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Assessment of the Effect of Ambient Air Quality on Some Biochemical Parameters of Trees in three Artificial Forest Reserves in Edo State, Niger Delta, Nigeria

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ABSTRACT---- ***It is a well-established fact that the plant helps in reducing the effect of air pollution on the environment since they could act as pollution sink. It is therefore necessary to be able to identify plant species that can play this important role in the development of a greenbelt. Green belt is important for mitigating effect of air pollution on the environment. This study thus evaluated the tolerant capacity of plant species in three artificial forest reserves in Edo State, Nigeria. Four physiological and bio-chemical parameters, namely; leaf extract pH, total chlorophyll, ascorbic acid content and relative water content were used. These parameters were computed into the air pollution tolerance index (APTI) formula to obtain the APTIs for the various plant species. All the plants studied were found to be sensitive with APTI ranging from 1.96 to 17.05. Since these plant species are sensitive, they have to be protected from environmental emissions, which would lead to air pollution. Graduation of tolerance was also calculated and used to classify the plant species. It was found that the status of plant ranged between sensitive(s), through intermediate to tolerance.***

Keywords--- APTI Tolerant, Sensitive, Forest Reserves, Air Pollution

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1. INTRODUCTION

Air pollution can be defined as the introduction of chemicals, particulate matter or biological materials that are harmful to man and properties into the atmosphere. Air pollution could either be anthropogenic or man-made. Whichever, is the source, the bottom-line is that it is injurious to man and the environment. The issue of air pollution has lately been on the front burner because of increased urbanization and industrialization, which would lead to increased human and vehicular activities in the urban areas. This eventually would lead to increased consumption of fuel and so gaseous and particulate pollutant. Some of the common air pollutants are oxides of Sulphur, Nitrogen and Carbon, Suspended particles and toxic particulate metals. Air pollution affects both men, plant and the properties. Mitigation of air pollution is very difficult since air cannot be restricted to any particular area. There are also no physical or chemical methods suitable to ameliorate aerial pollution. The best method is therefore the biological method of growing green plants around polluted environment (Ararawal 1988, Santra, 1995, Thakre 1995; Fukuoka, 1997; Ghosh and Majee, 2001, Palit et al, 2013, Esfahanu et 2013). The fact that plants are stationary and are constantly exposed to the atmosphere, air pollution injury to plants is proportional to the intensity of the pollution (Palit et al; 2013). It has also been reported that when plants are exposed to air pollution, it causes some changes in their anatomy and physiology before eventually showing any visible signs (Tivedi, 2001; Begun and Harikrishno, 2010). The responses of plants to air pollutant varies from specie to specie; while some may survive pollution other might not. This leads to the idea of a tolerant and sensitive plants. Tolerant species are those that can withstand pollution since they act as a sink to air pollutant sensitive species on the other hand are those that cannot withstand air pollution indicator. Naturally in the plant kingdom, Darwin's survival of the fittest also operates. Therefore, if sensitive plants are not protected, they might eventually go into extinction, but this must be prevented. Studies have shown that air pollution affects some physico-chemical parameters of plant and so can be used for bio-monitor the air pollution status of the environment. These physico-chemical parameters, included Ascorbic and content and total chlorophyll content (Flower et al, 2007) leaf extract pH (Klumpp et al 2000) and relative water content (Rao, 2006). It has, however, been observed that these individual parameters gave conflicting results for the same plant species and not advisable to be used individually but collectively. In order to resolve this conflict, Singh and Rao, 1983 developed a formula by combining these factors to give the Air Pollution Tolerance Index (APTI). The APTI is an indication of the resistivity and susceptibility of plants to air pollution. It is important for health workers, scientist and landscaper.

$$APTI = [AA(TC + P)RW]/10$$

APTI = Air Pollution Tolerance Index
AA = Ascorbic Acid Content (mg/g)
P = pH of leaf extract
RW = Relative Water Content (%)

This study was carried out to determine the APTI status of trees in three artificial forest reserves in Edo State, Nigeria in order to determine plant species suitable for green belt development to mitigate air pollution effect on the environment.

2. MATERIALS AND METHODS

2.1 Sampling Sites: Three Forest Reserve sites were selected in Edo State, Nigeria and were used for the study. These are Saponba Forest Reserve. This is a moist tropical forest reserve located in Orhionwon Local Government Area of Edo State, Nigeria. It lies between latitude 6^0 25' 32" N and longitude 05^0 5' 28"E. The second is Uniben Forest Reserve. This is in Egor Local Government Area in Edo State, Nigeria. The site is within latitude 6^0 24' 20.9" N and Longitude 5^0 28' 32" E. The third is the Ogba Forest Reserve. This is located in Oredo Local Government Area of Edo State, Nigeria. It lies between latitude $6^0$19'N and longitude 5^0 41' E.

Twenty tree species were identified and used for the work.

2.2 Experimental

Sample extractions and analyses were done according to standard methods as described earlier by Agbaire and Akporhonor 2012. Physico-chemical parameters determined are leaf extract pH, Ascorbic acid content, relative water content and total chlorophyll content.

3. DATA ANALYSIS

The APTIs of plants were determined by using the formular in section one above (Singh and Rao, 1983). Results were analyzed for Mean and Standard Deviation. One way analysis of variance (ANOVA) was carried to test for significant difference in the APTI in the three sites.

3.1 Classification of result (Randhi and Reddy, 2012)

APTI Values	Response
< 1	very sensitive
1 – 16	Sensitive
17 – 29	Intermediate
30 -100	Tolerant

3.2 Graduation of APTI (Liu *et al.*, 1983)

a. Tolerant (T): APTI> Mean APTI +SD
b. Moderately tolerant (MT): Mean APTI < APTI < Mean APTI +SD
c. Intermediate (IM): Mean APTI -SD<APTI <Mean APTI
d. Sensitive (S): APTI <Mean APTI -SD

4. RESULTS AND DISCUSSION

Results are presented in tables 1 – 5

TABLE 1: Air Pollution Tolerance Index of Plants in Ogba Forest Reserve

S/N	TREE SPECIES	pH	TCH (mg/gFW)	AA (mg/g)	RWC (%)	APTI
1	*Nauclea diderrichi*	4.56±0.72	76.66±18.90	0.21±0.06	23.91±11.12	4.64±0.68
2	*Terminalia catapa*	5.16±0.59	48.18±6.75	0.19±0.02	26.18±6.14	4.21±0.59
3	*Gmelina aborea*	6.35±0.45	31.63±7.30	0.19±0.03	19.37±6.14	3.07±0.81
4	*Khaya gradifiola*	6.06±0.39	38.79±15.75	0.18±0.02	34.37±19.12	5.68±1.16
5	*Tectona grandis*	6.20±0.31	53.31±10.65	0.16±0.01	16.43±2.23	2.88±0.44
6	*Gambaya albidum*	5.82±0.51	38.58±7.27	0.28±0.04	25.33±7.26	4.24±0.57
7	*Cedrala adorata*	6.44±0.39	39.72±11.80	0.19±0.03	17.33±3.61	2.85±0.24
8	*Triplochiton scleroxylon*	6.50±0.31	36.56±6.52	0.16±0.01	13.11±10.42	2.12±0.93
9	*Terminalia ivorensis*	5.02±0.27	38.29±18.90	0.21±0.07	32.31±9.52	4.56±0.94
10	*Garcina kola*	6.12±0.43	76.66±11.76	0.19±0.03	24.81±10.21	3.74±1.01
11	*Albizia lebbek*	6.50±0.00	40.61±17.65	0.26±0.05	25.99±11.83	4.35±0.81
12	*Irvinga garbonesis*	5.64±0.48	46.1±8.97	0.34±0.11	25.22±6.67	4.25±0.53
13	*Entandrophragma angolensis*	5.90±0.40	64.95±9.92	0.29±0.08	17.91±10.24	3.89±1.42
14	*Azadirachta indica*	6.19±0.39	38.92±10.45	0.17±0.01	22.76±13.40	3.25±1.16
15	*Hura creptians*	5.48±0.47	94.80±18.03	0.19±0.01	28.59±10.76	5.07±1.31
16	*Docryodes edulis*	4.93±0.66	69.59±10.95	0.25±0.09	27.66±15.01	4.84±1.65
17	*Psidium guajava*	5.87±0.37	34.91±8.43	0.28±0.03	24.90±6.79	3.78±0.54
18	*Citrus cenesis*	6.02±0.31	87.36±7.40	0.20±0.05	19.58±2.80	3.88±0.57
19	*Mangifera indica*	5.94±0.27	68.54±20.00	0.23±0.02	33.44±8.36	5.38±0.75
20	*Moringa oleifera*	6.23±0.41	36.21±110.14	0.21±0.04	27.81±4.52	6.35±0.34

TABLE 2: Air Pollution Tolerance Index of Plants in Uniben Forest Reserve

S/N	TREE SPECIES	pH	TCH (mg/gFW)	AA (mg/g)	RWC (%)	APTI
1	*Nauclea diderrichi*	4.50±0.38	23.18±12.36	0.15±0.01	19.07±25.50	2.76±2.64
2	*Terminalia catapa*	4.81±0.02	30.28±13.44	0.17±0.03	32.07±8.40	4.53±0.98
3	*Gmelina aborea*	5.93±0.46	24.27±16.98	0.17±0.02	25.20±17.36	3.56±1.91
4	*Khaya gradifiola*	5.65±0.19	35.42±18.07	0.18±0.03	27.38±17.35	4.01±1.67
5	*Tectona grandis*	5.92±0.23	69.82±28.09	0.15±0.02	10.56±.723	1.96±0.90
6	*Gambaya albidum*	5.56±0.21	29.53±.9.31	0.16±0.02	33.32±7.86	4.56±0.72
7	*Cedrala adorata*	6.19±0.07	34.21±32.68	0.16±0.08	23.75±7.83	3.42±0.62
8	*Triplochiton scleroxylon*	6.11±0.24	29.59±10.94	0.14±0.01	21.22±.9.90	2.96±0.85
9	*Terminalia ivorensis*	4.92±0.89	51.6±31.91	0.23±0.04	33.58±16.00	4.26±2.17
10	*Garcina kola*	6.04±0.45	29.67±11.41	0.17±0.01	34.37±21.66	4.68±1.98
11	*Albizia lebbek*	5.38±0.97	40.61±10.84	0.19±0.06	32.20±17.16	4.45±1.53
12	*Irvinga garbonesis*	4.48±0.48	32.72±11.13	0.22±0.02	18.05±8.42	2.59±0.75
13	*Entandrophragma angolensis*	5.31±0.38	67.75±27.96	0.20±0.02	15.09±9.15	3.00±1.63
14	*Azadirachta indica*	5.88±0.30	47.56±23.83	0.17±0.01	26.51±11.13	3.82±1.29
15	*Hura creptians*	5.6±0.40	46.88±26.19	0.18±0.02	26.08±11.53	3.79±1.45
16	*Docryodes edulis*	4.55±0.08	42.83±25.57	0.18±0.04	38.64±15.12	5.19±1.41
17	*Psidium guajava*	5.64±0.11	48.45±27.17	0.19±0.04	47.83±28.00	6.67±2.00
18	*Citrus cenesis*	4.49±0.32	54.21±28.87	0.15±0.01	38.05±10.12	5.28±0.14
19	*Mangifera indica*	5.05±0.55	39.76±43.10	0.16±0.04	38.01±4.22	5.10±0.57
20	*Moringa oleifera*	5.72±0.36	19.45±8.74	0.18±0.01	47.20±25.46	5.82±2.52

TABLE 3: Air Pollution Tolerance Index of Plants in Saponba Forest Reserve

S/N	TREE SPECIES	pH	TCH (mg/gFW)	AA (mg/g)	RWC (%)	APTI
1	*Nauclea diderrichi*	4.68±0.65	30.69±12.07	0.20±0.05	28.72±13.70	4.24±1.45
2	*Terminalia catapa*	4.73±0.67	32.27±13.62	0.22±0.07	24.62±18.11	17.05±17.43
3	*Gmelina aborea*	6.18±0.22	24.60±7.17	0.19±0.02	21.63±16.23	3.08±1.60
4	*Khaya gradifiola*	5.00±0.59	41.50±16.61	0.18±0.06	35.37±3.37	5.18±0.21
5	*Tectona grandis*	6.32±0.32	42.96±18.15	0.20±0.08	17.16±5.55	2.71±0.89
6	*Gambaya albidum*	5.79±0.45	35.19±.7.76	0.17±0.00	25.74±7.59	4.59±0.93
7	*Cedrala adorata*	6.36±0.34	50.26±11.72	0.39±0.11	18.10±19.06	2.49±2.20
8	*Triplochiton scleroxylon*	6.41±0.30	27.43±12.22	0.16±0.02	21.22±12.5	2.89±1.34
9	*Terminalia ivorensis*	5.39±1.06	53.87±53.13	0.34±0.17	18.32±9.98	3.44±1.72
10	*Garcina kola*	5.25±1.41	46.42±49.99	0.19±0.05	30.62±9.65	4.72±1.09
11	*Albizia lebbek*	6.24±0.29	59.64±34.09	0.21±0.17	29.45±1.50	3.87±0.95
12	*Irvinga garbonesis*	4.61±0.50	45.09±16.19	0.34±0.02	21.83±5.91	4.53±0.95
13	*Entandrophragma angolensis*	5.29±0.23	50.7±33.89	0.36±0.05	27.77±13.35	4.62±2.59
14	*Azadirachta indica*	6.01±0.40	34.48±6.35	0.20±0.04	34.37±13.45	4.62±2.59
15	*Hura creptians*	5.68±0.65	44.53±22.90	0.21±0.04	31.54±6.69	4.53±1.13
16	*Docryodes edulis*	4.33±0.24	32.67±11.76	0.19±0.13	29.38±12.14	14.67±12.25
17	*Psidium guajava*	5.13±0.15	26.65±6.83	0.41±0.09	33.37±12.32	5.23±1.62
18	*Citrus cenesis*	5.54±0.47	33.05±7.23	0.22±0.04	28.04±1.54	3.83±.0.12
19	*Mangifera indica*	5.10±0.70	27.43±9.33	0.22±0.07	34.63±13.47	4.55±1.06
20	*Moringa oleifera*	5.89±0.42	26.83±9.78	0.25±0.14	40.10±10.17	5.40±1.62

TABLE 4: The APTIs of the three Artificial Forest Reserves

Samples	Ogba	Uniben	Saponba	Mean ± SD
1	4.64±0.68	2.76±2.64	4.24±1.45	4.24±1.45
2	4.21±0.59	4.53±0.98	17.05±17.43	17.05±17.43
3	3.07±0.81	3.56±1.91	3.08±1.60	3.08±1.60
4	5.68±1.16	4.01±1.67	5.18±0.21	5.18±0.21
5	2.88±0.44	1.96±0.90	2.71±0.89	2.71±0.89
6	4.24±0.57	4.56±0.72	4.59±0.93	4.59±0.93
7	2.85±0.24	3.42±0.62	2.49±2.20	2.49±2.20
8	2.12±0.93	2.96±0.85	2.89±1.34	2.89±1.34
9	4.56±0.94	4.26±2.17	3.44±1.72	3.44±1.72
10	3.74±1.01	4.68±1.98	4.72±1.09	4.72±1.09
11	4.35±0.81	4.45±1.53	3.87±0.95	3.87±0.95
12	4.25±0.53	2.59±0.75	4.53±0.95	4.53±0.95
13	3.89±1.42	3.00±1.63	4.62±2.59	4.62±2.59
14	3.25±1.16	3.82±1.29	4.62±2.59	4.62±2.59
15	5.07±1.31	3.79±1.45	4.53±1.13	4.53±1.13
16	4.84±1.65	5.19±1.41	14.67±12.25	14.67±12.25
17	3.78±0.54	6.67±2.00	5.23±1.62	5.23±1.62
18	3.88±0.57	5.28±0.14	3.83±.0.12	3.83±.0.12
19	5.38±0.75	5.10±0.57	4.55±1.06	4.55±1.06
20	6.35±0.34	5.82±2.52	5.40±1.62	5.40±1.62

Table 5: Plant Tolerance Graduation

Species	Ogba	Uniben	Saponba
1	MT	S	MT
2.	IM	MT	T
3.	IM	T	S
4.	MT	S	S
5.	S	IM	S
6.	S	IM	S
7.	IM	T	S
8.	S	IM	S
9.	MT	S	S
10.	MT	IM	S
11.	IM	T	S
12.	MT	S	S
13.	MT	S	S
14	S	IM	S
15	MT	S	S
16	S	IM	T
17	S	IT	S
18	S	IT	S
19	T	MT	T
20	T	T	S

T= Tolerant, IM = Intermediate, MT = Moderately S = Sensitive

5. DISCUSSION

5.1 pH: The pH of any solution indicates the acidity or alkalinity level of the solution. Alkaline solution has pH above 7 while acidic has pH less than 7. Solutions with pH 7 are regarded as neutral. pH measurement is very important, since most chemical reaction is pH dependent. In this study, the pH value of leaf extract of plant species obtained from the Ogba Forest Reserve is between 4.56 – 6.5 with a mean value of 5.85±0.56. For Uniben Forest Reserve, the pH ranged from 4.48 – 6.11 with a mean value of 5.39±0.52. The pH value of leaf extract of Saponba Forest Reserve ranged between 4.33 to 6.41 with a mean of 5.50±0.64. From the above, the pH value of the tree forest reserved indicates acidity. Acidic pH could usually be attributed to acidic air pollutants (Swani *et al*, 2004). It has been reported that pH is highly correlated with plant sensitivity as well as photosynthesis. Low pH value has been reported to be positively correlated with sensitivity as well as reduced photosynthesis in plants (Yan-Ju and Hui, 2008; Thakar and Hishra, 2010). On the basis of pH, these plants could be regarded as sensitive. This is however not conclusive since we cannot use only this factor for classification.

5.2 Total chlorophylls: The total chlorophyll content of a plant is an indication of its photosynthetic activity. It also signifies growth and development of the biomass. High chlorophyll content is therefore an indication of high photosynthetic activity growth and development. Katiyar and Dubey (2001) reported that chlorophyll content varies from species to species and that it is equally depended on the age of the leaf, biotic and abiotic condition of the environment as well as the pollution level of the pollution. In this work, the chlorophyll content ranged from 31.63 to 94.80 mg/g with a mean of 51.01±19.02 mg/g in Ogba Forest, 19.45 to 69.82 mg/g with a mean of 39.86±13.88 mg/g in Uniben Reserve and 24.60-59.64 mg/g a mean of 38.31±10.38 mg/g. Of the three forest reserves, the Saponba forest has the least total chlorophyll, which could imply that this reserve is exposed to higher ambient air pollution load. Pollution leads to photosynthetic pigment degradation and so reduced total chlorophyll (Ninave *et al*, 2000).

5.3 Ascorbic Acid (Vitamin C) Content: Ascorbic acid is anti-oxidant which is found in large amount in growing plant parts. It influences resistance to adverse environmental condition (Keller and Schwager, 1977; Lin et al, 2000). It has also been reported to be important in cell division, defense and cell wall synthesis (Randhi and Reddy, 2012). It is a natural detoxicant which is reported to prevent the effects of air pollution in the plant tissues (Mohammed, Rashni and Pramod, 2011). The ascorbic acid content of leaf extracts from plant species from Ogba Forest Reserve ranged from 0.16 to 0.34mg/g with a mean of 0.22±0.05mg. For Uniben, the range is from 0.14 to 0.23mg/g with a mean value of 0.18±0.02mg/g. The result of the ascorbic acid content of leaves from Saponba Forest Reserve showed ranged from 0.16 – 0.4mg/g with a mean value of 0.24±0.07mg/g. It is believed that low ascorbic acid content is plants support the sensitive nature of these plants especially in acidic pollutants. (Chaudhary and Rao, 1977, Varsheney and Varshney, 1984; Tripathi and Gautam, 2007). All the plants in the study area had low ascorbic acid content. These trees could therefore be classified as sensitive plants.

5.4 Relative Water Content: Water is very important to life; Water is the medium for chemical reactions in living things. A high relative water content in plants helps to maintain its physiological balance under stress (Yan-Ju and Hui, 2008). Jyothi and Janga, 2010 reported that the high relative water content of leaves of plants under stress condition is indicative of plant tolerance to stress/air pollution. In this study, the relative water content of leaves of plant specie from Ogba Forest Reserve ranged from 13.11 to 34.37 % with a mean of 24.35±5.74 %. For Uniben the value ranged between 10.56 to 47.83% with a mean of 29.44±10.02 %, while that of Saponba Reserve had a range between 17.16 to 40.10 % with a mean value of 27.62±6.45 %. The low relative water content is these sites again is suggestive that these plants are sensitive plant species since sensitive plant species are known to have low relative water content.

5.5 Air pollution tolerance index (APTI): This is an index that gives the capability of a plant to combat air pollution. It is computed by combination four biochemical factors; ascorbic acid, total chlorophyll, relative water content and pH. This index is a more reliable method for screening plants with respect to their susceptibility to air pollution and stress plants with high APTIs are known of tolerant species because they are able to withstand air pollution and thrives in an air polluted environment. They act as a sink to pollutant and so could be used to mitigate air pollution. Those with lower APTIs cannot withstand pollution and these are known as less tolerant and more sensitive plant species. These are a bio-indicator of pollution and must be protected for them continue to exist. The air pollution tolerance index of plants from Ogba Forest Reserve ranged between 2.12 to 6.35 with a mean value of 4.15±1.03. For Uniben Forest Reserve it ranged between 1.96 and 6.67 with a mean of 4.12±1.17 while that of the plants from Saponba Forest Reserve ranged from 2.49 to 17.15 with a mean value of 5.32±3.72. These plants are all sensitive based on their APTI values of between 1.96 – 17.05 according to Randy and Reddy (2012)

5.6 Plant Tolerance Graduation: **From Table 5:** It was observed that based on this classification, there was a graduation from sensitive through intermediate moderated tolerant to tolerant. This further established the fact that plants sensitively vary with environmental conditions.

6. Conclusion: Air Pollution is both natural and man-made. Be, that as it may, it is a major problem affecting our nation, Nigeria due to increased urbanization and industrialization.

Since it is difficult to mitigate the effect of air pollution, physical and chemical, the biological method using APTI becomes very handy. It's appropriate usage would help in developing green belt with the planting of tolerant species around sources of air pollution while the sensitive ones would be protected so that they do not go extinct. From this study, all the plant species investigate were sensitive to air pollution. They therefore need to be protected.

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