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Soil Status of Kogo Forest Reserve in North-Western Nigeria

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----------ABSTRACT----------
This research was carried out to evaluate the physical and chemical properties as well as microbial count of soils of Kogo Forest Reserve in North-Western Nigeria. Eight locations were randomly selected within the forest reserve. Composite soil samples were collected at three different depths (0-15, 15-30 and 30- 45cm) from each sampled location and subjected to laboratory analyses. Bulk density of the soils varied from1.3-1.5gcm^3, porosity 36-57% and particle density ranged from 2.24–2.41gcm^{-3} with no significant difference ($p>0.05$) between means. Sand, silt and clay contents ranged from 71.9-88.2%, 8.7-16.5% and 3.1-11.6% respectively and were significantly different ($p<0.05$). Texturally, the soils were predominantly loamy sand. Soil pH was weakly acidic (6.13-6.63) and significant ($p<0.05$). Organic carbon was moderate (3.72-7.11g/kg) which decreased significantly with increased depth. Total Nitrogen ranged from 0.29-0.41g/kg with no difference ($p>0.05$) by location but differed significantly with increase in depth. Available phosphorous varied significantly with location (1.87-2.21mg/kg) and decreased with increase in depth and no significant difference ($p>0.05$). Exchangeable Ca, Mg K and Na were all significantly different ($p<0.05$) by location and decreased with increase in depth. CEC also varied significantly by location ($p<0.05$) and decreased with increase in depth with no significant difference. Kogo has fairly fertile soil, and hence closure of the forest for exploitation with maximum protection to allow the forest to fully regenerate will enhance the fertility of the soil and is therefore recommended.

KEYWORDS: *Characteristics, Forest, Kogo, Reserve, Soil*

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I. INTRODUCTION

Soil has a major ecological role in forest ecosystems, involving many chemical processes and a variety of organisms. It provides moisture, nutrients and physical support for plants, and serves as a filter for toxic substances and a receptor for natural wastes. In forestry, soil is the resource, whereas trees are merely a crop [1].The forest cover and the resultant forest floor provide a micro-climate and a spectrum of organisms different from those associated with most other soils. Forest trees help in improving soil fertility through biological nitrogen fixation, phosphorus solubilization and decomposition of organic matter in their rhizosphere and non rhizosphere zones. These zones processes play an important role in plant nutrition and maintaining soil fertility [2]. As Forestry involves the management of the land for whatever products and uses that may be needed in the interest of human welfare. Trees are always relied upon all over the world to rebuild soils damaged and degraded by human activities and other natural factors and to improve the properties of soils that are too fragile to withstand rain [3] and other human or environmental factors.

According to Pears [4], soil consists of matters existing in three basic forms, namely, solid (inorganic rock particles and organic plant and animal remains), liquid (soil water and chemicals in solution) and gaseous (atmospheric gases and those released by chemical and biological activity within the soil). This makes soil a dynamic zone within which physical, chemical and biological processes are at work. It is also a natural body consisting of layers (soil horizons) of mineral constituents of variable thicknesses, which differ from the parent materials in their morphological, physical, chemical, and mineralogical characteristics [5]. Simply, it is a mixture of mineral and organic constituents that are in solid, gaseous and aqueous states [6]. Often which climate, organisms, topographic relief, and parent material interacting through time are the dominant factors that control processes of soil formation and determine soil properties [7], which are well known to influence plant productivity [8]. In both forest and savanna ecosystems, vegetation affects soil properties through several pathways, which may likely be a basis for difference in physical and chemical properties as well as microbial load between forest soils and other arable crop-land soils or even more deserted natural landscapes. Because vegetation cover helps to conserve soil by reducing soil erosion, increasing soil organic matter, improving soil structure and assisting in nutrient cycling[8].

The importance of soil chemical and physical properties to vegetation growth has gained considerable attention in recent years, largely because of greater demands placed on forest soils in terms of productivity, and also due to indications that the recent decline in forest cover may be related to soil changes induced by atmospheric pollution and indiscriminate removal of vegetation as a result of land use changes [1] (Vanmechelen*et al.*, 1997). This requires management intervention to maintain the overall biodiversity, and to improve productivity and sustainability of the existing forests. This however pointed out the need to determine and document the forest soil properties for proper management planning. This research was aimed to determine the physical, chemical and microbial status of soils of Kogo Forest Reserve in Katsina State of North-Western Nigeria. This may be used to assess the soil's capacity to perform its ecological functions within the forest ecosystem, and to proffer solutions to problems of unproductivity of our forest reserves.

II. MATERIALS AND METHOD

2.1 Study Site

The study was carried out at Kogo Forest Reserve No: 10, as identified in Gazette No: 53 of 1931 under the Forestry Ordinance, 1927 of the Northern protectorate, and amended in 1937 as Katsina Native Administration Forest Reserve No: 10. It was re-amended in 1971 under The Forestry Law (CAP. 44) under section 23(5), and re-constituted as The Katsina Local Authority Forest Reserve No: 10 (Kogo Forests), as contained in the North-Central State of Nigeria Gazette No 27, Vol. 5. It lies between longitudes 10^0 84'- 11^0 23'E and latitudes 06^0 08'- 07^0 51'N. It covers approximately 212.65sq miles (340.24sq km), and falls within Faskari and Sabuwa Local Government Areas of Southern Katsina State, in North-western Nigeria at the extreme savanna of Northern Guinea. The area is characterized by defined wet (rainy) season spanning from May to October and peak rainfall in August (100-150cm) and the dry season occupies the rest of the year. The mean annual temperature is 27 ^{0}C, while humidity less than 60% [9]. It is a woodland savanna consisting of trees in association with perennial shrubs and annual grasses. The forest found in the area may be termed "Savannah bush of *doka* association" and the Reserve consists of rolling uplands and valleys with numerous tributaries feeding into 3 major rivers. Soil types from sandy loam to the darkest loam are present as contained in the proposal document of Katsina Native Administration Reserve No. 10 (Kogo Forests) of 1933.

2.2 Soil Sampling and Collection

Eight locations were randomly selected and three composite soil samples were randomly collected from each sampled location (plot) at 0-15, 15-30 and 30-45cm depth using auger to give a total of 24composite samples. Samples for bulk density were taken from the surface to 15cm depth using core sampler.

2.3 Laboratory Procedures

The collected soil samples were air dried, gently crushed and sieve through 2mm mesh for laboratory analysis. Samples for bulk density were also oven dried using standard laboratory procedures. Physical and chemical properties as well as microbial count of the soils were determined as follows:

2.3.1 Physical Properties Determination

[1] Particle size distribution was determined by the hydrometer method as described by [10]
[2] Particle density (Pd) determination using pycnometre bottle method.
[3] Bulk density (Bd) of the soil was determined by drying the undisturbed core samples to a constant weight at 105°C and dividing the oven dried weight of the sample by its volume[11]
[4] Porosity was calculated using the formula; Porosity = 1-Bd/Pd x 100 (As adopted by[12]

2.3.2 Chemical Properties Determination

[1] Soil pH was determined using electrode pH meter in 1:1 soil-water solution.
[2] Soil organic carbon content was determined by [13] method, and then multiplied by 1.724 to estimate organic matter content.
[3] Determination of total N was achieved by macro-Kjeldhal method with selenium catalyst [14], while available P by electro-photometer method [15], exchangeable K and Na by digital flame photometry, while exchangeable Ca and Mg were determined by EDTA.
[4] Cation exchange capacity of the soils was determined by saturating the soil with normal neutral ammonium acetate solution, washing excess with alcohol, distilled and titrated against standard hydrochloric acid [16].

2.3.4 Soil Microbial Count Determination

Top soil samples (1g each) collected was cultured by pour plate method as described by [17]. Colonies which developed after incubation were also counted using GallenKamp colony counter.

III. DATA ANALYSIS

Data from laboratory analysis of the soil samples were subjected to analysis of variance (ANOVA) using SPSS and where significant difference existed, Duncan's New Multiple Range Test (DNMRT) was used to separate the means.

IV. RESULTS AND DISCUSSION

4.1 Physical Properties

The results from the eight sampled locations indicated that; sand, silt and clay contents of the soil ranged from 71.9-88.2%, 8.7-16.5% and 3.1-11.6% respectively and were found to differ statistically ($p<0.05$) along the locations. Texturally, the soils were predominantly loamy sand because it contains 70-90% sand [18](Brown, 2009) with porosity ranging from 36 to 57%, indicating the percentage pore space which dictates the possible bulk density which is proportional to the rate at which water/air moves within the soil. Particle density ranged from 2.24 to 2.41gcm^{-3} and was found to be statistically the same, which is in close agreement with the report of [12]. Bulk density at 0-15cm depth varied from 1.3 to 1.5 g cm^{-3} and lies within the general limits of 1-2g cm^{2} [5]. Bulk density depends greatly on the mineral make up of soil and the degree of compaction [11] and is inversely related to the porosity of the same soil. The more pore spaces in a soil the lower the value of bulk density. Depth wise, sand increases insignificantly with increase in depth ($p>0.05$), silt followed an opposite direction with no significant difference. Clay showed a different trend with 15-30cm higher than 0-15cm and 30-45cm in that order, particle density also followed the same trend ($p>0.05$) with no significant difference as clearly shown in TABLES 1 and 2.

4.2 Chemical Properties

The result of the chemical properties of the soils is presented in TABLE 3, which showed a slightly acidic (6.13-6.63) condition which were statistically different ($p<0.05$) among sampled locations, and decreased with increase in soil depth. These values may be as a result of similarity in the parent material. Soil pH influences nutrient uptake and hence tree growth and a pH of 6.5-7.0 generally provide the best growing conditions [19] and may be responsible for the ability of the reserve to fairly accommodate or sustain a reasonable number of species despite limitations in terms of good management practices in place. Organic carbon content ranged from 3.72 to 7.11g/kg and the mean values were not statistically different ($p>0.05$), but it was found to differ significantly showing a decrease with increasing depth. These values were relatively low compared to the values of [20] where 1.0, 7.38, 11.57 and 8.42g/kg were recorded at Wassaniya, Jimajimi, Yartagimba and Daiji areas. This may be as a result of the lower microbial count that could undertake litter decomposition or low moisture that will enhance the microbial activity at Kogo. Organic matter that contributes to plant growth through its effect on the physical, chemical, and biological properties of the soil [21]. The value of the organic matter obtained in this study ranged from 6.41 to 12.26 by location with no significant difference and decreased significantly ($p<0.05$) with increase in depth. Total Nitrogen value ranged from 0.14 to 0.41g/kg and the mean values were statistically the same ($p>0.05$) along the locations but decreased ($p<0.05$) significantly with increasing depth.

The least value of 0.14g/kg obtained coincides with that of [5] at Inkouregaou and also slightly higher than that of [22] indicating that the result is within the range for the agro ecological zone. Available phosphorus which occurred in phosphate form, varied significantly with location (1.87 to 2.21mg/kg) and decreased with increase in depth with no significant difference ($p>0.05$). The values were quite lower than that of [20] (2.41-6.35) and slightly higher than that obtained by [23] who recorded 1.26. mg kg^{-1}Exchangeable bases (Ca, Mg, K and Na) in Kogo soils showed a significant difference between sampled locations and depth wise, the values decreased with increasing depth with significant difference only for Ca and Na (TABLE 3). The values recorded were quite higher than that of [23]; [5]; and [20]. [24] also recorded very high values for K and Na at 4.17 and 4.72cmol kg^{-1} respectively. This may likely be as a result of difference in the parent material of the soils or climatic factors that can induce mobilization and immobilization of these cations [25]. The CEC also differed significantly among the locations which decreased with increase in depth with no significant difference. The mean values ranged from 5.50 to 5.85cmol Kg^{-1} base on location. The result was in close agreement with that of [24] where they reported 5.1cmol kg^{-1}. This may be as a result of similarity in either clay or organic matter contents of the soils as the primary factors determining CEC of a soil [26]. The CEC gives an indication of the soils potential to hold plant nutrients and make it readily available for plant to absorb. Low organic matter content, excessive exposure and sandy nature of Kogo soils therefore may be responsible for its low CEC.

4.3 Microbial Count

The soil microbes (Bacteria and Fungi) also varied with location, with total absence of bacteria in locations 3, 5, and 6, and too numerous to count in location 7. The bacterial count within the sampled locations ranged from 2 to 16 $x10^4$. However, fungi were also absent in location 2, 3, 5, 7 and 8 the fungal count ranged from 16 to 20 x 10^4 (TABLE 4). This indicates a very low microbial load, may be due to the slightly acidic nature of the soil. Low moisture content, organic matter and poor nutrient content as factors that might have influenced the low microbial count. Thereby affecting the plant community nutrition, even though microbes tolerate a wide range of pH, that on the other hand affects the type and amount of anions and cations that soil solutions contain and that exchange with the soil atmosphere and biological organisms [27]). Considering the location of the reserve (at the extreme of Northern Guinea or transition to Sudan savanna) in which the trees were scattered (Iloeje, 2001), coupled with human interference in terms of over-exploitation of the woody plants which had already exposed much of the soil surface must have altered the soils in terms of structure, moisture content, reduced litter and possibly micro fauna and flora [29] . This must have in one way or the other had a negative consequences on the nutrient cycling processes and fertility [30] (Xiao, *et al.*, 2008) which in turn may alter the plant (tree) nutrition and hence its survival and growth.

Table 1: Physical Properties of Soils of KogoForest Reserve by Location

Location	Sand	Silt	Clay	Textural class	Porosity (%)	Particle Density	Bulk Density
	(%)					g/cm^3	
1	84.97^{ab}	9.27^{b}	5.76^{c}	Sand	42	2.35	1.4
2	83.03^{bc}	9.87^{b}	7.10^{bc}	Loamy Sand	41	2.40	1.3
3	79.74^{c}	10.56^{b}	9.70^{ab}	Loamy Sand	39	2.24	1.3
4	81.70^{bc}	10.57^{b}	7.73^{bc}	Loamy Sand	57	2.41	1.1
5	88.20^{a}	8.70^{b}	3.10^{d}	Sand	36	2.28	1.5
6	71.90^{d}	16.50^{a}	11.60^{a}	Loamy Sand	42	2.41	1.4
7	82.33^{bc}	10.57^{b}	7.10^{bc}	Loamy Sand	47	2.40	1.3
8	88.20^{a}	8.70^{b}	3.10^{d}	Sand	42	2.27	1.3
SE±	1.09	0.55	0.62			0.21	
Sig	*	*	*			Ns	

Means followed by the same letters(s) along the column are statistically the same ($p<0.05$). *indicates significant difference ($p<0.05$)

Table 2: Physical Properties of Soils of Kogo Forest Reserve by Depth

Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Particle Density
0-15	81.84	11.11	7.05	2.34
15-30	82.11	10.58	7.31	2.83
30-45	83.57	10.09	6.34	2.31
SE±	1.09	0.55	0.62	0.02
Sig	Ns	Ns	Ns	Ns

Table 3: Chemical Properties of Soils of Kogo Forest Reserve

Location	pH	Org. C	Org. Matter	N	P	Ca	Mg	K	Na	CEC
			(g/kg)		(mg/kg)			(Cmol/kg)		
1	6.53^{a}	5.18	8.93	0.41	2.19^{a}	1.32^{d}	0.92^{d}	0.70^{a}	0.52^{b}	5.50^{d}
2	6.63^{a}	4.65	8.01	0.35	2.05^{ab}	1.43^{bcd}	0.98^{d}	0.67^{ab}	0.47^{b}	5.65^{bcd}
3	6.50^{a}	4.72	8.14	0.37	2.21^{a}	1.52^{abc}	1.09^{a}	0.65^{ab}	0.69^{a}	5.56^{cd}
4	6.53^{a}	7.11	12.26	0.41	2.01^{bcd}	1.68^{a}	1.07^{ab}	0.48^{d}	0.53^{b}	5.64^{bcd}
5	6.50^{a}	3.72	6.41	0.34	1.87^{d}	1.58^{abc}	0.88^{d}	0.72^{a}	0.55^{b}	5.80^{ab}
6	6.40^{ab}	4.89	8.43	0.29	1.98^{cd}	1.65^{a}	0.96^{bc}	0.41^{d}	0.54^{b}	5.73^{abc}
7	6.13^{b}	4.14	7.14	0.37	2.17^{ab}	1.60^{ab}	0.90^{c}	0.61^{bc}	0.58^{b}	5.56^{cd}
8	6.16^{b}	4.38	7.55	0.35	2.11^{abc}	1.41^{cd}	0.86^{c}	0.56^{cd}	0.58^{b}	5.85^{a}
SE±	0.45	0.35	2.25	0.14	0.27	0.29	0.20	0.02	0.02	0.03
Sig	*	Ns	Ns	Ns	*	*	*	*	*	*
Depth (Cm)										
0-15	6.44	6.51^{a}	11.22^{a}	0.43^{a}	2.12	1.60^{a}	0.99	0.63	0.62^{a}	5.73
15-30	6.51	4.79^{b}	8.26^{b}	0.36^{b}	2.04	1.52^{ab}	0.97	0.60	0.55^{ab}	5.66
30-45	6.32	3.26^{c}	5.57^{c}	0.29^{c}	2.03	1.45^{c}	0.91	0.57	0.50^{b}	5.60
SE±	0.04	0.35	1.68	0.01	0.03	0.03	0.02	0.02	0.02	0.03
Sig	Ns	*	*	*	Ns	*	Ns	Ns	*	Ns

Means followed by different letters(s) along the column are statistically different ($p<0.05$). *indicates significant difference ($p<0.05$). ns= not significant

Table 4: Microbial Load Found in Kogo Forest Reserve Soils

Location	Bacteria (Cfu/ml)	Fungi (Cfu/ml)
1	2×10^4	16×10^4
2	16×10^4	Nil
3	Nil	Nil
4	6×10^4	18×10^4
5	Nil	Nil
6	Nil	20×10^4
7	TNC	Nil
8	2×10^4	Nil

TNC- Too numerous to count.

V. CONCLUSION

It was concluded that as a result of over-exploitation, climatic and/or edaphic factors which had already exposed much of the soil surface may likely be the reason for low nutrient status and low microbial population of the soils. This therefore, highlighted the need to draw an integrated management approach that will restore the diminishing potentialities of the forest soil, and to appropriately implement it.

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