils have produced through the process of laterisation based on the rock types of the Basement Complex. The vegetation is from the southern Guinea Savanna biome, which is characterized by sparsely spaced deciduous trees and grasses. However, some of the places have woods because they have not experienced considerable devegetation, and some of the forests border streams that receive a fair amount of precipitation throughout the year.

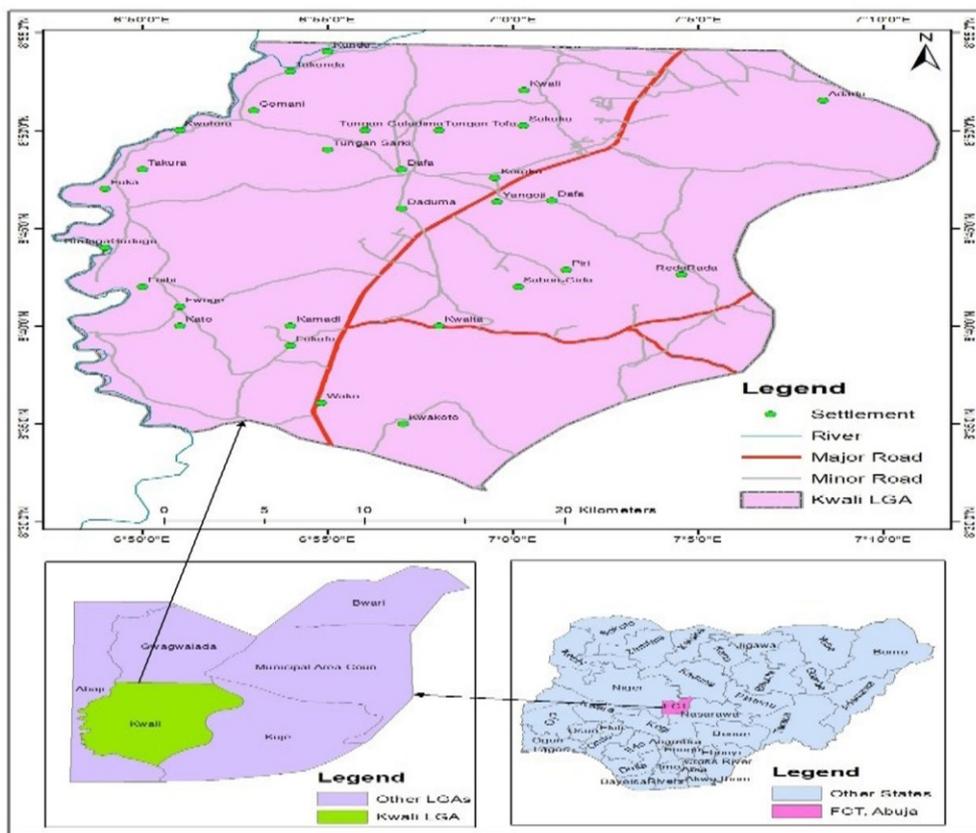


Figure 1: Map of Federal Capital Territory showing the Study Area
 Source: Bello and Akpu, 2022

Table 1: Samples Locations

S/N	Samples	Location	Coordinates
1.	Maize farmland	Kwali	8° 50'26" N, 7°01'18" E
2.	Cassava farmland	Kwali	8°52'11" N, 7°00'16" E
3.	Groundnut farmland	Kwali	8° 50'44" N, 7°01'15" E
4.	Potato farmland	Kwali	8°51'09" N, 7°02'54" E

Source: Field Survey, 2023.

Methods

Reconnaissance survey was carried out to have more understanding and to get familiarized with the study area. The reconnaissance survey was key because it helped in obtaining direct and useful information on the physical and human aspects of the study area and on the subject matter. After visiting and observing the different farmlands in the study area, the following sites were selected: maize farmland, cassava farmland, groundnut farmland and potato farmland (Table 1). GPS was used to determine the locations of the sampling points. Soil samples were collected using soil auger. Top-soils were collected at a depth of 0 – 15cm while sub-soils were collected at a depth of 16 – 30cm and were thoroughly mixed to have composite samples. Four replicate soil samples were

collected at each location. The samples were taken using polythene bags and labeled appropriately. In the laboratory, the collected soil samples were oven dried, gently crushed and sieved through a 2mm mesh for further analysis. The laboratory test was carried out at the Federal University of Technology Minna Laboratory. Soil texture (sand, silt and clay) were tested in the laboratory using the hygrometer method, bulk density and porosity were tested using volume displacement while soil colour was determined using diffuse reflectance spectrophotometers by using instruments to measure the reflectance of light at different wavelengths. ANOVA statistics was done using SPSS software version 23.

Results

Soil Physical Properties of land Use in the Study Area

Table 2 shows the results of the physical properties of soil for maize farmland in the study area. It was revealed that the soil was light grey in colour. The sand content was 30.5g/kg, silt content was 9.2g/kg,

clay content was 18.4g/kg, bulk density was 2.5g/kg, porosity content was 14.5g/kg, while the moisture content was 16.2g/kg.

Table 2: Soil Properties for Maize Farmland

S/N	Soil parameters	Maize	Mean \pm SD
1	Colour	Light grey	-
2	Sand g/kg	30.5	29.2 \pm 1.3
3	Silt g/kg	9.2	8.3 \pm 1.5
4	Clay g/kg	18.4	16.3 \pm 1.11
5	Bulk Density g/kg	2.5	2.2 \pm 0.4
6	Porosity g/kg	14.5	13.2 \pm 1.2
7	Moisture Content g/kg	16.2	15.5 \pm 1.5

Table 3 shows the results of the physical properties of soils for cassava farmland in the study area. The result shows that the soils in cassava farmland was light brown in colour. The sand content was 58.2g/kg, silt content was 10.4g/kg, clay content was 28.6g/kg, bulk density content was 1.9g/kg, porosity content was 26.2g/kg, while the moisture content was 23.4g/kg.

Table 3: Soil Properties for Cassava Farmland

S/N	Soil parameters	Cassava	Mean \pm SD
1	Colour	Light brown	-
2	Sand g/kg	58.2	53.1 \pm 2.2
3	Silt g/kg	10.4	10.2 \pm 1.5
4	Clay g/kg	28.6	27.0 \pm 1.6
5	Bulk Density g/kg	1.9	7.2 \pm 1.3
6	Porosity g/kg	26.2	44.1 \pm 1.2
7	Moisture Content g/kg	23.4	23.8 \pm 1.1

Table 4: Soil Properties for Groundnut Farmland

S/N	Soil parameters	Groundnut	Mean \pm SD
1	Colour	Light gray	-
2	Sand g/kg	61.2	59.2 \pm 1.7
3	Silt g/kg	11.2	9.6 \pm 1.1
4	Clay g/kg	20.2	19.3 \pm 1.7
5	Bulk Density g/kg	2.1	1.9 \pm 1.4
6	Porosity g/kg	24.2	23.1 \pm 1.2
7	Moisture Content g/kg	19.7	18.9 \pm 1.6

Table 4 shows the results of the physical properties of soils for groundnut farmland in the study area. The results revealed that the soil was light grey in colour. The sand content was 61.2g/kg, silt content was 11.2g/kg, clay content was 20.2g/kg, bulk density content was 2.1g/kg, porosity content was 24.2g/kg, while the moisture content was 19.7g/kg.

Table 5 shows the results of the physical properties of soils for potato farmland in the study area. The

results revealed that the soil was light brown in color. The sand content was 22.2g/kg, silt content was 10.2g/kg, clay content was 16.3g/kg, bulk density content was 1.1g/kg, porosity content was 10.6g/kg, while the moisture content was 12.8g/kg. Table 5: Soil Properties for Potato Farmland

Table 5: Soil Properties for Potato Farmland

S/N	Soil parameters	Potato	Mean \pm SD
1	Colour	Light brown	-
2	Sand g/kg	22.2	20.4 \pm 1.1
3	Silt g/kg	10.2	9.7 \pm 1.3
4	Clay g/kg	16.3	15.2 \pm 1.2
5	Bulk Density g/kg	1.1	0.8 \pm 0.2
6	Porosity g/kg	10.6	9.2 \pm 1.1
7	Moisture Content g/kg	12.8	11.1 \pm 1.4

Variations in the Physical Properties of Soil on Land Use in the Study Area

In Table 6, the Analysis of Variance (ANOVA) of the physical properties for maize, cassava, groundnut and potato shows statistical variation among the maize and groundnut farmlands at $p < 0.05$. The cassava and potato farmlands have no significant variations in the soil physical properties, $p > 0.05$.

Comparison of Soil Physical Properties across four Farmlands in the Study Area

Table 7, compares the six (6) soil physical properties (sand, silt, clay, bulk density, porosity, moisture content) of maize farmland, cassava farmland, groundnut farmland and potato farmland. The table shows that in all the four farmlands, the highest value of sand (61.2g/kg) was recorded on groundnut farmland with the lowest (22.2g/kg) on potato farmland. The highest value of silt (11.2g/kg) was recorded on groundnut farmland with the lowest (9.2g/kg) on maize farmland. The highest value of clay (28.6g/kg) was recorded on cassava farmland with the lowest (16.3g/kg) on potato farmland. The highest value of bulk density (2.5g/kg) was recorded on maize farmland with the lowest (1.1g/kg) on potato farmland. The highest value of porosity (26.2g/kg) was recorded on cassava farmland with the lowest (10.6g/kg) on potato farmland. The highest value of moisture content (26.2g/kg) was recorded on cassava farmland with the lowest

Table 6: Mean Variation of Soil Physical Properties over Maize, Cassava, Groundnut and Potato Farmlands

Land Use	Sand g/kg	Silt g/kg	Porosity g/kg	Clay g/kg	BDg/kg	MC g/kg	p-value
Maize	1.4	0.10	2.3	1.5	1.0	2.3	0.01
Cassava	0.5	2.1	1.1	0.7	0.1	1.1	0.11
Groundnut	1.0	0.3	1.3	0.4	2.1	2.0	0.02
Potato	1.1	1.3	0.3	0.2	1.5	1.4	0.13
Mean ± SE	0.4	2.1	1.0	0.1	0.7	1.2	

Source: SPSS Output, 2024.

Table 7: Comparison of Soil Physical Properties across four Farmlands

Farmlands/Soil Parameters	Maize (g/kg)	Cassava (g/kg)	Groundnut (g/kg)	Potato (g/kg)
Sand	30.5	58.2	61.2	22.2
Silt	9.2	10.4	11.2	10.2
Clay	18.4	28.6	20.2	16.3
Bulk density	2.5	1.9	2.1	1.1
Porosity	14.5	26.2	24.2	10.6
Moisture content	16.2	23.4	19.7	12.8

Source: Laboratory Report, 2023

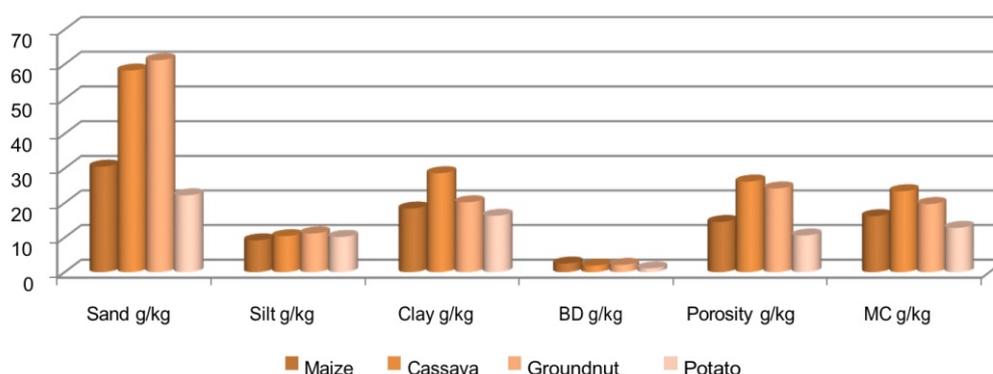


Figure 2: Graphical representation of the physical soil properties for maize, cassava, groundnut and potato farmlands

(12.8g/kg) on maize farmland. The table revealed that across the maize, cassava, groundnut and potato farmlands, the highest value of sand (61.2g/kg) was recorded on groundnut farmland, those of silt (11.2g/kg), clay (28.6g/kg), bulk density (2.5g/kg), porosity (26.2k/kg) and moisture content (23.4g/kg) were recorded on maize, cassava, maize, cassava and also cassava farmlands.

Representation of Physical Soil Properties for Maize, Cassava, Groundnut and Potato Farmlands

Figure 2 shows the graphical representation of physical properties of soils for maize, cassava, groundnut and potato farmlands in the study area. The Fig revealed that the sand contents recorded the highest values among the farmlands while bulk

density recorded the lowest values among the farmlands.

Discussion of Findings

The farmlands used for maize were light grey in colour, those used for cassava were light brown, those used for groundnuts were light grey, and those used for potatoes were light brown. Groundnut farmland had the highest sand concentration (61.2g/kg), whereas potato farmland had the lowest (22.2g/kg). The sand content of the study area recorded the highest values in the four different farmlands. This implies that the soils of the study area have weak structure, high permeability, highly sensitive to compaction, among others. This finding is in consonance with the work of Alghamdi *et al.* (2024),

who noted that sandy soils have high infiltration rate, low aggregate stability, and low moisture retention capacity which account for poor fertility and gloomy effects on biological, chemical, and physical soil properties. The study findings are also in line with findings of Oyetola *et al.* (2021), they observed that sand is the dominant fine earth fraction followed by silt and clay. The soil exhibited an irregular trend in particle size distribution with high proportion of sand which could be attributed to the high rainfall and variation in weathering of parent material.

Farmland with groundnuts had the greatest silt concentration (11.2 g/kg), whereas farmland with maize had the lowest (9.2 g/kg). Silty soils contain sufficient quantities of nutrients, both organic and inorganic. They are usually more fertile than other types of soil, which implies that they are good for growing of crops. The silt content of the study area when compared with that of sand and clay contents was low. Farmland growing cassava had the greatest clay level (28.6g/kg), whereas farmland growing potatoes had the lowest clay content (16.3g/kg). For clay, the soils of the different farmlands in the study area contain clay which are rich in nutrients, trace elements as well as minerals that are beneficial for plant growth. Clay soils provide a powerful base for plants by anchoring roots securely in the soil. Sainju *et al.* (2022) opined that clay accumulation is an important indicator of soil health that facilitates the retention of soil water and nutrients. Farmland growing maize had the highest bulk density content (2.5 g/kg), whereas farmland growing potatoes had the lowest (1.1 g/kg). Bulk density is influenced by natural or pedogenic processes such as mineralogy, texture, soil depth, and anthropogenic factors. It is an important parameter of soil quality. Sainju *et al.* (2022) in their work stated that increased bulk density as a result of soil compaction leads to decrease pore volume that reduces water infiltration, losses mycorrhizal fungi, reduces root growth, increases aeration stress, increases denitrification, and lowers soil temperature and nutrient cycling. Potato farmland had the lowest porosity (10.6g/kg), whereas cassava farming had the greatest (26.2g/kg). Porosity is the most important soil physical property that influences water infiltration and movement. Farmland growing cassava had the highest moisture content (23.4g/kg), whereas farmland growing potatoes had the lowest moisture content (12.8g/kg). There is no discernible difference in the physical characteristics of the soils between the cassava and

potato farms, $p > 0.05$. Among the farmlands, the sand contents recorded the greatest values, while bulk density recorded the lowest values.

Conclusion and Recommendation

The study examined soil physical properties at selected farmlands in Kwali Area Council, FCT-Abuja. The soil physical properties investigated were soil texture (sandy, silty, and clayey), bulk density, porosity, and moisture content among four different farmlands (maize, cassava, groundnut, and potato farmlands) in the study area. ANOVA result shows statistical variation among the maize and groundnut farmlands at $p < 0.05$. The cassava and potato farmlands have no significant variations in the soil physical properties, $p > 0.05$. Also, the result revealed that the sand contents recorded the greatest values in the study area, while bulk density recorded the lowest values. The study recommends that:

- i. The physical properties of the soil in the study area should be properly managed to protect the soil texture and structure required for agricultural production, likewise the application of agricultural techniques and processing techniques to expand the longstanding efficiency of the soil.
- ii. Organic amendments such as compost, manure, and biochar are necessary to improve soil structure, increase soil organic matter content, and enhance nutrient retention capacity. Amending soils with organic matter can significantly improve soil physical properties and promote sustainable land use practices.
- iii. Farmers should be educated on the importance of soil physical properties and appropriate management practices that can lead to better decision-making and improved sustainability outcomes.
- iv. Farming practices that will aid soil organic nutrient and foster soil structure like water leakage, soil aeration, among others should be considered.
- v. Sustainable agricultural practices should be adopted by farmers whereby different agricultural products can be cultivated.
- vi. Farmers should adopt conservation agriculture practices such as minimum tillage, mulching, and crop rotation. These practices will help to

maintain soil structure, reduce soil compaction, and enhance water infiltration, thereby improving soil physical properties and sustainability.

- vii. Monitoring and evaluation programs to assess changes in soil physical properties over time across different land uses should be adopted.

Regular monitoring can help identify trends, evaluate the effectiveness of management practices, and inform decision making for sustainable soil management in Kwali Area Council as well as Nigeria at large.

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