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ASSESSMENT OF THE PHYSICOCHEMICAL PROPERTIES OF SOIL IN FARMLANDS OF BIRNIN YERO, IGABI LOCAL GOVERNMENT AREA, KADUNA STATE, NIGERIA

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ABSTRACT

Globally, soil degradation is widely recognized as a major agricultural and environmental problem. This study assess the physicochemical properties of soil in farmlands in Birnin Yero, Igabi LGA, Kaduna State. Soil samples were collected from different farmlands and analyzed for particle size (sand, silt, and clay), pH, Organic Carbon (OC), Organic Matter (OM), Exchangeable Acidity (EA), Available phosphate (AP), Calcium (Ca), Magnesium (Mg), Potassium (K), and Sodium (Na). The study revealed that soils of the study area are sandy loam and loamy and the acidic pH indicates the need for soil amendments to improve nutrient availability for plant growth. The medium to low levels of OC, OM, and AP highlight the significance of using soil amendments and focused fertilization techniques to improve soil fertility. Correlations between physicochemical properties demonstrated interrelationships, where EA showed a negative correlation with pH, Mg showed a positive correlation with pH and a negative correlation with EA. K showed a positive correlation with AP and EA. Na showed a positive correlation with Ca. OM had a positive correlation with OM. The percentage of sand in the soils had a negative correlation with OC and OM. Silt soils correlated positively with OC. Then clay soils had a positive correlation with OC and OM. It was concluded that soils from the study area can impact water drainage, nutrient retention, and soil fertility. Furthermore, the physicochemical properties indicate that soil amendments and targeted fertilization strategies should be employed to enhance soil fertility.

Keywords: Physicochemical properties, Farmlands, Soil fertility, Soil degradation, Pollutants, Chemical fertilizers, Manure, Pesticides

INTRODUCTION

Soil, a complex mix of water, air, minerals, organic materials, and decomposing life remnants, forms the earth's "skin." This dynamic, living matrix is essential for agricultural production, food security, and sustaining life processes. As a storehouse of microbial biodiversity, soil plays a critical role in soil processes that drive plant productivity (Luo, 2011; Sheikh and Dwivedi, 2017). Although soil is considered one of earth's most valuable resources, it is frequently mishandled, risking degradation (Shokoohi *et al*., 2009; Gokulakrishnan and Balamurugan, 2010). Long-term applications of chemical fertilizers, manure, pesticides, and untreated wastewater in agriculture contaminate soils, altering their physicochemical properties (Salem *et al*., 2020). This accumulation of pollutants poses risks for food safety, surface runoff, and groundwater contamination (Wilson and Pyatt, 2007; Salem *et al*., 2020).

Human activities, including waste disposal, industrial emissions, and agricultural practices, have significantly impacted soils, elevating toxicant levels. The concentration and effects of soil toxicants depend on factors like parent rock, climate, and human activities, and these pollutants may ultimately enter the food chain, affecting human health (Misra and Mani, 2009; Jia *et al*., 2010). Chemical contaminants accumulate in soils, disrupting physicochemical properties and causing environmental pollution with negative impacts on ecosystems (Al-Khashman, 2012; Mtuazi *et al*., 2015). Farmland contamination, often a result of waste disposal, low-quality irrigation, rock weathering, and intensive pesticide and herbicide use, demands urgent attention (Dosumu *et al*., 2005; Khan *et al*., 2008; Zhang *et al*., 2010; Abdulhamid *et al*., 2015).

In farmlands, particularly in northern Nigeria, population growth has intensified soil degradation. Traditional practices of letting farmland rest for natural recuperation have become impractical, with shorter fallow cycles and the elimination of fallowing altogether (Idris, 2018). Practices such as bush burning, excessive fertilizer use, tillage, sewage sludge application, and continuous monocropping have compromised soil health and productivity, depleting fertility and harming crop yield (Yakubu, 2010). Enhanced understanding of soil management is urgently needed to boost agricultural productivity while maintaining soil health and preventing pollution (Pujar *et al*., 2012; Ruqia *et al*., 2015; Njoyim *et al*., 2016). In Birnin Yero community, where the majority of people rely heavily on agricultural produce for their living, this is an urgent concern. The knowledge of physicochemical properties provides limited information about their potential mobility and bioavailability (Bashir *et el*., 2014). Therefore, an effort should be made to understand the interaction of physicochemical properties of the soil in farmlands.

Several works have been conducted on the physicochemical properties of soils in Nigeria. Dawaki *et al.* (2013) focused their study on urban agricultural lands, Inobeme *et al*. (2014) study was on soils around paint industries, Abdulhamid *et al.* (2015) focused their study on content of soil samples from farms in Minna, Osakwe and Okolie (2015) focused on contents in soils and cassava plants from farmlands along a major highway, Abdullahi *et al.* (2016) focus was on seasonal quality of agricultural soils along the bank of tungan kawo dam, Okolo *et al*. (2016) focus was on the effects of industrial effluents on soils in challawa industrial area, Sani *et al*. (2019) focused their study on soil and plants along discharged effluent drainage in sharada industrial area, Mohammed and Yusif (2020) focus was on evaluation of soil fertility for maize production in Tamburawa, Kano, Mohammed and Yusuf (2021) focused their study on assessment of some soil health indicators and their distribution along Salanta River in Kano State, all of which revealed a significant number of concentrations in soils, but none was carried out with a view to comparing soils under different cultivated farmland such as maize, rice and vegetables. This, therefore, leaves a gap that this research intends to fill. Also, the farm practices as stated earlier have been shown to have affected the levels of physicochemical properties in agricultural soils (Odoemelam and Ajunwa, 2008). So, there is a need for frequent monitoring of the levels of physicochemical parameters in farmlands.

This research aims to assess the physicochemical properties of soil in farmlands in the Birnin Yero area of Igabi Local Government Area, Kaduna State, to understand the soil quality and fertility of cultivated farmlands in the study area.

MATERIALS AND METHODS

Study Area

Birnin-Yero is a village located in Igabi Local Government Area (LGA) of Kaduna State and situated within latitude 10° 48' 0.65"N and Longitude 7° 34' 56.36"E (Fig 1). Igabi LGA is one of the 23 local government areas in Kaduna State and was created in 1989 out of the Zaria Local Government in Kaduna State, which covers an area of about 445,659sq km. The LGA is made up of 12 wards namely: Afaka, Birnin Yero, Gadan, Gayan, Gwaraji, Igabi, Kerawa, Kwarau, Rigachikun, Rigasa, Sabon Birnin Daji, Turunku, Zangon Aya.

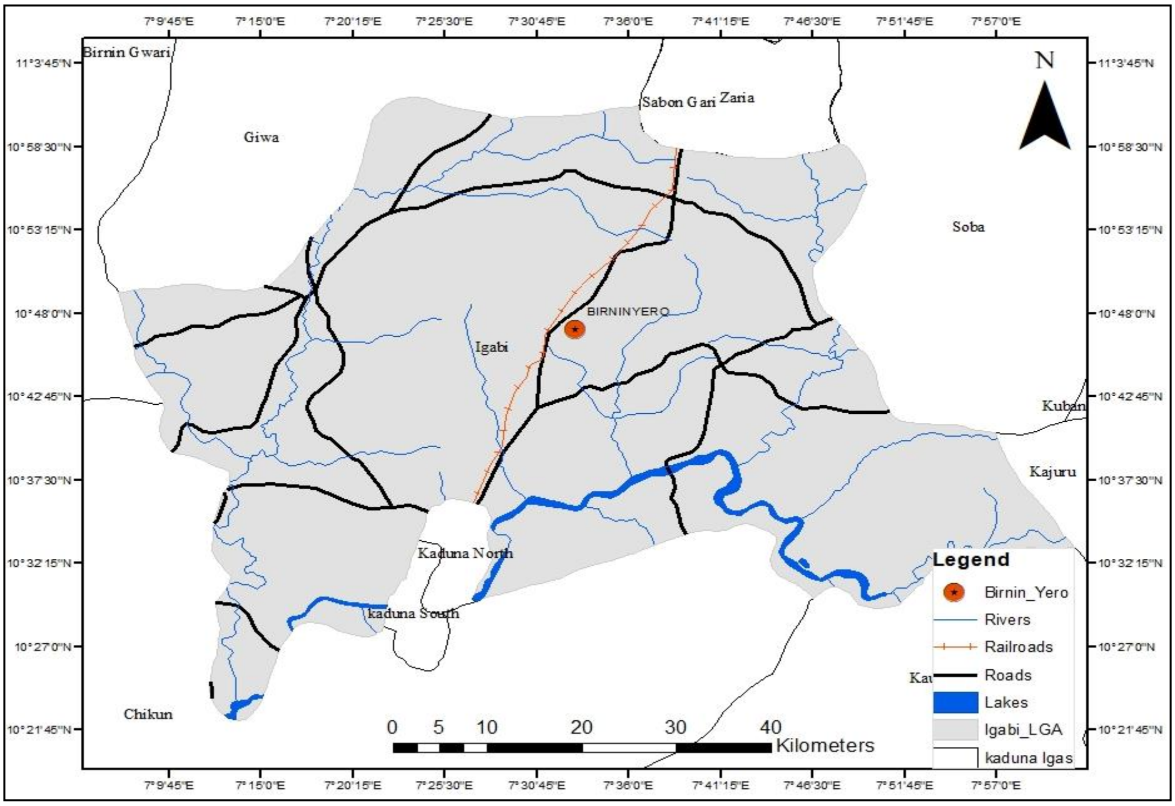

Figure. 1: Igabi Local Government Area Showing the Study Area
Source: Adapted from the Administrative Map of Kaduna State

The vegetation cover of the study area is uniform and monotonous typical of the Northern Guinea Savanna Zone. It contains three vegetation sub-types such as; *Isoberlinia doka* woodland grassland, Gallery or riparian vegetation, Shrub land composed of trees – shrub association (Green, 2007). The soil types of the study area correspond closely with the vegetation belts of the Guinea savanna which extends from east to west of Kaduna metropolis. Except for highland areas, with high temperatures which promote active chemical and biological changes in the soil. There are a few outcrops and some fossilized literate hills in the study area. Soil types include; sandy loams and a little clay in valleys (Oyedele, 2011).

Materials

The materials used in this study include a Global Positioning System (GPS) for recording coordinates of sampling points as shown in Table 1, measuring tape for measuring distance, a soil auger for collecting soil samples at specific depths, polythene bags for storing soil samples collected, pH meter for soil pH determination, basic laboratory equipment, reagent and glass wares were used for determining other physicochemical properties.

Table 1: Location of Soil Samples Collected from the Study Area

Code	Latitude	Longitude	Code	Latitude	Longitude
M1	10°45’15.996’’N	7°29’40.296’’E	R4	10°45’24.99’’N	7°29’36.996’’E
M2	10°45’16.974’’N	7°29’42.726’’E	V1	10°45’15.108’’N	7°29’39.408’’E
M3	10°46’50.61’’N	7°30’55.38’’E	V2	10°45’21.174’’N	7°29’48.156’’E
M4	10°46’49.368’’N	7°30’54.54’’E	V3	10°45’12.648’’N	7°29’40.758’’E
R1	10°45’16.656’’N	7°29’37.818’’E	V4	10°45’17.76’’N	7°29’41.298’’E
R2	10°45’15.678’’N	7°29’35.88’’E	C1	10°45’9.93’’N	7°29’41.244’’E
R3	10°45’23.082’’N	7°29’48.33’’E			

Source: Field Survey, 2023
M=Maize Farmland, V=Vegetable Farmland, R=Rice Farmland, C=Control

Sampling Technique

The farmlands were purposively selected based on the crops cultivated in the area. This technique was chosen because the study focused on selecting maize, rice and vegetable farms which are scattered around the study area.

Method of Sample Collection

Soil sample collection was conducted in January 2023. The surface of the soil was cleared with a hand trowel and soil samples were taken at a depth of approximately 0-15cm using a sharp-edged and closed circular auger (soil sampler) pushed manually down the soil profile. After every collection, the hand trowel and auger were washed and rinsed with distilled water to avoid sample contamination (Awofolu, 2005). The collected samples were stored in polyethene bags, labelled appropriately and taken to the laboratory at Soil Science Lab Bayero University New Site Kano within the standard time limit.

Laboratory Procedure

The collected soil samples from the designated farmlands were prepared for analysis by removing visible debris and stones, air-dried at room temperature to remove moisture, ground into fine powder and then sieved through a 2mm sieve.

Determination of Soil pH

The determination was done using standard procedure as reported by Estefan *et al*. (2013).

Determination of Organic Carbon (OC)

The OC was determined using the prepared soil samples which were weighed into a combustion tube. A combustion tube was connected to a carbon analyzer to combust the soil at high temperatures to convert the organic carbon to carbon dioxide (CO_2). The released CO_2 was measured using gas chromatography. Organic carbon content was then determined based on the measured CO_2 concentration (Haluschak, 2006; Estefan *et al*., 2013).

Determination of Organic Matter (OM)

The Walkely Black method was used to determine the percentage of organic matter in all samples of soil. A 10g of soil was weighed into a crucible and heated the soil sample in a muffle furnace at 550°C for 4 hours to combust the organic matter. After combustion, the crucible was cooled in a desiccator to room temperature. The crucible and the remaining residue (ash) were weighed using an analytical balance. OM content was calculated as the difference between the initial weight of the soil sample and the weight of the remaining ash (Roper *et al*., 2019).

Determination of Exchangeable Acidity (Ex.A)

The prepared amount of soil samples was weighed into a beaker. 1M of KCl is added to the beaker and stirred gently. The soil-extraction solution mixture was allowed to stand for 30 minutes to extract the Ex.A. The pH of the extracted solution was measured using a calibrated pH meter. Ex.A was calculated based on the pH value and the specific conversion factors (Robertson *et al*., 1999).

Determination of Available phosphate (AP)

AP was determined using portions of the prepared soil samples which were weighed into a beaker. A 0.5M of NaHCO3 extraction solution was added to the beaker and stirred gently. The soil-extraction solution mixture was allowed for 30 minutes to extract the AP which was filtered using a filter paper. The concentration of AP in the filtered extract was measured using colorimetry (Haluschak, 2006).

Determination of Calcium (Ca) and Magnesium (Mg)

The prepared soil samples were weighed in an appropriate amount in a beaker. 1m ammonium acetate was added into the beaker and stirred gently. The soil-extraction solution mixture was allowed to stand for 30 minutes to extract the Ca and Mg using filter paper. The concentration of Ca and Mg in the filtered extract was measured using atomic absorption spectroscopy (Haluschak, 2006; Estefan *et al*., 2013).

Determination of Potassium (K) and Sodium (Na)

The prepared soil samples were weighed in an appropriate amount in a beaker and1M ammonium acetate was added into the beaker and stirred gently. The soil-extraction solution mixture was allowed to stand for 30 minutes to extract the K and Na using filter paper. The concentration of K and Na in the filtered extract was measured using flame photometry (Estefan *et al*., 2013).

Determination of Particle Size (Sand, Silt, and Clay)

A separate portion of the collected soil samples from the designated farmlands was prepared by removing any visible debris or stones from the soil samples and air-drying them at room temperature. Clumps and large aggregates were gently crushed and sieved using a 2 mm sieve. An appropriate amount of soil sample 100 grams was weighed into a beaker, and distilled water was added to the soil sample in the beaker to fully saturate it and mix thoroughly to ensure proper dispersion. The soil-water mixture was transferred into a measuring sedimentation cylinder, filling it up to 1000 mL. The soil-water suspension was allowed to settle for 24 hours, in a stable environment without disturbance, after which the height of each of the sedimentation zones (sand, silt, and clay) was measured using a ruler. The percentage of each particle size fraction was calculated (sand, silt, and clay) using Stokes' Law (Gee and Or, 2002; Estefan *et al*., 2013).

Data Analysis

One-way ANOVA was used to determine if there was a significant variation between the physicochemical properties of soil from the farmlands and the control site. Also, the results from the laboratory analysis were compared with the Food and Agriculture Organization (FAO) and World Health Organization (WHO) standards for soil quality. The variability of physicochemical properties of soils among the farmlands was achieved using Analysis of Variance (ANOVA) to compare the means of the three groups of soil samples from maize, rice and vegetable farmlands in SPSS Version 25 tested at 0.05 level of significance. In determining the relationships between the physicochemical properties of soils in the study area, Pearson Moment Correlation Analysis was deployed to identify and correlate how soil properties influence one another using SPSS.

RESULTS AND DISCUSSION

Physicochemical Properties of Soils in Selected Farmlands within the Study Area

Soil Particle Size

The particle size and texture of soil from farmlands in Table 2. revealed that maize farmlands have a mean value of 46.5%, 39.5%, and 14% for sand, silt and clay respectively which can be categorized as a loamy textural class. Rice farmlands indicated mean values of 38%, 45.75%, and 16.25% for sand, silt and clay respectively referred to as a loamy textural class. Vegetable farmlands indicated mean values of 52.75%, 35.75%, and 11.75% for sand, silt and clay respectively and categorized as sandy loam textural class. The control site showed 44%, 47% and 9%, for sand, silt and clay respectively and referred to as loamy textural class.

Table 2: Particle Size and Texture of Soil from Farmlands

ID	Values	Sand	Silt	Clay	Textural Class
		←	(%)	→	
	Min	36	35	9	
	Max	52	43	21	
M	Mean	46.5	39.5	14	Loam
	±SD	7.12	2.96	4.58	
	CV	15.32	7.49	32.73	
	Min	30	43	9	
	Max	44	47	27	
R	Mean	38	45.75	16.25	Loam
	±SD	5.10	1.64	6.68	
	CV	13.42	3.58	41.14	
	Min	52	31	5	
	Max	54	43	15	
V	Mean	52.75	35.75	11.75	Sandy loam
	±SD	0.83	4.55	4.09	
	CV	1.57	12.72	34.77	
Cont.		44	47	9	Loam

Source: Laboratory Result, 2023

M=Maize Farmland, V=Vegetable Farmland, R=Rice Farmland, Cont.=Control, Min.=Minimum Max.=Maximum, SD=Standard Deviation, CV=Coefficient of Variation

The entire soil collected from maize, and rice farmlands and the control showed that the soils are of loamy textural class, except soils from vegetable farmlands are of sandy loamy textural class as indicated in Table 2. This implies that the majority of the farmlands investigated, including maize, rice, and the control, have soils classified as loamy which are generally considered to be agriculturally favourable due to their balanced composition of sand, silt, and clay.

The variation in particle size for soil samples in Fig 2.1. showed that the percentage of sand in soil samples is highest at 52.75% in vegetable farms, and the lowest at 38% in rice farms. The silt percentage is highest at 45.75% in rice farms and the lowest at 35.75% in vegetable farms. While clay content in the soil samples is highest at 16.25% in rice farms and lowest in the control at 9%.

Based on the results, the vegetable farms have the highest percentage of sand, which suggests relatively lower water-holding capacity, higher permeability, and potentially higher leaching potential. The rice farms have the highest percentage of clay, indicating higher water-holding capacity, lower permeability, and potentially lower leaching potential. These differences in particle size distribution can impact the porosity and bulk density of the soils in each farm type.

Table 3: Physicochemical Properties of Soil from Farmlands

ID	Values	Sand	Silt	Clay	O.C	O.M	pH	P	Ex.A	Ca	Mg	K	Na
		←		(%)	→		(H_2O)	(mg/kg)	←		(cmol/kg)	→	
M	Min.	36	35	9	0.57	0.98	4.56	15.33	1.33	1.09	1.56	0.13	0.16
	Max.	54	43	21	0.93	1.60	5.41	20.37	3.17	2.08	2.11	0.22	0.33
	Mean	46.5	39.5	14	0.76	1.24	4.93	17.85	2.39	1.59	1.79	0.19	0.21
	±SD	7.12	2.96	4.58	0.13	0.23	0.31	1.83	0.68	0.42	0.21	0.04	0.07
	CV	15.32	7.49	32.73	17.28	18.35	6.29	10.26	28.42	26.67	11.78	18.61	33.16
R	Min.	30	43	9	0.88	1.51	4.73	8.35	1.5	1.64	1.01	0.13	0.29
	Max.	44	47	27	1.66	2.87	5.66	10.37	2.83	1.97	2.63	0.21	0.33
	Mean	38	45.75	16.25	1.20	2.01	4.99	9.77	2.30	1.75	2.00	0.16	0.31
	±SD	5.10	1.64	6.68	0.29	0.51	0.39	0.82	0.49	0.13	0.60	0.03	0.01
	CV	13.42	3.58	41.14	24.17	25.57	7.8	8.42	21.46	7.49	30.02	21.04	4.81
V	Min.	52	31	5	0.63	1.11	4.32	7.25	1.82	1.66	1.45	0.15	0.23
	Max.	54	43	15	0.88	1.51	5.07	28.17	3.33	2.06	2.32	0.39	0.3
	Mean	52.75	35.75	11.75	0.72	1.25	4.77	14.10	2.54	1.89	2.02	0.22	0.27
	±SD	0.83	4.55	4.09	0.09	0.16	0.28	8.23	0.55	0.15	0.34	0.10	0.02
	CV	1.57	12.72	34.77	13.03	12.5	5.84	58.4	21.5	7.74	16.84	43.73	9.3
Cont.		44	47	9	1.05	1.80	5.15	8.44	0.83	2.13	1.29	0.35	0.23

Source: Author's Analysis, 2023

M=Maize Farmland, V=Vegetable Farmland, R=Rice Farmland, Cont.=Control, Min.=Minimum Max.=Maximum, SD=Standard Deviation, CV=Coefficient of Variation

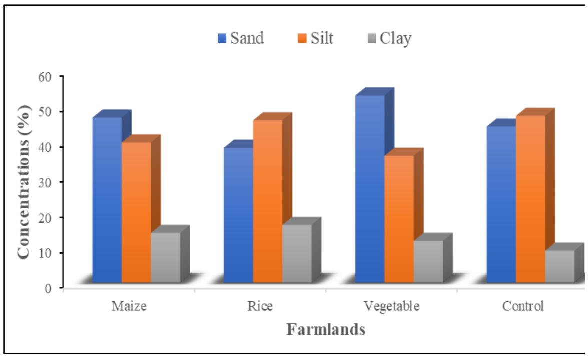

Figure 2.1: Distribution of Particle Size Distribution in Soil

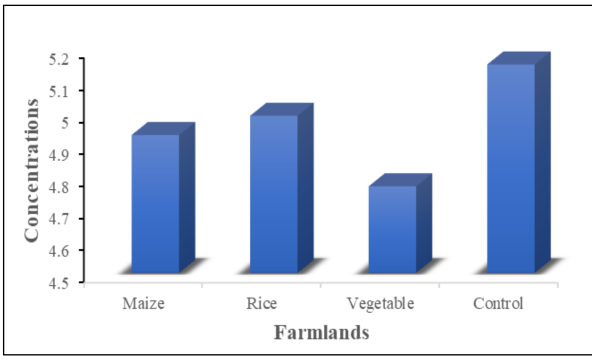

Figure 2.2: Distribution of pH Level in Soil

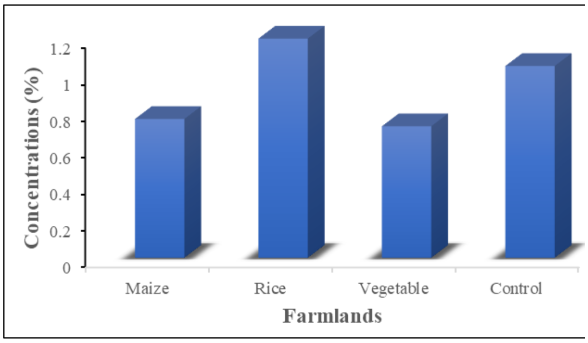

Figure 2.3: Distribution of Organic Carbon Level in Soil

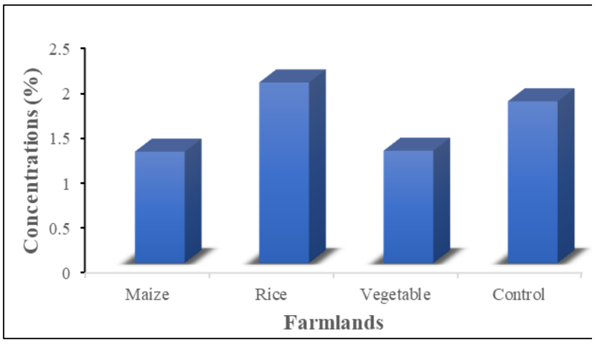

Figure 2.4: Distribution of Organic Matter Level in Soil

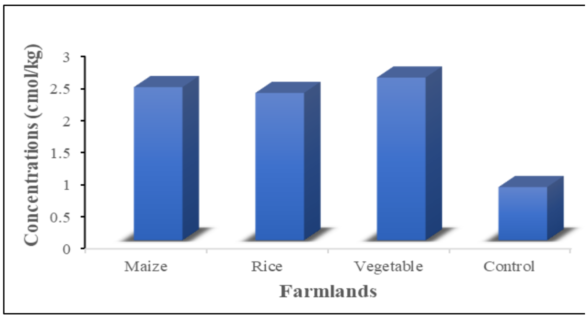

Figure 2.5: Distribution of Exchangeable Acidity Level in Soil

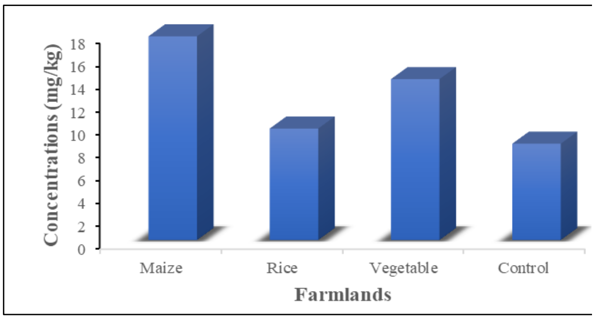

Figure 2.6: Distribution of Available Phosphorous Level in Soil

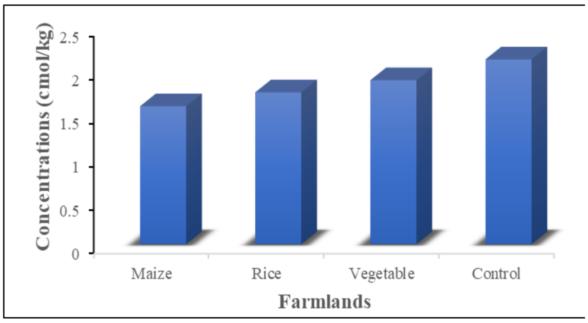

Figure 2.7: Distribution of Calcium Level in Soil

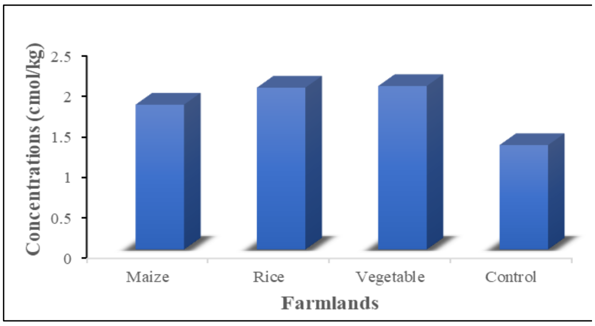

Figure 2.8: Distribution of Magnesium Level in Soil

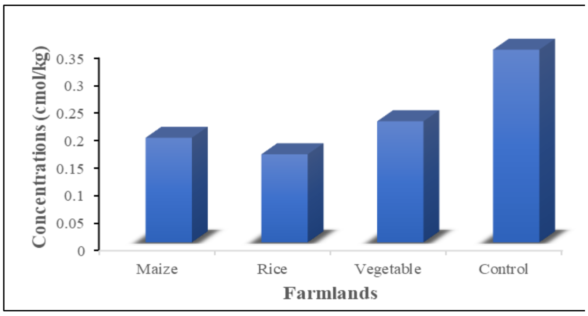

Figure 2.9: Distribution of Potassium Level in Soil

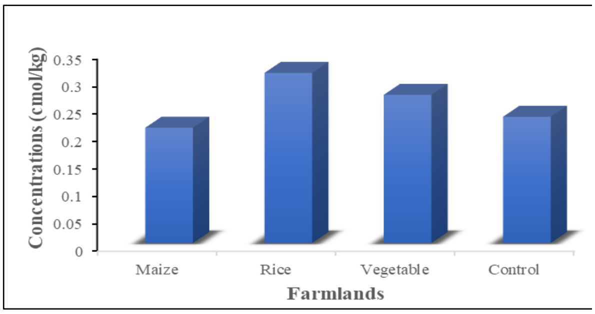

Figure 2.10: Distribution of Sodium Level in Soil

Soil pH

The pH values of the soil samples ranged between 4.56-5.41 for maize farmlands, 4.73-5.66 for rice farmlands, and 4.32-5.07 for vegetable farmlands. The mean values of soil pH levels showed 4.93, 4.99, and 4.77 in Maize, Rice, and vegetable farmlands while 5.15 in the control soil sample (Fig. 2.2). This is an indication that the level of pH is highest in control soils and lowest in vegetable farmlands. The pH value of the soils from the farmlands is low based on the description by Landon (1991) who explained that a pH of <5.5 indicates a low pH value. The result generally indicates that the soil from the study area is acidic which could be attributed to the use of fertilizers and irrigation practices. The pH levels are seen to be within levels that can enhance solubility and availability of some soil micronutrients affecting various soil processes, including nutrient reactions, microbial activity, and mineral dissolution. This is explained by Penn and Camberato (2019) who indicated that low pH values can give some indication of the potential availability of soil micronutrients. Also, Okeke *et al*., (2020) stated that soil pH is correlated with the availability of nutrients to plants.

Organic Carbon (OC)

The organic carbon from the samples ranges between 0.57-0.93%, 0.88-1.66%, and 0.63-0.88% for maize, rice and vegetable farmlands respectively. The distribution of organic carbon in soil showed mean values of 0.76%, 1.20%, and 0.72% in maize, rice and vegetable farmlands respectively and 1.05% in the control site (Fig. 2.3). The result generally indicates that the soils from rice farms have significantly high values in control sites. Based on the categorization of organic carbon contents by Landon (1991) soils in this study ranged from very low to medium organic carbon content. These levels of organic carbon are in significant amounts which influences the source of nutrients for soil microorganisms and in turn, mineralizes organic matter and releases nutrients in forms that plants can take up. It also influences nutrient solubility by enhancing the retention and release of nutrients in the soil. Therefore, soils with higher organic carbon content generally have better nutrient solubility and accessibility for plant uptake. This is explained by Bationo *et al*. (2007) who explained that soil organic carbon is simultaneously a source and sink for nutrients and plays a vital role in soil fertility maintenance. This is also in agreement with the study of Sainepo *et al*. (2018) who indicated soil organic carbon to be within the range that influences soil health and fertility.

Soil Organic Matter (OM)

The Organic Matter in soils from the study area ranges between 0.98-1.60%, 1.51-2.87%, and 1.11-1.51% for maize, rice and vegetable farmlands respectively. The highest mean percentage of soil Organic Matter 2.01% in rice soil and the lowest 1.24% in maize farmlands within the study area were observed (Fig. 2.4). The result generally indicates that the soil from the rice farms has more organic matter content compared to others which are in correlation with soil organic carbon and clay content. Based on the categorization of Landon (1991), all soils in the study had medium organic matter content. The soil organic matter content is within levels that influence essential nutrients, unexcelled capacity to hold water and absorb cations, as well as carbon sequestration. It also influences the availability of food sources for soil microbes, thereby helping enhance and control their activities. This is explained by Abdulhamid *et al*. (2015); Dan *et al*. (2018); Adeleka and Alawode (2011) who identified how soil organic matter content enhances the usefulness of soils for agricultural purposes.

Exchangeable Acidity (EA)

The exchangeable acidity for the study area ranges from 1.33-3.17cmol/kg, 1.50-2.83cmol/kg, and 1.82-3.33cmol/kg for maize, rice and vegetable farmlands respectively. The result revealed a higher mean concentration of 2.54cmol/kg of exchangeable acidity in vegetable farms and the lowest 0.83 cmol/kg in the control site within the study area (Fig. 2.5). According to Moore (2001), the exchangeable acidity levels of soils from cultivated farmlands are rated very high. Also, the higher concentrations as indicated can be attributed to the acidic nature of the soil from the cultivated farmlands.

Available Phosphorous (AP)

The AP from the soil in the sample farmlands ranges from 15.33-20.37mg/kg, 8.35-10.37mg/kg, and 7.25-28.17mg/kg for maize, rice and vegetable farmlands respectively. The higher mean concentration of available phosphorous 17.85mg/kg in soil from maize farms and the lowest 8.44mg/kg in the control site within the study area are evident (Fig. 2.6). Based on the categorization by Landon (1991), the soils from the study area range between medium to low concentration with maize farms having the highest and the lowest seen in the control site. This implies that AP of the soil from the various farmlands is in medium to low concentrations thereby impacting poorly on plant growth, root, seed and fruit development. This is in agreement with Dandwate (2020) who reported similar values.

Exchangeable Calcium (Ca)

The exchangeable calcium in the sampled soils for the study ranged between 1.09-2.08cmol/kg, 1.75-0.13cmol/kg, and 1.66-2.06cmol/kg for maize, rice and vegetable farmlands respectively. The gradual increase in the mean concentration of calcium from 1.59cmol/kg in Maize farmland to 2.13cmol/kg in the control site was observed (Fig. 2.7). According to Landon (1991), categorization levels of exchangeable calcium indicated that the concentration is considered as low. This could be attributed to the acidic nature of the soil from the various farmlands. As indicated by Brown *et al*. (2002) the result of calcium concentration implies a low calcium supply to plants which may result in poor plant growth since calcium ions strengthen plant cell membranes and cell walls and are essential for cell elongation and division.

Exchangeable Magnesium (Mg)

The exchangeable magnesium in the sampled soils for the study to range between 1.56-2.11cmol/kg, 1.01-2.63cmol/kg, and 1.45-2.32cmol/kg for maize, rice and vegetable farmlands respectively. The highest mean values of 2.00cmol/kg and 2.02cmol/kg was observed in rice and vegetable farmlands, while the lowest 1.29cmol/kg was recorded for the control sample (Fig. 2.8). According to the categorization by Landon (1991), all soils in the study area are of adequate magnesium levels. This suggests that these agricultural areas have suitable magnesium concentrations for supporting plant growth and development. This is not in tandem with Oluwatuyi *et al.* (2020) where magnesium concentrations were found to be way higher to levels of 36-72mg/kg for soils around dumpsites.

Exchangeable Potassium (K)

The exchangeable potassium content from the soils ranges between 0.13-0.22cmol/kg, 0.13-0.21cmol/kg and 0.15-0.39cmol/kg for maize, rice, and vegetable farmlands respectively. The distribution of potassium levels in rice farms indicated the lowest mean concentration of 0.16cmol/kg, while the control samples indicated the highest mean concentration of 0.35cmol/kg (Fig. 2.9). According to the categorization by Landon (1991), all soils from the farmlands had medium to high exchangeable potassium. The potassium concentration is within levels that influence water uptake through roots and water loss from stomata and trigger the activation of many growth-related enzymes in plants. This is explained by Marschner (2012); and Dandwate (2020) who described potassium in the soil as a major nutrient for the production of superior-quality crops.

Exchangeable Sodium (Na)

The exchangeable sodium concentration in soils from the farmlands ranges between 0.16-0.33cmol/kg, 0.29-0.33cmol/kg, and 0.23-0.30cmol/kg for maize, rice, and vegetable farmlands respectively. The distribution of sodium levels in rice farmland indicated the highest mean concentration of 0.31cmol/kg of exchangeable sodium while the soils from maize farmland indicated the lowest concentration of 0.21cmol/kg (Fig. 2.10). Based on the categorization by Landon (1991), the distribution of sodium levels in soil from the farmlands is of low range. The concentration of sodium is within trace amounts that may not be harmful to plants. This is explained by Edwin *et al*. (2022) who believe that the buildup of sodium in plants causes toxic levels that cause stunted growth and arrested cell development.

Variability of Physicochemical Properties of Soils Among the Farmlands

The result from the Duncan Multiple Range Test is shown in Table 4. which generally indicated no statistically significant variation ($P>0.05$) for parameters such as pH, AP, EA, Ca, Mg, K, Na and clay. Significant differences ($P<0.05$) were observed for organic carbon, organic matter, sand and silt parameters. Organic carbon and organic matter had significantly higher mean percentages in soils from rice farmlands 1.200±0.335 and 2.010±0.593 respectively than in soils from maize and vegetable farmlands. The mean percentage of sand in the soil samples was significantly higher in vegetable 52.750±0.957 and maize 46.500±8.226 farmlands. A significantly higher percentage of silt was recorded for soils from rice 45.750±1.893 farmlands compared to a decrease found in soils from maize 39.500±3.416 and vegetable 35.750±5.252 farmlands. The results suggest that the studied farmland types (rice, maize, and vegetable) exhibit significant differences in terms of sodium concentration, organic carbon, organic matter content, sand and silt percentage. These variations can have implications for soil fertility, water management, and overall crop production.

Table 4: Distribution of Physicochemical Parameters Among Crops Farmland

Parameters	Maize	Rice	Vegetable
pH	4.928±0.358^{a}	4.988±0.449^{a}	4.765±0.321^{a}
P	17.850±2.112^{a}	9.768±0.950^{a}	14.098±9.507^{a}
Ex.A	2.385±0.783^{a}	2.295±0.569^{a}	2.543±0.631^{a}
Ca	1.593±0.490^{a}	1.748±0.151^{a}	1.888±0.169^{a}
Mg	1.793±0.244^{a}	2.000±0.693^{a}	2.023±0.393^{a}
K	0.190±0.041^{a}	0.163±0.039^{a}	0.223±0.112^{a}
Na	0.210±0.080^{a}	0.308±0.017^{b}	0.268±0.029^{ab}
OC	0.755±0.151^{a}	1.200±0.335^{b}	0.723±0.109^{a}
OM	1.240±0.263^{a}	2.010±0.593^{b}	1.245±0.180^{a}
Sand	46.500±8.226^{ab}	38.000±5.888^{a}	52.750±0.957^{b}
Silt	39.500±3.416^{a}	45.750±1.893^{b}	35.750±5.252^{a}
Clay	14.000±5.292^{a}	16.250±7.719^{a}	11.750±4.717^{a}

Values are mean ± SD of three farmlands. Mean values with different superscripts across the row differ significantly ($p<0.05$).

The result presented in Table 5 shows the summary of the Sum of Squares; Mean square; degree of freedom; F-ratio of variation between groups and p-value computed. The level of significance (p-values) was compared with an alpha value of 0.05. The results from the ANOVA analysis suggest that there are significant differences ($p < 0.05$) in farmlands for organic carbon, organic matter, sand, and silt, indicating variations in soil organic content and texture. However, there are no significant differences ($p > 0.05$) for parameters such as pH, phosphorus, exchangeable acidity, calcium, magnesium, potassium, sodium, and clay, suggesting that these characteristics are relatively consistent across the sampled farmlands. The noticeable significant variations in organic carbon, organic matter, and soil texture among farmlands may be attributed to the distinct soil management practices, including the use of fertilizers, organic amendments, crop residue incorporation, and tillage methods.

Table 5: Variability of Physicochemical Parameters

Parameters	Sources of Variation	Df	Sum of Squares	Mean Square	F- ratio	P- value
pH	Farmlands	2	0.106	0.053	0.367	0.703
AP	Farmlands	2	130.876	65.438	2.050	0.185
EA	Farmlands	2	0.126	0.063	0.141	0.870
Ca	Farmlands	2	0.174	0.087	0.895	0.442
Mg	Farmlands	2	0.129	0.064	0.278	0.764
K	Farmlands	2	0.007	0.004	0.683	0.529
Na	Farmlands	2	0.019	0.010	3.801	0.064
OC	Farmlands	2	0.569	0.285	5.822	0.024
OM	Farmlands	2	1.571	0.785	5.197	0.032
Sand	Farmlands	2	438.500	219.250	6.370	0.019
Silt	Farmlands	2	204.167	102.083	7.150	0.014
Clay	Farmlands	2	40.500	20.250	0.553	0.594

Relationships Between the Physicochemical Properties of Soils

Correlation of the Various Levels of Some Physicochemical Properties

The correlation coefficients of physicochemical concentrations in the soil from farmlands in the study area are shown in Table 6. The result presented showed pH having a strong negative correlation with EA (r= -0.827) and a weak positive correlation with Mg (r= 0.616). The strong negative correlation between pH and EA suggests that as the pH of the soil decreases (becomes more acidic), the level of exchangeable acidity increases. This indicates that soil acidity, as reflected by the pH value, is closely associated with the presence of exchangeable acidic ions in the soil, such as hydrogen ions (H+). The weak positive correlation between pH and Mg suggests that as the pH of the soil increases (becomes more alkaline or less acidic), the concentration of Mg tends to increase slightly. This indicates that magnesium availability in the soil may be influenced by pH levels. Higher pH values in the soil can enhance the solubility and availability of magnesium, which is an essential nutrient for plant growth and development.

The level of AP showed a strong positive correlation with K (r= 0.701). The strong positive correlation suggests that as the level of AP increases in the soil, the concentration of K also tends to increase. The positive correlation between AP and K implies that soil fertility plays a role in the availability of these nutrients. Soils with higher levels of available phosphorus may also have higher levels of potassium, indicating the potential for nutrient-rich and fertile soils. This is particularly important for supporting optimal plant growth and crop productivity.

The level of EA showed a weak negative correlation with Ca (r= -0.653) and a weak positive correlation with Mg (r= 0.622). The weak negative correlation suggests that as the level of EA increases, the concentration of Ca in the soil tends to decrease slightly. This indicates that EA may influence the availability or retention of Ca in the soil. The weak positive correlation suggests that as the level of EA increases, the concentration of Mg in the soil also tends to increase slightly. This implies that higher EA levels can impact the pH of the soil, potentially influencing the solubility and availability of calcium and magnesium for plant uptake.

The concentration of Ca showed a weak positive correlation with Na (r= 0.582). The weak positive correlation suggests that as the concentration of sodium increases in the soil, the concentration of calcium also tends to increase slightly. This indicates that there may be an association between sodium and calcium levels in the soil, although the correlation is relatively weak, which suggests that soil salinity may influence the availability or dynamics of calcium in the soil.

The percentage of OC showed a strong positive correlation with OM (r= 0.985), and a weak positive correlation with Silt (r= 0.583) and Clay (r= 0.675). While a strong negative correlation with Sand (r= -0.873). The strong positive correlation between organic carbon and organic matter (r = 0.985) indicates a close relationship between these two parameters. The strong positive correlation suggests that as organic carbon content increases, organic matter content also increases proportionally. This indicates that higher levels of organic carbon contribute to greater organic matter content in the soil. The weak positive correlation between organic carbon and silt suggests that as the percentage of silt in the soil increases, the organic carbon content also tends to increase slightly. The weak positive correlation between organic carbon and clay indicates that as the percentage of clay in the soil increases, the organic carbon content also tends to increase slightly. The strong negative correlation between organic carbon and sand suggests that as the percentage of sand in the soil increases, the organic carbon content decreases significantly. The correlations between organic carbon and particle size fractions indicate that soil texture plays a role in organic carbon retention. Soils with higher proportions of silt and clay tend to have higher organic carbon content due to their larger surface area and greater capacity to hold and protect organic matter. On the other hand, sandy soils with a higher proportion of sand have a lower capacity to retain organic carbon, resulting in lower organic carbon content.

The percentage of OM showed a strong negative correlation with Sand (r= -0.838) and a weak positive correlation with Clay (r= 0.667). The strong negative correlation suggests that soils with a higher proportion of sand are likely to have lower organic matter content. As the percentage of sand in the soil increases, the organic matter content tends to decrease significantly. The weak positive correlation between organic matter and clay suggests that as the percentage of clay in the soil increases, the organic matter content also tends to increase slightly. Clay particles have a high surface area and a strong affinity for organic matter. This can positively influence soil fertility, nutrient availability, moisture retention, and overall soil health.

The percentage of Sand showed a strong negative correlation with Silt (r= -0.708) and a strong positive correlation with Clay (r= -0.737). The strong negative correlation between sand and silt indicates as the percentage of sand in the soil increases, the percentage of silt tends to decrease, and vice versa. It suggests that soils with a higher proportion of sand are likely to have a lower proportion of silt, and vice versa. This can impact soil structure, water-holding capacity, nutrient retention, and overall soil fertility. The strong positive correlation between sand and clay suggests a direct relationship between these two particle size fractions. As the percentage of sand in the soil increases, the percentage of clay also tends to increase, and vice versa, which implies that sandy soils, with their larger particle size, tend to have lower water-holding capacity and reduced nutrient retention compared to clayey soils.

Table 6: Correlation Coefficients of Some Physicochemical Parameters in Soil

Parameters	pH	AP	EA	Ca	Mg	K	Na	OC	OM	Sand	Silt	Clay
pH	1											
AP	-0.414	1										
EA	-0.827**	0.338	1									
Ca	0.284	-0.403	-0.225	1								
Mg	0.616*	-0.427	-0.653*	0.242	1							
K	-0.483	0.701*	0.622*	0.013	-0.521	1						
Na	0.366	-0.515	-0.455	0.582*	0.272	-0.195	1					
OC	0.012	-0.309	0.244	0.157	-0.396	0.141	0.383	1				
OM	0.020	-0.314	0.221	0.262	-0.399	0.138	0.419	0.985**	1			
Sand	-0.064	0.352	-0.282	0.025	0.282	0.057	-0.047	-0.873**	-0.838**	1		
Silt	-0.056	0.057	0.212	-0.365	-0.092	0.076	-0.053	0.583*	0.542	-0.708*	1	
Clay	0.144	-0.564	0.199	0.318	-0.303	-0.158	0.119	0.675*	0.667*	-0.737**	0.046	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Discussion

The levels of physicochemical properties of soil from the selected (maize, rice and vegetable) farmlands in the study area indicated the following; The results of this study revealed distinct differences in soil particle size distribution among the various farmlands, specifically, the vegetable farms exhibited the highest percentage of sand, implying a soil texture characterized by coarser particles. This indicates relatively lower water-holding capacity, higher permeability, and potentially higher leaching potential in these soils. On the other hand, the rice farms showed the highest percentage of clay, indicating a finer soil texture. This suggests a higher water-holding capacity, lower permeability, and potentially lower leaching potential compared to the vegetable farms. These variations in particle size distribution have significant implications for the physical properties of the soils in each farmland type. This is in line with the study of Akinde *et al* (2020) who identified similar characteristics among different landuse types.

Soil pH values indicate that the soil from the study area is acidic which could be attributed to the use of fertilizers, irrigation practices and intense cultivation. However, the pH values in this study area are in line with the pH values reported by Akinde *et al* (2020); and Ugwa *et al* (2022), and therefore concluded that this level is acceptable for crop cultivation in the tropics where the soil may be subjected to regular leaching of bases and often replenished by crop residues. Soil organic carbon and organic matter generally indicate low to medium contents and higher amounts in soils were seen in rice farmlands. The low to medium amounts can be attributed to the practice of burning dry plants/stalks after harvest. This is in agreement with the study of Obalum *et al* (2012) who reported low to medium organic matter and organic carbon content in soils. The level of exchangeable acidity (EA) shows a very high concentration in all soils from the farmlands. The highest value was seen in vegetable farms and the lowest in control samples within the study area. The higher concentrations as indicated can be attributed to intense cultivation activities and the increased soil acidity.

The finding corroborates with the results reported by Omoruyi *et al* (2021) in studies carried out in Kogi state. AP indicated medium to low concentrations for all soils from the farmlands. Higher values were recorded for soil samples from maize farms and lowest in control samples within the study area. The higher concentrations in soils from maize farms as indicated can be attributed to the intense use of inorganic fertilizers for maize cultivation such as NPK. The result corroborates with the earlier results reported by Chude *et al* (2011) where the available phosphorous values in the location are considered moderate as they are within the allowable range for most commonly cultivated crops. Exchangeable bases investigated include Ca, Mg, K and Na. The exchangeable calcium in soils showed low values in all the soils but values under uncultivated lands were higher as compared to maize, rice and vegetable farmlands.

Similar to the results of Kaiser *et al* (2016), Mg from this study showed adequate values for soils in rice and vegetable farmlands, while the lowest was recorded for uncultivated soils. Similar to the study of Adeoye *et al* (2001), K values showed a low to medium range from soils in the study area. Rice farms showed lower values while the uncultivated soils indicated a higher concentration. The values for Na showed a low to medium range, where the soils from rice farms had higher concentrations, while the soils from maize farmland indicated lower values. This was explained by Amusan *et al* (2006) that the low level of exchangeable bases within acceptable limits in these soils could be attributed to leaching processes, increased pH levels resulting from the high sand and silt proportion in the area and intense cultivation carried out. The results from the exchangeable bases investigated corroborate with the study of Abdulhamid *et al* (2015) where similar results were revealed.

The comparison of physicochemical parameters between soils from maize, rice, and vegetable farmlands indicated significantly higher levels of organic carbon, organic matter, and silt in rice farmlands indicating improved soil fertility and organic content in these areas. This is likely due to the cultivation practices associated with rice farming, such as the addition of organic amendments or the retention of crop residues. These factors contribute to enhanced soil nutrient content, water-holding capacity, and overall soil health. The significantly higher percentage of sand in soil samples from maize and vegetable farmlands suggests that these soils have a coarser texture and lower water-holding capacity. Coarser-textured soils with higher sand content tend to drain water more rapidly, potentially requiring additional irrigation or management practices to ensure proper moisture retention for plant growth.

The relationship between the physicochemical properties of the soil in the study area identified the following; The relationship suggests that as the pH of the soil increases, the exchangeable acidity decreases. Also, as exchangeable acidity increases, the availability of Mg in the soil decreases but K increases. This relationship highlights the influence of soil acidity on nutrient availability. The relationship between sand in the soil and OC/OM suggests that as the sand content increases, the levels of OC and OM tend to decrease. This is because coarser-textured soils with higher sand content typically have lower organic matter retention capacity, leading to reduced carbon and OM accumulation. The result from the study also indicated a positive correlation between K and AP, Na and Ca. While they are essential nutrients for plants, excessive levels can have detrimental effects on soil structure and fertility. Balancing their levels is important to maintain optimal soil conditions for plant growth. The positive correlation between OM and OC indicated that with increasing soil OM, the OC content tends to increase supporting soil microorganisms crucial for improving soil fertility, water-holding capacity, and nutrient retention. Promoting the accumulation of OM or OC through practices like organic amendments and cover cropping can improve soil health and overall productivity. Also, in terms of their relationship with soil particle size distribution, suggests that finer-textured soils with higher silt or clay content tend to have higher levels of organic carbon and organic matter. This is because finer particles provide more surface area for organic matter retention and can better hold moisture and nutrients. This conforms to the findings of Tsozue *et al* (2016) who showed correlations between soil physicochemical properties interfered with nutrient availability.

CONCLUSION

Based on the findings of this study, it is concluded that soils from the study area are generally sandy loam and loamy, which can impact water drainage, nutrient retention, and soil fertility. The acidic soil could be attributed to the use of fertilizers and irrigation practices. Furthermore, the medium to low levels of OC, OM and AP indicate that soil amendments and targeted fertilization strategies should be employed to enhance soil fertility. The significant differences observed in OC, OM, and the percentage of sand, highlight the variations among the different farmlands and may influence crop suitability and nutrient management. These findings emphasize the importance of site-specific approaches to optimize soil fertility, minimize contamination risks, and support sustainable agricultural practices in the study area. Since the soils in the study area were found to be slightly acidic, it is recommended to conduct soil pH testing regularly and adjust pH levels as necessary. Liming materials can be applied to raise soil pH and improve nutrient availability for optimal crop growth. Additionally, targeted fertilization strategies should be adopted based on soil nutrient levels and crop requirements to ensure balanced nutrient supply. Farmers should be encouraged to adopt sustainable agricultural practices, such as conservation tillage, cover cropping, and integrated pest management, to enhance soil health and reduce environmental impacts. Further studies are recommended to explore the long-term effects of soil management practices on soil health and nutrient dynamics.

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