Evaluation of Tree Species Diversity and Air Pollution Tolerance Index in Makurdi Metropolis, Benue State, Nigeria

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***Abstract*: Tree species diversity and Air Pollution Tolerance Index (APTI) in Makurdi Metropolis, Nigeria was evaluated. The study site was stratified into two areas, highly populated area (HPA) and less populated areas (LPA). In each of the area, five (5) major streets of 400 x 15 m were randomly selected for the study and all the tree species in the selected areas were enumerated and computed for diversity index estimation, using Shannon Wiener's index. Matured fresh leaves of the highest ranked tree species was used for the biochemical analysis. The result on the species diversity revealed that Mangifera indica and Anacardium occidentale had the highest frequency of 46 and 95 trees among the enumerated tree species in the HPA and LPA respectively. The estimated diversity indices for the LPA and HPA was 3.037and 2.870 respectively This indicates that the LPA is highly populated in term of plant species. The result on the biochemical analysis shows that Delonix regia and Anacardium occidentale had the highest ascorbic acid values of 1.51 and 3.36 mg/g in HPA and LPA respectively, while the chlorophyll contents values ranges between 8.27 and 5.14 mg/g for Mangifera indica and Elias guinensis. The acidic APTI values ranges from 5.0 to 6.0 and 6.89 to 10.77 among the selected tree species. Conclusively, due to the highly diverse and ability of the tree species sensitivity to air pollutants in Makurdi Metropolis, these species should be given adequate protection in order to minimize environmental pollution.**

***Keywords*: Stratified, Sensitivity, Populated, Environmental, Bio-chemical analysis,**

I INTRODUCTION

Forests are the richest biological communities on earth and have been recognized to harbour a significant proportion of global biodiversity (Myers et. al., 2000; Baraloto et. al., 2013). The forests provide many ecosystem services such as species conservation, prevention of soil erosion, and preservation of habitat for plants and animals (Armenteras et. al., 2009). The world tropical forests are interestingly diverse; they contain the vast majority of plants and animals and have high genetic resources because of variation in elevation, climate and soil ranging from the steamy jungles of the rain forests to the dry forests and savannas. More than 2.5 million people live in areas adjacent to forests. They rely on forest for their water, fuel wood and other Gebrehiwot (2003). Biotic factors such as seed quality, seedling survivorship, and recruitment are important in maintaining the tree diversity and composition of tropical forests Naidu, and Kumar (2016)

Air pollution is one of the severe environmental problems in the world today, posing significant risks to the environment and all its inhabitants. The effects of this pollution in the metropolis can be traced to the continual change in concentration levels of some gaseous and trace metals in the environment resulting from man's activities such as road transport traffic and industries (Joshi et. al., (2009); Tanee and Albert (2013). Air pollution can directly affect plant via leaves or indirectly via low carbon stock. Most plants experience physiological changes before exhibiting visible damage to leaves when exposed to air pollutants Liu, and Ding (2008). Pollutants can cause leaf injury, disturb membrane permeability, reduce growth and yield in sensitive plant species, premature senescence, stomata damage and decrease photosynthetic activities which reduce the removal of carbon from the atmosphere and subsequent accumulation of this carbon in the biosphere Tiwari et. al., (2006).

A large number of trees species have been identified as dust filters to check the rising urban dust pollution level Rai et. al., (2010). Plants provide an enormous leaf area for absorption and accumulation of air pollutants especially, carbon dioxide to reduce the pollution level in the atmosphere with various extents for different species Liu, and Ding (2008). Plants show varying degrees of sensitivity and tolerance to air pollution stress. In most plant species, the most common parameters in which air pollution tolerance can be traced includes: Chlorophyll content (Flowers, 2007) ascorbic acid content Hoque et. al., (2007); leaf pH Klumpp et. al., (2000) and relative water content Rao, (1979). Air pollution tolerance index (APTI) based on these four aforementioned parameters has been used to identify tolerance levels of plant species Tanee, . and Albert (2013). The APTI provides a reliable method for estimating the susceptibility level of tree species as the bio filter performance for managing ambient air quality in urban areas. Also, tolerance level of trees to air pollutants is specific to a site and varies with the type and level of air

pollution (Jain, et. al., (2019); Pandey, et. al., (2015); Karmakar and Padhy, (2019) APTI value uses distinct biochemical parameters such as ascorbic acid, total chlorophyll, relative water content, and leaf extract pH that collectively reflect stress indicators.

In Nigeria, most especially Makurdi metroplois, air pollution has been on the increase, industrialization and a general high rate of urbanization are the underlying factors responsible for air pollution in the country (Tanee et. al., 2014). Also, Meer et. al., (2020) identified agricultural practice such as bush burning, refuse burning and automobile emission as the major sources of air pollution in Northern and other parts of Nigeria. With all the above sources still operational, there is no question about air pollution in Makurdi and many cities in Nigeria. The concept of Air Pollution Tolerance Index (APTI) of plants in an environment is thus very crucial since any change in the environment is reflected in plant health status as suggested by Ogbonna et. al., (2015).

II. MATERIALS AND METHODS

Study Area

This research was carried out in Makurdi Metropolis which lies on coordinates: 7^0 20'50"N and $8^0$4 5'10'E (BNARDA/DFID, 2004). According to NPC, (2006) Benue State was created in 1976 and has a population of 273,724 people with 142,231 male and 129,483 female. The southern part of the town is made up of several wards viz: central ward, old GRA, new GRA, Ankpa ward, Wadata ward, Wurukum etc. Makurdi town is divided by the River Benue into the North and South Banks, which are connected by two bridges: the railway bridge, which was built in 1932, and the new dual carriage bridge commissioned in 1978. Owing to its location in the valley of River Benue, Makurdi Metropolis experiences warm temperatures most of the year.

Makurdi Metropolis lies within the annual weather Climate and experiences two distinct seasons, the wet/rainy season and the dry/summer season. The rainy season lasts from April to October with annual rainfall in the range of 100-200mm (BNARDA/DFID, 2004). The dry season begins in November and ends in March. Temperature fluctuates between 23-37 degrees Celsius in the year.

The vegetations of Makurdi Metropolis consists of rain forests which is found in the Western and Southern fringes, while, the Guinea savannah is found in the Eastern and Northern parts with mixed grasses and trees that are generally of average height. Its topography is mainly undulating plains with occasional elevations of between 1,500m and 3,000m above sea level (BNARDA/DFID, 2004) Makurdi Metropolis main geological formations are sandy-loam shelf basement complex and alluvial plains. These together with its transition belt between the north and south ecological zone act as a support for a wide variety of crops. Mineral deposits include Baryte, Gypsum. Feldspar, Kaolinite, mineral salts and Gemstone. The town comprises of several ethnic groups: Tiv, Idoma, Igede, Etulo, Abakpa, Jukun, Hausa and Nyifon. The Tiv are the dominant ethnic group followed by the Idoma and most of the people are farmers while, the inhabitants of the riverine areas engage in fishing (BNARDA/DFID, 2004).

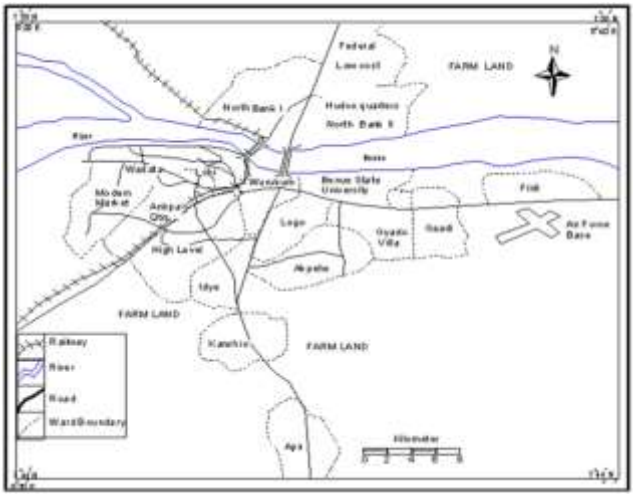

Fig. 1: Makurdi Local Government Area Showing Makurdi Metropolis

Source: (BNARDA/DFID, 2004).

Sampling Techniques and Data collection

Stratified and simple random sampling technique was adopted for this study. Makurdi metropolis was stratified into two strata: Highly populated (HPA) and less populated area (LPA). In each stratum, five (5) major streets of 400m long with a distance of 15 m on both sides of the street were randomly selected adopting Singh, (1997) method. Matured fresh leaves, directly exposed to the atmosphere (sun and rain) were randomly collected from five (5) tree species selected at random in each of the stratum between7:00 am and 11:00 am. The collected leaves were placed into polythene bags to minimize loss of moisture content and labeled. Composite sample of the collected leaves were bulked and transported to the Department of Chemistry Laboratory, Benue State University, Makurdi for biochemical analysis. In addition, the entire trees within the sampled area were enumerated and the species names recorded according to the International Plant Nomenclature Index [IPNI, (2008)]. Tree growth variables such as the Diameter at the base (D_b), Diameter at breast height (DBH), Diameter at the top (DT) and Height (H) were measured in metres (m) for further analysis on volume estimation (m^3). Tree species identification was carried out directly on the field, using the field identification guides book [Neelo et. al., 2015].

Estimation of Tree Species Diversity

The variety of species and their numbers were (diversity) taken into account to quantify their representation in the two areas. Species diversity was estimated a mathematical function, using Shannon Wiener's index (Equation 1.)

$$H = -\Sigma\left[\left(\frac{n_i}{N}\right) \times ln\left(\frac{n_i}{N}\right)\right] \ldots\ldots\ldots\ldots\ldots \text{Equation (1)}$$

Where:

n_i = number of individual species
N = Total number of individual species
H = Shannon Weiner's Index
Ln = Natural logarithm

Determination of biochemical parameters

The following biochemical analysis was carried out on the collected sampled leaves for the computation of air pollution tolerance index (APTI) values.

i. Percentage Relative Water Content (RWC)

On collection, the fresh leaves were immediately taken to the laboratory for the determination of the leaf fresh weight in order to minimize water loss as described by Singh, (1997). Fresh leaf sample was weighed on a weighing balance and recorded, soaked in distilled water inside a closed petri dish at room temperature for 24 hours for incubation. At the end of the incubation period, the leaf samples were wiped dry gently with blotted paper and re-weighed to obtain the Turgid Weight, and then placed in a pre-heated oven at 80^0 C for 48 hours to obtain the dry weight. The relative water content was then determined by using equation 2:

$$RWC = \frac{FW-DW}{TW-DW} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots \text{Equation (2)}$$

Where:
FW = Fresh Weight
TW = Turgid Weight
DW = Dry Weight

ii. Total Chlorophyll (TCh)

Total chlorophyll content was determined using the spectro photometric method as described by Arnon, (1949) and adopted by Chouhan et. al., 2012. Three (3) grams of fresh leaves were blended together and then extracted with 10 ml of 80% acetone and left for 5 minutes for thorough extraction. The liquid portion was decanted into another test-tube and centrifuged at 2,500 rpm for 3 minutes using a table top centrifuge. The supernatant was then collected and the optical density for absorbance taken at 645 nm (D_{645}) and 663 nm (D_{663}). The optical density (C_T) of the total chlorophyll was calculated using equation (3).

$$C_T = 20.2\,(D_{645}) + 8.07\,(D_{663}) \ldots\ldots\ldots\ldots 3$$

Where:

(C_T) = Optical density

D = Absorbance of extract at the wavelength (nm)

Therefore, total chlorophyll ((TCh) was calculated using equation (4)

$$TCh = 0.1C_T \frac{Leaf\ DW}{Leaf\ FW} \qquad \ldots\ldots\ldots\ldots\ldots\ldots 4$$

iii. Ascorbic Acid Content (AA)

Ascorbic acid content (AA) was measured using spectro photometric method described by [Begum, and Harikrishna. (2010)]. Ethylene di-amine-tetra acetic acid extracting solution was added to 1g of the fresh leaf in a test-tube, after which 1 ml of ortho phosphoric acid, 1 ml of 5% tetraoxosulphate VI acid, 2 ml of ammonium molybdate and 3 ml of water was added. The solution was allowed to stand for 15minutes, after which the absorbance at 760 nm was measured with a spectrophotometer. The concentration of ascorbic acid in the sample was then extrapolated from a standard ascorbic acid curve.

iv. Leaf Extract Acidity (pH)

The leaf extract acidity (pH) was determined according to the method of [Adamsab et. al. 2011]. Five grams of the fresh leaves was homogenized in a 50 ml of de-ionized water, and filtered with a Whitman filter paper. The pH of the leaf extract was determined from a calibrating pH meter.

The values of the biochemical parameters obtained were incorporated to calculate the APTI values of the selected tree species, using equation (5) as adopted by [Bakiyaraj, R. and Ayyappan, D.(2014)], while, [Bharti, et.al., 2017] method was used to categorize the APTI values of the tree species based on their tolerance level and responses to air pollution.

$$APTI = \frac{A(T+P)+R}{10} \ldots\ldots\ldots\ldots\ldots\ldots 5$$

Where:

A = Ascorbic Acid (mg/g)
T = Total Chlorophyll (mg/g)
P = pH of leaf extract
R = Relative water content (%)

Data Analysis

Data were analyzed using descriptive (Graph, frequency and percentages) and inferential statistical tools. (sampled paired t-test)

III. RESULTS

Tree Species Diversity

A total of Eight hundred and fifty-three (853) tree species were encountered in the study areas. The highly populated area (Appendix I) with only thirty-four species had a total number of 294 tree species, with *Mangifera indica* having the highest frequency of trees, this was followed by *Newbouldia levis*, with 39 trees, while more than five tree species had the least frequency of one (1) in the HPA, Also, in the LPA, with 559 tree species, *Anacardium occidentale* had the highest frequency of 95 trees and this was followed by *Daniella oleiferi*, with a frequency of 65 trees (Appendix II). The result on species diversity revealed that, the less populated area was more diverse than the highly populated area with an index of 3.019 and 2.859 respectively.

Biochemical Parameters of some Tree Species in the Study Area

The results (Table 1) of the biochemical parameters showed that in the highly populated area (HPA), *Delonix regia* recorded high ascorbic acid content (1.51 mg/g) against *Albizia lebbeck*

having the lowest ascorbic acid content of 0.38mg/g. In the less populated area (LPA), *Anacardium occidentale recorded* 2.36 mg/g against *Vitex doniana* having the lowest ascorbic acid content of 0.35mg/g (Figure 2).

Results from Figure 3 revealed that the total chlorophyll content of the investigated tree species was high in the study area, except *Polyanthia longifolia* in highly populated area and *Parkia biglobosa* in the less populated area. Presented in Figure 4 was the pH value of the sampled tree species, which ranges between 5 and 6 in all the study sites. The highest relative water content in highly populated area was seen in *Mangifera indica (*81.79±2.74) and lowest in *Eleais guinnensis* (61.53±2.34) (Figure 5). In the less populated area, the relative water content of leaves of the plant species varied from maximum of 95.54±1.98 in *Vitex doniana* to a minimum of 64.60±2.04 in *Eleais guineensis*

Presented in Table 1 are the results of APTI in the study area. It was revealed that the APTI value obtained in the highly populated area ranges from 6.89 to 9.17, while that of less populated area ranges from 7.00 to 10.77. The highest APTI value (9.17) was observed in *Mangifera indica* from highly populated area while *Anacardium occidentale* had the highest APTI value (10.77) in the less populated area. Since the value of APTI is greater than one and less than 16 in both study site, the species are therefore rated as being sensitive to air pollution.

Table 1: Biochemical Parameters and Air Pollution Tolerance Indices (APTI) of the Sampled Tree Species in the Study Area

Study Area	Species	A (mg/g)	T (mg/g)	pH	R (%)	APTI	Rating
Highly Populated area	Delonix regia	1.51	5.19	5.26	63.92±0.45	7.97	Sensitive
	Polyalthia longifolia	0.40	3.34	4.99	79.87±0.77	8.32	Sensitive
	Albizia lebbeck	0.38	5.08	5.50	74.21±0.46	7.82	Sensitive
	Mangifera indica	0.75	8.27	4.96	81.79±2.74	9.17	Sensitive
	Eleais guineensis	0.70	4.93	5.64	61.53±2.34	6.89	Sensitive
Less Populated area	Anacardium occidentale	2.36	5.03	5.16	83.64±1.16	10.77	Sensitive
	Eleais guineensis	0.50	5.14	5.39	64.60±2.04	7.00	Sensitive
	Parkia biglobosa	0.63	3.52	5.52	76.10±2.25	8.18	Sensitive
	Daniella oliveri	0.40	4.44	5.54	72.15±1.94	7.61	Sensitive
	Vitex doniana	0.35	4.42	5.28	95.54±1.98	10.00	Sensitive

Key: A = Ascorbic acid content, T = Total chlorophyll content, pH = Acidity of leaf extract, R = Relative Water Content.

APTI Rating Scale: Less than 1 = very sensitive; 1–16 = Sensitive; 17-29 = Intermediate tolerance; 30–100 = tolerant

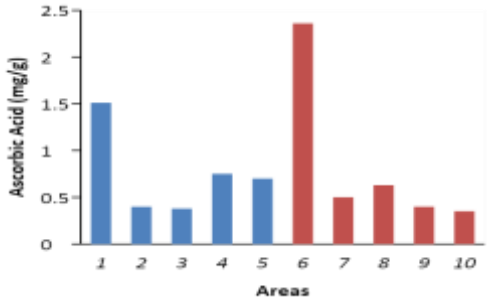

Fig. 2: Total Ascorbic acid of Tree Species in the Study Area

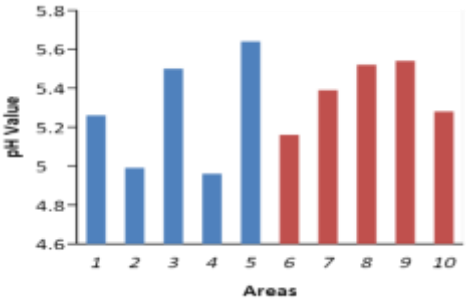

Fig. 4: pH Values of the Tree Species in the Study Area

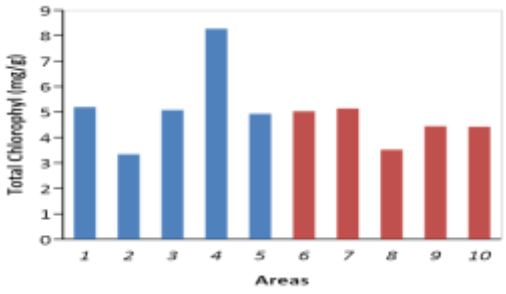

Fig. 3: Total Chlorophyll Contents of Tree Species in the Study Area

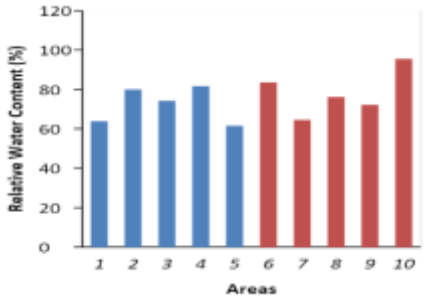

Fig. 5: Relative Water Content of the Sampled Tree Species in the Study Area

IV. DISCUSSION

Tree Species Diversity

In this study, large number of tree species were encountered in both less and highly populated areas. The higher number of plant species identified is far more than the one Saka et. al., 2018 obtained in their work carried out on quantitative analysis of tree species in Taraba State. The richness of plant species in the study area may be due to variation in the vegetation zones between the two states, although they both share boundary.

Biochemical Parameters of some Tree Species in the Study Area

It is observed that all the randomly sampled species collected from both sites exhibited acidic pH ranging from 5.0 to 6.0. The acidic nature of most tree species in the study area may be due to the pollution caused by human activities such as agriculture and industrialization and rapid

urbanization observed in the area. This agrees with Swami et. al., (2004) who states that acidic nature of tree species could be due to the presence of SO_2, NO_2 or other acidic pollutants due to human activities like agriculture and industrial emission in the ambient air causing a change in pH of the leaf sap towards acidic Impacts of environmental pollution on tree species depend on the biochemical status, which may influence species specific responses. Highest relative water content in the highly populated area was seen in *Mangifera indica (*81.79±2.74) and lowest in *Eleais guineensis (*61.53±2.34). In the less populated area, the relative water content of leaves of the plant species varied from maximum of 95.54±1.98) in *Vitex doniana* to a minimum of 64.60±2.04% in *Eleais guineensis.* The rating of the species in both study areas further indicates that all the tree species were sensitive to air pollution. Low leaf pH extract showed good correlation with sensitivity to air pollution and also reduce photosynthetic process in plants (Yan-Ju, and Hui, 2008); Thakar and Mishra, 2010). All the plant species in the study were found to contain high percentage of water. This may be connected to the climate and edaphic factors in the study area. High water content within a plant body will help to maintain its physiological balance under stress condition such as exposure to air pollution when the transpiration rates are usually high which may lead to desiccation. Maintenance of relative water content by the plant may decide the relative tolerance of plants towards air pollution (Verma, 2003). High water content within a plant body will help to maintain its physiological balance under stress condition such as exposure to air pollution when the transpiration rates are usually high which may lead to desiccation. According to Verma (2003), maintenance of relative water content by the plant may decide the relative tolerance of plants towards air pollution. The higher the relative water content in a particular species, the greater is its drought tolerance capacity Rai et.al., (2013). Thus, the higher relative water content in industrial site sample may be responsible for normal functioning of biological processes in plants Meerabai et. al., (2012).

According to Zhang et al., (2016) lower chlorophyll content reflect increased in the sensitivity of the plant species and *vice versa*. The decreased in total chlorophyll content, coupled with the biochemical and socioeconomic characters of the sampled tree species in the study area were a reflection of higher sensitivity of all tree species in the study. This study is in line with the earlier studies conducted by Anake et.al., (2019); Agbaire and Esiefarienrhe, (2009) who showed that decreased in total chlorophyll content is a reflection of higher sensitivity of plant species.

The range of APTI value in this study is in conformity to the findings of Ogbonna et. al., (2015) whose APTI values ranges between 1 and 11. in their study carried out in Ishiagu Zinc mining area of South Eastern Nigeria. The APTI result of this work is also in line with Rai, et. al., 2013; Agbaire and Esiefarienrhe (2009) who observed a high APTI value in *Mangifera indica* specie. Rai, et. al., (2013) opined that, dust pollution and chronic concentration of gaseous pollutants may affect the biochemical make up and tolerance capacity of plants to the air pollution. Rai et al., (2013) also reported that plants that are constantly exposed to environmental pollutants absorb, accumulate and integrate these pollutants into their systems. The variation of the APTI values of this finding can be attributed to the variation in the four biochemical factors which govern the computation of the index.

V. CONCLUSION

This research has shown Makurdi metropolis is highly diverse in term of plant species diversity. The more diverse the tree species, the more tolerant to air pollutant in the area, although all the tree species are sensitive to air pollution, but the less populated area, with more trees gave higher values of APTI than the highly populated area. Also, the high relative water content exhibited by the plant species enables the trees to maintain its physiological balance under stress condition which resulted to the tolerance capacity of the sampled tree species. This shows that different tree species respond differently to air pollution; hence the different indices resulting from the variation of the analyzed biochemical factors has proved to be the only good anticipated performance index species among the sampled tree species in the study area.

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Appendix I: HIGHLY POPULATED AREA (HPA)

S/No	Species	Frequency	Pi	LnPi	PiLnPi
1	Albizia lebbeck	3	0.010204	-4.58497	0.046785
2	Anacardium occidenlate	10	0.034014	-3.38099	0.115
3	Azadirachta indica	12	0.040816	-3.19867	0.130558
5	Calotropis gigentea	1	0.003401	-5.68358	0.019332
6	Carica papaya	6	0.020408	-3.89182	0.079425
7	Casuarina equsetifolia	2	0.006803	-4.99043	0.033949
9	Citrus sinensis	3	0.010204	-4.58497	0.046785
4	Coccos nucifera	9	0.030612	-3.48636	0.106725
11	Delonix regia	33	0.112245	-2.18707	0.245488
12	Deniella oleiferi	1	0.003401	-5.68358	0.019332
13	Eleais quineensis	28	0.095238	-2.35138	0.223941
14	Ficus altisima	10	0.034014	-3.38099	0.115
15	Ficus benjamina	2	0.006803	-4.99043	0.033949
16	Ficus sur	9	0.030612	-3.48636	0.106725
8	Giarcinia kola	1	0.003401	-5.68358	0.019332
18	Gmelina arborea	7	0.02381	-3.73767	0.088992
19	Khaya sinensis	2	0.006803	-4.99043	0.033949
20	Kigelia africana	1	0.003401	-5.68358	0.019332
21	Mangifera indica	46	0.156463	-1.85494	0.290228
22	Moringa oleifera	1	0.003401	-5.68358	0.019332
23	Newbouldia levis	39	0.132653	-2.02002	0.267962
24	Parkia biglobosa	2	0.006803	-4.99043	0.033949
25	Polyalthia longifolia	18	0.061224	-2.79321	0.171013
26	Raphia farinifera	5	0.017007	-4.07414	0.069288
27	Ravenale medascariena	2	0.006803	-4.99043	0.033949
28	Roystonea regia	2	0.006803	-4.99043	0.033949
29	Tectona grandis	15	0.05102	-2.97553	0.151813
30	Terminalia catappa	4	0.013605	-4.29729	0.058466
31	Terminalia glaucens	2	0.006803	-4.99043	0.033949
32	Terminalia mentaly	14	0.047619	-3.04452	0.144977
33	Tipuana tipu	1	0.003401	-5.68358	0.019332
34	Vitex donniana	3	0.010204	-4.58497	0.046785
	Total	**294**			**2.859588**

Appendix II: LESS POPULATED AREA (LPA)

S/No.	Species	Frequency	Pi	LnPi	PiLnPi
1	Adonsonia digitata	1	0.001686	-6.38519	0.010768
2	Albizia lebbeck	3	0.005059	-5.28658	0.026745
3	Anacardium occidenlale	75	0.126476	-2.06771	0.261514
4	Azadrachta indica	12	0.020236	-3.90029	0.078927
5	Bombax coslatum	2	0.003373	-5.69205	0.019197
6	Bridelia feruginea	1	0.001686	-6.38519	0.010768
7	Burkin africana	2	0.003373	-5.69205	0.019197
8	Caccos nucifera	1	0.001686	-6.38519	0.010768

9	Calotropis gigentea	1	0.001686	-6.38519	0.010768
10	Carica papaya	9	0.015177	-4.18797	0.063561
11	Casuarina equisetifolia	2	0.003373	-5.69205	0.019197
12	Ceiba pentandra	1	0.001686	-6.38519	0.010768
13	Giarcinia kola	1	0.001686	-6.38519	0.010768
14	Citrus sinensis	12	0.020236	-3.90029	0.078927
15	CoccOs nucifera	10	0.016863	-4.08261	0.068847
16	Dacrodes edulis	1	0.001686	-6.38519	0.010768
17	Daniella oleiferi	65	0.109612	-2.21081	0.242331
18	Delonix regia	34	0.057336	-2.85883	0.163913
19	Elaeis guinensis	36	0.060708	-2.80168	0.170085
20	Eucalyptus camaldulensis	1	0.001686	-6.38519	0.010768
21	Ficus altisima	7	0.011804	-4.43928	0.052403
22	Ficus benjamina	2	0.003373	-5.69205	0.019197
23	Ficus carica	5	0.008432	-4.77576	0.040268
24	Ficus sur	10	0.016863	-4.08261	0.068847
25	Gmelina arborea	13	0.021922	-3.82025	0.083749
26	Hymenocardia acida	4	0.006745	-4.9989	0.033719
27	Khaya sinensis	2	0.003373	-5.69205	0.019197
28	Kigelia africana	1	0.001686	-6.38519	0.010768
29	Lannca acida	3	0.005059	-5.28658	0.026745
30	Mangifera indica	52	0.08769	-2.43395	0.213432
31	Moringa oleiferi	2	0.003373	-5.69205	0.019197
32	Newbouldia levis	42	0.070826	-2.64752	0.187514
33	Parkia biglobosa	14	0.023609	-3.74614	0.088442
34	Perinari curatellifolia	9	0.015177	-4.18797	0.063561
35	Piliostigma thonningii	3	0.005059	-5.28658	0.026745
36	Polyathia longifolia	22	0.037099	-3.29415	0.122211
37	Prosipis africana	5	0.008432	-4.77576	0.040268
38	Psidium guajava	1	0.001686	-6.38519	0.010768
39	Raphia farinifera	5	0.008432	-4.77576	0.040268
40	Ravenale medascariena	2	0.003373	-5.69205	0.019197
41	Roystonea regia	2	0.003373	-5.69205	0.019197
42	Streculia africana	1	0.001686	-6.38519	0.010768
43	Syzygium guinensis	1	0.001686	-6.38519	0.010768
44	Teclona grandis	25	0.042159	-3.16632	0.133487
45	Terminalia avicennioids	16	0.026981	-3.61261	0.097473
46	Terminalia catappa	4	0.006745	-4.9989	0.033719
47	Terminalia glaucens	2	0.003373	-5.69205	0.019197
48	Terminalia mantaly	14	0.023609	-3.74614	0.088442
49	Tipuana tipu	1	0.001686	-6.38519	0.010768
50	Vitex donniana	19	0.03204	-3.44076	0.110243
	Total	**559**			**3.019143**