

Effects of Land Uses on Physicochemical Properties of Soil in Kano Metropolis, Northern Nigeria

Aisha M. Ali¹, Muhammad Ali^{2*}, Abubakar U. Zage³ and Alabira K. Salisu⁴

¹Department of Crop Sciences, Kano University of Science and Technology Wudil, Kano, Nigeria

²Department of Microbiology, Federal University Gusau, Nigeria

³Department of Microbiology, Kano University of Science and Technology Wudil, Kano, Nigeria

⁴Department of Geography, Kano State College of Education and Preliminary Studies, Nigeria

*Corresponding Author: Muhammad Ali, Department of Microbiology, Federal University Gusau, Nigeria, Email: alimuhd4real@gmail.com

ABSTRACT

The research was intended for comparative study of some physical (Texture, soil moisture, soil air, water holding capacity, and bulk density) and chemical properties (pH, Electric conductivity, Organic Carbon, organic matter content, Available Phosphorous, Exchangeable Sodium, Potassium, Calcium and Magnesium) of different soil samples studied in Kano metropolis which differed on land use. The locations include Garden (Horticultural land), Farm land (Cultivated land) and Irrigated land (Cultivated land) and uncultivated land (Naturally reserve land). The physico-chemical properties of the soil samples were determined using laboratory methods. The results showed that the level of percentage of sand, silt and clay particles of the soil samples is the major determinant of soil physical properties. Higher percentage of clay particles correlate with higher moisture, bulk density and organic matter content of the soil. The results also showed that the level of percentage of organic carbon content of 0.40%, 0.26%, 0.27 and 0.24% for sample A, B, C and D respectively is highly correlated with other chemical parameters such as available phosphorous, calcium, magnesium and potassium etc. The study found that the organic matter content of the soil determined the pH value of the soil i. e 0.40% with ph of 6.4, 0.26% with ph of 4.5, 0.27 with ph of 5.0 and 0.34% with ph of 5.3 for sample A, B, C and D respectively. Results obtained from the four locations were statistically shown to be not significantly different at $p < 0.05$.

Keywords: Chemical parameters; Kano; Physical property; Soil; Texture

INTRODUCTION

The soil may be defined as the uppermost weathered layer of the earth's crust in which are mixed organisms and products of their death and decay [1]. Roughly, the soil contains 50-60% mineral matter, 25-35% water, 15-25% air and little percentage of organic matter [2,3].

Soil can be seen as solid material on the Earth's surface that results from the interaction of weathering and biological activity on the parent material or underlying hard rock. [4]. Soil is the most precious natural resource and contains the most diverse assemblages of living organisms [5]. Indigenous microbial populations in soil are of fundamental importance for ecosystem functioning in both natural and managed agricultural soils because of their involvement in such key processes as soil structure formation, organic matter decomposition, nutrient cycling and toxic removal [4]. The community of soil flora and fauna is influenced directly or indirectly by

management practices e.g. cultivation and the use and application of organic and inorganic fertilizers [6].

A growing number of studies show that organic farming leads to higher soil quality and more biological activity (microbial populations and microbial respiration rate) in soil than conventional farming [7,8].

According to Wang et al. [9] climate and geological history are importance factors to affecting soil properties on regional and continental scales. However, land use may be the dominant factors of soil properties under small catchment scale. Land use and soil management practices influence the soil nutrients and related soil processes, such as erosion, oxidation, mineralization, and leaching, etc [10,11]. As a result, it can modify the processes of transport and re-distribution of nutrients. In non-cultivated land, the type of vegetative cover is a factor influencing the soil organic carbon content [11]. Moreover, soils

through land use change also produce considerable alterations [12], and usually soil quality diminishes after the cultivation of previously untilled soils [13].

Thus, land use and type of vegetation must be taken into account when relating soil nutrients with environmental conditions [11]. Soils have many different properties, including texture, structure, water holding capacity and pH (whether the soils are acid or alkaline).

These properties (physical and chemical) combined to make soils useful for a wide range of purposes. Soil properties govern what type of plants will grow in a soil or what particular crops grow in a region [14]. In the present research, soil samples were collected from four different locations (Garden, Farm land, Irrigated land and Uncultivated (reserve) land) within Kano metropolis to determine their physical and chemical properties and also to investigate how land use affect the fertility of the soil.

MATERIALS AND METHODS

Study Site

The study site is Bayero University, Kano which is located at latitude $11^{\circ} 58' N$ and longitude $8^{\circ} 28' E$. The area located within tropical dry climate and coded as AW by Koppen's classification. The climate is marked by distinct wet and dry seasons with flat topography and soil surface is well drained [15]. The rainfall lasts for about 4-5 month annually with average annual rainfall of between 370-750 mm. Temperature is moderate with annual mean of about $22-28^{\circ}C$ [15]. The research was conducted from November to December, 2015.

Samples Collection

The soil samples were collected from four (4) different locations; Garden (Horticultural land), Farmland (Cultivated land), Irrigated land (Cultivated land) and uncultivated land (Naturally reserve land) within Kano Metropolis by means of soil borer at a depth of about 15 to 30 cm using the procedure of [16]. The samples were collected in container and transported to Soil and Water laboratory in the Department of Geography Bayero University Kano for further treatments.

Physical Properties

Determination of Particle Size

Particle sizes distribution were analyzed by pipette method as described by Singh *et al.* [17]

which is achieved by sieving and sedimentation. The size limits for different fractions were also classified according to United State department of Agriculture [14].

Determination of Available Water Holding Capacity (AWC)

AWC was determined by saturating 10g (W_1) of soil sample with 5ml of water in a weighted plastic cup with a hole underneath. The water was allowed to drain freely for 24 hours after that weight of the drained soil was taken (W_2). The differences in weight (W_3) was regarded as AWC of the soil expressed in percentage as follows; $\% AWC = W_2 - W_1 / W_1 * 100/1$ [3].

Determination of Bulk Density

Core method as adopted as described by Grossman and Reinsch [18]. A double-cylinder, drop-hammer sampler with a core is designed to remove a cylindrical core of soil. The sampler head contains an inner cylinder and is driven into the soil with blows from a drop hammer. The inner cylinder containing an undisturbed soil core is then removed and trimmed to the end with a knife to yield a core whose volume can easily be calculated from its length and diameter. The weight of this soil core is then determined after drying in an oven at $105^{\circ}C$ for about 24 hours.

Determination of Moisture Content

10g of soil sample (W_1) was placed in a crucible and weighted (W_2) and heated for about 30minutes. After heating, the crucible was placed in a dessiccator for about 10mintees to cool down and then weighted (W_3). The weight of dried soil was $W_3 - W_2 = W_4$ and the moisture loss after heating was given as $W_1 - W_4 = W_5$. $\%$ soil moisture content was calculated as $W_5 / W_4 * 100/1$ [17].

Determination of Soil Air

In each measuring cylinder, $50cm^3$ of soil was placed. $50cm^3$ of water was then added and stirred gently with glass rod until all the air bubble between the soil particles has been released. The initial volume of water and soil was $100cm^3$ while the final volume was Xcm^3 . The $\%$ soil air was calculated as $100 - x/100 * 100/1$ [17].

Determination of Soil Organic Matter Content

Each soil sample was placed in a crucible and heated strongly for about 30minutes, this is to

remove soil moisture. It was then allowed to cool in a dessiccator. 10g of the dried soil (W_1) was placed in a crucible and weighted (W_2). Heat was applied for about 2 hours at 60°C and the crucible was partially covered. After heating, the crucible containing the soil was cooled and weighted (W_3). The weight of crucible was $W_2 - W_1 = W_4$. The weight of ash was $W_3 - W_4 = W_5$. The weight loss during heating was $W_1 - W_5 = W_6$. % organic matter was calculated as $W_6 / W_1 * 100/1$ [3].

Chemical Properties

Table1. The methods used for estimation of chemical parameters

S/N	Chemical parameter	Method	Reference
1	PH	Using PH meter	[17]
2	Electric Conductivity	Using EC Meter	[17]
3	Available Phosphorous	Ascorbic acid molybdate method	[19]
4	Organic Carbon	Walkey and Black method	[20]
5	Exchangeable Na^+ , K^+ , Ca^{+2} and Mg^{+2}	Titrimetric method	[16]

RESULTS

Physical Parameters

Table2. Physical properties of the soil samples

S/N	Physical parameter	Sample A	Sample B	Sample C	Sample D
1	Sand	0.744	0.803	0.784	0.760

Chemical Parameters

Table3. Chemical parameters of the soil samples

S/N	Chemical parameter	Sample A	Sample B	Sample C	Sample D
1	PH	6.4	4.5	5.0	5.3
2	El. Conductivity (dS. M^{-1})	0.23	0.15	0.15	0.16
3	Avail. Phosphorous (ppm)	18.8	13.6	14.2	14.4
4	Organic Carbon (%)	0.40	0.26	0.27	0.34
5	Exch. Sodium ($\text{cmol}_c.\text{kg}^{-1}$)	0.39	0.68	0.55	0.50
6	Exch. Potassium ($\text{cmol}_c.\text{kg}^{-1}$)	0.46	0.40	0.40	0.44
7	Exch. Ca^{+2} and Mg^{+2} ($\text{cmol}_c.\text{kg}^{-1}$)	9.80	7.00	7.50	7.80
8	OMC ($\text{g}.\text{kg}^{-1}$)	0.55	0.39	0.40	0.43

Key: OMC = Organic matter content

The chemical properties of the soil samples are presented in Table 3. The result shows that sample B is more acidic with less pH value of 4.5 while sample A has the highest pH value 6.4 while sample C and D found between A and B. Sample A has the highest electric conductivity with value of 0.23 dS. M^{-1} while sample B and C has 0.15 respectively.

	particles ($\text{g}.\text{kg}^{-1}$)				
2	Silt particles ($\text{g}.\text{kg}^{-1}$)	0.179	0.145	0.155	0.167
3	Clay particles ($\text{g}.\text{kg}^{-1}$)	0.077	0.052	0.061	0.073
4	AWC (%)	15.7	11.30	13.60	14.40
5	Bulk density ($\text{g}.\text{cm}^{-3}$)	1.58	1.57	1.56	1.56
6	Moisture (%)	5.4	2.0	2.8	3.3
7	Soil air (%)	14	22	19	17

Key AWC = Available water holding capacity.

The physical properties of the soil samples are presented in Table 2. The result shows that sample A contains highest clay particles ($07.70 \text{ g}.\text{kg}^{-1}$) and lowest sand particles ($74.40\text{g}.\text{kg}^{-1}$).

On the other hand, sample B contain least clay particles ($05.20 \text{ g}.\text{kg}^{-1}$) and highest sand particles ($80.30\text{g}.\text{kg}^{-1}$). However, samples C and D have moderate particle size when compared to samples A and B.

Higher percentage of clay particles correlate with high Available water holding capacity, bulk density, soil moisture and soil organic matter content. Sample A with high clay content have high percentage of AWC of 15.7% while sample B have 11.3%. Soil air is correlated with high sand particle in sample B having highest soil air of 22% while sample A contain 14%.

Sample A has the highest content of exchangeable Potassium and Calcium & Magnesium ions 0.46 and $9.80 \text{ cmol}_c.\text{kg}^{-1}$ but on the other hand contain lowest exchangeable Sodium ion ($0.39\text{cmol}_c.\text{kg}^{-1}$).

Lowest Potassium ion is recorded in sample B and C with value of 0.40 respectively. Available

phosphorous is higher in sample A (18.8ppm) while lowest in sample B (13.6ppm).

DISCUSSION

Texture represents one of the most important characteristic of soil which used to determine its physical properties, because it described the nature of soil particles [14]. Considering the sand, silt and clay particles of the soil samples, it shows that sample B and C are sandy soils, while sample A and D contain higher proportion of silt and relatively clay, and according to Courtney and Trudgil [3].

The best describing of study soil texture at A and D location consider as Loamy sand soil, depending on the texture triangle which stated that, soil containing more than 80% sand particle is sandy soil.

Available water holding capacity of 15.7%, 11.3%, 13.6% and 14.4% for A, B, C and D respectively shows that soil containing coarse and porous particles has low water holding capacity which accounted for low AWC value for sample B. Soil moisture content is correlated with soil texture and organic matter content.

Sample A with high percentage of clay particles and organic matter can hold moisture of about 5.4g.kg^{-1} while sample B with low clay particles and low organic matter content held moisture of about 2.0%. According to the present study, soil moisture is always inversely proportional to soil air. And the higher the clay particle in a soil the lower soil air, that's why Sample B contain higher percentage of soil air.

The organic matter content of any soil, play a vital role in the evaluation of its characteristics both physical and chemical. Properties like available phosphorous, exchangeable base and cations exchange capacity all increase with increasing organic carbon. In the present study, it shows that soil organic matter is highly correlated with soil organic carbon which in turn correlated soil fertility parameters.

The influence of land use practice without proper maintenance and good management such as fertilizer application resulted in low fertility as found in sample B which is associated low organic carbon, low base saturation, low cations exchange capacity and high acidity.

The result shows that organic carbon content in the soil keep ph higher. This agrees with the observation made by Ahn [21] that organic carbon lead to release of bases which ensure high base saturation.

Available phosphorous of 18.8, 13.6, 14.2 and 14.4ppm was found for sample A, B, C and D respectively on this study shows that much of available phosphorous in the soil is associated with organic matter because it's derived from mineralization of organic matter [21].

Exchangeable cation consists of calcium, magnesium, potassium and sodium and these elements exist in soil bound within clay particles. According to Gambarawa [22], the amount of organic carbon in the soil is the most important factor in determining the amount of exchangeable cations in the soil.

However, in the case of the analysis of exchangeable sodium in this study, the result shows that the relationship with organic carbon is independent. According to present study, soil organic matter content also correlated with particle size.

This is inconformity with the sayings of Clarke [23] that clay particles contain higher percentage of organic matter. From the result of the present study, Sample A contain high organic matter content (5.5%), this is due to decomposition of leaf litter and proper application of organic manure in that soil.

There is also high organic matter content in sample C due to litter decomposition, but due to the fact that the land is uncultivated and wasted, there is intense leaching which resulted in washing away of organic matter content, though it is accounted for 2.4%. Sample B has the least organic matter content (1.2%).

This is attributed to high sand particles (low clay content). The site is highly exposed to leaching, though it is cultivated but it is receiving poor treatment.

Efficient treatments given to Garden (sample A) lead to high organic carbon content compared to sample B and C. This is also associated high cation exchange capacity and low pH.

The organic carbon content of 0.40, 0.26, 0.27 and 0.34% from the present study can be compare with the work of Gambarawa [22] who evaluate the organic carbon content of upland and fadama area in Katsina state with value of 0.33 and 0.46 respectively.

CONCLUSION

Based on the findings of this study, it has been observed that the land use and effective treatment given to the soil affect its properties (both physical and chemical).

It was found that soil organic matter determined soil organic carbon content which in turn play vital role in determining other fertility parameters such as exchangeable cations (Na^+ , K^+ , Mg^{+2} and Ca^{+2}). Soil properties such as exchangeable cation bases, available phosphorous all increase with increasing organic carbon according the study.

Soil fertility can be corrected by certain treatment such as; fertilizer application, incorporation of organic manure, effective method of controlling erosion and leaching and other farm management practice such as shifting cultivation and crop rotation.

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