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Physical and chemical characterization of some selected soils in University of Maiduguri, Borno State Nigeria

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ABSTRACT

A semi-detailed survey was conducted to characterize some physical and chemical properties of soils of Teaching and Research Farm University of Maiduguri, Borno State. Three sites were selected on the basis of land forms and surface texture and their description were taken using two soil profile pits at each sites. The soils collected were subjected to laboratory analysis using standard procedure. The colour of the soils changes at both surface and subsurface layers within each layer due to reduction in organic matter content down the profile, majority of the topsoil layer were brown while light yellowish orange were found in the subsoil layer.The consistency of the soil changed from hard at the surface layers to soft at subsurface layers. Soil reaction ranged from6.72 to 7.36which is neutral to slightly alkaline at both surface and subsurface layer and the electrical conductivity shows no salinity effect at both surface and subsurface layers. Cation Exchange Capacacity ranged from 10.09 to 15.97 Cmol/kg which was very low. Organic carbon content was generally low to moderate which ranged from 0.2 to 0.60 % due to poor return in organic matter content. The soil texture of the surface and subsurface was predominately sandy loam. Sand content of P2 ranged from 537 g/kg to 762 g/kg, silt ranged from 141 (P4) to 441 (P1) g/kg and clay from 72 (P2) and 147 (P4) g/kg. Available phosphorus and potassium tend to be low while sodium was high, magnesium showed to be medium to high, while calcium was also low to medium. Bulk density of the soils, increases with increase in depth and the hydraulic conductivity decreases with increase in depth. The chemical and physical properties of the soil are good for crop production except for sodium that is high, which need some management practices for optimum crop production and as such evaluation on the capability and suitability of the area should be conducted.

1.0 Introduction

The longman contemporary dictionary university defined characterization as the act of describing distinctive characteristics or essential features of soil, these features are the morphological, physical and chemical properties ((LDOCE6, 2014).Soil characterization data can help scientists to predict likelihood of flooding and drought, itsallows scientist to interpret how the ecosystem function and make recommendation for soil use that have a minimal impact on the ecosystem. For example, soil characterization data can help to determine the types of vegetation and land use best suited to a location, it also helps to explain pattern observed from satellite imagery, vegetation growth across the landscape, or trend of soil moisture and temperature that might be related to weather (Globe, 2014).It can also help to guide whether a Agricultural garden should be planned or a school be built depending on the soils properties.Soil can be characterized by its structure, colour, texture, abundance of roots, rocks, bulk density, hydraulic conductivity, macro, micro elements and others. These. Soil morphology is the field observable attributes of soil within the various soil horizons and the description of kind and arrangement of the horizons, (Buol *et al.,*2003). The observable attributes ordinarily describe in the field, include soil structure, soil colour and other features such as mottling, distribution of roots and pores, evidence of translocated materials such as carbonates, iron, manganese, carbon, clay and consistency, (Buol *et al.,* 2003). Soil morphological properties are studied because they give an idea of the process that has taken part in the formation of the soil. Thus soil morphological properties are related to soil physico-chemical properties. They are cheap and quick to determine as a result they are used in soil survey to reduce cost; (Dent and young, 1981). Soil Physical property are the properties of soil that are measurable whose value describe a state of a physical system, Physical properties of soil greatly influence its use and behaviour, towards plant growth. Soil is made up of minerals, soil organic matters (SOM), water and air. The composition and proportion of these components greatly influence soil physical properties, (Buckman and Brady*,* 1998)**.** The aeration, retention of Moisture, and plant nutrients are linked with the physical condition of the soil. Physical properties also influence the chemical and biological behaviour of soil. The physical properties of a soil depend on the amount, size, shape, arrangement and mineral composition of its particles. These parameters also depend on organic matter content and pores spaces. The physical properties of soil includes: soil texture, soil structure, surface area, bulk density, soil porosity and hydraulic conductivity. The chemical properties of soil, deals with the behaviour of various elements in the soil (micro and macro), towards plants growth and yield. The macro elements are the elements required in large proportion by the plants. These elements include calcium, magnesium, phosphorus, potassium, sodium, molybdenum etc. The micro or trace elements are those elements though essential but are required in limited quantity; and all these affect the plants growth and yield. Sodium for instance affects the soil structure when it is excess, there by destroying the structure of the soil and causes plant wilting by (osmotic pressure) that is extracting water from the plants cells, (Buckman and Brady*,* 1998).

The Objective of the Study

The paper is aimed at investigating the morphological, physical and chemical properties of some selected soils of Maiduguri, Borno State.

2.0. Materials and methods

2.1 Description of the experimental sites

The experiment was conducted at University of Maiduguri Teaching and Research Farm, Maiduguri, Borno state in February 2016 during the dry season of the year. It has latitude N 11^0 83.33' longitude E 13^0 15.00'. The dominant texture class of the soil is sandy loam. The soils were generally well drained and appeared to be fairly homogenous (Rayar, 1983).

2.2 Climate and characteristics of the site

The climate of the area is semi-arid climate with wide seasonal and diurnal temperature ranges. The dry season is between 8-9 months, follows by a single rainy season of about 3-4 months. The mean annual rainfall is about 625mm and mean annual air temperature is between 27^0C to 32^0C (Grema and Hess, 1994), with a wet season of about 110 days (Walter, 1967). The pattern of the rainfall is a single peak type, beginning in late May with maximum rainfall in August and ends late October. The months between November – March are dry with a few light showers occurring in April and early May. Precipitation is usually low with rainfall of 75-100mm per day often recorded. The temperature is highest in the months of April and May with mean temperature of 29^0C-32^0C. The harmattan month is between November and March which is associated with wide diurnal fluctuations of temperatures, (Carrol, 1974). Humidity of the area rise sharply during the wet season and fall abruptly at the end of the season, with relative humidity of up to 100% recorded in August at night and 20% or less recorded during the hottest part of the day during harmattan. Evaporation from open water surfaces is very high, with rainfall exceeding evaporation in only two (2) months of the year. The harmattan, a dry dust-filled wind, originating from the Sahara desert, blows intermittently from November – March, being most common in December to February (Bigelstone, 1958). The dust usually remain suspended and under still-air conditions,it become concentrated towards the ground, thereby reducing visibility on the ground to 100m or even higher. It has been estimated that the harmattan winds deposit several million tons of dust every year (Sedlemeyer, 1964) thus becoming a very important soil forming factor in the area. The land is for both irrigation and rain fed farming system. The dominant crops cultivated are maize (*Zea mays)*, wheat (*Triticum*), and groundnuts (*Arachis hypogea*). The vegetables cultivated are cabbage *(Brassica oleracea*), Spinach (*Amarantus),* Onions (*Allium cepa*), tomatoes *(Lycopersicon esculentum*), etc and the area is dominated by short grasses, shrubs and small trees such as Acacia tree (*Acacia albida),* Desert date *(Balanites ficcusspp),* Neem tree *(Azadirachta indica),* Axel wood *(Anogeisusspp),* and Baoboa tree (*Adansoniadigitata)*.ŧThe shrub cover depends on the intensity of farming and the length of the rainy season.

2.3 Soil Survey and Sampling

A reconnaissance survey was carried out on the selected areas to know the major features of the terrain in terms of the soil type, vegetation and other biophysical features, there after a semi detail survey was undertaken to become familiar with the features. Three sites were selected and two profile pits were dug at each of the three sites. The profile pit has a dimension of 1m breath x 1.5m length and 2m depth for characterization purposes. Site description of the area was taken, the name of the surveyor, date, land use, vegetation, soil erosion, drainage status, elevation and slope were also taken and indicated in the soil description pro-forma sheet. Each profile pit was demarcated into different horizons (layers) and the depth of each layer was measured using a measuring tape to determine its thickness, the layers was described in terms of soil morphological properties i.e., the soil colour, consistency, depth and texture.

2.4 Laboratory Analyses

The soil samples collected from the field (pedons) were air -dried and gently crushed with porcelain pestle and mortar, and passed through a 2mm sieve. The physical and chemical properties of the soils were determined using the following standard laboratory procedures:

2.4.1 Soil pH determination

The pH of the soil sample was determined in water as soil water ration of 1:2.5 (10g of soil and 25ml of water), the sample were thoroughly mixed to form a suspension and allowed to stand for one hour. After which the samples were read with pH meter after standardization done in a buffer solution of 7 and 4 for calibration (Agbenin, 1995).

2.4.2 Determination of Electrical Conductivity (EC)

The EC was determined in water at a soil water ration of 1:2.5 (10g of soil and 25ml of water) and then allowed to stand for 1 hour. The EC was then measured using the EC meter.

2.4.3 Determination of Exchangeable Sodium Percentage

It was calculated as a proportion of CEC occupied by exchangeable sodium

$$ESP= \frac{\text{exchangeable sodium}}{\text{CEC}} \times 100$$

2.4.4 Determination of Sodium adsorption ratio (SAR)

SAR was calculated using the formular:

$$SAR = \frac{Na}{\sqrt{\frac{Ca + Mg}{2}}}$$

2.4.5 Determination of Organic Carbon

Organic carbon was determined by the Walkley - Black wet oxidation method (Walkley and Black, 1934) as described by Nelson and Summers (1982) and percent soil organic matter was obtained by multiplying percent soil organic carbon by a factor of 1.724 following the assumptions that organic matter (OM) is composed of 58 % carbon.

1g of air-dried soil was weighed into 250ml conical flask; 10ml of potassium-dichromate(vii) 1Nk2Cr2O7 solution was added into it then 20mls of concentrated sulphuric acid (H_2SO_4) was then disperse into the flask using a measuring cylinder and the flask was swirl gently for about 2 minutes. The flask was allowed to stand for 30 minutes. After cooling 100ml of distilled water was added, followed by 10ml of orthophosphoric acid solution (H_2PO_4), then 5 drops of diphenylamine indicator was then titrated against 0.5N ferrous ammonium sulphate (Fe NH_4 SO_4) solution to a given end point.

A blank was taken in the same way using all the reagent of 0.5N Fe NH_4 SO_4 using to titrate the blank was determined. Percentage organic carbon was calculated using the following formula.

% organic carbon = (B-I) x F x 0.003 x 1.3110

Where

B = the amount of ferrous ammonium sulphate ml of 0.5N $FeNH_4SO_4$; used to titrate the blank

T = mls of ferrous ammonium sulphate 0.5N $FeNH_4SO_4$ used to titrate the excess chronic acid in the soil sample

W = weight of soil sample

F = strength of ferrous ammonium sulphate$FeNH_4SO_4$ solution used calculation

$$S2 = \frac{S1 \times V1}{V2}$$

S2 = Strength of ferrous ammonium sulphate $FeNH_4SO_4$used in titrating blank.

V = Volume of ferrous ammonium sulphate $FeNH_4SO_4$ use in titrating blank

S1 = Strength of potassium-dichromate $K_2Cr_2O_7$

V1 = Volume of potassium-dichromate $K_2Cr_2O_7$ used

2.4.6 Particle size analysis

The particle size analysis of the soil sample was carried out using Boyoucous (1971) method, 40g of each soil sample was weighed into a 500ml beaker and 100ml of water and 5ml of 30% hydrogen peroxide, the beaker with the content were placed over a hot plate to evaporate the organic matter in the samples. The content of the beaker hexa-metaphosphate (Calgon) was added to disperse the soil. The content of the beaker were transferred to a dispersion cup, and mixed and transferred into a 100ml cylinder. All the adhering particles were rinsed into the cylinder and more distilled water was added to make up the volume to 1000ml. the content were mixed and hydrometer was immersed into suspension. After 40 seconds the first hydrometer reading was recorded. The temperature of the suspension at the time was also recorded. After two hours the second hydrometer reading together with temperature of the suspension were recorded. A blank was also prepared using 5mls of 50% Calgon solution and both hydrometer and the temperature reading were recorded. The percentage of particles in suspension at any given time was calculated using the following equation.

$$S = \frac{R\text{-}RL \pm rx100}{W}$$

Where

S = % particle in suspension

R = hydrometer reading

R1 = calibration correction (blank reading)

r = temperature correction (±0.36 for each degree differences from 20^0C)

w = Oven dry weight of the same percentage silt and clay were calculated using the hydrometer reading taken after 2 hours. Percentage sand was obtained by subtracting the percentage silt plus clay from 100%.

2.4.7 Determination of exchangeable cations

Exchangeable cations were extracted with 1N, NH_4OAc solution (pH 7). The extract was then read for exchangeable Ca and Mg using Atomic Absorption Spectrophotometer (AAS) while K and Na were read using flame photometer (Black, 1965).

2.4.8 Exchangeable acidity (titration method)

Exchange acidity ($A1^{3+}$, H^+) was determined by titration of soil solution with 1N KC1 (Black, 1965). 5g of air-dried soil was weighed into a 45ml plastic bottle and 30ml of1N KCl was added into the sample and was covered tightly with stopper and was shaken for 2 hours on a reciprocal decanted into a 100ml volumetric flask. Another 30ml of 1N KCl was added to the same soil sample and shaken for 3 minutes. The second step was repeated and the clear supernatant was transferred to the same volumetric flask, step 3 was repeated against and the clear supernatant transferred to the same volumetric flask and made up to a mark with 1N KCl.

2.4.9 Titration of H and Al

50ml of KCL was pipetted into 250ml conical flask and 50ml of distilled water was added. 5 drops of 1% phenolphthalein indicator was added and the solution was titrated with a 0.05N NaOH to a pink (permanent end point) with an alternate stirring and standing. The amount of base used is equivalent to the total amount of acidity (H + Al) in aliquot taken.

The exchangeable H and Al are expressed in meq/100g of soil.

$$\text{MeqKcl acidity} = \text{m/NaoH} = \frac{\text{ml Naoh blank} \times W \times 100}{\text{Weight of sample}}$$

The leachate was determined by flame photometer and exchangeable calcium and magnesium were estimated by (EDTA) titration method.

The exchangeable Ca and Mg were calculated using the following equation

$$\text{Meq of mg/100 of soil} = \frac{a \times TMg + V1 \times 100 \times 1000}{W \times ½ \times \text{eqwt of Mg}}$$

$$\text{Meq of Cal/100 of soil} = \frac{a \times TCa + V1 \times 100 \times 1000}{W \times ½ \times \text{eqwt of Ca}}$$

Where

a = mls of EDTA used for the titration of sample

Tca = Titration factor of EDTA against Ca

V1 = Total volume of leachate

V2 = ml of the leachate used in Ca determination

W = weight of sample taken for leachate.

The exchangeable K or Na were calculated using the following equation

$$\text{meqK/100 of soil} = \frac{a \times 100 \times 1000}{1000 \times 39.1 + \text{weight of soil}}$$

Meq Na/100 of soil = $\underline{\quad a \times 100 \times 100 \quad}$

1000 x 23 x weight of soil

Where

a = ppm of K and Na

2.4.10 Bulk density (B_d)

Bulk density was determined by collecting undisturbed core samples from each horizon using core samplers (metal rings). These were latter oven dried at 105^0C to constant weight. The mass of the oven dried soil was divided by the total soil volume (Vs = πr^2 h of cylinder case) to contain the bulk density, (Blake, 1965).

$$B_d = \frac{\text{Mass of oven dried soil}}{\text{Total soil volume}}$$

Where π = 22/7

r = radius of core sampler

h = height (cm)

2.4.11 Saturated hydraulic conductivity

Two samples of undisturbed soil were collected from each horizon with the core sampler. One of the samplers was covered with retainer cloth held in place with a rubber band. The undisturbed soil samples were put in a water trough for twenty four 24 hours for saturation. The laboratory method involves the direct application of the Darcy equation to a saturated soil column of uniform cross-sectional area. A constant hydraulic head differences was imposed on the soil column and resulting flux of water was maintained for about half hour before measurement commenced. Hydraulic conductivity was calculated from the Darcy's law derived from in vertical column (Hillel, 1980).

$$K = \frac{q1}{At\,(h+l)}$$

q = volume of water passing soil column (percolate) cm^2

K = Hydraulic conductivity, cm/h

A = cross sectional area of the soil column derived from internal dimension of the core cylinder cm^2

t = specific time for flux of water (hour)

h = depth of water on the soil column of length (cm)

1 = length (cm) of soil column

3.0. Results and Discussion

3.1 Morphological Properties of the Soil

The morphological properties of the soil are given in Table 1

Table 1:Some Morphological properties of the soil

Profile name	Soil Depth(cm)	Soil Colour	Soil Consistency
P1	0-22	10 YR 5/4	H
	22-89	10 YR 5/8	SH
	89-150	10 YR 6/8	S
	150-177	10 YR 8/6	S
	177-200	10 YR 8/4	S
P2	0-60	10 YR 5/4	H
	60-125	10 YR 6/8	H
	125-155	10 YR 6/6	S
`	155-170	10 YR 6/6	S
	170-200	10 YR 5/6	S
P3	0-40	10 YR 4/6	H
	40-100	10 YR 5/6	SH
	100-140	10 YR 6/6	S
	140-185	10 YR 8/6	S
	185-200	10 YR 8/4	S
P4	0-50	10 YR 5/4	H
	50-101	10 YR 5/8	S
	101-161	10 YR 6/8	S
	161-200	10 YR 8/6	S
P5	0-60	10 YR 4/6	H
	60-100	10 YR 5/6	S
	100-175	10 YR 6/6	S
	175-200	10 YR 8/6	S
P6	0-20	10 YR 5/4	H
	20-70	10 YR 5/8	S
	70-130	10 YR 6/8	S
	130-160	10 YR 8/6	S
	160-200	10 YR 6/6	S

H=Hard, SH=slightly hard, S=Soft, P=Profile

3.1.1 Soil colour

The result of soil samples colours for the six profiles are shown on Table 1. P1 colour ranged from dull yellowish brown in the top soil layer to yellowish orange in the subsoil layer, P2 colour ranged from brown colour at the top soil layer to light yellowish orange in the subsoil layer, P3 colour ranged from dull yellowish brown in the top soil layer to bright yellowish brown in the subsoil layer, P4 colour ranged from dull yellowish brown in the top soil layer to light yellowish brown in the sub soil layer, P5 colour ranged from brown at the top soil layer to yellowish brown in the subsoil layer, P6 colour ranged from dull-yellowish brown at the top soil to yellow orange in the sub soil layer. The colour of the soil tends to vary with depth which is in agreement with Brady and Weil, (1999), that soil colour typically change with depth through the various horizon in a soil profile. The changes in the soil colour could be attributed to the reduction in organic matter content as reported by Ahn (1970), that soil at the upper horizon tend to be dark because of addition of organic matter while the lower horizon is brighter because of reduction in organic matter. The bright subsurface colour is perhaps, an indication of good drainage, (Amusan, 1991). According to (Kohnke, 1968), soil colour has no direct effect on plant growth but rather exert an indirect influence through its effects on soil temperature and moisture. The significance of soil colour is most useful in identification and classification of soil (Saha, 2008). This shows that the result of the colour of the studied area those not have any effect on plants growth as reported above.

3.1.2. Soil consistency

The consistency of the soil samples were presented on Table 1. The consistency of the soil at the surface layers to the sub-surface layers changes from hard to soft at P1, 2, 3, 4, 5, and 6. This could be attributed to reduction in organic matter content. This agrees with the report of Russel (1968), that organic matter content, moisture holding capacity decreases down the profile which can change the condition of soil consistency from hard to soft.

3.2 Chemical Properties of the Soil

3.2.1 Soil pH

The pH value of the soil samples were shown on Table 2. P1 and P5 ranged from slightly alkaline (7.35) surface to neutral (7.47 and 7.3)subsurface layer respectively, P2 and P6 ranged from neutral (6.72)at the surface layer and slightly alkaline to neutral (6.83)at the subsurface layer, while P3 and P4 shows neutralat both surface (6.96 and 6.87) and subsurface layer, the differences in pH could be attributed to low leaching of cations; and this is because of low amount of rainfall in semi-arid region. The pH of the study area is considered to be neutral to slightly alkaline, this agrees with the findingsNoma et al. (2004), which shows neutral to slightly alkaline in their study. Landon (1984) and Alison *et al*.(2007) reported that soil pH from 6.0-8.0 is suitable for a wide range of crops. This shows that the result of the soil pH of the studied area is satisfactory for most crops production.

3.2.2 Electrical conductivity (EC)

The EC of the soil samples shows no salinity effect in the surface and subsurface layer of all the six pedon according to the soil fertility ratings of (FPDD, 2002) in Table3. The EC values ranged below 0.40dSm^{-1} and this agree with the report of Noma et al. (2004), who reported EC values of its soil samples to be non-saline. From the report of (Davis and Freitas1970) which reported that EC ratingsof 0 to 1 dSm^{1} non-saline and is a good soil for Agricultural production.

3.2.2.1 Phosphorus

The soil is considered to be low in available phosphorus (Table 3). The result showed that, P1 had value thatranged from very low (0.70mg/kg) at subsurface to moderate (7.35mg/kg) at surface layer. P2 ranged from low(4.20 mg/kg)to very low(2.80 mg/kg) at surface layer and very low (1.40 mg/kg)to moderate(7.35 mg/kg) at subsurface layer. P3ranged from low(4.85 mg/kg) at surface layer and very low (0.70 mg/kg)at subsurface layer, P4 showed very low(0.90 mg/kg) at the surface and subsurface(0.70 mg/kg) layer except in the middle layer which shows low(3.50 mg/kg) available phosphorus, P5 ranged from low(5.70 mg/kg) at the surface layer and moderate(7.00 mg/kg) to very low (1.40 mg/kg)at the subsurface layer, P6 ranged from low (4.85 mg/kg)to moderate(7.00 mg/kg) at the surface layer to low (3.50 mg/kg)at the subsurface layer, the low availablephosphorus in the area could be due to leaching because of the sandy nature of the area and also it could be due to the high uptake by plants in the studied area. Esu (1987), reported that low level of available phosphorus can be attributed to phosphate removal through leaching and soil erosion as well as low content of phosphorus in the parent materials. The low available phosphorus was also reported by Aduloju and Abdulmumini, (2014). The result of the studied area indicate that, the soil is deficient in available phosphorus which may not be good for some crops, because phosphorous has an important effect on Photosynthesis, Nitrogen fixation, Crop maturation to flowering and fruiting including seed formation, Root development, Protein synthesis, (Olsen S.R and Sommers L.E.1982).

3.2.2.2 Organic carbon

The soil samples are considered to be low in organic carbon content (Table 3). P1 ranged from very low (0.20 %) to low (0.40 %) at the surface layer and low at the subsurface layer, P2 showed low (0.35%) and(0.23 %) organic carbon content at both surface and subsurface layer, P3 and P4 ranged from moderate (0.60 %) and (0.55 %) at surface layer to low (0.28 %) and (0.40 %) at the subsurface layer which decrease with increase in depth, P5 and P6 were generally low at both surface (0.40 %)each and subsurface (0.23 %) and (0.26 %) respectively.The low level of organic carbon in thestudied could be due to the low amount of organic materials in the soils. Jones and Wild (1975), reported low to medium organic carbon for semi- arid soils which was attributed to inadequate return of crop residue. The result also agrees with the findings of Owusu and Bemoah *et al.* (1995), which reported low level of organic carbon on semi-arid soil of Ghana.

3.2.3 Exchangeable cations (Ca, Mg, Na, and K,)

3.2.3.1 Calcium

The results of exchangeable calcium of the soil samples ranged from low to medium (Table 3). According to FPDD (2002) soil ratings, soils of P1, P2, P3 and P5 were rated medium at both surface and subsurface layer, P4 and P6 ranged from medium at the surface layer to low at the subsurface layer with decreasein increase depth. Caires (1999), observe that surface liming increasescalcium content in the soil with depth. According to El Mahi*et al*. (1987), Calcium and Magnesium ions serve as plant nutrients in cation exchange capacity of soils and constitutes about 60 to 80% of total exchangeable cations. From the result obtained,calcium content in the studied area were medium, which shows that the calcium content is moderate for Agricultural production.

3.2.3.2 Magnesium

The result of exchangeable magnesium is shown on Table 2. Soil P1 ranged from high (6.40Cmol/kg) at surface to medium (1.20Cmol/kg) at the subsurface layer with decrease in increase depth. Soil P2 (6.80Cmol/kg), P3 (4.40Cmol/kg) and P4 (7.00Cmol/kg) showed high content of Mg content in both surface and subsurface layer. Soil P5 range from medium (2.00Cmol/kg) to high (5.20Cmol/kg) at the surface layer to high (8.00Cmol/kg) at subsurface layer, while P6 ranged from high (7.20Cmol/kg) at the surface layer and high (6.00Cmol/kg) to medium (2.00Cmol/kg) at subsurface layer which decrease and increase depth.The results of Mg in the studied area shows that the Mg content according to Soil and Plant Testing University of California (1994)rates the soils to be high to moderate. The high to moderate Mg could be due to the presence of Mg parent materials from which the soils were formed (El Mahi*et al.*,1987).

3.2.3.4 Exchangeable Sodium

The value of exchangeable sodium of the soil samples were shown in (Table 2). The result of P1 ranged from high (1.30Cmol/kg) at the surface layer and low (0.25Cmol/kg) to high (1.28Cmol/kg) at subsurface layer, P2 (1.57Cmol/kg), P5(1.48Cmol/kg) and P6 (0.73Cmol/kg) were high in both surface and subsurface layer, P3

(0.49Cmol/kg) and P4 (0.83Cmol/kg) both ranged from medium to high at surface and subsurface layer respectively. However, the high level of sodium content might be due to the sodic nature of Parent material and also might be attributed to some contamination with the irrigation water use in the study area or could be due to high evaporation in semi-arid region. Excess sodium in soil competes with Ca, and other cations thereby reducing their availability to crops. Sodium affects the soil structure when it is in excess, thereby destroying the structure of the soil and causes plant wilting by (osmotic pressure) that is extracting water from the plants cells as reported by (Buckman and Brady*,* 1998).This result showed that the high content of Sodium in the soils of studied area may have adverse effects on plant growths in the area due to sodium toxicity.

3.2.3.5 Potassium

The result of exchangeable potassium of the soil samples ranged from very low to moderate (Table 3). P1(0.18Cmol/kg), P3(0.18Cmol/kg), and P5(0.10Cmol/kg) shows very low in surface and subsurface layer, P2(0.40Cmol/kg) range frommoderate to very low (0.20Cmol/kg) at the surface layer and very low (0.20Cmol/kg) to moderate (0.40Cmol/kg) at subsurface layer, P4 ranged from very low (0.15Cmol/kg) to moderate (0.44Cmol/kg) at both surface and subsurface layer, while P6range from very low (0.20Cmol/kg) at the surface layer and moderate (0.42Cmol/kg) to low (0.27Cmol/kg) at subsurface layer. The low presence of exchangeable potassium might be attributed to highplantuptake or due to the continuous cultivation by rain fed and irrigation farmingthat do take place in the area seasonally. Alemayehu (1990), also observe observe low potassium under continuous cultivation.

3.2.4 Percent Base Saturation (PBS)

The result of percent base saturation at the surface and subsurface layer were generally high> 90 % in all the six pedon. The high PBS suggest high soluble forms of basic cations in soil solution. This finding is in total agreement with Uzu *et al.* (2004), who reported consistent high values of PBS in the soils of North Western Nigeria.The high base saturation might be due to the nature of parent materials or the presence organic matter which serves as an exchange sites, Pedon P5 and P6 increase with increase depth.

3.2.5 Cation exchange capacity (CEC)

The CEC of the soil samples as shown in Table 2, were generally medium in surface and subsurface layers of P1 (12.88Cmol/kg), P2 (13.17Cmol/kg), P3 (11.28Cmol/kg), P4 (16.18Cmol/kg), P5 (11.12Cmol/kg), and P6 (11.73Cmol/kg). The CEC of the soil are rated moderate in accordance with FPDD (2002) ratings (Table 3). The moderate CEC could be due to moderateclay and organic matter content in the studied area.A similar result of moderate CEC was obtained by Noma *et al.* (2004), while working on soils of Sokoto, Dundaye-Kwalkwalawa axis. The authors noted that the moderate CEC is an indication of presence of moderate kaolinitic clays in the fine earth fractions.

3.2.6 Effective Cation Exchange Capacity (ECEC)

The ECEC of the soil samples were generally high in surface and subsurface layer in P1, P2, P3, P4, P5, and P6 according to Table 3. The high level in ECEC might be due to the condition of soil pH of the studied area which is neutral to slightly alkaline.

Table 2: Chemical Properties of Soil

Pedon	Soil Depth (cm)	Ph (H_2O)	EC dSm^{-1}	O.C (%)	P (mg/kg)	Ca	Mg	Na	K	CEC	EA	ECEC	BS	TEB	ESP	SAR
						---- (cmol/kg) ----							---- (%) ----			
P1	0-22	7.35	0.08	0.20	1.05	5.00	6.40	1.30	0.18	12.88	0.50	13.38	96.30	12.88	10.09	0.77
	22-89	7.01	0.06	0.33	7.35	6.20	3.60	1.44	0.19	11.43	1.10	12.53	91.20	11.43	12.60	0.92
	89-150	7.36	0.07	0.39	7.35	8.00	2.00	1.50	0.19	11.69	0.40	12.09	96.70	11.69	12.83	0.95
	150-177	6.95	0.08	0.40	7.00	8.20	1.20	0.25	0.13	11.78	0.20	11.98	98.30	9.78	2.12	0.16
	177-200	7.47	0.07	0.40	0.70	6.80	1.20	1.28	0.19	11.47	0.50	8.97	94.40	9.47	11.16	0.91
P2	0-60	6.72	0.01	0.35	4.20	5.40	6.80	1.57	0.40	14.17	0.40	14.57	97.30	14.17	11.08	0.90
	60-125	7.11	0.11	0.25	2.80	7.00	4.40	1.57	0.20	13.17	0.50	13.67	93.20	13.17	11.92	0.93
	125-155	7.36	0.12	0.29	1.40	6.20	3.60	1.30	0.27	11.37	0.40	11.77	96.60	11.37	11.43	0.83
	155-170	7.08	0.31	0.21	2.80	5.20	3.80	1.44	0.20	10.64	1.40	12.04	88.40	10.64	13.53	0.96
	170-200	6.84	0.13	0.23	7.35	5.20	4.00	1.13	0.42	10.75	0.50	11.24	95.60	10.75	10.51	0.75
P3	0-40	6.96	0.05	0.60	4.85	6.20	4.40	0.49	0.19	11.28	1.40	12.68	88.90	11.28	4.34	0.30
	40-100	6.95	0.05	0.54	4.90	6.00	4.00	1.28	0.18	1146	1.10	12.56	91.20	11.46	0.11	0.81
	100-140	7.09	0.06	0.40	2.80	7.80	3.80	0.41	0.08	10.09	0.90	10.99	91.00	12.09	4.06	0.24
	140-185	7.13	0.09	0.33	0.70	7.20	4.00	0.39	0.08	10.47	1.40	11.87	88.20	11.67	3.72	0.23
	185-200	7.01	0.08	0.28	1.40	7.40	3.80	1.48	0.18	13.06	0.20	13.26	98.50	12.86	11.33	0.88
…P4	0-51	6.87	0.09	0.55	0.90	8.20	7.00	0.83	0.15	16.18	0.70	16.88	95.90	16.18	5.13	0.43
	51-101	6.70	0.14	0.54	3.50	7.80	4.60	0.61	0.44	13.11	0.30	13.41	97.90	13.45	4.65	0.35
	101-161	6.80	0.05	0.34	0.70	5.80	4.80	1.78	0.12	11.70	0.60	12.30	95.70	12.5	15.21	1.09
	161-200	6.74	0.16	0.29	0.70	4.40	4.00	0.46	0.31	15.97	0.70	16.67	95.80	9.17	2.88	0.32
P5	0-60	7.35	0.06	0.40	5.60	6.40	2.00	1.48	0.10	11.12	0.80	11.92	93.80	9.98	13.31	1.02
	60-100	7.07	0.09	0.33	3.50	6.80	5.20	1.33	0.20	13.11	0.90	14.23	93.70	13.53	10.14	0.77
	100-175	7.07	0.06	0.31	7.00	6.40	6.00	1.15	0.18	13.93	0.80	14.73	94.60	13.73	8.26	0.65
	175-200	7.36	0.09	0.23	1.40	6.00	8.00	1.54	0.18	15.75	0.80	16.55	95.20	15.72	9.78	0.82
P6	0-20	6.85	0.10	0.40	4.85	5.80	7.20	0.73	0.20	11.73	0.90	12.63	92.90	13.93	6.22	0.40
	20-70	7.02	0.08	0.22	7.00	5.20	6.00	1.39	0.27	10.46	0.80	11.26	93.00	12.86	13.29	0.83
	70-130	6.74	0.26	0.34	4.20	7.00	3.60	1.04	0.33	10.34	0.60	10.94	94.50	11.97	10.06	0.64
	130-160	7.35	0.11	0.39	4.90	8.80	5.00	1.43	0.42	10.65	0.30	10.95	97.30	15.65	13.43	0.77
	160-200	6.83	0.11	0.26	3.50	2.00	2.00	1.52	0.27	13.59	0.17	13.76	98.80	5.79	11.18	1.52

3.3 Physical Properties of the Soil

The following physical properties (soil texture, bulk density, and saturated hydraulic conductivity)of the soil were determined.

3.3.1 Soil texture

The result of the soil texturewere presented on Table 4.The soils of the studied area have high sand content followed by silt while clay has the lowest percentagewhich gives a textural class of sandy loam according to USDA textural triangle. The higher contents of sand and silt could be attributed to the nature of the environment which is semi arid.

3.3.2 Bulk density

Table 3: Soil fertility ratings

Parameter	Fertility Rating	Values
pH H_2O	Strongly acidic	5.0-5.5
	Moderately acidic	5.6-6.0
	Slightly acidic	6.1-6.5
	Neutral	6.6-7.2
	Slightly alkaline	7.3-7.8
EC (dsm^{-1})	No salinity effects	<0.40
	Very slightly saline	0.40-0.80
	Moderately saline	0.81-1.20
	Saline soil	1.21-1.60
Phosphorus	Very low	< 3
	Low	3-7
	Moderate	7-20
	High	>20
Potassium	Very low	0.12-0.2
	Low	0.21-0.3
	Moderate	0.31-0.6
	High	0.61-0.73
Organic Carbon	Very low	< 0.20
	Low	0.21-0.40
	Moderate	0.41-0.60
	Moderately high	0.61-0.80
	High	081-1.0
	Very high	>1.0
CEC	Low	<10
	Medium	10-25
	High	25-45
	Very high	>45
Mg	Very low	<0.3
	Low	0.3-1.0
	Medium	1.0-3.0
	High	3.0-8.0
Ca	Very low	<2.0
	Low	2.0-5.0
	Medium	5.0-10
	High	10.0-20.0
	Very high	>20.0
Na	Very low	<0.1
	Low	0.1-0.3
	Medium	0.3-0.7
	High	0.7-2.0
	Very high	>2.0

Source (FPDD, 2002)

The results of bulk density were shown on Table 4.Pedon P1 had bulk density values of 1.17 g/cm^3 and 1.57 g/cm^3,P2 had bulk density values of 1.15 g/cm^3 and 1.59 g/cm^3,P3 had bulk density values of 1.38 g/cm^3 and 1.60 g/cm^3, P4 had bulk density values of 1.38 g/cm^3 and 1.64 g/cm^3,P5 had bulk density values of 1.14 g/cm^3 and 1.48 g/cm^3,P6 had bulk density values of 1.12 g/cm^3 and 1.56 g/cm^3 both at their surfaces and sub surfaces respectively. The bulk density of the soils increases with increased in depth in all pedons.The increase in bulk density with depth could be due to low organic matter and usage of farm machinery in the studied area which causes compaction of sub surface layerthereby increasing bulk density value as reported by Islam and-Weil (2000), the authors stated that increase in bulk density is due to the compression caused by over burden weight. From the result obtain the bulk density of the study area is ideal for planting. According to Arshad *et al*. (1996), sandy clay, silt clay, some clay loams that have 35-45% clay texture having <1.10g/cm^3 has ideal bulk density, while bulk density that will affect root growth is 1.49g/cm^3 and anything above >1.58g/cm^3 will restrict root growth; likewise sand, sandy laom and loamy sands texture which have bulk density of <1.60g/cm^3 are ideal soils, bulk density that will affect root growth is between 1.69g/cm^3 to 1.79g/cm^3 and any soil that has bulk density of >1.80g/cm^3will restrict root growth. Finally silts and silt loams texture that have B.D <1.30g/cm^3 has ideal bulk density, while bulk density that will affect root growth is 1.60$g/cm^3$and anything above>1.5g/cm^3 will restrict root growth.

3.3.3 Saturated hydraulic conductivity

Result of Saturated hydraulic conductivity is presented in Table 4. P1 had values of 2.46 cm/s at surface and 4.29 cm/s at subsurface. P2 had values of 3.18 cm/s at surface and 2.12 cm/s at subsurface. P3 had values of 4.68 cm/s at surface and 2.09 cm/s at subsurface. P4 had values of 2.46 cm/s at surface and 3.18 cm/s at subsurface. P5 had values of 2.81 cm/s at surface and 2.11 cm/s at subsurface. P6 had values of 2.85 cm/s at surface and 2.00 cm/s at subsurface. The soil is considered to be moderate in hydraulic conductivity as contained in the ratings of Henry (1975). Hydraulic conductivity of the soil samples decreases with increase in depth, the reason for high saturated hydraulic conductivity at the top layer is because of the presence of more sand texture and less of clay than that of the lower layers. According to (kadam *et al*., 2005), hydraulic conductivity of soil ratings 2.0 to 6.25 is moderate. (Jarvis *et al.,* 2002), observed that particles size distribution have profound influences on the size of water conducting pores, which greatly affects hydraulic conductivity, they concluded that hydraulic conductivity increases with increasing particles size with coarse texture soils conducting water at a higher rate than fine textured soils.

4.0. Conclusion

Physical and chemical characterization of some selected soils in university of Maiduguri, revealed that the soils col-

Table 4: Soil Texture and some Physical Properties of the Soil

Profile Name	Soil Depth (cm)	Particle Size Distribution Sand	Silt	Clay	Class	Bulk density (g/cm^3)	Saturated hydraulic conductivity (10^{-4}) (cm/s)
P1	0-22	637	241	122	SL	1.17	2.46
	22-89	512	366	122	SL	1.34	2.41
	88.8-150	562	341	97	SL	1.41	2.51
	150-177	462	441	97	SL	1.55	2.31
	177-200	487	441	72	SL	1.57	4.29
P2	0-60	637	191	72	SL	1.15	3.18
	60-125	712	191	97	SL	1.23	2.67
	125-155	637	270	97	SL	1.33	2.37
	155-170	587	341	72	SL	1.33	2.15
	170-200	537	391	72	SL	1.59	2.12
P3	0-40	687	216	97	SL	1.38	4.68
	40-100	712	191	97	SL	1.47	2.15
	100-140	687	241	72	SL	1.53	2.13
	140-185	562	341	97	SL	1.55	2.11
	185-200	612	316	72	SL	1.60	2.09
P4	0-51	762	141	97	SL	1.38	2.46
	51-101	662	241	97	SL	1.40	2.31
	101-161	618	316	72	SL	1.44	2.28
	161-200	698	366	147	SL	1.64	3.18
P5	0-60	737	166	97	SL	1.14	2.81
	60-100	712	216	72	SL	1.18	2.16
	100-175	662	241	97	SL	1.34	2.14
	175-200	562	341	97	SL	1.48	2.11
P6	0-20	712	216	72	SL	1.12	2.85
	20-70	712	191	97	SL	1.28	2.72
	70-130	687	241	72	SL	1.33	2.08
	130-160	612	291	97	SL	1.38	2.02
	160-200	587	316	97	SL	1.56	2.00

SL=SandyLoam

our changes at both surface and subsurface layers within each profile due to reduction in organic matter down the profile which follow same trend with soil consistency and bulk density. The soils texture were predominantly sandy loam.Hydraulic conductivity was moderate and decreases with increase in depth. Soil reaction was neutral to slightly alkaline and no salinity effect at both surface and subsurface layers. The sodium content was high in the study and as such need some management practices for optimum crop production.

5.0. Recommendation

The soil should be classified and also a further evaluation on the capability and suitability of the area should be conducted. Farmers should grow sodium tolerant crops, such as legumes crop in the studied area.

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