Original Research Article

ECOLOGICAL AND PHYTODIVERSITY PROFILE OF IKOT EFRE ITAK FOREST, AKWA IBOM STATE

ABSTRACT

Aims: Ecological Profile Of Ikot Efre Itak Forest, Akwa Ibom State were accessed to ascertain its phytodiversity and soil physicochemical status.

Study Design: Systematic sampling method was used in sampling soil and vegetation parameters.

Place and Duration of Study: This study is carried out in Ikot Efre Itak forest in Ikono Local Government Area of Akwa Ibom State, Nigeria, between two seasons: rainy (April - October) and dry (November - March).

Methodology: Systematic sampling method was used in studying the vegetation and soil. A total of thirty plots were sampled in each season. Total area of vegetation sampled was 1500 m^2. Soil samples were analyzed following the standard procedures outlined by the Association of Official Analytical Chemist

Results: The result revealed a total of 30 plant species belonging to 18 families were encountered. Family Fabaceae had the highest number of 6 plant species followed by Meliaceae, Arecaceae, and Euphorbiaceae with 3 plant species each. The tallest and shortest species were *Berlinia confusa* (19.03 ± 3.05 m) and *Anchomanes difformis* (2.05 ± 0.03). Shannon-Wiener and Simpson diversity indices of 2.71 and 0.89 were recorded respectively. Physicochemical analyses revealed that in IEF the soils were moderately acidic and highly sandy, having low concentrations of some plant nutrients. Correlation analysis indicated significant relationships between plant species and plant nutrients. In this study, soil pH, organic carbon, total nitrogen, Zn, and Fe were the most outstanding soil variables influencing the structural properties of these forests.

Conculsion: It is concluded that the forests were not structurally complex as expected of a tropical rainforest partly due to anthropogenic activities but give an indication of good regeneration of constituents' plant species and thus reinforced the hope that these forests if preserved can return to its primary status.

Keywords: Dominance; Diversity; woody species; Floristic composition; Important Value Index.

1. INTRODUCTION

Ecology is simply the scientific analysis and study of interactions among organisms and their environments. Likens[29] defined ecology in a manner that favours common thoughts and collaborations, as the scientific study of the processes influencing the distribution and abundance of organisms, the interaction among organisms, and the interaction between organisms and the transformation and flux of energy and matter. Ecology is an encompassing and synthetic rather than fragmented field of science. Topics of interest to ecologists include the diversity, distribution, amount (biomass), and number (population) of particular organisms; as well as interactions between organisms, both within and among ecosystems. Thus, the ultimate subject matter of ecology is the distribution and abundance of organisms – where organisms occur, how many they are and what they do [39]. The science of ecology, therefore helps us to understand our environment and the changes that are likely to take place in it due to any kind of actions that we undertake [14].

According to FAO[12] forested lands are those areas having an extent of at least 0.5 ha with tree crown cover of more than 10%.The size and longevity of trees confer on them the ability to dominate other plant types by expropriating light and soil resources. This enables trees to control the major ecological processes, to determine the habitat for animals, microbes and other plant types, and to play a major role in determining the abundance of these other organisms in the forest. Forests can also be dominated by large plants with woody stems that are not strictly trees, such as bamboo or tree ferns. On the other hand, plantation is different from natural forest as these planted species are often of same type and do not support a variety of natural biodiversity.

Singh *et al.* [39] had seen forests as having productive, protective and regulative functions.In essence, the importance of forest to mankind cannot be overemphasized. For instance, Agbogidi and Eshegbeyi[2] noted that forests and forest products play vital roles in human life from the cradle to the grave. For millennia before the industrial revolution, forests, woodlands, and trees were the source of land for settlement and cultivation, products and materials for construction, woody biomass for fuel and energy, and indeed, directly for food and nutrition as well. The spread of agricultural revolution depended on the conversion of forests into cultivable land. The continuing contributions of forests to global biodiversity, to the fertility of agricultural lands, and to the welfare of those who depend on them mean that forests are immensely valuable for sustainability[12]. Furthermore, according to Udo *et al*. [44] a forest is a natural resource of multiple values, oftentimes, estimated from the stand point of population density or standing volume of timber tree species present, while ignoring the more valuable non-timber species.

It has been reported that soil is essential to ecosystem and agricultural sustainability and production because it supplies many of the essential requirements such as water, nutrients, anchorage, oxygen for roots, and moderated temperature for plant growth[49]. In Nigeria, it is an obvious fact that factors such as the soil temperature, soil nutrient status and texture could be used to investigate the different levels of tolerance and productivity of the plant species in any vegetation; and the level of response and adaptation of the properties of the soil create a distribution pattern for the vegetation [46]. Ubom *et al*[43] reported that using linear regression, the relationship between soil parameters and plants density, height, crown cover and basal area were positive; indicating that soil parameters form part of constellation of factors determining the existence of plants in a freshwater swamp forest. Also, in the work of Ichikogu[18] the result of multiple linear regression showed that soil organic matter, total porosity, water holding capacity, available phosphorus and ECEC were the most outstanding soil factors influencing the regenerative capacity of the vegetation structural properties in secondary forests. Based on these results, it was concluded that in the management of secondary forest specific consideration should be given to changes in soil physicochemical properties. Thus, it becomes imperative to consider soil in the study of forests for conservation and management purposes.

However, it is stated that there is a need to generate baseline information on species diversity patterns and population ranges of organisms in Nigeria in order to make appropriate conservation decisions[8] and phytosociological analysis of plant community is first and foremost basis of the ecological study of any piece of vegetation, and this study is important for understanding the functioning of any community[23, 45,50]. In recent years, Akwa Ibom State forest estate had suffered great perturbations due to rapid urbanization, increased infrastructural development, high population density and traditional farming practices resulting in unprecedented deforestation and environmental degradation [4].Upon this premise, this research aims at assessing the plant species diversity status, structure and soil physicochemical properties of this forest in the State so as to provide basis for formulating strategies for sustainable management.

2. MATERIAL AND METHODS

2.1. DESCRIPTION OF STUDY AREA

This study is carried out inIkot Efre Itak forest (Latitude 5°2’12” N and Longitude 7°50’57” E) in Ikono Local Government Area of Akwa Ibom State. The State is located in the south south region of Nigeria, between latitudes 4.32° N and 5.33°N and longitudes 7.25° E and 8.25° E. The mean annual rainfall is 2,000-2,500mm and the temperature range is 27 - 32℃. There are two seasons: rainy (April - October) and dry (November - March). The average relative humidity is about 80% with up to 95% occurring during the rainy season[5]. The soil is underlain mainly by sandstone, siltstone/shale and alluvial parent materials[48]. There are four eco-vegetation zones in the State: mangrove swamp forest, fresh water swamp forest, Lowland rainforest and moist savanna woodland[20].

2.2 DATA COLLECTION AND SOIL SAMPLE DIGESTION

Sampling was done by transects (plots). Each plot contained four quadrats. A quadrat size of 10 m x 10 m was used to sample the vegetation and soil, spaced at regular interval of 20 m according to the methods of Knight[28]. Plant identification and naming were done using relevant texts[3,16]. Plants that could not be identified on the field were collected and taken to Department of Botany and Ecological Studies Herbarium for identification and their features photographed so that they could be given future attention. Vegetation parameters measured were frequency of plant species, height, density, girth at breast height (gbh), and crown cover. Also, relative frequency, relative density, relative dominance and important value index (IVI) were evaluated using a formula recommended in Mandal and Joshi[30]. Using a soil auger in each of the quadrats, soil samples were obtained at a depth of 0-30 cm. From each forest, a total of twelve (12) composite soil samples were collected according to Mbong and Ogbemudia[31]. The soil samples were air-dried and preserved for laboratory analysis. Soil pH and electrical conductivity were determined using Hanna hand held multimeter. Total nitrogen was determined by Micro-Kjedahl method, Available phosphorus was determined using Bray No. 1 method while Exchangeable Ca and K was determined using Flame photometry[1]. Organic Carbon was determined using the Walkey-Black method[7]. Particle size distribution was determined using hydrometer meter. ECEC and Base saturation were computed according to the methods of Ubom[42].

2.3 STATISTICAL AND DATA ANALYSIS

Mean and standard error were computed from three replicates of soil physicochemical properties. The relationships between soil variables and vegetation variables within the study area were established by multivariate correlation technique using Statistical Package for Social Sciences (SPSS, version 18.0). Species diversity indices such as Shannon-Wiener, Simpson, Dominance, were used to assess plant species population in the forest using Paleontological software (PAST 3).

3. RESULTS AND DISCUSSION

Results

The results of the floristic compositions and soil physicochemical properties of the forest are presented below:

Table 1: Floristic inventory of Ikot Efre Itak forest

*Plant species	Family	Frequency	Density	Height	Crown cover	Basal area
Aframomum danielii	Zingiberaceae	10	75.00 ± 10.51	-	-	-
Afzelia africana	Fabaceae	40	190.00 ± 15.30	5.62 ± 0.63	2.06 ± 0.42	1.06 ± 0.08
Alchornea cordifolia	Euphorbiaceae	10	12.00 ± 1.69	3.62 ± 0.05	0.73 ± 0.002	0.04 ± 0.001
Alstonia boonei	Apocynaceae	10	10.00 ± 1.00	4.57 ± 0.05	0.38 ± 0.09	0.16 ± 0.05
Anchomanes difformis	Araceae	10	17.00 ± 1.50	2.05 ± 0.03	-	-
Anthonatha macrophylla	Fabaceae	20	30.00 ± 1.54	2.61 ± 0.30	0.45± 0.001	0.02 ± 0.001
Bambusa vulgaris	Poaceae	20	90.00 ± 10.82	5.59 ± 0.29	5.20 ± 0.89	0.20 ± 0.004
Barteria nigritiana	Passifloraceae	20	30.00 ± 2.81	6.97 ±0.29	0.39 ± 0.007	0.35 ± 0.07
Berlinia confusa	Fabaceae	20	20.00 ± 1.11	19.03 ± 3.05	5.78 ± 1.05	3.20 ± 0.62
Calamus deerratus	Arecaceae	60	175.00 ± 16.00	6.31 ± 0.63	-	-
Cannarium schweinfurthii	Burseraceae	20	40.00 ± 6.01	4.30 ± 2.00	2.02 ± 0.03	0.41 ± 0.07
Cnestis ferruginea	Connaraceae	10	35.00 ± 3.00	-	-	-
Coelocaryon preusii	Myristicaceae	40	30.00 ± 3.17	14.36 ± 3.83	3.05 ± 0.71	0.32 ± 0.08
Cola argentea	Sterculiaceae	10	10.00 ± 1.03	5.87 ± 0.28	5.50 ± 0.08	3.20 ± 0.47
Coula edulis	Olacaceae	10	10.00 ± 1.00	15.50 ± 5.12	5.10 ± 1.80	4.07 ± 0.15
Elaeis guineensis	Arecaceae	20	35.00 ± 4.51	7.20 ± 0.39	6.51 ± 1.08	2.19 ± 0.09
Erythrophleum ivorensis	Fabaceae	10	10.00 ± 0.80	6.23 ± 2.10	2.30 ± 0.06	0.70 ± 0.07
Guareacedrata	Meliaceae	10	10.00 ± 1.10	5.21 ± 1.00	3.04± 0.71	2.39 ± 0.20
Khaya ivorensis	Meliaceae	20	20.00 ± 3.01	8.50 ± 2.50	12.08 ± 2.30	6.21 ± 1.06
Khaya senegalensis	Meliaceae	10	10.00 ± 3.00	4.15 ± 0.73	5.28 ± 0.40	4.40 ± 0.80
Maesobotrya barteri	Euphorbiaceae	20	52.00 ± 7.80	3.14 ± 0.08	1.91 ±0.01	0.01 ± 0.004

Mansonia altissima	Sterculiaceae	30	50.00 ± 7.50	10.57 ± 1.80	4.12 ± 0.63	0.71 ± 0.04
Musanga cecropioides	Cecropiaceae	30	30.00 ± 3.20	11.69 ± 5.54	2.63 ± 0.41	0.55 ± 0.05
Palisota hirsuta	Commelinaceae	60	300 ± 13.00	3.00 ± 0.25	-	-
Pentaclethra macrophylla	Fabaceae	40	80.00 ± 7.50	9.88 ± 3.50	4.91 ± 0.51	3.67 ± 0.10
Piptadeniastrum africanum	Fabaceae	10	10.00 ± 1.02	14.20 ± 3.21	2.00 ± 0.03	0.35 ± 0.06
Podococcus barteri	Arecaceae	40	510.00 ± 28.51	-	-	-
Pycnathus angolensis	Myristicaceae	10	10.00 ± 1.68	8.58 ± 0.05	1.30 ± 0.02	2.01 ± 0.04
Smilaxanceps	Smilaceae	40	183.00 ± 10.65	-	-	-
Synsepalum dulcificum	Sapotaceae	20	20.00 ± 2.01	12.68 ± 4.01	3.36 ± 0.85	0.51 ± 0.01
TOTAL			2104		80.1	36.73

Table 2: Ecological dominance of plant species in Ikot Efre Itak forest

Plant species	Relative frequency (%)	Relative Density (%)	Relative dominance (%)	IVI
Aframomum daniellii	1.47	3.56	-	5.03
Afzelia africana	5.88	9.03	2.89	17.80
Alchornea cordifolia	1.47	0.57	0.11	2.15
Alstonia boonei	1.47	0.48	0.44	2.39
Anchomanes difformis	1.47	0.81	-	2.28
Anthonatha macrophylla	2.94	1.43	0.05	4.42
Bambusa vulgaris	2.94	4.28	0.54	7.76
Barteria nigritiana	2.94	1.43	0.95	5.32
Berlinia confusa	2.94	0.95	8.71	12.6
Calamus deerratus	8.82	8.32	-	17.14
Cannarium schweinfurthii	2.94	1.90	1.12	5.96
Cnestis ferruginea	1.47	1.66	-	3.13
Coelocaryon preusii	5.88	1.43	0.87	8.18
Cola argentea	1.47	0.48	8.71	10.66
Coula edulis	1.47	0.48	11.08	13.03
Elaeis guineensis	2.94	1.66	5.96	10.56
Erythrophleum ivorensis	1.47	0.48	1.91	3.86
Guarea cedrata	1.47	0.48	6.51	8.46
Khaya ivorensis	2.94	0.95	16.91	20.8
Khaya senegalensis	1.47	0.48	11.98	13.93
Maesobotrya barteri	2.94	2.47	0.03	5.44
Mansonia altissima	4.41	2.38	1.93	8.72
Musanga cecropioides	4.41	1.43	1.49	7.33
Palisuta hirsute	8.82	14.26	-	23.08
Pentaclethra macrophylla	5.88	3.80	9.99	19.67
Piptadeniastrum africanum	1.47	0.48	0.95	2.90
Podococcus barteri	5.88	24.24	-	30.12
Pycnathus angolensis	1.47	0.48	5.47	7.42
Smilax anceps	5.88	8.69	-	14.57
Synsepalum dulcificum	2.94	0.95	1.39	5.28

Table 3: Physicochemical characteristics of the soil in Ikot Efre Itak forest

Sand (%)	88.20 ± 1.50

Silt (%)	4.03 ± 1.29
Clay (%)	7.19 ± 0.96
Textural class	Loamy Sand
pH	5.98 ± 0.29
EC (ds/m)	0.13 ± 0.01
Organic carbon (%)	9.36 ± 0.65
Total Nitrogen (%)	0.16 ± 0.01
Available phosphorus (mg/kg)	16.89 ± 1.83
Ca (cmol/kg)	9.21 ± 0.58
Mg (cmol/kg)	2.88 ± 0.44
Na (cmol/kg)	0.06 ± 0.01
K (cmol/kg)	0.10 ± 0.01
EA	2.11 ± 0.56
ECEC (cmol/kg)	12.83 ± 0.73
Base saturation (%)	69.55 ± 2.79
Zn (mg/kg)	101.89 ± 10.72
Cu (mg/kg)	13.12 ± 0.56
Pb (mg/kg)	0.65 ± 0.31
Cd (mg/kg)	0.21 ± 0.06
Fe (mg/kg)	617.99 ± 96.83

***Mean (± S. E) of replicates**

Table 4: Diversity profile of Ikot Efre Itak forest

Taxa	30
Individuals	2104
Dominance	0.11
Simpson	0.89
Shannon	2.71
Evenness	0.69

Table 5: Correlation matrix between soil variables and vegetation parameters in Ikot Efre Itak forest

	Density	**Frequency**	**Height**	**Basal area**	**Crown cover**
Sand	.075	.634	-.690	.549	-.472
Silt	.361	-.525	.609	-.290	.877
Clay	-.035	.154	.737	.114	.075
pH	.919*	-.117	.388	.151	.873
EC	-.281	-.048	.663	.138	.821
Org.C	-.831	-.343	-.537	-.967*	-.425
Tot.N	.075	-.351	-.839	-.907*	-.777
Av.P	-.660	-.314	-.165	-.492	.259
Ca	-.231	.434	-.766	.439	-.244
Mg	-.768	-.139	.077	-.202	.326
Na	-.427	-.588	-.737	-.802	-.561
K	.013	.510	-.342	.629	.274
EA	.256	.069	.765	.062	.118
ECEC	-.366	.040	-.385	.180	.296
B.sat	-.788	.188	-.647	.250	-.266

Zn	-.619	-.626	-.443	-.964**	-.220
Cu	-.360	.069	.470	.285	.781
Pb	-.220	.014	-.807	.016	-.177
Cd	-.215	-.241	.399	-.047	.813
Fe	-.417	.751	-.087	.948*	.261

* Significant at p = 0.05; ** Significant at p = 0.01

Discussion

The floristic inventory of the forests revealed marked variations and heterogeneities in species composition and abundance. This may be an indication of varying levels of adaptation and differential responses of plant species to environmental and pedological factors.Favourable microsites or safe sites might have also accounted for the high density and frequency values recorded by species in IEF. This synchronizes with findings of Oswald and Neuenschwander[34] and Titus and Del Moral[41]. These researchers reported that spatial distribution of safe sites can often determine where establishment occurs, strongly influencing colonization and successional patterns in species. They went further to expound that microsite conditions can affect patterns of seed germination and seedling establishment in many communities. Be that as it may, the good reproductive strategies and high regeneration potentials of these species may not be overlooked as a contributor to their high density and frequency. This is quite true as Santamaria[37] opined that efficient dispersal abilities and good reproductive strategies are compendium of factors that could also explain dominance and rarity of species in diverse ecosystems. In the same vein, the low density and frequency values observed in most species in the forest are not far-fetched from the premise that they were unable to fully adapt to the soil conditions which is a prerequisite for their establishments. It can also be attributed to selective exploitation (as evidenced in IEF) of these plant species which may have led to slow rate of regeneration and low ecological tolerance[25].

Furthermore, the species composition in the forests corroborates with the findings of Onyekwelu *etal.* [33]; Ukpong *etal.* [47]; Udoakpan *etal.* [45]; Daniel *et al.* [11] and Jacob *etal.* [22]. These researchers reported that within the southern rainforests, a number of forest types can be recognized, some are rich in species of family Sterculiaceae, Moraceae, Meliaceae, Euphorbaceae, Mimosaceae (Fabaceae)and Apocynaceae with a middle storey of dense-crowned, wide-spreading trees and a ground flora that is mainly herbaceous and characterized by an abundance of creepers, mostly *Acacia sp* and rattan (*Calamus deerratus*).In IEF, family Fabaceae had the highest number of 6 plant species followed by Meliaceae, Arecaceae, and Euphorbiaceae with 3 plant species each.

The variations observed in IVI values among species may depict their various levels of adaptations in the forests as well as the different ecological importance of each species in the forest. The high IVI values recorded by *Podococcus barteri* may invariably suggest that this species was the most ecologically dominant and adaptive species. This may be attributed to the abundance of propagules or seeds that facilitated ecological succession[6, 21]. Furthermore, Olajide *etal*. [32] stated that the existence and population density of a plant species in a tract of a rainforest is a function of the availability of its seeds or propagules and the existence of favorable micro-climate for the seed germination and growth. Furthermore, the abundance and rarity of a plant species, especially those of great economic value, is a function of the intensity and pattern of exploitation which the forest is generally subjected to[44]. Also, another possible explanation for this could be selective exploitations of highly priced tree species for fuel wood.

Anthropogenic intrusions (selective exploitation and deforestation) and slow regenerative ability might also be attributed to low values in heights of plant species[36]. The gaps witnessed in the vegetation profile diagram might be attributed to anthropogenic intrusions such as species exploitation and susceptibility of species to wind action. Plant species with low values in height but large girth sizes and coverage might be said to be a reflection of their growth forms or habits. The presence of *Musanga cecropiodes* is suggestive of the fact that IEF is a secondary forest which enjoys a reasonable level of impact. This view is in synchrony with the earlier report of Ubom *et al.* [43].

The phytodiversity indices showed clearly that the IEF supported a good number of plant species. Shannon-Wiener and Simpson diversity indices of 2.71 and 0.89 were recorded respectively. These values fell between the range of 1.5 and 3.5 for forest as reported by Kent and Cooker[26]. However, these values are slightly higher when compared with the 2.20 by Sundaranpandian and Swamy[40] in tropical forest of Kodayar, Western Ghats of Southern India. These values are low when compared with values reported for other forest ecosystems [27, 35]. Dominance value was low in the forest implying that a mono-specific picture or pure stands in terms of species composition was not created in the forest. Furthermore, the high diversity and low dominance values obtained in the study reveal a healthy inter-specific competition among species in the forest. Evenness value was high. This may suggest equitability distribution of components species in IEF.

Soil properties especially nutrients are known to influence primary productivity and plant species richness. At the very least, the presence and availability of nutrients may, or may not, meet the nutrient requirements of different species and therefore defines a species' potential to survive in a given area[17]. The soil pH was acidic as in a typical forest. Texturally, the soils were highly sandy resulting in their poor structural stability, nutrients and water retention capacities. This may justify the low levels of some vital soil nutrients such as total nitrogen, available phosphorus, and potassium recorded in this study. This agrees with the findings of Jones and Wild[24] that low soil nutrients were attributed to high sand with low clay and silt contents as well as the level of litter availability. Nitrogen is a limiting nutrient for plant growth in many natural and semi-natural ecosystems. According to Brady and Wiel[9], nitrogen is the most commonly lacking nutrient in soils and this affects productivity of most ecosystems. Nitrogen content in surface mineral soils ranges between 0.02 and 0.5 % and that soil nitrogen occurs as part of organic molecule[38]. This corroborates with the findings of this study as

0.16 % was recorded for nitrogen. The levels of basic cations in the soil such as Ca, Mg and Na recorded in the study may substantiate that the soils had low sinks for these nutrients. Similar instance had been reported by Ubom[42] and Ita *etal*. [19]. The high values recorded for heavy metals such as Fe, Cd, Cu, Zn, Pb may underscore the various intensities of anthropogenic perturbations going on in the forests.

Correlation techniques are often used to examine the strength of the relationship between two variables that may be unevenly distributed over an area[10]. The correlations between vegetation and soil variables were used to assess the nature of these relationships and to identify the key soil variables that strongly influenced the vegetation. The current result furnishes evidences showing significant soil-plant relationships in IEF. Positive relationship between soil pH and density is well understood in keeping the views of Gould and Walker[15] that soil pH determines to a large extent the accessibility of soil nutrients to plants. The negative relationship between basal area of species and organic carbon, nitrogen and Zn may hint on the deficiencies of these vital soil nutrients due to high absorption rate by woody species with large girth sizes. This reciprocal relationship may also explain that there was no equilibrium between the rates of absorption and replenishment of this nutrient. The positive relationship between basal area of species and Fe may entail that the availability of this nutrient in increasing amounts in the soil aided the growth or increase in the girth sizes of trees in the forest.

Conclusion

This research concluded that different species growing together under similar environmental conditions varied in their response and adaptability to nutrients limits. The results of this work showed that there was a complex relationship existing between the vegetation characteristics and the soil properties. The forests supported a good number of plant species as revealed by the diversity indices. However, in terms of profile, the forests displayed the attributes of lower storey plant species with open canopies comprising of mainly mesophanerophytes. Thus, the forests though structurally not complex as expected of a tropical forest, possessed some features such as indigenous plant species composition and diversity that give prospects that these forests could possibly return to their primary status in the nearest future if adequate conservative and management measures are put in place. It is recommended that time series evaluation should be done to understand and monitor the floristic and soil dynamics in order to have adequate and up-to-date quantitative ecological data for successful management and conservation of IEF; and since physical observation in IEF forest revealed encroachment for fuel wood which negates the essence of preservation, the State forestry law should be strictly enforced to check the activities of illegal timber exploiters ravaging the forest. The information obtained in this result is expected to serve as a baseline data for other ecological studies and conservation activities within IEF.

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