

PAPER • OPEN ACCESS

## Tree Species for bio-monitoring and Green Belt Design: A Case Study of Ota Industrial Estate, Nigeria

To cite this article: Winifred U Anake *et al* 2018 *IOP Conf. Ser.: Earth Environ. Sci.* **173** 012022

View the [article online](#) for updates and enhancements.

### Related content

- [Chemical Speciation and Health Risk Assessment of Fine Particulate Bound Trace Metals Emitted from Ota Industrial Estate, Nigeria](#)  
Winifred U Anake, Godson R E E Ana, Akan B Williams *et al.*
- [The use of colour indicator as a smart packaging system for evaluating mangoes Arummanis \(Mangifera indica L. var. Arummanisa\) freshness](#)  
A Dirpan, R Latief, A Syarifuddin *et al.*
- [Impact of meteorological parameters over Covenant University, Ota, Nigeria](#)  
E O Falayi, M R Usikalu, T V Omotosho *et al.*



**IOP | ebooks™**

Bringing you innovative digital publishing with leading voices to create your essential collection of books in STEM research.

Start exploring the collection - download the first chapter of every title for free.

## Tree Species for bio-monitoring and Green Belt Design: A Case Study of Ota Industrial Estate, Nigeria

Winifred U Anake<sup>1\*</sup>, Jacinta E Eimanehi<sup>1</sup>, Hotom S Riman<sup>2</sup> and Conrad A Omonhinmin<sup>3</sup>

<sup>1</sup>Analytical and Environmental Chemistry Unit, Department of Chemistry, Covenant University, Km 10, Idiroko Road, Ota, Ogun State, Nigeria.

<sup>2</sup>Environmental Chemistry and Pollution Control Unit, Department of Chemistry, University of Ibadan, Ibadan, Oyo State, Nigeria.

<sup>3</sup>Applied Biology & Biotechnology Unit, Department of Biological Science, Covenant University, Km 10, Idiroko Road, Ota, Ogun State, Nigeria.

E-mail: winifred.anake@covenantuniversity.edu.ng

**Abstract.** Bio-chemical and physiological parameters of plants have been employed in the screening of suitable bio - monitors via the estimation of air pollution tolerance index (APTI) and anticipated performance index (API). In the present study, five plant species, *Elaeis guineensis*, *Mangifera indica*, *Terminata catappa*, *Musa spp* and *Araucaria heterophylla* within high concentrated industrial areas of Ota industrial estate were evaluated based on these two indices. APTI for all plant species ranged from 3.43 to 10.1 signifying their bio-monitoring status. Out of five species, *Terminata catappa* was identified as the most sensitive. Following API classification, *Mangifera indica* was graded as a good performer while *Elaeis guineensis* and *Terminata catappa* were grouped as moderate performers for green belt development. Further evaluation of screened trees for high grade tolerant species and carbon sequestration potential is recommended.

### 1. Introduction

Ambient air pollutants such as particulate matter and gaseous mixture released into the atmosphere from industrial chimneys, stacks, open burning of solid waste and mobile sources like cars have dramatically increased in Ota industrial estate, Nigeria [1] – [3]. The pollutants concentrations depend on the characteristics of the source of pollution such as influence area, meteorological and topographical conditions [4].

Different plant species have shown varied potentials in reducing air pollution levels by providing sizeable leaf area for air pollutant impression, absorption and accumulation [5], [6]. The impact of air pollution on the plants can be evaluated from a combination of Air Pollution Tolerance Index (APTI) and Anticipated Performance Index (API). APTI is a tool used for the identification and classification of plants into



tolerant and sensitive group based on variation in the biochemical parameters namely relative water content, pH of leaf extract, total chlorophyll content and ascorbic acid content. It has been used by several researchers for the selection of air pollution tolerant species in industrial areas [7], [8]. Based on the response of plant towards a particular stress, they can be classified as sensitive or tolerant [9].

The anticipated performance index value gives a good and sensible reason to classify different plant species for the development of green belt, reforestation and afforestation. It takes into consideration the air pollution tolerance index as well as the biological and socio-economical parameters of plant. API is very useful in the selection of plants that can perform dual functions of improving air quality and providing appealing and recreational value [10], [11].

Hence, the objectives of the present study were to investigate the potentials of trees within the high concentrated industrial areas of Ota industrial estate, Ogun state, Nigeria for (a) monitoring environmental pollution, and (b) green belt design.

## 2. Materials and Methods

### 2.1. Sample collection

Plant species namely *Elaeis guineensis*, *Mangifera indica*, *Terminata catappa*, *Musa spp* and *Araucaria heterophylla* were collected in triplicates between 7 and 11am for a period of 3 months (January to March, 2018) around Federated mill, gas plant, horticulture garden and Alluminium tower in Ota industrial estate, Ogun State, Nigeria. The collected samples were wrapped in a foil paper, preserved in ice chest box and transported immediately to the laboratory for identification. Afterwards, samples were washed with distilled water, air dried, ground and refrigerated.

### 2.3. Determination of Leaf Bio-chemical Parameters

In order to determine the bio-chemical parameters of plant species, four (4) parameters were evaluated, they are; pH of leaf extract, total chlorophyll content, ascorbic acid content and relative water content of the leaf. For pH of leaf extract, 4 g of fresh leaves was extracted in 40 mL distilled water, filtered and measured using a glass electrode pH [12]. The relative water content was determined according to [12], [13]. Analysis of total chlorophyll content was done by extracting 1 g of ground fresh leaves with 10 mL acetone for 15 minutes using a centrifuge at 2500 rpm for 3 minutes and the absorbance was taken at 643nm, 645nm and 663nm with ultraviolet spectrophotometer (Genesys). Further calculations were done according to Arnon equation [12], [13]. For ascorbic acid determination, 1g leaves was extracted with 4 mL oxalic acid-EDTA solution, 1 mL orthophosphoric acid, 2 mL of 5% sulphuric acid, 4 mL of ammonium molybdate and 3 mL of water. After 15 minutes, the absorbance of the filtered extract was taken at 730 nm with a spectrophotometer [13], [14].

### 2.4. Determination of Air Pollution Tolerance Index (APTI)

The method of calculating the APTI was proposed by [15]

$$APTI = A(T + P) + R/10 \quad (1)$$

where: A=Ascorbic acid content mg/g; T = Total chlorophyll content mg/g; P = pH of leaf extract and R= Relative water content of leaf (%).

### 2.5. Determination of Anticipated Performance Index

The APTI value combined with some biological and socio economic characters such as plant habit, canopy structure, type of plant and economic value as shown in Table 1 was used in evaluating the API of

various plants. Table 2 indicates the various categories of plant species based on their API score [9], [16]. Anticipated performance index (API) was calculated as follows:

$$API = \frac{\text{No. of "+" obtained}}{\text{Total No. of "+"}} \times 100 \quad (2)$$

**Table 1.** Grade distribution of plant species with respect to APTI, biological parameters and socioeconomic importance.

Character	Character State	Pattern of assessment	Grading allotted
Tolerance	APTI	9.0–12.0	+
		12.1–15.0	++
		15.1–18.0	+++
		18.1–21.0	++++
		21.1–24.0	+++++
Biological	Plant habit	Small	-
		Medium	+
		Large	++
	Canopy structure	Sparse/irregular/globular	-
		Spreading crown/open/semi-dense	+
		Spreading dense	++
	Type of plant	Deciduous	-
Evergreen		+	
Laminar structure	Size	Small	-
		Medium	+
		Large	++
	Texture	Smooth	-
		Coriaceous	+
	Hardness	Delineate	-
Hardy		+	
Socio economic		Economic value	< 3 uses
	3 or more uses		+
	5 or more uses		++

**Table 2.** Anticipated performance index (API) of plant species.

Grade	Scores (%)	Assessment category
0	< 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

### 3. Results and Discussion

#### 3.1 Bio-chemical Analysis of Plants

The results of the bio-chemical parameters for various plants are presented in Table 3. The RWC ranged from 91.5 to 25.1 as observed in *Musa spp* and *Terminate catappa* respectively. High RWC in plants regulate the physiological performance of plants that are exposed to high concentration of atmospheric pollutants and favours tolerance to pollution [14], [17]. Maximum and minimum TC content in this study was observed in *Musa spp* (1.13 mg/g) from horticulture farm and *Elaeis guineensis* (0.356 mg/g), located near Federated mill surrounded by several industries. A reduction in the TCC content in plants leaves is a function of blockage of stomatal opening/ closing by pollutants, drought, heavy metals accumulation in the soil etc. [18], [19]. Hence, increased in pollution levels lowers the chlorophyll content [20]. The low and high TTC contents in plant leaves exhibits sensitive and tolerance ability of plants in polluted environments [21]. pH of plant species showed the highest and lowest potential of hydrogen ion concentration in leaf extract of *Araucaria heterophylla* (6.60) and *Musa spp* (5.47) respectively. A lower pH value shows good correlation with sensitivity to air pollution and also reduces photosynthesis process in plants. Plants with pH lower than 7 are more susceptible while those with pH around 7 are more tolerant to pollution. Earlier findings indicate that a reduction of ascorbic acid content in plants is pH dependent [22]–[25]. As such, change in leaf extract pH can influence the stomatal sensitivity due to air pollution [26] – [28]. In addition, *Araucaria heterophylla* (1.58) and *Elaeis guineensi* (0.578) recorded the highest and lowest ascorbic acid contents respectively. Ascorbic acid is a strong reductant and it activates many bio-chemical and physiological activities of the cell such as cell wall synthesis and cell division. It is generally higher in tolerant plant species due to its stress reducing factor [29], [30].

**Table 3.** Biochemical parameters and air pollution tolerance indices (APTI) of the studied plant species.

Sample code	Taxon	Common name	A(mg/g)	P	T(mg/g)	R(%)	APTI	Rating
Federated Mill	<i>Elaeis guineensis</i>	Oil Palm	0.578	6.00	0.356	89.4	9.31	Sensitive
	<i>Mangifera indica</i>	Mango	1.40	5.91	0.599	66.6	7.57	Sensitive
By Gas plant	<i>Terminate catappa</i>	Almond	1.43	5.73	0.691	25.1	3.43	Sensitive
Honda/Horticulture	<i>Musa spp</i>	Plantain	1.36	5.47	1.13	91.5	10.1	Sensitive
Aluminum Tower	<i>Araucaria heterophylla</i>	Christmas Tree	1.58	6.60	0.549	28.9	4.02	Sensitive

### 3.2. Assessment of APTI and API of tree species for green belts

Table 3 shows the APTI values for the five investigated tree species within the Ota industrial estate. APTI, provides information on plants based on their sensitivity and tolerance to air pollutants using the biochemical parameters and APTI grading. APTI of screened plant species ranged from 3.43 (*Terminate catappa*) to 10.1 (*Musa. spp*). Based on APTI, plant species have been categorized into three gradations. Plants with APTI value 1 to 11 are termed sensitive, 12 to 16 are known as intermediate and those with APTI  $\geq 17$  classified as tolerant [10], [14], [31]. Present finding suggested that *Elaeisis guineensis*, *Mangifera indica*, *Terminate catappa*, *Musa spp* and *Araucaria heterophylla* can be used for biomonitoring of air pollution since their APTI value occurred in the ranged of sensitive species (APTI=1 to 11).

The API score categories presented in Table 1, were used in allotting scores for different selected plants as shown in Table 4 and 5. Plant species found under API category of excellent, very good, good and moderate performers can be recommended for cultivation as green belts species [16], [18], [32]. In the present study, according to table 4 and 5, tree species *Mangifera indica* (API = 4) was screened as a good performer, *Elaeisis guineensis* and *Terminate catappa* (API = 3) as moderate performers while *Musa spp L.* and *Araucaria heterophylla* (API = 2) were evaluated as poor performers. The API assessment of the tree species showed that *Mangifera indica*, *Elaeisis guineensis* and *Terminate catappa* could be cultivated as ideal species for green belts, in the study area, to alleviate pollution [17].

**Table 4.** Evaluation of plant species based on their APTI values, biological parameters and socioeconomic importance.

Taxon	APTI	PH	CS	TT	LT	LS	EI	Hardiness	Grade allotted	
									Total plus (+)	Scoring %
<i>Elaeisis guineensis</i>	+	++	+	+	-	+	++	+	9	56.2
<i>Mangifera indica</i>	-	++	++	+	+	++	++	+	11	68.8
<i>Terminate catappa</i>	-	++	++	+	+	-	++	+	9	56.2
<i>Musa spp L.</i>	+	+	+	+	-	++	+	-	8	50
<i>Araucaria heterophylla</i>	+	++	+	+	+	-	+	+	8	50

APTI: Air pollution tolerance index; PH: Plant habit; CS: Canopy structure; TT: Type of tree; LS: Laminar size; LT: Laminar texture; H: Hardiness and EI: Economic importance

**Table 5.** Anticipated Performance Index (API) value of the studied plant species.

Taxon	Grade allotted		API value	Assessment
	Total plus (+)	Percentage %		
<i>Elaeisis guineensis</i>	9	56.2	3	Moderate
<i>Mangifera indica</i>	11	68.8	4	Good
<i>Terminate catappa</i>	9	56.2	3	Moderate
<i>Musa spp L.</i>	8	50	2	Poor
<i>Araucaria heterophylla</i>	8	50	2	Poor

#### 4. Conclusions

Evaluation of anticipated performance index of plants is an important index for screening appropriate tree species. APTI gradation highlighted *Terminate catappa* as the most sensitive among other five species. *Mangifera indica*, *Elaeisis guineensis* and *Terminate catappa* were found suitable for greenbelt design in Ota industrial estate.

#### 5. Acknowledgment

The authors gratefully thank the management of Covenant University for financial support in processing the paper.

#### 6. References

- [1] Etim E U 2012 Estimation of pollution load from an industrial estate, South-western Nigeria *Afr J Environ Sci and Technol***6**125–9
- [2] Anake W U, Ana G R E E, Williams A B, Fred-Ahmadu I O H and Benson N U 2017 Chemical Speciation and Health Risk Assessment of Fine Particulate Bound Trace Metals Emitted from Ota Industrial Estate, Nigeria *Earth & Environ Science***6**81–7
- [3] Anake W U, Benson N U and Ana, G R E E 2016 Characterization of airborne fine particulate matter (PM<sub>2.5</sub>) and its air quality implications in Ogun State, Nigeria *Proc. 3<sup>rd</sup> Covenant University Int. Conf. on African Development Issues*543–7
- [4] Pahlavani P, Sheikhan Hand Bigdeli B 2017 Assessment of an air pollution monitoring network to generate urban air pollution maps using Shannon information index, fuzzy overlay and Dempster-shafer theory, A case study: Tehran, Iran *Atmospheric Environment***16**7254–69
- [5] Rai PK 2016 Impacts of particulate matter pollution on plants: Implications for environmental biomonitoring *Ecotoxicology and Environmental Safety***129**120–36
- [6] Rai PK and Panda LS 2014 Dust capturing potential and air pollution tolerance index (APTI) of some roadside tree vegetation in Aizawl, Mizoram, India: An Indo- Burma hotspot region *Air Qual. Atmos. Health***7**93–101
- [7] Ogunkunle C O, Suleiman L B, Oyediji S, Awotoye O O, Fatoba P O 2015 Assessing the air pollution tolerance index and anticipated the performance index of some tree species for biomonitoring environmental health *Agroforest Syst***89**447–54
- [8] Achakzai K, Khalid S, Adrees M and Bibi A 2017 Air pollution tolerance index of plants around brick kilns in Rawalpindi, Pakistan *J. Environ Manage***190**252–58
- [9] Patel D and Kumar J I 2018 An evaluation of air pollution tolerance index and anticipated performance index of some selected plant species *Open Journal of Air Pollution***7**1–13
- [10] Sahu H and Sahu S K 2015 Air Pollution Tolerance Index (APTI), Anticipated Performance Index (API), Carbon Sequestration and Dust Collection Potential of Indian Tree Species *International Journal of Emerging Research in Management & Technology***4**37–40
- [11] Rai, PK 2016b Impacts of particulate matter pollution on plants: Implications for environmental biomonitoring *Ecotoxicology and Environmental Safety***129** 120–136
- [12] Arnon D I, 1949 Copper enzymes in isolated chloroplasts: Polyphenol oxidase in *Beta vulgaris* *Plant Physiology***2**1–15
- [13] Zhang, PQ, Liu, Y, Chen, X, Yang, Z, Zhu, MH and Li, Y 2016, Pollution resistance assessment of existing landscape plants on Beijing streets based on air pollution tolerance index method *Ecotoxicology and Environmental Safety***132**212–23
- [14] Bharti, KS, Trivedi, A and Kumar, N 2017, Air pollution tolerance index of plants growing near

- an industrial site *Urban Climate*. <http://dx.doi.org/10.1016/j.uclim.2017.10.007>
- [15] Singh S K and Rao D N 1983 Evaluation of plants for their Tolerance to Air Pollution *Proc. of the symposium on Air Pollution Control* 218–24
- [16] Pathak V, Tripathi B D, Mishra V K 2011 Evaluation of Anticipated Performance Index of some tree species for green belt development to mitigate traffic generated noise. *Urban Forestry & Urban Greening* **10**61–6
- [17] Tsega, Y C and Devi-Prasad, A G 2014 Variation in air pollution tolerance index and anticipated performance index of roadside plants in Mysore India. *J Exp Biol* **35**185–90
- [18] Pandey A K, Pandey M, Mishra A, Tiwary S M and Tripathi B D 2015 Air pollution tolerance index and anticipated performance index of some plant species for development of urban forest *Urban Forestry & Urban Greening* **14**866–71
- [19] Socha, A N, Kandziora-Ciupa M, Trzesicki M and Barczyk, G 2017 Air pollution tolerance index and heavy metal bioaccumulation in selected plant species from urban biotopes *Chemosphere* **183**471– 82
- [20] Bakiyaraj R and Ayyappan D 2014 Air Pollution tolerance index of some terrestrial plant around an industrial area *International Journal of Modern Research and Reviews* **2**1–7
- [21] Balasubraman, A, Prasath, CN, Gobalakrishan, K and Radhakrishan S 2018 Air pollution tolerance index and anticipated performance index assessment in trees species of Coimbatore urban city, Tamil nadu, India *International Journal of Environmental and Climate change* **8**27–38
- [22] Subramani S and Devaanandan S 2015 Application of air pollution tolerance index in assessing the air quality *International journal of pharmacy and pharmaceutical sciences* **7**216–21
- [23] Meerabai G, Venkata R C and Rasheed M 2012 Effect of industrial pollutants on physiology of *Cajanus cajan* (L.)-Fabaceae. *International Journal Environmental Science* **2**1889–94
- [24] Shalom N C, Opeyemi C E, Franklyn N I, Solomon O R and Jacob O P 2018 Phylogenetic Relationship and Genetic Variation among *Thaumatococcus daniellii* and *Megaphrynium macrostachyum* Ecotypes in Southwest Nigeria *Asian J. Plant Sci.* **17**27–36
- [25] Iweala, EEJ, Uhegbu, FO, Adesanoye, OA 2013 Biochemical effects of leaf extracts of *Gongronema latifolium* and selenium supplementation in alloxan induced diabetic rats *Journal of Pharmacognosy and Phytotherapy* **5**91–7
- [26] Enetel C and Ogbonna C E 2012 Evaluation of air pollution tolerance index (APTI) of some selected ornamental shrubs in Enugu city, Nigeria *Journal of Environmental Science, Toxicology and Food Technology* **12**2–5
- [27] Ogboru, R O, Agboje, I, Mangodo, C and Okolie L P 2015 Effects of Air Pollution on Plants Around Okpai Gas Plant Area, Ndokwa- East Local Government Area, Delta State, Nigeria *International Journal of Applied Research and Technology* **4**70 –5
- [28] Sharma, M, Panwar, N, Arora, P, Luhach, J and Chaudhry S 2013 Analysis of biological factors for determination of air pollution tolerance index of selected plants in Yamuna Nagar India. *J. Environ. Biol* **34**509–14
- [29] Tripathi, A K and Gautam M 2007 Biochemical parameters of plants as indicators of air pollution *J. Environ. Biol* **28**127–32
- [30] Rathore, DS, Kain, T, Gothalkar, P 2018 A study of air pollution status by estimation of APTI of certain plant species around Pratapnagar Circle in Udaipur City *IJAEB* **11**33 – 8
- [31] Padmavathi, P, Cherukuri, J and Reddy, MA 2013 Impact of air pollution on crops in the vicinity of a power plant: a case study *Int J Eng Res Technol* **2**3641–51
- [32] Sarala, T D and Sabitha, M A 2011 Variation in air pollution tolerance index and anticipated performance near a sugar factory: implication for landscape-plant selection for industrial areas *Journal Resource Biology* **7**494–502