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Biochemical Parameters and Air Pollution Tolerance Index of Trees along New Ife Road and Within Forestry Research Institute of Nigeria in Ibadan, Oyo State, Nigeria

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ABSTRACT: Poor air quality is one of the renowned issues instigating health complications in urban areas today due to man's exposure to various gases. The paper assessed the ambient air along New Ife Road (NIR) and Forestry Research Institute of Nigeria Headquarters (FRIN), Ibadan, Oyo State using Biochemical changes and computed the air pollution tolerance indices from fresh leaf samples of ten (10) similar plant species selected randomly in triplicates in both study locations. *Monoon longifolium, Chrysophyllum albidum, Terminalia catappa, Dacryodes edulis* and *Terminalia ivorensis* had tolerant APTI values; *Mangifera indica, Psidium guajava, Terminalia ivorensis, Terminalia catappa* and *Cocos nucifera* were intermediate APTI while *Mangifera indica, Moringa oleifera and Azadirachta indica* were found to be sensitive to air pollution. The APTI values at both locations are not significantly different; therefore NIR and FRIN are rated as areas of high anthropogenic activities. *Terminalia ivorensis*, (31.58 in NIR) *Terminalia catappa* (30.56 in FRIN) *Dacryodes edulis*, (31.15 in NIR and 34.76 in FRIN) (*Chrysophyllum albidum* (34.78 in NIR and 39.78 in FRIN) and *Monoon longifolium* (49.83 in NIR and 57.50 in FRIN) were classified as sink of air pollution based on their APTI values which ranged from 30>100 obtained in both locations of study. It is however suggested that these plants identified as sink of air pollutants, should be used for landscaping and planted 50m from the roadside for bio-filtration of the atmosphere.

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Air pollution in major cities around the world is of emergent concern due to increased traffic load, urbanization and industrialization (Sharma *et al*., 2019). These various air pollution sources add toxic gases to the atmosphere thereby leading to vast deterioration of air quality. Mahecha *et al*. (2013); Kelly and Zhu (2016) and Viippola *et al*., (2018) stated that poor air quality is one of the renowned issues instigating health complications in urban areas today. This is due to man's exposure to the various gases (majorly carbon dioxide and oxides of Nitrogen) emitted from these sources (WHO, 2010). Automobile transport is one of the leading sources of urban air pollution worldwide and is known to cause deteriorating air quality in the atmosphere (Wang and Hao 2012). Around 80-90% of worldwide populace inhabit where air quality does not conform to World Health Organization air quality guidelines (WHO, 2016). Plants are well-known to sustain the atmosphere and improve air quality thereby making it

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safer and healthier to live in. They produce oxygen which is vital element of clean air and absorb carbon dioxide and other harmful gases (Ozone, oxides of nitrogen, etc) during photosynthesis through the stomata in their leaves. Vegetation traffic blockades along road side can be used as an active method to improving roadside air quality and to decrease human exposure to traffic air pollutants (Shrestha *et al.*, 2021). Recognizing bio-indicators and tolerant tree species have been long-established as eco-sustainable means for monitoring and reduction of atmospheric air pollutants. (Kour and Sharma, 2016, Ogboru *et al*., 2021). Air pollution tolerance indices are used in assessing and monitoring the level of pollution in an area. Air Pollution Tolerance Index (APTI) is an eco-friendly method to evaluate the impact and sensitivity of air pollution on plants. This is achieved through the assessing of diverse physiological and biochemical parameters of leaves, sampled from tree species in this area and compared with an area with same ecological characteristics but lesser anthropogenic activity. It is a technique designed by Singh and Rao (1983) which combines four biochemical parameters: ascorbic acid, total chlorophyll, pH and relative water content. Plants with higher Air Pollution Tolerance Index (APTI) value also act as natural sink or good source of carbon sequestration (Kour and Sharma, 2016). Plants can be classified as the most important bio-filters of the atmosphere and as such identifying which tree act as carbon sink and bio-indicator for monitoring air pollution is vital. Hence this study was designed to assess selected biochemical changes and Air Pollution Tolerance Index (APTI) values of trees along New Ife Road Ibadan and within the vicinity of Forestry Research Institute of Nigeria (FRIN), Jericho Area of Ibadan, Oyo State, Nigeria.

MATERIALS AND METHODS

Description of Study Area: The study areas are located within Ibadan Metropolis. Ibadan which is the capital of Oyo State, Nigeria is also described as one of the largest cities in tropical Africa. It lies between geographical longitude 7°2'E and 7°40'E and latitude 3°35'N and 4°10'N (Adewuyi *et al*., 2019) It is 128 km north-east of Lagos and 345 km southwest of Abuja, the Federal Capital of Nigeria. The study was conducted in two locations in the study area. They are the New Ife Road Ibadan and Forestry Research Institute of Nigeria (FRIN), Jericho Hill, Ibadan. Both study locations are situated at Oyo State are situated in the South Eastern part of Oyo State (Ariwado *et al*., 2012). New Ife Road is located between Longitude 07o24’02” N and 03o56’49’’E. There are large number of petroleum filling stations and heavy vehicular traffic along the New Ife Road. FRIN is located between longitude 07°23'18"N and 07°23'43"N and latitude 03°51'20"E and 03°51'43"E. There are no petroleum filling stations and fewer vehicular traffic within the vicinity of FRIN, consequently, this location could serve as a control. There are two peaks for rainfall which are in June and September with mean maximum and minimum temperature of 26.46 ^{0}C and 21.42 ^{0}C and the relative humidity of 74.55%. The flora is of lowland rain forest zone of South-West Nigeria (Agbeja *et al*., 2021).

Selection of Plant samples: Plant specimens at New Ife Road were collected at 30 -50 m from fuel dispensing stations and same tree species were also selected within the vicinity of Forestry Research Institute of Nigeria (FRIN). The plants selected for this study are given in Table 1.

Table 1: Selected plants in NIR and FRIN

S/N	**Botanical Name**	**Family**	**Common Name**
1	*Mangifera indica*	Anacardiaceae	Mango
2	*Psidium guajava*	Myrtaceae	Guava
3	*Terminalia ivorensis*	Combretaceae	Black afara
4	*Dacryodes edulis*	Burseraceae	African pear
5	*Azadirachta indica*	Meliaceae	Neem
6	*Terminalia catappa*	Combretaceae	India-almond
7	*Moringa oleifera*	Moringaceae	Moringa
8	*Cocos nucifera*	Arecaceae	Coconut
9	*Chrysophyllum albidum*	Sapotaceae	Cherry
10	*Monoon longifolium*	Annonaceae	Mast tree

Biochemical Parameters estimation: The Biochemical parameters estimated for the computation of Air Pollution Index include pH of leaf extract (Singh and Verma, 2007), total chlorophyll (Arnon 1949), ascorbic acid (Lui and Ding, 2008) and relative water content (Singh, 1977). These standard methods of analysis were also adopted by Sharma *et al*., (2019), Ghosh *et al*., (2021) and Elawa *et al*., (2022)

*Leaf extract pH***:** Fresh leaves (5.0 g) sample were mashed in a ceramic crucible with 10 ml of deionized water, the leaves extract was filtered with filter paper and pH of the extract was determined using a calibrated pH meter in buffer solutions of 4 and 9 (Singh and Verma, 1997).

Total chlorophyll content: This was carried out using the formulae described by Arnon (1949).1.0 g of leaves sample were cleaned with distilled water and dried at ambient temperature. It was then extracted with 20 ml of 80 % acetone for 15 minutes. The liquid portion was filtered into test tube and centrifuged at 2500 r.p.m for 15 minutes. The supernatant was collected and made up to volume of 50 ml using 80 % acetone. The absorbance was taken at 645nm and 663nm for chlorophyll a and b respectively using a UV

spectrophotometer. The total chlorophyll was determined using the following formula:

$$C = 20.2A_{645} + 8.02A_{663} \qquad 1$$

$$\text{T in mg/g} = 0.1\ xCx\ (leaf\ \frac{DW}{FW})\text{-}\ldots\ldots 2$$

Where: C = the sum of chlorophyll content (mg/litre) of acetone extract; A_{645} and A_{663} = Absorbance of the leaf extract at 645 nm and 663 nm; 0.1 = Constant; DW = Dry weight; FW = Fresh weight; T = Total Chlorophyll Content

Relative water content (RWC) of leaves: Singh and Verma (1997) method of estimating RWC was adopted. 5.0 g of leaves samples were soaked in water and removed after 2 hours, air-dried and then weighed to obtain its turgid weight (TW). Thereafter the leaves were oven dried at 105 ^{0}C for 2 hours and re-weighed to get the dry weight (DW). This experiment was done in triplicates and weights obtained were imputed in the relationship below as RWC.

$$RWC = \frac{FW-DW}{TW-DW} X \frac{100}{1} \qquad 3$$

Determination of ascorbic acid: 1 g of leaf sample was homogenized with distilled water (1 ml) and placed in test tubes. 4 ml of oxalic acid-EDTA, 1 ml of 5 % tetraoxosulphate (VI) acid and 2ml of ammonium molybdate was added in the test tubes. These were allowed to stand for 15 minutes after which the absorbance was measured at 760 nm using spectrophotometer (Jenway, UV/VIS spectrophotometry 6150 model). The concentration of ascorbic acid in the samples was induced from the calibration curve of standard ascorbic acid in mg/g.

Measurement of Air Pollution Tolerance Index (APTI): The air pollution tolerance indices of the plant species were determined following the method adopted by Singh and Rao (1983).

$$APTI = \frac{[AA(T+P)+R]}{10} \qquad 4$$

Where: APTI = Air Pollution Tolerance Index; AA = Ascorbic acid (mg/g); T = Total Chlorophyll (mg/g); P = pH of leaf extract; R = Relative water content (%)

APTI value categories of plant species: based on air pollution tolerance index include: 11 –16 Sensitive; 17 –29 Intermediate and ≥ 30Tolerant

Statistical analysis: Microsoft Excel was used to calculate the mean and standard deviation for the biochemical parameters and APTI for the experimental values obtained in this study while SPSS 21 was used for Analysis of Variance with Duncan HSD post hoc to separate the means of biological parameters and APTI.

RESULTS AND DISCUSSIONS

Biochemical analysis: The results of bio-chemical parameters and APTI values for the selected plants species in this study obtained in NIR and FRIN are presented in Table 2. pH values ranged from 4.27 to 6.40 in FRIN while in NIR they ranged from 4.27 to 6.53. *Cocos nucifera* had the lowest pH in both locations while *Dacryodes edulis* had the highest pH values in both study locations the higher the pH, the higher the tolerance level of the plant species according to Darley *et al*., 2012 and Kaur *et al*., (2016). Therefore species with higherpH,*Dacryodes edulis* is most tolerant to air pollution across both locations. Values of ascorbic acid for the experimental sites ranged from 0.23 mg/g to 3.12 mg/g (New Ife road) while that of FRIN ranged from 0.43 mg/g to 3.61 mg/g. *Monoon longifolium* showed highest ascorbic acid values in both NIR (3.12±0.09 mg/g) and FRIN (3.61±0.02 mg/g).Lowest values of ascorbic acid were obtained from *Cocos nucifera* in both locations (4.27±0.06mg/g and 4.02±0.1 mg/g respectively). Ascorbic acid brings about an increase of secondary metabolites and antioxidant activities which inhibit growth in plants during stress conditions such as pollution (Bharti *et al*., 2018). With increase in pollution, ascorbic acid content also increases to combat the stressed condition. It is a dominant reductant, electron donor, sifts free oxygen radicals, permits the reduction of sulphite to hydrogen sulphide and reduces the toxicity of SO_2 which are present in premium motor spirit (PMS) (Shrestha *et al*., 2021; Rudolph and Bukatsch1996). High ascorbic acid content observed in leaf samples of plant species indicates plants sensitivity to air pollution (Sharma *et al*., 2019). Total chlorophyll values vary from 8.57 mg/g/FW to 20.07 mg/g/FW in NIR and 11.57 mg/g/FWto 23.78mg/g /FW in FRIN. The lowest values of 8.57±0.31were in *Cocos nucifera* in NIR and 11.57±0.33 mm/g/FW in *Moringa oleifera* in FRIN. The values of total chlorophyll was higher in FRIN than NIR. Although all the species showed significant variation of decrease total chlorophyll values except in *Magnifera indica* as shown in Tables 2 and 3. The extent to which plant species were affected varied from species to species. The decrease in chlorophyll in NIR plants indicated that there is severe SO_2 pollution which is one of the primary gases in premium motor spirit. This decrease in chlorophyll was similar to studies by Kour and Raina (2014) along roadside trees in Jamui City, India. The study emphasized that

sulphur dioxide is one of the major contributors of air pollution in the urban and industrialized areas, places adjacent to a thermal power station burning fossils mostly coals; smelters, brick kilns, and in cities where there is mass growth of vehicles igniting oils (Bharali *et a*l., 2015a,b; Bharali., 2021). Low chlorophyll values also indicated that such plant is sensitive to air pollution (Anake *et al*., 2018) as shown in *Mangifera indica* and *Cocos nucifera* ranking them as sensitive plant species. RWC ranged from 23.79 % to 82.59% in NIR while in FRIN it was 25.76 % to 85.15 %. Lowest and highest values were obtained in *Moringa oleifera* and *Chrysophyllum albidum* in both study areas respectively. There was similar trend of reduced RWC values in plant species from NIR to FRIN except in *Azadirachta indica* where RWC values were higher in NIR than in FRIN. This trend could be due to the need for the plant species to adapt to the air pollutants present in NIR. Similar results were obtained in the studies of Prathipa *et al*., (2021) and Molnár *et al*., (2018) which evaluated plant species in locations where vehicular traffic was imminent. Water conveys nutrients all-round the plant and high relative water content means that the plant species are sufficiently provided with food and other nutrients essential for survival. Implying that low relative water content of the tree species could lead to senescence especially at the early stage of life and then death. High relative water content in plant leaves indicates tolerance to air pollution thereby maintaining physiological balance in the plant species according to Manjunath*et al*., 2019 and Bharti *et al*., 2018.

Table 2: Biochemical parameters of selected tree species on New Ife Road (NIR) and Forestry Research Institute of Nigeria (FRIN) locations and their corresponding APTI values and rating

Botanical Name	Location	pH	TCH	RWC	AA	APTI	Change in APTI	APTI Rating
Mangifera indica	NIR	5.65±0.09	14.93±0.62	46.30±1.05	0.24±0.03	14.44	-34.52	Sensitive
	FRIN	6.07±0.02	11.69±0.42	56.12±0.74	1.03±0.01	22.06		Intermediate
Psidium guajava	NIR	4.38±0.17	15.58±0.27	42.96±0.15	1.18±012	20.04	-12.60	Intermediate
	FRIN	4.96±0.07	18.49±1.02	49.95±0.11	1.14±0.02	22.93		Intermediate
Terminalia ivorensis	NIR	6.01±0.01	20.07±0.46	61.69±0.33	0.88±0.01	24.93	-21.05	Intermediate
	FRIN	5.75±0.11	23.78±0.77	67.74±0.47	1.26±0.008	31.58		Tolerant
Dacryodes edulis	NIR	6.53±0.03	11.24±0.31	72.23±0.58	1.48±0.05	31.15	-10.38	Tolerant
	FRIN	6.47±0.05	14.27±0.06	75.24±1.13	1.63±0.02	34.76		Tolerant
Azadirachta indica	NIR	4.4±0.10	14.39±0.41	35.61±0.37	0.22±0.01	11.76	-18.33	Sensitive
	FRIN	5.06±0.21	20.57±0.38	35.27±0.56	0.43±0.01	14.40		Sensitive
Terminalia catappa	NIR	5.73±0.15	9.38±0.16	66.85±0.15	1.15±0.11	25.59	-16.26	Intermediate
	FRIN	5.80±0.26	13.67±0.27	70.37±0.41	1.41±0.01	30.56		Tolerant
Moringa oleifera	NIR	6.50±0.10	9.48±0.16	23.79±0.22	0.32±0.002	8.64	-18.41	Sensitive
	FRIN	6.03±0.15	11.57±0.33	25.76±0.55	0.54±0.01	10.59		Sensitive
Cocos nucifera	NIR	4.27±0.06	8.57±0.31	28.47±0.48	2.66±0.04	20.06	-15.18	Intermediate
	FRIN	4.10±0.10	10.78±0.16	33.37±0.50	2.72±0.10	23.65		Intermediate
Chrysophyllumalbidum	NIR	5.90±0.10	18.76±0.44	82.59±0.75	1.26±0.003	34.78	-12.57	Tolerant
	FRIN	6.10±0.10	21.05±0.13	85.15±0.74	1.55±0.04	39.78		Tolerant
Monoon longifolium	NIR	6.10±0.10	14.89±0.48	74.41±0.55	3.12±0.09	49.83	-13.34	Tolerant
	FRIN	5.93±0.12	18.66±0.33	75.32±1.00	3.61±0.02	57.50		Tolerant

pH = pH of the leaf. T=Total chlorophyll content in mg/g per fresh weight. R= Relative water content in %. AA= Ascorbic acid in mg/g, APTI= Air pollution Tolerance Index., NIR=New Ife Road., FRIN= Forestry Research Institute of Nigeria

Table 3: ANOVA for Biochemical parameters

Tree Species	**Ph**	**TCH**	**RWC**	**AA**
Mangifera indica^{a}	5.86±0.19	13.31±1.47	51.21±4.35	0.63±0.35
Psidium guajava^{b}	4.67±0.27	17.17±1.28	46.46±3.07	1.16±0.06
Terminalia ivorensis^{a}	5.89±0.12	21.93±1.69	64.72±2.67	1.07±0.17
Dacryodes edulis^{c}	6.50±0.04	12.75±1.34	73.74±1.47	1.55±0.07
Azadirachta indica^{d}	4.73±0.31	17.48±2.72	35.44±0.37	0.32±0.09
Terminalia catappa^{a}	5.77±0.16	11.46±1.83	68.61±1.56	1.28±0.13
Moringa oleifera^{a}	6.11±0.35	10.39±0.80	24.52±0.67	0.42±0.09
Cocos nucifera^{e}	4.18±0.09	9.67±0.98	30.91±2.18	2.68±0.06
Chrysophyllum albidum^{a}	6.00±0.11	19.90±1.02	83.87±1.24	1.40±0.12
Monoon longifolium^{a}	6.01±0.11	16.77±1.67	74.87±0.70	3.37±0.22
F-Statistics	55.19***	27.00***	345.17***	138.68***

*Abcde: mean value with different superscripts are statistically different across locations; ***P<0.01*

Air Pollution Tolerance Index values ranged from 8.64 to 57.50 in both locations which is between the sensitive and tolerant grade of plant species. The lowest APTI (sensitive plant species) was obtained from *Moringa oleifera* in NIR while the highest values were from *Monoon Longifolium* also in NIR road. The sensitive trees in this study include *Mangifera indica*, *Azadirachta indica* and *Moringa oleifera* in both locations because their APTI values were from 1-16. Intermediate tree species include *Mangifera indica* in

NIR, *Psidium guajava* in NIR and FRIN, *Terminalia ivorensis* in NIR and *Cocos nucifera* in NIR and FRIN because their values fell from 17-29. The tolerant trees species in this study include *Terminalia ivorensis* in FRIN, *Dacryodes edulis* in NIR and FRIN, *Terminalia catappa* in FRIN, *Chrysophyllum albidum*in NIR and FRIN and *Monoon longifolium* in NIR and FRIN it was seen that APTI values were consistently higher in FRIN than NIR. The lowest APTI change of -34.52 was in *Mangifera indica* while the highest of -10.38was in *Dacryodes edulis*

Table 3 shows the F-Statistics across the different parameters and it revealed that there was significant difference in pH, TCH, RWC and AA across the tree species. The values were significantly different at 1%. The post hoc test indicated by the superscript separated the means and showed the sources of differences. The pH of *Mangifera indica* (5.86±0.19) is not statistically different from that of *Terminalia ivorensis* (5.89±0.12), *Terminalia catappa* (5.77±0.16), *Moringa oleifera* (6.11±0.35), *Chrysophyllum albidum* and *Monoon longifolium* (6.01±0.11) while the converse holds for *Psidium guajava* (4.67±0.27), *Dacryodes edulis* (6.50±0.04), *Azadirachta indica* (4.73±0.31) and *Cocos nucifera*4.18±0.09. The pH values for these other four tree species are statistically different from one another. The same explanation also holds for TCH, RWC and AA.

Table 4: ANOVA for APTI of plant species

Tree Species	APTI
Mangifera indica^{a}	18.29±3.34
Psidium guajava^{a}	22.44±0.31
Terminalia ivorensis^{b}	27.89±2.77
Dacryodes edulis^{a}	32.87±1.59
Azadirachta indica^{a}	13.06±1.45
Terminalia catappa^{c}	29.73±3.03
Moringa oleifera^{d}	9.60±0.84
Cocos nucifera^{a}	23.47±3.07
Chrysophyllum albidum^{e}	36.76±1.58
Monoon longifolium^{f}	53.65±3.43
F-Statistics	110.367***

*Abcdef: mean value with different superscripts are statistically different; ***P<0.01*

The F- statistics on APTI tables revealed that at least two tree species have statistically different APTI. The post hoc test shows that the mean APTI of *Psidiumguajava* (22.44±0.31), *Dacryodes edulis* (32.87±1.59), *Azadirachta indica* (13.06±1.45), *Cocos nucifera* (23.47±3.07) are not statistically different from *Mangifera indica* (18.29±3.34) at 1%. But others are statistically different from *Mangifera indica*

Conclusion: The impact and sensitivity of the sample trees species are not statistically different to air pollution in NIR and FRIN, both area can be rated to be of high anthropogenic activity. Therefore *Terminalia ivorensis*, *Terminalia catappa*, *Dacryodes edulis*, *Chrysophyllum albidum* and *Monoon longifolium* are recommended as sink for air pollutants based on the APTI values. It is however suggested that these plants identified as sink should be used for landscaping and planted 50m from the roadside for bio-filteration of the atmosphere.

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