Soil Properties as Determinant of Woody Trees Distribution in Kanawa Forest Reserve, Gombe State, Nigeria

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***Abstract*:- The present study examined the influence of soil properties on the distribution of woody tree species in the study area. Point CenteredQuarter sampling method was employed to collect soil and vegetation data from six contrasting vegetation types.Composite soil samples were collected at two pre-determined (0-15 and 15-30cm) soil depths. The samples were analysed using standard procedures in the laboratory. The study revealed that soil physico-chemical properties varied from site to site and were dominated by certain plant species (*Raphia sudanica, Elaeis guineensis, Senna siamea, Ficus congoensis, Ficus polita, Gmelina arborea, Azadirachta indica, Anogeissus leiocarpus, Vitex doniana and Albizzia lebbeck*). Correlations between soil types and vegetation types showed significant and positive correlations within the various soil parameters studied at all the vegetation types. However, there was a negative correlation within some of the vegetation types. From this findings, it was concluded that the variations within soil physical and chemical properties influence the distribution pattern of flora in the area. The differences are therefore indications of the variation in biophysical components such as soil, water, topography among others. It was recommended that this study would act as a basis for making sound ecological predictions and land use decisions.**

***Keywords:* Soil properties, Plant distribution, Kanawa Forest Reserve, Vegetation types.**

I. INTRODUCTION

The effects of environmental variables on plant species have been the subject of many ecological studies in recent years(Ramirez *et al*.,2007). Plant species diversity has attracted particular attention because of its applicability in assessing current species performance and predicting future community composition (Wang *et al*. 2008). Environmental factors play key roles in determining the spatial variation of biodiversity across broad geographic extents. Quantitative classification and ordination have been widely used to analyze the community structures and understand the relationships between communities and their environment in the study of community ecology (Leps and Smilauer, 2003, Zhang *et al*.2008, Zhu *et al*. 2012).

Soil conditions are different in different forest areas and are also related to the restoration process (Zhang *et al.*, 2010).At different spatial and time scales, biotic organisms respond positively to conditions that are favourable or within their range of tolerance. As such different organisms mostly plants are known to have different climatic and edaphic requirements (Iwara *et al*., 2011). Plants like animals and humans alike are attracted to locations where the Site conditions are favourable to them, which suggest that differences in the distribution and abundance of plant species in any environment are an indication of the variation in soil properties (Graham *et al*.,2005; Engler and Guisan,2009). A sound understanding of soil properties and their relationship with flora distribution is believed to be highly essential for integrated and sustainable flora management programmes (Udoh *et al*.,2007).

Of the numerous factors affecting species, soil has large impact on the composition and structure of plant community. Heterogeneity of soil properties, such as soil texture, moisture content, electric conductivity and pH create nitches with specific conditions, which in turn affect plant distribution pattern of plants (Vazquez and Givnish, 1998). Soil PH directly affects the nutrient toxicity, and microbial activity, as well as extending the direct effect on protoplasm of the root cells (Gould and Walker, 1999).Soil nutrients which are related to moisture can play a major role in species distribution (Philipse, 2003). Among all, clay soils with greater amount of nutrients and water availability have higher support for thick vegetation cover (Schuur and Matson, 2001).The variations in climatic and edaphic conditions influence the speciation survival and distribution pattern of flora in a given environment(Iwara *et al*., 2011). Success or failure of agricultural projects often hinges on the properties of the soil used. The occurrence and growth of many plant species and the movement of water and solutes over and through the soil are closely related to soil physical properties (Nyle, 1999). Thus the inherent ability of soil to support plant growth is determined largely by both its physical and chemical properties which directly control the nutrient supply of plants. Since the suitability of a soil as a medium for crop production depends on the availability of nutrients at the quality in the soil and efficient utilization of the nutrient resources, the usefulness of soil characterization has been recognized for many decades (Pedro, 1994). In Gombe State, few studies have attempted to assess amounts of soil macro and micronutrients in relation to supporting vegetation types in KFR. Such trend has led to partial understanding of the status and variability of macro and micronutrients in KFR. This study, therefore, aimed at determining variability of soil macro and micronutrients along the different vegetation types of the study area. The information generated can serve for planning soil management interventions to sustain soil macro and micronutrients sufficient levels and addressing deficiencies in the study sites.

II. MATERIALS AND METHODS

Study Area

This study was carried out in Kanawa Forest Reserve,GombeState, Nigeria.Kanawa Forest Reserve (KFR) is located in Yamaltu/Deba Local Government Area of Gombe State, Nigeria, and it lies in the Southern part of the Sudan Savanna between latitude 10^{o} 16'N and 10^{o} 18' N longitude 11^{o} 18'10'' E and11^{o}22' 09'' E with an altitude of 336m-390m above sea level. The size of the forest was 41 hectares (Gombe Native Authority, 1945). It was initially established as a small Native Authority forest plantation mainly of *Senna siamea* D.C between 1940 and 1945. The soil is good and tree growth is rapid. It aIso contained an excellent plant nursery which was situated near Poli stream on the lower side of the forest plantation which supplies trees for roadside, towns and villages throughout a large part of Gombe division (Gombe Native Authority, 1945). Kanawa Forest was gazetted as a forest reserve by the Native Authority notice number 15 of 1953 contained in the Forestry Ordinance Chapter 75 of the Federal Republic of Nigeria by the then Governor of the Northern region in Kaduna State, Nigeria.The terrain is generally undulating; the drainage pattern is generally dendritic shallow V-shaped stream channels that tend to broaden into plains as the streams in the area approaches the lowlands (Samaila, 2011). The vegetation of the study area is a mosaic made up of dense Sudan Savanna vegetation especially around the hilly part of the reserve and marshy, riparian, lowland rainforest vegetation near the Poli stream, grassland with tall grasses and tropical thorn forests, in the drier part of the forest (Abba,2014).. The forest is a savanna of trees and shrubs with a continous layer of annual and perennial grasses with climbers and epiphytes (Abba, 2014). The climate of the area is characterized by two distinct seasons: a humid and wet season from April through October and a dry season which runs from November through March. Of the climatic factors, rainfall, temperature and relative humidity normally exert the most powerfull influences upon the vegetation. The study area is generally cool with unimodal rainfall pattern. The mean annual rainfall in the area ranges from 500 to 1000 mm, most of it falling between May and September. The mean annual potential evapotranspiration ranges from 1600 to 2000 mm. The rainy season lasts for five (5) months (Abba, 2014)Temperature in the study area is typical of the West-African Sudan Savanna climatic belt of Nigeria. It is characterized by marked diurnal temperature variation expressed by hot days and cold nights. Mean annual air temperatures vary from 24 to 28°C (Abba, 2014). During the rainy season, the moisture content of the air increases and the humidity is very high. At the peak of the dry season relative humidity is very low during the months of November-March and higher values were from May –October (Abba, 2014).The soils of Kanawa Forest Reserve is mainly of two types: Loamy sand and Sandy loam with rich black colour (Abba,2014).

Soil Sampling

For the purpose of soil sampling, three transects 1,2,3 were laid per site and three replicate soil samples were collected along each transect for each sampling site across the forest using soil auger. Soil samples were collected at two depths namely 0-15cm (top soil) and 15-30cm (sub soil) respectively. The soil samples were air dried after which the big lumps were broken up with the aid of a mortar and pestle. The samples were then mixed thoroughly and sieved through a 2mm sieve and then stored in polythene bags ready for analysis. The following standard analytical procedures were used to analyze the collected soil samples. (Particle Size Composition was determined using the Hydrometer method (Bouyoucos 1926); Organic Carbon by the Walkley- Black method (1934); Total Nitrogen by the Kjeldahl method (Bremner and Mulvaney 1982); Available Phosphorus was determined by the method of Bray and Kurtz (1945). The soils were leached with 1N neutral ammonium acetate to obtain leachates used to determine exchangeable bases adapted from the method described by Daly *et al.* (1984). Soil Cation Exchange Capacity was determined by the summation method; while pH values were determined usinga glass electrode testronic digital pH meter with a soil: water ratio of 1:2.

Experimental Procedures

Site Selection

The selection of sites was done to satisfy and provide for reasonable sampling of the main floristic types in the area. The number of vegetation types identified and sampled for the study were as follows. Site 1-6,namely Riparian, Lowland rainforest, Grassland, Marshy, Thorn, Sudan Savanna.

Vegetation Sampling

For vegetation sampling, the Point Centred Quarter (PCQ) method for sampling grassland and woodland was employed. Using the PCQ technique, a starting point was selected at random (Cottam and Curtis 1956; Evans and Lowe, 1957; Dix, 1961; Abdullahi, 2010; Abba,2014) and a steel pin pushed into the soil to act as a marker. A tape was attached to this sampling point and four quarters were demarcated and the nearest plant (trees) in terms of distance to the point was recorded in meters (m) in each quarter. This was done for all the sampling points on each transect. There were 10 sampling points, with a total of 30 sampling points with 120 species per site. For trees the distance from the sampling point to the centre of the trunk or rooted base was taken respectively.

The Diameter at Breast height of trees (DBH ≤ 10 cm) were measured with measuring tape in each quarter and recorded. For fluted or buttressed trees, diameter measurements were taken 30 cm above the point where the flute or buttress disappeared into the stem.The woody plant size (age) class distributions at Kanawa Forest Reserve (KFR) were obtained by plotting the number of individual in each class with the size class.

Data Analysis

Data collected from soil was subjected to Analysis of Variance (ANOVA). Duncan's Multiple Range Test (DMRT) was used for mean separation at 5% level of probability. Data representing soil properties from various vegetation types (sites) of the reserve were further subjected to correlation analysis. MINITAB for windows (Ver. 11.0) software package was employed, mainly the multiple correlations (MCs). MCs using the principal components analysis (PCA) approach was performed at 0.05% probability level in order to determine the relative contributions of soil physical and chemical properties to the variation in the distribution pattern of species within the different sites (Dantata, 2014, Private Communication).The vegetation data determinedincluded population of tree species withwoody stems 10 centimeters (cm) dbh (DBH1.37cm from the ground) were identified andcounted. In each plot, tree density andpercentage distribution were determined. In the same way,

III. RESULTS

Composition Of Tree Species Identified At Kanawa Forest Reserve (KFR), Gombe State, Nigeria.

25 species of trees under 22 genera and 15 families were identified within a 53 hectares forest reserve in Gombe State, Nigeria in the Northern Savanna Woodlands which was divided into Six Sites. From the results of the study, the families that had the most common tree species were Combretaceae and Leguminosae: Mimosaceae which had the highest number of four species each. The families Anacardiaceae, Meliaceae, Moraceae, Myrtaceae were represented by two species each. The other five families namely Leguminosae: Fabaceae, Balanitaceae, Bombacaceae, Verbanaceae, Rubiaceae, Bignoniaceae, Arecaceae, Palmae and Ulmaceae were represented by one species each.Tree species in the area indicated differences in their distribution across the study area. 10 tree species based on their density and relative frequency were selected to examine the relative effects of soil properties on their occurrence. The 10 most abundant species were (*Raphia sudanica, Elaeis guineensis, Senna siamea, Ficus congoensis, Ficus polita, Gmelina arborea, Azadirachta indica, Anogeissus leiocarpus, Vitex doniana and Albizzia lebbeck*).with densities of 15.29% , 16.77%, 14.92%, 10.73%, 12.82%, 12.75%, 12.71%, 11.80%, 11.80%, and 21.78% as well as relative frequencies of 58.89%, 62.35%,46.73%, 19.17%,23.43%, 39.24%, 18.33%, 25.53%, 27.44%, and 32.50 % respectively. These selected species showed wide range of distribution compared to others that were site selective.

Correlation Analysis Between Soil Properties And Vegetation Types

Correlation matrix between soil properties and vegetation types (Site) (Table1) revealed significant and positive correlations in the various soil parameters studied at all the vegetation types. However, there was a negative correlation in percent Sand at Site III – VI, so also in percent Silt (at Site I – III and VI), Clay (at Site II and V) and Moisture (at Site II, IV and VI).The same trend was recorded in pHw and pHc (Site I, III and V) Organic Carbon (at Site III - V), Total Nitrogen (Site III, V and VI), Available P (Site III - V) and CEC (Site II and III as well as V and VI). Calcium (Ca) at Site VI, Magnesium (Mg) at Site V and VI, Potassium (K) at Site II, Sodium (Na) at Site II –V and Zinc (Zn) at Site II, III and V. Including Copper (Cu) at Site II – IV, Iron (Fe) at Site I – III and Manganese (Mn) at Site I, II ,V and VI were negatively correlated.

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Table 1. Correlation Matrix between Vegetation Types and Soil Properties in Kanawa Forest Reserve in Gombe State, Nigeria

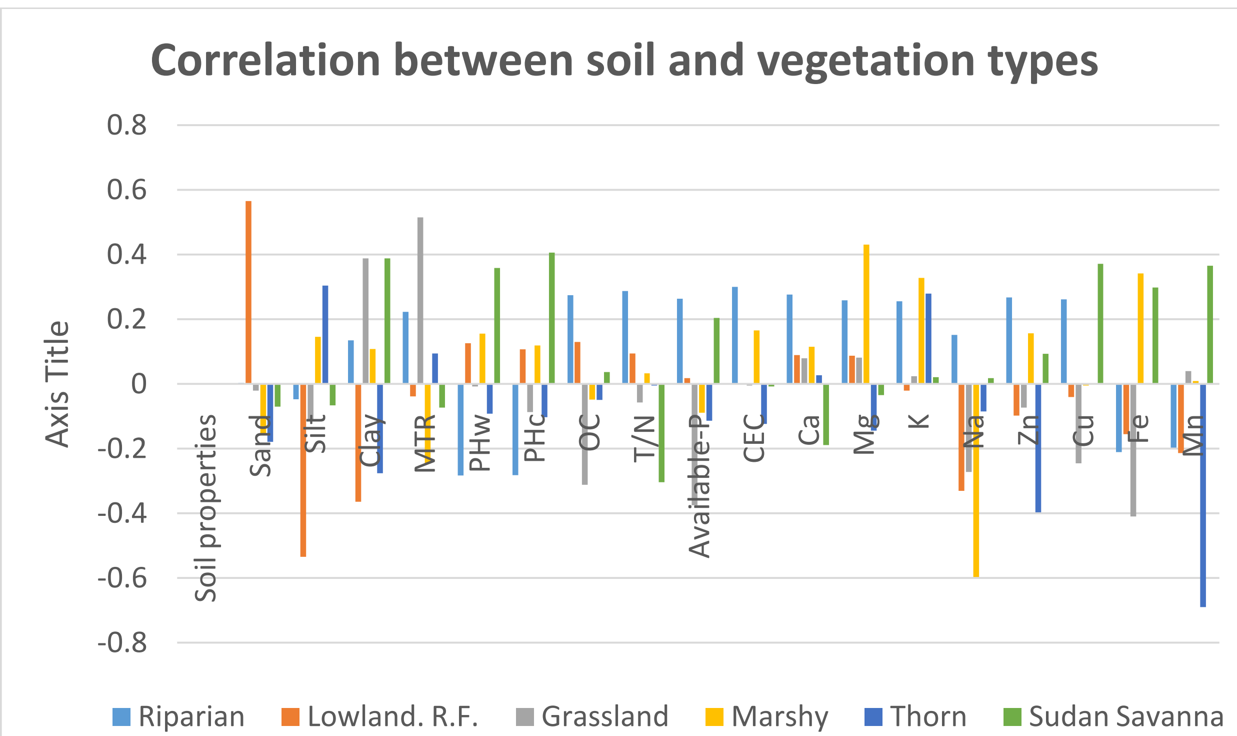
	Vegetation types					
Soil properties	Riparian	Lowland.R.F.	Grassland	Marshy	Thorn	SudanSavanna
Sand	0.003	0.565	-0.021	-0.155	-0.179	-0.070
Silt	-0.048	-0.535	-0.114	0.146	0.304	-0.066
Clay	0.135	-0.364	0.388	0.108	-0.276	0.388
MTR	0.223	-0.039	0.515	-0.247	0.094	-0.073
PHw	-0.283	0.126	-0.008	0.155	-0.092	0.358
PHc	-0.282	0.107	-0.087	0.119	-0.103	0.406
OC	0.274	0.130	-0.312	-0.049	-0.050	0.037
T/N	0.287	0.094	-0.057	0.033	-0.005	-0.304
Available-P	0.263	0.018	-0.375	-0.089	-0.114	0.204
CEC	0.300	-0.002	-0.005	0.165	-0.124	-0.008

Ca	0.276	0.089	0.079	0.115	0.027	-0.189
Mg	0.258	0.087	0.081	0.431	-0.145	-0.035
K	0.255	-0.021	0.024	0.328	0.279	0.021
Na	0.151	-0.331	-0.272	-0.597	-0.085	0.018
Zn	0.267	-0.098	-0.073	0.156	-0.397	0.093
Cu	0.261	-0.041	-0.246	-0.005	0.001	0.371
Fe	-0.211	-0.155	-0.410	0.342	0.002	0.298
Mn	-0.197	-0.214	0.040	0.009	-0.690	0.365

Source: Abba, 2014

Key to Vegetation Types
Site 1 = Riparian
Site 11=Lowland rainforest
Site 111=Grassland
Site 1V=Marshy
Site V=Thorn
Site V1=Sudan

Key to Soil properties
TSD= Total Sand
TST= Total Silt
TCT= Total Clay
MTR%= Moisture
pHw= pH water
pHc= pH carbon
ORG.C=Organic Carbon
T/N= Total Nitrogen
AV-P= Available Phosphorus
CEC= Cation Exchangeable Capacity
Ca = Calcium
Mg = Magnesium
K = Potassium
Na = Sodium
Zn = Zinc
Cu = Copper
Fe = Iron
Mn=Manganese



IV. DISCUSSION

The results of the plant distribution showed negative correlation exhibited by some of the soil properties in various sites (Table 1), may signify that, as the accumulation of such parameters increases in the Site there could be a reduction in the abundance and type of plant species in such Sites. It may also imply insufficiency of such parameters in the vegetation type for the presence and even distribution of the species. Similar conclusions were drawn by Medinski (2007), John *et al.*, (2007), Udoh *et al.*, (2007), Cannone *et al.* (2008), Iwara *et al.*, (2011) and Zare *et al.* (2011). These researchers identified negative influences of soil physical and chemical characteristics as main factors of consideration in explaining species variation and distribution of life forms in Sites. The current results also confirms the work of Iwara *et al.* (2011). The results of positive correlations were consistent with those of Veeranjaneyulu and Dhanaraju (1990), Engler and Guisan (2009) and Graham *et al.* (2005) who reported significant and positive correlations in the distribution of floral species. These workers reported that plant species were attracted to locations where the site conditions were favourable to them. This according to them further suggests that differences in the distribution and abundance of plant species in any vegetation type were an indication of the variation in soil properties and several other site conditions. They reported that plant species were selective of nutrients as well as depended entirely on the spatial heterogeneity of soil in nutrient distribution and availability.The results of this study alsorevealed that out of the 10 dominant vegetation variables (tree species) entered only fifteen showed some form of positive and negative relationship with the predictor variables. Also, out of the 15 predictor variables (soil properties) simultaneously entered, only four(4) showed significant effects on the distribution of species, the joint contribution of the soil properties indicated that SAND+CLAY+ MOISTURE CONTENTS+pHw and pHccontributed to the distribution of flora species in the area. While SILT, NA, ZN, CU Mn, Fe created nitches with specific conditions which in turn affected plant distribution patterns of plants in Kanawa Forest Reserve.The soil types of Kanawa Forest Reserve (KFR) were variable comprising of loamy sand, sandy loamy sand. The mean textural class shows higher sand and lower silt and clay fractions. Silt showed negative significance in (Site II). Silt are essential macro nutrients that influence flora distribution. This result is expected as silt because of its smaller particle size, is known to have a slower water intake, but a higher nutrient and water holding capacity. Silt, according to Ukpong (1994), is a physical site quality associated with nutrient availability, mostly CEC and organic carbon; and it facilitates forest regeneration. It might have been responsible for the distribution of (*Vitex doniana, Prosopis africana, Combretum ghasalense*).The ability of soil to retain nutrients is related to its organic matter, drainage and cation exchangeable capacity (CEC). All of this are influenced by the soil texture (Hugget, 2004). He further, pointed out that, the CEC of sandy soils result in few nutrients being held by the soils, and the good drainage of sandy soil allows leaching of nutrients.The CEC was generally low ranging from 4.69-2.02 cmol (+) kg^{-1} with a mean of 3.39. The low range is probably indicating that the soils have low ability to store and retain nutrients cations against leaching indicating the presence and dominance of 1:1 kaolinitic and/or Fe and Al oxide clays. The distribution within the sites were irregular in pattern. This might explain the distribution of vegetation types in the area. In Site 1 and IV, the values were significantly the same supported plants such as (*Elaeis guineensis*, *Ficus congoensis*, *Khaya senegalensis*, *Mangifera indica*, *Raphia sudanica*,*Ficus polita*). Site II and III supported plants such as (*Albizzia lebbeck*,*Elaeis guineensis*, *Mangifera indica*,*Raphia sudanica*).Site V and VI supported plants such as (*Albizzia lebbeck, Anogeissus leiocarpus, Azadirachta indica, Bombax costata, Combretum ghasalense, Combretum hypopilinum, Eucalyptus camaldulensis, Haematostophis barteri, Parkia biglobosa, Prosopis africana, Vitex doniana*). There were significant clay in both grassland (Site III) and Sudan savanna vegetation types(Site V) therefore only high sand, silt and clay –loving species may be encountered in such sites (such as *Azadirachta indica, Combretum ghasalense, Tricalysia chevaleiri, Prosopis africana, Anogeissus leiocarpus, Balanite aegyptiaca, Bombax costatum*). The decomposition of organic matter is a source of nutrients whereas clay soil has a high CEC and so can retain nutrients. Huggett (2004) concluded that the best soil for agriculture is the clay loam soil that possess a high CEC ability but also will allow some drainage to prevent water logging. The soil types of the study area generally had moderate moisture contents. The highest value could be due to higher percentage of clay in the particular Site (II), hence higher water retention capacity Supporting plants such as (*Senna siamea, Elaeis guineensis, Khaya senegalensis, Ficus polita* , *Mangifera indica, Raphia sudanica, Ficus congoensis, Psidium guajava*). The lowest percentage of moisture content (Site VI) could be due to higher percentage of sand, hence lower water retention capacity and are dominated by Plants such as *Azadirachta indica, Combretum ghasalense, Tricalysia chevaleiri, Prosopis africana, Anogeissus leiocarpus, Balanite aegyptiaca, Bombax costatum occurred in* neutral to alkaline soils which grow in shallow, stony, sandy loamy soils with very low moisture percentage The vegetation types dominated by *Raphia sudanica, Khaya senegalensis, Ficus congoensis, Ficus polita*and *Elaeis guineensis* ndicated that these species could be well adapted to loamy sandy soil and were better characterized by relatively high soil moisture hydromorphic conditions.

Soil pH was strongly acidic in Sites 1 and IV with estimated value of 5.88 and 5.53 (Supporting plants such as *Raphia sudanica, Ficus congoensis, Ficus polita, Elaeis sudanica*) to alkaline in site VI with a value of 7.10 (Supporting plants such as *Azadirachta indica, Combretum ghasalense, Tricalysia chevaleiri, Prosopis africana, Anogeissus leiocarpus, Balanite aegyptiaca, Bombax costatum*).Alkaline Soil pH was due to increased concentrations of exchangeable bases as a result of translocation and soil depositions and their exposure to the surface by evaporation. Similarly, soil pH indicated positive correlation with Fe, and Mn and negative correlation with and Zn. This implied that soil pH influenced the availability of soil micronutrients in the study area.

The type of soil pH determines the type of plants grown in a particular area (Abaje, 2007). Soil reaction has a great influence on the availability of plant nutrients which is generally highest between pH 6 and 7.5. This condition in soil is favourable for nutrient uptake by plants and tree growth (Tisdale and Nelson, 1975). Aduayi and Ekong (1981) also stated that the factors partly responsible for the high pH values in the Savanna include the presence of and return of exchangeable bases (Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}) to the surface soil by the plant vegetation in an area. Exchangeable bases in the study area was generally low except for potassium in site IV which was moderate.Soil pH therefore greatly influences how soluble different available phosphorus compounds are in the soil. In the study area phosphorus was highest in site 1(22.40 $mgkg^{-1}$).The extractable micronutrients concentrations were low in zinc, medium in copper and iron and high in manganese. The pattern indicated by soil pH coincided with changes in the availability of the micronutrients implying that it has direct influence. Other studies have indicated that soil pH influences micronutrients availability by favouring conditions which accelerates oxidation, precipitation, and immobilization (Martens and Westermann,1991; White and Zasoski,1999). Positive correlations were found for Mn, and Fe with soil pH , therefore providing favourable conditions for their availability. Solubility of Mn, and Fe is known to increase with lowering soil pH (Foth, 1990).

Soil pH indicated negative correlation with Zn. This implied that strong acidity in the some sites and alkaline conditions in other sites in the study area reduced the availability of the Zn. Saline soils tend to enhance formation of insoluble oxides and hydroxides of Zn, which limits their availability (Brady and Weil, 2010) .It was noted, however, that soils from all the sites contained medium Cu contents ranging from 0.95-0.25 $Mgkg\text{-}^{1}$ with a mean of 0.42 .The medium content could be due to the acidic nature of the soil in the study area,Any concentration of Cu above 60 mgkg−1 is considered to be toxic (Senkondo *et al.*, ,2015). High concentration of Mn and Fe is known to suppress extractable heavy metals like Zn and Cu (Kitundu and Mrema,2006). This is in line with the findings of this study which reported low concentrations of Zinc ranging from 1.28 -0.18 $Mgkg\text{-}^{1}$ with a mean of 0.675. This could be due to involvement of natural and anthropogenic factors that limit adequate plant nutrient availability and create nutrient imbalances. Therefore, other factors, including soil pH, remain responsible.Mclaren *et al.*, (1997) also concluded that CEC and organic matter influenced the adsorption and desorption of Zn. Although the amount of zinc needed for crop growth is far less than that of macronutrients. It therefore, follows that for successful and sustainable plant growth in all the sites studied, Zn application will prove beneficial. Furthermore, a positive and significant correlation between Fe and Mn existed, which underlines the fact that Mn influences availability of Fe. This implied that, under the same soil pH level, increase in concentration of Mn was likely to increase Fe availability (Reddy *et al.*, 1987). This is consistent with the findings of this study where Iron (Fe) in the soils of the study sites was classified as medium ranging from 3.19-9.11 mgkg-1 with a mean of 5.18. Manganese status was rated “High” ranging from 17.51-6.73 Mgkg-1 with a mean of 12.80 while Mn content was high. Sodium (Na^{+}) in the soils of the study area was classified as low and it ranges from (0.11-0.20) with a mean of 0.17 cmol (+) $kg\text{-}^{1}$). The low amount could be due to continuous leaching caused by increased precipitation.Similarly, the abundance of the micronutrients seems to adequately support the growth of different vegetation types. The accession proved the findings of (Lombin, 1985; Cox, 1994; Raji *et al.*,2000). It was concluded that the Sand, Moisture Content, Electric Conductivity, pH ,Silt, Na, Zn, Cu, Mn, Fe create nitches with specific conditions which in turn affect plant distribution patterns of plants in Kanawa Forest Reserve.This result therefore indicated that the spatial distribution was related to the spatial heterogeneity in soil resource distribution in such a way that the pattern of distribution suggested speciation to different levels of essential resources within their range of tolerance.

V. CONCLUSION

It was concluded that out of the 10 dominant vegetation variables (tree species) entered only fifteen showed some form of positive and negative relationship with the predictor variables. Also, out of the 15 predictor variables (soil properties) simultaneously entered, only four(4) showed significant effects on the distribution of species, the joint contribution of the soil properties indicated that SAND+CLAY+ MOISTURE CONTENTS +pHw and pHccontributed to the distribution of flora species in the area. While SILT, NA, ZN, CU Mn, FE created nitches with specific conditions which in turn affected plant distribution patterns of plants in Kanawa Forest Reserve.

VI. RECOMMENDATION

It is recommended that the information generated can serve for planning soil management interventions to sustain soil macro and micronutrients sufficient levels and addressing deficiencies in the study site

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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