Journal of Forestry Research and Management. Vol. 18(4).50-59; 2021, ISSN 0189-8418
www.jfrm.org.ng

BIOMONITORING OF AIR POLLUTION FOR SELECTED PLANT SPECIES ALONG ONDO-IFE ROAD AND OLUWA FOREST RESERVE IN ONDO STATE, SOUTH-WEST, NIGERIA.

*Ogboru, R.O[1], Bobadoye, A.O,[1]Ishola, B.F[1] and Oke, R.A[1]

[1]Research Coordinating Unit; Forestry Research Institute of Nigeria, Ibadan, Oyo State
Corresponding Author's Email: rachov44@gmail.com
Tel number: +2348034519060

ABSTRACT

Air pollution tolerance index (APTI) and Anticipated performance index (API) are established eco-friendly biomonitoring techniques used to evaluate suitability of different plant species as air pollution sink or bio-indicators and establishment of green belts in a particular environment. This study aims to determine the Air Pollution Tolerance Index and Anticipated Performance Index values of plant species in Oluwa Forest Reserve (OFR) which has been trespassed on by illegal fellers and Ondo-Ife express road (OIR) with has high vehicular traffic and increased population due to urbanization. Composite leaf samples were randomly collected from eight selected plant species from both study sites and analyzed for relative water content, ascorbic acid, pH and total chlorophyll content. Data were analyzed using descriptive statistics and Analysis of Variance. The mean pH ranged from 4.10±0.10 to 6.50± 0.10 in OFR while 4.30±0.17 to 6.50±0.15 values were obtained in OIR. Total chlorophyll value ranged from 36.49±0.04 to 86.71±0.10 mg/g/FW for OIR while in OFR the values ranged from 33.9±0.10 to 69.32±0.02 mg/g/FW. Mean relative water content values ranged from 19.45±0.01 to 36.70.±0.04 % in OIR while OFR values ranged from 14.76±0.03 to 87.79±0.01 %. Ascorbic acid results revealed values from 0.12±0.10 to 3.71±0.13 mg/g for OIR while for OFR the values obtained ranged from 0.17±0.03 to 4.36±0.17 mg/g. APTI values ranged from 2.14 to 27.83 for OFR and 2.75 to 26.20 for OIR respectively. Results revealed that *Carica papaya*, *Azadirachata indica*, *Trecuilia africana* and *Artocarpus altilis* showed increased APTI value, while *Tectona grandis, Dacryodes edulis, Gmelia arborea and Mangifera indica* showed decrease APTI values from OIR to OFR. *Gmelina arborea* was mildly tolerant to air pollution at OIR and OFR while other plant species were sensitive to air pollution. Based on API classification, *Gmelina arborea* was grouped as the best performer for green belt development having an API grade allotment of 93.75 %, thus suggested OFR. For OIR *Gmelina arborea* should be planted 100 meters from the express road to act as sink to air pollution due to high vehicular traffic emissions on the road. The APTI values 27.83 and 26.20 from OFR and OIR respectively were obtained from *Gmelina arborea* plant species which classifies it as a tolerant tree species for biomonitoring of air pollution in both study locations. The mean of the biochemical parameter and APTI values were separated using least significance difference at p<0.01.

Keywords: Air Pollution Tolerance Index (APTI), Bio-indicators, Ondo state, Carbon sink

Introduction

The earth is facing at present the foremost crisis of air pollution, which has become of great environmental concern in most cities globally especially with increased human population and industrialization (Dhadse *et al*., 2011). The main contributors to air pollution in an urban setting are the emission from exhaust of vehicle, increased industrial and human activities such as building construction and inappropriate management of waste (Molnár *et al*., 2018). Their byproducts include greenhouse gases, hydrocarbons, dust and particulate matter (Porta, 2016). They have been associated with different disease conditions in human which varies from respiratory diseases, toxicity of the neurons, autism spectrum and mood disorder (Volk *et al*., 2011; Perera, 2017).

Green plants through a well-known process called photosynthesis remove air pollutant in the atmosphere through gaseous exchange in the stomata of the leaves (Leghari *et al*., 2019) and prevents the production of secondary pollutants. This process provides oxygen and primary metabolite like carbohydrate, which have made trees the most competent pollution sink (Agbaire *et al*., 2016). These processes are achieved by absorption, accumulation and conversion of air pollutants (Das and Prasad, 2010). Incessant exposure of plant leaves to the atmosphere, means that the air quality is typically reflected on the plant by alternation in the physiological, morphological and biochemical parameters. As a result, biomonitoring is a suitable tool to access the level of air pollution in an environment (Choudhury and Banerjee, 2009).

Air Pollution Tolerance index is an eco-friendly method for evaluating the impact and ascertain the sensitivity or tolerance of the plants to air pollution. It was designed to monitor four key biochemical parameters in the leaves: relative water content, ascorbic acid, total chlorophyll and pH (Singh and Rao, 1983). Plants with higher air pollution tolerance index (APTI) value also act as natural sink or good source of carbon sequestration (Kour and Sharma, 2016). Since plants are important bio-filters of air pollutant, identifying which tree act as carbon sink and bio-indicator is very vital.

Anticipated Performance Index (API) is an advanced ecological approach which further combines the APTI values and biological features such as plant height, canopy structure, plant size, texture, hardness and uses. This further helps in the classification of plants as best (91-100%), Excellent (81-90 %), very good (71-80%), good (61-70%), moderate (51-60%), poor (41-50%) and very poor (31-40%)performers respectively. (Prajapati and Tripathi, 2008). Thus estimation of API aids to evaluate the ability of plant species to reduce air pollution and indicate their economic uses as well. In Nigeria much attention is given to general industrial pollution with little reference to forest reserves which are no longer in their natural state due to degradation. Forest Reserves are the most important bio-filters of the atmosphere and as such identifying which tree act as strongest carbon sink and bio-indicators of air pollution is vital to regenerate it. Hence this study was carried out to compare the air pollution tolerance indices and Anticipated performance index of selected trees within Ondo-Ife road (OIR) and Oluwa Forest Reserve (OFR), South-West Nigeria, in order to access their response to ambient air pollution and also make recommendations on which tree species is ideal for green belt design and afforestation of the forest reserve studied.

Material and Methods

Description of Study Area

The study was conducted along OIR as the experimental site and OFR as the control site, OFR have more tree cover with multiple canopies and lianas with little or no vehicular activities in the area than the OIR. The OIR study site is located in Ondo town, which is the second largest city in Ondo state and largest producer of cocoa in western Nigeria. Ondo town lies on Latitude $7^{0}04^{l}$N and Longitude $4^{0}04^{l}$E. It is situated in a humid sub-tropical rainforest zone, southwest of Nigeria (Akinyemi and Andreas, 2011). In addition to a viable growing population, Ondo town has roads linking major towns into other cities like Lagos, Ibadan and Ijebu-Ode to the west, Okene to the north, Benin to the east hence there are heavy vehicular traffic en-route the town.

OFR is located 50 km and 26 km east of Omo and Ore in Ondo state with latitude and longitude of 10°37’N and 9°20’E and square area of 878.16 km^2. It has a topography that is surging with a mean altitude of 90 m above sea level, average moisture and daily temperature of 80 % and 25 °C respectively (DRS., 2010; Udoakpan, 2013;). It covers 829 km^2. It is part of the Omo-Shasha–Oluwa Forest Reserves and falls within the tropical rain forest. This reserve is geographically distinctive but vulnerable to agricultural activities, hunting and deforestation. It comprises of natural forest and plantations with numerous indigenous tree species. (Adeoti, 2019)

Sample Collection

Composite leaf samples were randomly collected in triplicates, between the hours of 8-10 am when the humidity is high from both sites, 100 m away from the road. The plant species used for this study include *Tectona grandis, Dacryodes edulis, Gmelina arborea, Carica papaya, Azadirachata indica, Trecuilia africana, Artocarpus altilis,* and *Mangifera indica.* They were carefully selected through the help of a taxonomist of Forestry Research Institute of Nigeria, Ibadan. The leaves were washed in running water, rinsed in distilled water and kept in an ice-block chest before proceeding to the laboratory for analysis.

Biochemical Analysis Evaluation

Relative Water Content (RWC) of leaves

Methods described by Singh, (1997) were adopted for this biochemical parameter. 5g leavesamples were submerged in water for 24 hrs. This was blotted dry and then weighed to obtain the turbid weight (TW). The leaves were then oven dried at 105 ^{0}C for 2 hrs and re-weighed to get the dry weight (DW), this experiment was done in triplicates. Thus the relationship below was used to calculate RWC

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

RWC= Relative water content
FW= Fresh weight
DW= Dry weight
TW= Turgid weight

Determination of Ascorbic Acid

Fresh leaves (1.0 g) homogenized in 4.0 ml oxalic acid-EDTA extracting solution for half a minute 0.5 ml of orthophosphoric acid-acetic acid and 1.0 ml of 5 % v/v tetraoxosulphate (VI) acid and 2 ml of ammonium molybdate was added to the test tube after diluting with distilled water. These was allowed to stand for 15 minutes after which the absorbance at 760 nm was measured with a UV/Visible spectrophotometer (Jenway 671). This experiment was done in triplicate and the actual concentration of ascorbic acid in the sample was extrapolated from the standard ascorbic acid curve in mg/g (Bajaj and Kaur, 1981).

Leaf Extract pH

Fresh leaves (5 g) sample was crushed in a mortal by a pestle with 10 ml of deionized water, the leave extract was filtered with filter paper and pH of the leave extract was determined by using a calibrated pH meter in buffer solutions of 4, and 9 (Singh and Rao, 1983).

Total Chlorophyll Content

Fresh green leaves 1.0 g were carefully selected, cleaned in running water and dried at ambient temperature. It was then extracted with 20 ml of 80 % acetone for 15 minutes each for thorough extraction. The liquid portion was filtered into another 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 645 nm and 663 nm for chlorophyll a and b respectively using a spectrophotometer. The total chlorophyll was calculated by using the formulae described by Arnon (1949):

$$C = 20.2A_{645} + 8.02A_{663} \text{------------------}2$$

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

The T in mg/g $= 0.1\ x\ C\ x\ (leaf\ \frac{DW}{FW})$--------3

0.1 is a constant, DW= Dry weight, FW= Fresh weight, T = total chlorophyll content

Measurement of Air Pollution Tolerance Index (APTI)

The air pollution tolerance indices of the plant species was determined following the method adopted by Singh and Rao (1983).

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

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

Measurement of Anticipated Performance Index

Table 1. Standard Grading Criteria of plants for anticipated performance index (API)

S/N	Classifying character	Parameter	Outline For valuation	Grading Characters
1	Tolerance	APTI	01-04	--
			05-08	-
			09-12	+
			13-16	++
			17-20	+++
			21-24	++++
			25-28	+++++
2	Biological characteristics	Height of plant	Minor	-
			Average	+
			Big	++

		Structure of canopy	Thin/rough	-
			Partial thick	+
			Dispersal thick	++
		Plant type	Deciduous	-
			Evergreen	+
3	Structure of laminar	Size	Small	-
			Medium	+
			Large	++
		Texture	Smooth	-
			Coriaceous	+
		Economic uses	Less than 3 uses	-
			3 or more uses	+
			5 or more uses	++

Source: Leghari*et al.*, 2019; Parajapti and Triphati, 2008.

Biological Characteristics and structure of Laminar were physically determined and obtained from PROTA., 2008

Maximum number of '+' for a single species can be 16:

(+) =1 point ,(++) =two points, (+++) =three points (++++) = four points (+++++) = five points (-) = zero point

The % grade is calculated thus:

$No\ of + obtained \div Maximum\ no\ of + obtained \times 100/1$ 5

Assessment category of plants on the basis of their API score using grading percent score and categories

0 = 30 Not recommended (NR), 1 = 31-40 Very poor (VP), 2 = 41-50 Poor (P), 3 = 51-60 Moderate (M), 4 = 61-70 Good (G), 5 = 71-80 Very good (VG), 6 = 81-90 Excellent (E), 7 = 91-100 Best (B).

Statistical Analysis: The data collected in this study where analyzed using descriptive statistics and Analysis of Variance.

Results

The result in Table 2 showed that *Azadirachata indica* had the lowest pH value of 4.10 ± 0.10 while *Carica papaya* had the highest pH value of 6.50 ± 0.10 in OFR. *Tectona grandis* and *Trecuilia africana* showed the lowest and highest pH value of 4.30 ± 0.17 and 6.50 ± 0.15 for OIR. These revealed a slight increase of 0.2 in the minimum pH value from OFR to OIR. This indicate that increase vehicular movement could increase the pH of the leaves sample. The higher pH values were observed to be unaffected by air pollution in OIR. Further comparison of the individual plants from both sites, indicated decrease in the pH value in *Tectona grandis, Gmelia arborea, Carica papaya* and *Artocarpus altilis*, while an increase was observed with *Dacryodes edulis*, *Azadirchata indica*, *Trecuilia africana* and *Magnifera indica*.

The result also showed the total chlorophyll value obtained from the experimental site (OIR)varies from 36.49 ±0.04 to 86.71±0.10 mg/g FW while Oluwa forest reserve ranges from 33.94±0.10 to 69.32± 0.02 mg/g FW. Considering the two locations *Tectona grandis* had a wider range of 86.71±0.10 to 45.32±0.02 mg/g FW. *Gmelina arborea* had a narrow range of 54.92±0.17 to 53.87±0.15 mg/g FW in both location. The relative water content for the experimental site was found to be as low as 19.45 ± 0.01 % in *Carica papaya* and high as 36.70 ± 0.04 % in *Magnifera indica.*When compared to the control site there was 25.21 % increase in *Tectona grandis*, 75.10 % increase in *Dacryodes edulis*, 12.47 % decrease in *Gmelina arborea*, 31.78 % decrease in *Caricapapaya*, 26.85 % decrease in *Azadirchata indica*, 31.94 % decrease in *Trecuiliaafricana*, 10.94 % increase in *Artocapus altilis* and 23.03 % decrease in *Magnifera indica*. From these data, it was observed that *Tectona grandis, Dacryodes edulis* and *Artocarpus altilis* had increase in water content when the experimental and control sites were evaluated. These could be due to increased pollution in the experimental site and decrease pollution in the control site. There was decrease in the relative water content for *Gmelina arborea*, *Carica papaya*, *Azadirchata indica*, *Trecuilia africana* and *Magnifera indica*. The eight species showed a wide variation in the Ascorbic acid values from 3.71 ± 0.13 to 0.12 ± 0.10 mg/g for the experimental site while at the control site, the range varies from 4.36±0.17 to 0.17±0.03 mg/g. *Gmelina arborea* showed the highest ascorbic acid value and *Tectona grandis* had the lowest

Journal of Forestry Research and Management. Vol. 18(4).50-59; 2021, ISSN 0189-8418

www.jfrm.org.ng

ascorbic acid value in the experimental site. The level of significance across parameters of the plant species shows that pH and AA of OFR is lower than OIR while RWC and TCH of OFR is significantly higher than OIR as shown in Table 2. Anticipated performance in Table 3 and 4 revealed that *Gmelina aborea* had percentage scoring of 93.75% in both locations (OFR and OIR). These values were deducted from Table 1 classification done by Prajapat and Triphati (2008). *Tectona grandis* had 62.5% in both locations as well. *Trecuila africana*, *Dacryodes edulis* and *Artocarpus altilis* had 56.25% in OFR. *Mangifera indica* also had 56.25% scoring in OIR. *Carica papaya* exhibited low values of 25.0% and 12.5% scoring in OFR and OIR respectively. *Azadirchata indica* had 37.5% scoring in both locations as well.

Table 2: Biochemical parameters of selected tree species in OFR and OIR and their APTI values.

S/N	Trees species	RWC (%)	pH	AA (mg/g)	TCH (mg/g)/FW	APTI	Difference in APTI
1	*Tectonagrandis* (OFR)	34.63±0.03	4.9±0.10	0.21±0.04	45.32±0.02	4.52	+0.86
	(OIR)	25.9±0.04	4.3±0.17	0.12±0.10	86.71±0.10	3.66	
2	*Dacryodesedulis* (OFR)	89.79±0.01	5.9±0.03	0.17±0.10	48.14±0.10	9.87	+6.42
	(OIR)	22.36±0.10	6.3±0.05	0.19±0.02	54.90±0.01	3.45	
3	*Gmelinaarborea*(OFR)	15.78±0.04	6.4±0.15	4.36±0.17	53.87±0.15	27.83	+1.63
	(OIR)	34.79±0.17	6.1±0.17	3.72±0.13	54.92±0.17	26.20	
4	*Carica papaya* (OFR)	14.76±0.03	6.5±0.10	0.17±0.10	33.94±0.10	2.14	-0.61
	(OIR)	19.45±0.01	6.3±0.56	0.19±0.10	36.49±0.04	2.75	
5	*Azadirachataindica* (OFR)	33.41±0.01	4.1±0.10	0.20±0.16	47.14±0.05	4.34	-0.77
	(OIR)	42.38±0.10	4.4±0.10	0.22±0.17	36.58±0.16	5.11	
6	*Trecuiliaafricana* (OFR)	25.83±0.05	5.4±0.14	0.37±0.10	39.47±0.04	4.25	-0.51
	(OIR)	34.08±0.01	6.5±0.15	0.25±0.10	48.36±0.12	4.76	
7	*Artocarpusaltilis* (OFR)	25.05±0.15	6.3±0.10	0.17±0.03	36.45±0.10	3.24	-1.34
	(OIR)	22.31±0.12	5.8±0.02	0.31±0.05	69.30±0.05	4.58	
8	*Mangiferaindica* (OFR)	29.83±0.10	4.6±010	0.34±0.17	69.32±0.02	5.49	+0.45
	(OIR)	36.70±0.04	5.3±0.11	0.19±0.10	66.32±0.15	5.04	
					8967.10		
	F value (OFR)	8731.81	136.38	16584.93	51159.10		
	(OIR)	390.27	151.54	34688.86	***		
	Significance (OFR)	***	***	***	***		
	(OIR)	***	***	***			

pH= pH of the leaf. T=Total Chlorophyll content in mg/g per fresh weight. R= Relative water content. AA= Ascorbic acid. OFR= Oluwa Forest Reserve OIR= Ondo-Ife Road

***P<0.01

Table 3. Anticipated performance index (API) for selected tree species in OFR

S/N	Plant names	APTI	Height	Structure of canopy	Plant type	size	Texture	economic	Grade allotted	% Scoring	API Grading
1	*Tectonagrandis*	--	++	++	+	++	+	++	10	62.5	Good
2	*Dacryodesedulis*	+	++	++	+	++	-	++	9	56.25	Very poor
3	*Gmelinaarborea*	+++++	++	++	+	++	+	++	15	93.75	Best
4	*Carica Papaya*	--	-	+	+	-	-	++	4	25.00	Not recommended
5	*Azadirachataindica*	--	+	+	+	+	+	++	6	37.5	Very poor
6	*Trecuilaafricana*	--	++	+	-	++	-	++	9	56.25	Poor
7	*Artocarpusaltilis*	--	++	++	+	+	-	++	8	50	Poor
8	*Mangiferaindica*	-	++	++	+	++	-	++	9	56.25	Moderate

Table 4: Anticipated performance index (API) for selected tree species along OIR

S/N	Tree species	APTI	Height	Structure of canopy	Plant type	Size	Texture	economic	Grade alloted	% Scoring	API Grading
1	*Tectonagrandis*	--	++	++	+	++	+	++	10	62.5	Good
2	*Dacryodesedulis*	--	+	+	+	+	-	++	6	37.5	Moderate
3	*Gmelinaarborea*	+++++	++	++	+	+	+	++	15	93.75	Best
4	*Carica Papaya*	--	-	-	-	-	-	++	2	12.5	Not recommended
5	*Azadirachataindica*	-	+	+	+	+	-	++	6	37.5	Very poor
6	*Trecuilaafricana*	--	++	+	-	++	-	++	7	43.75	Moderate
7	*Artocarpusaltilis*	--	++	++	+	+	-	++	8	50	Poor
8	*Mangiferaindica*	-	++	++	+	++	-	++	9	56.25	Moderate

Journal of Forestry Research and Management. Vol. 18(4).50-59; 2021, ISSN 0189-8418
www.jfrm.org.ng

The results in Table 5 showed the values of APTI of different plant species. It was revealed that in Oluwa forest reserve (OFR), *Gmelina arborea* had the highest value APTI of 27.87. The values of APTI in *Tectona grandis, Dacryodes edulis, Artocarpus altilis, Azadirachta indica, Trecuila africana,* and *Mangifera indica* were 4.52, 9.85, 4.32, 4.23, 3.24 and 5.48 respectively. *Carica Papaya* had the least value 2.12 and 2.70 in OFR and OIR respectively. Similarly *Gmelina arborea* had highest APTI value 26.20 in OIR. While in *Tectona grandis, Dacryodes edulis, Artocarpus altilis, Azadirachata indica, Trecuila africana,* and *Mangifera indica* had 3.66, 3.45,4.58, 5.11, 4.75 and 5.04 respectively. The values obtained with other plant species in OIR followed the same trend with the value obtained at OFR. These mean APTI values were statistically different from one another.

Table 5: ATPI values of different plant species across the study locations

S/N	Tree species	APTI value	
		Oluwa	**Ondo**
1	*Tectonagrandis*	4.52±0.021[d]	3.66±0.011[f]
2	*Dacryodesedulis*	9.85±0.019[b]	3.41±0.008[g]
3	*Gmelinaarborea*	27.87±0.052[a]	26.10±0.054[a]
4	*Carica Papaya*	2.12±0.012[h]	2.700±0.026[h]
5	*Azadirachataindica*	4.32±0.012[e]	5.120±0.005[b]
6	*TrecuilaAfricana*	4.23±0.012[f]	4.753±0.008[d]
7	*Artocarpusaltilis*	3.24±0.006[g]	4.550+0.020[e]
8	*Mangiferaindica*	5.48±0.013[c]	5.023±0.008[c]
F-value		15515.62	15515.62
Level of significant		***	***

[Abcdefgh]: mean value with different superscripts are statistically different

***P<0.01

Discussion

Change in pH depends on how sensitive or tolerant a plant is, as the rate of decrease in pH is observed more, in sensitive plants compared to tolerant plants (Gholami *et al*., 2016). The decrease in pH indicated in some of the leaves sampled, may be due to increased gaseous pollutant such as sulphur dioxide and nitrogen dioxide (Kashyap *et al*., 2018) emanated from vehicles, other acidic pollutant (Tiwari and Tiwari, 2006) or decreased level of basic pollutant. pH in leaves have shown good correlation with sensitvity to air pollution and thus lower the process of photosynthesis and plants highly sensitive to gaseous pollutants like sulphur dioxide and nitrogen dioxide closes their stomata faster when in a polluted environment (Yan and Hui, 2008, Thambavani and Prathipa, 2012; Abiya *et al*. 2017)

The amount of chlorophyll in plant is very important since photosynthetic is driven by it and other factors such as levels of pollution, leaf age, biotic and abiotic conditions (Ninave *et al*., 2001). The presence of pollutant in an environment could alter these pigments in plant by attacking the site of photosynthesis through part denaturation, reducing the chlorophyll content in the cells (Anthony, 2001; Ogunrotimi *et al*., 2017). Low levels of chlorophyll in samples obtained from the Oluwa forest reserve could be due to increased plumbing activity which could be generating dust particles that are blocking the leaf stomata and preventing proper photosynthesis (Tripathi and Gautam, 2007; Mir *et al*., 2008). Also the production of alkaline condition from chemicals in dust particles, result in the blockage of the stomata for proper diffusion of air and changing the metabolic process in the plant, thus reducing level of chlorophyll.

The importance of water to the survival of plant and the fact that most biochemical reactions take place in the water cannot be over emphasized. Moisture content in plantscan be altered due to unsafe environmental conditions which plants are faced within the atmosphere which reduces it growth, metabolism and yield.. Thus relative water content in plants decrease with increase in air pollution levels (Kaur and Gupta, 2005).

These difference in their ascorbic acid value could be linked to their various ability to withstand pollution. This increase may also be seen as an improvement in the plant defense process (Cheng *et al*., 2007). *Gmelina arborea* high ascorbic acid content could be due to its ability to adapt and control pollution when compared to other species. It is also possible that *Gmelina arborea* had the ability to synthesize and storage antioxidants due to stress and reduced rainfall (Prajapati and Tripathi, 2008).

The sensitivity and tolerance of plants to air pollution can be assessed from the APTI values (Tanee and Albert, 2013). Low value indicates sensitivity to air pollution, while high value indicates tolerance to air pollution. The result of this study showed that *Carica papaya*, *Azadirachta indica*, *Trecuilia africana*, *Artocarpus altilis*, *Tectona grandis*, *Dacryodes edulis and Mangifera indica* had APTI values below 16. This further proves that these species are sensitive to air pollution and can be used as bio-indicators (Agbaire *et al*., 2016: Sapkota and Devkota., 2021) while *Gmelina arborea* was moderated tolerant in both locations of the study.

Gmelina arborea can be grouped as best performer with an API value of 93.75 % from both study locations as inferred from table 3 and 4while *Tectona grandis*was grouped as very good with an API value of 62.5 % from both locations as well. This indicates that both plant species will be good for green belt development. in both study locations according to Prajapati and Tripathi (2008).

Conclusion

Air Pollution Tolerance Index (APTI) has become handy for bio-monitoring of air pollutants using green plants to filter the atmosphere. From this study *Gmelina arborea* had the highest APTI value in both locations which classified as an intermediate (Moderately tolerant) for biomonitoring of air pollutants. Evaluation of anticipated performance index (API) of plants is an important index for screening suitable tree species for green belt design. *Gmelina arborea* also emerged the best trees species from both locations respectively. However, it is recommended for re-vegtation of the Oluwa forest reserve (OFR) and also suggested to be planted 100 meters from the Ondo-Ife road as excellent wind breakers and sink to air pollution in both locations.

Acknowledgement: We wish to thank Prof A.O. Adepoju, the Director General of Forestry Research Institute for approving funding for this study.

References

Abiya, S.E., Odiyi, B.O., Bakare, T.S. (2017). Air Pollution Tolerance Indices (Apti) of Some Selected Plants Growing Close to Iron and Steel Industry in Ile- Ife, Osun State Nigeria. *Ethio. J. Environ. Stud Man.* 10(7): 858 – 865, 2017. doi: https://ejesm.org/doi/v10i7.3.

Adeoti, O.O. (2019). Volume Equations for Five economic hard wood species in Oluwa Forest Reserve , Ondo State, *Nigeria. Journal of Research in Forestry Wildlife and Environment* 11(3): 230-238

Agbaire, P.O., Ogboru,R.O., and E.E Akporhonor. (2016). Assessment of the Effect of Ambient air quality on some biochemical parameters in Edo State, Niger-Delta, Nigeria. *Asian Journal of Applied Sciences.* 4(3): 696-703

Akinyemi, G.O. and Andreas M. (2011). Climate and Bioclimate analysis of Ondo State, Nigeria. *MetereologischeZeitschrift*. 20(5): 531-539

Anthony P. (2001). Dust from walking tracks, impact on rainforest leaves on epiphylls. Co-operative Res Center for Tropical Rainforest Eco and Manage, Australia.

Arnon, D. I. (1949): Copper enzymes in isolated chloroplasts. Polyphenoloxidase in Beta vulgaris. *Plant Physiol*. 24:1-15.

Bajaj K.L and Kaur K. (1981). Spectroscopic determination of L-ascorbic acid in fruits and vegetable.*Analyst* 106 :117-120

Cheng, F.Y., Burkey, K.O., Robinson, J.M. and Booker, F.L. (2007). Leaf extracellular ascorbate in relation to ozone tolerance of two soya bean cultivars. *Environ. Pollution,* 150: 355-362.

Choudhury, P., Banerjee, D. (2009). Biomonitoring of air quality in the industrial town of Asansol using the air pollution tolerance index approach. *Res. J. Chem. Environ*. 13(1), 46-51.

Das, S., Prasad P. (2010). Seasonal variation in air pollution tolerance indices and selection of plant species for industrial areas of Rourkela. *Ind. J Environ. Prot.* 30(12):978-988

Dhadse, S.D.G., Gajghate, P.R., Chaudhari, D.R.S., Wate, S.R. (2011). Interactions of Urban Vegetation cover to Sequester Air Pollutants from Ambient Air Environment. Chapter 14 in a book *Air Pollution-New developments*.304-314 DOI: 10.5772/21567

DRS. (2010). Facts and Figures on Ondo State. Department of Research and Statistics, Ministry of Economic Planning and budget, Akure, Ondo State. 21pp.

Gholami A, Mojiri A and Amini H. (2016). Investigation of the air pollution tolerance index using some plant species in Avhaz region. *J. Ani.Pl. Sci*. 26:475-80.

Kashyap R, SharmaandUniyal S.K. (2018).Bioindicator responses and performance of plant species along a vehicular pollution gradient in western Himalaya. *Environ Monit Assess*. 190: 301-317. https://doi.org/10.1007/s10661-018-6682-7.

Kaur, N., Gupta, A.K. (2005) Signal transduction pathways under abiotic stresses in plants. *Curr. Sci*. 88(11), 1771-1780.

Kour, K. and Sharma S. (2016). Carbon Sequestration Potential of Tree Species in the Premises of Various Educational Institutes, Vijaypur, India. *Inter. J. Res. Environ*. Sci. 2, 4, 40-44.

Leghari., S.K., Akbar, A., Quasim. S., Ullah, S., Asari M., Rohali, H., Ahmed, S., Mehmood, K. and Ali, I. (2019). Estimating anticipated Performance index and Air pollution Tolerance Index of some threes and ornamental plant species for the construction of Green Belts. *Pol. J. Environ, Stud*. 28(3): 1-11

Mir QA, Yazdani T, Kumar A, Narain K, Yunus M. (2008). Vehicular population and pigment content of certain avenue trees. *Pollut Res*.27:59-63. 25.

Molnár E.V., Tóthmérész, B., Szabo, S., Simo, E. (2018). Pollution assessment in urban areas using air pollution tolerance index of tree species.W*IT Trans. Eco. En*vir. 230:367-374. DOI: 10.2495/AIR180341.

Ninave, S.Y., Chaudhari, P., Gajghate, D.,Tarar, J.L. (2001). Foliar Biochemical Features of Plants as Indicators of Air Pollution. *Bull. Environ. Contam. Tox*i. 67(1):133-40. DOI: 10.1007/s001280101.

Ogunrotimi, D.G., Adereti, F.K., Eludoyin, A.O., Awotoye, O.O. (2017). Urban air Pollution control: selection of trees for ecological monitoring using anticipated performance indices in a medium size urban area in Southwest Nigeria. *Inter. Environ. Rev*. 18(1):40-54.

Perera, F. (2017). Pollution from Fossil-Fuel Combustion is the Leading Environmental Threat to Global Pediatric Health and Equity: Solutions Exist. *Int J Environ. Res. Pub. Hea*. 15(1):16. doi:10.3390/ijerph15010016.

Porta D., Narduzzi S., Badaloni C., Bucci S., Cesaroni G., Colelli V., Davoli M., Sunyer J., Zirro E., Schwartz J. (2016). Air pollution and cognitive development at age 7 in a prospective italian birth cohort. *Epidemiology*. 27:228–236. doi: 10.1097/EDE.0000000000000405.

Prajapati, S.K. and Tripathi, B.D. (2008): Seasonal variation of leaf dust accumulation and pigment content in plant species exposed to urban particulate pollution. J Environ. Qual. 37: 865-870

.Sapkota,, S and Devkota (2021). Comparative assessment of biochemical characteristic of plants from polluted and non-polluted regions of urban areas. *Octa Journal of Environmental Research* 9(1):1-12

PROTA, 2008. Plant Resources of Tropical Africa 7(1): (Prota, 2008): Timbers 1Pp 18-129

Singh, S.K. (1977). Practical Plant Physiology. Kalayani Publishers, New Delhi, 226 pp. 1977.

Singh S.K and Rao D.N (1983): Evaluation of the plants for their Tolerance to Air Pollution, Symposium on Air Pollution control held at IIT, Delhi, pp 218-224

Singh, S. K., Rao, D. N., Agrawal, M., Pandey, J. & Narayan, D. (1991). Air Pollution Tolerance Index of Plants. J. *Environ. Man*. 32, 45-55

Tanee F.B.G and Albert, E. (2013). Air pollution tolerance indices of plants growing around Umuebulu Gas flare station in Rivers state, Nigeria. *Afr. J Environ. Sci. Tech*. 7(1): 1-8.

Thambavani S. and Prathipa D.V. (2012). Assessment of air quality through biomonitors of selected sites of dindigul town by air pollution tolerance index approach. *J Res Biol*. 2:193-9.

Tiwari S and Tiwari M. (2006). Air pollution tolerance indices of few plants growing near Raigarh (India). *J. Environ. Res. Dev*. 1:129-34.

Tripathi A.K. andGautam M. (2007). Biochemical parameters of plants as indicators of air pollution. *J Environ Biol*. 28:127-32.

Udoakpan, U.I. (2013). An Evaluation of Wood Properties of *Pinuscaribeae* (Morelet) in Oluwa Forest Reserve, Ondo State, Nigeria.*Ethiop. J. Environ. Stud. Man*. 6.2.159-170.

Volk H.E., Hertz-Picciotto I., Delwiche L., Lurmann F., McConnell R. (2011). Residential proximity to freeways and autism in the charge study. *Environ. Health*

Perspect.119:873–877. doi: 10.1289/ehp.1002835.

Yan J. L,and Hui D. (2008). Variation in air pollution tolerance index of the plant near a steel factory; Implication for landscape plant species selection for industrial areas. *WSEAS Trans Environ. Dev*.1:24-32.