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Floristic Profile of Selected Ponds in Sub-Urban District of Akwa Ibom State, Nigeria

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Authors' contributions

This work was carried out in collaboration between both authors. Author EDA designed the study, coordinated the whole work and participated in the correction of the manuscript. Author REI performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors EDA and REI managed the analyses of the study. Both authors read and approved the final manuscript.

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ABSTRACT

Floristic population around and within selected ponds of a sub-urban area in Akwa Ibom State was examined. Soil physical and soil chemistry were determined to ascertain influences on floristic distribution pattern. Twenty five (25) plant species were identified belonging to seventeen (17) families. *Alchornea cordifolia* was the most abundant species with the density value of 2666.67±100.32 st/ha while *Crinum* sp. had the least density value of 33.33±10.25 st/ha. *Chromolaena odorata* and *Pteridium aquilinum* had the highest frequency of occurrence of 75%, respectively. In terms of height, *Elaeis guineensis* was the tallest species (8.00±2.08 m) while the shortest species were *Clappertonia ficifolia* (1.20±0.11 m) and *Cnestis ferruginea* (1.20±0.02 m). Correlation analysis showed significant relationship between plant distribution and soil properties. Negative relationships showed limiting nutrient levels while positive showed optimum nutrient levels. Although, results showed a clear relationship between soil properties and type of flora around the study area, yet, present floristic population noted points to the rapid incursion of human activities and influence within and outside the district landscapes.

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1. INTRODUCTION

Plants are considered as one of the key pointers of wetlands' health status based on their interaction with environmental variables and growth medium such as soil and water. The complex interactions within the ecological complexes are noted to be responsible for community composition and diversity [1-3]. More so, plant species exhibit a unique set of ecological tolerances, adaptations, and life history strategies that ultimately reflect the biological integrity of the wetland [4,5]. Wetland vegetation, in particular, has been described by various scholars who distinguished diverse number of typical plant communities [6-8]. These scholars suggested various edaphic factors such as soil, water and soil nutrients (nitrogen, organic carbon, phosphorus and calcium) to be the main environmental factors affecting wetland plant communities. In this regard, assessing the type of vegetation across wetland landscapes may assist in the appropriate assortment and implementation of appropriate conservation and management plans for sustainable use of such ecosystems [9]. Furthermore, floristic data are important for establishing the present situation for environmental impact assessment and monitoring changes in ecosystem quality in terms of changing species composition [10]. For instance, the conspicuous dominance of particular species in the landscape may provide an indication of hydrological or water quality changes that have taken place over time [1,3].

Coastal communities such as those of the study area are fragile ecosystems and are particularly vulnerable to various environmental changes, including human perturbations. The study area is fast becoming an urban hub with the rapid industrialisation and a burgeoning university community. Thus, wetlands within the area are imperiled as sand filling activities and reclamation increases their vulnerability. In view of this ongoing changes, the present study was designed to document present floristic diversity in line with soil properties of the study area.

2. MATERIALS AND METHODS

2.1 Method of Study

The study area is situated along the axis of Akwa Ibom State University (7º46' 3'' E; 4º37' 22'' N) in Mkpat Enin Local Government Area, Akwa Ibom State, Nigeria (Fig. 1). The topography of the area is undulating with sparsely distributed homesteads with cultivated lands close to residential areas. Imposingly, is the vast area of land acquired and cleared for the proposed Akwa Ibom State, coconut factory; hence the heavy presence of tractors and other vehicular transportation is a common feature around the study area.

Vegetation and soil were systematically sampled with a five (5) 5 m x 5 m quadrat spaced at regular intervals of 20 m intervals along established transect. In each quadrat, plants were identified to species level and their frequency, density, basal area, height and crown cover of species were measured. Unknown plant species were collected and identified with the aid of voucher specimens in Botany and Ecological studies Departmental Herbarium. Two (2) soil samples were collected in each quadrat using a calibrated soil auger at different rooting depths of 0 – 15 cm and 15 – 30 cm. Samples collected were analysed in the laboratory for their physicochemical properties.

2.2 Determination of Vegetation Parameters

The Density of plant species was determined using the method of Cochran [11].

2.2.1 Frequency

The frequency of each species occurrence was calculated thus:

$$\text{Frequency} = \frac{\text{Number of occupied quadrat for a species}}{\text{Total number of quadrats thrown}} \times 100$$

2.2.2 Height

The heights of woody species were measured using a Haga altimeter (43913 model). The reading was taken 15 m away from the base of the woody plant from where the crown was sighted through the eye piece of the altimeter and the upper reading taken. The base of the woody plant was similarly sited and the lower altimeter readings taken. The height of each species was calculated using the relation:

Height (m) = Algebraic sum of the reading of the top and bottom of each plant × horizontal distance from observer to each species divided by scale factor used on the altimeter.

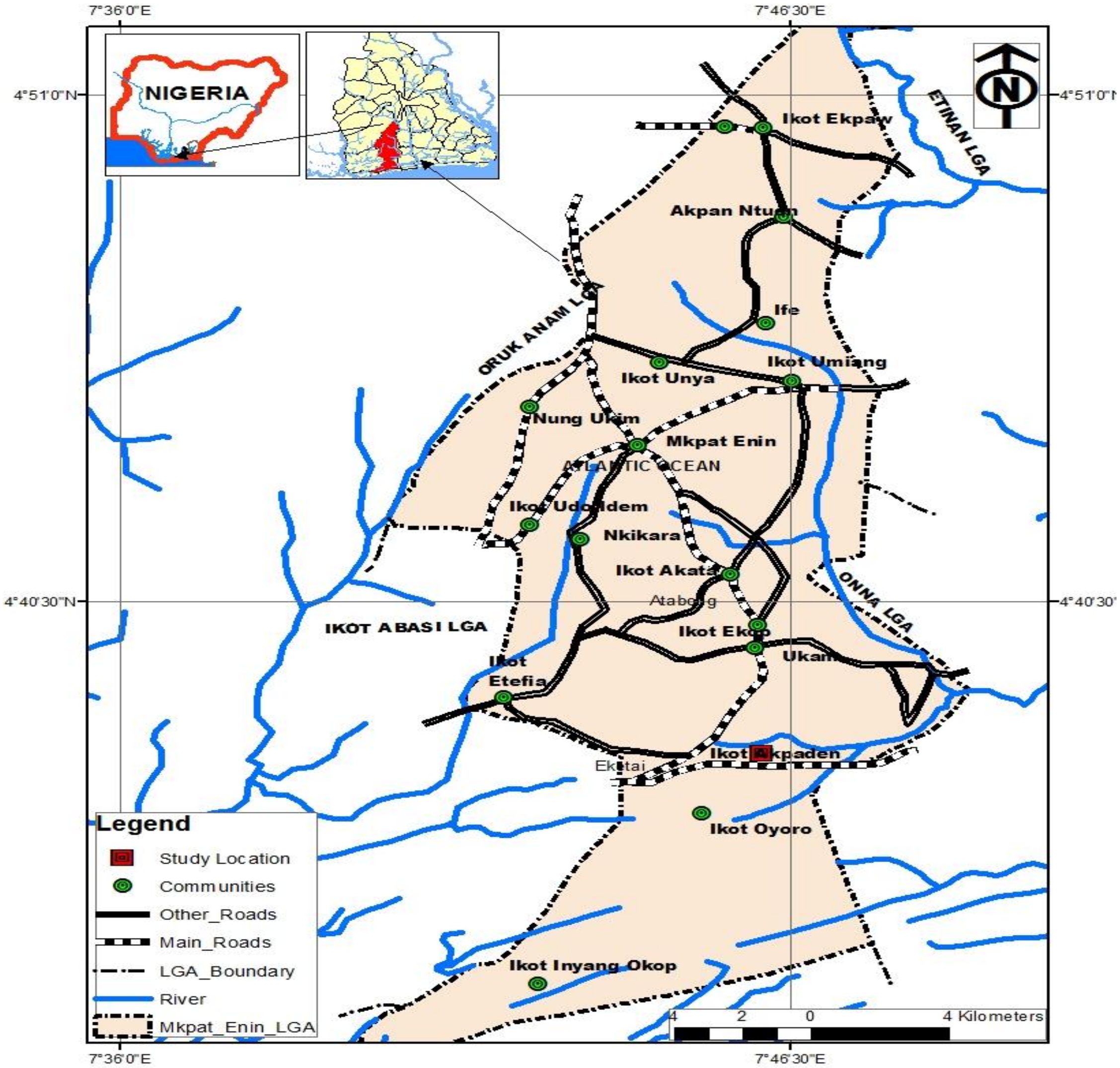

Fig 1. Map of the study area

2.2.3 Basal area

This was calculated using the relation:

$$\text{Basal Area} = \frac{C^2}{4\pi}$$

Where,

$4\pi = 4 \times 3.142 = 12.568$
C = girth size of the species at breast height

2.2.4 Crown cover

The crown cover of woody plant species was determined by the crown cover diameter method [12].

2.3 Physical and Chemical Analysis of Soil

Soil particle sizes (sand, clay and silt), organic carbon, total nitrogen and available phosphorus were determined using the Hydrometer method, Walkey Black wet oxidation method, Micro-Kjeldahl method and Bray No 1 method [13]. pH, electrical conductivity, and exchangeable acidity were determined using a Beckman's glass electrode pH meter [14], conductivity meter (Jenway Pcm 128723 model) and titration with 1N KCL [15], respectively. Total exchangeable bases were determined by EDTA titration method while potassium and sodium were determined by photometry method. The Effective Cation

Exchange Capacity (ECEC) was calculated by the summation method (that is summing up of the Exchangeable Bases and Exchange Acidity (EA). Base Saturation was calculated by dividing total exchangeable bases by ECEC multiplied by 100.

2.4 Data Analysis

Statistical Package for Social Science (SPSS 20.0) was employed for descriptive statistics and bivariate correlation.

3. RESULTS

3.1 Floristic Inventory of the Pond

The floristic composition of the study area is presented in Table 1. A total number of twenty five (25) plant species belonging to 17 families were recorded. *Alchornea cordifolia* was the most abundant species with a density value of 2666.67±100.32st/ha while *Crinum* sp. had the least density value of 33.33±10.25st/ha. The most frequent species were *Chromolaena odorata* (75%) and *Pteridium aquilinum* (75%). In terms of height, *Elaeis guineensis* was the tallest species (10.00±2.08 m) while the shortest species were *Clappertonia ficifolia* (1.20±0.11 m) and *Cnestis ferruginea* (1.20±0.02 m). *Elaeis guineensis* also had the largest basal area (1.56±0.32 m^2/ha) while the least basal area value was recorded by *Raphia hookeri* (0.99±0.06 m^2/ha). *Cocus nucifera* had the largest crown cover value (3.65±0.99 m^2/ha) while the least value in this vegetation attribute was recorded by *Anthocleista vogelli* (0.81±0.02 m^2/ha). However, only four (4) woody species were encountered while the rest were ephemerals with negligible girth sizes and coverages.

3.2 Physical and Chemical Characteristics of Soil

Table 2 shows the physical and chemical characteristics of soil in the study ponds. Result of analysis of particle size followed this decreasing order: sand > clay > silt. The pH of the soil was moderately acidic. Nutrients such as total nitrogen, organic carbon and available phosphorus were relatively low. For the cations, Ca dominated and this was followed by Mg, K and then Na. Exchangeable acidity ranged between 2.18 and 2.20 cmol/kg while ECEC values ranged from 6.75 to 6.90 cmol/kg. The values obtained for base saturation were high and these ranged between 64.36 and 65.65 %. Among the heavy metals, Mn dominated followed by Zn, Cu, Pb and Cd.

3.3 Soil – Soil Correlates of the Pond

Table 3 shows the correlation matrix between pairs of soil variables. Sand fragments had a negative relationship with clay ($r = -0.934$, $p = 0.01$). Total nitrogen correlated positively with organic carbon ($r = 0.987$, $p = 0.01$) while available phosphorus showed positive relationships with pH ($r = 0.881$, $p = 0.05$), calcium ($r = 0.813$, $p = 0.05$) and sodium ($r = 0.884$, $p = 0.05$). Calcium also established a positive relationship with Mg ($r = 0.920$, $p = 0.01$), ECEC ($r = 0.965$, $p = 0.01$) and base saturation ($r = 0.966$, $p = 0.01$) and a negative relationship with Cu ($r = -0.999$, $p = 0.01$). Magnesium also correlated positively with ECEC ($r = 0.949$, $p = 0.01$) and base saturation ($r = 0.939$, $p = 0.01$) and negatively with Cu ($r = 0.999$, $p = 0.01$). Sodium and potassium correlated positively with each other ($r = 0.965$, $p = 0.01$) while ECEC established a direct relationship with base saturation ($r = 0.939$, $p = 0.01$). A negative relationship was observed between base saturation and Cu ($r = 0.999$, $p = 0.01$) as well as Pb with Zn ($r = 0.956$, $p = 0.01$).

3.4 Correlation between Soil and Vegetation Attributes

The soil – vegetation correlates is shown in Table 4. The density of species correlated positively with silt ($r = 0.882$, $p = 0.05$), organic carbon ($r = 0.963$, $p = 0.01$) and Pb ($r = 0.927$, $p = 0.01$). Height of plant species correlated positively with Mg ($r = 0.815$, $p = 0.05$) and base saturation ($r = 0.816$, $p = 0.05$). Basal area correlated negatively with available phosphorus ($r = -0.867$, $p = 0.05$) while crown cover of species correlated positively with silt ($r = 0.938$, $p = 0.01$), base saturation ($r = 0.883$, $p = 0.05$) and negatively with Cu ($r = -0.855$, $p = 0.05$).

4. DISCUSSION

4.1 Floristic Composition

The results shown in this study revealed that the floristic inventory of the wetland portrays a rich diversity which supports a compendium of obligate and facultative aquatic plant species. This pattern of species occurrence and

Table 1. Floristic inventory of the pond

Plant species	Family	Density (st/ha)	Frequency (%)	Height (m)	Basal area (m^2/ha)	Crown cover (m^2/ha)
Acroceras zizanioides (Kunth) Dandy	Poaceae	2333.33±90.62	50	-	-	-
Ageratum conyzoides L.	Asteraceae	2000±80.32	50	-	-	-
Alchornea cordifolia (Mull) Arg	Euphorbiaceae	2666.67±100.32	50	7.75±1.55	-	-
Anthocleista vogelli Planch	Gentianaceae	100.00±15.20	50	5.00±0.58	1.02±0.04	0.81±0.02
Aspilia africana C. D. Adams	Compositae	666.67±45.10	50	-	-	-
Caladium bicolor (Aiton) Vent.	Araceae	100.00±16.00	50	-	-	-
Chromolaena odorata (L) King & H. E. Robins	Asteraceae	1000±50.14	75	-	-	-
Clappertonia physifolia (Willd.)	Malvaceae	166.67±20.32	50	1.20±0.11	-	-
*Cnestis ferruginea*Vahl ex DC	Connaraceae	133.33±20.14	50	1.20±0.02	-	-
Cocus nucifera L.	Arecaceae	66.67±9.65	50	9.00±1.00	1.42±0.07	3.65±0.99
Commelina benghalensis L.	Commelinaceae	666.67±40.00	50	-	-	-
Crinum sp L.	Amaryllidaceae	33.33±10.25	50	-	-	-
Cyperus haspan L.	Cyperaceae	133.33±20.45	50	-	-	-
Cyperus zollingeri L.	Cyperaceae	666.67±41.30	50	-	-	-
Cyrtosperma senegalense (Schott) Engl.	Araceae	66.67±5.62	50	-	-	-
Elaeis guineensis Jacq.	Arecaceae	133.33±18.24	50	10.00±2.08	1.56±0.32	3.00±0.83
Icacinia trichantha Oliv.	Icancinaceae	100±18.62	50	1.30±0.00	-	-
Ipomoea involucrata P. Beauv	Convolvulaceae	200±26.10	50	-	-	-
Lygodium microphyllum (Cav.) R. Br	Lygodiaceae	100.00±15.01	50	-	-	-
Mitragyna ciliata (K. Krause)	Rubiaceae	66.67±15.21	50	-	-	-
Paspalum vaginatum SW.	Poaceae	1333.33±19.50	50	-	-	-
Pteridium aquilinum (L.) Kuhn	Dennstaedtiacceae	2333.33±83.20	75	-	-	-
Raphia hookeri Mann &Wendl.	Arecaceae	133.33±19.63	50	6.50±1.04	0.99±0.06	1.91.0.05
Selaginella myosurus (SW) Alston	Selaginellaceae	1666.67±40.12	50	-	-	-
Setaria verticillata P. Beauv	Poaceae	2000±75.21	50	-	-	-

st/ha=stems per hectare

Table 2. Physical and chemical characteristics of the soil

Soil parameters	Station 1	Station 2	Station 3
Sand (%)	88.26±0.86	88.95±0.95	87.23±0.84
Silt (%)	4.92±0.05	4.85±0.03	4.80±0.025
Clay (%)	7.15±0.67	6.20±0.45	7.97±0.71
pH	5.25±0.09	5.16±0.05	5.36±0.10
EC (ds/m)	0.10±0.02	0.11±0.02	0.13±0.03
Organic carbon (%)	2.45±0.37	3.01±0.39	2.49±0.38
Total nitrogen (%)	0.06±0.01	0.05±0.00	0.07±0.00
Available phosphorus (mg/kg)	4.17±0.42	4.05±0.08	5.12±0.68
Ca (cmol/kg)	3.00±0.34	2.94±0.26	2.98±0.25
Mg (cmol/kg)	1.32±0.12	1.50±0.17	1.35±0.20
Na (cmol/kg)	0.07±0.001	0.05±0.001	0.06±0.001
K (cmol/kg)	0.13±0.02	0.12±0.01	0.14±0.03
Exchangeable acidity (cmol/kg)	2.18±0.20	2.20±0.22	2.19±0.21
ECEC (cmol/kg)	6.86±0.39	6.90±0.41	6.75±0.38
Base Saturation (%)	65.65±2.87	64.52±2.53	64.36±2.50
Cd (mg/kg)	2.21±0.19	2.00±0.14	2.18±0.16
Pb (mg/kg)	7.95±0.70	5.62±0.63	5.89±0.41
Mn (mg/kg)	48.72±4.28	49.23±4.56	45.23±4.00
Zn (mg/kg)	30.06±0.52	35.12±1.10	32.10±0.68
Cu (mg/kg)	10.74±0.30	8.17±0.25	8.50±0.28

± S.E = Standard error

Table 3. Soil – soil correlates of the pond

	Sand	Silt	Clay	pH	EC	Org.C	T.N	Av.p	Ca	Mg	Na	K	EA	ECEC	B.Sat	Cd	Pb	Mn	Zn	Cu
Sand	1																			
Silt	.557	1																		
Clay	-.934**	-.526	1																	
pH	.127	.385	-.325	1																
EC	-.098	.577	.188	.522	1															
Org.C	-.665	-.377	.680	-.196	.114	1														
T.N	-.609	-.338	.652	-.318	.061	.987**	1													
Av.p	-.120	.461	.021	.881*	.740	.064	-.047	1												
Ca	.114	.244	-.146	.794	.644	.157	.048	.813*	1											
Mg	-.167	.116	.200	.573	.718	.477	.382	.755	.920**	1										
Na	-.545	.187	.400	.687	.712	.371	.261	.884*	.586	.657	1									
K	-.615	.195	.482	.523	.661	.524	.443	.775	.449	.589	.965**	1								
EA	-.720	-.282	.438	.374	.015	.248	.156	.363	.000	.027	.679	.673	1							
ECEC	-.117	.146	.090	.768	.726	.245	.121	.566	.965**	.949**	.722	.587	.152	1						
B.Sat	.067	.063	-.042	.628	.560	.260	.158	.668	.966**	.939**	.461	.332	-.112	.939**	1					
Cd	.721	.571	-.471	.573	.380	.522	.071	.693	.846	.891	.419	.500	-.304	.732	.696	1				
Pb	.467	-.038	.038	-.746	-.461	-.775	-.038	-.884	-.746	-.683	-.688	-.771	-.831	-.857	-.690	-.277	1			
Mn	.940	.644	-.644	-.483	.256	-.148	.644	-.340	-.105	-.014	-.630	-.556	-.689	-.288	-.024	.441	.740	1		
Zn	-.447	.060	-.060	.653	.481	.789	.060	.635	.761	.699	.192	.676	.528	.669	.706	.298	-956**	-.725	1	
Cu	-.279	-.722	.722	-.105	-.648	-.396	-.722	-.560	-.999**	-.999**	-.816	-.415	-.211	-.794	-.999*	-.757	.719	.065	-.735	1

***. Correlation is significant at the 0.01 level (2-tailed).*

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

Table 4. Soil – vegetation correlates

Soil parameters	Density	Height	Basal area	Crown cover
Sand	0.187	.049	-.032	.632
Silt	.882*	.079	.122	.938**
Clay	-.089	.176	.279	-.668
pH	.126	.181	-.474	580
EC	.683	.637	.169	.618
Organic carbon	.963**	.284	-.419	-.018
Total nitrogen	-.006	.242	-.343	-.024
Available phosphorus	.405	.412	-.867*	.588
Ca	.078	.701	-.622	.841
Mg	.135	.815*	-.588	.768
Na	.303	.218	-.269	.194
K	.391	.143	-.269	.172
Exchangeable acidity	-.181	-.454	-.270	-.382
ECEC	.077	.719	-.520	.687
Base Saturation	-.062	.816*	-.715	.883*
Cd	.198	.285	. -.661	0.524
Pb	.927**	.203	.504	-.255
Mn	791	.809	.382	.461
Zn	-.152	-.181	-.514	.277
Cu	-.559	-.534	.447	-.855*

***.Correlation is significant at the 0.01 level (2-tailed)*
**.Correlation is significant at the 0.05 level (2-tailed)*

distribution shows that plant do not grow in isolation, but rather different species have a tendency of growing together in the same habitat under similar environmental conditions [16]. The conspicuous dominance of *Alchornea cordifolia* is a reflection of the fact that this species had an inherent ability to adapt and tolerate fully to the prevailing hydric conditions. The closeness in frequency and density values of some species may be interpreted to mean a high level of competition among taxa in this habitat. Furthermore, *Alchornea cordifolia* and *Cyrtosperma senegalense* are both natives of wetlands within this area [17]. Also, the establishment and wide distribution of *Elaeis guineensis* is indicative of prolonged anthropogenic presence and influence around the wetland.

4.2 Soil-Soil Correlates

The correlation matrices established that there were relationships existing between the soil variables. The negative correlation between sand fragments and clay pinpoints their inverse relationship implying that clay content in the soil tends to decrease with increasing sand fragments. The source of sand in this wetland is not unrelated to precipitation and subsequent run-off which deposits sand particles from the surrounding environment into the wetland area, especially in view of ongoing developmental projects stated earlier on. The synergistic relationship evidenced between total nitrogen and organic carbon is not unprecedented but rather confirms the reports of Brady and Weil [18] that organic carbon through litter generation and decomposition is a major source of nitrogen and other vital nutrients in the soil. Available phosphorus showed positive relationships with pH, calcium and sodium. The positive association between available phosphorus and pH may imply that the pH of the soil was optimal for the retention of this soil nutrients in increasing amounts. Also, the direct relationships between available phosphorus with calcium and sodium may imply same source of nutrient allotment in this wetland. Calcium also established a positive relationship with Mg. The negative correlation of Ca and Mg with Cu may expound the negative effects this metal has on soil nutrients when added in increasing amount. Lindsay [19] reported that high application rates of Cu lead to a subsequent reduction in soil nutrients which affects plant productivity. The direct relationship of ECEC with base saturation may imply that the saturation of basic cations in increasing amounts in the soil will lead to an elevation in values of the cation exchange complex [20].

4.3 Soil – Vegetation Correlates

The synergistic relationship of density with silt and organic carbon may justify the intrinsic roles and influences of textural class and organic carbon on the growth and distribution of species. This implies that as the silt and organic carbon contents increase, the density of plant species increase as well. While silt particles aids aeration, permeability of water, nutrient retention and root penetration because of its moderate compaction in structural pores [21], organic carbon plays important roles in provision of substrate and nutrients and stabilisation of soil structure [22]. The positive synergy between density and Pb is vague but this relationship may be interpreted with respect to pollution tolerance. The negative correlation between basal area and available phosphorus may imply that this important soil nutrient required for the nourishment and growth of plants was taken up by woody species with large girth sizes faster than it can be replenished in the soil. Crown cover of species correlated positively with silt, base saturation and negatively with Cu. This synergistic relationship of crown cover with silt and base saturation explains the roles played by textural class of silt and basic cations such as Ca, Mg and Na in the growth and development of plant species.

5. CONCLUSION

Conclusively, evidences from this study confirms the unique relationship between soil and vegetation in this wetland. Also, there is an indication that forested wetland soils are complex systems resulting from various intricate interactions between abiotic (nutrient and textural properties) and biotic (plants, humans and invertebrates) factors that keep changing even within short distances. Soil physical and chemical attributes such as exchangeable bases, macro and micro nutrients and organic matter are the key factors in determining species composition and structure in wetlands. However, the floristic population of the wetland area, points to rapid incursion of human activities and influence within and outside the district landscapes, thus control measures must be adopted to maintain the wetlands ecological integrity.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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