Journal of Research in Forestry, Wildlife & Environment Vol. 13(4) September, 2021
E-mail: *jrfwe2019@gmail.com*; *jfewr@yahoo.com*
http://www.ajol.info/index.php/jrfwe
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ISBN: 2141 – 1778
Akindele et al., 2021

TREE SPECIES DIVERSITY, ABUNDANCE, AND SOIL PHYSICO-CHEMICAL STATUS OF PSP 29, AKURE FOREST RESERVE, ONDO STATE, NIGERIA

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ABSTRACT
Protected area is one of the in-situ methods of conservation that are needed to be protected from human anthropogenic activities. The Vulnerability and failure of protected areas to achieve their primary function due to evidence of increasing challenges in and outside these areas have been a major challenge to Sustainable Forest Management in Nigeria. This study was conducted to assess tree species diversity and abundance in the Permanent Sampling Plot 29 (PSP29) of the Akure Forest Reserve and relate them with the soil physicochemical status. Tree diversity and soil assessment provide direction for the management of forest areas and protect forests from degradation and deforestation. Sample plots were laid using the systematic line transect method. Four sampling plots of 50 m × 50 m were laid using systematic line transect. The sample plots laid were also used for soil collection. Soils were collected at three depths (0-15 cm, 15-30 cm and 30-45 cm) along the diagonal in each of the sample plot with the aid of soil auger. A total of 12 soil samples were collected from the study area. A total 210 stems distributed among 54 species and 25 families were enumerated in this study. The study area had a Shannon weinner index of 3.44. *Celtis zenkeri* was the dominant trees species. The soil was found to be moderately acidic. Correlation analysis indicated that Potassium and Cation Exchangeable Capacity (CEC) significantly (P>0.05) influenced tree species diversity in the forest. When subjected to Principal Component Analysis, Na, P, Clay content and pH were found to be the fundamental soil properties that represented what determined the quality of trees in the study sites. The study therefore recommended that the remaining protected areas should be safeguarded from anthropogenic activities and more protected areas be established.

Keywords: Protected areas, conservation, anthropogenic activities

Correct Citation of this Publication
Akindele T. F., Adekunle, V. A. J and Lawal, A. (2021). Tree Species Diversity, Abundance, And Soil Physico-Chemical Status of PSP 29, Akure Forest Reserve, Ondo State, Nigeria. *Journal of Research in Forestry, Wildlife & Environment* Vol. 13(4): 120 - 129

INTRODUCTION
Nigeria is one of the countries endowed with the richest biodiversity in Africa. However, the threats on tropical forest have led to a reduction in species richness, thereby resulting in biodiversity loss. Protected area is one of the in-situ methods of conservation that are needed to be protected from human anthropogenic activities. The process of securing biodiversity in protected areas begins with assessing the status of the biodiversity of such areas. USAID/Nigeria (2008) has reported that there is the problem of lack of adequate data on the status of biodiversity in the country.

Studies on the relationship between species diversity and soil factors are the basis of community ecology and biodiversity conservation and management (Peng *et al*., 2015). Considering the importance of plant diversity in maintaining a balanced ecosystem, it is important to recognize the relationships between tree species diversity and soil properties status of protected areas. Protected areas are the major storehouse of biodiversity. The impact of the management strategies in functioning of protected areas cannot be over emphasized.

Past studies have concentrated more on assessing tree species diversity, sidelining its relationship with soil properties (Adeduntan, 2009; Adekunle, *et al*., 2013; Omomoh, *et al*., 2019). Understanding the responses of species diversity to soil nutrient factors would enhance the knowledge on species coexistence and also promote effective conservation strategies. In this situation, there is still insufficient basic information on the soil physical and chemical systems associated with tree species diversity and abundance in the Permanent Sampling Plot 29 of the Akure Forest Reserve. Therefore, this study was conducted to determine the diversity and abundance of tree species in PSP 29 and to relate species diversity and abundance to soil physiochemical status.

MATERIALS AND METHODS

The Study Area

The research was carried out in the Permanent Sampling Plot (PSP 29) of the Akure Forest Reserve located on (longitude 5^0 00’E - 5^o 30'E and latitude 6^o 00’N - 6^o 30’N). Akure Forest Reserve is geographically located in a humid rainforest zone of Akure South Local government area of Ondo State, Southwestern Nigeria, having one of the six SNRs in the country. The mean annual temperature is about 26 ºC and the rainy season lasts for 9 months annually, between March and November, while the dry seasons usually last for 3 months, between December and February.

Data Collection

Sampling Techniques and Selection of Sample Plots

Using the systematic line transect method, two parallel transects with 200m distance apart were centrally located after a 50 meter off set to the existing roads. Equal size plots (50 x 50m) were laid alternatively on the parallel transect.

Tree species diversity and abundance assessment

On each sample plot, all trees were tagged, measured, identified and classified into families. Frequency of occurrence were also obtained to ascertain tree species diversity and abundance. The number and scientific names of all the tree species encountered in each field plot were recorded. Local names were used for tree species whose scientific names were not known immediately on the field. Parts (such as leaves, backs and fruits) of trees that could not be identified were collected and taken to the herbarium for identification. All trees were assigned to families and the number of species in each family were obtained.

Tree growth variable measurement

The tree growth variables that were measured on all trees within each plot were the diameter at the breast height (DBH) ≥ 10 cm, diameter at the top (Dt), diameter at the middle (Dm) diameter at the base (Db) using girth tape and the total height was measured using Spiegel relaskop.

Soil Properties

Soil sample at three depths, namely, 0-15cm, 15-30cm and 30-45cm were collected along the diagonal using the soil auger. The soil samples collected within each plot at a particular depth were bulked and mixed together. The bulked samples for each soil depth were air dried and sieved with a 2mm sieve and transferred to the laboratory for physiochemical analyses.

Method of Data Analysis

Basal Area Estimation

Basal area per hectare was obtained by multiplying the mean plot basal area by the number of plots per hectare

$$BA = \frac{\pi D^2}{4} \quad \text{……………….. [1]}$$

Where BA = Basal area (m^2), D = Diameter at breast height (cm) and π = Pie (3.142).

Volume Estimation

The volume of individual trees will be estimated using the Newton formula (Husch *et. al.*, 2003)

$$V = \frac{\pi h}{24}\left(D_b^{\ 2} + 4D_m^{\ 2} + D_t^{\ 2}\right) \quad \text{……….. [2]}$$

Where: V = Volume of tree (m^3), D_b = Diameter at the base (cm), D_m = Diameter at the middle (m), D_t = Diameter at the top (m), H = Total height (m)

Since there are 4 sample plots (50 m x 50 m) in one hectare, the volume of trees per hectare was obtained multiplying the volume per plot by 4.

Biodiversity Indices and Tree Species Classification

Species Relative Density

Species relative density was computed as:

$$RD = \frac{n_i}{N} \times 100 \quad \text{………… [3]}$$

Where: RD (%) = species relative density; n_i = number of individuals of species; N = total number of all tree species in the entire community

Species relative dominance (RDo)

Species relative dominance was computed as:

$$RD_O = \frac{\sum Ba_i \times 100}{\sum Ba_n} \quad \text{………….. [4]}$$

Where: Ba_i = basal area of individual tree belonging to species i and Ba_n = stand basal area

The Shannon's maximum diversity index

Species diversity was calculated using the Shannon–Wiener diversity index equation (Kent & Coker, 1992).

$$H' = -\sum_{i=1}^{S} p_i \ln(p_i) \quad \text{……….. [5]}$$

Where H' = Shannon diversity index, S = the total number of species in the community, pi = proportion S (species in the family) made up of the ith species and ln = natural logarithm.

The Species Evenness (E_H)

Shannon's equitability equation was adopted to obtain the species evenness in each plot (Kent and Coker, 1992)

$$E_H = \frac{H'}{H_{Max}} = \frac{\sum_{i=1}^{S} P_i \ln(P_i)}{\ln(S)} \quad \text{……. [6]}$$

Margalef's index

Margalef's index was calculated using the equation:

$$D = \frac{S-1}{lnN} \quad \text{………. [7]}$$

Where S = Number of species, and N = Number of individuals

Simpson's index

Simpson's index was calculated using the equation:

$$D = 1 - \sum\left(\frac{n_i}{N}\right) \quad \text{…….[8]}$$

where n_i = number of individual of species *i*, and *N* = total number of all tree species in the entire community.

Family importance value (FIV)

FIV is defined as the sum of its relative dominance (RDo), its relative density (RD) and its relative frequency (RF), which was calculated as follows:

$$RDo = \frac{Total\ basal\ area\ for\ a\ family}{Total\ basal\ area\ for\ all\ families} \times 100 \quad \text{…….. [9]}$$

$$RD = \frac{Number\ of\ individuals\ of\ a\ family}{Total\ number\ of\ all\ families} \times 100 \quad \text{…...[10]}$$

$$RF = \frac{Frequency\ of\ a\ family}{Sum\ of\ frequencies\ of\ all\ families} \times 100 \quad \text{……[11]}$$

Thus,

$$FIV = \frac{RD + RDo + RF}{3} \quad \text{…………….. [12]}$$

Physico-chemical Properties Analysis

Soil samples collected from each depth were separately air dried and sieved through 2 mm sieve. The selected soil physicochemical properties investigated were: Sand, silt, clay, calcium, magnesium, soil pH, phosphorus, potassium, nitrogen, Soil Organic carbon, Organic matter and Cation Exchangeable Capacity (CEC).

Statistical Analysis

Mean and standard error were computed from three replicates of soil physico-chemical properties. Analysis of variance (ANOVA) and DUNCAN were employed to ascertain significant differences between the means of the physicochemical properties of the studied soils. Pearson correlation method was used to establish the relationships between soil factors and diversity indices (diversity and evenness) within the study area. A two-tailed (=2) p-values less than 0.05 ($P < 0.05$) was considered statistically significant. Data representing soil properties were further subjected to Principal Component Analysis (PCA) approach at 0.05% probability level in order to determine the relative contribution of soil physicochemical properties to the distribution pattern of species within the study site. Analyses were performed using SPSS software (version 20.0).

RESULTS

A total of 210 trees representing 54 species belonging to 25 families were identified from the study plots located within the survey area. Of these tree species, *Celtis zenkeri* Engl. which belongs to Ulmaceae family was the tree species with the highest frequency of occurrence with 31 stems. This was followed by *Ricinodendron heudelotii* (Ball.) Pierr of the family Euphorbiaceae with 22 stems. Fabaceae and Sterculiaceae were the dominant family in the area represented by six species each (Table 1). The pioneer species: *Mansonia altissima*, *Triplochiton scleroxylon*, *Entandrophragma angolense*, *Khaya grandifolia*, etc.; and exotic species: *Gmelina arborea*, were among the records found in the study area. The Shannon wiener Index values of 3.44 was obtained. In terms of IVI, *Brachystegia eurycoma*, *Celtis zenkeri*, *Cordia millenii*, *Diospyros dendo*, *Ricinodendron heudelotii*, *Sterculia rhinopetala*, and *Triplochiton scleroxylon*, were the dominant tree species. The summary of tree growth variables and biodiversity indices is presented in table 2. 210 stems per hectare was obtained with a volume per hectare of 144.21 m^3 was recorded. The basal area per hectare obtained in this study was 10.96 m^2. The Importance value index (IVI) of tree species in the study site is presented in Table 3. The highest IVI was recorded for *Ricinodendron heudelotii* (10.49) while the lowest IVI was recorded for *Myrianthus arboreus* with an IVI of 0.26.

Table 1. Tree species distribution and Shannon wiener index of the study area

S/N	Tree Species	Family	Freq.ha^{-1}	H^1
1	*Alchornea triplinervia* (Spreng.) Muell. Arg	Euphorbiaceae	1	-0.03
2	*Alstonia boonei* De Wild	Apocynaceae	3	-0.06
3	*Anthonotha macrophylla* P. Beauv	Fabaceae	5	-0.09
4	*Baphia nitida* Lodd	Fabaceae	1	-0.03
5	*Barteria fistulosa* Mast.	Passifloraceae	1	-0.03
6	*Blighia sapida* K Konig K Konig	Sapindaceae	1	-0.03
7	*Brachystegia eurycoma* Harms	Fabaceae	5	-0.09
8	*Buchhoizia coriacea* Engl.	Capparaceae	2	-0.04
9	*Celtis mildbraedii* Engl.	Ulmaceae	4	-0.08
10	*Celtis philipensis* Blanco	Ulmaceae	8	-0.12
11	*Celtis zenkeri* Engl.	Ulmaceae	31	-0.28
12	*Cleistopholis patens* (Benth)Engl.& Diels	Annonaceae	2	-0.04
13	*Cola gigantea* A.Chev.	Sterculiaceae	7	-0.11
14	*Cola heterophylla* (P. Beauv.)Schott & Endl.	Sterculiaceae	1	-0.03
15	*Cola nigerica* Brenan & Keay	Sterculiaceae	2	-0.04
16	*Cordia millenii* Bak.	Cordiaceae	9	-0.13
17	*Cordia platythyrsa* Bak.	Cordiaceae	3	-0.06
18	*Desplatsia subericarpa* Bocq.	Malvaceae	1	-0.03
19	*Dialium guianense* (Aubl.) Sandwith	Fabaceae	1	-0.03
20	*Diospyros dendo* Welw.ex Hiern	Ebenaceae	7	-0.11
21	*Diospyros mespiliformis* Hochst	Ebenaceae	1	-0.03
22	*Drypetes palawanensis* var. parvifolia Merr.	Putranjivaceae	1	-0.03
23	*Entandrophragma angolense* (Welw.) C DC	Meliaceae	1	-0.03
24	*Ficus vogeliana* (Miq.) Miq.	Moraceae	1	-0.03
25	*Ficus sur* Forssk	Moraceae	6	-0.1
26	*Funtumia elastica* Stapf(Preuss) Stapf	Apocynaceae	9	-0.13
27	*Gmelina arborea* Roxb.	Lamiaceae	3	-0.06
28	*Khaya grandifoliola* C. DC.	Meliaceae	1	-0.03
29	*Malacantha alnifolia* (Baker) Pierre	Sapotaceae	4	-0.08
30	*Mansonia altissima* A. Chev	Malvaceae	7	-0.11
31	Microdesmis puberula Hook.f. ex Planch	Pandaceae	1	-0.03
32	*Myrianthus arboreus* P. Beauv	Urticaceae	6	-0.1
33	*Nauclea diderrichii* De wild. & Th. Dur.	Rubiaceae	1	-0.03
34	*Nesogordonia papaverifera* A.Chev.	Malvaceae	2	-0.04
35	*Picralima nitida* (Stapf) T.Durand & H.Durand	Apocynaceae	2	-0.04
36	*Psychotria faxlucens* Lorence & Dwyer	Rubiaceae	1	-0.03
37	*Pterocarpus osun* Craib	Fabaceae	1	-0.03
38	*Pterygota macrocarpa* K Schum	Malvaceae	1	-0.03
39	*Pycnanthus angolensis* (Welw.) Warb.	Myristicaceae	2	-0.04
40	*Ricinodendron heudelotii* (Ball.) Pierr	Euphorbiaceae	22	-0.24
41	*Rinorea apiculate* Hekking	Violaceae	1	-0.03
42	*Rinorea grandifolia* Melch.	Violaceae	3	-0.06
43	*Spathodea stipulate* Wall	Bignoniaceae	3	-0.06
44	*Sterculia oblongata* K. Schum	Sterculiaceae	3	-0.06
45	*Sterculia rhinopetala* K. Schum	Sterculiaceae	12	-0.16
46	*Sterculia tragacantha* K. Schum	Sterculiaceae	2	-0.04
47	*Strombosia pustulata* Oliv.	Strombosiaceae	1	-0.03
48	*Tetrapleura tetraptera* Schumach. And Thonn)	Fabaceae	1	-0.03
49	*Trema orientale* (L.) Blume	Cannabaceae	1	-0.03
50	*Trichilia monadelpha* A. Juss	Meliaceae	2	-0.04
51	*Trilepisium madagascariense* Dc. Fl. Cam	Moraceae	5	-0.09
52	*Triplochiton scleroxylon* K. Schum.	Malvaceae	6	-0.1
53	*Voacanga africana* Stapf.	Apocynaceae	1	-0.03
54	*Zanthoxylum zanthoxyloides* (Lam.) Zepern. & Timler	Rubiaceae	1	-0.03
		Total	54	

Table 2. Summary of tree growth variables and biodiversity indices of the study area

Growth Variables & Biodiversity Indices	
No of trees ha^{-1}	210
No of species	54
No of families	25
Mean DBH (cm)	22.15
Mean Height (m)	17.38
Basal Area per hectare (m^2)	10.96
Volume per hectare (m^3)	144.21
Shannon Wiener Index (H^1)	3.44
Pieolus Species Evenness (E)	0.86
Simpson's concentration (λ)	0.78
Margalef's index of Spp. Richness (M)	13.29

Table 3. Tree species dominance in terms of IVI at the study site.

S/N	Tree Species	RD%	RDo%	IVI
1	*Brachystegia eurycoma* Harms	0.95	0.36	4.38
2	*Celtis zenkeri* Engl.	0.95	0.65	15.49
3	*Cordia millenii* Bak.	1.43	0.49	7.66
4	*Diospyros dendo* Welw.ex Hiern	0.48	0.5	3.88
5	*Ricinodendron heudelotii* (Ball.) Pierr	1.43	0.51	10.49
6	*Sterculia rhinopetala* K. Schum	0.48	0.19	7.68
7	*Triplochiton scleroxylon* K. Schum.	0.48	0.09	4.09

Note: The values of IVI are out of 210 tree species

Soil-Tree Species Diversity Relationship in the Study Sites

The result of the Pearson's correlation analysis between tree species diversity and soil properties for the study site is presented in Table 5. Pearson's correlation analysis indicated that Shannon-wiener diversity was positively related to K content and CEC. This relationship was found to be significant (P = 0.05 and r = 0.58, P = 0.05 and r = 0.59) (Table 4). Therefore, the number of tree species declines as the concentration level of K and CEC increases. On the contrary, K and CEC content were not significantly correlated with either species evenness and Simpson's diversity (r =0.54, -0.40; r =0.52, -0.50). It is worthy of note that this relationship was close to be significant. However, percentage sand, silt and clay, available P, Na, Ca, Mg, N contents, pH and total organic matter and organic carbon were not correlated with any of the biodiversity variables.

Table 4. Pearson correlation coefficients (r) with significance levels (*p < 0.05, **p < 0.01) between tree species diversity and soil variables.

Statistical Parameters	P-Values	Significant Codes
Sand*DIV	-0.49	NS
Clay*DIV	0.01	NS
Silt*DIV	0.43	NS
Soil pH*DIV	0.05	NS
Phosphorus*DIV	0.19	NS
Potassium*DIV	**0.58***	Sig.
Sodium*DIV	0.57	NS
Nitrogen*DIV	0.09	NS
Organic Carbon*DIV	0.37	NS
Organic Matter*DIV	0.37	NS
Calcium*DIV	0.48	NS
Magnesium*DIV	0.28	NS
Cation Exchange Capacity*DIV	**0.59***	Sig.

**Correlation is significant at the 0.05 level*

Relationship among soil properties in the selected protected areas using PCA

PCA was performed for thirteen (13) soil properties to determine the main soil variables that facilitate the regenerative capacity of the study site. The ordinary component matrix of soil properties is shown in Table 5. Six soil properties loaded on component I, the variables were exchangeable potassium (0.90), sodium (0.88), organic carbon (0.94), organic matter (0.94), magnesium (0.75), cation exchange capacity (0.92), and they accounted for 6.01% of eigenvalue loading and 46.65% of the variance in the soil data. Components 2 and 3 had single soil property; this included clay (-0.87) and soil pH (0.76), and they accounted for 17.1% and 12.31% of the variation in soil data, respectively. However, the remaining components (Component 4) had no soil property loaded on them based on the threshold that only component loadings ≥ ±0.70 are significant, but they accounted for 8.4% of the combined variation in the data set. The lack of spread of component loadings across the five extracted components affected interpretation as well as understanding of the dimension in the soil data. For better distribution of component loadings and interpretation of soil structure, the components were rotated (Table 6).

Table 6 shows loadings of rotated components on soil properties of the study sites. It shows that five components with eigenvalue loadings of ≥1 and above were extracted, and they accounted for 84.46% of the total variance in the original data set. On component 1, four soil properties, potassium (0.97), sodium (0.98), exchangeable calcium (0.8) and CEC (0.77), loaded heavily and as such accounted for 4.48 eigenvalue loading and 34.42% total variance in soil data set. On component 2, only phosphorus loaded heavily with coefficient value of 0.87. This accounted for 19.25% of the variance in soil data. Component 3 and 4 had two soil properties that loaded heavily on it; this component accounted for 70.79% and 84.46% total explanation in the soil data. The two soil properties identified on this component were clay (-0.94) and silt (0.72), sand (-0.8) and pH (0.83), respectively.

Table 5: Ordinary Component Matrix of Soil Parameter

Soil Parameters	Principal component for PSP 29			
	1	2	3	4
Sand	-0.285	0.599	-0.636	0.081
Clay	-0.293	-0.868	0.135	0.346
Silt	0.574	0.396	0.429	-0.446
pH	0.251	-0.071	0.76	-0.261
Phosphorus (Cmol/kg)	0.522	-0.628	-0.272	-0.273
Potassium (Cmol/kg)	0.897	-0.031	0.019	0.415
Na (Cmol/kg)	0.881	0.07	0.094	0.444
Nitrogen (Nm3)	-0.112	0.568	0.238	0.199
O.C (%)	0.937	0.065	-0.273	-0.143
O.M (%)	0.937	0.066	-0.274	-0.144
Ca (Cmol/kg)	0.693	0.368	0.244	0.335
Mg (Cmol/kg)	0.747	-0.089	-0.256	-0.241
CEC (%)	0.919	-0.268	0.027	0.069
Eigen values	6.065	2.223	1.6	1.093
% Variance	46.651	17.1	12.307	8.404
Cumulative explanation	46.651	63.751	76.059	84.463

Table 6. Rotated Component Matrix of Soil Parameters

Soil parmeters	Principal component for PSP 29			
	1	2	3	4
Sand	-0.149	-0.265	0.322	-0.809
Clay	-0.129	0.219	-0.936	0.19
Silt	0.275	0.003	0.72	0.526
pH	0.076	-0.059	0.143	0.827
Phosphorus (Cmol/kg)	0.208	0.869	-0.083	0.106
Potassium (Cmol/kg)	0.968	0.185	0.023	0.083
Na (Cmol/kg)	0.983	0.066	0.065	0.112
Nitrogen (Nm3)	0.081	-0.611	0.227	-0.017
O.C (%)	0.691	0.53	0.468	-0.033
O.M (%)	0.69	0.529	0.469	-0.034
Ca (Cmol/kg)	0.8	-0.218	0.271	0.161
Mg (Cmol/kg)	0.465	0.59	0.354	0.014
CEC (%)	0.77	0.507	0.074	0.258
Eigen values	4.475	2.502	2.225	1.778
% Variance	34.423	19.246	17.116	13.678
Cumulative explanation	34.423	53.67	70.785	84.463

DISCUSSION

Tree species abundance and diversity in the tropical rainforest are undergoing noteworthy decreasing changes due to climate change and over exploitation of natural resources. Due to its importance to forest biodiversity, many conservation efforts have emerged to stop and reverse this degradation, among which the establishment of protected areas is considered one of the most effective (Jekins and Joppa, 2009). The result obtained in the study site was similar to the Shannon wiener value (3.74) obtained by Adekunle *et al*., (2013) in Akure Forest Reserve, Nigeria and Aigbe and Omokhua (2015) who obtained 3.80 for the Rainforest of Oban Forest Reserve, Nigeria. The high number of tree species and Shannon index value obtained in this study are indication that biodiversity can be conserved through in situ method if proper managerial actions are put in place.

The tree with the highest importance value in was *Celtis zenkeri* (15.49%). According to Curtis and McIntosh (1951), high importance value index (IVI) of a species indicated its dominance and ecological success, its good power of regeneration and greater ecological amplitude. This implies that these species require adequate monitoring. However, the tree species with low importance value in the study area need high conservation effort as they have a lesser potential for regeneration. These species include: *Alchornea triplinervia*, *Rinorea apiculate*, *Psychotria faxlucens Microdesmis puberula*, *Diospyros mespiliformis, Cola heterophylla.* The presence of species such *Gmelina arborea* is suggestive of the fact that the vegetation has been disturbed in the recent past, but currently displays signs of recovery. These observations confirm that species diversity assessments are important to understand the status of an ecosystem and how disturbance factors are affecting it.

Soil pH influences the rate of organic matter decomposition, microbial activities, forms and extent of nutrient availability and nutrient uptake by plant. Soil in the study area was generally mildly acidic. This result is comparable with Onyekwelu, *et al*., (2008) in a similar forest ecosystem. Highest concentration of most of the chemical properties was discovered at the topsoil (depth 0–15 cm). Calcium content, potassium content and sodium content and available phosphorus were observed to decrease with increase in soil depth.

Plant diversity is generally shown to be related with soil properties. The direct correlation observed supports our hypothesis that there should be some relationships between tree species diversity and soil nutrient factors. Shannon-Wiener tree species diversity was found to be significantly correlated with potassium content and CEC (positive relationship). On the contrary, Nadeau and Sullivan (2015), found a negative relationship in tree species diversity with CEC. Moreover, Long *et al* (2018) found a positive significant correlation between tree species diversity and K contents in a tropical secondary forest. Therefore, for forest recovery, there is a need for maintenance of higher available K and CEC. Shannon-Wiener tree species diversity was not related to any of the other soil variables (Sand, Silt, Clay, pH, K, Ca, Na, Mg, P, CEC, total N, organic C and organic matter). This means that these other soil variables did not influence the diversity and distribution of species in the study area.

5.4.2 PCA of soil parameters

PCA was performed to determine the main soil factors sustaining the regeneration, enrichment, and productivity of the forest vegetation. In component 1, sodium (Na) and potassium (K) have very high loadings and both of which have positive signs. Thus, Na and K vary together. This means increase in Na content is associated with increase in K content in the soil of PSP 29. The second component is primarily represented by Phosphorus. However, in component 3, clay and silt have very high loading, but clay with the highest loading has negative sign. This implies that increase in clay content is associated with decrease in silt content. Also, in component 4, an increased in sand content was associated with decreased pH.

Although PCA was performed on 13 soil parameters, the factors that seem to have more weight in the floristic composition of the study site are Na, P, Clay content and pH. These variables fundamental soil properties that represented what determined the quality of trees and helped to sustain the regrowth and unique characteristics of PSP 2. Therefore, changes in magnitude of any of the factors involved in these relations could likely impact the composition and diversity of tree species in the study sites. The findings of this study somehow corroborated the work of Aweto (1981) who identified, based on the threshold of $\geq \pm 0.70$ pH, sand proportion, total nitrogen content, clay, silt, and potassium as paramount soil components.

CONCLUSION

Determining the relationship between soil and plants allows us to better understand the ecosystem condition and can help to manage the protected forest areas. The results of the present study revealed the basic information on the tree diversity and soil properties in the study area and these can be used for the development of a proper management strategy. The analysis revealed that K and CEC content are the most influential variables responsible for tree species diversity in the study site. Na, P, Clay content and pH were fundamental soil properties that represented what determined the quality of trees and helped to sustain the regrowth and unique characteristics of PSP 2

The present study therefore provides a baseline information about the relationship between tree species diversity and soil physiochemical properties in PSP 29 of the Akure Forest Reserve. Nevertheless, assessment of mesofauna diversity and composition, could also help to better understand and correctly manage the forest ecosystem. The study therefore recommended that the remaining protected areas should be safeguarded from anthropogenic activities and more protected areas be established.

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