EVALUATION OF PHYSICAL AND CHEMICAL PROPERTIES OF KALGO SOILS, NORTHWESTERN NIGERIA

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ABSTRACT

The study was carried out to evaluate the physical and chemical properties of Kalgo soils in Kebbi state, Northwestern Nigeria. The nature of soils of the study area has not been investigated and hence their characteristics are therefore unknown. This study apart from revealing inherent properties of the soil, it will also serve as reference point for other research works. Soil samples were taken at depth of 15, 30 and 45cm for determination of physical properties that include soil texture, moisture content, bulk density and porosity. Samples were also taken to the laboratory for the determination of chemical properties that include soil pH, cation exchange capacity (CEC), organic carbon, organic matter, total Nitrogen and available Phosphorus. The texture of the soil was found to be loamy sand from the sieve analysis result. The maximum and minimum dry bulk densities were found to be 1.63gcm^{-3} and 1.45gcm^{-3} respecively. The maximum dry bulk density obtained (1.63gcm^{-3}) is below the critical bulk density limit (1.80gcm-3) for the soil type under study. The result shows the highest pH of 6.1 and the lowest pH of 5.5 which means the soil is slightly acidic (5.6-6.8) and this also indicated that pH value of the soil is below the normal pH range of Agricultural soil of (6.5-8.4). The values of the organic carbon (0.56-0.08%) and organic matter content (0.97-0.14%) obtained from the study are very low. The level of CEC (4.12-3.76cmolkg^{-1}), total Nitrogen (0.081-0.063%) and available phosphorous (0.57-0.52mgkg^{-1}) are also low and this indicated poor nutrients fertility in the soil. The study recommends the application of agricultural limestone to increase the soil pH and also application of compound fertilizers or organic manures that are rich in Nitrogen, phosphorous and potassium to improve the nutrient status of the soil.

Keywords: *Physicochemical properties, Soil texture, Soil fertility, Kalgo soil*

1.0 INTRODUCTION

Soil is the bed rock of Agriculture as all agricultural activities from pre-planting to post planting operations, all these revolve round the soil. Soil is defined by the Soil Science Society of America as the unconsolidated mineral or organic material on the immediate surface of the Earth that serves as a natural medium for the growth of land plants. Soil is also defined by the same society as the unconsolidated mineral or organic matter on the surface of the Earth that has been subjected to and shows effects of genetic and environmental factors of: climate (including water and temperature effects), and macro- and microorganisms, conditioned by relief, acting on parent material over a period of time. A product-soil differs from the material from which it is derived in many physical, chemical, biological, and morphological properties and characteristics (SSSA, 2008).

Soils are formed by the weathering of rocks or materials deposited by rivers or wind. The kind, rate and the extent of soil formations are affected by group of factors namely Climate, organisms, parent material, topography and time. Soil from one place is different from another because of the differences in the influence of these factors. The influence of climate is directly due to temperature and rainfall and indirectly through its influence on organisms. (SSSA, 2017; FAO, 1987)

Information about the physical and chemical properties of soil of any farm is one of the primary steps required before embarking on crop production as the poor knowledge of this step can greatly affect yield and profit potential of any farm. The knowledge of physical and chemical properties of any soil is also essential for good management practices as both properties have significant influence on crop production. Physical properties play an important role in determining soil's suitability for agricultural production. Physical characteristics like soil structures affect the way in which water and air infiltrate into the soil, root growth and the activities of micro-organisms (Singh *et al,* 2004). The texture, structure and moisture regime of the soil can be used to determine the effect of movement of water into and through the soil (Baker and Eldershaw, 1993)

Soil chemical properties such as soil pH and cation exchange capacity affect soil fertility, nutrients retention capacity and the quality of ground water (USDA, 2014). The

pH of the soil also affects microbial activity as well as well as extending direct effect on protoplasm on plant root cells (Larcher, 1980; Marschner, 1986). The overall health of the soil is function of organic matter as it affects both physical and chemical properties of the soil and also influences the effects of chemical amendments, fertilizers, pesticides and herbicides (FAO, 2005)

The study of soil chemical properties is necessary since it is the basis of soil fertility and provides the needed knowledge to understand the differences in fertility among different soils and their response to fertilization. The nature of the soil of the study area has not been investigated and hence its characteristics are unknown. This study is aimed at determining and evaluating the physical and chemical properties of Kalgo soils in Northwestern Nigeria, and also proffers appropriate recommendation on physicochemical properties of the soils.

2.0 METERIALS AND METHODS

2.1 Description of the Study Area

The study was carried out in Kalgo town, Kalgo local government area, Kebbi state. Kalgo lies at latitude $12°19'00"$N and longitude $4°12'00"E$ on the altitude 233m above the mean sea level in the Sudan Savannah vegetation zone in northern Nigeria. The area has a semi arid climate that is characterized by a long dry October-May and a short wet June-September season, with a mean annual rainfall of 785mm. The minimum and maximum temperature in the area is 13°C and 45^{0}C respectively. (Adekunle, 2004).

2.2 Depth of Soil Samples

Measurement points were randomly selected for sampling within the study area. Samples were taken at depths of 0-15cm, 15-30cm and 30-45cm for Laboratory determination of Bulk density, moisture content, soil texture, soil pH and cations exchange capacity (CEC), organic matter, organic carbon, Nitrogen and available phosphorous.

2.3 Soil Moisture Determination

Soil moisture content was determined at both; the field capacity- 24hours after irrigation when the soil is still saturated and gravity water has practically ceased, and at wilting point a day to irrigation when the moisture is bound tightly to the soil and plant can no more extract water. A Polythene sheet was used to cover the soil sample to check evaporation. The moisture content was determined using

$$M.C = \frac{M_w}{M_d} \times 100 \quad (1)$$

Where M.C = moisture content

M_w = mass of water in the soil (g)

M_d = mass of dry soil

And the available water capacity (AWC) is;

AWC = moisture content at field capacity ($\%F_c$) – moisture content at wilting point ($\%W_p$) (FAO, 1985) (2)

2.4 Determination of Bulk Density and Porosity

Bulk density was determined using undisturbed method. Three (3) metal core samplers of known weight and volume were used to obtain undisturbed soil samples. The core sampler was driven into the saturated soil in the field through its cutting edge with a rubber mallet. The sampler was carefully removed. Using a knife, the sampler was trimmed level in the core to equal its volume. The weights of wet sample and container were taken and the material placed in the oven for drying at 105^{0}C for 24hours (Blake and Hartge, 1986). The dry weight was then taken and recorded.

The bulk density was calculated thus:

Weight of container $= w_1$(g)

Weight of wet soil + container $= w_2$(g)

Weight of dry soil + container $= w_3$(g)

Weight of moisture $= w_2 - w_3$(g)

Weight of dry sample $= w_3 - w_1$(g)

Volume of cylindrical core sampler $v = \pi r^2 h\ (cm^3)$

$$\rho_b = \frac{W_{3-W_1}}{v}\ (gcm^{-3}) \quad (3)$$

The porosity was calculated thus:

$$\text{Porosity } F = 1 - \frac{\rho_b}{\rho_p} \quad (4)$$

Where ρ_b= bulk density (g/cc)

ρ_p= particle density (approximately 2.65gcm^{-3}) (USDA, 2008).

2.5. Soil Texture Determination

The mechanical Sieve Analysis was used to determine the percentage of sand, silt and clay within the soil as suggested by Krishna (2002) for coarse soils.

2.6 Determination of Chemical Properties

The cation exchange capacity was determined by the summation method. The organic carbon and organic matter

were determined by the modified Walkley-Black method (Nelson and Sommers, 1982,). The total nitrogen was determined by the Kjeldahl method (Bremner, 1996; Isaac and Johnson, 1976) while Available phosphorus was determined by the method of Bray (Diamond, 1995; Olsen and Sommers, 1982). The pH values were determined using Potentiometric method as described in McLean (1982).

3.1 RESULT AND DISCUSSION

3.1 Sieve Analysis Result

The result of the sieve analysis is presented in table 1

Table 1: Sieve analysis Result

Sieve size (mm)	Mass retained (g)	percentage of mass retained (%)	Cumulative percentage retained (%)	Percentage passing (%)
2.00	109	10.96	10.96	89.04
1.18	21.8	2.19	13.15	86.85
0.600	49.5	4.98	18.13	81.87
0.425	91.7	9.22	27.35	72.65
0.300	156.3	15.71	43.06	56.71
0.212	201.2	20.23	63.29	36.71
0.150	142.3	14.31	77.60	22.40
0.063	111.5	11.20	88.80	11.20
Pan	111.4	11.20	100	0
Total	**994.7**			

The result of the sieve analysis shows 84% sand, 10% silt and 6% clay. The texture of the soil was found to be loamy sand using a USDA textural triangle.

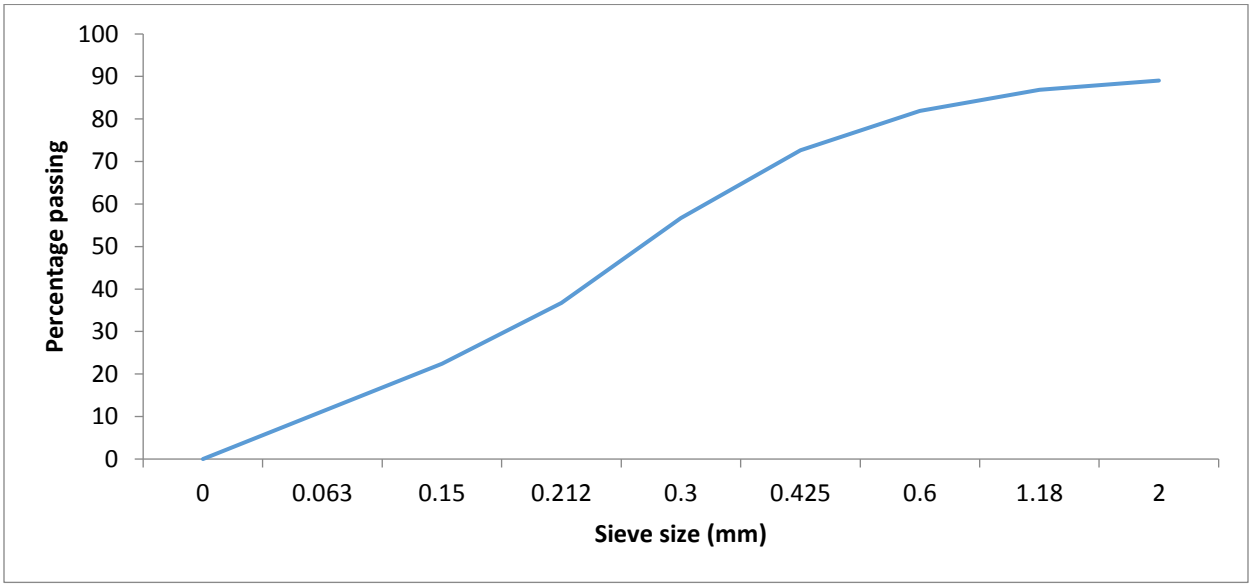

Figure 1: Sieve analysis of soil sample

3.2 Physical Property of Soil in the Study Area

The result of the physical properties (i.e. Bulk density, moisture content and porosity) determined are presented in the Table 2

Table 2: Some physical characteristics of soil obtained from the study area

Soil sample	Sampling depth (cm)	Moisture content (%)	Dry Bulk density (gcm^{-3})	porosity

A_1	0-15	10.48	1.45	0.45
B_1	15-30	10.43	1.48	0.44
C_1	30-45	12.18	1.54	0.42
A_2	0-15	11.56.	1.55	0.42
B_2	15-30	11.25	1.57	0.41
C_2	30-45	10.41	1.58	0.40
A_3	0-15	7.40	1.45	0.45
B_3	15-30	7.14	1.51	0.57
C_3	30-45	10.00	1.63	0.38

The maximum and minimum dry bulk densities were found to be 1.63gcm^{-3} and 1.45gcm^{-3}respecively. The maximum dry bulk density obtained (1.63gcm^{-3}) is below the critical bulk density limit (1.80gcm^{-3}) for the soil type under study. The result show the highest pH of 6.1 and the lowest pH of 5.5 which means the soil is slightly acidic (5.6-6.8) and this also indicated that pH value of the soil is below the normal pH range of Agricultural soil of (6.5-8.4).

3.3 Chemical Properties of Soil in the Study Area

The result of the chemical properties (i.e. pH, Organic carbon, Organic matter, Total Nitrogen, Available phosphorous, exchangeable cations (Ca^{2+}, Mg^{2+}, Na^{+} and K^{+}) and Cation exchange capacity (CEC) determined were presented in table 3

Table 3: Chemical Properties of the Soil

Soil Sample Number	A_1	B_1	C_1	A_2	B_2	C_2	A_3	B_3	C_3
Sampling Depth	0-15	15-30	30-45	0-15	15-30	30-45	0-15	15-30	30-45
pH	6.1	6.0	6.0	5.6	5.7	5.7	5.8	5.6	5.5
% Org C	0.26	0.30	0.32	0.24	0.16	0.08	0.44	0.52	0.56
% Org M	0.45	0.52	0.55	0.41	0.28	0.14	0.76	0.90	0.97
% N	0.081	0.074	0.074	0.067	0.067	0.060	0.074	0.063	0.063
P (mg/Kg)	0.55	0.55	0.54	0.53	0.52	0.52	0.57	0.56	0.55
Ca (CMol/kg)	1.70	1.60	1.60	1.40	1.40	1.30	0.95	0.95	0.95
Mg (CMol/kg)	0.25	0.25	0.25	0.25	0.20	0.30	0.75	0.75	0.70
K (CMol/kg)	0.08	0.05	0.05	0.08	0.08	0.08	0.08	0.05	0.05
Na (CMol/kg)	0.22	0.22	0.22	0.26	0.22	0.13	0.26	0.22	0.22
CEC (Cmol/kg)	4.12	4.08	4.08	3.76	3.76	3.70	3.89	3.94	3.92

The maximum CEC obtained from the result is 4.12 Cmol/kg which is low when compared with the normal CEC range values of 5-10 Cmol/Kg for the soil type under study. The maximum values obtained for the individuals cations of Ca^{2+}, Mg^{2+}, $K^{+}$and Na^{+} are 1.7, 0.75, 0.08 and 0.26 Cmol/kg respectively which are also low when compared with their normal values of 5, 1, 0.5 and 0.3 Cmol/kg.

The result of the study shows low Nitrogen and phosphorous content in the soil with the Nitrogen and phosphorous having the highest value of 0.81 % and 0.57mg/kg respectively. The maximum values of organic carbon and organic matter obtained from the results are 0.56 and 0.97 both of which are low for the soil type under study. The result of the study reveals low soil fertility and organic matter content

4.0 CONCLUSION

The result of the research shows that physical properties obtained from the study are within the normal range of agricultural soil. The result of the research shows that pH obtained for the soil is below the normal pH of Agricultural soil as the pH of the soil is slightly acidic. The values of the CEC and organic matter content obtained from the study are very low which indicate poor nutrients fertility in the soil. The study recommends application of agricultural limestone to the increase the soil pH and application of compound fertilizers or organic manure that are rich in Nitrogen, phosphorous and potassium to improve the nutrient status of the soil.

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