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Assessment of Selected Chemical Properties of Soils of the Sokoto-Rima Floodplains at Sokoto, Nigeria

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Abstract: *The levels of soil chemical properties largely determine the suitability of soils for agriculture. This study examined selected chemical properties of soils in the Sokoto-Rima floodplains in Sokoto, Nigeria. Two locations were selected for the study (Kwalkwalawa and Nasarawa), both within the Sokoto-Rima floodplains. Soil samples were collected from the genetic horizons of profile pits dug in the two locations and analyzed for physical and chemical properties using standard laboratory procedures. Texturally, the soil varied from sandy loam to loam sand and silt clay loam. The values of sand, silt, and clay contents were significantly ($p < 0.05$) different between the two locations. Soil pH values ranged from moderately acidic to strongly alkaline (5.5 - 8.7) and were significantly ($p < 0.05$) different between the two locations. Soils in both floodplains were rated low in organic carbon (< 10 g/kg) and total nitrogen (< 1.5 g/kg), while available phosphorus was rated low to high. Soils in Nasarawa floodplains had significantly ($p < 0.01$) higher exchangeable potassium (K) and sodium (Na) levels than soils in Kwalkwalawa floodplains. Soils in Kwalkwalawa floodplains were rated low to high in exchangeable K and medium to high in sodium (Na), magnesium (Mg), and calcium (Ca). However, soils in Nasarawa were rated low to high in K, Na, Ca, and Mg. Exchangeable acidity values were rated low in both locations (< 1.0 cmol/kg). Cation exchange capacity (CEC) was significantly ($p < 0.05$) different between the two locations, with values rated low to high (< 6 to > 12) in both locations. Generally, soils in Nasarawa floodplains were more fertile than those in Kwalkwalawa floodplains. The low fertility in terms of organic carbon and exchangeable bases will require the adoption of proper management practices, including organic and inorganic fertilizer application, to sustain soil fertility.*

Keywords: Soil chemical properties, Floodplain, Sokoto-Nigeria.

INTRODUCTION

Comprehensive information on Nigeria's land resources is crucial for effective land use and management decisions at various levels of natural resource development (Fasino et al., 2021). Accurate land resource data enhances the efficient utilization of soil and water, optimizing agricultural productivity while mitigating land degradation (Anita et al., 2020). However, certain landforms, such as floodplains, remain under-researched despite their significant agricultural potential. Floodplains are low-lying areas adjacent to rivers that experience periodic inundation, consisting of levees, flood basins, point bars, and oxbow lakes. These ecosystems play a vital role in maintaining soil fertility, as floodwaters deposit nutrient-rich sediments from upland areas, replenishing essential minerals required for crop growth (Mitsch & Gosselink, 2000; Ande et al., 2016). This natural enrichment makes floodplains highly suitable for agriculture, particularly in regions prone to soil fertility depletion.

Floodplains serve as viable alternatives to upland farming, especially in arid and semi-arid zones, where water availability is limited and rainfall variability threatens agricultural productivity. Studies have shown that floodplain soils can support long-growing season crops, offering greater resilience to drought conditions than upland soils (Afu et al., 2019). Moreover, controlled floodplain farming has been successfully utilized in various parts of the world, including the Indo-Gangetic Plains in South Asia and the Nile Valley in Africa, where seasonal flooding sustains agriculture through natural irrigation and soil nutrient replenishment (Hossain et al., 2011; Akpan-Idiok & Ogbaji, 2013).

The physical and chemical characteristics of floodplain soils are influenced by seasonal wetting and drying cycles, which affect their texture, structure, and nutrient availability (Ande et al., 2016). Studies indicate that these soils are generally characterized by moderate to high contents of basic cations (calcium, magnesium, potassium), organic carbon, and a moderate to high fertility status (Ogban & Babalola, 2009; Hossain et al., 2011). However, prolonged water saturation can lead to leaching of essential nutrients, soil acidity, and potential nutrient imbalances, thereby influencing soil productivity (Afu et al., 2019). Floodplain soils have also been reported to contain substantial levels of exchangeable bases, making them suitable for intensive cropping under proper management (Ande et al., 2016). Research conducted in Southern Nigeria suggests that wetlands and floodplains contribute significantly to regional food security by supporting high-yield crop production (Akpan-Idiok & Ogbaji, 2013). However, in Northern Nigeria, the potential of floodplain soils remains largely untapped due to limited research and inadequate soil management practices.

Despite their agricultural potential, floodplain soils face several challenges. Periodic flooding can lead to erosion, nutrient loss, and the deposition of heavy metals and other contaminants, particularly in areas affected by industrial or urban runoff (Mitsch & Gosselink, 2000). Additionally, the unpredictability of flood cycles, influenced by climate change, poses a challenge for consistent agricultural planning. Climate models suggest that increased variability in rainfall patterns could either enhance or reduce the productivity of floodplain agriculture, depending on the intensity and frequency of flooding (Anita et al., 2020). Furthermore, while extensive research has been conducted on the agro-potential of wetland and floodplain soils in Southern Nigeria, similar studies are lacking in Northern Nigeria, particularly within the Sokoto-Rima floodplains. Limited soil characterization and inadequate land-use planning have restricted the effective utilization of these fertile lands. Given the importance of floodplains in sustaining agricultural productivity and mitigating land degradation, a detailed assessment of their soil properties is essential. This study aims to evaluate the chemical properties of soils in the Sokoto-Rima floodplains to determine their suitability for sustainable crop production.

MATERIALS AND METHODS

Study Area

Sokoto State is located in the North-West Sudano-Sahelian Savannah ecological belt of Nigeria between Latitudes 13° 05' - 13° 16' N and Longitudes 05° 09' and 05° 16' E. It has an area of 25,973 Km^2. It is bordered by Niger Republic to the north, Zamfara State to the east and south, and Kebbi State to the west. Presently, the State has twenty-three (23) Local Government Areas (LGAs) (Figure 1). The study area has a typical Sudan Savanna vegetation type. The area is intensively cultivated foran array of crops such as onion, tomato, cowpea and millet. The length of the growing period is 90-150 days (Ojanuga, 2006). The climate of Sokoto State is wet and dry, generally hot semi-arid tropics in Koppen classification of AW type. It is characterized by a long dry season from October through May/June and a short but intensive wet season from May/June through September with a mean annual rainfall slightly below 750 mm. The rainfall pattern shows a marked seasonal variation with a single peak reaching a maximum in August (Kowal and Knabe, 1972). The mean annual rainfall decreases gradually from the south to northern parts of the state. The rainy season is then followed by a short dry spell which could last for two to three months known as Harmattan. A period of cold, dry and dusty weather normally precedes the fairly long dry season. The temperature fluctuates within a range of 16 ^{0}C during cold nights to over 40 ^{0}C during hot days. The relative humidity during the dry season is about 15-20% and reaches up to 70-75% during the rainy season.

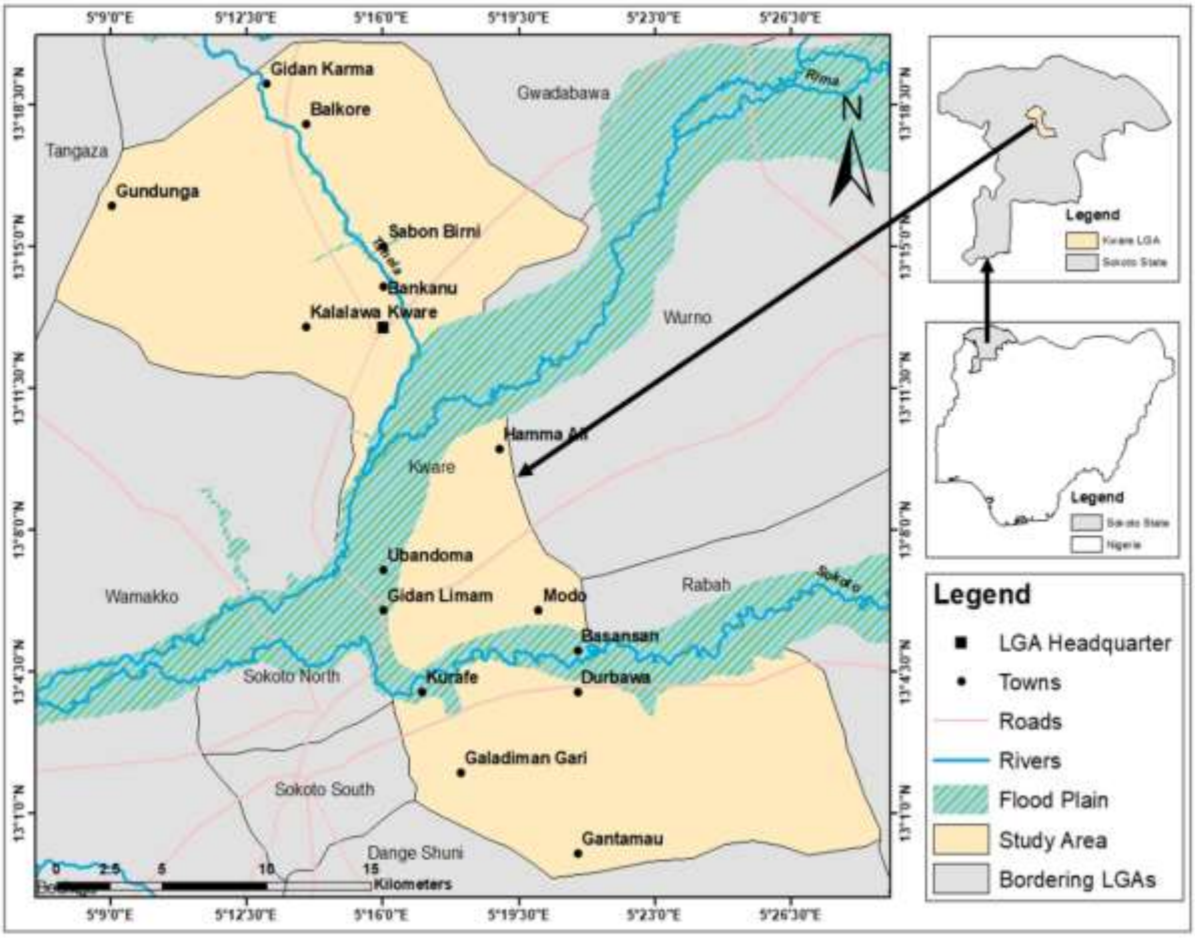

Figure: 1. The Study Areas

Field study and Soil Sampling

The study involved a detailed soil survey using rigid-grid method (100 m × 100 m) superimposed on the two floodplains (Kwalkwalawa and Nasarawa floodplains). Transects at 100-meter intervals were constructed at right angles to either side of the baseline. This was followed by auger borings from 0-15cm and 15-30cm to examine and describe the soils consistently at 100 meters interval along each traverse. Observations relating to morphological properties of the soils, physiographic position, topography, colour, were used to observed soil variation. Six (6) profile pits were dug on the six hectares of Kwalkwalawa while twelve (12) pits were dugs on the eighteen hectares of Nasarawa floodplains. The soil profiles were described according to FAO (2006) manual while the collection of bulked samples was made from each genetic horizon for laboratory analysis.

Laboratory Methods

The samples were air-dried, gently crushed using a wooden mortar and pestle and then sieved through a 2mm mesh. The sieved samples were stored for chemical and physical analyses.

Particle size distribution was determined by the hydrometer method (Agbenin, 1995). Soil pH (1:1) in H_20 was determined using glass electrode pH meter (Agbenin, 1995). Organic carbon content of the soils was determined by the modified Walkley-Black method as described by Agbenin, (1995). Avail P was determined using Bray 1 method while TN was determined by the kjeldahl method (Agbenin, 1995). The cation exchange capacity (CEC) was determined by saturating soil with normal ammonium acetate solution (Agbenin, 1995). Exchangeable bases (calcium, magnesium, potassium and sodium) in the soil were determined using HCl extract from the CEC determination. Sodium and K were determined using flame photometer while Ca and Mg were determined using atomic absorption spectrometer. Percentage Base Saturation (PBS) was calculated using the following formulae by Agbenin (1995).

$$PBS = \frac{\text{Total Exchangeable Bases}}{\text{CEC}} \times 100$$

Data Analysis

The data collected from soil analysis was subjected to t-test analysis to assess variation in soil properties between the two floodplains at 0.05 level of significant in statistical package for social science (SPSS) software, version 23.

RESULTS AND DISCUSSION

Particle size distribution

Sand contents range from 52.0 to 86.0 (mean 68.3 %) in Kalkwalawa floodplains and 1.0 to 72.0 (mean 18.0 %) in Nasarawa floodplains. Soils in Kalkwalawa was significantly ($p < 0.05$) higher in sand content than soils in Nasarawa floodplains. Sand contents generally increased with an increase in soil depths in Kalkwalawa floodplains and sand content increase from A to B horizon and later decrease in C horizon in soils of Nasarawa floodplains. Silt contents range from 6.0 to 22.0 (mean 14.0 %) in Kalkwalawa and 16.0 to 76.0 (mean 55.9 %) in Nasarawa. Soils in Nasarawa was significantly ($p < 0.001$) higher in silt content than soils in Kalkwalawa. Silt content also has irregular increase and decrease with soil depth in both Kalkalawa and Nasarawa area. Clay contents range from 8.0 to 30.0 (mean 17.65 %) in Kalkwalawa and 4.0 to 70.0 (mean 26.4 %) in Nasarawa. Soils in Nasarawa were significantly ($p < 0.05$) higher in clay content than soils in Kalkwalawa.

Table 1: Ranking of Mean Soil Properties Across the study area

Location/ Parameters	Clay	Silt	Sand	pH H2O	O.C	TN	Avail. P.	K	Na	Ca	Mg	Acidity	CEC	BS
Units		%			g/kg		mg/kg			Cmol/kg				%
Kolkalawa	17.65	14.00	68.35	8.28	2.65	0.78	7.24	0.12	0.40	7.26	1.96	0.06	10.63	83.05
Nasarawa	26.41	55.90	18.00	7.50	2.98	0.66	6.02	0.31	1.05	7.90	2.26	0.15	15.72	77.63
P-value	0.04	0.00	0.00	0.00	0.51	0.31	0.31	0.00	0.00	0.58	0.37	0.00	0.04	0.25
LOS	*	**	**	**	NS	NS	NS	*	*	NS	NS	**	*	NS
SE+	1.77	2.55	2.96	0.05	0.20	0.05	0.49	0.03	0.06	0.47	0.14	0.01	1.03	1.93
Surface	25.29	47.06	27.65	7.78	3.84	0.79	10.24	0.39	1.03	8.88	2.56	0.13	15.27	85.46
Subsoils	24.35	46.98	28.98	7.63	2.66	0.66	5.21	0.23	0.88	7.46	2.10	0.13	14.47	76.98
P-value	0.83	0.99	0.85	0.21	0.02	0.26	0.00	0.01	0.33	0.21	0.17	0.86	0.75	0.07
LOS	NS	NS	NS	NS	*	NS	*	*	NS	NS	NS	NS	NS	NS
SE+	1.77	2.55	2.96	0.05	0.20	0.05	0.49	0.03	0.06	0.47	0.14	0.01	1.03	1.93

Source: Authors' Computation

Clay content increase with soil depth in soils of Kalkwalawa while an irregular increase and decrease in clay content with soil depth were observed in soils of Nasarawa area. This result revealed that there is some textural variation among the two locations. Kalkwalawa with sandy soils form more slowly due to their smaller surface area and weathering process. Soils in Nasarawa with Clayey soils have a higher nutrient content due to their larger surface area and complex bonding with nutrients, making them more accessible to plants.

Soil texture

The soil texture varies from sandy loam in the surface horizon to sandy clay loam in the subsurface in Kalkwalawa floodplains while soil texture varies from silt loam to loam on the surface horizon and silt clay, silt clay loam to clay in the subsoils of soils in Nasarawa. Generally, soils in Nasarawa flood plains were heavy in texture been dominated by silt clay loam texture. Soil texture is a near permanent attribute of the soil which hardly changes due to vegetation type/age, land use and management or conservation (Ahukaemere et al., 2016). The surface soil which was characterized by coarse texture while subsoil horizon was dominated by fine texture. This was attributed to the illuviation of fine particles by illuviation processes into the subsoils (Ahukaemere et al., 2016). The change in texture is an indication of active eluviation - illuviation of clay to form a zone of maximum clay accumulation (argilluviation).

Soil pH

Soil pH in water ranged from 7.7 to 8.6 (mean 8.3) in Kalkwalawa and 7.0 to 8.6 (mean 7.5) in Nasarawa. Soils in Kalkwalawa were significantly ($p < 0.001$) higher in soil pH than soils in Nasarawa. Soil in Kalkwalawa were slightly alkaline to strongly alkaline while soils in Nasarawa were neutral to strongly alkaline. Sharu et al. (2013) also reported alkaline nature of Sokoto soils. The soil pH of surface soils mean value was 7.78 while subsoils mean value was 7.63. Surface soil was higher in soil pH than subsoils though the difference was not statistically significant. Similar trends were observed and reported by Sharu et al. (2013) and pH range of 5.5 to 7.0 is the preferred range for most crops.

Soil organic carbon (O.C)

Soil organic carbon (O.C) ranged from 0.4 to 6.8 gkg^{-1} (mean 2.6 gkg^{-1}) in Kalkwalawa and 0.58 to 9.5 (mean 2.9 gkg^{-1}) in Nasarawa. Soil in Nasarawa were higher in O.C than Kalkwalawa but the difference was not statistically significant. Soils in both locations were rated low in O.C been less than 10 gkg^{-1}. The soil O.C of surface soils mean value was 3.84 while subsoils mean value was 2.66. Surface soil was significantly ($p < 0.01$) higher in soil O.C than subsoils. Previous studies in Sokoto also reported low O.C in soils of the region (Chude et al., 2012; Chaudhari et al., 2018; Uke and Haliru, 2021). The low OC reported in this study confirm the report of Aliyu et al. (2020) who submitted that soil of Sokoto is low in organic matter content and attributed it to factors such as continuous cultivation, frequent burning of farm residues commonly carried out by farmers in the area which tends to destruction of much of the organic materials that could have been added to the soil. The generally low OC content of these soils might be due to continuous cultivation without fallow, bush burning, high rate of mineralization due to high temperature and crop removal for livestock feeding, fuelwood, fencing and building purposes (Odunze and Kureh, 2009; Fasina et al., 2015; Uke and Haliru, 2021).

Total Nitrogen (T.N.)

Total nitrogen (T.N.) ranged from 0.28 to 1.40 gkg^{-1} (mean 0.77 gkg^{-1}) in Kalkwalawa and 0.06 to 1.96 gkg^{-1} (mean 0.66 gkg^{-1}) in Nasarawa floodplains. Soils in Kalkwalawa were higher in T.N than Nasarawa floodplains but the difference was not statistically significant. Soils in both locations were rated low in T.N. been less than 1.5 gkg^{-1}. The T.N of surface soils had a value of 0.78 while subsoils value was 0.65. Surface soils were higher in T.N than subsoils though the difference was not statistically significant. Total N is mobile in soils, as a result its losses through various mechanism like NH_3 volatilization, succeeding denitrification, chemical and microbial fixation, leaching and runoff results in residual/available N becomes poor in soils (Awanish et al., 2014). Similar results of low N values were reported by Maniyunda (2014) in Zaria, Sharu et al. (2013) Uke and Haliru (2021) in soils of Sokoto State. Tropical soils are intrinsically low in N and these low N values may be due to low organic matter content of the soils since inorganic nitrogen contribute to only a small portion of total nitrogen in savannah soils (Bensemann et al., 2018).

Available phosphorus (A.p.)

Available phosphorus (A.p.) ranged from 2.2 to 31.4 (mean 7.2 $mgkg^{-1}$) in the soils of Kalkwalawa and 3.7 to 27.1 (mean 6.1 $mgkg^{-1}$) in Nasarawa floodplains. Soil in Kalkwalawa were higher in A.p. than Nasarawa but the difference was not statistically significant. Soils in both locations were rated low to high in A.p. been between less than 10 to greater than 20 $mgkg^{-1}$. The A.p. of surface soils had a mean value of 10.21 while subsoils mean value was 5.2 $mgkg^{-1}$. Surface soil was significantly ($p < 0.01$) higher in soil Avail. p. than subsoils. Sharu et al. (2013) and Uke and Haliru (2021) also reported low Avail. P. values in soil of Sokoto. The reason for the observed low phosphorus could be due to the prevalent soil management practices which encourage the export of nutrients in harvested crops without adequate replacement (Haruna, 2009), while higher values could be attributed to deposition from upland areas.

Exchangeable Bases

Exchangeable potassium(K) ranges from 0.05 to 0.42$Cmolkg^{-1}$ (mean 0.12 $Cmolkg^{-1}$) in Kalkwalawa and 0.04 to 1.0 $Cmolkg^{-1}$ (mean 0.31 $Cmolkg^{-1}$) in Nasarawa floodplains. Soils in Nasarawa floodplains was significantly ($p < 0.01$) higher in K than soils in Kalkwalawa floodplains. Soils in both locations were rated low to high in K been between less than 0.15 to greater than 0.30 $Cmol.kg^{-1}$. The exchangeable K of surface soils mean value was 0.39 while subsoils mean value was 0.23. Surface soil was significantly ($p < 0.01$) higher in K than subsoils.

Exchangeable sodium (Na) ranged from 0.15 to 1.05 $Cmolkg^{-1}$ (mean 0.39 $Cmolkg^{-1}$) in Kalkwalawa floodplains and 0.01 to 2.12 $Cmolkg^{-1}$ (mean 1.05 $Cmolkg^{-1}$) in Nasarawa floodplains. Soils in Nasarawa were significantly ($p < 0.001$) higher in Na than soils in Kalkwalawa floodplains. Soils in Kalkwalawa floodplains were rated medium to high while soils in Nasarawa floodplains were rated low to high in exchangeable Na. Exchangeable Na of surface soils mean value was 1.02$Cmolkg^{-1}$while subsoils mean value was 0.88$Cmolkg^{-1}$. Surface soils had higher Na than subsoils though the difference was not statistically significant.

Exchangeable calcium (Ca) ranged from 2.20 to 18.20 $Cmolkg^{-1}$ (mean 7.25$Cmolkg^{-1}$) in Kalkwalawa and 1.8 to 17.2 (mean 7.89) in Nasarawa floodplains. Soil in Nasarawa floodplains were higher in Ca than Kalkwalawa but the difference was not statistically significant. Soils in Kalkwalawa were rated medium to high while soils in Nasarawa were rated low to high in exchangeable Ca. Exchangeable Ca of surface soils mean value was 8.88 while subsoils mean value was 7.45. Surface soil was higher in soil Ca than subsoils though the difference was not statistically significant.

Exchangeable magnesium (Mg) ranged from 0.59 to 3.46Cmolkg^{-1} (mean 1.95Cmolkg^{-1}) in Kalkwalawa and 0.20 to 5.16Cmolkg^{-1} (mean 2.25Cmolkg^{-1}) in Nasarawa fadana. Soil in Nasarawa were higher in Mg than Kalkwalawa but the difference was not statistically significant. Soils in Kalkwalawa were rated medium to high while soils in Nasarawa were rated low to high in exchangeable Mg. Exchangeable Mg of surface soils mean value was 2.55 while subsoils mean value was 2.19Cmolkg^{-1}. Surface soil was higher in soil Mg than subsoils though the difference was not statistically significant.

Calcium and magnesium are the predominant basic cations in the soils. The lowest proportion of the exchangeable bases was occupied by potassium followed closely by sodium. Similar observations have been made in the past for West African soils (Kowal and Knabe, 1972; Obi et al., 2011; Sharu et al., 2013 and Uke and Haliru, 2021). The predominance of Ca may be due to calcium bearing parent material in the soil (Nahusenay et al., 2014; Jimoh et al., 2020). Further, the high concentration of calcium is not good for optimum soil properties. Abundance of Mg alone or in association with excess exchangeable sodium may behave like Na in soil degradation (Qadir and Schubert, 2002 in Uke and Haliru, 2021). Exchangeable Mg and Na soils develop hydraulic conductivity that is lower than soils under similar environmental conditions. This is because hydrated Ca is lesser in size than hydrated Mg. Therefore, water is accumulated in the soil surface than when exchangeable Ca is present, resulting in weakened soil binders. Calcium to magnesium ratio determines how tight or loose a soil is. The more calcium a soil has, the looser it is, and the more magnesium, the tighter the pore spaces are, making the soil to drain more slowly and organic matter will break down poorly.

Exchangeable acidity (EA)

Exchangeable acidity (EA) ranged from 0.05 to 0.20Cmolkg^{-1} (mean 0.05Cmolkg^{-1}) in Kalkwalawa and 0.01 to 0.40Cmolkg^{-1} (mean 0.15Cmolkg^{-1}) in Nasarawa. Soils in Nasarawa was significantly ($p < 0.001$) higher in EA than soils in Kalkwalawa. Soils in both locations were rated low in EA been less than 1.0 cmol.kg^{-1}. Exchangeable acidity of surface soils mean value was 0.12 while subsoils mean value was 0.13. Subsoils were higher in soil EA than surface soils though the difference was not statistically significant. The low EA of the soils implies that the soils have little or no acidity problems. Raji and Mohammed (2000), Jibrin et al. (2008), Jimoh et al. (2020) reported similar results and submitted that the contribution of exchange acidity to potential acidity is very low in soils of Nigerian savannas.

Cation exchangeable capacity (CEC)

Cation exchangeable capacity (CEC) ranges from 4.69 to 18.05 cmol.kg^{-1} (mean 10.63 cmol.kg^{-1}) in Kalkwalawa floodplain sand 3.10 to 40.98 cmol.kg^{-1} (mean 15.72 cmol.kg^{-1}) in Nasarawa floodplains. Soils in Nasarawa floodplains was significantly ($p < 0.05$) higher in CEC than soils in Kalkwalawa floodplains. The CEC of surface soils mean value was 15.2

cmol.kg^{-1}while subsoils mean value was 14.5 cmol.kg^{-1}. Surface soil was higher in CEC than subsoils though the difference was not statistically significant. Cation Exchange Capacity rating of <6 low, 6-12 medium and >12 high. The lower CEC of Kalkwalawa floodplains could be attributed to the nature of clay minerals (kaolinite) and low organic carbon of the soils (Hassan et al., 2011). Yakubu et al. (2011) opined that organic matter content of soils which normally influences the CEC is low and therefore the CEC values may not be attributed to the amount of organic matter. Uke and Haliru (2021) also reported low to medium CEC in some soil of Sokoto floodplains. The medium level of the CEC in Nasarawa might be a reflection of the intensity of weathering that produced the soils. The value of CEC indicated good nutrient retention, release and buffering capacity of the soil.

Base saturation (BS)

Base saturation (BS) ranged from 42.6 to 97.3 % (mean 83.0 %) in Kalkwalawa and 14.5 to 98.6 % (mean 77.6 %) in Nasarawa. Soil in Kalkwalawa floodplains were higher in BS than Nasarawa floodplains but the difference was not statistically significant. Base saturation of surface soils mean value was 85.5 % while subsoils mean value was 76.9 %. Surface soil was higher in soil BS than subsoils though the difference was not statistically significant. FAO (1999) and Anni et al. (2018) reported that soils with base saturation of >50% are regarded as fertile soils while soils with less than 50% were regarded as not fertile soils. Based on this therefore, the soils are generally fertile. This corroborates Uke and Haliru (2021) who also reported BS of >50 in some Floodplains soils of Sokoto State.

CONCLUSION AND RECOMMENDATION

This study assessed selected chemical properties of soils of the Sokoto-Rima floodplains at Sokoto, Nigeria. The results showed that Soil texture was loam sand in Kalkalawa fadama and silt clay loam in Nasarawa fadama. Sand, silt and clay content were significantly ($P < 0.05$) different between the two locations. Mean soil pH value were rated slightly alkaline to strongly alkaline in Kalkalawa and moderately acidic to strongly alkaline in Nasarawa (7.2 – 7.9), organic carbon was low (5.3 – 9.7 g/kg) while cation exchange capacity was medium to high (8.7 – 19.7 cmol/kg) and base saturation (70 - 71 %) were high in the two locations respectively. Soil pH, O.C, CEC and BS were significantly ($P < 0.05$) different between the two location. The soil in Nasarawa was higher in fertility than the soil in Kalkalawa. Based on fertility, Kalkalawa fadama was low in fertility (low in potassium, organic carbon, total nitrogen and CEC) when compared with Nasarawa Fadama. Generally, the soils were low in fertility and needed the adoption of proper management practices in terms of organic and inorganic fertilizer application to sustain the soil fertility most especially Kalkalawa soils.

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