Sjournals
Scientific Journals
Scientific Journal of Biological Sciences (2012) 1(2) 43-51

Contents lists available at Sjournals
Scientific Journal of
Biological Sciences
Journal homepage: www.Sjournals.com

Original article

Soil-vegetation relationship in fresh water swamp forest

R.M. Ubom*, F.O. Ogbemudia, K.O. Benson
Department of Botany and Ecological studies, University of Uyo, Uyo, Akwa-Ibom State, Nigeria

*Corresponding author; Department of Botany and Ecological studies, University of Uyo, Uyo, Akwa-Ibom State, Nigeria

A R T I C L E I N F O

Article history:
Received 18 August 2012
Accepted 26 August 2012
Available online 29 August 2012

Keywords:
Soil
Vegetation
Fresh water swamp forest
Akwa Ibom

A B S T R A C T

Soil and vegetation relationships were studied in freshwater swamp forest in Ikot Umiang Ede in Etinan Local Government Area, Akwa Ibom State. The systematic sampling method was used to sample the vegetation in 10 x 10m quadrats. Plants were identified to species level. Frequency, density, height, basal area and crown cover were determined for each species. In each quadrat two soil samples were taken and then bulked into a composite sample. A total of 40 soil samples were collected. Soil physiochemical properties were analysed in the Soil Science Laboratory of University of Uyo, Uyo. The results showed that *Elaeis guineensis* was the dominant species with 40% frequency of occurrence, while 11 plant species had the least occurrence of 5% frequency. They are *Baphia nitida, Cyrtosperma senegalensis, Homalium letestui, Marantochloa cuspidata, Nauclea diderrichii, Poga oleosa, Palisota hirsuta, Smilax anceps and* Smilax *kranssiana. Bambusa vulgaris,* had the highest density of 760 ± 62.8 stem /ha while *Palisota hirsuta* had the least density of 2.15 ± 0.00 stems/ha. *Zanthoxylum zanthoxyloides* was the tallest plant with a height of 21.00±0.00m while *Poga oleosa* and *Palisota hirsuta* were the shortest species with a height of 0.01 ± 0.00m each. The soil was acidic (5.25 ± 0.11). Organic carbon, total nitrogen and potassium were low with mean values of 4.57 ± 0.25cmol/kg, 0.39 ± 0.02cmol/kg and 0.29 +0.00cmol/kg respectively. Exchangeable cations were low. Among the heavy metals, Fe had the highest mean value of 184.0 ± 52.54mg/kg. The soil had a high sand content (65.45 ±00.93%) and low silt and clay contents 23.25 ± 0.49 and 11.77±0.92%, respectively. Linear regression shows that, the relationship between soil parameters and plants density, height, crown cover and basal area were positive; indicating that soil parameters forms part of constellation of factors determining the existence of plants in the freshwater swamp.

1. Introduction

Vegetation and Soil are inter-related and exert reciprocal effects on each other. This is because soil gives support in terms of moisture, nutrients and anchorage to vegetation to grow effectively on the one hand, and on the other, vegetation provides covers for soil, suppresses soil erosion as well as helps to maintain soil nutrients through liters accumulation and subsequent decay (Eni *et al.,* 2001). Vegetation strongly affects soil characteristics, including soil volume, chemistry and texture, which feedback affects various vegetation characteristics including productivity, structure and floristic composition (Agren and Bosatta, 1996).

The complexity of the relationships between the vegetation and the soil makes the soil one of the major factors determining the vegetation performance (Kusman and Kozlawski, 1990). Soil nevertheless is fundamental to ecosystem, agricultural sustainability and production because it supplies many of the essential requirements for plant growth like water, nutrients, anchorage, oxygen for roots and moderated temperature (Jensen *et al.,* 1990). The dynamic interaction between vegetation and soil is so strong that it is unclear which is dominant (Archibold, 1994). Brady and Weil (2004) observed that the physical, chemical and biological properties of the soil affect its productivity. Soil productivity is highly influenced by several balances including soil temperature, water, air balance and soil fertility (Brady and Weil, 2008). Freshwater swamp forest grows on fertile alluvial soils and the wide variety of soils are reflected in a diversity of vegetation type that range from grassy marshes to palm or pandanus dominated forest which is similar in structure and composition to lowland rainforest (IUCN, 1991). Trees in freshwater swamp forests endure prolonged periods of flooding, causing the soil to become anaerobic. Pneumatophores, specialized respiratory structures on the roots, are common on many trees species and assist in respiration during oxygen-poor periods. Emergent trees attain height of 50 – 60m. The floras of the freshwater swamp forest are influenced by tidal effects, salinity, siltation, river mouth accretion, flood profile and illumination. The vast floodplains of the freshwater swamps forest are extensively cultivated in certain areas during the dry season (IUCN, 1991). The dominant species in freshwater swamp forest community is an indication of species ecological optima and consequently the level of competition and adaptation in which they achieve. Nutrients and water availability to plants are the determinants of the variation in vegetation structure (Walker, 1987). Sanford and Isichei (1986) stated that patterns of vegetation occur in relation to soil characters. Shallow soils have decreased moisture availability, increased leaching of nutrients, increased soil temperature which together affect vegetation pattern. Hence, soil exerts a substantial influence upon the type of vegetation community present in a given locality (Young, 1976), and vegetation influences soil properties directly or indirectly. Vegetation supplies humus through litter fall, thereby adding organic matter and retains soil surface nitrogen (Muoghalu and Riley, 1989). Soil is protected by vegetation it supports which indirectly determines the rate and quantity of organic matter addition (Bormann *et .al*, 1974). 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 (Ukpong, 1991). This is because the level of response and adaptation of the properties of the soil create a distribution of pattern for the vegetation (Ukpong 1991). Hence, the hypothesis is that the distribution pattern and performance of any vegetation is greatly influenced by the physiochemical properties of the soil. The present study examines the soil-vegetation relationship of freshwater swamp forest of Ikot Umiang Ede in Etinan Local Government Area using a regression analytical approach in order to determine critical vegetation and soil properties that sustain this integrative association.

2. Materials and methods

2.1. Study area

The study was conducted in a freshwater swamp forest at Ikot Umiang Ede in Etinan Local Government Area, Akwa Ibom State. The area is situated between longitudes 7^o50 and $8^o00`$ E and between latitudes $5^o30`$ and 7^o00N (Ukpong *et.al*, 2001). The area of this swamp forest is made up of recent deposit of sand, clay and mud. The forest covers about ten hectares in area and contains various floral components. The topography is plain/flat, the surrounding lands are cultivated. The study area being in the typical rainforest zones of south-south Nigeria is marked with a distinct rainy and dry season with most of the rainfall occurring between February and October with annual rainfall of between 2000 and 300mm. The average relative humidity is about 80% with up to 95% occurring during the rainy season while the duration of the dry season is November to April (AKSG, 2008).

2.2. Vegetation and soil sampling

Systematic sampling method was used in sampling the area (Knight, 1978), species were sampled in 10m x 10m quadrat, spaced at regular interval of 20m. Plants were enumerated and species were properly identified to the species level. Vegetation measurement includes the frequency of plant species, density, basal area, height and the crown cover of the plant species encountered. Tree height was measured with a Hagar Altimeter. Diameter at breast height was measured with a girthing tape; crown cover was obtained by the crown diameter method (Mueller Dambois and Ellenberg, 1974). In each of the quadrants two soil samples were obtained to a depth of 40cm using soil auger. The soil samples were put in plastic bags and transferred to the soil science laboratory for further treatment and analysis.

2.3. Physicochemical Analysis of Soil Samples

Soil samples were analyzed following the standard procedures outlined by the Association of Official Analytical Chemist (AOAC, 1975). Soil pH was measured using Beckman's glass electrode pH meter (Meclean, 1965). 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 sodiumhexametaphosphate 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.

3. Results

3.1. Vegetation analysis

Vegetation floristic analysis in Table 1 shows the mean values of the vegetation characteristics of the vegetation studied. The results showed that 28 plant species were identified from the study area. The plant species belonged to 22 families and 27 genera. The family Fabaceae had the highest number of species while the family Arecaceae, Smilacaceae and Euphorbiaceae had 2 numbers of species each. The species were made up of 27 genera. *Elaeis guineensis* had 40%, highest frequency while *Baphia nitida* had the least frequency of 5%. *Bambusa vulgaris* had the highest density of 760 ± 62.8 stems/ha followed by *Elaeis guineensis* and *Uapaca staudtii* with the density of 260 ± 1.00 stems/ha each respectively, while *Palisota hirsuta* had the least density of 2.15 ± 0.00 stems/ha. *Zanthoxylum zanthoxyloides* was the tallest plant with a height of 21.00±0.00m, while *Poga oleosa* was the shortest plant with a height of 0.01 ± 0.00. *Zanthoxylum zanthoxyloides* had the largest girth size of 0.82± $0.01m^2$/ha, and the largest crown cover of 94.99 ± 15.71^2/ha while *Marantochloa cuspidata* had the least crown cover value of 0.09 ±$0.02m^2$/ha.

3.2. Soil analysis physiochemical properties

Table 2 represents means of the physiochemical properties of soil of the vegetation in Ikot Umiang Ede, Etinan. It shows that the sand fraction was the most abundant with mean value of 65.45 ± 0.93%, followed by silt with mean value of 23.25 ± 0.494% while clay had the lowest mean value of 11.77±0.92%.

Table 1
Mean (±SE) vegetation characteristic in Ikot Umiang Ede, Etinan L. G. A.

S/N	Species	Family	Freq. (%)	Density (Stem/ha)	Heights (m)	Basal area (m^2/ha)	Crown cover (M2/ha)
1	*Anthodeista vogelii.* Planch	Loganiaceae	10	40.00 ± 0.00	12.00 ±0.00	0.07 ± 0.01	20.12± 13.04
2	*Baphia nitida* lodd	Favaceae	5	60.00 ±0.00	0.90 ±0.00	-	0.34 ±0.21
3	*Bambusa vulgaris*Schrad. ex. J. C. Wendl	Poaceae	15	670 ±62.8	8.70 ±2.59	0.01 ±0.00	2.55 ± 0.27
4	*Cyrtosperma senegalensis* (schott) Engl.	Araceae	15	220 ±1.26	1.49 ± 0.26	-	0.037 ±0.08
5	*Cola argentea* Mast.	Sterculiaceae	5	40±0.00	4.50 ±0.00	0.01 ±0.00	7.27 ±2.35
6	*Coelocaryon preussi.* Warrb	Myristicaceae	10	60.00± 0.00	14.25 + 1.74	0.11 ± 0.02	36.11±8.91
7	*Costus schlecterii.*(De Wild. Th. Dur. Merri)	Costaceae	5	60.00± 0.00	1.46 ± 0.00	-	0.47 ±0.17
8	*Elaeis guineensis* Jacq.	Arecaceae	40	260± 1.00	15.00±1.97	0.43 ± 0.04	39.38±9.02
9	*Zanthoxylum zanthoxyloides* Lam	Rutaceae	5	20.00 ± 0.00	21.00±0.00	0.82 ± 0.01	94.99±15.71
10	*Homalium letesui*-Pellegr.	Salicaceae	5	40.00± 0.01	17.01 ± 1.74	0.43 ± 0.07	53.87 ±9.71
11	*Lasienthera africanum* P. Beauv.	Icacinaceae	15	180.00±0.00	1.00 ± 0.09	0.01 ± 0.00	0.48 ± 0.18
12	*Macaranga barteri* Mull. Arg	Euphorbiaceae	10	120.00±0.00	3.65 ±2.05	0.02 ± 0.00	3.76 ± 0.95
13	*Marantochloa cuspidata*. (Rosc) Milne.Redh	Marantaceae	5	60.00 ±0.00	0.76 ±0.00	-	0.09 ± 0.02
14	*Musanga cecropioides* R. Br.	Cecropiaceae	20	80.00 ±0.00	10.13 ± 1.87	0.16 ± 0.12	44.50± 16.46
15	*Nauclea diderrichi (*De. Wild. ST. Durand) Mirril.	Rubiaceae	5	40.00 ±0.00	4.00 ± 0.00	0.01 ± 0.00	8.74 ± 3.83
16	*Oxystigma mannii* (Baill) Harms.	Fabaceae	15	120.00±0.00	10.00 ± 2.08	0.09 ± 0.02	18.48 ± 3.23
17	*Poga oleosa* (Pierre) Ridl	Anisophylleaceae	5	16.00 ±0.01	0.01 ± 0.01	0.01 ± 0.00	15.85 ± 0.00
18	*Palisota hirsuta* (thum) K. Schum	Connaraceae	5	2.15 ±0.00	0.01 ±0.00	0.25 ± 0.14	0.55 ±0.09
19	*Pteris filismas* Willd	Salviniaceae	10	120.00±0.00	1.40 ±045	0.25± 0.14	0.39 ±0.16
20	*Pterocarpus mildbraedii* Harms	Fabaceae	10	120.00±0.00	3.85±2.45	0.02 ±0.00	9.52 ± 1.40
21	*Pentaclethra macrophylla.* Benth.	Fabaceae	10	60.00±0.00	10.50±0.50	0.05 ±0.00	12.63 ± 5.56
22	*Raphia hookeri G. Mann* & H. Werdl.	Arecaceae	15	60.00±0.00	8.60 ±1.78	0.23 ± 0.05	33.69± 5.89
23	*Symphonia globulifera* Linn. F.	Clusiaceae	15	140.00±0.00	17.00±1.74	0.25 ± 0.06	10.79 ± 4.00
24	*Smilax anceps* willd.	Smilacaceae	5	80.00 ±0.00	-	-	-
25	*Smilax kranssiana* Meisn	Simlacaceae	5	100.00±0.00	1.00±0.00	-	0.18± 0.07
26	*Selaginella martensii* Linn	Selaginallaceae	20	-	-	-	-
27	*Uapaca staudtil welw*	Euphorbiaceae	35	260.00±0.00	11.70±1.80	0.11 ±0.03	26.57±7.53
28	*Harungana madagascariensis* lam.ex.poir.	Hypericaceae	10	26.70 ± 5.16	15.30 ±0.88	0.25 ±0.14	72.52 ±5.33

The soil textures was sandy loam the pH of 5.25 ± 0.11 indicated that the soil was acidic. The most abundant cation was calcium with the mean value of 4.28 ±0.08 cmol/kg followed by magnesium with value of 1.41 ±0.03 (cmol/kg while sodium ranked last with the mean value of 0.13 ±0.00 cmol/kg. organic carbon, total Nitrogen and electrical conductivity with the mean values of 4.57±0.25, 0.39 ±0.02 and 0.14 ±0.02 respectively were relatively low. Base saturation was high with the mean value of 67.54 ± 2.31%, while available phosphorus had the mean value of 8.81 ± 1.42. Considering the heavy metals concentrations in the soil, iron had highest value with mean of 184.01 ± 52.54mg/kg, followed by Manganese with the mean of 12.09 ± 0.24mg/kg while Lead had the least mean value of 4.26 ± 0.36mg/kg.

Table 2

Mean physiochemical properties of the study area.

Soil properties	Unit	Value
pH		5.25 ± 0.11
Electrical conductivity	(ds/m)	0.14 + 0.02
Organic carbon	(%)	4.57 ± 0.25
Total Nitrogen	(%)	0.39 ±0.02
Available phosphorus	(mg/kg)	8.81 ± 1.42
Calcium	(cmol/kg)	4.28 ± 0.08
Magnesium	(cmol/kg)	1.41 ±0.03
Sodium	(cmol/kg)	0.13 ± 0.00
Potassium	(cmol/kg)	0.29 ± 0.00
Exchangeable Acidity (EA)	(cmol/kg)	3.17 ± 0.37
ECEC	(cmol/kg)	8.75 ± 0.43
Base saturation	(%)	67.54 ± 2.31
Iron	(mg/kg)	184.01 ± 52.54
Zinc	(mg/kg)	5.46 ± 0.33
Copper	(mg/kg)	6.37± 0.32
Manganese	(mg/kg)	12.09 ± 0.24
Lead	(mg/kg)	4.26 ± 0.36
Sand	(%)	65.45 ± 0.93
Silt	(%)	23.25 ±0.49
Clay	(%)	11.77 ± 0.92
Soil Texture		Sandy loam

3.3. Relationship between vegetation characteristics and soil parameters

Figure 1, 2, 3 and 4 show relationships between soil parameters and plant density, Height, Basal area and crown cover. All these figures show a positive relationship between soil parameters and vegetation characteristics. This pattern of relationship indicates that as the soil parameters increase, the plant density, Height, basal area and crown cover also increase.

4. Discussion

The frequency, density, basal area and crown cover in the vegetation reflected species responses to environmental factors. Krebs (1994), pointed out that basal area is an important measure of species performance. Table 1 show that the vegetation variables varied considerably. The variability in the values of height, density, basal area and crown cover of some plant species portrayed their ability to adapt to environmental factors which include soil pH, soil texture, organic carbon, availability of cation and available phosphorus. The low level of species height, density, basal area and crown cover may be due to their poor adaptability to environmental stresses such as habitat degradation, fluctuation in nutrient and acidic level of the soil in the freshwater swamp forest, (Archibold, 1994). Table 2, has revealed that the soil of the vegetation ecosystem is acidic and typically sandy loam sand and has low concentrations of plant nutrients. The results of particle size distribution indicated that the soil sample were prominently sandy with low content of silt and clay. Sandy soil holds less organic matter than clay. The clay fraction is a source of plant nutrient and of cation exchange capacity. Clay plays a cementing role between mineral particles and enhances soil water –retaining and nutrient holding capacities. The low content of clay in the soil must have contributed to low cation contents. Webster and Wilson (1980) agreed with this fact and stated that soil texture influences the nutrient status and water holding capacity of the soil pointing out that soil texture also affects the presence of the soil Nitrogen content. The acidic nature of the soil results in low values of nutrients as observed in this study. The percentage organic carbon present was low and this reflected the level of humus contents in the soil. This could be attributed to decomposition of dead roots, and leaves under the action of soil bacteria and fungi (Nwoboshi, 2000). Observation showed that there was less humus present in the soil of the freshwater swamp forest vegetation.

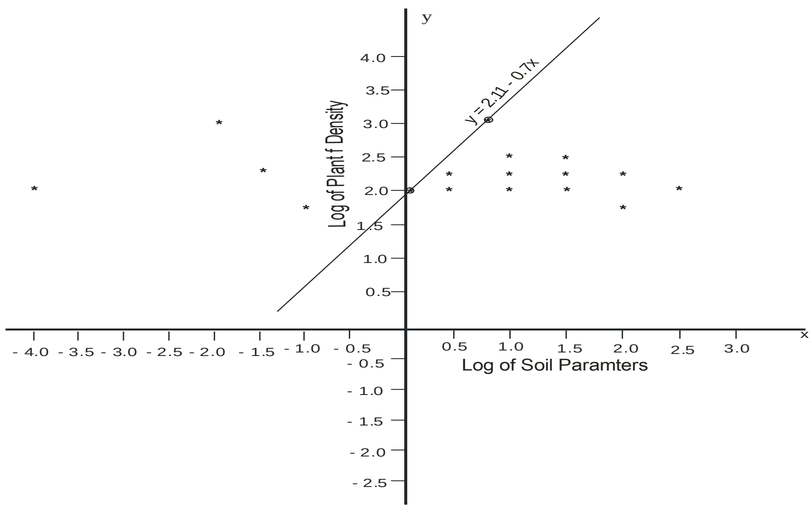

Fig. 1. Relationship between plant density and soil parameters.

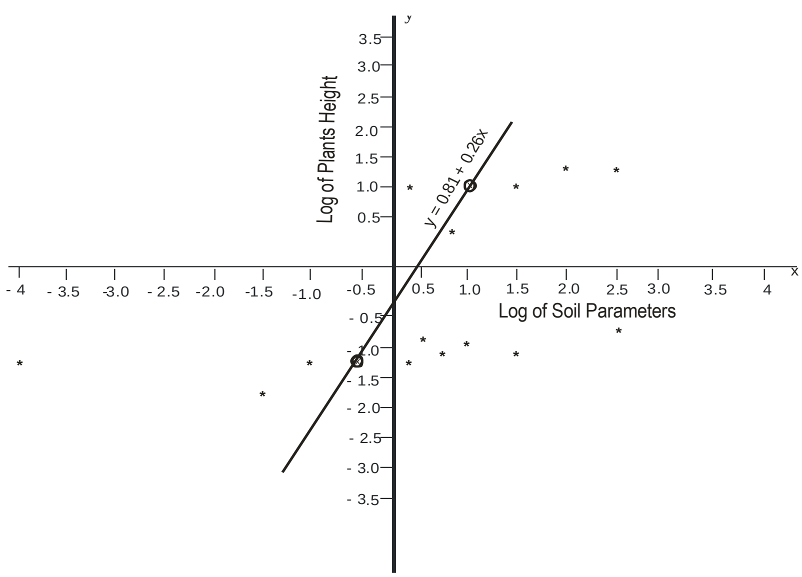

Fig. 2. Relationship between plant heights and soil parameters.

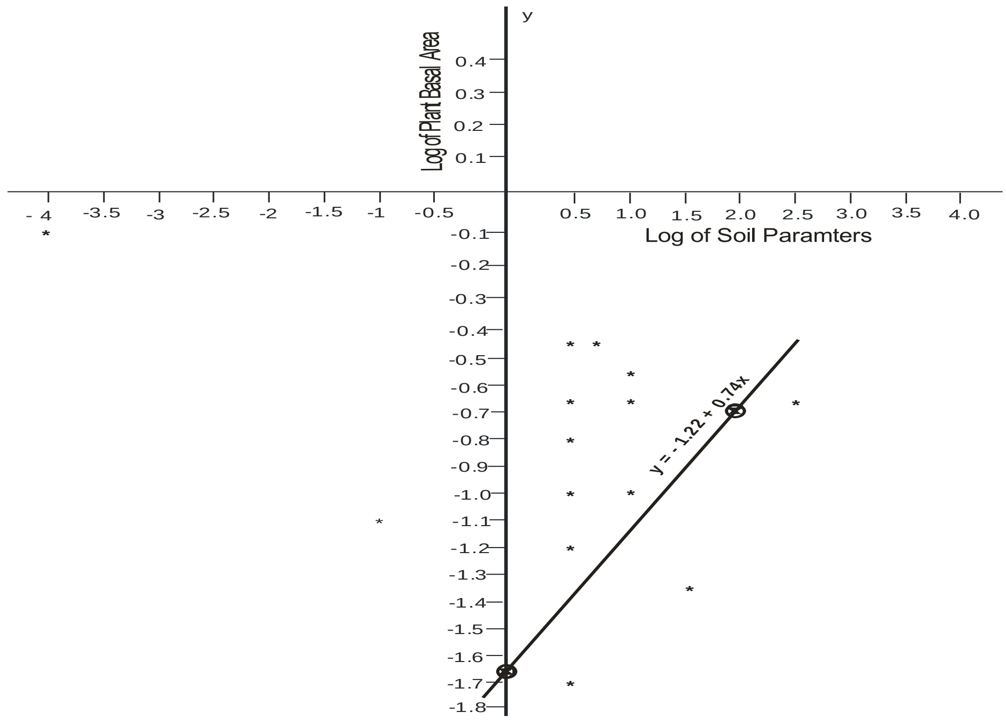

Fig. 3. Relationship between plant basal area and soil parameters.

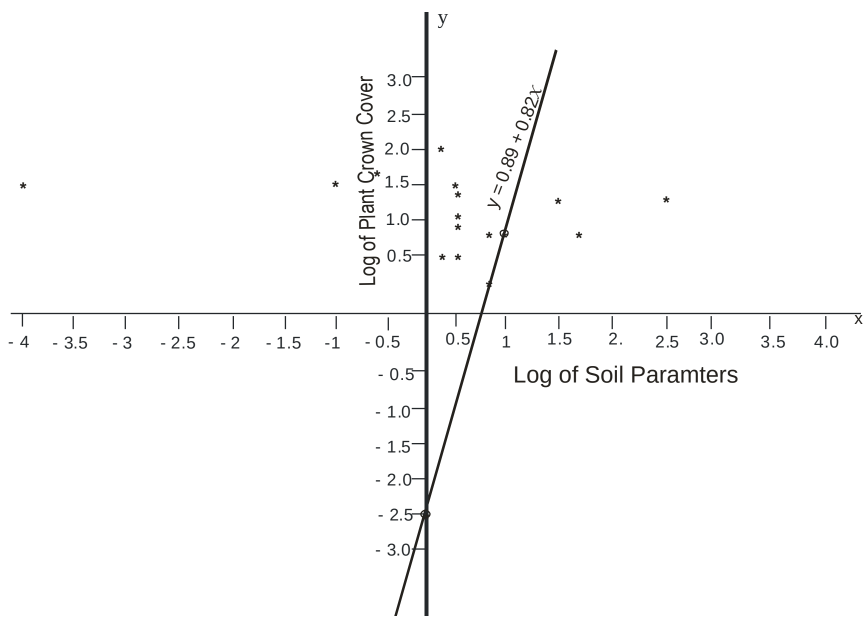

Fig. 4. Relationship between plant crown cover soil parameters.

The supply of nutrients to plant in appropriate quantities at the correct time is essential for plant growth. Hence, organic matter content improves soil structure and root penetration, moisture retention, resistance to erosion; maintenance of nitrogen and phosphorus levels and increase in exchange capacity of the soil (Bicklehaupt, 2002). Low values of total nitrogen, potassium, calcium, Electrical conductivity and magnesium may have led to the sparse distribution of plants observed within the study area. Availability of iron in the soils shows that the soil is highly weathered. Heavy metals such as zinc, copper, manganese and lead were relatively low.

Regression is a biometric method that obtains an indication as to whether there is any interrelationship or association between variables. It discovers the nature of the association between these variables. Soil parameters in this study seemed to have an association with the plant density, height and crown cover and basal area positively. Biometric methods are quantitative procedure of measuring relationships among samples for which comparism are made. The techniques used in this work explained variation in ecological response variable obtained in the result. This distribution of species could have varied as a function of other factors including a biotic factor. Conclusively, the results of this present study showed that soil properties have a major impact on vegetation nutrition, growth and distribution. Some of the important factors are the pH, nutrients, and soil texture (sand, silt and clay). The positive interactions of the plant species with the soil parameters indicated their importance in the vegetation ecosystem. The plant species show adaptation or tolerance to the varying ranges of pH, though some species may be restricted to certain pH ranges (Krebs, 1994).The Biometric methods used in this work compared the degree of relationships in vegetation composition and the soil properties among samples for which comparisms were made. Regression plays a role by providing estimation technique for determining the form of relationship best suited for the patterns exhibited by the measured data.

5. Conclusion

The results of this research showed that there is actually a complex relationship between the vegetation growth, distribution and the soil properties. The information obtained from this research could be essential for the management and conservation of our vegetation ecosystems and measures should be taken to increase and conserve organic matter, since it is an important soil component that enhances soil fertility by natural regeneration.

References

AKSG, 2008. Geography and Location. About Akwa Ibom State. www.aksgonline.com. Retrieved 17-12-2010.

Agren, G.L., Bosatta, E., 1996. Theoretical Ecosystem Ecology understanding elements cycles. Cambridge University press, Cambridge 187p.

AOAC, 1975. Association of Official Analytical Chemist. Methods of Analysis, 12th edition. AVI Publishing Company Inc. Washington DC. 986p.

Archibold, O.W., 1994. Ecological of World vegetation New York. Pp. 50 – 52.

Bickelhaupt, D.I., 2002. Salinity in the south Greek catchment of western Sydney. J. Ecol. 30, 61 – 82.

Bormann, F.H., Likens, G.E., Sicama, T.G., Eaten, J.S., 1974. The export of Nutrient and recovery of stable conditions following Deforestation at Husband Brook. Ecol. Monograph. 44, 55 – 277.

Brady, N.C., Weil, R., 2008. The nature and properties of soils. 14th ed. Prentice Hall. Upper Saddle River. New. York. 975p.

Chesworth, N.W., 2008. Encyclopedia of soil science. Springer verlag Dordrecht ISBN, 14020 39948 pp 78 – 80.

Cochran, W.G., 1963. Sampling Techniques 2nd ed. Wiley Eastern Limited, New Delhi, 413p

Eni, D.D., Iwara, A.I., Offiong, R.A., 2001. Principal component Analysis of soil. Vegetation interrelationships in south-southern secondary forest of Nigeria. www.hinidawi.comjournal. 18, 148 – 158.

IUCN, 1991. World Conservation Strategy: living resource conservation for sustainable development. Washington D. C. Ecology and Society, 59, 39 – 45.

Iwara, A.I., 2009. Impact of Road construction on soil and vegetation resources in Tinapa Area, Cross River State. Unpublished M. Sc. Thesis submitted to the Dept. of Geography, University of Ibadan, Nigeria.

Jackobson, S.T., 1992. Chemical Reactions and Air Change during Decomposition of Organic matter. Res. Conserve Recycle. 6, 259-266.

Jackson, M.I., 1962. Soil chemical Analysis. Englewood Cliffs, Prentices – Hall Inc. New Jersey 498 p.

Jensen, M.E., Simonson, G.H., Dosskey, M., 1990. Correlation between soils and Sagebrush dominated plant communities of Northeastern Nevada. Soil Sci. Soci. Amer. J. 54, 902 – 910.

Knight, D.H., 1978. Methods for sampling vegetation: Manual Ark Industries, Laramic Wyoming 87pp.

Kramprath, E.J., 1967. Conservation of soils and Tissue Testing for accessing the phosphorus status of soils. In: The Role of phosphorus in Agriculture. Khagwnch (ed). Ameri. Soci. Agro. pp. 433-469

Krebs, C.J., 1944. Ecology. The Experimental Analysis of Distribution and Abundance., 4th ed. Harper and Row Publishers, New York. 76p.

Kusman, P.L., Kozlowski, T.T., 1990. Physiology of Trees. McGraw Hill, Book Co., New York. 642p.

Meclean, I.O., 1965. Aluminum. Agro. J. 9, 978-988.

Muller, D., Ellenberg, H., 1974. Aims and methods of Vegetation ecology. John Wiley, London 498pp.

Muoghulu, E., Riley, J.P., 1989. Available phosphorous determination. And chan. Acta, 27, 31 – 36.

Nwoboshi, L. C. (2000). The Nutrient Factor in Sustainable forestry. Ibadan University Press, Ibadan. 287p.

Sanford, W.W., Isicher, A.O., 1986. Savanna In: G. W. (ed). Plant ecology in West Africa. John Wiley and Sons, Obickester. Pp 149 – 195.

Suzuki, D., 1997. The Sacred balance: Rediscovering our place in nature. MIR Publisher MOSCOW.

Udo, E.J., Ogunwale, J.A., 1986. Laboratory Manual for the Analysis of Soil, Plants and Water Sample. University of Ibadan Press, Ibadan.

Ukpong, D., Akpan, M., Akang, N., 2001. Ikono the Gradle of Ibiobio; Historical origin and cultural heritage. Doranol Publishers, Uyo.

Ukpong, I.E., 1990. Performance and distribution of species along soil salinity gradients of mangrove swamps in southeastern Nigeria. Vegetatio. 95, 63

Walker, B.H., 1987. A general model of savanna structure and function. In: Determinants of Tropical Savannas. Ed: Walker, B. H. pp 1 – 12 Iesu press, Maimi

Webster, J.P., Wilson, C.L., 1980. Nutrient Recycling and stability of Ecosystems. Pp 1 – 27 In: Howell, F. Gentry.

Young, A. (1976), Tropical soils and soil survey. Cambridge University Pres, Cambridge. 468p.