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Physico-chemical properties of soils in flooded and upland forest areas of Yola-North and Yola-South local government areas, Adamawa state, Nigeria

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Abstract
This study examined the Physicochemical properties of soils in flooded and upland forest areas of Yola-North and Yola-South Local Government Areas. Composite soil samples were collected from three selected points in two locations of both flooded and upland areas of the two LGAs. These were Jambutu and Runde in Yola-North and Yolde-Pate and Ngurore in Yola-South LGA. The depths of collection of soil samples in each point were 0-30, 31-60 and 61-90 Cm using hand auger. Laboratory analysis showed that the physical properties of the soil samples in Yola-North; sand, silt, clay, bulk density and porosity had values ranging from 37-70%, 11-16.67%, 19-46%, 1.28-1.53 gcm-3 and 37-51.67% while the chemical properties of soil, pH, EC, OC, TN, AV-P, Ca, Mg, Na, K, TEB, TEA, ECEC and PBS had values ranging from 6.57-6.75, 1.01-1.09 dS/m, 6.20-7.63 g/Kg,1.50-1.57 g/Kg, 7.68-9.34 mg/Kg, 7.27-12.00 Cmol/Kg, 1.82-3.10 Cmol/Kg, 0.11-0.39 Cmol/Kg, 0.09-0.51 Cmol/Kg, 5.13-8.01 Cmol/Kg, 1.28-2.23 Cmol/Kg, 10.46-18.45 Cmol/Kg and 72.70-79.33% in the LGA. Similarly, results from the physical properties of the soil samples in Yola-South; sand, silt, clay, bulk density and porosity had values ranging from 40-51%, 14.67-20.60%, 32-39%, 1.29-1.40 gcm-3 and 36.83-50.33% while the chemical properties of soil, pH, EC, OC, TN, AV-P, Ca, Mg, Na, K, TEB, TEA, ECEC and PBS had values ranging from 6.57-6.72, 1-1.08 dS/m, 6.70-7.70 g/Kg, 1.55-1.70 g/Kg, 7.80-9.30 mg/Kg, 8.50-12.70 Cmol/Kg, 1.90-3.61 Cmol/Kg, 0.1-0.25 Cmol/Kg, 0.11-0.52 Cmol/Kg, 5.30-8.01 Cmol/Kg, 1.6-2.10 Cmol/Kg, 12.41-18.45 Cmol/Kg and 71.93-78.14%. Multivariate Analysis of Variance (MANOVA) and Pearson Product Moment Correlation were used to test for significant differences in the physical and chemical properties of soils from the two LGAs. The mean separation of nutrient values was done using the Duncan Multiple Range Test. The results showed that all the physical properties except bulk density showed significant differences at $p \leq 0.05$ between upland and flooded soils. The assessment of the chemical properties of the soil samples showed significant differences at OC, AV-P, Ca, K + and TEB while there were no significant differences at $p \leq 0.05$ in the other properties. The R-values of correlation ranged from-0.01 and 0.97 in both the physical properties of the two LGAs. Similarly, the r-value ranged from-0.02 and 0.98 in both the chemical properties of the two LGAs. Thus it is concluded that some nutrients are leached during flooding; some are added as deposits while some are unaffected by flood. Further research could be geared towards identifying flood-tolerant tree species in the study area for forest conservation.

Keywords: Flood, upland, composite soil sample, physical and chemical properties

Introduction

Flood Management is currently a key focus of many national and international research programs with flooding from rivers, estuaries and the sea posing a serious threat to millions of people around the world during a period of extreme climate variability, [Flood Risk Management Research Consortium (FRMRC), 2010] [10]. The dramatic river flooding in Adamawa State that destroyed farmlands and claimed lives and property has affected various parts of the region. Sequel to the topography and sediment type of the study area, the possibility of spread exists. Some of the flood-prone areas include Yola-North and Yola-South, Numan, Fufore and Demsa (Drogue *et al*., 2014) [9]. Galtima and Bashir (2002) [11] recorded very severe destruction in Fufore LGA to the extent that as many as 13 villages were submerged and hundreds of hectares of farmland were washed away. The need and means to protect the environment is of great concern to man. Flood occurrences in Adamawa State floodplain are threats to lives and properties and the frequency is increasing dramatically.

According to the International Federation of Red Cross and Red Crescent Society (IFRCS, 2012) [14], Floods in Adamawa state usually leave over 2,000 people displaced many of them with no access to clean drinking water, leading to cholera outbreaks.

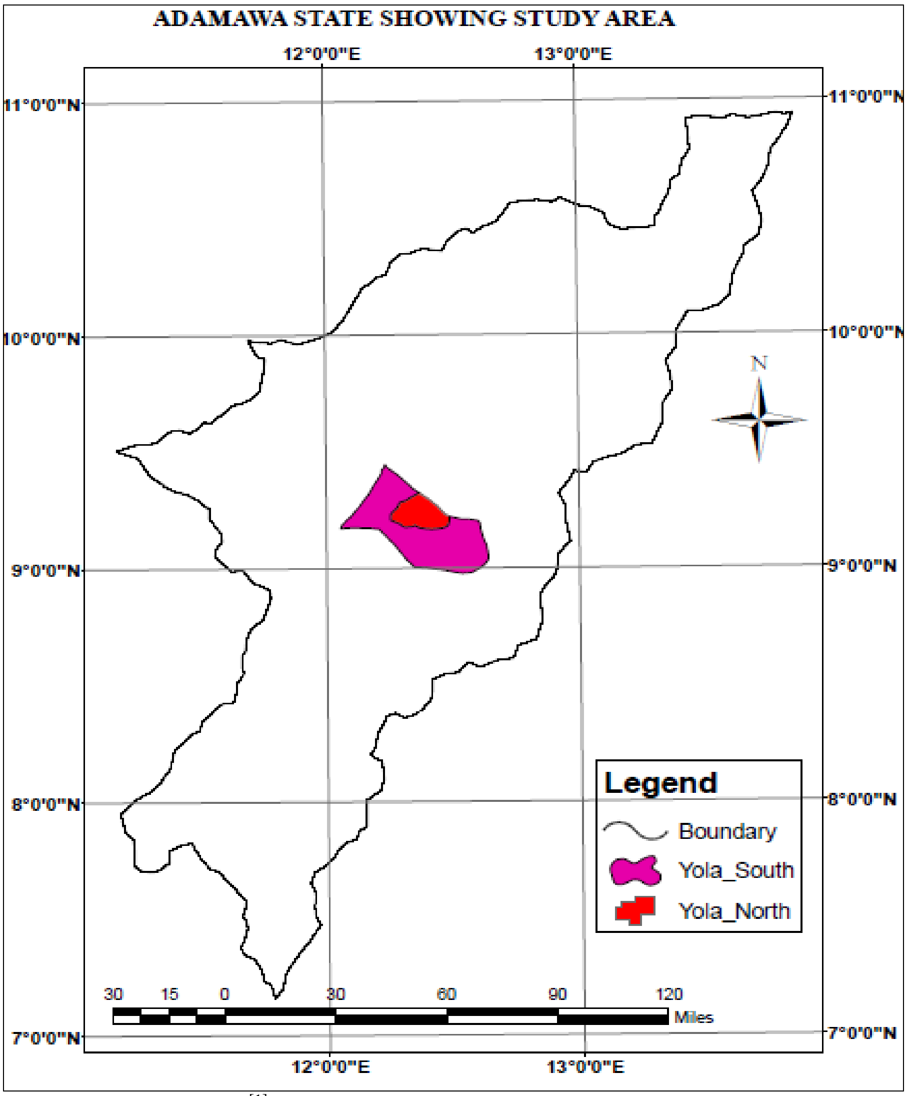
According to the Nigeria Emergency Management Agency (NEMA, 2010) [16], five districts, namely, Fufore, Demsa, Yola North, Yola South and Numan were flooded in August and early September, when River Lagdo burst its banks. Demsa and Fufore districts, along with nearby Maiha, were hit with a cholera outbreak which left 70 people dead out of over 300 infected (Daily Trust, 2010) [5].

Soil nutrients are classified as primary, secondary, or micronutrients. Primary nutrients are used in the largest quantities by plants and are usually the first to become deficient in the soil (Dezzeo *et al*., 2010) [7]. Primary and secondary nutrients are sometimes known as macronutrients. Secondary nutrients are macronutrients but are less frequently deficient in soils. Micronutrients also known as trace or minor elements, are required in small amounts and are less frequently deficient. Nutrient are positively charged cations in soil which include K +, Ca_2 +, Zn + 2, Mg + 2, Mn + 2, NH_4 +, Na +, H +, Al + 3 and negatively charge anions which include NO_3-, SO_4-2 H_2PO_4-, HPO_4-2, Cl-, BO_3-2, MoO_3-2, CO_3-3. Adamawa plains are extensively flooded periodically, thus subject to intermittent leaching, siltation, nutrient deposit and washing away by flood in the flooded area unlike that of the upland area which is unaffected by flooding (Dezzeo *et al*., 2010) [7]. Flooding can lead to both increases and decreases in soil nutrient content (Gallardo, 2011) [12]. During flooding the soil becomes highly reduced, resulting in a decrease in pH which leads to an increase in the mobility of soil nutrients such as P, N, Mg, Ca, Na and K. These nutrients include those that were deposited by the previous flood and those released from organic matter decomposition accumulated during dry periods. Soil flooding can cause hypoxia leading to a reduction in the soil nutrient content available to plants. As a result of hypoxia, the organic matter decomposition rate is reduced, leading to low soil nutrient content release (Gallardo, 2011) [12].

Materials and Methods

The Study Area

Adamawa State is located in the North Eastern part of Nigeria. It lies between latitude 7o and 11o N of the equator and between longitude 12o and 13o E of the Greenwich meridian E in the Upper Benue catchment (Figure 7). It shares a boundary with Taraba State in the South and West, Gombe State in its Northwest and Borno State to the North. Adamawa State has an international boundary with the Cameroon Republic along its eastern border. The State covers a land area of about 38,741 km2. It is divided into 21 Local Government Areas (Figure 7). It has a population of 3,168,101 (National Bureau for Statistics, 2007) [17].



Source: Adebayo (1999) [1]

Fig 1: Map of Adamawa State showing the two LGAs were the study site located

Data Collection

Collection of soil samples

Soil samples were randomly selected from three points in each of the flooded forest areas (location A) and 200 m adjacent from the site i.e. at the upland forest area (location B), in two areas *viz*: Ngurore and Yolde-Parte in Yola-South LGA. Runde-Baru and Jambutu in Yola-North LGA. They have both the flooded and upland areas. At each point, samples were taken at three depths, 0-30 cm, 31-60 cm and 61-90 cm using hand Auger. All samples were labelled appropriately in cellophane bags for onward determination of soil physical and chemical properties in the laboratory. Similarly, soil samples were also collected from upland forest areas of each location adjacent to the study sites for comparison (Dishan, 2016) [8].

Determination of physical and chemical properties of the Soil Samples

The determination of the physical and chemical properties of the soil samples was carried out in the Soil Science Laboratory of the Modibbo Adama University of Technology Yola. The samples were first air-dried and later ground using pestle and mortar. They were then sieved to pass through a < 2 mm sieve (Dent and Young, 1981) [6].

Laboratory Analysis

The soil samples were air-dried and crushed using a mortar and pestle to pass through a 2 mm sieve. The samples were well packaged in polythene bags and labelled accordingly. The samples were characterized for their physical and chemical properties following standard laboratory procedures (Jaiswal, 2003) [15].
Soil Physical Analysis

(i) Mechanical Analysis

Mechanical analyses of the soil samples were determined using a Soil Hydrometer after dispersing the soil water solution with Calgon (Sodium metahexaphosphate solution). The sand, silt and clay fractions were computed from hydrometer and thermometer readings (Idoga *et al*., 2007) [13].

(ii) Soil Bulk Density

Soil bulk density was determined from soil cores taken from the field. The oven dry weight of the sample was determined in the laboratory and the bulk density was determined by dividing the weight of the soil by the volume of the core sampler.

BD = Mass of dry soil (g) / Vol. of same (cm3) as described by (Dent and Young, 1981) [6].

(iii) Porosity

Total porosity was calculated using the formula:
$F = 1 - Db/Dp \times 100$
Where F = Total porosity
Db = Bulk density
Dp = particle density (Dent and Young, 1981) [6].

Soil Chemical Analysis

(i) Soil pH

Soil pH was determined in 1: 2 (Soil: Water) suspension using a pH meter, value was adjusted to 200 C (Jaiswal, 2003) [15].

(ii) Electrical Conductivity EC

The soil Electrical conductivity was determined in 1: 2 (soil: Water) suspension using an electrical conductivity meter as described by (Black, 1965 and Jaiswal, 2003) [4, 15].

(iii) Organic Carbon Determination (OC %)

Soil organic carbon was determined using the Wet Oxidation method of Walkley and Black (1965) [18], using Potassium Dichromate and concentrated Sulphuric Acid. A blank experiment always runs without soil to know the unused potassium dichromate in soil sample experiments (Black, 1965) [4].

(iv) Available Phosphorus (Av P)

Available phosphorus in soil was determined by extracting the soil with dilute HO (Bray-1) where the pH of the soil was neutral or acidic. Sodium-bicarbonate (Olson's method) extraction was used where the soil pH was alkaline. The extract was used for the determination of available P calorimetrically developing blue colour (Brady and Weil 2008) [2].

(v) Total Nitrogen (TN)

The total nitrogen content of the soil was determined by the Kjeldahls wet digestion method using sulphuric acid and CuS04 and Na2S04 catalyst mixture (Bremner and Mulvaney, 1982) [3].

(vi) Exchangeable Cations

Exchangeable cations Calcium (Ca), Magnesium (Mg), Potassium (K) and Sodium (Na) were determined from the extract of soil treated with neutral normal ammonium acetate (pH 7.0). Calcium and Magnesium were determined by titration, while K and Na were determined using a flame photometer as described by (Brady and Weil, 2008) [2].

(vii) Total Exchangeable Acidity (TEA)

The exchangeable acidity (H + Al) of soil samples was determined by extraction from the soil samples with 1N, KCl and the extract was titrated with 1N Sodium hydroxide. The exchangeable acidity was calculated from titre value (Jaiswal, 2003) [15].

(Viii) Total Exchangeable Bases (TEB)

The total Exchangeable bases of soil were determined by summing up the values of all the exchangeable cations (Ca, Mg, K and Na) as described by (Jaiswal, 2003) [15].

(ix) Effective Cations Exchange Capacity (ECEC)

Effective Cations Exchange Capacity of soil was determined by summing up the values of all the exchangeable cations (Ca, Mg, K, Na, Al and H) as described by (Brady and Weil, 2008) [2].

(x) Base Saturation BS (%)

The percentage base saturation was calculated by dividing the value of Effective Cations Exchange Capacity by the total value of exchangeable bases (Ca, Mg, K and Na plus exchangeable acidity) and multiplied by 100.

BS = TEB/ECEC x 100 (Brady and Weil, 2008) [2]

(xi) Sodium Absorption Ratio (SAR)

SAR was calculated using the formula:

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

Where: Na= Sodium, Ca = Calcium and Mg = Magnesium, (Jaiswal, 2003) [15]

Data Analyses

The concentrations of physical and chemical properties in the soils of the flood plains were subjected to Multivariate Analysis of Variance (MANOVA) and Pearson Product moment correlation in a Randomized Completely Block Design (RCBD).

Results

Physical and Chemical Properties of Flooded and Upland Soils in Yola-North Local Government Areas

Physical properties of the flooded and upland soils in Yola-North LGA

The results of the physical properties of flooded and upland soils are presented in Table 1.

Sand content of the flooded and upland soils

In the flooded forest area, the highest and the least sand content of 47.00% and 30.67% were recorded at the depths of 30-60 cm and 0-30 cm respectively. Location-wise, Jambutu (L1) and Runde-Baru (L2) had the least and the highest sand content of 37.00% and 39.00% respectively (Table 1). Also, in the upland forest area this LGA, the highest and the least sand content of 67.00% and 50.50% were recorded at depths 0-30 cm and 30-60 cm respectively and location-wise, Jambutu (L1) had the highest sand content of 70.00%, while the least sand content of 58.67% was recorded at Runde-Baru (L2). The Analysis of the variance of sand content of flooded and upland forest areas shows a significant difference at ($p<0.05$).

Silt content of the flooded and upland soils

The results of silt content for the flooded and upland forest areas are presented in Table 1. In the flooded forest area, the highest and the least silt content of 19.50% and 15.00% were recorded at depths of 0-30 cm and 60-90 cm respectively. Location-wise, Jambutu (L1) and Runde-Baru (L2) had the highest and the least silt content of 16.67% and 15.00% respectively. Also, in the upland forest area, the highest and the least silt content of 13.00% and 7.00% were recorded at depths of 60-90 and 0-30 cm respectively and location-wise, Runde-Baru (L2) had the highest Silt content of 12.00%, while the least silt content of 11.33% was recorded at Jambutu (L1). The analysis of variance of the silt content of the flooded and upland forest area shows a significant difference at ($p<0.05$).

The clay content of the flooded and upland soils

In the flooded forest area, the highest and the least clay content of 38.50% and 35.67% were recorded at the depths of 60-90 cm and 0-30 cm respectively. Across the location, Jambutu (L1) and Runde-Baru (L2) had the highest and the least clay content of 46.00% and 35.67% respectively (Table 1). Also, in the upland forest area, the highest and the least clay content of 32.50% and 26.00% were recorded at depths of 30-60 cm and 0-30 cm respectively and location-wise, Runde-Baru (L2) had the highest clay content of 29.33%, while the least clay content of 19.00% was recorded at Jambutu (L1). Analysis of variance results of the flooded and upland forest areas show significant differences ($p<0.05$) in clay content.

Texture classes of the flooded and upland soils

The results of the texture classes for the flooded and upland forest areas show that in all locations and across depths, the sand texture classes were dominated by sandy clay, clay and loam.

Bulk density of the flooded and upland soils

In the flooded forest area, the highest and the least bulk densities of 1.34 gcm-3 and 0.88 gcm-3 were recorded at depths of 30-60 cm and 0-30 cm respectively. Location-wise, Runde-Baru (L2) and Jambutu (L1) had the highest and the least bulk density content of 1.29 gcm-3 and 1.28 gcm-3 respectively (Table 1). Also, in the upland forest area, the highest and the least bulk densities of 1.49 gcm-3 and 1.35 gcm-3 were recorded at depths 0-30 cm and 30-60 cm respectively, while, Jambutu (L1) had the highest bulk density of 1.53 gcm-3 and the least bulk density of 1.39 gcm-3 was recorded at Runde-Baru (L2). Analysis of variance of bulk density of flooded and upland forest areas shows no significant difference ($p>0.05$).

Porosity of the flooded and upland soils

In the flooded forest area, the highest and the least porosity of 53.22% and 49.59% were recorded at the depths of 60-90 cm and 0-30 cm respectively. Location-wise, Jambutu (L1) and Runde-Baru (L2) had the highest and the least porosity of 51.67% and 49.36% respectively (Table 1). Also, in the upland forest area, the highest and the least porosity of 39.13% and 33.45% were recorded at depths of 30-60 cm and 0-30 cm respectively, and location-wise, Runde-Baru (L2) had the highest porosity of 38.36%, while the least porosity content of 37.12% was recorded at Jambutu (L1). Analysis of the variance of Porosity of flooded and upland forest areas shows a significant difference at ($p<0.05$).

Table 1: Physical Properties of the Flooded and Upland Forest Area in Yola-North LGA

Sample	Sand (%)	Silt (%)	Clay (%)	Textural Classes	Bulk Density (gcm^{-3})	Porosity (%)
Flood Area Depths						
0-30	30.67c	19.50a	35.67b	Clay	0.88b	53.22a
30-60	42.00 C	16.00b	38.50a	Sandy clay	1.33a	50.34b
60-90	47.00b	15.00a	38.00a	Clay	1.34a	49.59b
S.E +	6.112	1.453	3.885		0.153	5.379
CV%	24.779	19.868	20.155		22.297	21.184
Location						
L1	37.00b	16.67a	46.00a	Sandy, Loam	1.28a	51.67a
L2	39.00b	15.00a	35.67a	Clay	1.29a	49.36a
S.E +	10.833	2.333	8.333		0.057	2.152
CV%	32.029	23.022	31.288		5.995	6.145
Upland Area Depths						
0-30	67.00a	07.00b	26.00 C	Sandy, clay	1.49a	33.45c
30-60	50.50a	13.00a	32.50ab	Sandy clay	1.35a	39.13a
60-90	54.50b	09.00a	31.00b	Sandy clay	1.41a	36.90b
S.E +	7.217	3.609	3.609		0.048	1.988
CV%	22.936	47.481	19.335		5.859	7.341
Location						
L1	70.00a	11.33b	19.00b	Clay	1.53a	37.12a
L2	58.67a	12.00b	29.33b	Loamy Sand	1.39a	38.36a
S.E +	15.500	1.833	13.333		0.122	4.773
CV%	40.221	19.692	58.318		12.217	14.395
P-value	0.041	0.032	0.025		0.611	0.015

Source: Umar M. R (2019)

L1 and L2 at Yola-North are Jambutu and Runde-Baru respectively,

Chemical Properties of Flooded and Upland Soils in Yola-North LGA

The results of the chemical content of the flooded and upland soils are presented in Table 2.

pH of soils sampled from flooded and upland forest areas

The result of pH level is presented in Table 2. In flooded forest areas, the pH values ranged between 6.76-and 7.09, with the highest and the least values recorded at 30-60 cm and 0-30 cm respectively. Samples from Runde-Baru (L2) had the highest pH value of 6.75 while the lowest pH value of 6.57 was recorded in the samples from Jambutu (L1). The pH values of the upland forest area show that the highest and the least pH values of 6.66 and 6.63 were recorded at 0-30 cm and 30-60 cm respectively, while the highest and least pH values of 6.65 and 6.64 were found in samples from Runde-Baru (L2) and Jambutu (L2) respectively. Analysis of the variance of pH content of flooded and upland forest areas shows no significant difference at (p>0.05).

EC properties of soils sampled from flooded and upland forest areas

In the flooded area, the highest and the least EC values of 1.02 ds/m and 1.11 ds/m were recorded at 0-30 cm and 30-60 cm respectively (Table 2). The highest EC value of 1.09 ds/m was recorded at Jambutu (L1) and the lowest EC value of 1.07 ds/m was recorded at Runde-Baru (L2). In the upland forest area, the EC values ranged between 1.00 and 1.040 ds/m, and the highest and the least values were recorded at 0-30 cm and 30-60 cm respectively. With regards to location, the EC value of 1.02 ds/m was recorded at Jambutu (L1), while at Runde-Baru (L2) EC value of 1.01 dS/m was recorded. Analysis of the variance of EC content of flooded and upland forest areas shows no significant difference at (p>0.05).

OC properties of soils sampled from flooded and upland forest areas

The results of Organic Carbon (OC) for the sampled soils from flooded forest areas are also presented in Table 2. In the flooded forest areas, the highest and the least OC values of 6.70 g/kg and 6.10 g/kg were recorded at 0-30 cm and 30-60 cm respectively. The highest and the least values of 6.52 g/kg and 6.20 g/kg were recorded at Runde-Baru (L2) and Jambutu (L1) respectively. In the upland forest area, the highest and the least OC values of 7.85 g/kg and 7.20 g/kg were recorded at 30-60 cm and 0-30 cm respectively, while across the locations, the highest OC value of 7.63 g/kg was recorded at Runde-Baru (L2) and the least OC value of 7.4 g/kg was recorded at Jambutu (L1). Analysis of the variance of OC content of flooded and upland forest areas shows a significant difference at (p<0.05).

TN properties of soils sampled from flooded and upland forest areas

In flooded forest areas, the highest and the least TN values of 1.80 g/kg and 1.40 g/kg were recorded at 30-60 cm and 0-30 cm respectively, while the highest and the least TN values of 1.53 g/kg and 1.50 g/kg were recorded at Runde-Baru (L2) and Jambutu (L1) respectively (Table 2). In the upland forest area, the highest and the least TN values of 1.75 g/kg and 1.40 g/kg were recorded at 30-60 cm and 60-90 cm respectively, while the highest TN value of 1.57 g/kg was recorded at Runde-Baru (L2) and the least TN value of 1.53 g/kg was recorded at Jambutu (L1). Analysis of the variance of TN content of flooded and upland forest areas shows no significant difference at (p>0.05).

Av-P in soils sampled from flooded and upland forest areas

Results of the available phosphorus (Av-P) in the sampled soils of flooded and upland forest areas are presented in Table 2. In the flooded forest area, the highest and the least Av-P values of 8.22 $mgkg^{-1}$ and 7.01 $mgkg^{-1}$ were recorded at 60-90 cm and 0-30 cm respectively. About the location, the highest Av-P value of 8.23 $mgkg^{-1}$ was recorded at Jambutu (L1), while the lowest Av-P value of 7.68 $mgkg^{-1}$ was recorded at Runde-Baru (L2) respectively. In the upland forest area, the highest and the least values of 9.90 $mgkg^{-1}$ and 9.43 $mgkg^{-1}$ were recorded at 0-90 cm and 30-60 cm respectively, while the highest Av-P value of 9.34 $mgkg^{-1}$ was recorded at Jambutu (L1) and the least Av-P value of 9.30 $mgkg^{-1}$ was recorded at Runde-Baru (L2) respectively. Analysis of the variance of Available Phosphorus content of flooded and upland forest areas shows a significant difference at (p<0.05).

Ca_2 + in soils sampled from flooded and upland forest areas

The results of Ca_2 + found in the sampled soil in flooded and upland forest areas are presented in Table 2. In the flooded area, the highest and the least Ca_2 + values of 8.11 $Cmolkg^{-1}$ and 4.33 $Cmolkg^{-1}$ were recorded at 60-90 cm and 0-30 cm respectively. Concerning location, Runde-Baru (L2) and Jambutu (L1) recorded the highest and lowest value of Ca_2 + of 7.46 $Cmolkg^{-1}$ and 7.27 $Cmolkg^{-1}$ respectively. In the upland forest area, the highest and the lowest values of Ca_2 + were 12.07 $Cmolkg^{-1}$ and 11.67 $Cmolkg^{-1}$ recorded at 60-90 cm and 0-30 cm respectively. While Jambutu (L1) recorded the highest Ca_2 + value of 12.00 $Cmolkg^{-1}$ and Runde-Baru (L2) recorded the least Ca_2 + value of 11.65 $Cmolkg^{-1}$. Analysis of the variance of Ca_2 + content of flooded and upland forest areas shows a significant difference at (p<0.05).

Mg_2 + in soils sampled from flooded and upland forest areas

The Mg_2 + level found in the soil sampled from flooded and upland forest areas is presented in Table 2. In the upland forest area, the highest and the least Mg_2 + values of 3.95 $Cmolkg^{-1}$ and 2.25 $Cmolkg^{-1}$ were recorded at 0-30 cm and 30-60 cm respectively. Location-wise, the highest Mg_2 + value of 3.10 $Cmolkg^{-1}$ was recorded at Jambutu (L1), while the lowest Mg_2 + value of 3.04 $Cmolkg^{-1}$ was recorded at Runde-Baru (L2) respectively. In the upland forest area, the Mg_2 + values across depths were generally less than that of the flooded area, with the highest value of 2.06 recorded at 60-90 cm, while the lowest Mg_2 + value of 1.97 was recorded at 0-30 cm respectively. Analysis of the variance of Mg_2 + content of flooded and upland forest areas shows no significant difference at (p>0.05).

Na + in soils sampled from flooded and upland forest areas

Results of values of sodium (Na +) level in the sampled soils from flooded and upland forest areas are presented in

Table 2. In the flooded forest area, the highest and the least Na + values of 0.13 $Cmolkg^{-1}$ and 0.08 $Cmolkg^{-1}$ were recorded at 30-60 cm and 0-30 cm respectively. Location-wise, the Na + value of 0.14 $Cmolkg^{-1}$ was recorded at Jambutu (L1), while the least Na + value of 0.11 $Cmolkg^{-1}$ was recorded at Runde-Baru (L2). Likewise, in the upland area, the values of Na + level in the sampled soils were generally higher than that of the flooded area, with the highest value of 0.57 $Cmolkg^{-1}$ recorded at 0-39 cm depths, while the least value of 0.13 $Cmolkg^{-1}$ was recorded at 60-90 cm. Concerning location, Runde-Baru (L2) had the highest Na + value of 0.39 $Cmolkg^{-1}$, while Jambutu (L1) had the lowest value of 0.36 $Cmolkg^{-1}$ respectively. Analysis of variances of the Na + content of flooded and upland forest areas shows no significant difference at (p>0.05).

K + in soils sampled from flooded and upland forest areas

Results of values of K + found in the sampled soils from flooded and upland forest areas are presented in Table 2. In the flooded forest area the highest and the least K + values of 0.12 $Cmolkg^{-1}$ and 0.08 $Cmolkg^{-1}$ were recorded at 0-30 cm and 60-90 cm respectively. Location-wise, Runde-Baru (L2) had the highest K + value of 0.11 $Cmolkg^{-1}$, while Jambutu (L1) had the least K + value of 0.09 $Cmolkg^{-1}$. In the upland forest area, the values of K + recorded across depths and location-wise were generally higher than that of the flooded area, with the highest value of 0.67 $Cmolkg^{-1}$ recorded at 0-30 Cm, while the least value of 0.29 cmlkg-1 was recorded at 30-60 cm respectively. Location-wise, Runde-Baru (L2) had the highest K + value of 0.51 $Cmolkg^{-1}$, while Jambutu (L1) had the least K + value of 0.48 $Cmolkg^{-1}$. Analysis of the variance of K + content of flooded and upland forest areas shows a significant difference at (p>0.05).

TEB in soils sampled from flooded and upland forest areas

The results of the total exchangeable base (TEB) found in the sampled soils from flooded and upland forest areas are presented in Table 2. In the flooded forest area, the highest and the least TEB values of 6.60 $Cmolkg^{-1}$ and 5.10 $Cmolkg^{-1}$ were recorded at 60-90 cm and 0-30 cm respectively.

Regarding location, the highest TEB value of 6.44 $Cmolkg^{-1}$ was recorded at Runde-Baru (L2), while the lowest TEB value of 5.13 $Cmolkg^{-1}$ was recorded at Jambutu (L1). In the upland area, the TEB values recorded were generally higher across depths than that of the flooded area, ranging between 8.01-8.08 Cmolkg1.

Likewise, across locations, the highest and least TEB values of 8.01 $Cmolkg^{-1}$ and 7.93 $Cmolkg^{-1}$ were recorded at Runde-Baru (L2) and Jambutu (L1) respectively. Analysis of the variance of TEB content of flooded and upland forest areas shows a significant difference at (p<0.05)

TEA in soils sampled from flooded and upland forest areas

Results of total exchangeable acidity (TEA) found in the sampled soils from flooded and upland forest areas are presented in Table 2. In the flooded forest area, the highest and the least TEA values of 2.18 $Cmolkg^{-1}$ and 1.67 $Cmolkg^{-1}$ were recorded at 30-60 cm and 60-90 cm respectively, while across the location-wise, the highest TEA value of 2.23 $Cmolkg^{-1}$ was recorded at Jambutu (L1) and the least TEA value of 1.28 $Cmolkg^{-1}$ was recorded at Runde-Baru (L2). In the upland area, the highest and the least TEA values of 2.07 $Cmolkg^{-1}$ and 1.62 $Cmolkg^{-1}$ were recorded at 60-90 cm and 0-30 cm respectively. The highest TEA value of 2.00 $Cmolkg^{-1}$ was recorded at Runde-Baru (L2), while the lowest TEA value of 1.80 $Cmolkg^{-1}$ was recorded at Jambutu (L1). Analysis of the variance of TEA content of flooded and upland forest areas shows no significant difference at (p>0.05).

ECEC in soils sampled from flooded and upland forest areas

The Results of ECEC found in the sampled soils from flooded and upland forest areas are presented in Table 2. In the flooded forest area the highest and the least ECEC values of 14.07 $Cmolkg^{-1}$ and 9.91 $Cmolkg^{-1}$ were recorded at 60-90 cm and 0-30 cm respectively. Location-wise, the highest ECEC value of 13.08 $Cmolkg^{-1}$ was recorded at Runde-Baru (L2), while the lowest ECEC value of 10.46 $Cmolkg^{-1}$ was recorded at Jambutu (L1). In the upland forest area, the highest and the least ECEC values of 18.78 $Cmolkg^{-1}$ and 14.74 $Cmolkg^{-1}$ were recorded at 0-30 cm and 60-90 cm respectively. Likewise, across locations, the highest ECEC value of 18.34 $Cmolkg^{-1}$ was recorded at Runde-Baru (L2), while the lowest ECEC value of 17.94 $Cmolkg^{-1}$ was recorded at Jambutu (L1). Analysis of the variance of ECEC content of flooded and upland forest areas shows no significant difference at (p>0.05).

PBS in soils sampled from flooded and upland forest areas

Results of PBS found in the sampled soils from flooded and upland forest areas are presented in Table 2. In the flooded forest area, the highest and the least PBS values of 75.06% and 70.03% were recorded at 60-90 cm and 0-30 cm respectively. Location-wise, the highest PBS value of 73.29% was recorded at Runde-Baru (L2), while the lowest PBS value of 72.70% was recorded at Jambutu (L1). In the upland area, the highest and the least PBS values of 79.55% and 75.89% were recorded at 0-30 cm and 60-90 cm respectively. Likewise, the highest PBS value of 79.33% was recorded at Runde-Baru (L2), while the lowest PBS value of 74.94% was recorded at Jambutu (L1). Analysis of the variance of PBS content of flooded and upland forest areas shows a significant difference at (p<0.05).

Table 2: Chemical Properties of the Flooded and Upland Forest Area in Yola-North LGA

	pH	EC (dS/m)	O.C (g/kg)	TN (g/kg)	Av-p (mg/kg)	Ca_2^+ (cmol/kg)	Mg_2^+ (cmol/kg)	Na^+ (cmol/kg)	K^+ (cmol/kg)	TEB (cmol/kg)	TEA (cmol/kg)	ECEC (cmol/kg)	PBS (%)
Flood Area Depths													
0-30	6.84b	1.11a	6.70a	1.40a	7.01 C	4.33c	3.95a	0.08b	0.12a	5.10b	2.08a	9.91b	75.06a
30-60	7.09a	1.02b	6.10b	1.80a	8.07b	6.06b	2.25b	0.13a	0.08a	5.21b	2.18a	13.34a	70.03c
60-90	6.76b	1.12a	6.11b	1.60b	8.22a	8.11a	3.75a	0.11a	0.10a	6.60a	1.67b	14.07a	72.05b
SEM	0.139	0.030	0.02	0.012	0.114	0.084	0.204	0.009	0.013	0.271	0.059	0.220	1.162
%CV	3.620	4.833	4.965	12.762	2.301	4.598	13.723	10.345	23.324	7.721	6.043	4.912	2.755
Location													
L1	6.57b	1.09a	6.20b	1.50a	8.23a	7.27a	3.10a	0.11a	0.11a	5.13b	2.23a	10.46b	72.70a
L2	6.75a	1.07a	6.53a	1.53a	7.68a	7.46a	3.04a	0.14a	0.09a	6.44a	1.28b	13.08a	73.29a
SEM	0.093	0.007	0.038	0.005	0.198	0.102	0.473	0.028	0.013	0.355	0.042	0.312	0.657
%CV	1.982	0.873	7.69	4.466	3.268	4.543	26.046	27.634	19.506	8.251	3.490	5.671	1.271
Upland Area Depths													
0-30	6.66a	1.04a	7.20	1.55b	9.90a	11.67a	2.05a	0.57a	0.67a	8.08a	1.62c	18.78a	79.55a
30-60	6.63a	1.00a	7.85	1.75a	9.43ab	11.87a	1.97a	0.21b	0.30b	8.07a	1.74b	16.51b	75.89b
60-90	6.65a	1.02a	7.50	1.40b	9.68a	12.07a	2.06a	0.13c	0.29c	8.01a	2.07a	14.74c	78.98a
SEM	0.007	0.012	0.019	0.009	0.136	0.002	0.170	0.009	0.049	0.173	0.039	0.1360	1.135
%CV	0.189	1.984	4.328	10.714	2.712	0.086	14.309	9.840	45.946	5.291	3.267	3.0360	2.517
Location													
L1	6.65	1.02	7.40	1.53a	9.34a	12.00a	1.82	0.39a	0.48a	7.93a	1.80a	17.94a	74.94b
L2	6.64	1.01	7.63	1.57a	9.30a	11.65a	2.02	0.36a	0.51a	8.01a	2.00a	18.34a	79.33a
SEM	0.007	0.005	0.012	0.017	0.330	0.283	0.235	0.027	0.008	0.533	0.067	0.600	1.197
%CV	0.142	0.694	2.195	16.836	5.383	11.902	16.120	23.089	6.370	13.302	4.562	10.963	2.166
P-value	0.058	0.125	0.001	0.839	0.041	0.007	0.740	0.222	0.067	0.007	0.468	0.069	0.036

Source: Umar M. R (2019)

L1 and L2 at Yola-North are Jambutu and Runde-Baru respectively

Physical and Chemical Properties of Flooded and Upland Soils in Yola-South Local Government Areas

Physical properties of flooded and upland soils in Yola-South LGA

The results of the physical properties of the flooded and upland soils are presented in Table 3.

Sand content of the flooded and upland soils

In the flooded forest area, the highest and the least sand content of 42.50% and 26.67% were recorded at the depths of 30-60 cm and 0-30 cm respectively. Location-wise, Yolde-Pate (L1) and Ngurore (L2) had the highest and the least sand content of 43.33% and 40.00% respectively (Table 3). The sand content of the upland forest area shows that the highest and least sand content of 58.50% and 54.00% were recorded at 0-30 cm and 30-60 cm respectively, while Yolde-Pate (L1) had the highest sand content of 51.00 and Ngurore (L2) had least sand content of 49.33% respectively. Analysis of the variance of sand content of flooded and upland forest areas in Yola-South LGA shows a significant difference at ($p<0.05$).

Silt content of the flooded and upland soils

The highest and the least silt content of 19.00% and 18.00% were recorded at the depths of 0-30 cm and 60-90 cm respectively in the flooded forest. Across the location, Yolde-Pate (L1) and Ngurore (L2) had the highest and the least silt content of 20.60% and 20.00% respectively (Table 3). The silt content of the upland forest area ranged between 12.67%-16.50%, with the highest value recorded at 60-90 cm, while the least value was recorded at 0-30 cm. Location-wise, Yolde-Pate (L1) had the highest silt content of 17.00%, while the least content of 14.00% was recorded at Ngurore (L2). The analysis of the variance of silt content of flooded and upland forest areas shows a significant difference at ($p<0.05$).

The clay content of the flooded and upland soils

The highest and the least clay content of 41.00% and 37.67% were recorded at the depths of 60-90 cm and 0-30 cm respectively in the flooded forest. Across the location, Yolde-Pate (L1) and Ngurore (L2) had the least and the highest clay content of 37.00% and 39.00% respectively (Table 3). The clay content of the upland forest area was generally less than that of the flooded area with 30-60 cm depths which had a clay content of 36.50% and 0-30 cm which had a clay content of 33.50%. Similarly, Yolde-Pate (L1) had the least clay content of 32.00% while; Ngurore (L2) had the highest clay content of 35.00%. However, Analysis of the variance of the clay content of flooded and upland forest areas shows a significant difference at ($p<0.05$).

Texture classes of the flooded and upland soils

The results of the texture classes for the flooded and upland forest area show that in all locations and across depths, the sand texture classes were dominated by sandy clay, clay and loam.

Bulk density of the flooded and upland soils

In the flooded forest area, the highest and the least bulk density of 1.34 gcm-3 and 0.85 gcm-3 were recorded at the depths of 30-60 cm and 0-30 cm respectively, while Yolde-Pate (L1) and Ngurore (L2) had the highest and the least bulk density of 1.33 gcm-3 and 1.32 gcm-3 respectively (Table 3). The bulk density of the upland forest area shows that the highest and the least bulk density of 1.39 gcm-3 and 1.32 gcm-3 were recorded at 0-30 cm and 30-60 cm respectively, while across the location, Yolde-Pate (L1) had the highest bulk density of 1.40 gcm-3, and the least bulk density of 1.32 gcm-3 was recorded at Ngurore (L2). Analysis of variance of bulk density of flooded and upland forest areas shows no significant difference at ($p>0.05$).

Porosity of the flooded and upland soils

In the flooded forest area, the highest and the least Porosity of 51.56% and 49.84% were recorded at the depths of 0-30 cm and 30-60 cm respectively, while Ngurore (L2) and Yolde-Pate (L1) had the highest and the least Porosity of 50.33% and 49.50% respectively (Table 3). The Porosity of the upland forest area shows that the highest and the least Porosity of 38.58% and 36.67% were recorded at 60-90 cm and 30-60 cm respectively. Also, according to the location, Yolde-Pate (L1) had the lowest porosity content of 36.83% while Ngurore (L2) had the highest porosity of 39.50%. Analysis of the variance of Porosity of flooded and upland forest areas shows a significant difference at (p<0.05).

Table 3: Physical Properties of the Flooded and Upland Forest Area in Yola-South LGA

Sample	Sand (%)	Silt (%)	Clay (%)	Textural Classes	Bulk Density (gcm^{-3})	Porosity (%)
Flood Area Depths						
0-30	26.67c	19.00a	37.67b	Sand Clay, Loam	0.85b	51.56a
30-60	42.50 C	18.50ab	40.50a	Clay	1.34a	49.84ab
60-90	41.50b	18.00a	41.00a	Sand Clay, Loam	1.31a	50.50a
S.E +	5.409	1.402	4.363		0.146	5.675
CV%	25.060	15.954	20.770		21.745	21.890
Location						
L1	43.33a	20.60a	37.00ab	Sand Clay Loam	1.33a	49.50a
L2	40.00b	20.00a	39.00a	Clay	1.32a	50.33a
S.E +	1.500	2.667	4.000		0.022	1.000
CV%	5.071	21.757	13.797		2.336	2.800
Upland Area Depths						
0-30	58.50a	12.67c	33.50b	Clay	1.39a	37.34a
30-60	54.00a	15.50b	36.50a	Sand Clay, Loam	1.32a	36.67ab
60-90	55.50b	16.50a	35.50a	Clay	1.36a	38.58a
S.E +	1.732	0.441	1.155		0.016	0.722
CV%	6.593	4.055	5.634		2.022	2.573
Location						
L1	51.00a	17.00b	32.00b	Sand Clay Loam	1.40a	36.83b
L2	49.33a	14.67b	35.00a	Clay	1.29a	39.50a
S.E +	5.500	1.833	3.500		0.042	1.750
CV%	17.095	13.767	13.943		4.327	5.094
P-value	0.023	0.039	0.030		0.574	0.031

Source: Umar M. R (2019)

L1 and L2 at Yola-South are Yolde-Pate and Ngurore respectively,

Chemical Properties of Flooded and Upland Soils in the study areas

The results on chemical content of flooded and upland soils are presented in Table 4.

pH of soil sampled from the flooded and upland forest areas

In the flooded forest area of this LGA, the highest and the least pH values of 7.02 and 6.68 were recorded at 0-30 cm and 30-60 cm respectively, while across the location, the highest pH value of 6.75 was recorded at Ngurore (L2) and the least pH value of 6.67 was recorded at Yolde-Pate (L1). The results of pH values of the upland area show that the highest and the least pH values of 6.69 and 6.51 were recorded at 0-30 cm and 30-60 cm respectively (Table 4). Regarding location, the highest and the lowest pH values of 6.67 and 6.57 were recorded at Ngurore (L2) and Yolde-Pate (L1) respectively. Analysis of the variance of pH content of flooded and upland forest areas shows no significant difference at (p>0.05).

EC properties of soils sampled from flooded and upland forest areas

The results of EC value in the soil samples from the flooded forest area showed the highest and the lowest EC values of 1.07 dS/m and 1.05 dS/m, recorded at 30-60 Cm and 0-30 cm respectively (Table 4). Concerning location, the highest EC value of 1.08 ds/m was recorded at Yolde-Pate (L1), while the lowest EC value of 1.04 dS/m was recorded at Ngurore (L2) respectively. In the upland forest area, the highest and the least EC values of 1.09 dS/m and 0.89 dS/m were recorded at 30-60 cm and 0-30 cm respectively. Across the location, 1.017 ds/m was the EC value recorded at Yolde-Pate (L1), while at least the EC value of 1.000 ds/m was recorded at Ngurore (L2). Analysis of the variance of EC content of flooded and upland forest areas shows no significant difference at (p>0.05).

OC properties of the soils sampled from the flooded and upland forest areas

In the flooded forest area the highest and the least OC values of 6.80 g/kg and 6.30 g/kg were recorded at 30-60 cm and 60-90 cm respectively (Table 4). Across the location, the highest OC value of 6.77 g/kg was recorded at Ngurore (L2), while the lowest OC value of 6.70 g/kg was recorded at Yolde-Pate (L1). In the upland forest area, the highest and the least OC values of 7.85 g/kg and 7.55 g/kg were recorded at 30-60 cm and 0-30 cm respectively, while the highest OC value of 7.70 g/kg was recorded at Yolde-Pate (L1) and the least OC value of 7.40 g/kg was recorded at Ngurore (L2). Analysis of the variance of OC content of flooded and upland forest areas shows a significant difference at (p<0.05)

TN properties of soils sampled from flooded and upland forest areas

The results of TN found in the samples of soils in flooded and upland forest areas are presented in Table 4. In the flooded forest area, the highest and the least TN values of 1.70 g/kg and 1.35 g/kg were recorded at 0-30 cm and 60-90 cm respectively. Across the location, the highest TN value of 1.7 g/kg was recorded at Ngurore (L2), while the lowest TN value of 1.55 g/kg was recorded in Yolde-Pate (L1) respectively. In the upland forest area, the highest and the least TN values of 1.75 g/kg and 1.55 g/kg were recorded at 30-60 cm and 0-30 cm respectively. Regarding location, the highest TN value of 1.63 g/kg was recorded at Ngurore (L2), while the lowest TN value of 1.50 g/kg was recorded at Yolde-Pate (L1). Analysis of the variance of TN content of flooded and upland forest areas shows no significant difference at (*p*>0.05).

Av-P in soils sampled from flooded and upland forest areas

In the flooded forest area, the highest and the least Av-P values of 8.20 $mgkg^{-1}$ and 7.20 $mgkg^{-1}$ were recorded at 60-90 cm and 0-30 cm respectively (Table 4). Location-wise, the highest Av-P value of 8.20 was recorded at Ngurore (L2), while the lowest value of 7.80 $mgkg^{-1}$ was recorded at Yolde-Pate (L1). In the upland forest area, the highest and the least Av-P values of 9.70 $mgkg^{-1}$ and 9.30 $mgkg^{-1}$ were recorded at 60-90 cm and 0-30 cm respectively. While across the location, the Av-P values of 9.30 $mgkg^{-1}$ were recorded at Ngurore (L2) and 9.10 $mgkg^{-1}$ was recorded as an Av-P value at Yolde-Pate (L1). Analysis of the variance of Av-P content of flooded and upland forest areas shows a significant difference at (*p*<0.05).

Ca_2 + in soils sampled from flooded and upland forest areas

In the flooded forest area, the highest and the least Ca_2 + values of 9.55 $Cmolkg^{-1}$ and 3.37 $Cmolkg^{-1}$ were recorded at 60-90 cm and 0-30 cm respectively, while the Ca_2 + values of 8.50 $Cmolkg^{-1}$ and 8.60 $Cmolkg^{-1}$ were recorded at Yolde-Pate (L1) and Ngurore (L2) respectively (Table 4). In the upland forest area, the highest and the lowest values of Ca_2 + were 12.79 $Cmolkg^{-1}$ and 12.52 $Cmolkg^{-1}$ recorded at 30-60 cm and 60-90 cm respectively. Concerning location, the highest and least Ca_2 + values of 12.70 $Cmolkg^{-1}$ and 12.53 $Cmolkg^{-1}$ were recorded at Yolde-Pate (L1) and Ngurore (L2) respectively. Analysis of the variance of Ca_2 + content of flooded and upland forest areas shows a significant difference at (*p*<0.05).

Mg_2 + in soils sampled from flooded and upland forest areas

In the flooded forest area, the highest and the least Mg_2 + values of 3.34 $Cmolkg^{-1}$ and 2.12 $Cmolkg^{-1}$ were recorded at 0-30 cm and 30-60 cm respectively (Table 4). Across the location, the highest Mg_2 + value of 3.61 $Cmolkg^{-1}$ was recorded at Ngurore (L2), while Yolde-Pate (L1) had the least Mg_2 + value of 3.50 $Cmolkg^{-1}$. In the upland forest area, the values of Mg_2 + across depths were all less than that of the flooded area. The highest value of 2.33 $Cmolkg^{-1}$ was recorded at 30-60, while the lowest value of 1.06 $Cmolkg^{-1}$ was recorded at 0-30 cm respectively. Analysis of the variance of Mg_2 + content of flooded and upland forest areas shows no significant difference at (*p*>0.05).

Na + in soils sampled from flooded and upland forest area

The highest and the least Na + values were 0.16 $Cmolkg^{-1}$ and 0.09 $Cmolkg^{-1}$ recorded at 60-90 cm and 0-30 cm respectively (Table 4). Across locations, the Na + value of 0.12 $Cmolkg^{-1}$ was recorded at Yolde-Pate (L1) which was slightly higher than the Na + value of 0.11 $Cmolkg^{-1}$ recorded at Ngurore (L2). In the upland forest area, the values of Na + level in the sampled soils were generally higher than that of the flooded area, with the highest value of 0.55 cmlkg-1 recorded at 0-30 cm, while the least value of 0.14 cmlkg-1 recorded at 60-90 Cm. Location-wise, Yolde-Pate (L1) recorded a Na + value of 0.25 $Cmolkg^{-1}$ which is slightly higher than the Na + value of 0.23 $Cmolkg^{-1}$ recorded at Ngurore (L2). Analysis of the variance of Na + content of flooded and upland forest areas shows no significant difference at (*p*>0.05).

K + in soils sampled from flooded and upland forest area

The results of K + found in the soil samples in the flooded and upland forest areas are presented in Table 4. In the flooded forest area, the highest and the least K + values of 0.62 $Cmolkg^{-1}$ and 0.028 $Cmolkg^{-1}$ were recorded at 0-30 cm and 30-60 cm respectively. Across the location, Yolde-Pate (L1) had the highest K + value of 0.12 $Cmolkg^{-1}$ which is slightly higher than the K + value of 0.11 $Cmolkg^{-1}$ recorded at Ngurore (L2). In the upland forest area, the K + values recorded across depths and locations were generally less than that of the flooded area, with the highest value of 0.62 recorded at 0-30 Cm, while the lowest value of 0.28 was recorded at 60-90 Cm respectively. Across the location, Yolde-Pate (L1) had the highest K + value of 0.52 $Cmolkg^{-1}$ which is slightly higher than the K + value of 0.50 $Cmolkg^{-1}$ recorded at Ngurore (L2). Analysis of the variance of K + content of flooded and upland forest areas shows a significant difference at (*p*>0.05).

TEB in soils sampled from flooded and upland forest area

The highest and the least TEB values of 7.33 $Cmolkg^{-1}$ and 5.18 $Cmolkg^{-1}$were recorded at 60-90 cm and 0-30 cm respectively, while across the location, Yolde-Pate (L1) had the highest TEB value of 6.35 $Cmolkg^{-1}$ and the least TEB value of 5.30 $Cmolkg^{-1}$ was recorded at Ngurore (L2) (Table 4). In the upland forest area, the highest and the least TEB values of 8.06 $Cmolkg^{-1}$and 7.72 $Cmolkg^{-1}$were recorded at 30-60 cm and 0-30 cm respectively, whereas, across the location, Yolde-Pate (L1) had the highest TEB value of 8.01 $Cmolkg^{-1}$, while the least TEB value of 7.77 $Cmolkg^{-1}$ was recorded at Ngurore (L2). Analysis of the variance of TEB content of flooded and upland forest areas shows a significant difference at (*p*<0.05).

TEA in soils sampled from flooded and upland forest area

The results of TEA found in the soil samples in the flooded and upland forest areas are presented in Table 4. The highest and the least TEA values of 2.21 $Cmolkg^{-1}$ and 1.74 $Cmolkg^{-1}$ were recorded at 0-30 cm and 60-90 cm respectively. Across the location, Ngurore (L2) had the highest TEA value of 2.10 $Cmolkg^{-1}$, while the lowest TEA value of 2.08 $Cmolkg^{-1}$ was recorded at Yolde-Pate (L1). In the upland forest area, the TEA values recorded across depths and locations were generally less than that of the flooded area. Analysis of the variance of TEA content of flooded and upland forest areas shows no significant difference at (*p*>0.05).

ECEC in soils sampled from flooded and upland forest area

The highest and the least ECEC values of 12.96 Cmolkg^{-1} and 8.98 Cmolkg^{-1} were recorded at 60-90 cm and 0-30 cm respectively (Table 4). Across the locations of this LGA, Ngurore (L2) had the highest ECEC value of 12.50 Cmolkg^{-1}, while the lowest ECEC value of 12.41 Cmolkg^{-1} was recorded at Yolde-Pate (L1). In the upland forest area, the highest and the least ECEC values of 19.22 Cmolkg^{-1} and 13.60 Cmolkg^{-1} were recorded at 0-30 cm and 60-90 cm respectively. Across the location, Yolde-Pate (L1) had the highest ECEC value of 18.45 Cmolkg^{-1}, while the lowest ECEC value of 18.34 Cmolkg^{-1} was recorded at Ngurore (L2). Analysis of the variance of ECEC content of flooded and upland forest areas shows no significant difference at (p>0.05).

PBS in soils sampled from flooded and upland forest area

The results of PBS found in the soil samples of the flooded and upland forest areas of this LGA are presented in Table 4. The highest and the least PBS values of 77.06% and 70.70% were recorded at 60-90 cm and 0-30 cm respectively. Across the location, Yolde-Pate (L1) had the highest ECEC value of 72.75%, while the least PBS value of 71.93 Cmolkg^{-1} was recorded at Ngurore (L2). In the upland forest area, the highest and the least PBS values of 80.12% and 71.79% were recorded at 0-30 cm and 60-90 cm respectively. Location-wise, Yolde-Pate (L1) had the highest PBS value of 78.14%, while the lowest PBS value of 73.76% was recorded at Ngurore (L2). Analysis of the variance of PBS content of flooded and upland forest areas shows no significant difference at (p>0.05).

Table 4: Chemical Properties of the Flooded and Upland Forest Area in Yola-South LGA

	pH	EC (dS/m)	O.C (g/kg)	TN (g/kg)	Av-p (mg/kg)	Ca_2^+ (cmol/kg)	Mg_2^+ (cmol/kg)	Na^+ (cmol/kg)	K^+ (cmol/kg)	TEB (cmol/kg)	TEA (cmol/kg)	ECEC (cmol/kg)	PBS (%)
Flood Area Depths													
0-30	7.02a	1.05a	6.60a	1.70a	7.20b	3.37c	3.34a	0.09b	0.13a	5.18b	2.21a	8.98a	70.70 C
30-60	6.68b	1.07a	6.80a	1.60b	8.13a	6.73b	2.12b	0.15a	0.10a	5.19b	2.19a	12.94b	77.06a
60-90	6.69a	1.06a	6.30b	1.35c	8.20a	9.55a	3.13a	0.16a	0.12a	7.33a	1.74b	12.96b	72.87b
SEM	0.042	0.006	0.023	0.003	0.046	0.104	0.121	0.003	0.009	0.029	0.039	0.010	0.681
%CV	1.091	0.985	5.557	3.125	0.928	5.07	9.859	3.125	13.679	0.830	3.492	0.221	1.555
Location													
L1	6.67b	1.08a	6.70a	1.55b	7.80a	8.50a	3.50a	0.10a	0.11a	6.35a	2.08a	12.41a	72.75a
L2	6.72a	1.04b	6.77a	1.70a	8.20a	8.60a	3.61a	0.12a	0.12a	5.30b	2.10a	12.50a	71.93a
SEM	0.073	0.02	0.055	0.01	0.320	0.05	0.370	0.010	0.005	0.322	0.133	0.453	0.120
%CV	1.560	2.677	10.778	8.839	5.250	1.992	24.566	8.839	6.332	7.550	9.753	8.058	0.224
Upland Area Depths													
0-30	6.69a	0.89a	7.55b	1.55c	9.30ab	12.55a	1.06b	0.55a	0.62a	7.72a	1.10b	19.22a	71.79c
30-60	6.51b	1.09a	7.85a	1.75a	9.70a	12.79a	2.33a	0.19b	0.33b	8.06a	1.60a	18.97a	80.12a
60-90	6.65a	1.01a	7.70a	1.65b	9.50a	12.52a	2.01a	0.14c	0.28c	8.04a	1.80a	13.60b	75.95b
SEM	0.081	0.045	0.009	0.004	0.117	0.154	0.185	0.012	0.030	0.331	0.115	0.217	2.403
%CV	2.107	7.687	2.239	4.875	2.383	7.607	15.920	11.765	30.300	9.882	11.111	4.937	5.480
Location													
L1	6.57	1.017	7.70a	1.55b	9.10a	12.70a	1.90a	0.23a	0.52a	8.01a	1.60a	18.45a	78.14a
L2	6.67	1.000	7.40b	1.63a	9.30a	12.53a	2.12a	0.25a	0.50a	7.77a	1.70a	18.34a	73.76b
SEM	0.075	0.008	0.03	0.007	0.402	0.183	0.110	0.023	0.023	0.057	0.200	0.145	2.192
%CV	1.596	1.169	6.332	6.018	6.684	7.373	7.739	19.411	19.037	1.383	15.713	2.700	4.081
P-value	0.512	0.213	0.003	0.448	0.008	0.028	0.118	0.289	0.061	0.043	0.120	0.065	0.476

Source: Umar, M. R (2019)

L1 and L2 at Yola-South are Yolde-Pate and Ngurore respectively,

Correlational Analysis of Physical and Chemical Properties of Flooded and Upland Soils in Yola-North and Yola-South Local Government Areas

Correlation Analysis of physical properties of flooded and upland soil in Yola-North LGA

The coefficient of the physical properties of the flooded and upland forest areas are presented in Tables 5 and 6 respectively. The results in Table 5 show that the Clay property was inversely related to Sand (r =-0.79) and related strongly to Silt (r = 0.75). Also, the bulk density related strongly with Sand (r = 0.88) and related strongly but negatively with silt (r =-0.61) and Clay (r =-0.92). Porosity related strongly but inversely with Sand (r =-0.88) and Bulk Density (r =-0.94) but related strongly with Silt (r = 0.59) and Clay (r = 0.97). The results in Table 6 reveal the correlation coefficient of the physical properties of the upland soil samples from Yola-North LGA. The results established a significant but inversely relation between silt and sand (r =-0.91). Likewise, Clay properties are inversely related to Sand (r =-0.93). The relationship between bulk density and other properties shows that bulk density related strongly with sand (r = 0.95), but related negatively with Silt (r =-0.79) and Clay (r =-0.94). The Soil porosity for the upland soil samples in Yola-North is related inversely to Sand (r =-0.91) and Bulk Density (r =-0.92). However, the porosity properties show a similar increased trend with Silt (r = 0.78) and Clay (r = 0.51) respectively.

Table 5: Correlational Analysis of Physical Properties of Flooded Forest Area in Yola-North

Properties	Sand	Silt	Clay	Bd	Porosity
Sand	1				
Silt	-0.28	1			
Clay	-0.79*	0.75*	1		
Bd	0.88*	-0.61*	-0.92*	1	
Porosity	-0.88*	0.59*	0.97*	-0.94*	1

Source: Umar, M. R (2019)

*. Correlation is significant at the 0.05 level (2-tailed).

Table 6: Correlational Analysis of Physical Properties of Upland Forest Area in Yola-North

	Sand	**Silt**	**Clay**	**Bd**	**Porosity**
Sand	1				
Silt	-0.91*	1			
Clay	-0.93*	0.02	1		
Bd	0.95*	-0.79*	-0.94*	1	
Porosity	-0.91*	0.78*	0.51*	-0.92*	1

Source: Umar, M. R (2019)
*. Correlation is significant at the 0.05 level (2-tailed).

Correlation analysis of chemical properties in flooded and upland soil in Yola-North LGA

The results of correlation analysis among the chemical properties of the flooded and upland soil samples are presented in Tables 7 and 8 respectively. The results in Table 7 established that EC related strongly with pH (r = 0.86), while TN (total Nitrogen) had a negative relation with pH (r =-0.65). The Av-P related strongly with pH (r = 0.50). The Mg_2 + related strongly with pH (r = 0.69), O.C (r = 0.63) and Ca_2 + (r = 0.77). Also, Na + shows a strong but inverse relationship with Ca_2 + (r =-0.55). K + related strongly with O.C (r = 0.58) and Ca + (r = 0.57) but weakly related with Na + (r = 0.46). TEB related strongly with pH (r = 0.57), EC (r = 0.70) and Mg_2 + (r = 0.95) but inversely related with Ca_2 + (r =-0.55). TEA is inversely related to O.C (r =-0.74) but strongly related to CA_2 + (r = 0.83). The ECEC related strongly with pH (r = 0.60), EC (r = 0.73), Mg_2 + (r = 0.86) and TEB (r = 0.89). The PBS related strongly with O.C (r = 0.60), Mg_2 + (r = 0.53) and TEB (r = 0.59), whereas, the relationship that exists between PBS and TEA was inversely significant (r =-0.91).

The results of the correlation analysis among chemical properties of soil samples from the upland forest area in Yola-North LGA are presented in Table 8. The results established a weak and inverse relationship between O.C. and EC (r =-0.44). The TN related strongly but negatively with pH (r =-0. 51) and related positively but weakly with EC. Av-P is related weakly with pH (r = 0.40). It is also related weakly but inversely with TN (r =-0.49). The relationship between Mg_2 + and other soil chemical properties shows that Mg_2 + is related strongly to pH (r = 0.62) but related inversely to Ca_2 + (r =-0.67). The TEB related strongly with pH (r = 0.61), Ca_2 + (r = 0.87) and Mg_2 + (r = 0.86). The TEA is related weakly to pH (r = 0.40) and strongly related to Av-P (r = 0.56). The ECEC related strongly with pH (r = 0.72), Ca_2 + (r = 0.71), Mg_2 + (r = 0.84) and TEB (r = 0.91). PBS related strongly with Ca_2 + (r = 0.65), TEB (r = 0.57) and inversely with TEA (r =-0.80).

Table 7: Correlation Analysis of Chemical Properties of Flooded Forest Area in Yola-North

	PH	**EC**	**O.C**	**TN**	**AV-P**	**CA_2^+**	**MG_2^+**	**NA^+**	**K^+**	**TEB**	**TEA**	**ECEC**	**PBS**
PH	1												
EC	0.86*	1											
O.C	0.03	-0.22	1										
TN	-0.65*	-0.19	-0.13	1									
AV-P	0.50*	.062	0.22	-0.26	1								
CA_2^+	0.63	-0.32	-0.02	-0.06	0.08	1							
MG_2^+	0.69*	0.22	0.63*	-0.18	0.13	0.77*	1						
NA^+	0.18	0.37	-0.22	-0.28	-0.39	-0.55*	-0.30	1					
K^+	-0.07	-0.09	0.58	-0.01	-0.26	0.57*	-0.27	0.46	1				
TEB	0.57*	**0.70***	0.07	-0.24	0.14	-0.55*	0.95*	-0.10	0.01	1			
TEA	0.09	0.14	-0.74*	-0.30	-0.35	.083	-0.19	0.14	-0.11	-0.22	1		
ECEC	0.60*	0.73*	-0.28	-0.38	-0.02	-0.51*	0.86*	-0.04	-0.04	0.89*	0.24	1	
PBS	0.09	0.11	0.60*	0.19	0.30	-0.26	0.53*	-0.14	0.14	0.59*	-0.91*	0.17	1

Source: Umar, M. R (2019)
*. Correlation is significant at the 0.05 level (2-tailed).

Table 8: Correlation Analysis of Chemical Properties of Upland Forest Area in Yola-North

	PH	**EC**	**O.C**	**TN**	**AV-P**	**CA_2^+**	**MG_2^+**	**NA^+**	**K^+**	**TEB**	**TEA**	**ECEC**	**PBS**
PH	1												
EC	-0.32	1											
O.C	0.04	-0.44	1										
TN	-0.51*	0.44	-0.15	1									
AV-P	0.40	-0.16	0.01	-0.49*	1								
CA_2^+	0.41	-0.27	-0.16	-0.13	-0.06	1							
MG_2^+	0.62*	0.02	-0.34	.101	-0.10	-0. 67*	1						
NA^+	0.19	0.08	0.22	0.26	0.23	-0.05	0.16	1					
K^+	0.32	-0.03	0.11	0.12	0.18	0.08	0.05	-0.24	1				
TEB	0.61*	-0.15	-0.26	0.01	-0.07	0.87*	0.86*	0.11	0.12	1			
TEA	0.40	-0.10	-0.12	-0.20	0.56*	-0.17	0.18	0.28	0.12	0.02	1		
ECEC	0.72*	-0.18	-0.28	-0.08	0.17	.071*	0.84*	0.21	0.16	0.91*	0.44	1	
PBS	.098	-0.05	-0.07	0.08	-0.43	0.65*	0.36	-0.19	-0.01	0.57*	-0.80*	0.18	1

Source: Umar, M. R (2019)
*. Correlation is significant at the 0.05 level (2-tailed).

Correlation analysis of physical properties in flooded and upland soil in Yola-South LGA

The results of the Correlation analysis of the physical properties of flooded and upland forest areas in Yola-South LGA are presented in Tables 9 and 10 respectively. The results in Table 9 show that the Clay property is inversely related to Sand (r =-0.83). Also, the bulk density related strongly with Sand (r = 0.91) and related strongly but negatively with Clay (r =-0.89). Porosity related strongly but inversely with Sand (r =-0.88) and Bulk Density (r =-0.92) but related strongly with Clay (r = 0.91).

Also, the results in Table 10 revealed the coefficient among the physical properties of upland soil samples from this LGA. The results indicated a significant but inversely relation between Silt and Sand (r =-0.72). Likewise, Clay properties are inversely related to Sand (r =-0.65) and also related positively to Silt (r = 0.60). The relationship between bulk density and other properties shows that bulk density related strongly with Sand (r = 0.90), but related negatively with Silt (r =-0.67) and Clay (r =-0.87). The Soil porosity for the upland soil sample in Yola-North is related inversely to Sand (r =-0.91) and with Bulk Density (r =-0.89). However, the porosity properties show a similar trend with Silt (r = 0.67) and Clay (r = 0.61) respectively.

Overall, the correlation analysis among the physical soil properties of the flooded and upland forest areas in Yola-North and Yola-South LGAs shows that in the floods sample, the clay properties indicated increment rate, alongside porosity, while some sand properties in the upland area increased with bulk density. However, it is observable from the flooded area that Sand and Silt did not show any significant relation, while in the upland area, the more the Sand, the less the Silt recorded across the two localities.

Table 9: Correlation Analysis of Physical Properties of Flooded Forest Area in Yola-South

	Sand	Silt	Clay	Bd	Porosity
Sand	1				
Silt	-0.16	1			
Clay	-0.83*	-0.01	1		
Bd	0.91*	-0.22	-0.89*	1	
Porosity	-0.88*	0.13	0.97*	-0.92*	1

Source: Umar M. R, 2019

*. Correlation is significant at the 0.05 level (2-tailed).

Table 10: Correlation Analysis of Physical Properties of Upland Forest Area in Yola-South

	Sand	Silt	Clay	Bd	Porosity
Sand	1				
Silt	-0.72*	1			
Clay	-0.65*	0.60*	1		
Bd	0.90*	-0.67*	-0.87*	1	
Porosity	-0.91*	0.67*	0.61*	-0.89*	1

Source: Umar M. R, 2019

*. Correlation is significant at the 0.05 level (2-tailed).

Correlation analysis of chemical properties of flooded and upland soil in Yola-South LGA

The results of correlation analysis among the chemical properties of the flooded and upland soil samples are presented in Tables 11 and 12 respectively. The results in Table 11 established that Av-P related inversely with EC (r =-0.80). Also, Ca_2 + related strongly with pH (r = 0.72), O.C (r = 0.57) and TN (r = 0.69). But, Mg_2 + had a weak relationship with pH (r = 0.46) and was strongly related to O.C (r = 0.76), TN (r = 0.72) and Ca_2 + (r = 0.6), while the relationship between Mg_2 + and Av-p was inversely correlated (r =-0.67). More so, Na + shows a strong relationship with TN (r = 0.64), and Ca_2 + (r = 0.64) and is inversely related to Mg_2 + (r =-0.58).

Also, K + related strongly with TN (r = 0.71), Ca + (r = 0.76) but weakly related with Na + (r = 0.46). TEB is inversely related to Av-P (r =-0.54), but positively related to Ca_2 + (r = 0.78). TEA is inversely related to pH (r =-0.64). The ECEC related strongly but inversely with pH (r =-0.74), Av-P (r =-0.53) but positively related with Mg_2 + (r = 0.65) and TEB (r = 0.72). While PBS related strongly with O.C (r = 0.58), Ca_2 + (r = 0.59) and TEB (r = 0.52), whereas, the relationship that exists between PBS and TEA was inversely significant (r =-0.93).

The results of correlation analysis among the chemical properties of soil samples from the upland area are presented in Table 12. The results established a strong but inversely relationship between TN and O.C (r =-0.68). Av-P related strongly with EC (r = 0.77). The relationship between Mg_2 + and other soil chemical properties in the upland area shows that Mg_2 + is related strongly to O.C (r = 0.69). The TEB related strongly with O.C (r = 0.50), Ca_2 + (r = 0.75), Mg_2 + (r = 0.83) and Na (r = 0.74), while K + related negatively with TEB (r =-0.55). The TEA related strongly with pH (r = 0.64). The ECEC related strongly with Ca_2 + (r = 0.72), Mg_2 + (r = 0.73), and TEB (r = 0.91). PBS had an inverse relationship with pH (r =-0.67) and TEA (r =-0.78). The cross-observation of the results in Tables 9, 10, 11 and 12, shows Ca_2 +, Mg_2 +, K + and O.C showed consistent significant increments in the flood area across the two Local Governments.

Table 11: Correlation Analysis of Chemical Properties of Flooded Forest Area in Yola-South

	PH	EC	O.C	TN	AV-P	CA_{2}^{+}	MG_{2}^{+}	NA^{+}	K^{+}	TEB	TEA	ECEC	PBS
PH	1												
EC	-0.26	1											
O.C	0.21	0.15	1										
TN	-0.12	-0.13	-0.21	1									
AV-P	0.30	0.80*	0.28	0.02	1								
CA_{2}^{+}	0.72	0.21	0.57*	0.69	0.11	1							
MG_{2}^{+}	0.46	0.06	0.76*	0.72	-0.67*	0.68	1						
NA^{+}	-0.23	0.07	0.38	0.64*	-0.10	0.64*	-0.58*	1					
K^{+}	-0.29	0.16	0.23	0.71*	-0.14	0.76*	0.67*	0.46	1				
TEB	-0.34	0.19	-0.28	0.37	-0.54*	0.60*	0.78*	0.25	0.21	1			
TEA	-0.64*	0.13	-0.23	0.09	-0.10	-0.35	-0.02	-0.30	0.12	-0.19	1		
ECEC	-0.74*	0.26	-0.39	0.38	-0.53*	0.23	0.65*	0.17	0.27	0.72*	0.55*	1	
PBS	0.32	-0.06	0.58	0.09	-0.08	0.59*	0.28	0.12	-0.02	0.52*	-0.93*	-0.22	1

Source: Umar M. R, 2019

*. Correlation is significant at the 0.05 level (2-tailed).

Table 12: Correlation Analysis of Chemical Properties of Upland Forest Area in Yola-South

	pH	EC	O.C	TN	Av-P	Ca_{2}^{+}	Mg_{2}^{+}	Na^{+}	K^{+}	TEB	TEA	ECEC	PBS
pH	1												
EC	-0.05	1											
O.C	0.25	0.11	1										
TN	-0.21	-0.18	-0.68*	1									
Av-P	0.05	0.77*	-0.14	-0.30	1								
Ca_{2}^{+}	-0.12	0.22	0.23	-0.07	0.24	1							
Mg_{2}^{+}	0.03	-0.29	0.69*	-0.19	-0.21	-0.26	1						
Na^{+}	-0.04	-0.12	0.23	-0.32	0.22	0.52*	0.43*	1					
K^{+}	0.10	0.08	-0.33	0.13	-0.13	-0.24	-0.27	-0.70*	1				
TEB	-0.23	0.04	0.50	-0.18	0.12	0.75*	0.83*	0.74*	-0.55*	1			
TEA	0.64*	0.15	-0.10	0.03	0.26	0.07	-0.10	0.05	0.04	-0.03	1		
ECEC	0.05	0.10	0.38	-0.15	0.30	0.72*	0.73*	0.18	-0.29	0.91*	0.29	1	
PBS	-0.67*	-0.07	0.32	-0.07	-0.25	0.17	0.16	0.14	-0.10	0.25	-0.78*	0.29	1

*. Correlation is significant at the 0.05 level (2-tailed).

Source: Umar M. R, 2019

Discussion

Physical Properties of Flooded and Upland Soils in Yola-North and Yola-South LGAs

The result indicated that the upland forest area recorded more sand content, which significantly differed from the sand content in the flooded forest area ($p<0.05$). This may be attributed to the high volume of flood that eroded some sand properties of the soil in both locations. This shows that there were high percolation rates and low capillary action at the upland area as a result of minimal impact of running water at the upland. Also, the overall results of silt content in the flooded and upland forest areas in both Yola-North and Yola-South Local Government Areas show that the flooded forest area recorded more silt content which is significantly higher than the upland forest area at ($p<0.05$).

The overall observation of the results shows that in both Yola-North and Yola-South LGAs, the flooded forest area recorded more clay content than the upland forest area which is significant at ($p<0.05$). This could be a result of the effect of the flood that had washed away the sand property leaving behind more clay in the flooded area.

The results of the texture classes for the flooded and upland forest area in the Yola-North and Yola-South Local Government Areas showed that in all locations and across depths, the sand texture classes were dominated by sandy clay, clay and loam.

The overall results of the bulk density of the flooded and upland forest areas in the Yola-North and Yola-South Local Government Areas showed that the bulk density is generally lower across the depths in flooded forest areas than in upland forest areas. However, the analysis of variance shows no significant difference at ($p>0.05$).

The Porosity in both the flooded forest area is highly significant at ($p<0.05$) than in the upland forest area for respective Yola-North and Yola-South LGAs. This shows that the rate of infiltration and the water-holding capacity are higher in flood plains and lowest in upland areas.

Chemical Properties of Flooded and Upland Soils in Yola-North and Yola-South LGAs

The overall results of pH values in the flooded and upland soils from both Yola-North and Yola-South LGAs show that pH values in the flooded forest area were slightly higher than the values recorded in upland the forest area, though, not significantly different at ($p>0.05$). The higher value of pH observed in the flooding area in this study may not be unconnected with the effects of flood which makes the pH value to approach neutrality. The high pH value could also influence micronutrients, which thrived at the expense of soil wetness.

The results of the electrical conductivity (EC) in the two LGAs showed that the electrical conductivity of the flooded soils was slightly higher than that of upland soils, though, the result of analysis of variance indicated no significant difference ($p>0.05$). Thus, the slight rise in the electrical conductivity of the soils could be attributed to the presence of flooding water. The increment in the EC of the flooded soils could be a result of more moisture content than upland soils.

The results of Organic Carbon (OC) in Yola-North and Yola-South LGAs, show that the Organic Carbon in the flooded forest area are generally lesser than that of the upland area and showed a significant difference ($p<0.05$). The reduction in Organic Carbon in the flooded forest area could be as a result of bacterial decomposition or ration that took place after flooding effects in the study area. In a nutshell, the decreased Organic Carbon content of soil could adversely affect soil quality and fertility since Organic Carbon is required to stimulate microbial respiration and activities.

The results of total nitrogen (TN) in Yola-North and Yola-South LGAs, show that the nitrogen values in both flooded and upland forest areas ranged from 1.35-1.80 g/kg and 1.40-1.75 g/kg respectively which are not significantly different ($p>0.05$).

The results of available phosphorus (Av-P) in the two LGAs showed that the value of available phosphorus in the flooded forest area was less than that of the upland forest area which is significantly different at ($p<0.05$). The decrease in the values of available phosphorus in the flooded soils could be attributed to the effect of flood water as a result of the leaching of available phosphorus as phosphate in the soil, since in water columns, anaerobic conditions render it soluble.

The results of the calcium (Ca_2 +) value in the study area showed that the calcium reduced significantly at ($p<0.05$) in the flooded forest area than values of calcium found in the upland forest area.

The results of the magnesium (Mg_2 +) in the Yola-North and Yola-South LGAs showed that the flooded forest area had less magnesium than the upland forest area. However, the results of the analysis of variance indicated no significant difference ($p>0.05$). However, the slight rise in the value of magnesium can be attributed to the effect of flooding. The increase in the value of magnesium as a result of flooding showed that flooding plays a part in healthy development since magnesium is among the essential micronutrients required in the soil for improved soil productivity.

The results of the level of sodium (Na +) in these LGAs, showed that the flooded forest area had a lesser sodium value than those found in the upland forest area, though not significantly different ($p>0.05$). It could be expected that during a high flood, more soil nutrients dissolve in water and are lost through leaching as water infiltrates the soil. It could also be expected that because clay is negatively charged cations would bond to the soil particles, thus reducing leaching.

The results from this study show that the levels of potassium (K +) found in the flooded area of both the Yola-North and Yola-South are significantly different ($p<0.05$) from those found in the upland forest area respectively. Generally, the potassium levels were lower in the flooded forest area when compared with those in the upland. Thus, the reduction in the value of potassium could be attributed to the effect of flooding water. A high flood is expected to lead to anoxic conditions because of increased water depths and prolonged water logging, which leads to the mobilization of potassium and results in its increase. However, potassium is among the macronutrients that are not only required for healthy plant growth in the soil but also for proper microbial functioning, therefore a reduction in potassium levels in flood-affected soils hurts soil quality.

The results on Total Exchangeable Base (TEB) found in both Yola-North and Yola-South LGAs, show that in the flooded forest area, TEB values were generally lesser than those found in the upland forest area, with a significance difference at ($p<0.05$). However, the slightly higher values of TEB established that there was a high rate of acidity in the flooded forest area compared to that in the upland forest area. This means that there is a high rate of negative changes in organic matter in flooded soils.

The results on Total Exchangeable Acidity (TEA) found in these LGAs, showed that in the flooded forest area, TEA values were generally higher than those found in the upland forest area, though, the analysis of variance shows no significant difference $p>0.05$. However, the slightly higher values of TEA established that there is a high rate of acidity in the flooded forest area compared to that in the upland forest area. This means that there is a high rate of negative changes in organic matter in flooded soils.

The results of the Effective Cation Exchange Capacity (ECEC) from both Yola-North and Yola-South LGAs showed that ECEC values from flooded and upland forest areas were not significantly different ($p>0.05$). However, the ECEC in the flooded forest area was generally less than that of the upland forest area and this could be a result of a reduction in the organic matter, usually experienced in the flood-affected soil. The fact that reduction in cation exchange capacity levels on the flood is likely to affect farmlands.

The results of the Percentage Base Saturation (PBS) found in both LGAs from the flooded forest areas were generally less than that in the upland soils. However, the difference was not significant ($p>0.05$). This result shows that there was a loss in percentage base saturation during flooding.

Correlational Analysis of Physical and Chemical Properties of Flooded and Upland Soils of Yola-North and Yola-South LGAs, Adamawa State

Correlational analysis among physical properties

The correlation among the physical properties of soils in both flooded and upland forest areas in Yola-North and Yola-South LGAs shows that in the flood samples, the clay properties indicate a strong and significant relationship ($p<0.05$), alongside porosity, while in an upland area, sand content were found significantly related with bulk density. However, it was observed from the flooded forest area that Sand and Silt did not show a signification relation. This shows the impact of flooding effects on the physical properties of sampled soils that tend to increase some properties than others across the two Local Government Areas.

Correlational analysis among chemical properties

The correlation among the chemical properties of the flooded soils in both LGAs revealed that chemical properties such as pH, Ca_2 +, Mg_2 +, TN, TEB and EC show a strong relationship at ($p<0.05$). Whereas, TEB, O.C, Na, TEA, AV-P and ECEC are strong but inversely related. However, these results differed with correlational analysis in the chemical properties of upland forest areas in both Yola-North and Yola-South Local Government Areas, where TEA and pH show a strong relationship. Likewise, ECEC related strongly with Ca_2 +, K + and TEB and the rest of pH and PBS, as well as PBS and TEA related inversely at (p<0.05). These results show a sharp reduction in some proportion of chemical properties found in the flooded forest area, which could not be unconnected with the effect of flooded water, that likely to have resulted in the unusual increment of some chemical properties such as ECEC TEA, EC, while other like Na, Ca_2 +, Mg_2 +, TN, are reducing.

Conclusion

The findings of this study concluded that some nutrient levels in both the upland and flooded forest soils of the study areas are significantly different while some are not inferring that some nutrients are leached during flooding, some are added through deposits from rivers and streams, while some are unaffected by flood. The level of depletion and addition of such soil properties may perhaps be connected to the level and duration of flooding and the slope of the affected areas. This makes the effect of flood on forest soils and indeed any other soil unpredictable.

Recommendations

Based on the findings of this study, the following recommendation is made.

Since flooded areas do not normally support arable farming, but support tree growth to some extent, some forms of agroforestry systems could be developed by the government where the upland areas are put to arable farming while the flood areas are converted to forest plantations involving trees that show flood tolerance like River birch, Black tupelo, Red/Swamp maple, Red mangrove Dogtooth and Black spruce

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