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NUTRIENT FLUX IN SOILS OF FLOOD PRONE FOREST AREAS OF YOLA-NORTH LOCAL GOVERNMENT AREA, ADAMAWA STATE, NIGERIA

E.E. Dishan, M.R. Umar, N. Yekini and E.M. Ayuba

Department of Forestry and Wildlife Management, School of Agriculture and Agricultural Technology, Modibbo Adama University of Technology, Yola

ABSTRACT

This study was conducted to compare physical and chemical properties of soils in flooded and upland forest areas of Yola-North LGA of Adamawa State as a measure of nutrient flux resulting from flooding. Two locations within the LGA (Jambutu and Runde-Baru) were selected and composite soil samples were collected in each location (flooded and upland forest areas) at depths of 0-30cm, 30-60cm and 60-90cm. Laboratory analysis was conducted to determine both the physical (sand, silt, clay, bulk density and porosity) and chemical (pH, EC, OC, TN, Av-P, Ca, Mg, Na, K, TEB, TEA, ECEC and PBS) properties of the soil samples. Multivariate Analysis of Variance (MANOVA) was used to test for significant difference, while Pearson Product Moment Correlation was used to establish relationship between physical and chemical properties of soils from the flooded and upland areas. The results from the comparative analysis showed that all physical properties except bulk density were significantly different ($p<0.05$) between upland and flooded forest soils. The assessment of chemical properties of the soil samples showed significant difference ($p<0.05$) only in OC, Av-P, Ca, K and TEB between upland and flooded areas, pH EC, TN, Mg, Na and ECEC shows no significant difference. Correlation analysis revealed that clay, bulk density and porosity correlated both positively and negatively between upland and flooded forest soil while silt correlates negatively in both areas. Also, OC, TN, Av-P, Ca, Mg, Na, K, TEB, TEA, ECEC and PBS correlated both positively and negatively between the two soils while EC correlated positively in flooded area and negatively in upland area. This indicated an unpredicted movement of nutrients where some are leached during flooding; some are added as deposits while some are unaffected by flood.

Keywords: Physical properties; chemical properties; flooded; forest areas

INTRODUCTION

Floods are among the most devastating natural disasters and cost many lives every year (Azuhan, 2015). Flooding seriously affects people's lives and property (Zhang *et al*., 2013). In a time period of 6 years (1989–1994), 80% of federal declared disasters in the US were related to flooding; flood themselves around the world average four billion dollars annually in property damage alone (Njoku and Okoro, 2015). The frequency with which they occur is on the increase in many regions of the world (Drogue *et al*., 2014). Going by number and economic losses, flood disasters account for about a third of all natural disasters (Nwilo *et al.,* 2012). Nigeria like other countries experienced flooding in recent times. Many communities have suffered losses due to flood problem. Nigeria like many other coastal countries of the world is blessed with a plethora of drainage systems of varied river morphometry (Daffi, 2013). Flood Management is currently a key focus of many national and international research programmes 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.

Soil nutrient dynamics in seasonal floodplain ecosystems are highly complex as a result of flood pulses and changing redoximorphic state (Gallardo, 2011). It facilitates soil nutrient exchange between rivers and their associated seasonal floodplains. During floods, soil nutrients dissolve in floodwaters and are transported from seasonal floodplain surfaces into adjacent rivers. Soil nutrients may also be transported from the river into seasonal floodplains through lateral flow. Flooding can lead to both increases and decreases in soil nutrient content (Gallardo, 2011). 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).

The dramatic river flooding in Adamawa State that destroyed farmlands and claimed lives and property has affected various parts of the region. Some of the flood prone areas include Yola North and South, Numan Council areas, Loko, Dasin, Fufore areas and Demsa (Drogue *et al*., 2014). The need and means to protect the environment are of great concern to man. Flood occurrences in Adamawa State floodplain are threats to lives and properties and the frequency is increasing dramatically. 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 are unaffected by flooding (Dezzeo *et al.,* 2010). Punch Editorial Board (2012) reported that according to the Nigeria Emergency Management Agency, five Local Government Areas, namely, Fufore, Demsa, Yola North, Yola South and Numan were flooded in August and early September, 2010 when River Lagdo over flowed its banks. Demsa and Fufore districts, along with nearby Maiha, were hit with cholera outbreak which left 70 people dead out of over 300 infected (Punch Editorial Board, 2012)

Large populations of people of Adamawa State, especially Yola-North LGA live in flood prone area are heavily dependent on forest for both subsistence and cottage industrial needs. Vital aspect of rural livelihood, food security, nutrition, health and commerce are linked to diverse wildly growing trees and are thus probably affected by incessant flooding through nutrient flux (Dishan *et al.,* 2016). It is therefore crucial to assess differences in physical and chemical properties of flooded forest areas and upland forest areas that may perhaps be occasioned by flooding.

MATERIALS AND METHODS

The Study Area

Adamawa State is located at the North Eastern part of Nigeria. Yola North is one of the 21 LGAs in Adamawa State. It lies on the south bank of the Benue River and on the highway between Zing and Girei. It lies on latitude 9°14'31.78" N and longitude 12°31'29.53" E. Adamawa State shares boundaries 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 Republic of Cameroon along its eastern border. The State covers a land area of about 38,741 km^2. It has a population of 3,168,101 (National Bureau for Statistics, 2007). The wet or rainy season falls between April and November, which is characterized by single Maxima in August. Seventy percent of the total rainfall in the area happens within four months of May-August (Adebayo and Nwagboso, 1999). The average annual rainfall of the area is 972mm. (Adebayo and Nwagboso, 1999). The soils of Adamawa State include Luvisols, Legosols, Cambisols, Vertisols and Lithosols (Adebayo and Nwagboso, 1999).

The vegetation of Yola North LGA is largely controlled by the rainfall distribution as affected by topography. The identifiable vegetation type in Yola North LGA is Sudan savannah. The Sudan is characterized by short grasses and short trees commonly found in the Northern parts. To the south, the vegetation is thick with tall grasses and trees, constituting the Guinea Savannah zone.

Sampling and Data Collection

Soil samples were collected from three randomly selected points in the forest areas flooded (location A) and upland (location B) and at three points in the upland forest areas in Jambutu each at three depths: 0 – 30cm, 30 – 60cm and 60 – 90cm. Also, similar sampling pattern was repeated in Runde-Baru forest area all in Yola North LGA using hand Auger (Dishan, 2016). All samples were labeled appropriately in cellophane bags for onward determination of soil physical and chemical properties in the laboratory for the purpose of comparison (Jaiswal, 2003).

Analysis of Soil Sample

The soil samples collected were air dried and crushed using a mortar and pestle to pass through a 2mm sieve (Jaiswal, 2003). The samples were characterized for their physical and chemical properties following standard laboratory procedures.

Physical properties of the soils 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).

Data Analysis

The result of physical and chemical properties of flooded forest and upland soils were subjected to Multivariate Analysis of Variance (MANOVA) to test for significant differences, Duncan’s Multiple Range Test was used to separate the means. Pearson Product moment correlation was used to determine the relationship among physical & chemical properties of the soils in Randomized Complete Block Design (RCBD).

RESULTS AND DISCUSSION

Physical Properties of the Flooded and Upland Forest Soils in Yola-North LGA

Results of physical properties of flooded and upland forest soil of Yola-North LGA area are shown in Table 1.

Table 1: Physical properties of flooded and upland forest area of Yola-North LGA

Sample	Sand (%)	Silt (%)	Clay (%)	Textural Class	Bulk Density(gcm^{-3})	Porosity (%)
Flood Area						
Depth						
0–30	30.67c	19.50a	35.67b	Clay	0.88b	53.22a
30–60	42.00c	16.00b	38.50a	Sandy/clay	1.33a	50.34b
60–90	47.00b	15.00a	38.00a	Clay	1.34a	49.59b
Mean	39.89	16.83	37.39		1.18	51.05
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						
Depth						
0–30	67.00a	07.00b	26.00c	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
Mean	57.33	9.67	29.83		1.42	36.49
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

L1 & L2 at Yola-North are Jambutu and Runde-Baru respectively Source: Field Survey, 2017

Mean values of sand, silt, clay, bulk density and porosity in upland forest area were 57.33, 9.67, 29.83, 1.42 and 36.49 respectively. Mean values of same properties of the flooded forest area were 39.89, 16.83, 37.39, 1.18 and 51.05 respectively. Analysis of variance showed that sand, silt and clay showed significant differences ($P<0.05$) while bulk density and Porosity showed no significant difference ($P>0.05$) between upland and flooded forested areas. This result conforms with the findings of Ubuoh *et al*. (2016); Njoku and

Okoro (2015); Madueke *et al*. (2012) and Dezzeo *et al*. (2010) who reported that sand and Bulk density are higher in upland forest areas than in flooded forest areas while silt, clay and porosity are higher in flooded forest areas than in upland forest areas of their study sites. The result of the texture classes of the flooded and upland forest areas showed that in all locations and across depths, the sand textural classes were dominated by sandy clay, clay and loam soils. The result is in line with the result of Njoku and Okoro (2015), that texture was a permanent component of the soil and did not change as much with time.

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

Table 2 shows the results of chemical properties of flooded and upland forest area of Yola-North LGA. Generally, the pH of soils of both flooded and upland forest areas were slightly acidic as the pH range was between 6.5 and 7.09 with mean value of 6.89 at flooded forest areas and 6.65 at upland forest areas. Analysis of variance showed that pH value was not significantly different ($P>0.05$). This result conforms with the findings of Oviasogie and Omoruyi (2010). It was observed that pH was higher in flooded forest area and lower in upland. EC, 0.C, TN, Av-P, TEB, TEA, ECEC and PBS had mean values of 1.08, 6.30, 1.60, 7.77, 5.64, 1.98, 12.44 and 72.38 respectively in flooded forest area. The upland forest areas had value of; 1.02,7.52,1.57, 9.67, 8.05, 1.81, 16.68 and 78.14. Analysis of Variance showed that EC, TN, TEA and ECEC showed no significant difference ($P>0.05$) between the upland and flooded forest area. The results obtained agree with the findings of Njoku *et al*. (2011), Njoku and Okoro (2015) and Connelly *et al*. (2015), who stated that EC, TN and ECEC are higher at the flooded forest areas than upland forest areas, while ECEC is lower at flooded forest area and higher in upland area. Similarly, Analysis of Variance showed significant difference in O.C, Av-P, TEB and PBS. This finding agrees with that made by Steven and Cole (2011), Osakwe *et al*. (2014), Rasmussen *et al*. (2010) and Shehu *et al*. (2015) who reported that OC, Av-P, TEB and PBS are generally higher in upland forest areas than those found in flooded forest areas.

The mean values of exchangeable bases Ca^{2+}, Mg^{2+}, Na^{+} and K^{+} in flooded forest area were 6.17, 3.32, 0.11 and 0.10 respectively while in upland forest area, their values were 11.87, 2.03, 0.30 and 0.42 respectively. Analysis of variance also showed that Ca^{2+} and K^{+} were significantly different while Mg^{2+} and Na^{+} were not significantly different at ($P>0.05$) between upland and flooded forest areas. This result agrees with the observation made by Clilverd *et al*. (2013) and Diane *et al.* (2016), that flooded forested areas recorded lesser $Ca^{2+}$and K^{+} in the upland forest areas. Shao (2010) also reported that Mg^{2+} and Na^{+} were higher at upland forest areas and lower at flooded forested areas.

Table 2: Chemical properties of the soils of 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+}	Mg^{2+}	Na^{+}	K^{+} (cmol/kg)	TEB	TEA	ECEC	PBS (%)
Flood Area													
Depth													
0-30	6.84b	1.11a	6.70a	1.40a	7.01c	4.33c	3.95a	0.08b	0.12a	8.48c	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	8.52b	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	12.07a	1.67b	14.07a	72.05b
Mean	6.89	1.08	6.30	1.60	7.77	6.17	3.32	0.11	0.10	5.64	1.98	12.44	72.38
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	10.59a	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	10.73a	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													
Depth													
0-30	6.66a	1.04a	7.20	1.55b	9.90a	11.67a	2.05a	0.57a	0.67a	14.89a	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	14.28a	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	14.55a	2.07a	14.74c	78.98a
Mean	6.65	1.02	7.52	1.57	9.67	11.87	2.03	0.30	0.42	8.05	1.81	16.68	78.14
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	14.69a	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	14.54a	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

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

Source: Field Survey (2017)

Correlational Analysis of Physical Properties of Flooded and Upland Soils in Yola-North LGA

The results on correlation analysis of physical properties of flooded and upland forest area in Yola-North LGA are presented in (Tables 3 and 4) respectively. The results in Table 3 show that clay property inversely related with sand (r = -0.79) but, positively related strongly with silt (r = 0.75). Also, the bulk density related strongly with sand (r = 0.88) and also related strongly but negatively with silt (r = -0.61) and clay (r = -0.92) respectively. 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 4 reveal the correlation analysis among the physical properties of upland forest soil in Yola-North LGA. The results established a significant but inverse relation between silt and sand (r = -0.91). Likewise, clay properties inverse related with sand (r = -0.93). The relationship among bulk density and other properties showed that bulk density related strongly with sand (r = 0.95), but negatively with silt (r = -0.79) and with clay (r = -0.94). The soil porosity for the upland soil inversely related with sand (r = -0.91) and bulk density (r = -0.92). However, the porosity properties showed increasing trend with silt (r = 0.78) and clay (r = 0.51).

Generally, the correlation among the physical properties of forest soils in flooded and upland forest areas of Yola-North LGA showed that in the flood soils, the clay properties indicated strong and significant relationship at 5% level of probability, alongside porosity, while in upland forest area, sand content were found to be significantly related with bulk density. However, it was observed in flooded forest area, that sand and silt did not show signification relation. This indicates that flooding affects physical properties of soils in that it tends to increase some properties more than others across the LGA. This agrees with the findings of Kefas *et al*. (2016) that as a result of flood, some physical properties of soils tend to disproportionally increase more than others. Weil and Brady (2016) indicated that there are high chances that flooding alter the physical properties of soils, where some will sharply rise above others.

Table 3: Correlation analysis of physical properties of the soils of flooded forest area in Yola-North

Property	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

*. Correlation is significant ($p<0.05$) Source: Field Survey, 2017

Table 4: Correlation analysis of physical properties of the soils of upland forest area in Yola-North

Property	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

*. Correlation is significant ($p<0.05$) Source: Field Survey, 2017

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

The results of correlation analysis among the chemical properties of flooded and upland forest soil samples of Yola-North LGA are presented in Tables 5 and 6, respectively. The results in Table 5 established that EC related strongly with pH (r = 0.86), while TN (total nitrogen) had negative relation with pH (r = -0.65). Av-P related strongly with pH (r = 0.50). Mg^{2+} related strongly with pH (r = 0.69), O.C (r = 0.63) and Ca^{2+} (r = 0.77) where Na^{+} showed strong but inverse relationship with Ca^{2+} (r = -0.55). Also, 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 inversely related with O.C (r = -0.74) but strongly related with 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); PBS related strongly with O.C (r = 0.60), Mg^{2+} (r = 0.53) and TEB (r = 0.59), while, the relationship that exist between PBS and TEA was inversely significant (r = -0.91).

The results of correlation analysis among chemical properties of sampled soils from upland forest area in Yola-North LGA are presented in (Table 6). The results established weak and inverse relationship between O.C and EC (r = -0.44). TN related strongly but negatively with pH (r = -0. 51) and related positively but weakly with EC. Av-P related weakly with pH (r = 0.40). It also related weakly but inversely with TN (r = -0.49). The relationship between Mg^{2+} and other soil chemical properties in upland forest area showed that Mg^{2+} related strongly with pH (r = 0.62) but inversely with Ca^{2+} (r = -0.67). TEB related strongly with pH (r = 0.61), Ca^{2+} (r = 0.87) and Mg^{2+} (r = 0.86). TEA related weakly with pH (r = 0.40) and strongly with Av-P (r = 0.56). 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 5: Correlation analysis of chemical properties of the soils 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

*. Correlation is significant ($p<0.05$) Source: Field Survey, 2017

Table 6: Correlation analysis of chemical properties of the soils 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

*. Correlation is significant at the 0.05 level (2-tailed) Source: Field Survey, 2017

Overall, the correlation among the chemical properties of flooded forest soils in Yola-North LGA revealed that chemical properties such as pH, Ca^{2+}, Mg^{2+}, TN, TEB and EC indicated strong relationship at ($P<0.05$); whereas, TEB, O.C, Na, TEA, Av-P and ECEC were strongly but inversely related. However, these results differed with correlation analysis of the chemical properties of upland forest area in Yola-North LGA, where TEA and pH showed strong relationship. ECEC related strongly with Ca^{2+}, K^{+}, TEB and Mg+. Also, pH, PBS and TEA related inversely at ($P<0.05$). These results showed sharp reduction in values of some chemical properties found in the flooded forest area, which may not be unconnected with the effect of flood water, which perhaps resulted in the unusual increment of some chemical properties such as ECEC TEA, EC, while others like Na, Ca^{2+}, Mg^{2+}, TN, reduced. Brady and Weil (2010) mentioned that flooding of soil over a period of time can drastically reduce some chemical properties such as Av-P, Na, and Ca^{2+} as a result of leaching. Likewise, study by Tian (2011) reported a reduction in the level of Mg^{2+}, Ca^{2+} and Na in flood affected area than upland area which was attributed to the effect of leaching and dilution. However, Tian *et al*. (2017) argued that the reduction found in the level of chemical properties of some flooded soils is more of dilution effect than leaching, because flooding increases the solubility of mineral nutrients. A similar argument was put forth by Kolahchi and Jalali (2013) that during a high flood, more soil nutrients dissolve in water and are lost through leaching as water infiltrates the soil.

CONCLUSION

The findings of this research revealed that in both upland and forests areas of Yola north LGA, textural classes of the soils were dominated by sandy clay, clay and loam indicating that flooding does not significantly change the soil texture. The chemical properties on the other hand showed a different trend. While some related significantly, others did not. Correlation analysis among the soil parameters also showed a similar trend. It can thus be concluded that the effect of flooding on soils properties is unpredictable. This is buttressed by the fact that the values of some of the parameters increased, some reduced while some remained unchanged.

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