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Air Pollution Tolerance, Anticipated Performance, and Metal Accumulation Indices of Some Tree Species in Warri City, South-South Nigeria

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ABSTRACT :

When particulate matter (PM) builds up on their leaf surfaces, trees in urban areas can absorb PM from the environment and enhance the quality of the air. A plant's physiology, morphology, and biochemistry may change in response to air pollution, which might have an impact on the plant's development and function. Using the air pollution tolerance index (APTI), the anticipated performance index (API), and the metal accumulation index (MAI), three tree species that are frequently grown along roadside in Warri City- Polyalthia longifolia, Mangifera indica, and Terminalia catappa - were assessed for their susceptibility to air pollution. An extrapolative foliar metal accumulation index (MAI) was developed after the deposition of four heavy metals (Cd, Zn, Pb, and Cu) on the leaves of the aforementioned tree species was investigated using an atomic absorption spectrophotometer. Nonetheless, there was an increase in ascorbic acid levels in the experimental sites. The results of the biochemical analyses showed that the leaf extract's pH, relative water content, and total chlorophyll were all lower at the experimental sites. The APTI of the trees in the control site ranged from 8.37 (Polyalthia longifolia) to 13.43 (Terminalia catappa), while in the experimental sites it ranged from 11.32 (Polyalthia longifolia) to 26.85 (Terminalia catappa). The plant's tolerant response level to vehicular air pollution was as follows: Mangifera indica > T. catappa > P. longifolia. The anticipated performance index revealed that M. indica is a very good performer, while T. catappa is a good performer, and as such, they can be planted along the roadsides for the mitigation of auto air pollution. P. longifolia was rated poorly and unsuitable as a pollution sink. The metal accumulation index (MAI) values ranged from 9.38-12.02; 4.27-15.94 and 9.30-10.9 at Control and Experimental sites for Polyalthia longifolia, Mangifera indica and Terminalia catappa respectively. Mangifera indica had the highest MAI. The findings show that the experimental sites had greater levels of traffic pollution's detrimental impacts on the tree species. Out of the three tree species that were tested, M. indica turned out to be the most resilient to traffic-related air pollution, while P. longifolia was the most vulnerable. P. longifolia is an excellent bioindicator of vehicular air pollution in the Warri metropolis, but M. indica may be employed as a sink for vehicular air pollution.

Keywords: Vehicular Pollution, Air Pollution Tolerance Index, Anticipated Performance Index, Metal Accumulation Index, Tolerant species

INTRODUCTION :

According to Croitoru et al. (2020), road transport accounts for over 90% of petroleum product consumption in Nigeria. Despite the fact that Nigeria's transport sector does not report annual anthropogenic air emissions, the country has conducted numerous studies on traffic-related pollution, and the findings of these studies have established Nigeria's transport networks as major contributors of anthropogenic emissions (Odekanle et al., 2017; Odunlami et al., 2018; Odogun and Georgakis, 2018; Fakinle et al., 2020). A significant portion of the automobiles on Nigerian roads are imports that have been driven for more than 15 years and are in acceptable condition (Croitoru et al., 2020).

According to Aliyu et al. (2019), there is a general increase in Nigerian automobiles that are old or badly maintained, which is thought to be exacerbating the country's air pollution problem. Most cars' exhaust contains catalyst beds that were intended to serve as an end-of-pipe treatment for pollutants, but they are usually no longer functional. Furthermore, despite the nation's massive reserves of crude oil with extremely low sulphur content (Faruq et al., 2012; Okedere et al., 2017a), the local refineries do not operate as planned, which means that the majority of the premium motor spirit (also known as petrol) and diesel (also known as automotive petrol oil) used in the nation are imported.

The use of these imported petroleum products has been linked to the atmospheric loading of pollutants such SO_x and certain heavy metals (Jimoda et al., 2014; Olatunji et al., 2015; Okedere et al., 2017a). Using the unique qualities of trees, nations all around the world are attempting to reduce urban air pollution. However, pollution-tolerant species of trees are best suited for their functional purposes. Since roadside vegetation is an essential component of urban areas, multi-stress tolerant plants have a great deal of potential to act as air pollution sinks, especially for particles and hazardous chemicals produced from particulates.

In order to determine which tree species are resistant to air pollution in Warri city's high traffic areas, this study used three different indices: the metal accumulation index (MAI), the expected performance index (API), and the air pollution tolerance index (APTI). In order to identify tolerant plants for usage in severely polluted situations, the main goal of this study was to evaluate the adaptability of frequently encountered roadside tree species exposed to air pollution.

MATERIALS AMD METHODS

Study area

Warri in Delta State, Nigeria, is lowland located between latitudes 5.29°N and 5.34°N and longitudes 5.41°E and 5.49°E. It is where major oil exploration and exploitation industrial activities occur as well as a major constellation of petrochemical complexes. It is located in southern part of Nigeria, within the rainforest subregion with an estimated population of about a million (Mustapha *et al*, 2011).

Sampling sites:

The sampling of trees was carried out from three locations inside the Warri town namely: Esisi road, Refinery road and Nigerian Port Authority (NPA) road served as the polluted (or experimental) sites. A pristine environment of a rural community Ugbomro was also taken for comparison, which is around 10 km away from the town, was selected as the control.

Sample collection:

Three plant species (*Polyalthia longifolia, Mangifera indica* and *Terminalia catappa*) growing along the roadsides of sampling locations was selected for the present study. The reason for selection of these plants was their common occurrence at all the studied sites. Biological characteristics like plant habit, canopy structure, type of plant, leaf size, leaf texture, leaf hardiness, economic value of the trees was recorded from tree species on the selected sampling locations in Warri Metropolis. Five exposed leaves in triplicates were carefully cut (at the base of their petiole) from three trees of each species and immediately transported to laboratory for analysis. Three trees of each species were gotten 5 leaves from each tree with 3 replications for every species in each site were analysed.

Evaluation of the biochemical effect of air pollution on the plant species

Chlorophyll was estimated following the method of Garty *et al*., 2001. Leaf extract pH using the method of Shannigrahi *et al*., 2004. Relative moisture content was measured by the method of Gharge and Menon, (2012). Ascorbic acid was determined using the method of Abida and Harikrishna, (2010).

Heavy metal analysis

The contents of different heavy metals like Cu, Zn, Cd and Pb was determined in leaf samples of plant species and the Soil collected from base of each selected plant under study using atomic absorption spectrophotometer.

Determination of the susceptibility levels of the plants species on the basis of their Air Pollution Tolerance Index (APTI).

Air Pollution Tolerance Index (APTI) will be determined by the method of Singh and Rao (1983).

APTI is given as:

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

- AA = Ascorbic Acid
- P = pH
- T = Total Chlorophyll
- R = Relative water Content.

Based on the Air Pollution Tolerance Index (**APTI)** values, the plants was grouped using the method of Thakar and Mishra (2010), which are as follows:

1. Tolerant (T): APTI > mean APTI + SD*
2. Moderately tolerant (MT): mean APTI < APTI < mean APTI + SD
3. Intermediate tolerant (IT) : mean APTI—SD < APTI < mean APTI
4. Sensitive (S): APTI < mean APTI—SD

Anticipated performance index (API) of studied tree species

The APTI index shows the effect of the pollutants only on the biochemical parameters. In order to combat air pollution by planning the green belt development in a particular area, many socio-economic factors are to be considered. Hence the Gradation of plant species based on APTI as well as

GRADE	SCORE (%)	ASSESSMENT CATEGORY
0	Up to 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

morphological parameters and socio-economic importance was used (Table 1). The method contains a grading system where a tree species is graded based on various parameters. Anticipated Performance Index was obtained and trees classified based on method of Govindaraju *et al*., 2011 (Table 2).

Table 1: Criteria for the Gradation of plant species based on APTI as well as morphological parameters and socio-economic importance

Grading character	Parameter	Pattern of assessment	Grade allotment
Tolerance	APTI	9.0 – 12.0 12.1 – 15.0 15.1 – 18.0 18.1 – 21.0 21.1 – 24.0	+ ++ +++ ++++ +++++
Biological and Socio-economic	Canopy structure	Global/round Spreading Dense	- + ++
	Type of plant	Deciduous Evergreen	- +
	Plant size	Small Medium Large	- + ++
Laminar size	Leaf size	Small Medium Large	- + ++
	Texture	Smooth Coracious	- +
	Hardiness	Delineate Hardy	- +
	Economic value (Uses)	Less than three Three or four Five or more uses	- + ++

Table 2: Anticipated Performance Index (API) for species

Metal accumulation index (MAI)

To evaluate the overall performance of the trees vis-`a-vis metal accumulation, the MAI was computed according to the following equation (Liu et al. 2007):

$$\mathbf{MAI} = (\mathbf{1}/N)\sum_{J=1}^{N} \boldsymbol{Ij}$$

where N refers to the total number of metals analyzed and Ij (= x/dx) is the subindex for variable j, obtained by dividing the mean value (x) of each metal by its standard deviation (dx) (Liu et al. 2007).

Data analysis

The data generated was subjected to descriptive statistics and one way Analysis of Variance (ANOVA) using SPSS and Microsoft Excel Software. Correlation was carried out between independent variables namely Chlorophyll, pH, RWC, ascorbic acid and dependent variable such as APTI.

Ascorbic acid

The ascorbic acid content of all the three tree species at the experimental sites were higher and significantly different than those of the control site ($p<0.05$). The ascorbic acid ranged from 6.69 (*Polyalthia longifolia*) to 12.34mg/g (*Terminalia catappa*) in the control and 8.87 (*Polyalthia longifolia*) to 19.57 mg/g (*Terminalia catappa*) in the experimental sites (Esisi, Refinery and NPA roads). The ascorbic acid content of *Polyalthia longifolia* taken from Esisi road was significantly different from that of Refinery and NPA roads ($p<0.05$). The ascorbic acid content of *Terminalia catappa* was significantly different among the Refinery and NPA roads ($p<0.05$) (Table 3).

Relative water content

Relative water content of leaf samples of all the four tree species at experimental sites (Esisi, Refinery and NPA roads) were higher and significantly different from those at the control site ($p< 0.05$) Relative water content of leaf samples at the experimental sites ranged between 65.26and 91.60%, whilst those at the control site were ranging from 49.67to 65.78%. The highest relative water content in leaves of *Polyalthia longifolia* (73.72%), *Mangifera indica (*83.20%) and *Terminalia catappa* (91.60%) were observed in NPA road. While the lowest relative content in the leaves of *Polyalthia longifolia* (49.67±0.38a%), *Mangifera indica (*44.16%) and *Terminalia catappa* (65.78%) were lowest in the control (Table 3).

Leaf extract pH

Leaf extract pH of leaf samples of all the three tree species at the experimental sites were lower than and not significantly different from those at the control site except for sampling site NPA road. ($p=0.05$). There was no significant difference ($p>0.05$), in the leaf extract pH values of *Polyalthia longifolia* (73.72%), *Mangifera indica (*83.20) and *Terminalia catappa* collected from Sampling sites B and C, when compared to the Control site (Table 3).

Total chlorophyll

The total chlorophyll content of all the three tree species at the experimental sites (Esisi, Refinery and NPA roads) were higher and significantly different than those of the control site ($p<0.05$) except for *Polyalthia longifolia*. The mean concentration of the total chlorophyll content in the control site varied between 0.42 (*Polyalthia longifolia*) and 12.34 (*Terminalia catappa*) mg/g, while that in the experimental sites varied between 0.56 (*Polyalthia longifolia*) and 1.54 (*Mangifera indica).* The total chlorophyll content of the studied leaves was not significantly different among the experimental sites (Table 3).

Table 3: Effect of vehicular air pollution on biochemical parameters of the studied tree species

Biochemical parameters	Sites	Tree species		
		Polyalthia longifolia	*Mangifera indica*	*Terminalia catappa*
Ascorbic acid	Control (Ugbomro)	$6.69±0.57^{a}$	$13.46±0.41^{a}$	$12.34±0.82^{a}$
	Esisi road	$8.87±0.30^{b}$	$16.88±0.21^{b}$	$15.58±0.22^{b}$
	Refinery road	$11.36±0.43^{c}$	$18.58±0.11^{bc}$	$15.64±0.28^{b}$
	NPA road	$12.56±0.51^{c}$	$17.46±0.37^{c}$	$19.57±0.34^{c}$
	LSD	0.000	0.000	0.000
Relative water content	Control	$49.67±0.38^{a}$	$44.16±6.12^{a}$	$65.78±1.90^{a}$
	Esisi road	$65.26±0.58^{b}$	$68.61±0.30^{b}$	$83.58±0.43^{b}$
	Refinery road	$65.68±0.49^{b}$	$80.07±0.57^{bc}$	$86.46±0.41^{b}$
	NPA road	$73.72±0.49^{c}$	$83.20±0.21^{c}$	$91.60±0.67^{c}$
	LSD	0.000	0.000	0.000
pH	Control (Ugbomro)	$4.66±0.19^{a}$	$5.05±0.04^{a}$	$5.03±0.04^{a}$
	Esisi road	$4.84±0.06^{a}$	$5.42±0.07^{a}$	$5.36±0.33^{a}$
	Refinery road	$5.02±0.40^{a}$	$5.62±0.18^{a}$	$5.62±0.21^{a}$
	NPA road	$7.71±0.59^{b}$	$6.73±0.31^{b}$	$7.66±0.67^{b}$
	LSD	0.001	0.001	0.005
Total Chlorophyll	Control (Ugbomro)	$0.42±0.03^{a}$	$0.67±0.01^{a}$	$0.52±0.04^{a}$
	Esisi road	$0.56±0.04^{a}$	$1.00±0.01^{b}$	$0.85±0.04^{b}$
	Refinery road	$0.74±0.02^{ab}$	$1.13±0.01^{b}$	$0.96±0.04^{b}$
	NPA road	$1.34±0.32^{b}$	$1.54±0.08^{c}$	$1.38±0.09^{c}$
	LSD	0.017	0.000	0.000

Mean + SE in the same column with different letters in superscript differs significantly ($P < 0.05$)

AIR POLLUTION TOLERANCE INDEX

The APTI of the trees in the control site ranged from a minimum of 8.37 (*Polyalthia longifolia*) to a maximum of 13.43 (*T. catappa*),while that in the experimental sites (B, C and D) ranged from a minimum of 11.32 (*Polyalthia longifolia*) to a maximum of 26.85 (*T. catappa*). A comparison of the APTI values of different trees in control and experimental sites is presented in Table 1. It was noted that the APTI values are higher in experimental sites (B, C and D) than in their counterparts in the control site.

Air pollution tolerance index classification

At the control site, *Polyalthia longifolia* was graded as sensitive, while, *Mangifera indica* and *Terminalia catappa* were graded as intermediately tolerant. At the experimental site B, *Polyalthia longifolia* was graded as sensitive, while *Mangifera indica* and *Terminalia catappa* were graded as moderately tolerant. *Polyalthia longifolia* was graded *as* intermediately tolerant, *Mangifera indica* and *Terminalia catappa* moderately tolerant at the experimental sites C. However, in Experimental site D, *Polyalthia longifolia* was moderately tolerant, *whilst Mangifera indica* and *Terminalia catappa* were graded as tolerant plants.

Table 4: Air pollution tolerance index (APTI) and classification of the studied tree species

Tree species	Site	Ascorbic acid (mg/g)	Relative water content (%)	pH	Total Chlorophyll (mg/g)	APTI	Classification Thakar and Mishra
Polyalthia longifolia	Control (Ugbomro)	6.69	49.67	4.66	0.42	8.37	S
	Esisi road	8.87	65.26	4.84	0.56	11.32	S
	Refinery road	11.36	65.68	5.02	0.74	13.11	IT
	NPA road	12.56	73.72	7.71	1.34	18.74	MT
Mangifera indica	Control (Ugbomro)	13.46	44.16	5.05	0.67	12.12	IT
	Esisi road	16.88	68.61	5.42	1.00	17.70	MT
	Refinery road	18.58	80.07	5.62	1.13	20.55	MT
	NPA road	17.46	83.2	6.73	1.54	22.76	T
Terminalia catappa	Control (Ugbomro)	12.34	65.78	5.05	0.52	13.43	IT
	Esisi road	15.58	83.58	5.42	0.85	18.03	MT
	Refinery road	15.64	86.46	5.62	0.96	18.94	MT
	NPA road	19.57	91.6	6.73	1.38	26.85	T

IT = Intermediately Tolerant, **MT** = Moderately Tolerant, **T** = Tolerant, **S** = Sensitive.

Correlation between APTI values and studied biochemical parameters

The Pearson Correlation values presented in table 5 shows the association of the four biochemical parameters with the dependent parameter APTI. It was observed that strong positive correlation exists between APTI and ascorbic acid content of leaf samples collected from the control and the experimental sites (Table 5).

APTI had a significant strong positive correlation (r = 0.999) with relative water content at NPA road. There was a strong a significant strong positive correlation (r = 0.999) with pH content of leaf samples collected from Esisi road and strong negative correlation (r = -0.864) at NPA road. Similarly, APTI values had s positive correlation with total chlorophyll of leaf samples in the experimental sites (table 5)

Table 5: Correlation matrix between the APTI values and some studied parameters

Biochemical parameters	Control APTI	Esisi road APTI	Refinery road APTI	NPA road APTI
Ascorbic acid	0.918	0.981	0.978	0.973
Relative water content	0.504	0.674	0.872	0.999*
pH	0.968	0.999*	0.979	-0.864
Total Chlorophyll	0.629	0.927	0.971	0.184

* Correlation significant at 0.05 level

Assessment of anticipated performance index (API) of the selected tree species

In the selection of tolerant species to develop a greenbelt, APTI alone is not enough, hence with the integration of APTI and biological and socio-economical characters, Anticipated Perfomance Index (API) is calculated. API values of this study are presented in Table 6. Utilizing the anticipated performance index score class given in Table 6. Scores of sampled tree species revealed that *Polyalthia longifolia* was identified as a poor performer and *Mangifera indica* was assessed to be very good performers. *Terminalia catappa* was evaluated to be a good performer.

Table 6: Assessment of tree species gradation based on air pollution tolerance index, morphological parameters and socio-economic importance

S/no	Grading character	*Polyalthia longifolia*	*Mangifera indica*	*Terminalia catappa*
	Air Pollution Tolerance Index	2	4	4
	Type of Plant	1	1	0
	Plant size	1	1	1
	Canopy structure	0	1	1
	Laminar structure (a) Leaf size (b) Texture (c) Hardiness	1 1 1	1 1 1	1 1 1
	Socio-economic value	0	2	1
	Total (+)	7	12	10
	API (%)	43.75	75	62.5
	API Grade	2	5	4
	Assessment	Poor	Very Good	Good

Heavy metal concentrations of foliage of the studied tree species

Heavy metal concentrations and metal accumulation index of leaves sample from the sampling sites are presented in Table 7.

Lead

There was a significant difference in the Pb accumulation of tree species between the polluted sites and the control ($p < 0.05$). *Polyalthia longifolia had the highest Pb accumulation of* 5.79±1.41 mg/kg, while *Mangifera indica* recorded the least (3.55±0.90mg/kg). The maximum increase in Pb accumulation was observed in *Terminalia catappa* (521.51%); while *Polyalthia longifolia* had the least (144.30%).

Cadmium

Cadmium accumulation of leaf samples obtained at the polluted and control sites ranged from 3.65±0.59b to 6.30±2.88b and 0.51±0.04-0.80±0.23 respectively (Table …). Cd content in the leaves of *Terminalia catappa* showed statically significant difference ($p < 0.05$) between the polluted and control sites. Among the studied tree species, *Terminalia catappa* accumulated the highest Cd (6.30±2.88) in the polluted site. The maximum increase in Cd accumulation was observed in *Terminalia catappa* (1135.29%); while *Mangifera indica* had the least (**356.25**%).

Copper

Copper accumulations ranged between 0.20±0.10- 0.60±0.15mg/kg and 3.59±2.63-6.55±2.91 in the control site and polluted sites respectively (Table …….). The maximum Cu amounts were found in *Terminalia catappa* (6.55±2.91b) leaves in the polluted site and the lowest Cu accumulation 0.20±0.10a) detected in *Polyalthia longifolia* in the control site. It was also observed that statically significant increases were found in *Mangifera indica* and *Terminalia catappa* between the polluted sites and the control ($P < 0.05$). *Polyalthia longifolia* recorded maximum percentage increase (1,695%) in Cu accumulation, while the least was found in *Mangifera indica* (677.78%).

Zinc

The highest Zn amounts were found in *Terminalia catappa* (.13±2.53b 0) leaves in the polluted site and the lowest Zn accumulation (0.61±0.16b) detected in *Mangifera indica* in the control site. It was also observed that statically significant difference were found in *Polyalthia longifolia* and *Terminalia catappa* between the polluted sites and the control ($P < 0.05$). *Mangifera indica* recorded maximum percentage increase (**675.41**%) in Zn accumulation, while the least was found in *Polyalthia longifolia* (**307.56**%).

Metal accumulation index (MAI)

Metal accumulation index value of **15.94** was highest in *Mangifera indica* at the polluted site followed by *Polyalthia longifolia* (**12.02**) (Table 4…..), while at the control site, *Polyalthia longifolia also* recorded highest MAI value of **9.38** and the least MAI value of **4.27 was** found in *Mangifera indica.*

Table 7: Levels of Heavy metal (mg/kg) and Metal accumulation index (MAI) in the foliage of tree species at the studied sites

Tree species	Sampling sites	Heavy metal				Metal Accumulation Index (MAI)
		Pb	Cd	Cu	Zn	
Polyalthia longifolia	Control	$2.37±0.37^a$	$0.75±0.39^a$	$0.20±0.10^a$	$1.72±0.46^a$	9.38
	Polluted	$5.79±1.41^b$	$5.68±3.56^a$	$3.59±2.63^a$	$7.01±1.42^b$	12.02
	% increase	144.30	657.33	1,695.00	307.56	
Mangifera indica	Control	$1.13±0.30^a$	$0.80±0.23^b$	$0.54±0.09^a$	$0.61±0.16^b$	4.27
	Polluted	$3.55±0.90^b$	$3.65±0.59^b$	$4.20±1.35^b$	$4.73±1.75^b$	15.94
	% increase	214.16	356.25	677.78	675.41	
Terminalia catappa	Control	$0.93±0.06^a$	$0.51±0.04^a$	$0.60±0.15^a$	$1.29±0.26^a$	9.30
	Polluted	$5.78±1.59^b$	$6.30±2.88^b$	$6.55±2.91^b$	$7.13±2.53^b$	10.9
	% increase	521.51	1135.29	991.67	452.71	

Mean + SE in the same column with different letters in superscript differs significantly (P < 0.05)

DISCUSSION :

The tolerance behaviour of trees to air pollutants can be best described to assess their potential in remediating the air pollution problem and purifying the local air of an area (Sahu et al, 2020). Ascorbic acid in plant leaves has multiple functions to perform through cell wall synthesis, cell division, photosynthetic carbon fixation and acts as a strong reducer protecting the plants against reactive oxygen species (ROS), thereby improving the tolerance ability of the trees against air pollution. The tolerance level in plants is enhanced with increase in ascorbic acid content (Lima et al. 2000). In this investigation, ascorbic acid in the leaves of the studied tree species was higher at the experimental sites when compared to the control site. This is in agreement with the reports of Uka et al. 2019 and Nwadinigwe (2014). This could be attributed to the better tolerance of plants in a polluted environment through an increase ascorbic acid synthesis.

Relative water content in plant leaves help maintain the physiological water balance in adverse environmental conditions. High relative water content of leaf favours transpiration rate and pollution resistance in plants (Jyothi and Jaya, 2010). In this study, the leaves of the studied tree species had higher relative water content at the experimental sites than at the control site which implies that tree species had responded well in the experimental sites. Similar result was obtained by Uka et al. 2019, Jyothi and Jaya (2010) and Das and Prasad (2010).

The leaf extract pH is known to impact the ascorbic acid synthesis of trees. Increase in the leaf extract pH value has been reported to efficiently convert the hexose sugar to ascorbic acid and therefore a high pH is considered good for the tolerance of trees against air pollution (Ifeanyi and Ogbonna, 2012, Shannigrahi et al 2014). In this study, the tree species in the experimental sites were found to have high leaf extract pH in the experimental sites than those of the control site. This might have been due to the presence of acidic air pollutants like SO_2 and NO_2 in the air that lowered the pH of the leaves (Rai et al. 2013). pH signals the occurrence of detoxication process in plant necessary for tolerance (Thawale et al. 2011). Similar observation was reported by Sahu et al. 2020; Uka et al. 2019 and (Swami et al. 2004)

This study revealed that total chlorophyll in the tree species leaves were reduced due to increased concentration of vehicular air pollutants in the experimental sites buttresses Tripathi and Mukesh's (2007) assertion that chloroplast is the first site of attack by vehicular air pollutants which consist of SPM, SO_2 and NO_X. Air pollutants gain entry into the tissues across the stomata and partially denaturises the chlorophyll, thus a reduction in the chlorophyll content in the polluted leaves cells (Pant and Tripathi 2012).

The APTI value in this study was increased in the experimental sites than in the control site. This supports previous report that the trees subjected to pollution have the tendency to increase their tolerance ability with high APTI values; can be used as a sink. Whereas the trees showing a decrease in APTI value can be used as indicator (Jyothi and Jaya, 2010; Prajapati and Tripathi, 2008). *Polyalthia longifolia* was sensitive, intermediately tolerant and moderately tolerant. However, other tree species (*Mangifera indica and Terminalia catappa*) in the experimental sites were moderately tolerant and/or tolerant, thus they are highly recommended for urban greening. The consideration of these tree species for urban greenery stems from the fact that they are tolerant and moderately tolerant at least two or three of the studied sites. Zhang *et al*. (2016) opined that plant species with tolerant and moderately tolerant grades may be applied in green belt planning for urban and suburb areas. It was also observed that tree species had different tolerant grades at different study sites. This could be as a result of differentials in air pollution and other environmental factors that may have influenced the four parameters in the APTI formula.

From this study, *Mangifera indica* and *Ficus platyphylla* were considered under very good category are highly recommended for planting as urban tree for auto exhaust mitigation. These tree species possess dense canopy of evergreen leaves as well as economic values. It has been reported also that *Mangifera indica* is fast growth tree and stores high amount of carbon in its tissues, thus its high priority rating (Miria and Khan, 2013). *Terminalia catappa* was judged to be a good performer. *Polyalthia longifolia* was found to be unsuitable as a pollution sink because of its low anticipated performance. The API of the trees in the present study was evaluated according to the obtained APTI value and the various morphological parameters and socio-economic importance. *Mangifera Indica* was classified as a very good performer, while *Terminalia catappa* was rated as a good performer, thus are highly recommended for planting as urban tree for auto exhaust extentuation. *Polyalthia longifolia* was found to be unsuitable as a pollution sink because of its low anticipated performance.

Foliar heavy metal concentrations of the studied tree species

All the studied heavy metals concentrations were higher at experimental sites, when compared to the control. Vehicular and industrial activities directly or indirectly emit heavy metals into the atmosphere of urban area (Simon et al., 2016). Heavy traffic load, wear and tear of tire, brake shoe, combustion of vehicle lubricating oil are the main sources of Cd in air pollution (Gope et al., 2017). Traffic emissions are also sources of other heavy metals, like, Cu from engine, brake pad wear, Zn from lubricant and tire emission, Pb from exhaust emissions etc. (Padmavathiamma and Li, 2007; Hu et al., 2014). The metal concentration in plant leaves varies with different tree species. According to Karmakar and Padhy, 2019, the uptake and accumulation of metals by plant species is dependent on various factors like, species, the metal involved and the ecotype and specimens of the same ecotype inhabiting in a particular area can behave differently.

In this study the MAI value (5.35) was highest in *Mangifera indica* at the polluted site followed by *Polyalthia longifolia* (4.30). There were changes in MAI in all the studied tree species resulting from different pollution burden and an indication that the removal capabilities of plant species differ from each other (Karmakar and Padhy, 2019). In this study the MAI value (15.94) was highest in *Mangifera indica* followed by *Polyalthia longifolia* (12.02), while *Terminalia catappa* (10.9) had the least metal accumulation index at the polluted site (Table 5). There were changes in MAI in all the studied tree species resulting from different pollution burden and an indication that the removal capabilities of plant species differ from each other (Karmakar and Padhy, 2019). This result agrees with Liu et al. 2007, report of higher MAI values of plant species collected from the distance of 1–9 m from the road, while the plant species obtained from 10 m had lower MAI values. In the present study, the maximum MAI value found in *Mangifera indica* (15.94) and *Polyalthia longifolia* (12.02) reveals that they possess good accumulation in heavy metal when growing in a polluted condition. Thus, it could be used as buffer between polluted and susceptible areas (NadgorskaeSocha et al. 2017).

CONCLUSION :

This study revealed the biochemical changes in plant species due to air pollution, and secondly, this study put a light in the selection of tolerant plant species through the APTI value which can help in the future planning of plantation in the industrial and urban areas. These research findings provide an understanding about the identification of tolerant species and sensitive species in any study area so that these species can be used for a green belt development to prevent the air pollution problems. A higher metal accumulation index value found in *Mangifera indica* and *Polyalthia longifolia* reveals that they possess good accumulation in heavy metal while growing in polluted environments. The usage of urban trees as bioindicators is a cost-effective and simple strategy and thus provides a sustainable ecological method for the conservation of urban habitats.

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