

Influence of flora species on soil properties in Inyang Etim Ekpo River Valley, Akwa Ibom State, Nigeria

Enyiekere, S. I., I¹ & Offiong, R. A.²,

¹Nigerian Senate, National Assembly, FCT, Abuja, Nigeria

²Department of Geography and Environmental Science, University of Calabar, Calabar

Corresponding Author: raphyxx5@gmail.com

Abstract

This study focused on the influence of flora species on soil properties in Inyang Etim Ekpo River Valley, Akwa Ibom State, Nigeria. The main aim of this paper is to examine the major vegetation variable that influences soil properties in the study area. The data for the study was collected through direct field observation, measurement and enumeration. The vegetation and soil parameters were collected in a laid out quadrat of 100m X 100m at 100m interval. The soil samples were taken to the laboratory for analysis. The Principal Component Analysis (PCA) and Multiple Regression Analysis (MRA) were used in analysing the data. The result showed that when the soil components were regressed on the vegetation components, only herbaceous species composition was responsible for 26.8% of the changes that took place in topsoil exchangeable bases. From the study analysis, the ANOVA result showed that herbaceous species composition significantly influenced topsoil cation ($F = 4.757$, $p < 0.05$). The result also identified herbaceous species composition to exert significant influence on topsoil exchangeable bases ($t = 2.181$, $p < 0.05$). Further, the herbaceous species composition was the major vegetation parameter that influenced soil properties. This is as a result of the high positive relationship between the herbaceous species composition as against basal cover and girth on the topsoil exchangeable bases such as Ca^+ , Mg^+ , K^+ , Na^+ , and NH_4^+ . The study therefore recommends that the anthropogenic activities that lead to deforestation and removal of herbaceous species in the Inyang Etim Ekpo River Valley should be discouraged.

Keywords: Influence; Flora composition; Soil Characteristics; Inyang Etim Ekpo; River valley

Introduction

Plant species distribution plays an important part in the Earth Systems (soil, water, and atmosphere), which render an essential service(s) to both the ecosystem and human societies. However, vegetation helps in supporting the functions of soil, which include decomposition, nutrient cycling, soil respiration, invasion resistance, and ecosystem stability (Berendse, Van Ruijven, Jongejans, & Keesstra, 2015). Hence, soil biodiversity on the other hand, in turn provides many ecosystem services to the environment, such as the avoidance of environmental contamination through cycling of dead biomass. Also, soil biota plays a significant role in determining the soil physicochemical properties. Plants species in particular, have been reported to play a role in shaping soil profile with the diverse architecture of their root systems, being the center of soil-plant-microbial interactions (Brevik, Cerdà, & Mataix-Solera 2015).

Nevertheless, vegetation has immensely contributed to the stocking of soil organic carbon, which is essential for good soil structure and nutrient availability that support the soil biota and above ground productivity. Higher organic carbon concentration and storage were reported under vegetated lands compared with those in bare fields (Debasish-Saha, Kukal, & Bawa, 2014). Trees create a unique microenvironment around them by positively modifying their underneath soil physicochemical properties and by direct influence on sunlight and atmospheric conditions. Transpiration and canopy are the main factors affecting air temperature, wind speed, the quantity and quality of light, and soil temperature, pH, moisture, and nutrient availability (Zemmrch, Manthey, Zerbe, & Oyunchimeg, 2010). The change in soil physicochemical properties depends on the litter quality and quantity and the canopy architecture, which in turn depends on the tree species.

Flora species diversity tends to have also influenced soil properties of given ecosystem around them through litter-fall input, which is relative to the tree species and individual sizes. Some studies have showed that soils are sandier and slightly acidic under canopies of medium and large trees compared to small trees, which have slightly alkaline soils and that soils in the tree interspaces have significantly higher silt and clay content than beneath trees (Zhang, Shao, & Ma, 2011). Hence, edaphic factors distribution such as, organic matter, nitrogen, phosphorus, and potassium, as well as microbial activities, becomes spatially and vertically concentrated under the tree canopy. Elsewhere, soils under canopies were found to have significantly higher levels of organic matter, calcium, magnesium, and pH than those in open grassland as reported by (Mlambo, Nyathi, & Mapaire, 2005).

Generally, vegetation contributes significantly to the control of soil erosion, which is a serious threat to ecosystem functioning in many parts of the world. It was reported that the magnitude of impact of plants in rendering ecosystem services, particularly in controlling soil erosion, depends on structural architecture of the plant's morphologies (roots systems, crown shape and size, etc.), which in turn depends on the species (Seitz, Goebes, Song 2015). Hence, diversity within vegetation has been shown to have remarkable effects on ecosystem functions and stability. More often, increasing biodiversity enhanced ecosystem productivity and stability. For example, Seitz et al. (2015) report that tree monocultures in afforestation have only limited mitigation potential for soil losses and that there is growing evidence that higher species richness can reduce soil erosion. Therefore, plant species can influence the composition of underlying soil microbial communities as observed by (Garbeva, Postma, Van Veen, & Van Elsas, 2006). These influences can be due to differences in forest cover, rooting depth, and litter quality and quantity or to secondary effects on soil pH, moisture, and nutrient levels. Microbes (bacteria, archaea, fungi, and protozoan) are very important in all processes related to soil function (Adekunle & Dafiwhare, 2008). Hence, the study seeks to examine the influence of flora species on soil properties in Inyang Etim Ekpo River Valley, Akwa Ibom State, Nigeria.

Material and methods

Etim Ekpo Local Government Council lies within latitudes $4^{\circ} 0'$ and $34.2''$ N of equator and longitudes $7^{\circ} 37' 11.64''$ and $8^{\circ} 48''$ East of the Greenwich meridian. As a distinct geographical expression it is located 50km from Uyo the capital city of Akwa Ibom State. Etim Ekpo Local Government Area is bounded in the North by Abak Local Government Area, South by Azunimi in Abia State, East by Ukanafun Local Government Area, West by Ika Local Government Area and Essien Udim Local Government Area. It comprises of seventy four (74) villages and five (5) clans (Utu, Uruk, Ikono, Obong and Utut anang clan). It occupies 183.3 square kilometers with Utu Etim Ekpo town as the headquarter (Essien, 2010). Statistically, Etim Ekpo Local Government Area has a population of over 105,418 people of which males are 55,771 and females 49,647 (National Population Commission, 2006) and a projected population figure of (148,800) as at 2016. Topographically, the land is flat with no part of it rising beyond 180 meters above sea level. The river is very unique and to a greater extent serves as a hotspot to some indigenous people (s) who are deriving their source of income from the river. The rainy season in Etim Ekpo commences in late march and lasts till October while the hot dry season is usually in the months of February and March. The chilly harmattan weather is often associated with fog. The vegetation of the area along the river valley include trees (*Elaeis guineensis*), Bamboo (*Bambusa africana*), plantain and banana (*Musa spp*), and guinea grass (*Panicum maximum*). The common activities across the entire stretch of the river are fishing and agricultural crop farming especially during the dry season.

Research design: The study employed experimental research design in the data collection through direct field observation and measurement.

Types of data: Floristic composition of the riparian forest ecosystem in the study area (nominal scale of measurement), structural composition of the tree/shrub species in the area (ratio scale of measurement) and soil physico-chemical properties in the study area (ratio scale of measurement).

Sources of data: The data source for this study was obtained from primary. Primarily, data on flora species, floristic and structural composition were collected from the vegetation component at 500m radius on the alignment of the Inyang Etim Ekpo River. In the same vein, the edaphic (soil) components were collected from the adjoining soils along the river stretch.

Sampling techniques and procedure: The data for the study were sampled using simple random sampling technique, systematic and stratified sampling techniques. Systematically, the river valley was segmented into quadrat within the Utu Etim Ekpo community. The total numbers of quadrats were forty at opposite direction (twenty on each side) of the river valley at 100m interval. Given this scenario, vegetation samples were collected from ten quadrats of 100m X 100m which was further reduced into 10mx10m for easy access, identification and enumeration of vegetation at the alternate direction. Lastly, the simple random sampling was employed to enumerate the vegetation data. However, from the forty quadrats which gives the researcher twenty sampling point each from the opposite direction, ten sampling points was actually sampled for final data collection alternately. This therefore meant that at the end, the entire vegetation species was reduced into ten sampling point by merging opposite samples as one. For soil sample collection, the composite technique was adopted. The soil auger was used in sampling soil at the surface (10-15cm) and subsurface (15cm-30cm). The soil samples were collected in the quadrats where the vegetation sampling was carried out. Therefore, vegetation and soils sampling were direct field observation, measurement and enumeration using cover and chart quadrant. For the data collection procedure to be completely effective and efficient, the following materials were used in the field namely; tree caliper, diameter or basal area tape, conversion tables, measuring tapes, strings and pegs, hammer, data sheet, identification guide, polythene bags, masking tapes, soil auger, geographic positioning systems (GPS), cutlass and camera to bring the study to a clearer perspective.

Technique of data analysis: The data were analyzed using descriptive and parametric statistics. Descriptively, the data obtained from the field was analyzed using tables, charts frequencies, percentages, averages, indices, graphs, maps and photographs. On the other hand, the parametric statistics was also used in testing the stated study hypotheses.



Source: GIS unit, Department of Geography and Environmental Science, University of Calabar

The effect of vegetation characteristics on soil properties in the study area was examined through the postulation of study hypothesis that *vegetation characteristics do not significantly affect the soil along the River valley*. The hypothesis was tested using Principal Component Analysis (PCA) and Multiple Regression Analysis (MRA). First, PCA was carried out to reduce the vegetation and soil data before subjecting them into stepwise multiple regression analysis. Therefore, the influence of vegetation on soil characteristics was determined by the outcome of the test of hypothesis.

The result shows in Table 1 that out of the 4.27 vegetation variables, only three (3) were extracted and they accounted for 73.1% of the total variance in the vegetation data set. It showed that PC₁ had one variable with loadings $\pm \geq 0.80$. The only variable loaded heavily and positively on PC₁, implying increase in basal cover. The variable that loaded on the first principal component was basal cover (0.902). Based on the types of vegetation variable that loaded on PC₁, it could be said to represent basal cover. On PC₂, one variable that loaded negatively and positively on it; the variable was herbaceous species composition (0.875) implying increase in herbaceous density.

PC₂ exemplified herbaceous species composition. PC₃ also had only one variable that loaded on it and the variable was girth (0.853). PC₃ represented girth and was responsible for 23.3% variation in vegetation data set. The result therefore recognizes basal cover, herbaceous species composition and girth as the main vegetation characteristics along the River valley. These vegetation components play diverse roles in soil nutrient accretion and preservation. For instance, herbaceous species composition helps in reducing topsoil nutrient loss as well as adding nutrients (organic matter) to the soil via litter dropping and decay. Basal cover helps to loosen the soil nutrient exchange, while girth helps in nutrient build-up in the soil through stem flow (Iwara, Njar, Ogundele and Tokula 2018).

Table 1: Rotated component matrix on vegetation characteristics

Variables	Principal components		
	PC ₁	PC ₂	PC ₃
Basal cover	0.902	0.197	-0.171
Tree height	0.784	-0.180	0.201
Herbaceous species composition	0.290	0.875	0.236
Herbaceous cover	-0.097	0.752	-0.045
Tree/shrub composition	-0.126	0.671	-0.557
Girth	0.214	0.145	0.853
Crown cover	-0.422	-0.119	0.685
Total	1.76	1.72	1.63
% of Variance	25.17	24.61	23.34
Cumulative %	25.17	49.78	73.12

*Variables underlined with loadings $\pm \geq 0.80$ are considered significant

Source: Author's fieldwork analysis 2024

PCA result for soil properties

The result in Table 2 shows that out of the thirty (30) soil variables, only six (6) were extracted and they accounted for 91.96% of the total variance in the soil data set. PC₁ had six soil variables with loadings of $\pm \geq 0.80$. With the variables on PC₁, it therefore represented topsoil nutrient. PC₁ explained 21.9% of the variance in the data set. On PC₂, three soil variables loaded negatively and positively on it. PC₂ explained 17.4% of the variance in the data set and it represented subsoil acidity. On PC₃, three soil variables loaded positively on it; PC₃ was responsible for 17.2% of the variance in the original data set.

PC₃ on the account of the soil variables that loaded on its signified subsoil organic matter, PC₄ had two variables that loaded positively on it; this component was responsible for 16.4% of the variance in the soil data. PC₄ exemplified subsoil K/Na. On PC₅, three soil variables loaded positively. PC₅ explained 13.9% of the variance in the data set and it represented topsoil cation. PC₆ had only one soil variable with positive loading. PC₆ was responsible for 5.08% of the variance in the original data set, and its signified subsoil P. The result in Table 2 therefore identifies topsoil nutrient, topsoil acidity, subsoil organic matter, subsoil K/Na, topsoil exchangeable bases and subsoil P as the main soil components or characteristics along the River valley.

Table 2: Rotated component matrix on soil properties

Variables	Principal components					
	PC ₁	PC ₂	PC ₃	PC ₄	PC ₅	PC ₆
Silt S	0.912	-0.089	0.091	-0.187	0.125	-0.139
TN S	0.904	-0.172	0.240	0.085	0.206	-0.078
OC S	0.897	-0.185	0.249	0.081	0.213	-0.083
AL ⁺⁺ S	0.873	0.129	-0.063	0.018	-0.433	0.016

Sand S	-0.868	0.157	-0.055	0.351	-0.143	0.077
ECEC S	0.808	-0.012	0.107	0.283	0.434	-0.184
AL ⁺⁺ SS	0.357	-0.862	0.135	0.043	-0.067	0.052
pH SS	-0.070	0.856	0.044	-0.407	-0.079	0.020
BS SS	-0.318	0.855	-0.062	0.175	-0.060	0.338
Sand SS	-0.066	0.753	-0.604	-0.033	-0.051	-0.212
H ⁺ SS	-0.046	-0.722	0.266	0.236	0.480	-0.159
Av. P	0.479	0.580	-0.018	-0.300	0.042	-0.124
OC SS	0.082	-0.014	0.952	0.201	0.059	-0.041
TN SS	0.085	-0.012	0.951	0.202	0.058	-0.049
Silt SS	0.134	-0.307	0.866	0.217	0.237	-0.114
Mg S	-0.318	0.406	-0.715	0.200	0.166	0.166
pH S	-0.592	0.018	0.648	-0.378	0.094	-0.083
Clay SS	-0.120	-0.490	-0.554	-0.290	-0.296	0.444
K SS	-0.067	-0.203	0.201	0.873	0.204	-0.105
Na SS	-0.172	-0.301	0.056	0.827	0.125	0.204
Clay S	0.102	-0.336	-0.132	-0.791	0.121	0.232
H ⁺ S	0.363	-0.332	-0.168	0.767	-0.231	-0.093
Ca SS	-0.276	0.159	0.392	0.702	0.382	0.137
ECEC SS	0.262	-0.422	0.402	0.662	0.146	-0.075
Mg SS	0.139	0.564	-0.059	0.567	-0.314	0.227
K S	0.156	0.020	0.039	0.061	0.970	-0.083
Na S	0.250	-0.250	-0.127	0.044	0.883	0.005
Ca S	0.193	-0.074	0.468	0.051	0.800	-0.232
BS S	-0.647	0.145	0.264	-0.114	0.664	-0.048
Av. P SS	-0.304	0.151	-0.210	-0.039	-0.214	0.864
Total	6.57	5.23	5.16	4.93	4.17	1.52
% of Variance	21.88	17.44	17.21	16.43	13.91	5.08
Cumulative %	21.88	39.32	56.53	72.96	86.87	91.95

*Variables underlined with loadings $\pm \geq 0.80$ are considered significant

Source: Author's fieldwork analysis 2024

The result in Table 3 showed that out of the 6 extracted soil properties, only one was retained and significantly influenced by herbaceous species composition. The result in Table 3 showed that when the soil components were regressed on the vegetation components, only herbaceous species composition was responsible for 26.8% of the changes that took place in topsoil exchangeable bases. The ANOVA result showed that herbaceous species composition significantly influenced topsoil cation ($F = 4.757$, $p < 0.05$). The result also identified herbaceous species composition to exert significant influence on topsoil exchangeable bases ($t = 2.181$, $p < 0.05$).

The un-standardised regression coefficients further implied that a unit increase in herbaceous species composition will bring about 58.2% increases in topsoil exchangeable bases. The positive regression sign means increase in topsoil cation with the increase in herbaceous species composition. The positive association is expected considering the contributions of this vegetation component to nutrient build-up in the soil. Thus, the results in Table 3 gives answer to the research hypothesis. It shows that vegetation characteristic (herbaceous species composition) significantly affects the soil (topsoil exchangeable bases) along the River valley.

Herbaceous species composition helps in providing surface cover to the soil and this plays a considerable role in nutrient accretion and retention in the topsoil (Iwara, 2018). In so doing, herbaceous species composition slows down the leaching of nutrients from the soil and

this enables cation exchange sites to hold Ca^+ , Mg^+ , K^+ , Na^+ , and NH_4^+ ions in the soil (Iwara et al., 2018). Herbaceous species composition or density adds nutrients to the soil through leaves decay. In a related study, Gilliam (2007) stated that herbaceous species composition or density mediates carbon dynamics and energy flow and influences the cycling rates of essential nutrients, including N, P, K, and Mg.

Table 3: Multiple regression analysis on the effects of vegetation on soil

Independent variable	Dependent variable	R ²	Level of explanations	F-Value	Regression equation
HSC	TSEC	0.268	26.8	4.757*	-0.257 + 0.582HSC

*Significant at 5% alpha level; Probability value = 0.048

HSC = Herbaceous species composition; TSC = Topsoil exchangeable bases

Conclusion and Recommendation

In the study area, the herbaceous species composition was the major vegetation parameter that influenced soil properties. This is as a result of the high positive relationship between the herbaceous species composition as against basal cover and girth on the topsoil exchangeable bases such as Ca^+ , Mg^+ , K^+ , Na^+ , and NH_4^+ . This however, showed that herbaceous species composition helped in reducing the topsoil nutrient loss and also adding nutrient to the topsoil in the study area. The study therefore, recommends that the anthropogenic activities that leads to deforestation and clean clearing which removes herbaceous species in the Inyang Etim Ekpo River Valley should be discouraged.

References

- Adekunle, V.A.J. and Dafiwhare, H.B. (2008). Diversity and abundance of microbes, pH and organic matter in soils of different forest types in tropical humid lowland forest ecosystem Nigeria. *Journal of Biodiversity and Ecology* 1(4): 333-342.
- Berendse, F., Van Ruijven, J., Jongejans, E. and Keesstra, S. D. (2015) "Loss of plant species diversity reduces soil erosion resistance of embankments that are crucial for the safety of human societies in low-lying areas," *Ecosystems*, vol. 18, no. 5, pp. 881–888
- Brevik, E. C., Cerdà, A., Mataix-Solera, J. (2015) "The interdisciplinary nature of *SOIL*," *SOIL*, vol. 1, no. 1, pp. 117–129
- Debasish-Saha, S. Kukal, S and Bawa, S. S. (2014) "Soil organic carbon stock and fractions in relation to land use and soil depth in the degraded Shiwaliks hills of lower Himalayas," *Land Degradation and Development*, vol. 25, no. 5, pp. 407–416.
- Essien, U.I. (2010). Brief History of Etim Ekpo. An Online Publication <http://www.etimekpo4goodluckandgodswill2011.org/brief-history.html>
- Garveba, A., Postma, J., Van Veen, J. A., and Van Elsas, J. D. (2006). Effect of Above-ground plant species on soil bacteria community structure and its impact on suppression of *Rhizoctonia solani* AG3. *Environmental Microbiology*, (2), 233-246
- Gilliam, F. S. (2007). The ecological significance of the herbaceous layer in temperate forest ecosystems. *BioScience*, 57, no. 10, 845–858.
- Iwara, A. I; Njar, G. N; Ogundele, F. O; Tokula, A. E, (2018) Influence of Vegetation Characteristics on Nutrient Loss in the Rainforest Belt of Agoi- Ekpo, Cross River State, Nigeria: *Journal of Applied Sciences and Environmental Management*, Vol. 22 (7) 1043 –1050.

- Mlambo D., Nyathi, P. and Mapaire, I. (2005). "Influence of *Colophospermum mopane* on surface soil properties and understorey vegetation in a southern African savanna," *Forest Ecology and Management*, vol. 212, no. 1–3, pp. 394–404.
- Seitz, S., Goebes, P., and Song, Z. (2015) "Tree species identity and functional traits but not species richness affect interrill erosion processes in young subtropical forests," *SOIL Discuss*, vol. 2, no. 1, pp. 701–736
- Zemmrch A. Manthey M. Zerbe S. and Oyunchimeg D. (2010) "Driving environmental factors and the role of grazing in grassland communities: a comparative study along an altitudinal gradient in Western Mongolia," *Journal of Arid Environments*, vol. 74, no. 10, pp. 1271–1280.
- Zhang, L., Mi, X., Shao, H. and K. Ma, (2011) "Strong plant-soil associations in a heterogeneous subtropical broad-leaved forest," *Plant and Soil*, vol. 347, no. 1, pp. 211–220.