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Determination of Anticipated Performance Index of Some Plant Species Planted in Ikom, Cross River State Nigeria

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ABSTRACT

This study was carried out in Ikom to determine the Anticipated Performance Index of some plants from July- October, 2019. Eight trees species were sampled randomly and analyzed of their biochemical and physiochemical properties. Results showed that *Azadirachta indica* and *Cassia fistula* recorded the highest air pollution tolerance index of 9.16 and 9.15;*Mangifera indica*and *Terminalia catapa*had the API percentage scores 75 68.75% and assessed as very good (VG) and Good (G) category,and recommended for extensive use in urban greening programmes while serving the purpose of bio-indicators and aesthetics, while the rest can be planted for beautification purposes in the study area.Their percentage scores in descending order is given below: *M. indica* (75%) >*T. catapa* (68.75%) >*P. longifolia* (56.25%) = *G. arborea* (56.25%) >*A. indica* (50%) = *T. grandis* (50%) >*C. fistula* (43.75%) = *D. regia* (43.75%). The study concludes that a combination of APTI and API of plants gives a more reliable result than when one parameter is used when testing the resilience of plants to air pollutants.

Keywords: Biomonitors; API;Plants; Ikom.

INTRODUCTION

Air pollution is a regional and global problem and is one of the major factors deteriorating the quality of life in urban areas, making people more vulnerable to diseases all over the world (Esfahani *et al*., 2013). Cities are said to be responsible for the emission of energy related to global greenhouse gases worldwide. The International Energy Agency (IEA) estimates that urban areas currently account for more than 71% of energy-related global greenhouse gases and this is expected to rise to 76% by 2030 (Hoornweg *et al*., 2011) and vehicular emission is one of the major contributors for emission of combustion gases, due to increasing dependency on private transportation (Tiwari *et al*., 2011).

The Global Burden of Diseases (GBD) (2013) Institute for Health Metrics and Evaluation, said that air pollution is among top six (6) most important risk factors for disease burden globally. On plants,some of the observable effects include; physiological (pigment degradation), chemical (decreased chlorophyll) and morphological (leaf coloration) injuries to plants.

These plants play an important role in monitoring and maintaining the ecological balance by actively participating in the cycling of nutrients and gases like carbon dioxide, oxygen and also provide enormous leaf area for impingement, absorption and adsorption (Sahu *et al*., 2020) and accumulation of air pollutants to reduce the pollution level in the environment (Escobedo *et al*., 2008).Plants also have positive impacts on soil and water quality of the area, besides adding aesthetic value to it (Pradhan *et al*., 2016).

A lot of research work exist on the use of trees for monitoring of air pollutants; (Ibironke *et al*., 2016; Nwaogwugwu *et al*., 2017; Udeagbala *et al*., 2017 have also carried out researches using trees as biomonitors of air pollution.

Keeping in view the importance of trees towards air pollution abatement, this study will be conducted to determine the sensitivity and performance of some trees planted in Ikom town using anticipated performance index of plants. This work will assist researchers, estate developers, foresters, landscapers and environmental scientists and in the identification and selection of air pollution tolerant plants species that can act as a sink as well as screen air pollution; in urban ecosystems for future monitoring and assessment; the identified plants will also act as biomonitors in the management and control of air pollution in the environment.

Thus, in order to combat urban air pollution using green plants, anticipated performance index (API) is a more useful tool which is calculated based on some socioeconomic and biological characteristics (Pandey and Tripathi 2015; Govindaraju *et al*., 2012), including air pollution tolerance index (APTI).

MATERIALS AND METHODS

Description of the study area

Ikom is one of the towns in Cross River State. It is the headquarters of Ikom Local Government area. Ikom lies between Latitude 5° 57' 59" N and longitude 8° 43' 18" E of the Equator (Fig 1) with an elevation of 99.98 metres above sea level. Ikom has a land mass of 1, 861.926km^2 and a population of 162,383 (NPC, 2006). It is bounded on the North by Ogoja, South by Obubra, North-East by Boki and on the East by Etung Local Government Areas. The town has an average yearly temperature of 30.36°C with an annual average rainfall of 220.61mm.

Sampling Technique

This study was restricted to Ikom town, Cross River State. Eight trees species were randomly sampled systematically. Both deciduous and evergreen trees wereselected. Samples were collected from trees situated along high traffic and low traffic areas. Eight(8) trees were sampled at each of the locations. From each tree, six (6) leave samples were collected from the foliage facing the road, mixed together to form a composite sample. The leaves were then put in labeled polythene bags, oven dried, crushed and taken to the laboratory for analysis of biochemical properties like leaf p^H, total chlorophyll, relative water content and ascorbic acid content

Relative Water Content

The per cent of leaf relative water content was calculated using the initial, turgid and final weight of leaf material as shown in the following equation (Singh, 1977). Fresh weight was obtained by weighing the fresh leaves. The leaves were then immersed in water over night, blotted dry and then weighed to get the turgid weight. Next, the leaves were dried over-night in an oven at 70° C and reweighed to obtain the dry weight.

$$RWC = \left(\frac{FM - DM}{TM - DM} \right) \times 100$$

Where; FM= Fresh mass, DM=Dry mass and TM= Turgid mass

Determination of Total Chlorophyll

Total Chlorophyll was determined according to the method described by Arnon (1949). It was extracted with 80% acetone and determined spectrophotometrically. The total chlorophyll of the sampled leaves was then calculated thus;

Chlorophyll a = 12.7DX663 – 2.69DX645 x V/1000W mg/g

Chlorophyll b = 22.9DX645 – 4.68DX663 x V/1000W mg/g

T. chl. = 20.2 DX 645 + 8.02 DX 663 X vmg mg/g

Where: TCh = chlorophyll a + b; mg/Dx = Absorbance of the extract at the wavelength Xnm; V = total volume of the chlorophyll solution (ml), and W = weight of the tissue extract (g).

Determination of Ascorbic Acid Content

Ascorbic acid content (expressed as mg/g) was determined using the method described by (Bajaj and Kaur, 1981).1 gram of the sample was measured into a test-tube. Then 4ml oxali-ethylenediaminetetraacetic acid (EDTA) extracting solution, 1 ml of orthophosphoric acid, 1 ml 5% tetraoxosulphate (vi) acid, 2 ml ammonium molybdate and then 3 ml of water were added successively. The solution was then allowed to stand for 15 min, after which the absorbance at 760 nm was measured with a JENWAY spectrophotometer (model 7305).

pH

The leaf extract pH was obtained by homogenizing 0.2g of the pulverized leaf samples in 10ml of distilled water. The obtained solution was then measured with a pH meter after calibration with a buffer solution of pH 4 and 9 (Tsega and Prasad, 2013).

Determination of Air Pollution Tolerance Index (APTI) of Plants

The air pollution tolerance index of sampled trees was calculated by incorporating the values of all the above parameters (relative water content, ascorbic acid, pH and total chlorophyll) in an equation as suggested by Singh and Rao (1983) using the formula:

$$APTI = \frac{[A\ (T + P) + R]}{10}$$

Where, A = Ascorbic acid (mg/g), T = Total Chlorophyll content (mg/g), P = pH of leaf extract and R = Relative Water Content (%).

The APTI index range was categorized viz; (Table 1)

Table 1: Air pollution Tolerance Index (APTI) Range for Plants

APTI value	Response
1 – 11	Sensitive
12 – 16	Intermediate
17 and above	Tolerant

Shreshta *et al*. (2021)

Determination of Anticipated Performance Indices (API) of Plants

The APTI values obtained, along with various plant parameters including; plant habit, size, texture, hardiness, canopy structure, economic value etc. (Singh *et al*., 1991; Ogunkunle *et al*., 2015) was employed in the computation of API following the grade distribution pattern which apportion plants into grade, scores and different assessment categories as follows: Grade 0 = < 30%, assessed as not recommended; grade 1 = 31- 40%, assessed as very poor; grade 2 = 41-50%, assessed as poor; grade 3 = 51-60%, assessed as moderate; grade 4 = 61-70%, assessed as good; grade 5 = 71-80%, assessed as very good; grade 6 = 81-79%, assessed as excellent and grade 7 = 91-100%, assessed as best (Pathak *et al*., 2011; Ogunkunle *et al*., 2015). API was then computed thus:

$$\% \text{ scoring} = \text{API} = \frac{\text{No of '+' obtained}}{\text{Total No. of '+'}} \times 100$$

Maximum grade that can be scored by a plant=16 (Kour and Raina, 2017).

Table 2: Anticipated Performance Index (API) of plant species

Grade	Score	Assessment category
0	0 – 30	Not recommended
1	31 – 40	Very poor
2	41 – 50	Poor
3	51 – 60	Moderate
4	61 – 70	Good
5	71 – 80	Very good
6	81 – 90	Excellent
7	91 - 100	Best

(Prajapati and Tripathi, 2008

Statistical Analysis

A two-way analysis of variancewas used to analyze the results of APTI values obtained. Where statistical differences were observed, Duncan multiple Range Test (DMRT), was used to separate mean values at $P \leq 0.05$.

RESULTS AND DISCUSSION

The air pollution tolerance index (APTI) of trees refers to an empirical value used in denoting the ability of plants to withstand air pollution. It is a special index that integratesfour different biochemical variables, viz; Ascorbic Acid (AA), Total Chlorophyll (T. Chl), pH and Relative Water Content (RWC).

Azadirachta indica recorded the highest APTI value *(*9.16mg/g1 dw*)* followed by *Cassia fistula (*9.15mg/g¹dw) and the lowest was observed in *Delonix regia* (8.52mg/gm¹)(Table 3).Analysis of variance (ANOVA) showed that there were marked significant variations in the APTI of trees across the study period, The ability of plants to combat air pollution varies from species to species, type of pollutant, its reaction mechanism, duration of exposure and concentration (Badamasi, 2017).

Table 3: Mean values (dw)of APTI of Trees plantedin Ikom, Cross River State, Nigeria.

Taxon	AA (Mg/g^1)	TCl (Mg/g^1)	pH	RWC (%)	APTI	
Mean ± S. E.						
Azadirachta indica	0.07	13.07	7.89	90.12	9.16	
Cassia fistula	0.11	20.86	7.48	88.52	9.15	
Delonix regia	0.15	17.12	7.95	81.39	8.52	
Gmelina arborea	0.05	21.41	7.75	86.79	8.81	
Mangifera indica	0.11	17.98	7.65	88.17	9.11	
Polyalthia longifolia	0.08	13.44	7.67	88.53	9.02	
Tectona grandis	0.05	23.46	7.71	86.13	8.76	
Terminalia catapa	0.12	11.63	7.57	87.42	8.97	
P.V		0.00**	0.00**	0.00**	0.00**	0.00**

P.V = p. value

Anticipated Performance index (API) of studied plants

Anticipated performance index is used to estimate the tolerance of plants species to air pollution. When used, it provides good and logical reasons for usage of plants in urban greening towards air pollution amelioration.

In this study, sampled trees were evaluated on the basis of the APTI obtained from each tree with their physiological and socio-economic attributes such as plant height, canopy structure, type of plant, laminar structure (size, texture and hardness) and economic value.

Mangifera indica had the highest API percentage score (75%) with a total of twelve (12) plus (+) and assessed as very good (VG) fell under API grade 5. *Terminalia catapa,* fell under the Good (G) category with a percentage score of 68.75%, total plus (11) an API grade (4). They are recommended for extensive use in urban greening programmes while serving the purpose of bio-indicators and aesthetics while the rest can be planted for beautification purposes in the study area.*Tectona grandis, Gmelina arborea, Azadirachta indica and Polyalthia longifolia* ranked under the moderate category with a percentage score of 50 – 56.25%, total plus (8-9) and in API grade 3.Other trees species like *Terminalia catapa* has been categorized under the moderate category (Anake *et al*., 2018).

Table 4: Anticipated performance index (API) of trees planted in Ikom, Cross River State

Trees species	**Grade**		**API grade**	**Assessment**
	Total plus (+)	**Percentage score (%)**		
Azadirachta indica	8	50.00	3	Moderate
Cassia fistula	7	43.75	2	Poor
Delonix regia	7	43.75	2	Poor
Gmelina arborea	9	56.00	3	Moderate
Mangifera indica	12	75.00	5	Very good
Polyalthia equisetifolia	9	56.25	3	Moderate
Tectona grandis	8	50.00	3	Moderate
Terminalia catapa	11	68.75	4	Good

Trees species like *Delonixregia* and *Cassia fistula* fell under API grade 2, with total plus (7) and categorized under the poor category. Their percentage scores in descending order is given below: *M. indica* (75%) >*T. catapa* (68.75%) >*P. longifolia* (56.25%) = *G. arborea* (56.25%) >*A. indica* (50%) = *T. grandis* (50%) >*C. fistula* (43.75%) = *D. regia* (43.75%) (Table 4).

Table 5: Assessment of sampled trees based on their APTI, physiological and socioeconomic characteristics

S/N	Tree Speces	APTI grade	T H	C S S	TT T H	Leaf lamina	E V
1.	*Azadirachta indica*	+	++	++	++	+ -	- +
2.	*Cassia fistula*		+	+	+	+	- - -
		-	++	+	-	++	- - ++
4.	*Gmelina arborea*	-	++	+	+	++	+ - ++
5.	*Mangifera indica*	+	++	++	+	++	+ + ++
6.	*Polyalthia equisetifolia*	-	+	+	+	++	+ + ++
7.	*Tectona grandis*	-	+	+	-	++	+ + ++
8.	*Terminalia catapa*	-	++	++	+	++	+ + ++

The high percentage score by *Mangifera indica* agrees with the findings of Anake *et al.* (2018) who worked on APTI of trees in air pollution control. A recent study by Anake *et al.* (2022) also identified *Mangifera indica* as very good performer. Trees under the very good and good assessment category can be used as bio-sinks for the abatement of air pollution in Ikom.

Trees ranked under the moderate category example, *Polyalthia longifolia*with a percentage score of 56.25% could be used as bio-indicators of air pollution. This is in consonance of the result of Patel and Kumar (2018) who categorized *Polyalthia longifolia* under the moderate category. Trees species like *Delonix regia*and *cassia fistula* were categorized under the poor category. This results agrees with the work of Patel and Kumar (2018) who found *Cassia fistula* and *Mangifera indica* in the poor category in a study evaluating the APTI and API of trees species considered for green belt development.

Trees under the moderate to very good performers (*Tectona grandis, Gmelina arborea, Azadirachta indica, Polyalthia longifolia, Terminalia catapa*) are recommended for extensive use in urban greening programmes while serving the purpose of bio-indicators and aesthetics while the rest can be planted for beautification purposes in the study area. Therefore, an evaluation of the anticipated performance index of plants may be useful in the selection suitable plants species for urban greening.

CONCLUSION

When two or more parameters are combined to determine the sensitivity of plants to air pollution it gives a more reliable result than using one parameter (Nayak *et al*., 2018).By integrating the resultant APTI values with some important biological and socio-economic characters (plant habit, canopy structure, type of plant, laminar structure and economic value), the API was calculated for various species. All the biochemical, physiological, biological as well as socio-economic parameters of the plant species played an important role in determining the sensitivity and tolerance of plants to air pollution.

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