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**Assessment of Some Physical and Chemical properties of Soils at Kwa  
 Village, Dawakin Tofa, Kano State**

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**ABSTRACT**

The function of soil is to sustainably support crop growth and development. Its assessment has been due to its variability in time and space. Farmers often depend on soil to produce food, fiber and fodder in most developing countries including Nigeria. Therefore, the study was carried out to determine some physical and chemical qualities of soil. A stratified random sampling technique was employed to collect soil sample from 10 points at the depth of 0-30cm. Both soil physical and chemical analysis were carried out using standard methods. The results showed that the soil were predominantly sandy loam, with low bulk density (1.28g/cm<sup>3</sup>) and low water holding capacity (<15%). The soil were slightly acidic (4.7) and electrical conductivity range from (19.05-110 microsm<sup>-1</sup>), organic carbon and total Nitrogen were generally low (0.66%) and (0.08%) respectively. While cation exchange capacity was rated moderate (11.4%). Available phosphorus, magnesium, and Calcium were rated low (<10, 1.0, 2.0, and 0.5cmol/kg). But potassium appeared to be moderate and sodium was considered high. The study area has sufficient level of Cu (10.9mg/kg), Zn (14.1mg/kg), but insufficient level of Manganese (0.86mg/kg) and Fe was rated to be moderate (67.8mg/kg). The result revealed that, the study area is generally low in soil fertility and under this situation; crop yield and sustainability of production will decline. It is recommended that oriented techniques toward sustainability should be incorporated and these techniques should include application of organic and inorganic fertilizers, mulching, cover crop, and return of residues among others.

**Keywords:** Physical; Chemical; Stratified; Sampling; Mulching;

## 1.0 INTRODUCTION

Soil is one of the most active and complex natural resources on the earth's surface. It is essential for the existence of many forms of life and provide medium for plants growth and also supplies the organisms with most of their nutritional requirement (Gaur, 1997). Very fertile soils produce not only better food, fiber and fodder but also help to establish natural ecosystem and enhance water and air quality (Griffith, 2010).

The physical and chemical characteristics of soil play a very important role in the plants ability to obtain water and nutrients. The physical properties of soil usually depend upon the amount, shape, structure, size, pore spaces, organic matter and mineral composition of the soil. On the other hand chemical properties of the soil are the interaction of various chemical constituents among soil particles and the soil solution. These physical and chemical

properties include soil texture, bulk density, soil structure, soil colour, pH, electrical conductivity, cation exchange capacity, organic carbon, organic matter and soil nutrients. Most soils have different properties and working with these properties requires understanding of these properties (Griffith, 2010).

The knowledge of the physical and chemical properties of soil in managing resources especially if working with a particular soil is very important. The properties need to be studied for agricultural purpose, which is to increase productivity and to improve workability of the soil mass, because all agricultural production and development depends upon physico-chemical parameters of the soils. The soil quality analysis includes an analysis of parameters and processes which have effects on soil to operate efficiently as a component of a sound

ecosystem (Tale and Ingole, 2015). Soil quality may include a capacity for water retention, plant productivity, waste remediation and other functions, all these explore the use of soil chemical and physical attributes as determinants of soil quality and the present challenges for local farmers is to assess these properties for the advancement of sustainable food production (Tale and Ingole, 2015).

The overall attack is that specific soil properties and chemical properties that suggest changes in directions of ecosystem function should be monitored because they are indicators of sustainability (Chauhan, 2001). So for predicting

capability of soil for production in a given sites the evaluation of the soil physical and chemical would be determined more readily. Thus, the objective of this study is to assess some physical and chemical soil properties of the soil so as to determine the condition of the soil as this will guide local farmers to the increase of efficient soil management to increase the soil quality.

## 2.0 MATERIALS AND METHOD

### 2.1 Study Area

Kwa village is one of the most important villages in Dawakin Tofa local Government. It is therefore located between Latitude  $12^{\circ} 14'$  N of the equator and Longitude  $8^{\circ} 38'$  of Green wich meridian.

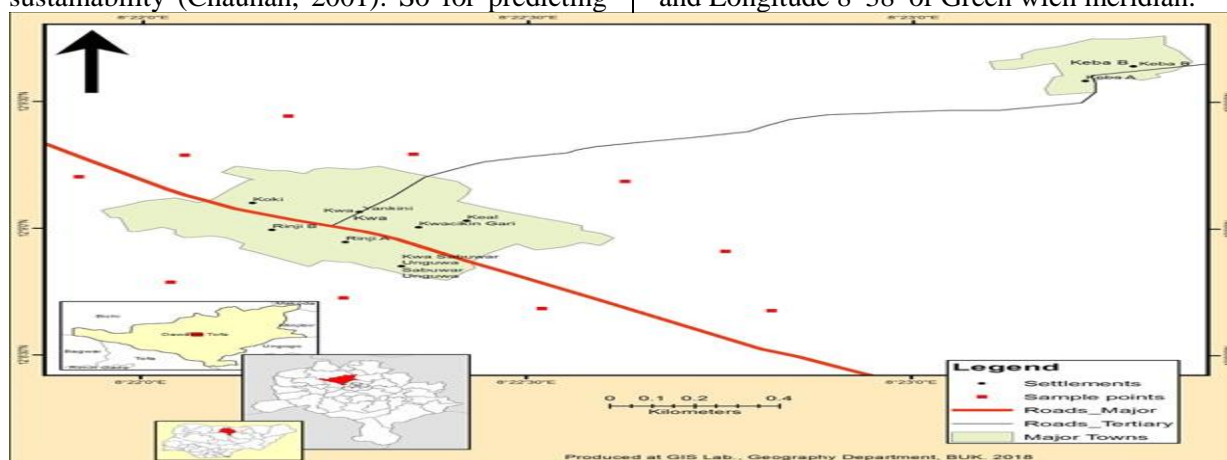


Figure 1. Map of the study area

The Kwa village being geographically positioned in the Sudan climate, enjoys the influence of North-easterly wind from October to April. Despite the diurnal and monthly variation, it received average annual rainfall of about 650mm to 7500mm in four to five months of a year, with a single maximum in July and August. On the average the wettest month is August where the highest number of rainstorm and sediment transport is recorded. The mean monthly temperature is between  $21$  to  $23^{\circ}$  C with diurnal temperature range of  $12$ - $14^{\circ}$  C and the mean annual temperature is  $28^{\circ}$  C. The vegetation is typically Sudan Savannah while the dominant soil of the area is ferruginous soil. Agricultural land use involves rain fed cultivations and the major arable crops grown include maize sorghum and millet.

### 2.2 Sampling and Sample Collection

Soil samples were collected from the entire area using stratified random sampling technique. Soil samples from 0-30cm depth were taken with soil

auger. The samples were then collected into an improvised (cotton) samples bags and labelled with a unique index to avoid ambiguity. The coordinate of individual points were taken and recorded using Global Positioning System (GPS). Other instrument used include, digger, 30cm plastic rule, recording sheet, metal shovel. Other relevant information such as erosion hazard is also observed concurrently with samples collection.

### 3.0 LABORATORY ANALYSIS

The samples were taken to laboratory, air dried and gently crushed with porcelain pestle and mortar: and then passed through a 2mm sieve to remove coarse fragments. The fine soil samples (<2mm soil portion) collected were analyzed. Particle size distribution was determined hydrometer method (Gee and Burder, 1986). Sand, silt and clay were determined by dispersing the soil samples in 5% calgon (sodium hexametaphosphate) solution. The dispersed samples were then shaken on a

reciprocating shaker after which particle size distribution was determined with the aid of Bouyoucos hydrometer at progressive time intervals the textural classes were determined with the aid of USDA textural triangle.

The soil pH was determined both in water and 0.01M CaCl<sub>2</sub> solution, using a soil to solution ratio of 1:2.5 (IITA). On equilibrium, pH was reading with a glass electrode on a pye-Unicam model 290mk pH meter. Delta pH (dpH) values were determined. The walkley- Black wet digestion method was used to determine the organic carbon content of the soil samples. Total nitrogen was determined using the micro kjedhal method. Soil available phosphorus was determined using the Bray I method calorimetrically. Electrical conductivity of the saturated paste extract of 1:2.5 soils to water ratio was determined using a rheostat, wheat-stone bridge model at 25<sup>o</sup> C (Brower and Wilcox, 1965). Exchangeable Ca, Mg, Na, and K were extracted with 1m ammonium acetate (1M NH<sub>4</sub>OAc) solution buffered at pH 7.0 as described by Anderson and Ingram (1998) Potassium and Salinity in the extract were read on a Gallen Kamp flame Analyzer. The extracts were diluted two times with the dilution of 2ml of 6.5% lanthanum chloride solution to prevent ionic interference before Ca and Mg was read. The Ca and Mg were read on a pye unicam model SP 192 atomic absorption Spectrophotometer (AAS) at 423 and 285nm wavelength respectively. The sum of Ca, Mg, Na, and K gave total exchangeable bases. The heavy metals were also determined using atomic absorption spectrophotometer (AAS).

The soils were leached with 1m KCL solution. Exchange acidity (Al+H) in the KCL extract was determined by titration with 0.1m sodium hydroxide solution as described by Anderson and Ingram (1998). Cation exchange capacity (CEC) of the soil were determine with 1m NH<sub>4</sub>OAc (1m ammonium acetate), buffered at pH 7.0 (Chapman, 1965, Rhodes, 1982). The excess acetate were displace with 10% sodium chloride (pH) and determine by the Kjeldahl procedure (Soil Survey Staff, 1972).

#### 4.0 RESULT AND DISCUSSION

#### 4.1 Physical Properties

Data on the physical properties of the soil of the study area are provided in table 1. Particle size distribution in the surface horizons of the soils studied has an overall texture of gravelly sandy loamy. The sand, silt and clay fraction ranged from 68.8 to 78.8, 8.56 to 14.56 and 18.64 to 12.64% respectively. The soils are freely drained because the sand appears to be the dominant fraction followed by clay and silt being the least. The clay content of the soil can retain considerable amount of water for crop production. The soil investigated had bulk density (BD) values ranging between 1.25 to 1.32g/cm<sup>3</sup>. The value of DB obtained are generally considered to below and may be attributed to low content of organic carbon, less aggregate, root penetration as well as compaction caused by the weight of overlying soil layer (Vickers, 1979). It was pointed out by Donahue *et al.*, 1990 that good plant growth is best at bulk densities below 1.40g/cm<sup>3</sup>. The soil studied therefore has no mechanical impedance for plant roots and also have adequate aeration. The total porosity ranged from 40.1 to 56.6%. The range of values showed sandy material which can enhance easy movement of water in the soils. Soils with 50% total porosity are well granulated and may have high moisture retention for crop plants (Landon, 1991). Brady and Weil (2013) indicated that a high porosity value in the sub-surface horizon could be attributed to continuous cropping which result in a reduction of macro pore spaces on the agricultural plough layer or surface soil. Incorporation of organic matter to the soils normally increases the bulk density and ultimately increases the percentage pore distribution thereby enhancing the soil physical condition for better crop production and food security (Hassan and Shuaibu, 2006).

The available water holding capacity (AWHC) of the soil studies is 13.7%. The value is considered to be low because of the low level of organic carbon and with low level of silt and clay in the soil. Clay and silt have much higher surface area to hold greater quantity of water and since they are less in the soil they affect the available water holding capacity (AWHC).

**Table 1: Physical Properties of the Soil**

Parameters	Mean	Maximum	Minimum
Sand%	73.94	78.8	68.8
Silt%	11.96	16.56	8.56
Clay%	14.56	18.56	12.56
Bulk Density(g/cm <sup>3</sup> )	1.28	1.32	1.25
Porosity%	49	56.6	40.1
Available Water Holding Capacity%	13.7	15.2	11.1

Source: Author 2018

#### 4.2 Chemical Properties

The chemical properties of the surface soil are presented in (Table 2, 3 and 4). In table 1, it shows that the soils were generally strongly acidic with a mean value of (4.7). The low level of pH reflect unfavourable situation for soil biological activities, nutrient release and exchange and plant uptake. The result of the study indicated the soils had lower organic carbon which ranged between 0.2- 0.8% and the mean value was 0.48%. The low values of organic carbon content coincide with the study of Mustapha and Nnalee, 2007; Mustapha *et al.*, 2011 and Voncir *et al.*, 2007. They pointed out that the savannah zones of Nigeria are characterized by low organic carbon content. Also Aydinalp (2010) attributed the low organic content to the prevailing dry conditions, where the biomass production is low and rate of mineralization is high. The low level of organic carbon is not surprising because of the continuous of intensive cropping without much addition of organic matter inform of crop residue and manures.

Total Nitrogen was found to be low in the studied soil with a mean value of 0.0784%. The low level of the total Nitrogen obtained in the soil could be partly associated with the low level of organic matter as well as high rate of leaching, soil erosion, volatilization and losses of Nitrogen through denitrification processes among other factors (Ekwonya and Ojanuga, 2002). Level of available phosphorus in the soil as determined by Bray 1 was generally low and it ranged from 4.3 to 8.3 with a mean value of 5.12mg/kg. The low level of phosphorus is attributed to the low value of phosphorus in the content of parent material of most of the soils in savannah and its propensity to sorption on mineral surface; such soils require

phosphorus fertilizer application for high yield of crops (Aki *et al.*, 2017).

Level of calcium (8.3-283.3mg/kg) with a mean value of 119.17mg/kg was observed in the study area. This indicates that Calcium is in abundant in the study area. Also moderate Cation exchange capacity was seen in the area and it ranged between 4.8 to 15.8mg/kg and has a mean value of 11.42meq/100g and this could be attributed to the low level of clay particles, low organic matter as well as low available water holding capacity and pH (Noma *et al.*, 2005 and (Hazleton and Murphy, 2007). The moderate level of CEC signifies that the soils are leached. Values for electrical conductivity of the studied soil were generally low and the values were observed to be in the range from 0.0019 to 0.11dsm<sup>-1</sup>. Soil electrical conductivity measures the dissolved material in aqueous solution which relate to the particles of the material to conduct electric current through it. Hence, suitable fertilizer should be added to the soils for ensuring maximum crop production (Teewari *et al.*, 2016).

The available potassium content in the soils ranged from 22.67 to 49.33mg/kg and has a mean value of 42.8mg/kg. The value of potassium appeared moderate and potassium is considered to be one of the primary macronutrients of the soil and it's important in providing vitality and performance of plant growth. The level of sodium was found to be moderate, which ranged from 8 – 20mg/kg and has a mean value of 13.133mg/kg. The soil studied was found to have sufficient in available magnesium. The magnesium has a value that ranged between 20 – 30mg/kg and mean value is 25mg/kg. The sufficient magnesium may be attributed to low rainfall of the area which

**Table 2: Chemical Properties of the Soil**

Parameters	Mean	Maximum	Minimum
Total Nitrogen %	0.0784	0.133	0.028
Available Phosphorus mg/kg	5.12	8.3	4
Organic Carbon%	0.48	0.8	0.2
pH	4.774	5.58	4
EC(ds m <sup>-1</sup> )	0.0522	0.1106	0.0019

Source: Author 2018

**Table 3: Exchangeable Cations and CEC of the Soil**

Parameters	Mean	Maximum	Minimum
Mg (mg/kg)	25.0	30.0	20.0
Ca (mg/kg)	119.17	283.333	8.333
K(mg/kg)	42.8	66	22.667
Na(mg/kg)	13.133	20	8
CEC meq/100g	11.42	15.8	4.8

Source: Author 2018

**Table 4: Level of Extractable Zn, Cu, Fe And Mn**

Parameters	Mean	Maximum	Minimum
Zn(mg/kg)	11.538	50	6.944
Cu(mg/kg)	10.9084	18.181	4.545
Fe(mg/kg)	81.04	150	29.63
Mn(mg/kg)	1.38	5	0.74

Source: Author 2018

favour least leaching of magnesium.

The values of the extractable micronutrients were presented in table 4. The iron (Fe) content in the studied soil was sufficient in the surface horizon ranging from 29.6 to 150mg/kg with mean value of 67.7mg/kg. The sufficient iron content might probably be from the parent material as it was pointed out by Mammam *et al.*, (2010) that the available Fe is generally high in tropical soils, but

localized deficiencies of Fe are known to occur and while available Fe poses no fertility problem in the soils.

The content of available Copper (Cu) in the soil ranged between 4.54mg/kg to 18.18mg/kg and was considered to be high. The higher value of Copper could be attributed to the acidic nature of the soils of the study area. Lombin (1983) reported that the

content of available copper in soils of Northern Nigeria Savanna are adequate and have no fertility implication. Zinc was observed to be sufficient in the studied soil and it ranged from 6.94mg/kg to 50mg/kg with a mean value of 14.1mg/kg. Generally, the value of Zinc was higher than the values that were reported on the plinthic landscape at Zaria (Sims and Johnson, 1991). The high value of Zinc and Copper corresponds with the studies of Dan'azumi et al (2017) which revealed that values of Zinc and Copper were higher than the critical limit for arable crop production at the Challawa Gorge micro watershed soils of Kano. Manganese values in the studied soil ranged between 0.7 to 1.4mg/kg with a mean value of 0.81mg/kg. This implies that the soil contain insufficient Mn for successful agricultural production in the area studied as they are below the critical limits of 1-4mg/kg (Esu, 1987).

## 5.0 CONCLUSION

The results indicate that the physical and chemical properties of the soil studied had some problem. It was observed that low organic carbon, low total Nitrogen, low available Phosphorus and very strong acidic are the limiting factors regarding the soil productivity. Under this situation, crop yield and sustainability of crop production might decline. Even though the soil may be considered as less fertile, but can support some agricultural production, if well managed.

In line with the above findings, it is recommended that deliberately chosen techniques oriented towards sustainability should be adopted for food sufficiency and security. These management should include non-blanket application of organic and inorganic fertilizers (containing especially Nitrogen, Phosphorus), crop rotation, green manures and finally proper and periodic monitoring of the physical and chemical properties of soil, so that appropriate preventive measures could be embarked upon as then due, for sustainable agricultural productivity.

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