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Roadside Plant Diversity and Soil Analysis in Uyo Sub-urban Environment Akwa Ibom State Nigeria

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Abstract: A study on roadside plant diversity and soil analysis in Uyo sub-urban environment was carried out using systematic sampling method. A quadrat of 5m x 5m was used to sample the vegetation spaced at regular intervals. The vegetation parameters determined were density and frequency. Soil samples were collected at different depths (0 – 15 cm and 15 – 30 cm) and analysis done using standard methods. From the results, 42 plant species were found along Abak road, 38 species along Etinan road and 45 species along Idoro road. Variations in vegetation parameters such as density and frequency were observed in the different routes as an attribute of the soil parameters. The soil-vegetation relationships within the study areas were proven using bivariate correlation method and these were significant at P = 0.05. Biodiversity indices revealed that Idoro road had high Shannon Weigner index value of (3.38) and Simpson's value of (0.96). Dominance values across the study areas were relatively low with values ranging between 0.04 and 0.06. Equitability value was highest in Etinan road (0.90) and least in Abak road (0.87). Low values ranging from 0.28 to 0.33 were obtained for Sorenson's similarity index across the study areas. The result obtained in this study reveals that understanding the complex effects of geo-physical factors and anthropogenic perturbations are important for developing and implementing conservation strategies for the protection, restoration of plant diversity and maintaining the integrity of roadside vegetation.

Keywords: Roadside, Plant diversity, soil, sub-urban environment, correlation, diversity indices.

Introduction

Roads cover extensive areas and exert a wide range of ecological influences on nearby plant communities. They also occupy major portions of the landscape and there is growing concern about the effects of roads on local and regional ecosystems (Parendes and Jones, 2000). The effect of a road on the environment is complex and includes disturbances during construction, alteration of normal hydrological flows (Forman and Alexander, 1998), the introduction of chemicals, including salts (Spellerberg, 2002) and heavy metals (Storch *et al.*, 2003), and fragmentation of natural habitats (Heilman *et al.*, 2002). Roads are very important to local and national economic development. However, they can also be major causes of biodiversity loss (Trombulak and Frissell, 2000) because the access provided by them to previously isolated areas increases rates of deforestation (Fearnside *et al.*, 2009). Several researches have shown that solid particle emissions, oxides of carbon, sulphur, nitrogen, and gases such as ozone and ethylene through vehicular emissions (Ball, *et al*., 1998), may affect plant photosynthesis, composition, competition and growth (Angold, 1997, Larson, 2003). These authors, also reported that anthropogenic disturbances such as trampling, crushing and heavy metal emissions are widely recognized as primary influences on the soil structure and plant community composition.

The value of plants in urban environment is now generally recognized both aesthetically and functionally in helping to make cities and towns conducive to live and work in. With the advent of economic growth, the urban environment of Uyo Metropolis is experiencing increase in infrastructural and industrial encroachments. As a result, the balance of urban climate is disrupted and most of the vegetation are being altered and destroyed to make way for "urban development". With these in mind, there is also rapid spread of exotic invasive species in our environment due to their wide adaptability to different habitat situations. In the light of this, the study seeks to carry out a routine compilation of plants species richness along roadsides their distribution and significance to roadside ecology with an ultimate aim of providing possible conservation and management.

Study Area

This Research was conducted along three major roads in Uyo Local Government Area of Akwa Ibom State in Nigeria. They include Abak road, Idoro road and Etinan road. The Study area lies between latitude 7°55'E and 7.917°E and longitude 5°2'N and 5.033°N. The climate is characterized by two seasons, the wet and dry season. The average humidity is about 80%, and up to 95% occurring at the peak of the wet season (AKSG, 2008).

Vegetation and Soil Sampling

Systematic sampling method (that is the method in which there is a chance of counting a species within the study area) was used to sample the vegetation using a quadrat of 5m × 5m spaced at regular intervals. At each sampling point, plant species encountered in the quadrat were identified to species level with their density and frequency enumerated. Unknown plant species were also collected for identification and confirmation from the voucher specimens in Botany and Ecological studies Departmental Herbarium, University of Uyo, Uyo. Using a soil auger, soil samples were collected at two different depths 0 – 15 cm and 15 – 30 cm. A total of four soil samples (20) in all were collected and were late bulked to make composite sample that was used for soil physicochemical analysis. These were stored in well-labeled Ziploc bags and preserved for laboratory analysis.

Quantitative Determination of Vegetation Parameters

Density: The density of each plant species in the study was estimated by enumerating all individuals of each species present in each quadrat. The mean number of individual species were taken as a proportion of the area of the quadrats to a given density in m^2 which was multiplied by $10{,}000m^2$ (Cochran, 1963).

Frequency: The frequency of each species occurrence was calculated thus:

$$\text{Frequency} = \frac{\text{Number of occupied quadrat for a species}}{\text{Total number of quadrats thrown}} \times 100$$

Physico-chemical Analysis of Soil

Soil pH was 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, 1992). The total Nitrogen content was determined by Micro-Kjeldahl method (Jackson, 1992). Soil particle size distribution was determined by the hydrometer method using mechanical shaker, and sodium hexametaphosphate as physical and chemical dispersant. Exchange Acidity was determined by titration with 1N KCL. 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. Heavy metals were analyzed using Unicam 939 Atomic Absorption Spectrometer (AAS).

Statistical Analysis

Mean and standard error were computed from triplicates of physico-chemical parameters of soil. The relationships between soil variables and vegetation within the study area were established by bivariate correlation method using Statistical Package for Social Sciences (SPSS) version 20.0.

Results

The distribution of plant species along Abak road is represented in Table 1. A total of 42 plant species belonging to 25 families were encountered. *Panicum maximum* had the highest density value of 6000±10.00 st/ha while species such as *Mangifera indica* and *Alstonia boonei* had the least density values of 100 stem/ha, each. Species such as *Pandiaka heudelotti*, *Xanthosoma mafaffa* and *Panicum maximum* had highest frequency values of 100 %, respectively. Along Etinan road, 38 plant species were found belonging to 19 families (Table 2). *Aspilia africana* dominated in density with a mean value of 3350 ± 10.52 st/ha while *Musa paradisiaca* had the least density value of 150 ± 1.50 st/ha. High frequency values were associated with species such as *Aspilia Africana* (100%) and *Pandiaka heudelotti* (100 %). Along Idoro road, 45 plant species were found belonging to 18 families (Table 3). The dominant species in terms of density were *Ageratum conyzoides* (2500 ± 9.86 st/ha) and *Sida corymbosa* (2500 ± 8.36 st/ha) while *Dacryodes edulis* was the species with the least density value (100 ± 0.98). Highest frequency of 67 % each, were observed in species such as *Amaranthus hybridus*, *Ageratum conyzoides*, *Terminalia macrophylla*, *Ipomoea involucrata*, *Calopogonium mucunoides*, *Centrosperma pubescens*, *Desmodium scorplurus*, *Sida acuta*, *Sida corymbosa*, and *Panicum maximum*.

Table 1: Vegetation Characteristics of Abak Road

S/N	Plant Species	Family	Frequency (%)	Density (stems/ha)
1	*Acanthus montanus* (Nees) T. Anderson	Acanthaceae	33	1000±2.36
2	*Ageratum conyzoides* L.	Asteraceae	33	500±1.80
3	*Alchornea cordifolia* Mull.Arg.	Euphorbiaceae	33	400±0.91
4	*Alstonia boonei* De Wild.	Apocyanaceae	33	100±0.28
5	*Amaranthus hybridus* L.	Amaranthaceae	33	500±1.70
6	*Aspilia africana* Thouars	Asteraceae	67	1300±1.30
7	*Asystasia gangetica* (L.) T. Anderson	Acanthaceae	33	500±1.77
8	*Caladium bicolor* (Ait) Vent.	Araceae	67	200±0.33
9	*Calopogonium mucunoides* Desv.	Fabaceae	67	3300±5.20
10	*Centrosema pubscens* Benth.	Fabaceae	67	2500±4.91
11	*Chromolaena odorata* (L.) R.M. King &H.ROD	Asteraceae	67	2500±4.80
12	*Cleome rutidosperma* DC.	Cleomaceae	33	500±1.82
13	*Commelina africana* L.	Commelinaceae	33	300±0.55
14	*Costus afer* Ker Gawl.	Costaceae	67	2300±4.00
15	*Dioscorea sp.* Linn.	Dioscoreaceae	33	200±0.30
16	*Fleurya aestuans* (L.) Chew	Urticaceae	33	300±0.38
17	*Gongronema latifolia* Benth.	Apocyanaceae	33	200±0.29
18	*Ipomoea involucrata* P. Beauv.	Convolvulaceae	33	300±0.30
19	*Kyllinga erecta* Schumach. Var. erecta	Cyperaceae	33	500±1.98

20	*Kylllinga squamulata Thonn ex Vahl*	Cyperaceae	33	1500±2.01
21	*Lagenaria breviflora* (Benth.) Roberty	Cucurbitaceae	33	1500±2.00
22	*Ludwigia abyssinica* A. Rich.	Onagraceae	33	500±1.71
23	*Luffa aegyptiaca* Mill.	Cucurbitaceae	67	3000±5.00
24	*Mangifera indica* L.	Anacardiaceae	33	100±0.20
25	*Manihot esculentus* Crantz.	Euphorbiaceae	67	1100±1.95
26	*Mariscus longebracteatus* Cherm.	Cyperaceae	33	500±1.69
27	*Mormodica charantia* L.	Cucurbitaceae	33	1000±1.75
28	*Mucuna pruriens* (L.) DC.	Fabaceae	33	800±0.96
29	*Musa sapientum* L.	Musaceae	33	300±0.14
30	*Pandiaka heudelotii* (Moq.) Hook. f.	Amaranthaceae	100	2600±4.87
31	*Panicum maximum* Jacq.	Poaceae	100	6000±10.00
32	*Phyllanthus niruri* L.	Euphorbiaceae	33	300±0.40
33	*Pteridium aquilinium* (L.) Kuhn	Dennstaedtiaceae	33	500±1.81
34	*Setaria barbata* (Lam.) Kunth	Poaceae	33	1000±1.76
35	*Sida corymbosa* R.E Fries	Malvaceae	33	800±0.86
36	*Solenostemom monostachyus* (p. Beauv.) Briq.	Lamiaceae	67	800±1.75
37	*Spermacoce verticillata* Linn.	Rubiaceae	33	500±0.58
38	*Stachytarpheta indica* (Linn.) Vahl.	Verbanaceae	33	200±0.23
39	*Synedrella nodiflora* (L.) Gaertn.	Asteraceae	33	300±0.56
40	*Talinum triangulare* (Jacq.) Willd.	Talinaceae	33	200±0.11
41	*Urena lobata* L.	Malvaceae	33	800±1.25
42	*Xanthosoma mafaffa* Schott.	Araceae	100	1500±2.52

Table 2: Vegetation Characteristics of Etinan Road

S/N	Plant Species	Family	Frequency (%)	Density (stems/ha)
1	*Ageratum conyzoides* L.	Asteraceae	33	1000±1.26
2	*Aspilia africana* DC.	Asteraceae	100	3350 ± 10.52
3	*Asystasia gangetica* (L.) T. Anderson	Acanthaceae	33	1800±1.89
4	*Bambusa vulgaris* Shreb.	Poaceae	33	250±0.85
5	*Boerhavia diffusa* Linn.	Nyctaginaceae	33	250±0.91
6	*Bracharia lata (*Schumach) C.E. Hubbard	Poaceae	33	250±0.87
7	*Caladium bicolor* Vent.	Araceae	67	500±1.00
8	*Centrosema pubescens* Benth.	Fabaceae	33	500±1.14
9	*Chromolaena odorata* (L.) R.M. King & H.ROD	Asteraceae	33	1250±2.65
10	*Cleome rutidosperma* DC	Cleomaceae	33	250±0.99
11	*Colocasia esculenta* (L.) Schott.	Araceae	33	500±1.71
12	*Commelina erecta* L.	Commelinaceae	33	600±1.14
13	*Costus afer* Ke-Gawl	Costaceae	33.	500±2.06
14	*Desmodium scorpiurus* (Sw.) Desv.	Fabaceae	33	250±1.00
15	*Eleusine indica* (L.) Gaertn	Poaceae	33	500±2.60
16	*Fleurya aestuans* (L.) Gaudich	Urticaceae	33	250±1.02
17	*Indigofera hirsuta* Linn. var. hirsute	Fabaceae	33	500±2.65
18	*Ipomoea aquatic* Forssk.	Convolvulaceae	33	600±1.00
19	*Ipomoea batatas* (L.) Lam	Convolvulaceae	67	250±0.78
20	*Ipomoea involucrata* p. Beauv.	Convolvulaceae	67	750±1.24
21	*Kyllinga bulbosa* Beauv.	Cyperaceae	67	1500±3.25
22	*Kyllinga erecta* Schumach. Var erecta	Cyperaceae	67	2200±5.69
23	*Lagenaria breviflora* (Benth.) Roberty	Cucurbitaceae	67	750±1.56
24	*Manihot esculentus* Crantz.	Euphorbiaceae	33	250±0.66
25	*Mariscus longibracteatus* Vahl.	Cyperaceae	33	500±1.85

26	*Marisus alternifolius* Vahl.	Cyperaceae	33	250±0.63
27	*Musa paradisiaca* L.	Musaceae	33	150±1.50
28	*Pandiaka heudelotii* (Moq.) Benth.	Amaranthaceae	100	1900±4.12
29	*Panicum maximum* Jacq.	Poaceae	67	1250±2.14
30	*Phyllanthus amarus* Schum.	Euphorbiaceae	33	550±1.85
31	*Sesamum alatum* Thonning	Pedaliaceae	33	250±0.99
32	*Setaria barbata* (Lam.) Kunth	Poaceae	33	400±1.62
33	*Sida acuta* Burm. f.	Malvaceae	33	250±0.56
34	*Sida rhombifolia* L.	Malvaceae	33	250±0.95
35	*Synedrella nodiflora* Gaertn.	Asteraceae	33	500±1.21
36	*Talinum triangulare* (Jacq.). Willd.	Talinaceae	33	250±0.88
37	*Urena lobata* L.	Malvaceae	33	250±0.71
38	*Xanthosoma mafaffa* Schott.	Araceae	67	700±2.65

Table 3: Vegetation Characteristics of Idoro Road

S/N	Plant Species	Family	Frequency (%)	Density (stem/ha)
1	*Ageratum conyzoides* L.	Asteraceae	67	2500 ± 9.86
2	*Amaranthus hybridus* L.	Amaranthaceae	67	250±1.60
3	*Aspilia africana* C. D. Adams	Asteraceae	33	2000±8.12
4	*Bambusa vulgaris* Shreb.	Poaceae	33	150±1.10
5	*Boerhavia erecta* Linn.	Nyctaginaceae	33	250±1.59
6	*Caladium bicolor* (Ait) Vent.	Araceae	33	350±2.00
7	*Calopogonium mucunoides* Desv.	Fabaceae	67	250±1.75
8	*Centrosema pubescens* Benth.	Fabaceae	67	1000±4.36
9	*Commelina africana* L.	Commelinaceae	33	250±1.67
10	*Cyperus tuberosus* Rottb.	Cyperaceae	33	600±3.52
11	*Dacryodes edulis* (Seedling) (G. Don) H.Lam.	Burseraceae	33	100±0.98
12	*Desmodium scorplurus* (Swi) Desv	Fabaceae	67	500±3.00
13	*Elaeis guineense* Jacq.	Arecaceae	33	250±1.58
14	*Emilia coccinea* (Sims.) G. Don.	Asteraceae	33	250±1.14
15	*Emilia practermiis* Milne-Redh.	Asteraceae	33	750±2.58
16	*Emilia sonchifolia* (L.) DC. ex Wight	Asteraceae	33	250±1.50
17	*Eragrostis aliens* (Linn.) R. Br	Poaceae	33	1000±2.95
18	*Euphorbia heterophylla* Linn.	Euphorbiaceae	33	250±1.78
19	*Fleurya aestuans* (L.) Gaudich	Urticaceae	33	150±1.00
20	*Gomphrena celosioides* Mart.	Amaranthaceae	33	750±3.51
21	*Hyptis lanceolatus* Poir	Lamiaceae	33	1000±4.62
22	*Indigofera hirsuta* Linn.	Fabaceae	33	1000±4.50
23	*Ipomoea batata* (L.) Lam	Convolvulaceae	33	200±1.47
24	*Ipomoea involucrata* p. Beauv.	Convolvulaceae	67	1600±5.69
25	*Ipomoea triloba* Linn.	Convolvulaceae	33	250±1.60
26	*Kyllinga erecta* Schumach. Var erecta	Cyperaceae	33	2000±6.32
27	*Kyllinga squamulata* Thonn. Ex Vahl.	Cyperaceae	33	2000±6.01
28	*Ludwigia abyssinica* A. Rich.	Onagraceae	33	250±1.48
29	*Manihot esculentus* Crantz.	Euphorbiaceae	33	250±1.40
30	*Mariscus longibracteatus* Vahl.	Cyperaceae	33	1500±2.12
31	*Mucuna pruriens* (L.) DC.	Fabaceae	33	250±0.95
32	*Pandiaka heudelotii* (Moq.) Benth.	Amaranthaceae	33	1000±4.00
33	*Panicum maximum* Jacq.	Poaceae	67	1200±4.12
34	*Phyllanthus amarus* Schum	Euphorbiaceae	33	250±1.63
35	*Sida acuta* Burm. f.	Malvaceae	67	750±2.40
36	*Sida corymbosa* R. E. Fries	Malvaceae	67	2500 ± 8.36
37	*Sida rhombifolia* L.	Malvaceae	33	250±1.71

38	*Solenostemom monostachyus* (P. Beauv.).Brig.	Lamiaceae	33	1750±4.98
40	*Spilanthes filicaulis* (Schum & Thonn.) C.D. Adams	Asteraceae	33	250±1.52
41	*Stachytarpheta indica* (Linn.) Vahl.	Verbenaceae	33	200±1.40
42	*Synedrella nodiflora* Gaertn	Asteraceae	33	250±1.36
43	*Terminalia microphylla* Spruce ex Eichler	Combretaceae	67	150±1.12
44	*Tridax procumbens* L.	Asteraceae	33	250±1.40
45	*Urena lobata* L.	Malvaceae	33	1500±2.23

Table 4 shows the physical and chemical properties of soils in the study areas. The textural class in these soils was dominated by sand with values ranging from 87.40 to 91.50 %. This was followed by clay particles (6.3 to 10.20 %) and lastly silt particles (2.20 to 3.00 %). The pH of these soils were moderately acidic with values ranging between 4.40 and 4.95. Organic carbon and total nitrogen contents in the soils were relatively low in comparison to the high values obtained for available phosphorus in these routes. In terms of the basic cations, Ca dominated with values ranging from 6.20 to 7.40, followed by Mg (1.50 to 2.20), K (0.10 to 0.11) and Na (0.03 to 0.06).Exchangeable acidity (EA) was high in soils along Idoro road (1.56±0.36) while Abak road and Etinan road recorded the least values of 0.67, respectively. High values for ECEC and base saturation were recorded in soils along Abak road while the least values for ECEC and base saturation were obtained in soils along Etinan road and Idoro road, respectively. In terms of the heavy metals, Cu was high in soils along Abak road (3.68±0.54) and least in soil along Idoro road. High Pb content was observed in soil along Etinan road (1.23±0.26) and least in soil along Idoro road (0.01±0.00).

Table 4: Physical and Chemical Properties of Soil in the Study Areas

Soil parameters	Abak road	Etinan road	Idoro road
Sand (%)	91.5±0.00	88.45±0.95	87.4±0.01
Silt (%)	2.2±0.10	3.00±0.28	2.25±0.15
Clay (%)	6.3±0.1	8.55±1.35	10.20±0.00
pH	4.95±0.20	4.70±0.10	4.4±0.1
EC (ds/m)	0.063±0.01	0.067±0.022	0.053±0.00
Organic carbon (%)	1.63±0.11	3.08±0.19	1.65±0.46
Total N (%)	0.04±0.00	0.08±0.005	0.04±0.005
Available Phosporus (mg/kg)	21.00±1.00	43.34±5.34	48.34±1.00
Calcium (cmol/kg)	7.40±0.20	6.20±0.20	6.20±0.60
Magnesium (cmol/kg)	2.20±0.2	1.50±0.10	1.60±0.00
Sodium (cmol/kg)	0.04±0.02	0.03±0.00	0.06±0.00
Potassium (cmol/kg)	0.11±0.005	0.11±0.03	0.10±0.005
Exchange acidity (cmol/kg)	0.67±0.00	0.67±0.14	1.56±0.36
ECEC (cmol/kg)	10.41±0.02	8.50±0.46	9.49±0.99
Base Saturation (%)	93.57±0.02	90.21±0.87	84.27±1.61
Copper (mg/kg)	3.68±0.54	3.36±0.07	2.04±0.58
Lead (mg/kg)	0.98±0.35	1.23±0.26	0.01±0.00

Table 5 shows the soil-vegetation correlates along Abak road. Frequency correlated positively with EC (r = 0.955, p = 0.05) and ECEC (r = 0.951, p = 0.05) while density of plant species correlated positively with ECEC (r = 0.969, p = 0.05).

Table 5: Correlation between soil and vegetation parameters along Abak road

Soil properties	Frequency	Density
pH	.133	.262
EC	.955*	.946
Org.C	.315	.364
Total.N	-.419	-.621
Av.P	-.378	-.283
Ca	.593	.536
Mg	.250	.199
Na	-.821	-.736
K	-.469	-.536
Ea	.673	.496
ECEC	.951*	.969*
Base.sat	.208	.315
Cu	.533	.315
Pb	.767	.617
Sand	.260	.435
Silt	-.141	.000
Clay	471	.480

*. Correlation is significant at 0.05 level

Table 6 shows the correlation between the response variables (vegetation) and the explanatory variables (soil) along Etinan road. Density correlated positively with organic carbon (r = 0.826, p = 0.05), available phosphorus (r = 0.870, p = 0.05) and Lead (Pb) (r = 0.831, p = 0.05).

Table 6: Correlation matrix between soil and vegetation parameters along Etinan road

Soil properties	Frequency	Density
pH	.055	.423
EC	.328	.806
Org.C	.532	.826*
Total.N	-.043	-.032
Av.P	.413	.870*
Ca	-.107	.000
Mg	.440	-.005
Na	.000	.213
K	-.430	-.429
Ea	.084	-.792
ECEC	-.278	-.630
Base.sat	-.159	-.165
Cu	-.362	-.029
Pb	.391	.831*

Sand	-.310	.447
Silt	.656	.613
Clay	-.153	-.631

*. Correlation is significant at 0.05 level

Table 7 shows the correlation between the soil and the vegetation parameters along Idoro road. Frequency had a significant positive relationship with available phosphorus and ECEC (r = 0.999, p = 0.05) while density had a significant negative relationship with EC (r = - 0.999, p = 0.05) and a positive relationship with Ea (r = 0.999, p = 0.05).

Table 7: Correlation between soil and vegetation parameters along Idoro road

Soil properties	Frequency	Density
pH	-.006	-.968
EC	-.288	-.999*
Org.C	.996	.338
Total.N	.888	-.215
Av.P	0.999*	.259
Ca	.991	.387
Mg	.842	.738
Na	-.792	-.794
K	-.834	-.748
Ea	-.306	.999*
ECEC	.999*	.218
Base.sat	.179	.997
Cu	.753	.830
Pb	.260	-.866
Sand	.929	-.118
Silt	-.037	.956
Clay	-.642	.575

*. Correlation is significant at 0.05 level

The diversity status of the three study areas are shown in Table 8. Dominance values ranged between 0.04 and 0.06. Abak road had high dominance value (0.06) while Idoro road had the least. Shannon values ranged between 3.24 and 3.38. Idoro road had high Shannon values (3.38) while Etinan road had the least value (3.24). High Simpson's value was recorded in Idoro road (0.96) and the least in Etinan road (0.93). Equitability value was highest in Etinan road (0.90) and least in Abak road (0.87).

Table 8: Diversity status of the study areas

	Abak road	Etinan road	Idoro road
Taxa S	42	38	45
Dominance	0.06	0.05	0.04
Shannon	3.27	3.24	3.38
Simpson	0.95	0.93	0.96
Equitability	0.87	0.90	0.89

Table 9 shows the Sorenson similarity matrix of the study areas. The values ranged from 0.28 to 0.33 with high similarity of plant species occurring along Abak and Etinan roads (0.33).

Table 9: Sorenson's similarity matrix of the study areas

	Abak road	Etinan road	Idoro road
Abak road	-		
Etinan road	0.33	-	
Idoro road	0.32	0.28	-

Discussion
Floristic Composition

The vegetation attributes showed variations in the floristic composition in the study areas and this is suggestive of the fact that different plant species respond and adapt differently to soil conditions. Variations occurred in density and frequency of species and this is not unrelated to the various levels of biomass production in the soil along these routes (Ubom, Ogbemudia and Ita, 2012). Idoro road had the highest number of plant species and this may be attributed to the suitability of the soil conditions which favoured the high frequency of establishment of these species. The least number of plant species recorded along Etinan road could either be linked to their inability to adapt to prevailing soil conditions, time of species introduction or anthropogenic perturbations. It could also be as a result of the slow regeneration rates of these species which could not compensate for high mortality and exploitation rates. Intense herbivory and competition for environmental resources may further account for the low species recorded along this road. These may lead to habitat loss, low diversity status and extinctions in the long run. This corroborates with the findings of Maron (1998) and Remegie and Yansheng (2008). The dominance of grasses in these roads maybe a reflection of the major growth form/habit along these roads and this bears similarities to the earlier reports of Angold (1997). The conspicuous and repeated occurrences of species such as *Pandiaka heuelotii*, *Panicum maximum*, *Kyllinga erecta*, *Aspilia africana*, *Urena lobata*, *Kyllinga squamulata* and *Ipomoea involucrata* is a reflection of their wide ecological range. It also shows that these species have inherent ability to adapt fully to varying soils conditions.

Soil-vegetation relationships

Along Abak road, frequency correlated positively with Electrical conductivity and ECEC. This explains the synergistic roles played by these soil variables in increasing the frequency of establishment of plant species. Also, increase in the frequencies of plant species with increasing EC could be explained in terms of the adaptability of the plant species to increasing salt contents, implying that only plant species which are tolerant to increasing salt content had high frequency while the intolerant species to salt content had low frequency. Also density of plant species along this route correlated positively with ECEC. The increase in density with increasing ECEC portrays the importance of exchangeable cations complex (comprising of Ca, Mg and Na) in the distribution of plant species with respect to density. Ca is required for cell growth, division, elongation, and various essential biological functions (Hirschi, 2004). Calcium boosts the nutrient uptake, improves the plant tissue's resistance, makes cell wall stronger, and contributes to normal root system development (Berridge *et al*., 2000; Hirschi 2004). Ca also helps in enzymes activation, inducing water movement and salt balance in plant cells, activating K to control the process of opening and closing of stomata (Hepler, 2005). Magnesium plays a major role in plant photosynthesis at a decreasing level, it will may affect the various important chloroplast enzymes. (Shaul, 2002). Magnesium also alleviates heavy metal stresses in plant species and this is well documented by Chen and Ma (2013). Sodium also plays an important role in plant species distribution. This view is in unison with the documentation of Pedler *et al*. (2000) that Na aids metabolism and synthesis of chlorophyll during photosynthesis thereby enhancing growth.

Along Etinan road, the density of plant species had a positive relationship with organic carbon, phosphorus and lead. The positive correlation between density and organic carbon outlines the importance of organic carbon in the growth and numerical abundance of plant species. This report corroborates with the views of Brady and Weil (1996) and Ita (2017) that organic carbon through litter decomposition is a major source of soil various nutrients required by plants for their growth and distribution. This further implies that the organic carbon increases, a corresponding increase in density will be evidenced in plants. The positive correlation of density with available phosphorus also points out the supporting role of phosphorus increasing plant density. Phosphorus is an essential component for growth and development of plants and its deficiency in soil causes significant reduction in crop yields (Huang *et al*., 2011). Additionally, Kavanová *et al*. (2006) reported that lack of phosphorus content causes a decline in cell division and cell elongation in the leaves of various grasses. Also, P is a necessary component of photosynthetic processes which are systematically implicated in creation of sugars, oils, and starches and which further helps in the conversion of solar energy into chemical energy, proper plant maturation, and stress tolerance (Kavanová *et al*., 2006). The positive correlation of density of plant with Lead (Pb) is not clearly understood but the increase of this biological nuisance as a function of density could be interpreted in terms of pollution tolerance (Ita, 2017). This may denotes that only plant species who could adapt and tolerate the infiltration and accumulation of this heavy metal in the soil had high density while those with low adaptability and tolerance limits decreased in density.

The soil-vegetation relationship along Idoro road revealed that frequency showed a significant positive association with available phosphorus and ECEC. This could be inferred to mean that the frequency of establishment of species along this road was dependent on these soil variables because they play a contributive role in the growth, distribution and establishment of plant species. Density correlated negatively with EC and exchangeable acidity. This relationship with density could be explained in terms of tolerance to road salt and acidic contents in the soil. This suggests that plant species with high tolerant to salts and acidic conditions had high density while those with low tolerance limits to these soil variables had low density.

Diversity Status of the Study Areas

The diversity indices values computed for Shannon and Simpson in this study were high reflecting high plant species richness in the study areas. Evenness and equitability values were higher in Etinan road and this further explains the uniform distribution of plant species in that route. This further justifies the low dominance values recorded in this area. Sorenson's similarity values computed generally was low in this study. Based on the computed values, Abak and Etinan roads had high plant species similarities while Idoro and Etinan roads had least similarities in plant species. These similarities in species in these routes may suggest that the establishment of new species were less along these roadsides and that only species with high ecological tolerance to soil conditions could thrive there.

Conclusion

The study revealed that these routes support a good number of diverse plant species. It also showed that variations exist in the distribution of plant species along the different roads as a function of soil nutrients, varying re-vegetation efforts during road construction, differences in sequences of species colonization, timing of species introduction and anthropogenic perturbations.

Soil-vegetation correlation revealed positive and negative relationships with each other. Positive correlations showed the levels of nutrients required to enhance plant growth while negative associations revealed levels of nutrients that were limiting to plants. Assessment of diversity using biological indices revealed high species richness and evenness along the studied roads. Conclusively, the results obtained in this study indicate that the complex effects of environmental factors, land use and road disturbances are very important to develop and implement the strategies to protect and conserve our diverse plant species in order to restore integrity of roadside ecosystems.

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