Journal of Research in Forestry, Wildlife & Environment Vol. 14(4) December, 2022
E-mail: *jrfwe2019@gmail.com; jfewr@yahoo.com*
http://www.ajol.info/index.php/jrfwe
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ISBN: 2141 – 1778
Akintan et al.,2022

BIOCHEMICAL RESPONSES OF SELECTED TREES TO AIR POLLUTION IN AKURE AND OLUWA FOREST RESERVES IN ONDO STATE

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ABSTRACT

Trees species with pollution tolerance for reforestation of deforested Oluwa Forest Reserve to mitigate gaseous and particulate pollutants on the high anthropogenic Lagos-Benin express road was Determined. This study compared the air pollution tolerance indices (APTI) of nine different trees species in Queen's Plot (Akure Forest Reserve) and Investigation 309 (FRIN Research Forest in Ore) which served as control and polluted areas respectively. Biochemical parameters: pH of leaf extract, leaf relative water content (RWC), ascorbic acid content (AAC) and total leaf chlorophyll (TLC) were used to compute the Air pollution tolerance indices (APTI).The result of APTI showed order of tolerance for plants as Mansonia altissima (83.08), Triplochiton scleroxylon (62.74) and Chrysophyllum albidum (59.18) at polluted site but Mansonia altissima (78.08), Triplochiton scleroxylon (56.91) and Chrysophyllum albidum (47.80) at control site. Order of intermediate APTI result showed Treculia africana (27.70), Annonidium manni (25.59) and Entandrophagma utile (24.89) at polluted site but Treculia africana (23.22), Annonidium manni (17.00), Entandrophagma utile (17.82) and at control site while order of sensitive APTI result showed Musanga cecropioides (11.89), Sterculia oblongata (11.17), and Celtis zenkerii (9.92) at polluted site but Sterculia oblongata (9.31), Musanga cecropioides (7.48) and Celtis zenkerii (11.66) at control site. Result of pH for samples ranged from 4.60 to 5.40 at polluted site and 5.60 to 6.7 at control site; trees at polluted site were of more acidic content than those at control site. RWC ranged from 53.00 to 63.00 at polluted site and 31.00 to 55.00 at control site; relative water content of trees at polluted site were higher than those at control site; AAC ranged from 6.80 to 119.60 at polluted site and 4.90 to 89.60 at control site; trees at polluted site contained higher ascorbic acid content than trees at control site. TLC ranged from 0.67 to 1.02 at polluted site and 1.04 to 1.70 at control site; trees at control site have higher total leaf chlorophyll than those at polluted site. The APTI of these tree species (M. altissima > T. scleroxylon > C. albidum > T. africana > A. manni > E. utile > M. cecropioides > S. oblongata > C. zenkerii) suggests them in suitability order for reforestation and mitigation of deforested Oluwa Forest Reserve.

Keywords: Reforestation, Deforested, Air Pollution, Air Pollution Tolerance Index

Correct Citation of this Publication
Akintan, C. I., Akintan, A. O., Asinwa, I. O., Kazim-Ibrahim, F. and Sobola O.O. (2022). Biochemical Responses of Selected Trees to Air Pollution in Akure And Oluwa Forest Reserves in Ondo State. *Journal of Research in Forestry, Wildlife & Environment* Vol. 14(4): 34 – 40.

INTRODUCTION

Poor air quality is one of the renowned issues instigating health complications in developing and developed countries today (Viippola *et al*., 2018). The various air pollution sources add toxic gases to the atmosphere thereby leading to vast deterioration of air quality, crop yield losses and widely believed to have detrimental effects on plants (Joshi and Swami, 2007, Honour *et al*., 2009, Mahecha *et al*., 2013; Kelly and Zhu, 2016). Increasing automobile vehicles and industries are one of the leading sources of urban air pollution worldwide and are known to cause deteriorating air quality in the atmosphere (Wang and Hao 2012). Crop plants are very sensitive to gaseous and particulate pollutions such as carbon monoxide, oxides of nitrogen and sulphur, hydrocarbon (benzene, methane and ethylene), ozone, particulate matters, hydrogen flouride, peroxyacl nitrate, etc (Joshi *et. al.,* 2009). Forest ecosystems services is one of the very important life-supporting system that is available to man naturally. They are essential to human well-being such as sucking of dangerous greenhouse gasses that bring about climate change which affect environmental conditions for people and wildlife species both directly and indirectly, reduce the amount of rainfall, and unfavorable weather condition among other things (Putz *et al.*, 2001). Forests everywhere are undergoing systemic changes through the intentional threat pose by forest speculators and other factors (Ijaware, 2021). Nigeria is one of the world's tropical countries experiencing huge deforestation and forest degradation and losses its forest at 3.5% per annum (Ladipo, 2010). In a Soil Adjusted Vegetative Index (SAVI) research by Ijaware (2021), Oluwa Forest Reserve was discovered to contain more Shrub (bush) and grassland than trees in declining order. He observed that the rate at which dense vegetation (tress) is depleting without replacement is greater in the forest reserve area. Trees are recommended to monitor the effects of air pollution because crop plants are mostly annual which cannot show the long-term effects produced by the pollutants (Luliana and Barbu, 2011). Plants have been used for remediation of pollutants from air, soils and water, which has been termed as phytoremediation (Huang *et al.,* 1997). Plants responses to air pollution can be understood by analyzing the physiological and biochemical resistance and susceptibility (Seyyednejad *et al.,* 2011). Change in leaf extract pH, relative water content, ascorbic acid content and total chlorophyll content have been used in evaluating impact of air pollution on plants (Chouhan *et al.,* 2012). Air pollution tolerance index based on the four aforementioned parameters has been used to identify tolerance levels of plant species (Mohammed *et al.,* 2011).

This study attempts to determine the air pollution tolerance indices (APTI) of trees growing in high anthropogenic (Ore, Ondo State) and less anthropogenic areas (Queen's Plot, Akure, Ondo State).

MATERIALS AND METHODS

Collection of samples

Composite leaves were randomly collected from nine trees species (*Treculia africana, Triplochiton scleroxylon, Mansonia altissima, Annonidium manni, Musanga cecropioides, Entandrophagma utile, Sterculia oblongata, Chrysophyllum albidum* and *Celtis zenkerii*) that were predominant in both experimental locations. The locations were: Queen's Plot (Akure Forest Reserve) and FRIN Research Forest in Ore (Oluwa Forest Reserve) which served as control and polluted areas respectively being indicators of air pollution. Ore which is located along Lagos/Benin Express way in the Ondo State Axis is one of the busiest areas of Ondo State with a very high traffic density and industries such as quarry, ethanol factory and plywood making factory. FRIN Research Forest in Ore is part of Oluwa Forest Reserve located in Odigbo Local Government Area. The reserve covers an area of 256 ha. It lies between latitude 6°44'40.30" N and 6°44`43.04" N and longitude 4°51`37.34" E and 4°51'40.80" E. Queen's Plot is a designated Strict Nature Reserve since 1936. It is well located in an area of no anthropic interference. The reserve covers an area of 32 ha, with a buffer of 256 ha and lies along Ondo – Akure Road at about 20 km South of Akure, the capital of Ondo State. It is located on latitude 7°16' N and 7°18'N and longitude 5° 02'E and 5°22'E.

Biochemical estimation of samples

Composite fresh leaf samples were collected, washed and kept in polythene bags before further processing. These samples were used for the estimation of pH, total chlorophyll and ascorbic acid content.

Chlorophyll estimation: The chlorophyll content of leaves was estimated following the procedure described by Arnon (1949). The volume of solvent extraction was made up to 100 ml by adding 80% acetone. The absorbance was measured by using spectrophotometer at 645 nm, and 663 nm.

Ascorbic acid content: The total ascorbic acid content (expressed in mg/g) was estimated using the method of Bajaj and Kaur (1981). Fresh foliage (1 g) was put in a test-tube, 4 ml oxalic acid EDTA (Ethylenediaminetetraacetic acid) extracting solution was added, them 1 ml of Orthophospheric acid and then 1 ml of 5% tetraoxosulphate (vi) acid was added to this mixture, 2 ml of ammonium molybdate was added and then 3ml of water. The solution was then allowed to stand for 15 minutes after which the absorbance at 760 nm was measured with a spectrophotometer. The concentrations of ascorbic acid in the sample were then extrapolated from a standard ascorbic.

Relative water content (RWC)

Lui and Ding (2008) method of estimating RWC was adopted. 5.0 g of fresh leaves (FW) samples were soaked in water over night blotted dryand then weighed to obtain its turgid weight (TW) using high precision electronic kitchen scale. Thereafter the leaves were dried in an oven at 70°C and reweighed to obtain dry weight (DW). This experiment was done in triplicates and weights obtained were imputed in the relationship below as RWC.

$$RWC = \frac{FW-}{TW-DW} X \frac{100}{1} \quad .... [1]$$

Where: RWC=Relative Water Content; FW=Fresh Weight; DW=Dry Weight; TW=Turgid Weight

pH

pH of aqueous leaf extract was determined using digital pH meter.

Air Pollution Tolerance Index

Air Pollution Tolerance Index (APTI) was determined by calculating the ascorbic acid content, total chlorophyll content, pH of leaf extract and relative water content of leaf. APTI was calculated by the method described by Singh and Rao (1983):

$$APTI = \frac{[AA(T+P)+R]}{10} .... [2]$$

Where:

AA = Ascorbic acid (mg g^{-1} FW);

T = Total chlorophyll (mg g^{-1} FW);

P = Leaf extract pH; and

R = Relative water content (%) of the leaves.

APTI value categories of plant species based on air pollution tolerance index (Thambavani and Kumar, 2011):

i. 1 - 16 Sensitive
ii. 17 - 29 Intermediate
iii. 30 - 100 Tolerant

RESULTS

The analysis value of the four biochemical parameters along with the calculated APTI for the nine tree species are shown in Tables 1 and 2 respectively. All biochemical parameters analyzed for the APTI played an important role to determine species tolerance or sensitivity to the atmospheric stress. From Table 1, trees ranged in pH from 4.60 to 5.40 in Polluted Site with the lowest in *Chrysophyllum albidum*followed by *Triplochiton scleroxylon*/*Annonidium manni* and the highest *Mansonia altissima* and from 5.60 to 6.80 in Control Site with the highest in *Celtis zenkerii* followed by *Musanga cecropioides* and the lowest in *Entandrophagma utile*.

The leaf relative water content (RWC) varied from 53 % to 63 % in Polluted Site with the highest in *Mansonia altissima* followed by *Triplochiton scleroxylon* and the lowest in *Chrysophyllum albidum* and from 31 % to 55 % in control site with the highest in *Mansonia altissima* followed by *Celtis zenkerii* and the lowest in *Treculia africana*/*Sterculia oblongata*.

Total Leaf Chlorophyll (TLC) content ranged from 0.67 mg/g to 1.02 mg/g in Polluted Site with the highest in *Mansonia altissima* followed by *Celtis zenkerii* and the lowest in *Chrysophyllum albidum* and from 1.04 mg/g to 1.70 mg/g in Control Site with the highest in *Mansonia altissima* followed by *Triplochiton scleroxylon* and the lowest in *Chrysophyllum albidum*/ *Entandrophagma utile*.

The ascorbic acid content (AAC) ranged between 6.8 mg/g to 119.6 mg/g in Polluted Site with the highest in *Mansonia altissima* followed by *Chrysophyllum albidum* and the lowest in *Celtis zenkerii* and from 4.9 mg/g to 89.6 mg/g in Control Site with the highest in *Mansonia* *altissima* followed by *Chrysophyllum albidum* and the lowest in *Musanga cecropioides*.

The APTI values (Table 1) obtained for sampled trees ranges from 56.74 to 83.08 at Polluted site with the highest in *Mansonia altissima* followed by *Triplochiton scleroxylon* and the lowest in *Chrysophyllum albidum* and from 50.52 to 78.08 in control site. Air pollution tolerance index values were found to be higher in *Mansonia altissima*and least in *Musanga cecropioides* at polluted and control sites respectively.

Table 1: Leaf extract pH, relative water content (RWC), Air Pollution Tolerance Index (APTI), acid ascorbic content (AAC) and total leaf chlorophyll (TLC) of plant species growing in polluted (P) and control (C) sites.

Plant name	Location	pH	RWC (%)	APTI	AAC (mg/kg)	TLC (mg/kg)
C. albidum	P	4.60	53.00	59.18	116.50	0.67
	C	5.70	33.00	47.80	80.20	1.04
A. manni	P	4.70	57.00	25.59	36.70	0.72
	C	6.50	32.00	17.00	18.20	1.08
E. utile	P	5.10	59.00	24.89	32.80	0.69
	C	5.60	52.00	17.82	19.00	1.04
M. altissima	P	5.40	63.00	83.08	119.60	1.02
	C	6.40	55.00	78.08	89.60	1.70
C. zenkerii	P	5.20	58.00	9.92	6.80	0.86
	C	6.80	52.00	11.66	8.20	1.08
M. cecropioides	P	5.10	60.00	11.89	10.20	0.67
	C	6.70	35.00	7.48	4.90	1.43
S. oblongata	P	4.80	57.00	11.17	9.80	0.78
	C	6.60	31.00	9.31	7.80	1.36
T. africana	P	4.90	55.00	27.70	38.40	0.88
	C	5.90	31.00	23.22	27.60	1.39
T. scleroxylon	P	4.70	62.00	62.74	99.90	0.96
	C	6.50	38.00	56.91	65.00	1.67

Key: P = polluted site; C = control site

Table 2: APTI values and rating ofplant species growing in polluted and control sites

Plant name	Location	APTI	APTI Rating
C. albidum	P	59.18	Tolerant
	C	47.80	Tolerant
M. altissima	P	83.08	Tolerant
	C	78.08	Tolerant
T. scleroxylon	P	62.74	Tolerant
	C	56.91	Tolerant
A. manni	P	25.59	Intermediate
	C	17.00	Intermediate
E. utile	P	24.89	Intermediate
	C	17.82	Intermediate
T. africana	P	27.70	Intermediate
	C	23.22	Intermediate
S. oblongata	P	11.17	Sensitive
	C	9.31	Sensitive
M. cecropioides	P	11.89	Sensitive
	C	7.48	Sensitive
C. zenkerii	P	9.92	Sensitive
	C	11.66	Sensitive

Key: P = polluted site; C = control site

DISCUSSION

In this research work, *Chrysophyllum albidum*, *Mansonia altissima* and *Triplochiton scleroxylon* showed APTI values ranging from47.80 to 83.08 which falls within the classification range of 30 to 100 and are designated as tolerant (Thambavani and Kumar, 2011). Among the designated tolerant trees, *Chrysophyllum albidum* had the least APTI value followed by *Triplochiton scleroxylon* while the highest value was *Mansonia altissima*. *Annonidium manni, Entandrophagma utile* and *Treculia africana* showed APTI values range of 17.00 to 27.70 and are designated as intermediate.*Annonidium manni* had the least value followed by *Entandrophagma utile* while *Treculia africana* had the highest value. *Sterculia oblongata*, *Musanga cecropioides* and *Celtis zenkerii* showed APTI values range of range 7.48 to 11.89 and are designated as sensitive. *Musanga cecropioides* had the highest value followed by *Celtis zenkerii* while *Sterculia oblongata*had the least value. According to Kanwar *et al.,* (2016); Thambavani and Kumar, (2011), the higher the APTI value, higher is the tolerance towards air pollution. Therefore, the order of tolerance for the sampled trees species are *M. altissima* >*T. scleroxylon* > *C. albidum* > *T. africana* > *A. manni* > *E. utile* > *M. cecropioides* > *S. oblongata* > *C. zenkerii*.

The three tolerant trees species: *Mansonia altissima*, *Chrysophyllum albidum* and *Triplochiton scleroxylon* exhibited higher AAC in polluted and control sites. According to Zamble*et al.*, (2015) the aforementioned trees species are resistant plants, this is also corroborated by Keller and Schwager, (1977); Lee *et al.,* (1984) whose works showed that high amount of AAC favours pollution tolerance in plants.Ascorbic acid is a natural detoxicant, which may prevent the damaging effect of air pollutants in plant tissues and it activates many physiological and defense mechanism (Singh *et al.,* 1991). This adaptive feature makes them a highly recommended tree species for reforesting the deforested land.

Higher level of RWC was observed in polluted plants which showed more tolerance to pollutants (Gharge and Menon, 2012; Enete *et al.*, 2013). The observed tolerance in these tree species shows adaptation for conditions within the polluted forest reserve because pollutants affects transpiration rate in leaves (Swami *et al.*, 2004); protoplasmic permeability which in cells cause loss of water and dissolved nutrients, resulting in early senescence of leaves (Agrawal and Tiwari 1997).

Low level of TLC was observed in all tree leaves species of polluted site when compared with control site, this is corroborated by Speeding and Thomas (1973) who suggested that the chlorophyll level in plants decreases under pollution stress. Sharma *et al*., (2013), stated that Chlorophyll undergoes several photochemical reactions such as oxidation, reduction, reversible bleaching under stress conditions influenced by pollution level as well as other biotic and abiotic stresses. Despite the stresses undergone by *Mansonia altissima*, *Triplochiton scleroxylon* and *Chrysophyllum albidum* they exhibited higher tolerance among the trees in the polluted site therefore making them recommendable for pollution prone areas.

Leaf extract pH was more acidic in tree leaves of polluted site. Thambavani and Ma, (2011) reported that in the presence of an acidic pollutant, leaf pH was lowered and the decline is greater in sensitive than in tolerant plant. Photosynthesis is strongly associated with leaf pH; low leaf pH in plant species indicates reduced photosynthetic rate (Chouhan *et al*., 2012). More acidic pH is more susceptible to abate air pollution, whereas neutral (pH 7) and more basic pH are considered to be more tolerant (Singh and Verma, 2007).Despite the stresses undergone by *Mansonia altissima*, *Triplochiton scleroxylon* and *Chrysophyllum albidum* they exhibited higher tolerance among the trees in the polluted site therefore making them recommendable for pollution prone areas.

CONCLUSION

From the present study, computation of APTI from biochemical parameters (pH, relative water content, total leaf chlorophyll and ascorbic acid content) showed order of tolerance as *M. altissima* >*T. scleroxylon* > *C. albidum* > *T. africana* > *A. manni* > *E. utile* > *M. cecropioides*

> *S. oblongata* > *C. zenkerii*.This provides useful information for selecting trees with better mitigation of gaseous and particulate pollutants. Planning for reforestation of deforested land mass has basis for selecting preferred species.

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