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PEDOLOGICAL ATTRIBUTES, FLORISTIC COMPOSITION AND PROFILE OF A COASTAL ECOSYSTEM IN SOUTHERN NIGERIA

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ABSTRACT

Mangroves have important roles in the mitigation of on-going climate change as new evidence shows, and are critical natural assets for coastal communities in the face of accelerated sea level rise. Yet, they are imperilled through unsustainable practices such as logging and crude oil mining activities. The effect of crude oil mining and flaring of associated gas across the mangrove ecosystems within the Niger Delta region is well articulated in literature and visibly apparent as one traverses coastal communities of the Delta. However, the abuse and devastation of this ecosystem is unabated five decades after the discovery of oil. This devastation consequently influences the physiognomy of the mangroves, connected fauna and is likely to cascade down the different trophic levels of this unique ecosystem. In light of their importance and current threats within the Niger Delta we assessed the floristic structure of the Okorombokho mangrove, Eastern Obolo Local Government Area of Akwa Ibom State. Five (5) quadrats of 50 x 10 m within 5 sampling plots were used to sample vegetation and soil parameters using systematic sampling method. Results showed variations in the floristic composition and structure of the mangrove ecosystems; with a total of 16 plant species recorded from 13 families. Bivariate correlation analysis was employed to show significant relationships ($p = 0.05; p = 0.01$) between the vegetation attributes and soil factors. A prediction model using stepwise multiple regression technique showed the responses of the vegetation attributes to soil gradients. Additionally, the profile diagrams of the study area show a trend from mono-specific plots to mixed vegetation e.g. station 4 that was completely dominated by *Rhizophora mangle*; whereas other stations (1-3) showed a mixed vegetation of *Rhizophora mangle*, *Avicennia africana*, *Nypa fructicans* and others. These different zones of growth are indicative of the response of the flora to various stressors that warrants constant monitoring and management adjustments for maintenance of extant mangrove vegetation.

Key Words: Mangroves, Species Diversity; Bivariate Correlation; Regression, Climate change

1. Introduction

Mangroves unique services include protecting coastal communities from sea level rise, erosion, storms and ocean waves (Massel *et al.*, 1999; Burbidge *et al.*, 2000; McIvor *et al.*, 2012); wood and fuel sources (Connolly and Lee, 2007; Anwana *et al.*, 2010); act as spawning grounds for fisheries and other aquatic fauna (Duke and Larkum, 2008; Narayan, 2016). These various ecological niches make tropical mangrove ecosystem the most productive natural ecosystems worldwide (Alongi, 2009). Yet, despite the economic importance of mangroves and their vast coverage in tropical and sub-tropical areas, they are found to be under threat from a variety of anthropogenic activities (e.g. Walters *et al.*, 2008; Nfotabong-Atheull *et al.*, 2009; Mukherjee *et al.*, 2010) leading to losses in coverage area, with high rate of deforestation in many developing countries including Nigeria (Alongi, 2002; Duke *et al.*, 2007, Rakotomavo and Fromard, 2010).

Most of Nigerian's mangroves is contained within the Niger Delta, where mangrove cover is estimated at about 7,500km making Nigeria 27 in the world ranking of countries with the largest extent of mangroves (Giri *et al.*, 2011). Additionally, extant mangrove ecosystems is between the Benin and Cross River estuaries (Folorunsho and Awosika, 2010). It is the biocoenosis (i.e. the living assemblage of plants and animals) of the Niger Delta that contributes to the rich nutrient profile of the region and this with other geological processes explains the vast store of crude oil embedded in the earth of the area. It is this store of crude oil and gas that attracts heavy investment of multinational companies within the Niger Delta. Impacts of oil mining within the region are well articulated in literature (e.g. Abii and Nwosu, 2009; Enemugwem, 2009; Adekola and Mitchell)

As well as direct impacts from human activity, mangroves may also be under threat from global warming. Their intertidal location means they are likely to be one of the first habitats to be affected by a rise in sea level (Field, 1995). Based on the foregoing the present study was designed to assess current floristic structure of the study area's mangrove environment with the aim of elucidating data that will ultimately enhance the restoration of this mangrove where appropriate.

2. Materials and Method

Study Area

This study was carried out in a mangrove ecosystem at Okorombokho in Eastern Obolo Local Government Area of Akwa Ibom State, Nigeria (Figure 1).

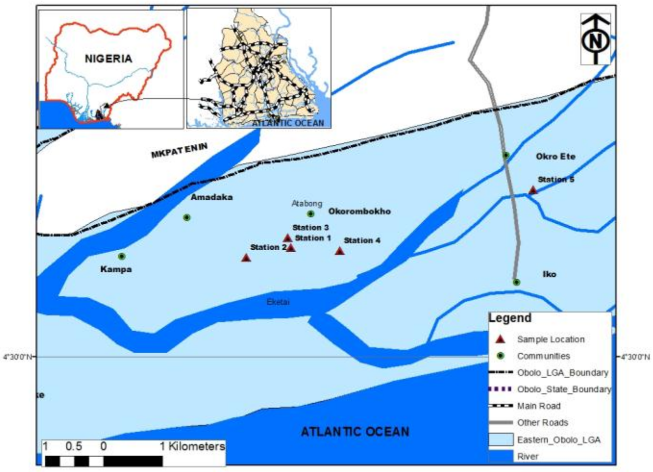

Figure 1: Map of the study area showing sampling stations

Eastern Obolo Local Government is located within the Niger Delta between Imo and Qua Iboe Rivers estuaries and lies between latitudes 4° 28` and 4° 53` N and longitudes 7° 50` and 7° 55`E with an altitude of about 650 m above sea level. It is bounded in the North by Mkpat Enin Local Government Area, North East by Onna**,** West by Ikot Abasi, South East by Ibeno Local Government Areas and in the South by the Atlantic Ocean (Akwa Ibom State Government, AKSG, 2008). The population of Eastern Obolo LGA is 109,052 (National Population Commission, NPC, 2007). The area lies within the tropical rainforest zone and has two major seasons which include a rainy season (May to October) and a dry season (November to April). The footprints of the multinational oil company, Shell Petroleum Development Company of Nigeria (SPDC), is evident within the community and their operations within the Eastern Obolo Local Government Area which includes the following towns; Iko, Okorombokho, Okoroiti and Okoroete Towns spans over five decades (Enemugwem, 2009)

Vegetation and Soil Sampling

Systematic sampling method was used to sample the vegetation and soil using a quadrat of 50 x 10 m. In each quadrat, vegetation components (plants) were identified to species level and their frequency and density were obtained by enumeration. Unknown plant species specimens were collected for identification and confirmation from voucher specimens in the herbarium of the department of Botany and Ecological Studies, University of Uyo. The parameters of the vegetation measured were; frequency of plant species, height, density, basal area, and crown cover. Using a soil auger in each of the quadrats, soil samples were obtained at two depths; 0-15cm and 15-30 cm. These were stored in labelled Ziploc® bags and taken to the laboratory for physicochemical analyses.

3. Results

Floristic Composition

The floristic composition of the mangrove wetland is shown in Table 1. In station 1, two plant species (*Nypa fruticans* and *Rhizophora mangle*) were encountered with *Rhizophora mangle* dominating in density (16.00±1.24 st/ha), frequency (80%), height (11.25±0.83 m), basal area (1.60±0.02 m^2/ha) and crown cover (1.03±0.05 m^2/ha). *Nypa fruticans* had the least values for these vegetation parameters.

In station 2, only *Rhizophora mangle* was encountered with density, frequency, height, basal area and crown cover values of 28.00±4.36 st/ha, 100%, 15.29±1.13 m, 1.85±0.21 m^2/ha, and 3.34±0.33 m^2/ha, respectively.

In station 3, three plants species were encountered. *Nypa fruticans* dominated in density (16.00±2.08 st/ha) and frequency (60%). *Elaeis guineensis* dominated in height (7.12±1.05 m) and basal area (1.14±0.45 m^2/ha) while *Rhizophora mangle* had the widest crown cover (3.25±0.10 m^2).

In station 4, twelve (12) plant species were found. *Paspalum vaginatum* dominated had the highest density and frequency values of 1200±50.15 st/ha and 100% while *Avicennia africana* and *Terminalia superba* had the least density values of 8.00±2.98 st/ha and 8.00±1.00 st/ha, respectively. *Platycerium stemaria*, *Achrosticum aureus*, *Terminalia superba*, *Fimbristylis ferruginea and Staudtia stipitata* had the least frequency value of 20 % each. *Rhizophora mangle* was the tallest species with height of 10.45m while *Achrosticum aureus* was the shortest species (4.12 m). *Elaeis guineensis* had the highest values for basal area (1.41±0.05 m^2/ha) and crown cover (10.57±2.58 m^2/ha) while the least values for basal area (0.16±0.02 m^2/ha) and crown cover (0.59±0.001 m^2/ha) were recorded by *Avicennia africana*.

A total of six (6) plant species were encountered in station 5 with *Dracena arborea* having the highest values for density (44.00± 3.64 st/ha), frequency (60%) and height (11.91±0.83 m). *Piptadeniastrum africanum* had the least density value (3.00±3.10 st/ha) while *Alchornea cordifolia* had the least value for height (3.33±0.88 m). *Elaeis guineensis* had the highest value for basal area (0.98±0.02 m^2/ha) while *Rhizophora mangle* had the largest crown coverage of 6.14± 0.98 m^2/ha. *Alchornea cordifolia* had the least basal area and crown cover values of 0.008±0.0002 m^2/ha and 0.04±0.001 m^2/ha, respectively. In all, a total of 16 plant species were conspicuous in this wetland belonging to 13 families. However, some plant species were ephemerals with negligible girth sizes and crown cover.

Physicochemical Properties of the Soil

The physicochemical properties of the wetland soil as shown in Table 2 revealed that the pH of the soil ranged between 6.60 and 7.55. Electrical conductivity values ranged from 7.03 to 10.72 with stations 4 and 2 recording the highest and least values. Organic carbon and total nitrogen contents in the soil were highest in station 2 and least in station 4. Available phosphorus had values ranging between 3.23 (station 3) and 27.83 (station 4). Calcium and magnesium values were highest in station 4 (11.18±0.4 and 4.66±0.10) and least in station 1 (8.00±2.00 and 3.06±0.60). Sodium content were relatively low across the sampled stations with values ranging between 0.30 and 0.94. Potassium contents ranged between 0.40 and 1.79 with the highest and least values in stations 1 and 3. Exchangeable acidity was highest in station 2 (3.10±0.10) and least in station 4 (2.07±0.05). Effective Cation Exchange Capacity (ECEC) was highest in station 5 (19.57±1.22) and least in station 4 (9.52±0.46). Base saturation was highest in station 5 (83.49±0.93) and least in station 2 (77.67±7.98). In terms of the particle size class, sand contents were highest in station 4 (92.46±2.00) and least in station 5 (50.46±6.00), silt was highest in station 5 (29.30±3.00) and least in station 2 (9.30±3.00) while clay content was highest in station 5 (20.24±3.00) and least in station 4 (3.24±0.00).

Table 1: Floristic Composition of Okorombokho mangrove ecosystem

Plant species	**Family**	**Density (stems/ha)**	**Frequency (%)**	**Height (m)**	**Basal Area (m^2/ha)**	**Crown Cover (m^2/ha)**
STATION 1						
Nypa fruticans Wurmb.	Arecaceae	5.00±0.17*	40	4.00±0.02	0.18±0.05	0.63±0.02
Rhizophora mangle L.	Rhizophoraceae	16.00±1.24	80	11.25±0.83	1.60±0.02	1.03±0.05
STATION 2						
Rhizophora mangle L.	Rhizophoraceae	28.00±4.36	100	15.29±1.13	1.85±0.21	3.34±0.33
STATION 3						
Elaeis guineensis Jacq.	Arecaceae	6.00±0.68	40	7.12±1.05	1.14±0.45	3.14±0.76
Nypa fruticans Wurmb.	Arecaceae	16.00±2.08	60	2.96±0.02	0.01±0.004	1.65±0.33
Rhizophora mangle L.	Rhizophoraceae	8.00±0.96	40	5.00±0.50	0.03±0.00	3.25±0.10
STATION 4						
Cocus nucifera L.	Arecaceae	28.00±4.58	60	6.58±1.85	1.31±0.05	6.98±0.04
Paspalum vaginatum Sw.	Poaceae	1200±50.15	100	-	-	-
Ipomoea involucrate P. Beauv	Convolucaceae	80.00±10.36	60	-	-	-
Platycerium stemaria (P.Beauv.)Desv.	Polypodiaceae	16.00±2.65	20	-	-	-
Achrosticum aureus L.	Pteridaceae	12.00±1.36	20	4.12±0.54	-	-
Avicennia africana P. X Beau	Avicenniaceae	8.00±2.98	40	5.12±0.85	0.16±0.02	0.59±0.001
Elaeis guineensis Jacq.	Arecaceae	28.00±3.68	60	9.5± 0.5	1.41±0.05	10.57±2.58
Nypa fruticans Wurmb.	Arecaceae	50.12±6.52	40	4.51±0.58	0.21±0.05	4.23±0.14
Terminalia superba Engl. and Diels.	Combretaceae	8.00±1.00	20	9.02±1.05	1.05±0.15	5.65±0.85
Rhizophora mangle L.	Rhizophoraceae	60.41±8.04	80	10.45±1.20	0.92±0.05	1.14±0.08
*Fimbristylis ferruginea (*L) Vahl	Cyperaceae	50.00±1.95	20	-	-	-
Staudtia stipitata Warb.	Myristicaceae	9.00±1.20	20	7.20±0.99	0.8±0.04	2.69±0.41
STATION 5						
Dracena arborea		44.00± 3.64	60	11.91±0.83	0.13±0.04	.00±0.76
Mytragyna ciliate (Aubrey and Pellegr)	Rubiaceae	3.41±0.64	20	4.01±0.24	0.82±0.04	3.10±0.26
Alchornea cordifolia (Schum andThonn) Mull. Arg	Euphorbiaceae	12.00±1.25	40	3.33±0.88	0.008±0.0002	0.04±0.001
Elaeis guineensis Jacq.	Arecaceae	4.00±0.04	20	5.62±0.14	0.98±0.02	2.77±0.63
Piptadeniastrum africanum (Hook f.) Brenan.	Fabaceae	3.00±3.10	20	8.05±0.72	0.42±0.03	4.91±0.75
Rhizophora mangle L.	Rhizophoraceae	18.00±0.72	40	9.00±1.07	0.52±0.01	6.14± 0.98

*Results are represented as Mean ± Standard Error (SE)

Heavy metal contents in the soil revealed that Pb was highest in station 5 (0.71±0.02) and least in station 2 (0.49±0.01), Cd was relatively low with values ranging between 0.03 and 0.05, Fe content was highest in station 3 (366.77±14.36) and least in station 2 (209.38±7.14), Zn content was highest in station 5 (71.04±8.14) and least in station 2 (54.86±6.01) while Mn had its highest and least contents in stations 3 (22.36±3.18) and 5 (10.87±1.71).

Table 2: Physicochemical properties of soil in Okorombokho mangrove ecosystem

Parameters	Station 1	Station 2	Station 3	Station 4	Station 5
pH	6.95±0.15*	7.35±0.05	6.60±0.00	7.10±0.04	7.55±0.07
EC (ds/m)	8.68±0.88	7.03±2.37	9.04±4.13	10.72±0.23	9.08±0.03
Organic carbon (%)	6.38±0.13	7.63±0.88	3.25±1.00	1.65±0.65	2.03±0.03
Total nitrogen (%)	0.16±0.005	0.20±0.02	0.08±0.02	0.04±0.01	0.06±0.005
Available Phosphorus (mg/kg)	5.83±0.84	8.33±1.25	3.23±0.11	27.83±0.07	16.04±10.21
Calcium (cmol/kg)	8.00±2.00	10.75±0.55	9.10±0.31	11.18±0.4	4.80±0.42
Magnesium (cmol/kg)	3.06±0.60	4.46±0.47	3.60±0.05	4.66±0.10	4.36±0.44
Sodium (cmol/kg)	0.94±0.03	0.69±0.11	0.30±0.00	0.41±0.005	0.46±0.02
Potassium (cmol/kg)	1.79±0.07	1.04±0.41	0.40±0.00	0.58±0.01	0.71±0.03
Exchange acidity	2.94±0.28	3.10±0.10	2.80±0.00	2.07±0.05	2.87±0.37
ECEC (cmol/kg)	17.70±1.87	15.05±4.49	16.01±0.05	9.52±0.46	19.57±1.22
Base saturation (%)	80.51±5.90	77.67±7.98	82.50±6.52	78.23±1.53	83.49±0.93
Sand (%)	58.41±1.95	58.46±2.00	74.46±8.00	92.46±2.00	50.46±6.00
Silt (%)	23.33±7.00	9.30±3.00	8.80±2.50	4.30±2.00	29.30±3.00
Clay (%)	18.26±5.10	32.24±1.00	16.74±5.50	3.24±0.00	20.24±3.00
Pb (mg/kg)	0.54±0.02	0.49±0.01	0.63±0.03	0.67±0.03	0.71±0.02
Cd (mg/kg)	0.05±0.001	0.03±0.002	0.04±0.005	0.03±0.001	0.04±0.003
Fe (mg/kg)	347.12±10.65	209.38±7.14	366.77±14.36	289.15±9.21	362.11±11.0
Zn(mg/kg)	63.72±5.30	54.86±6.01	67.08±5.91	65.42±5.46	71.04±8.14
Mn (mg/kg)	18.12±3.17	14.66±2.04	22.36±3.18	11.24±1.98	10.87±1.71

*Results are represented as Mean ± Standard Error (SE)

Stepwise Multiple Regression Analysis
The summary of the predictive equations for the floristic determinants in the study area is presented in Table 3.

In station 1, organic carbon predicted density, Zn, total nitrogen and Pb predicted height, while available phosphorus predicted basal area. In station 2, Na predicted density, pH, Mg and Cd predicted basal area while silt, pH and Na predicted crown cover. In station 3, only one vegetation parameter was predicted. Clay, electrical conductivity (EC) and silt predicted height. Density, basal area and crown cover yielded no predictor variables. In station 4, silt, calcium and Fe predicted density, height was predicted by clay, EC and silt while basal area was predicted Ca and total nitrogen. In station 5, only one vegetation parameter was predicted. Electrical conductivity (EC) and sodium (Na) predicted crown cover while the rest of the vegetation parameters failed to yield predictor variables.

Table 3: Predictive equations for the floristic determinants in Okorombokho mangrove ecosystem

Stations	Variable	Equation
Station 1	Density, Y	= 45.95 – log0.99 Organic carbon
	Height, Y	= 27.95 – log1.09 Zn – log 0.29 Tot.N + log0.03 Pb
	Basal area, Y	= – 12.67 + log1.00 Av.P
Station 2	Density, Y	= 3.43 + log1.00 Na
	Basal area, Y	= 53.65 – log1.07 pH + log0.29 Mg –log 0.02 Cd
	Crown cover, Y	= – 13.59 + log1.15 silt + log0.16 pH – log0.08 Na
Station 3	Height, Y	= 0.98 + log0.91 Clay – log0.19 EC + log 0.02 Silt
Station 4	Density, Y	= 15.10 – log0.96 Silt + log 0.66 Ca + log0.38 Fe
	Height, Y	= 5.20 + log1.06 Clay – log 0.29 EC – log0.04 Fe
	Basal area, Y	= 6.95 – log0.87 Ca – log0.14 Tot. N
Station 5	Crown cover, Y	= – 7.98 + log0.98 EC + log 0.02 Na

Vegetation Density
The regression of density on twenty (20) soil variables across the stations yielded prediction model equations of these forms:
Station 1 Y = 45.95 – log0.99 Organic carbon
Station 2 Y = 3.43 + log1.00 Na
Station 4 Y = 15.10 – log0.96 Silt + log 0.66 Ca + log0.38 Fe

From these models, it can be deduced that vegetation density had indirect relationships with organic carbon and silt in station 1 and 4 and direct relationships with Na (station 2), Ca and Fe (station 4).

Vegetation Height
The regression of height on 20 soil variables across the stations yielded prediction model equations of these forms:

Station 1Y = 27.95 – log1.09 Zn – log 0.29 Tot.N + log0.03 Pb
Station 3 Y = 0.98 + log0.91 Clay – log0.19 EC + log 0.02 Silt
Station 4 Y = 5.20 + log1.06 Clay – log 0.29 EC – log0.04 Fe
From these models, it can be deduced that vegetation height across the stations had indirect relationships with Zn, total nitrogen, EC and Fe and direct relationships with Pb, Clay and silt.

Vegetation Basal Area
The regression of basal area on 20 soil variables across the stations yielded prediction model equations of these forms:
Station 1Y = – 12.67 + log1.00 Av.P
Station 2Y = 53.65 – log1.07 pH + log0.29 Mg –log 0.02 Cd
Station 4Y = 6.95 – log0.87 Ca – log0.14 Tot. N
From these models, it can be deduced that vegetation basal area across the stations had direct relationships with available phosphorus, Mg and inverse relationships with pH, Cd, Ca and total nitrogen.

Vegetation Crown Cover
The regression of basal area on 20 soil variables across the stations yielded prediction model equations of these forms:
Station 2Y = – 13.59 + log1.15 silt + log0.16 pH – log0.08 Na
Station 5Y = – 7.98 + log0.98 EC + log 0.02 Na
From these models, it can be deduced that vegetation cover had direct relationships with silt, pH (station 1), EC (station 1) and Na (station 2) and an inverse relationship with Na (station 1).

Vegetation Profile
The vegetation profile diagrams consisted of five sampled stations and were determined using the nearest neighbour distance measurement in one plane. Figures 1 – 5 show profile diagrams of woody species in the five (5) stations. Generally, stations 4 and 2 had the highest (12) and least number (1) of plant species respectively when compared to other stations. *Paspalum vaginatum* in station 4 dominated in density (1200 stems/ha) while *Piptadeniastrum africanum* in station 5 had the least density (3 stems/ha). *Rhizophora mangle* found in station 2 was the tallest woody plant species (15.29 m) while the shortest woody plant species being *Nypa fruticans* (2.96 m) occurred in station 1. *Rhizophora mangle* in station 2 also had the largest basal area (1.85 m^2/ha) while *Alchornea cordifolia* (0.008 m^2/ha) in station 5 had the least value for basal area. *Cocus nucifera* in station 4 had the largest crown cover (6.98 m^2/ha) while the least was *Alchornea cordifolia* (0.04 m^2/ha) in station 5.

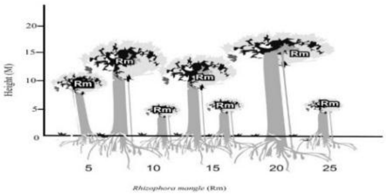

Figure 4.2: Profile diagram of Station 2

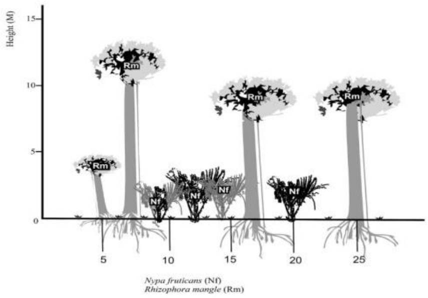

Figure 4.1: Profile diagram of Station 1

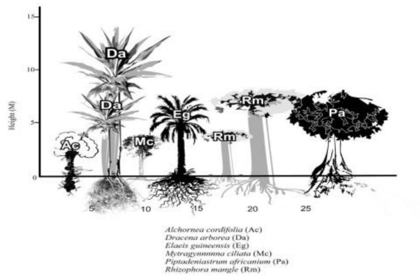

Figure 4.5: Profile diagram of Station 5

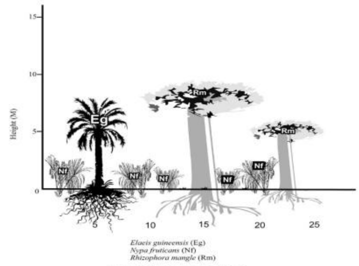

Figure 4.3: Profile diagram of Station 3

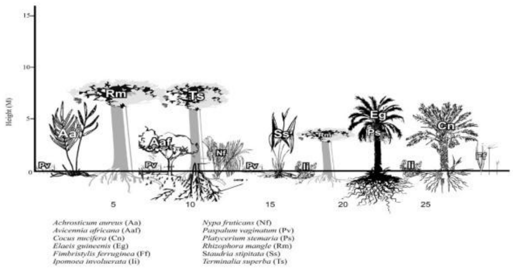

Figure 4.4: Profile diagram of Station 4

4. Discussion

Floristic Variations in Okorombokho Mangrove Ecosystem
The vegetation characteristics of the mangrove ecosystem showed variations and heterogeneity in abundance and composition of plant species. These variations may point to the fact that plant species adapt differently to varying changes in topographic, anthropogenic and edaphic factors in their environment (Sherman *et al*., 2003). The conspicuous dominance of *Rhizophora mangle* in all the stations in contrast to other available species lends credence to its wide ecological tolerance and inherent ability to colonize mudflats and adapt persistently to the pedological

and hydrological regimes within this ecosystem (Pitchairamu *et al.*, 2008). However, while other sampling stations had several other plant species, Station 2 depicted a monospecific plot. Most of the plant species found in these stations were woody species

Ecological Interrelationships

The stepwise multiple regression techniques showed the responses of vegetation along environmental gradients. It identified those explanatory variables (soil) having strong relationship with the response variables (vegetation) (Ubom, 1992). The most frequently retained environmental variables were sodium (Na), electrical conductivity (EC) and silt. Na was involved in prediction models involving density and crown cover while Electrical conductivity was involved in equations involving height and crown cover. The prediction of these variables by electrical conductivity is unclear but may be interpreted to mean that for the growth of trees to be possible with respect to height and crown cover, such species of trees must be tolerant to saline conditions (Joshi and Ghose, 2003). The prediction by silt particles highlights the relevance of textural class to plants as it aids aeration, permeability of water, nutrient retention and root penetration because of its moderate compaction in structural pores (Ubom, 1992).

The second most retained environmental variables were total nitrogen, pH, clay, calcium (Ca) and Fe. Total nitrogen was involved in equations predicting height and basal area. Several studies have outlined the specific functions performed by this macronutrient to plants. For instance, Nursu'aidah *et al*. (2014) reported that nitrogen is an essential constituent of chlorophylls and is closely associated with photosynthetic process. Furthermore, it helps to improve the fruit and seed production along with rapid plant growth, quality of forage crops, and leaf (Marschner, 2011).

Conclusion

This study has shown that there are variations in the composition and distribution of plant species in the mangrove due to varying physico-chemical properties of the soil and water. It has also illustrated the dominating influence of soil parameters in the prediction and determinants of vegetation parameters such as density, height, basal area and crown cover. The vegetation prediction models used, and physiognomy of the area as depicted on the profile diagrams serves as a reference for monitoring and management adjustments in maintaining the integrity of extant mangrove vegetation within the area.

References

Abii, T.A and Nwosu, P.C (2009). The Effect of Oil-Spillage on the Soil of Eleme in Rivers State of the Niger-Delta Area of Nigeria. *Research Journal of Environmental Sciences, 3: 316-320.*

Adekola, O and Mitchell, G (2011). The Niger Delta wetlands: threats to ecosystem services, their importance to dependent communities and possible management measures. International Journal of Biodiversity Science, Ecosystem Services and Management, *7*: 50-68

AKSG (2008). Geography and Location about Akwa Ibom State. Available online at <http://www.aksg.online.com>

Alongi, D. M. (2002). Present state and future of the world's mangrove forests. *Environmental Conservation* 29: 331 – 349.

Alongi, D.M. (2009) Paradigm shifts in mangrove biology. *Coastal wetlands: an Integrated ecosystem approach* (ed. By G.M.E. Perillo, E.Wolanski,D.R. Cahoon and M.M. Brinson), pp. 615–640. Elsevier, Amsterdam.

Anwana, E.D., Cheke, R.A., Martin, A.M., Obireke, L., Asei, M., Otufu, P and Otobotekere, D. (2010). *The Crocodile is our Brother: Conservation Management of the Sacred Lakes of the Niger Delta, Nigeria*. In B. Verschuuren, R. Wild, J. McNeely and G. Oviedo (eds.) Sacred Natural Sites, conserving nature and culture, Earthscan, London, Pp. 129-138.

Burbidge, A. H., McKenzie, N. L. and Harvey, M. S. (2000). A biogeographic survey of The southern Carnarvon Basin, Western Australia: background and methods. *Records of the Western Australian Museum* 61: 1 – 12.

Connolly, R. M. and Lee, S.Y. (2007). Mangroves and Saltmarsh. In: Connell, S. D. and Gillanders, B. M. (eds.) *Marine Ecology*. New York: Oxford University Press, pp. 485-514.

Duke, N. C., Meynecke J. O., Dittmann, S., Ellison A. M., Anger, K., Berger, U., Cannicci, S., Diele, K., Ewel, K. C., Field, C. D., Koedam, N., Lee, S. Y., Marchand, C., Nordhaus, I., and Dahdouh-Guebas, F. (2007). A World without Mangroves? *Science* 317: 41 – 42.

Duke, N. C. and Larkum, A. W. (2008). Mangroves and Seagrasses. In: Hutchings, P. Kingsford, M. J. and HoeghGuldberg, O. (eds.) *The Great Barrier Reef: Biology, Environment and Management*, Collingwood, Victoria, Australia: CSIRO Publishing. pp. 156-170.

Enemugwen, J. H. (2009). Oil Pollution and Eastern Obolo Human Ecology. *African Research Review* 3: 136-151

Field, C. D. (1995). Impact of expected climate change on mangroves. *Hydrobiologia* 295: 75 – 81.

Folorunsho, R and Awosika, L (2010). *Coastline Erosion: Implications for Human and Environmental Security in Nigeria*. In: Eze, C. O and Oche, O (eds.), Climate Change and Human Security in Nigeria. Pg. 327-352.

Giri, C., Ochieng, E., Tieszen, L.L., Zhu, Z., Singh, A., Loveland, T., Masek, J. and Duke, N. (2011) Status and distribution of mangrove forests of the world using earth observation satellite data. *Global Ecology and Biogeography*, *20*: 154–159.

Joshi, H. and Ghose, M. (2003). Forest structure and species distribution along soil salinity and pH gradient in mangrove swamps of the Sundarbans. *Tropical Ecology* 44: 197-206.

Marschner, H. (2011). Marschner's mineral nutrition of higher plants, Vol 89. Academic, London, p.651

Massel, S.R., Furukawa, K. and Brinkman, R.M. (1999) Surface wave propagation in mangrove forests. *Fluid Dynamics Research*, *24*: 219–249.

McIvor, A.L., Möller, I., Spencer, T and Spalding, M. (2012a). *Reduction of wind and swell waves by mangroves*. Natural Coastal Protection Series: Report 1. The Nature Conservancy and Wetlands International, Cambridge, UK.

Mukherjee, N., Dahdouh-Guebas, F., Kapoor, V., Arthur, R., Koedam, N., Sridhar, A. and Shanker, K. (2010). From bathymetry to bioshields: A review of post-tsunami ecological research in India and its implications for policy. *Environmental Management* 46: 329–339.

National Population Commission, NPC (2007). Nigerian Population highlights. Population Bulletin (No.1:23). National Population Commission Report, National Population Reference Bureau, Lagos, Nigeria.

Nfotabong-Atheull, A., Din, N., Longonje, S. N., Koedam, N. and Dahdouh-Guebas, F. (2009). Commercial activities and subsistence utilization of mangrove forests around the Wouri estuary and the Douala-Edea reserve (Cameroon). *Journal of Ethnobiology and Ethnomedicine* 5: 35 – 41.

Nursu'aidah, H., Motior, M. R., Nazia, A. M. and Islam, M. A. (2014). Growth and photosynthetic responses of long bean (*Vigna unguiculata*) and mung bean (*Vigna radiata*) response to fertilization. *Journal of Animal and Plant Science* 24:573 78.

Pitchairamu, C., Muthuchelian, K. and Siva, N. (2008). Floristic inventory and uantitative vegetation analysis of tropical dry deciduous forest in Piranmal, forest, Eastern Ghats, Tamil Nade, India. *Ethnobotanical Leaflets* 12: 204 – 216.

Rakotomavo, A. and Fromard, F. (2010). Dynamics of mangrove forests in the Mangoky River Delta, Madagascar, under the influence of natural and human factors. *Forest Ecology and Management* 259: 1161–1169.

Sherman, R. E., Fahey, T. J. and Martinez, P. (2003). Spatial patterns of biomass and aboveground net primary productivity in a mangrove ecosystem in the Dominican Republic. *Ecosystems* 6: 384-398.

Ubom, R. M. (1992*). Structure and Distribution of Plant* in *Isoberlinia* (Craib and Stapf) Woodlands. Unpublished Ph.D thesis submitted to Obafemi Awolowo University, Ile-Ife, p. 125

Walters, B. B., Rönnbäck, P., Kovacs, J. M., Crona, B., Hussain, S. A., Badola, R., Primavera, J. H., Barbier, E. and Dahdouh-Guebas, F. (2008). Ethnobiology, socio-economics and management of mangrove forests: a review. *Aquatic Botany* 89: 220–236.