Plant Diversity Status and Soil Physicochemistry in a Flood Plain

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ABSTRACT

Diversity status of plant species and physico-chemical profile of a floodplain ecosystem were studied. The study involved comparing plant diversity within and among different plots in the flood plain. Also soil samples were obtained at different points within and around the water body. The result records a total of fifteen plants from fourteen genera belonging to fourteen families. Plant diversity was compared using Shannon, Simpson and Simpson-inverse indices while plant distribution was compared using Berger-Parker, Evenness and Equitability (J) indices. There was a marked variation in diversity and plant distribution within and between the sampling units. Also, the physico-chemical analysis of the soil of the habitat revealed the significant ($p<0.05$) differences in the distribution of nutrients factors within the flood plain. While some soil nutrient factors reduced with increase in distance from the water front, diversity increased away from the pond. These differences were attributed to variation in species adaptation to the hydric conditions of the floodplain. These results have practical applications in environmental management and biodiversity conservation.

Keywords: *Biodiversity, Flood Plain, Distribution, Dominance and Pterocarpus sp.*

INTRODUCTION

Wetland may be used to describe an area of land whose soil is saturated with water either permanently or seasonally (Butler, 2010). Wetlands, according to Carter (1981) are ‘land transitional between terrestrial and aquatic systems where the water level is usually at or near the surface or the land is covered by shallow water.’ Willard and Rezneat (1982) also defined wetlands as those areas, which are capable of supporting water related vegetation. Oyebande, Obot, Bdiliya and Oshunsanya (2003), quoted the Ramsar Convention definition of wetlands as “areas of marsh, fen, peatland or swamp whether natural or artificial, permanent or temporary, associated with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed 6 meters.” The recurrent or prolonged presence of water (hydrology) at or near the soil surface is the dominant factor that determines the nature of soil developed and the types of plant and animal communities living in the soil and on its surface (Turner, 1990). Wetlands can be identified by the presence of those plants (hydrophytes) that are adapted to live in the soils that form under flooded or saturated conditions, that is, hydric soils (Mitsch and Gosselink, 1993).

Floodplain**,** also called Alluvial Plain, flat land area adjacent to a stream, composed of unconsolidated sedimentary deposits (alluvium) and subject to periodic inundation by the stream. Floodplains are produced by lateral movement of a stream and by overbank deposition; therefore they are absent where downcutting is dominant.

Less attention in science literature has been directed towards plant diversity status and geochemical variations within floodplains especially in this area. This has led to paucity in available information in this regard. Upon the foregoing, this research aims at documenting the floral diversity status and the physico-chemistry of a flood plain in Akwa Ibom State.

MATERIALS AND METHODS

Study Area

The study was conducted in a Riverine flood plain located in Afaha Etok village in Ibesikpo Asutan Local Government Area, Akwa Ibom State. The area is situated between longitudes 7^0 50' and 8^0 00 E' and between latitudes 5^0 30' and 7^0 N and shares boundaries with Uyo, Uruan and Nsit ibom, Nsit Atai and Nsit Ubium Local Government Areas (AKSG,2008).

Vegetation and soil sampling

Systematic sampling was used in sampling the vegetation and soil (Knight, 1978). Species were sampled in twenty 10m x 10m quadrats, spaced at regular intervals of 20m. In each quadrat, plants were enumerated and species were properly identified to the species level. Voucher specimens of unknown species were collected for proper identification at the Botany and Ecological Studies Departmental Hebarium. Total number of plant species encountered per sampling unit (quadrat) was recorded in the research diary. Also within each quadrat, a swamp 'corer' (Greig-smith, 1983) was used to obtain 2 soil samples at opposite ends of the quadrat to a rooting depth of 40cm. The soil samples were air- dried and preserved for laboratory analysis.

Physicochemical Analysis of Soil Samples

Soil samples were analyzed following the standard procedures outlined by the Association of Official Analytical Chemist (APHA, 1998). Soil pH were measured using Beckman's glass electrode pH meter (Mcclean, 1961). Organic Carbon by the Walkey Black wet oxidation method (Jackson, 1962), available Phosphorus by Bray P-1 method (Jackson, 1962). The total Nitrogen content was determined by Micro-Kjeldahl method (Jackobson, 1992). Soil particle size distribution was determined by the hydrometer method (Udo and Ogunwale,

1986) using mechanical shaker, and sodium hexametaphosphate as physical and chemical dispersant. Exchange Acidity was determined by titration with 1N KCl (Kamprath, 1967). Total Exchangeable Bases were determined after extraction with 1M NH_4OAc (One molar ammonium acetate solution). Total Exchangeable Bases were determined by EDTA titration method while sodium and Potassium 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.

RESULTS

Table 1 shows the diversity status of plant species of a floodplain ecosystem. It records a total of fifteen plants with fourteen genera belonging to fourteen families. Elaeis guinnesis seem to have been the most widely distributed having been cited in all but one of the sampling units of this study. *Hetherantera caulifolia* and *Pteridium aquilinum* were the least abundant being present in only one sampling unit of this study. Plot three was the most diverse with ten species present. Also plot five had a high diversity having rooted up to eight species. The least distributed habitats were plot two and six each having three and two species respectively.

Table 1: Plant Diversity status of the Flood plain

	Plot 1	**Plot 2**	**Plot 3**	**Plot 4**	**Plot 5**	**Plot 6**
Elaise guinneensis	4	5	8	4	6	0
Dacroydes edulis	0	0	1	0	2	0
Musanga cercropiodes	0	0	2	1	0	0
Costus afer	0	3	1	0	1	0
Carica papaya	2	0	1	2	1	0
Ananas comosus	10	0	0	0	1	0
Acanthus montanus	0	2	0	1	0	0
Raphia hookeri	1	0	0	0	2	0
Pterocarpus sp.	0	0	1	0	1	9
Musanga cercropiodes	0	0	4	0	0	0
Musa sapientum	0	0	4	0	0	0
Pteridium aquilinum	0	0	8	0	4	0
Heteranthera caulifolia	0	0	0	0	0	5
Costus schlecteri	0	0	1	0	0	0

Plant diversity analysis of the flood plain is shown on table 2. The result reveals that plot three had the highest number of Taxa (10) followed by plot five (8), plot one and plot four each had 4 taxa then plot two (3) and plot six (2). Also there were more individuals in plot three (31) than in other plots.

Table 2: Diversity Analysis of different plots of the flood plain

Plots	1	2	3	4	5	6
Taxa S	4	3	10	4	8	2
Individuals	17	10	31	8	18	14
Dominance D	0.42	0.38	0.18	0.34	0.19	0.54
Shannon H	1.07	1.03	1.96	1.21	1.83	0.65
Simpson 1-D	0.58	0.62	0.82	0.65	0.80	0.45
Evenness e^H/S	0.73	0.93	0.71	0.84	0.78	0.96
Equitability J	0.77	0.94	0.85	0.87	0.88	0.94
Berger-Parker	0.59	0.50	0.26	0.50	0.33	0.64

Table 3 shows the means of the physicochemical properties of the Point 1 (Middle of the reservoir) and Point 2 (5 meters from the water body). It shows that with respect to particle size, the sand fraction was the most abundant and had a mean value of 64.40±6.2% and 82.40±9.0% in point 1 and 2 respectively. Silt followed with a value of 7.60±3.7 in point 1 and 20.60±1.2 in the other. Clay fragments were the least of all the three soil physical components (11.0±2.0 in point 1 and 10.0±0.00 in point 2). The middle of the reservoir had a higher pH 6.2 while the other was 5.9. Total nitrogen ranged between 0.12±0.01 in point 1 down to 0.07±0.00 in point 2 while organic matter content ranged from 3.6±0.5 to 3.2±0.8 respectively in the study area. Available phosphorus was high in both soils (66.66±15.11 and 33.99±3.6 in point 1 and 2 respectively). The value for electrical conductivity was 0.102±0.001 in point 1 and 0.100±0.00 in point 2. The most abundant cation in the two flood plain was calcium (11.84±1.87 and 5.02±0.24) followed by magnesium (2.0±0.01 in point 1 and 1.82.0±0.16 in point 2). Sodium was the least abundant cation in the within and away (5.0m) from the water body. The value of base saturation was 70.98±4.0 in point 1and 69.84±2.0 in site 2 while the effective cation exchange capacity of 9.16±1.7 at the first point and 7.06±2.0 in the second. The table also revealed that exchangeable acidity was 2.09±0.08 in site 1 and 2.07±0.041

Table 3: Physical and chemical properties of the flood plain.

Particle size Analysis	Point A	Point B
Sand (%)	68.40±6.2	82.40±9.0
Silt (%)	7.6±3.7	20.60±1.2
Clay (%)	11.00±2.0	10.00±1.3
Textural Class	Sandy Loam	Loamy Sand
pH	6.20±0.14	5.90±0.00
E. conduct. (ds/m)	0.102±0.001	0.100±0.00
Organic matter (%)	3.6±0.5	3.2±0.8
Total Nitrogen (%)	0.12±0.01	0.07±0.00
Available Phosphorus (mg/kg)	60.66±15.11	33.99±3.6
Ca (Cmol/kg)	11.84±1.87	5.2±0.24
Mg (Cmol/kg)	2.0±0.01	1.8±0.16
Na (Cmol/kg)	0.06±0.00	0.07±0.02
K (Cmol/kg)	0.12±0.001	0.10±0.00
Exchange Acidity (Cmol/kg)	2.28±0.19	2.4±0.62
ECEC (Cmol/kg)	9.56±1.7	7.06±2.0
Base saturation (%)	70.98±6.20	69.84±4.0

DISCUSSION

The vegetation attributes of the floodplain ecosystem is as represented on Table 1. The study shows clearly that this ecosystem supports a good number plant species. According to Kumara, Raghavendra Gowda and Pramod (2011) numerical quantification of biological diversity and (or) its elements can be of great value because that kind of evaluation is objective and enables a comparison of current biodiversity status to be made between similar habitats. It further confirms that plant species growing in the same environmental conditions show marked variation in their response to nutrient limits. This result also reflected that both ecological diversity and dominance varied with plots. Generally, this work corroborates diversity trends which had earlier been proposed by Clarke and Warwick, (2001). He proposed that species diversity and dominance value varied together but inversely in different ecosystems. This is evident in this work in that Plots 3 which is the hallmark of plant diversity in the flood plain records the least dominance value whereas plot 6 which has the least Shannon-diversity index has the highest dominance value across the plots. The low species richness in plot 6 (which is the centre of the water body) is believed to be associated with the perpetual all year round anaerobic or hydric condition of the soil in this area and the inability of some of the species encountered to adapt to this stress factor. The dominating presence of *Pterocarpus milbreadii* emerging from the hydric soil indicates its affinity to high soil moisture regimes. The seedling of this plant seems to emerge from the enriched mud during the dry season, with a fast regeneration ability to withstand the prevailing water logging conditions in the wet season. Due to this, their presence is evenly spread within the water bound area of the flood plain. This is an indication that frequency and density of this species will continuously increase over time. Also, the presence of *Hetherantera caulifolia,*which is an aquatic macrophyte is characteristic for this ecosystem. The low values of frequency and density recorded for other species may be linked with their inability to fully adapt to environmental stress factors such as inundations and habitat degradation in the terrain. It could also be as a result of the slow rate of regeneration of these species which cannot compensate for mortality and exploitation rate. The high density of *Ananas comosus* species and the fact that it is confined to a single plot is suggestive of plantation agricultural systems. Same reason explains the high and the density of *Elaise guineensis* in some parts of the floodplain. The occurrence of high profile economic plant species such as *Elaeis guineensis, Dacryodes edulis, Carica papaya, Musa sapientum, Ananas comosus* etc is a reflection of anthropogenic interactions in the area which is a function of the economic value attached to this wetland. The equitability and evenness indices as computed in this work confirmed the views of Clarke and Warwick, (2001) who opined that both equitability and evenness indices increase with a decrease in species richness. The pH of the habitat was lower away from the water body but less acidic in the water front of the flood plain. This is believed to arise from the dissolution of soluble lime materials in the waterbound area than in the surrounding less humified land area. Generally, the moderate acidity of the floodplain could be linked to rapid decomposition of litter arising from dead plant materials which is facilitated by the action of bacterial and fungal populations which tends to thrive in damp and humid conditions. Similar trends had been reported by Young (1976). Young suggested that litter conversion begets organic matter production and usage by plants. The organic matter present in the soil serves as cations exchange complex and so the moderateness of the often moist parts of the plain results due to sufficient availability of cations in the soil. Also the distribution of cations in this study plots corroborates with Young's (1976) views. Isichei, (1982) observed that organic matter and total nitrogen most often than not vary together. This pattern is evident in this research as these soil factors tend to increase more in the parts of the flood plain with higher soil moisture content. Again, this could be linked to the dampness in the soil of these areas which is a credit factor to the multiplication and enhancement of the activities of decomposers (bacteria, fungi, worms etc) who then act on available organic substrate (dead leaves and enriched sediments) to produce this results. Again Treshow, (1970) showed that soil texture determines the capacity of the soil to absorb heat energy. This heat retention, which differs based on the soil texture, could be regarded as a culprit in the process of breaking down of dead plant materials at different points in the studied site leading to marked variability in nutrient distribution in the wetland.

Jones and Wild, (1975) posited that soil texture contributes to the presence of soil nitrogen since its availability is proportional to organic matter status of the soil which relies on the soil clay content. This explains the enhanced nitrogen content in the clay rich soils of the flood plain compared to the values reported for garden soils by Mbong, et al. (2013). Other researchers had observed that there is a negative significant relationship between total nitrogen and silt relating that a high value of silt soils is associated with nitrogen deficiency in wetlands (Mbong, 2013). This trend has been observed in this research. Shukla and Chandel (2008) had reported that the nitrogen content in surface soils range between 0.02-0.5% and that soil nitrogen occur as part of organic molecule. This is evident in this research. This result also revealed that Ca was higher in point A (at the centre of the water) than in point B (at the margins of the water). Calcium is a principal constituent of plant as calcium pectate which resides within the middle lamella of the plant cell wall. It is irreplaceable by any other element. It provides a base for the neutralization of organic acids and is concerned with the growing root apices (Mbong, 2013, Verma and Verma, 2007). This forms the bases for a fairer pH at the first sampling point. It is also believed that it contributes to healthy root development. This very necessary in this context, in that shrubs and tree species growing in the water body need healthy roots which will provide anchorage against wind current.

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