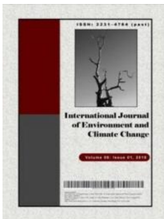

International Journal of Environment and Climate Change

8(1): 27-38, 2018; Article no.IJECC.2018.003
Previously known as British Journal of Environment & Climate Change
ISSN: 2231–4784

Air Pollution Tolerance Index (APTI) Assessment in Tree Species of Coimbatore Urban City, Tamil Nadu, India

A. Balasubramanian[1], C. N. Hari Prasath[1*], K. Gobalakrishnan[2] and S. Radhakrishnan[1]

[1]Department of Silviculture, Forest College and Research Institute, TNAU, Mettupalayam – 641 301, Tamil Nadu, India.
[2]Tamil Nadu Forest Department, Coimbatore, Tamil Nadu, India.

Authors' contributions

This work was carried out in collaboration between all authors. Author AB designed the study analysis and wrote the protocol. Author CNHP wrote the first draft of the manuscript and managed the analyses of the study. Author KG performed the statistical analysis and analyse the leaf sample. Author SR managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJECC/2018/v8i127106

Original Research Article

Received 4th November 2017
Accepted 24th January 2018
Published 10th March 2018

ABSTRACT

Aims: Forest restoration in urbanized and polluted cities is paving the way for mitigation of climate change by reducing the air pollutants level and carbon content level in atmosphere. So, the study was conducted at Coimbatore urban city, Tamil Nadu by using twenty five tree species to know their air pollution tolerance index (APTI) level.
Study Design: The sample procedure used for assessing the APTI was stratified random sampling.
Place and Duration of Study: The leaf sample was collected from different zones of Coimbatore urban city and the sample analysis was carried out in Department of Silviculture, Forest College and Research Institute, Mettupalayam, Tamil Nadu between August 2015-April 2017.
Methodology: Five zones namely residential, industrial, commercial, heavy traffic and control zone were identified from Coimbatore city for estimating the air pollution tolerance index (APTI). In order to assess the air pollution tolerance index of tree species, the biochemical parameters like ascorbic acid content, total chlorophyll content, leaf extract pH and relative water content (RWC) were estimated.
Results: Among the 25 tree species tested, *Thespesia populnea* recorded highest APTI of 16.07, 15.76, 14.63 and 14.37 in heavy traffic zone, industrial zone, control zone and residential zone

**Corresponding author: E-mail: prasathforestry@gmail.com;*

respectively. In commercial zone, *Pongamia pinnata* accounted highest APTI value of 13.96. On contrary, the lowest level of APTI was registered by *Michelia champaca* in industrial zone (10.21), *Peltophorum pterocarpum* in heavy traffic zone (10.93), *Spathodea campanulata* in residential zone (11.11) and *Albizia saman* in commercial zone (11.46).
Conclusion: On an overall, *Thespesia populnea* and *Pongamia pinnata* were performed well with highest APTI and they can be used for controlling the air pollution level in urban cities.

Keywords: Air pollution; air pollution tolerance index; tree species; biochemical characters; urbanisation.

1. INTRODUCTION

Urbanization is the spatial concentration of people and economic activity. Urbanization have resulted in a profound deterioration of air quality which is a major problem arising from industrialization in both developed and developing countries. Air pollution is related to the atmosphere through vehicular emissions and untreated industrial smoke. Urban air often contains high levels of pollutants that are harmful to humans as well as animals due to the increasing air pollution. In order to reduce and mitigate the air pollution, various efforts have been made in India, but could not achieve it because of lack of awareness and stringent rules.

There are many technologies available for controlling atmospheric pollution, but controlling pollution through vegetation (Trees) is one of the best natural way for cleaning the atmosphere by providing an enormous leaf area for impingement, absorption and accumulation of air pollutants [1]. Trees and Plants act as sink and living filters to minimize air pollution by absorption, detoxification, accumulation and metabolization without causing foliar damage or declining the growth and thus improved the air quality by releasing oxygen to the atmosphere [2]. Also they play an important role in monitoring and maintaining the ecological balance by actively participating in the cycling of nutrients and gases like carbon dioxide, oxygen and gaseous pollutants [3]. Trees, when exposed constantly to environmental pollutants it induces functional weakening and structural simplification. The resistance and susceptibility of plants to air pollutants can be determined by its physiological and bio-chemical levels. The present study was aimed to estimate the Air pollution tolerance index of twenty five tree species that are commonly seen in different polluted zones of Coimbatore city of Tamil Nadu.

2. MATERIALS AND METHODS

The study area Coimbatore is situated in West Tamil Nadu, India. Due to industrialization and rapid expansion of the city, the environmental problems are increasing in larger scale especially the air pollution. To evaluate the impact of air pollution on tree species, five different zones were selected in Coimbatore city (Fig. 1). These zones are control zone (VOC Park), residential zone (Ganapathy, Saibaba Colony, Ram Nagar), heavy traffic zone (Gandhipuram, Ukkadam, Singanallur), industrial zone (Cement Factory, Foundry Unit, SIDCO) and commercial zone (R.S.Puram, Peelamedu, Railway Station). Twenty five tree species namely Lebbeck tree *(Albizzia lebbeck),* Rain tree (*Albizzia saman),* Blackboard tree *(Alstonia scholaris),* Custard Apple *(Annona squamosa),* Neem (*Azadirachta indica),* Bidi leaf tree *(Bauhinia racemosa),* Kassod tree *(Cassia siamea),* Gulmohar *(Delonix regia),* Indian Fig Tree *(Ficus racemosa),* Peepal tree *(Ficus religiosa),* Indian Elm *(Holoptelia integerifolia),* Subabul *(Leuceana leucocephala),* Mango *(Mangifera indica),* Chinaberry tree *(Melia azadirach),* Champak *(Michelia champaka),* Jamaica Cherry *(Muntigea calibera),* Copper pod *(Peltophorum pterocarpum),* False Ashoka *(Polyalthia longifolia),* Karanj *(Pongamia pinnata),* Nandi Flame *(Spathodea campanulata),* Jamun *(Syzygium cuminii),* Tamarind *(Tamarindus indica),* Teak *(Tectona grandis),* Indian Almond Tree (*Terminalia catappa)* and Indian tulip tree *(Thespesia populnea)* were selected to screen for air pollution tolerance or susceptibility, in Coimbatore.

In order to assess the air pollution tolerance index of these tree species, biochemical parameters like ascorbic acid content, total chlorophyll content, leaf extract pH and relative water content (RWC) were estimated.

The air quality status for Coimbatore, Tamil Nadu was collected from Department of Environment, ENVIS centre, Government of Tamil Nadu for 2003 to 2017. The air quality standards as per the Government of India notification from the Central Pollution Control Board (CPCB) during 2009 denotes that the standard for SO_2 (Resident-60 and Industrial-80), NO_x (Resident-60 and Industrial-80) and RSPM (Resident-60 and Industrial-120).

2.1 Biochemical Constituents

2.1.1 Relative water content (%) in leaves

The leaf samples of the selected tree species were made into 50 uniform discs and recorded their fresh weight. The leaf discs are floated in water for 12 hour to attain full turgid weight and after the water droplets sticking on the leaf surface are wiped out by using filter paper. The turgid weight was recorded immediately after an hour of floating in water. The leaf discs are transferred to butter paper cover and then kept in hot air oven at 80°C for 48 hours after recording the dry weight (Fig. 3). Relative water content will be calculated using the formula as described [4] below:

$$RWC = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Turgid weight} - \text{Dry weight}} \times 100$$

2.1.2 Total leaf chlorophyll content (mg g^{-1}) by acetone method

Totally take 250 mg of fresh leaf sample was weighed and transferred to a pestle and mortar. The leaf samples macerated with 10 ml of 80 per cent acetone. The content was centrifuged at 3000 rpm for 10 minutes. The supernatants are collected after centrifuging and the volume made up to 25 ml by using 80 per cent acetone (Fig. 2). The optical density was measured at 663 nm and 645 nm by a spectrophotometer.

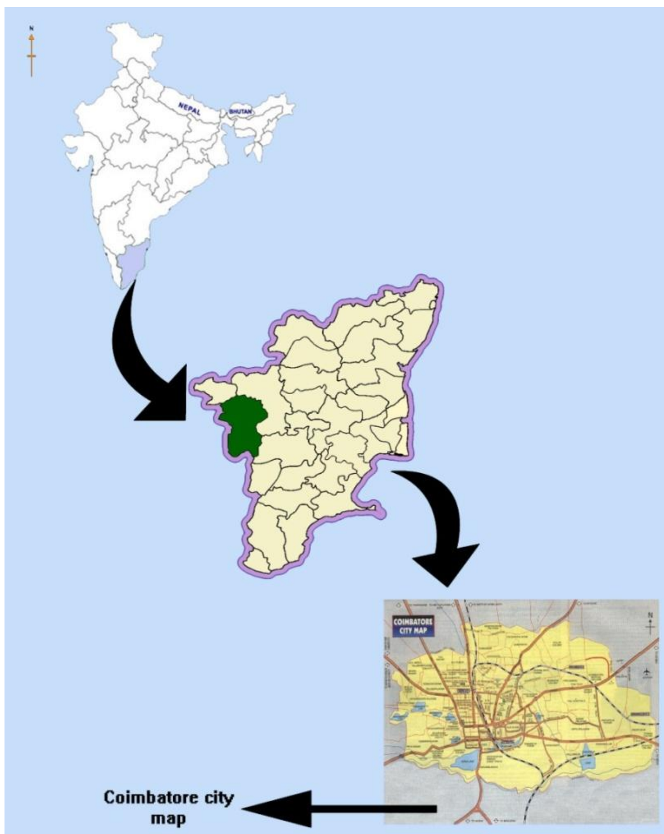

Fig. 1. Coimbatore urban city map

Table 1. Air quality index status of Coimbatore urban city during 2013-17

Sl. no.	Year (Timeline)	Average annual concentration of air pollutants (µg/m^3)								
		Industrial Areas			Mixed Areas			Residential Areas		
		RSPM	NO_x	SO_2	RSPM	NO_x	SO_2	RSPM	NO_x	SO_2
1	2003-04	62	56	13	43	51	10	46	46	10
2	2004-05	84	48	9	53	39	7	51	41	7
3	2005-06	73	47	10	39	43	8	44	38	7
4	2006-07	102	40	11	44	32	10	44	32	9
5	2007-08	130	39	9	57	36	8	52	40	7
6	2008-09	116	37	6	59	30	5	50	31	5
7	2009-10	100	27	7	60	23	5	51	23	5
8	2010-11	102	34	6	60	24	6	56	21	5
9	2011-12	205	35	5	68	30	5	68	29	5
10	2012-13	198	28	5	70	30	5	70	26	5
11	2013-14	215	25	4	65	28	5	65	25	4
12	2014-15	220	25	4	69	26	4	69	30	4
13	2015-16	200	24	4	63	24	4	68	32	4
14	2016-17	198	29	4	68	29	4	70	29	4

Total chlorophyll content (mg/gm) = (8.02 x OD at 663) + (20.2 x OD at 645)

Fig. 2. Leaf chlorophyll estimation

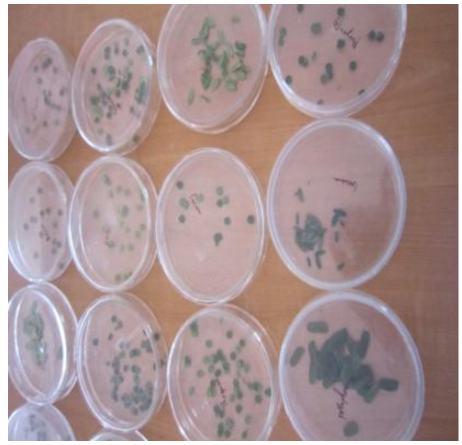

Fig. 3. Relative water content estimation

2.1.3 Leaf extracts pH

Take 5 gram of fresh leaf was homogenized in 10 ml deionized water and then filtered. The pH of leaf extract was determined after calibrating pH meter with buffer solution of pH 4.2, pH 7.0 and pH 9.1 (Fig. 5).

2.1.4 Ascorbic acid content in leaves

Ascorbic acid content (expressed as mg per gram) was measured by using spectrophotometric method. One gram of the sample was measured into test tube, 4 ml oxalic acid-EDTA extracting solution was added and one ml of orthophosphoric acid followed by one ml 5 per cent tetraoxosulphate (VI) acid was added. To this 2 ml ammonium molybdate and 3 ml of water were added (Fig. 4).

The solution was allowed to stand for 15 minutes and the absorbance was measured at 760 nm using spectrophotometer. The concentration of ascorbic acid in the sample will then extrapolate from a standard ascorbic acid curve.

2.2 Calculation of Air Pollution Tolerance Index (APTI)

Air pollution tolerance index was the measure of four biochemical parameters *viz*., ascorbic acid content, total chlorophyll content, leaf extract pH and relative water content of the leaves [5].

$$APTI = [A (T + P) + R] / 10$$

Where, A - Ascorbic acid content (mg/g), T - Total chlorophyll content (mg/g), P - pH of leaf extract and R - Relative leaf water content (%).

On the basis of APTI values tree species were categorized into three groups *viz*., Sensitive species: < 10, Intermediate species: 10-17 and Tolerant species: >17.

Fig. 4. Ascorbic acid estimation

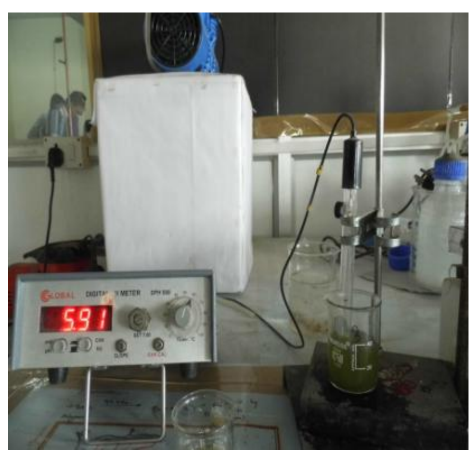

Fig. 5. Leaf pH estimation

2.3 Statistical Analysis

The results were statistically analyzed and interpreted by one way ANOVA using Software Package for Social Sciences (SPSS), version 16.0.

3. RESULTS AND DISCUSSION

The response of plants to air pollution at biochemical levels can be understood by analyzing the factors that determine resistance and susceptibility to pollutants [6]. The bio-chemical parameters such as ascorbic acid content, total chlorophyll content, leaf extract pH, relative water content and air pollution tolerant index were estimated.

3.1 Effect of Air Pollutants on Plant Physiology

The sudden changes in the environment especially due to air pollution leads to a huge change in the morphological, physiological and bio-chemical functioning of the plants/trees. The common physiological modification that happens in the plants or trees during the environmental changes (Air pollution) was change in stomatal and epidermal cell size, lower recurrence, thickening of cell wall, epicuticular wax deposition alterations and chlorosis are among the auxiliary alterations in leaves [7].

Studies on impact of micro morphology and leaf epidermal components of plants revealed that in the polluted sites, leaves became smaller with reduced length and width and stomata index per leaves area [8]. The change in the physiological pattern and functioning of the plants leads to the decrease in the general characteristics of the morphological and anatomical characters of plant species [9].

3.2 Biochemical Constituents

3.2.1 Relative water content in the leaves of air pollution affected tree species

Relative Water Content (RWC) in leaf tissues are commonly calculated to assess the water status of plants as it gives the relative amount of water present in the plant tissues. Leaf water status is intimately related to several leaf physiological variables, such as leaf turgour, growth, stomatal conductance, transpiration, photosynthesis and respiration [10]. *Polyalthia longifolia* in industrial zone observed highest relative water content of 94.19 per cent followed by *Muntigea calabura* (92.05%) in control site, *Leucaena leucocephala* (88.87%) in residential zone and *Holoptelia integrifolia* (88.11%) in commercial zone and *Pongamia pinnata* (80.16%) in Heavy traffic zone.

On supporting the present study, high water content within a plant body will help to maintain its physiological balance under stress condition such as exposure to air pollution when the transpiration rates are usually high (Table 2).

Fig. 6. Trees with high APTI value (*Thespesia populnea* and *Pongamia pinnata*)

Table 2. Relative water content (%) of selected tree species in Coimbatore city

Species name	Control Zone	Residential Zone	Industrial Zone	Commercial Zone	Heavy Traffic Zone
Albizia lebbeck	72.79	62.54	82.24	75.10	68.07
Albizia saman	76.43	72.08	81.63	73.23	58.78
Alstonia scholaris	73.12	73.51	75.98	66.71	75.00
Annona squamosa	69.87	73.90	66.40	74.31	65.14
Azadirachta indica	77.03	80.11	72.32	83.56	73.67
Bauhinia racemosa	74.49	83.59	87.04	79.58	73.29
Cassia siamea	76.09	88.33	79.25	62.06	74.76
Delonix regia	73.33	76.01	78.96	68.86	69.54
Ficus racemosa	69.79	73.07	90.59	76.40	61.62
Ficus religiosa	63.32	73.83	88.64	67.19	70.82
Holoptelia integerifolia	63.22	72.88	82.40	88.11	61.99
Leuceana leucocephela	72.54	88.87	72.78	72.07	67.21
Mangifera indica	61.79	69.69	82.43	82.24	75.18
Melia azadirach	62.97	73.21	84.18	78.62	71.23
Michelia champaka	70.16	80.62	63.26	74.03	79.03
Muntigea calibera	92.05	86.95	82.51	81.09	77.41
Peltoforum terocarpum	64.61	72.28	72.25	70.35	69.45
Polyalthia longifolia	74.71	76.14	94.19	78.34	73.40
Pongamia pinnata	76.74	68.70	73.06	73.65	80.16
Spathodeacam paniculata	71.16	52.78	74.04	78.52	61.46
Syzigium cuminii	68.03	79.51	62.73	68.60	73.27
Tamarindus indica	72.19	63.47	69.58	72.51	75.45
Tectona grandis	62.20	78.58	90.69	77.25	67.40
Terminalia cadappa	73.40	63.20	70.16	75.77	68.60
Thespesia populnea	76.64	72.39	91.27	73.52	73.99
SEd	0.529	0.551	0.581	0.545	0.525
CD	1.065	1.108	1.168	1.095	1.055

3.2.2 Total chlorophyll content in leaves of air pollution affected tree species

Total chlorophyll content signifies its photosynthetic activity as well as the growth and development of biomass in tree or plant species [11]. The higher levels of total chlorophyll observed is due to its tolerance nature to air pollutants in the atmosphere [12]. The highest total chlorophyll content was observed in *Alstonia scholaris* (5.11 mg g^{-1}), *Pongamia pinnata* (4.95 mg g^{-1}), *Thespesia populnea* (4.75 mg g^{-1}) and *Syzygium cuminii* (3.65 mg g^{-1}) in control site, residential zone, industrial zone and heavy traffic zone respectively and *Pongamia pinnata* (3.88 mg g^{-1}) in commercial zone (Table 3).

Similar findings on total chlorophyll of leaves have been reported by previous researchers in different regions of world regarding the higher chlorophyll content favoured tolerance to air pollutants in plants [13,14,15]. The production of reactive oxygen species (ROS) in the chloroplast under water stress decreases the chlorophyll content in the leaves [16].

3.2.3 Leaf extract pH of the air pollution affected tree species

All five polluted zones exhibited a pH towards acidic nature in the leaves extract of tree in Coimbatore city. This indicates the low level of pH may be due to the presence of SO_2 and NO_x in the ambient air causing a change in pH of the leaf sap towards acidic side of the pH scale [17].

The findings was that, *Delonix regia* was ascertained with highest leaf extract pH of 7.03 in control site, *Ficus religiosa* (6.97) in residential zone, *Mangifera indica* (6.59) in industrial zone and *Annona squamosa* (6.47 and 6.34) in heavy traffic zone and commercial zone (Table 4). Hence, the leaf extract pH on the higher side gives tolerance to plants against pollution. Higher leaf extract pH in plants, especially in polluted conditions may tend to increase their tolerance level [18].

Table 3. Total chlorophyll content (mg/g) in leaves of air pollution affected tree species in Coimbatore city

Species name	Control Zone	Residential Zone	Industrial Zone	Commercial Zone	Heavy Traffic Zone
Albizia lebbeck	2.16	1.68	0.98	1.15	0.99
Albizia saman	3.49	3.16	2.83	2.94	2.71
Alstonia scholaris	5.11	3.63	4.62	2.66	2.80
Annona squamosa	3.20	2.66	1.33	2.43	2.96
Azadirachta indica	2.92	2.29	1.98	2.00	2.03
Bauhinia racemosa	2.10	1.95	1.58	1.73	1.75
Cassia siamea	2.07	1.71	1.39	1.54	1.38
Delonix regia	2.54	2.07	1.84	2.41	1.88
Ficus racemosa	2.90	1.52	1.55	1.43	1.90
Ficus religiosa	2.37	2.04	2.15	2.16	2.08
Holoptelia integerifolia	3.93	3.42	2.94	2.31	1.57
Leuceana leucocephela	2.50	1.84	1.66	1.74	1.14
Mangifera indica	4.04	3.59	3.43	1.51	1.83
Melia azadirach	2.73	1.98	1.84	1.02	1.79
Michelia champaka	1.96	1.43	1.47	1.53	1.57
Muntigea calibera	2.98	1.14	1.00	1.11	1.52
Peltoforum terocarpum	2.78	1.99	1.78	2.02	1.46
Polyalthia longifolia	2.01	1.65	1.37	1.46	1.73
Pongamia pinnata	4.97	4.95	2.87	3.88	2.67
Spathodeacam paniculata	4.53	3.30	4.24	3.45	1.08
Syzigium cuminii	4.88	2.25	1.93	3.19	3.65
Tamarindus indica	3.15	2.08	1.77	2.94	2.63
Tectona grandis	2.82	2.26	2.42	2.25	1.41
Terminalia cadappa	2.27	1.78	2.94	2.96	0.99
Thespesia populnea	3.49	3.24	4.75	2.70	2.70
SEd	0.023	0.019	0.019	0.017	0.015
CD	0.046	0.038	0.039	0.035	0.030

Table 4. Leaf extract pH of the air pollution affected tree species in Coimbatore city

Species name	Control Zone	Residential Zone	Industrial Zone	Commercial Zone	Heavy Traffic Zone
Albizia lebbeck	5.42	4.59	5.84	5.56	5.56
Albizia saman	5.35	5.56	5.62	6.03	5.64
Alstonia scholaris	4.62	6.03	6.18	5.25	5.29
Annona squamosa	5.83	5.70	5.68	6.34	6.47
Azadirachta indica	5.53	6.44	5.80	5.30	5.23
Bauhinia racemosa	5.93	6.64	5.79	6.06	5.20
Cassia siamea	5.93	5.77	5.84	5.63	4.90
Delonix regia	7.03	6.77	6.54	6.26	6.36
Ficus racemosa	5.73	5.54	6.29	5.96	5.83
Ficus religiosa	5.23	6.97	6.54	5.10	5.20
Holoptelia integerifolia	5.83	5.80	5.89	5.80	5.56
Leuceana leucocephela	5.43	5.84	6.29	5.06	4.80
Mangifera indica	5.43	4.20	6.59	6.26	4.43
Melia azadirach	5.83	5.47	5.99	4.70	5.66
Michelia champaka	5.63	4.74	5.54	5.70	5.10
Muntigea calibera	6.23	5.60	5.74	5.73	5.23
Peltoforum terocarpum	5.83	5.50	5.34	6.10	5.96
Polyalthia longifolia	5.93	6.77	6.39	5.93	4.63
Pongamia pinnata	5.73	6.57	5.29	6.16	5.63
Spathodeacam paniculata	5.33	5.30	5.69	4.48	4.86

Species name	Control Zone	Residential Zone	Industrial Zone	Commercial Zone	Heavy Traffic Zone
Syzigium cuminii	5.33	5.77	5.39	5.30	5.96
Tamarindus indica	5.83	5.77	6.04	5.26	5.53
Tectona grandis	4.13	5.27	6.19	6.33	5.40
Terminalia cadappa	5.75	5.81	5.70	6.20	5.57
Thespesia populnea	5.75	6.55	5.45	5.46	5.62
SEd	0.096	0.043	0.043	0.043	0.040
CD	0.194	0.086	0.086	0.086	0.080

3.2.4 Ascorbic acid content (mg/g) in the leaves of selected tree species

An increased level of ascorbic acid in leaves is known to increase air pollution tolerance in plants. Among the 25 tree species studied, the highest values have been observed in the *Holoptelia integrifolia* (10.91 mg g^{-1}) in heavy traffic zone then *Peltophorum pterocarpum* (8.18 mg g^{-1}) in commercial zone which show statistically on par performance with *Terminalia catappa* (8.09 mg g^{-1}) in residential zone, *Ficus religiosa* (7.96 mg g^{-1}) in control site and *Mangifera indica* (6.59 mg g^{-1}) in industrial zone (Table 5).

The presence of higher ascorbic acid content in leaves might be a strategy to protect thylakoid membranes from oxidative damage under such water stress conditions [19].

Studies related to lower ascorbic acid contents in the leaves of various tree species supports the sensitive nature of tree species towards air pollutants, particularly automobile exhausts [20,21].

Table 5. Ascorbic acid content (mg/g) of the air pollution affected tree species in Coimbatore city

Species name	Control Zone	Residential Zone	Industrial Zone	Commercial Zone	Heavy Traffic Zone
Albizia lebbeck	6.15	7.98	5.84	6.17	6.81
Albizia saman	6.69	7.21	5.62	4.63	10.46
Alstonia scholaris	7.42	6.13	6.18	6.72	5.86
Annona squamosa	5.87	6.18	5.68	5.18	5.10
Azadirachta indica	5.86	6.08	5.80	6.90	8.49
Bauhinia racemosa	6.63	5.99	5.79	5.33	10.50
Cassia siamea	5.12	4.14	5.84	5.99	7.60
Delonix regia	5.87	5.84	6.54	7.43	6.53
Ficus racemosa	7.73	7.69	6.29	6.45	9.85
Ficus religiosa	7.96	4.68	6.54	7.17	6.93
Holoptelia integerifolia	7.19	5.67	5.89	4.71	10.91
Leuceana leucocephela	5.91	3.84	6.29	7.53	8.92
Mangifera indica	7.07	6.00	6.59	5.31	8.55
Melia azadirach	6.89	5.95	5.99	7.23	5.11
Michelia champaka	5.87	6.44	5.54	7.20	5.93
Muntigea calibera	4.95	7.29	5.74	7.49	10.00
Peltoforum terocarpum	5.77	7.07	5.34	8.18	5.37
Polyalthia longifolia	5.84	6.10	6.39	7.03	9.90
Pongamia pinnata	5.35	5.78	5.29	6.56	5.17
Spathodeacam paniculata	5.05	6.78	5.69	5.18	10.90
Syzigium cuminii	5.75	5.60	5.39	6.73	5.36
Tamarindus indica	4.86	6.43	6.04	6.17	5.73
Tectona grandis	7.93	5.00	6.19	4.96	8.80
Terminalia cadappa	5.75	8.09	5.72	5.62	6.82
Thespesia populnea	7.55	7.28	6.50	6.45	10.42
SEd	0.046	0.046	0.044	0.048	0.060
CD	0.093	0.043	0.088	0.096	0.120

Table 6. Air Pollution Tolerance Index (APTI) of the selected tree species in Coimbatore city

Species name	Control Zone	Residential Zone	Industrial Zone	Commercial Zone	Heavy Traffic Zone
Albizia lebbeck	11.94	11.26	12.20	11.65	11.27
Albizia saman	13.56	13.49	12.91	11.46	14.61
Alstonia scholaris	14.54	13.27	14.27	11.99	12.25
Annona squamosa	12.29	12.55	10.63	11.98	11.32
Azadirachta indica	12.66	13.32	11.75	13.40	13.54
Bauhinia racemosa	12.78	13.50	12.98	12.12	14.63
Cassia siamea	11.71	11.93	12.15	12.07	12.26
Delonix regia	12.95	12.77	13.38	13.33	12.34
Ficus racemosa	13.65	12.74	14.00	12.41	13.77
Ficus religiosa	12.37	11.60	14.55	11.93	12.13
Holoptelia integerifolia	13.34	12.51	13.45	12.63	14.01
Leuceana leucocephela	11.94	11.84	12.28	12.33	12.02
Mangifera indica	12.88	11.64	14.85	12.36	12.87
Melia azadirach	12.19	11.75	13.11	12.00	10.94
Michelia champaka	11.47	12.03	10.21	12.61	11.86
Muntigea calibera	13.77	13.61	12.12	13.24	14.49
Peltoforum terocarpum	11.43	12.53	11.03	11.90	10.93
Polyalthia longifolia	12.11	12.75	14.38	13.04	13.64
Pongamia pinnata	13.40	13.53	11.63	13.96	12.31
Spathodeacam paniculata	12.10	11.11	13.06	11.95	12.62
Syzigium cuminii	12.67	12.44	10.22	12.58	12.49
Tamarindus indica	11.57	11.39	11.68	12.32	12.23
Tectona grandis	11.73	11.62	14.41	11.98	12.74
Terminalia cadappa	11.95	12.46	11.96	12.73	11.34
Thespesia populnea	14.63	14.37	15.76	12.62	16.07
SEd	0.092	0.092	0.094	0.091	0.094
CD	0.185	0.185	0.190	0.183	0.188

3.3 Assessing Air Pollution Tolerance Index (APTI) of the Selected Tree Species

Air pollution tolerance index is used by landscapers to select plant species tolerant for air pollution. The results related to air pollution tolerance index (APTI) of twenty five tree species was calculated and showed marginal difference in terms of biochemical parameters viz., Ascorbic acid content, Leaf extract pH, Total chlorophyll content and Relative Water Content (RWC) of the selected tree species seen in different levels of air pollution affected areas in Coimbatore city.

Among 25 tree species selected, *Thespesia populnea* accounted highest APTI of 16.07 in heavy traffic zone, industrial zone (15.76), control site (14.63) and residential zone (14.37) followed by *Pongamia pinnata* (13.96) in commercial zone (Fig. 6).

In the present study, certain trees species showed maximum APTI value in control site (Table 6) which was similar to the study result of [22].

4. CONCLUSION

Air pollution in urban areas of Coimbatore city can be mitigated by developing urban forest in the city by choosing air pollution tolerant trees. To fulfill this aim air pollution tolerance index (APTI) for 25 commonly found tree species were estimated. APTI was found highest for *Thespesia populnea* in heavy traffic zone, industrial zone, control site and residential zone followed by *Pongamia pinnata* in commercial zone. Present study revealed that *Thespesia populnea* and *Pongamia pinnata* would be excellent performers in urban forest. Similarly, *Alstonia scholaris, Azadirachta indica, Mangifera indica* and *Muntigea calibera* were estimated to be very good performers in the all five polluted zones. This study is relevant as this experiment can be performed with locally available green vegetation in any part of the world to select best suited trees for development of urban forest.

ACKNOWLEDGEMENT

The authors acknowledge National Agricultural Development Programme (NADP), Department of Agriculture, Government of Tamil Nadu for funding the research project on "Design and Development of Urban Forestry Models to Combat Environmental Pollution in Tamil Nadu".

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Das S, Prasad P. Seasonal variation in Air Pollution Tolerance Indices and selection of plants species from industrial area of Rourkela. IJEP. 2010;30:978-988.
2. Krishnaveni M, Chandrasekar R, Amsavalli L, Madhaiyan P, Durairaj S. Air Pollution Tolerance index of plants at Perumalmalai Hills, Salem. Int. J. Pharm. Sci. Rev. Res. 2013;20:234-239.
3. Escobedo FJ, Wagner JE, Nowak DJ. Analyzing the cost effectiveness of Santiago, Chiles policy of using urban forest to improve air quality. J. of Environmental Management. 2008;86:148-157.
4. Singh Sarin SM, Shanmugan D, Sharma N, Attri AK, Jain WK. Ozone distribution in the urban environment of Delhi during winter months. Atmospheric Environment. 1997;31:3421-3427.
5. Singh SK, Rao DN. Evaluation of plants for their tolerance to air pollution. In: Proceedings of the Symposium on Air Pollution Control, 1983;218-224.
6. Agbaire PO, Esiefarienrhe E. Air pollution tolerance indices (APTI) of some plants around Otorogun Gas Plant in Delta State, Nigeria. J. Al. Sci. Environ. Manage. 2009;13:11–14.
7. Uka U, Hogarh J, Belford EJD. Morpho-Anatomical and Biochemical Responses of Plants to Air Pollution. International Journal of Modern Botany. 2017;7(1):1-11.
8. Saadabi AMA. Effects of Auto-exhaust Pollution on the Micro-Morphology and Leaf Epidermal Features of Ornamental Plants in Khartoum, Sudan. Journal of Applied Sciences Research. 2011;7(3): 270.
9. Seyyednejad SM, Niknejad M, Koochak H. A review of some different effects of air pollution on plants. Research Journal of Environmental Sciences. 2011;5(4):302.
10. Kramer PJ, Boyer JS. Water relation of plants and soils. Academic Press, San Diego. 1995;495.
11. Katiyar V, Dubey PS. Sulphur dioxide sensitivity on two stage of leaf Development in a few tropical tree species. Ind. J. Environ. Toxicol. 2001;11:78-81.
12. Jyothi JS, Jaya DS. Evaluation of air pollution tolerance index of selected plant species along roadsides in Thiruvananthapuram, Kerala. Journal of Environmental Biology. 2010;31:379-386.
13. Rai P, Panda LS. Dust capturing potential and air pollution tolerance index (APTI) of some road side tree vegetation in Aizawl, Mizoram, India: An Indo-Burma hot spot region air quality. Atmos. Health. 2014; 7:93-101.
14. Prajapati SK, Tripathi BD. Anticipated performance index of some trees species considered for green belt development in and around an urban area: a case study of Varanasi city. India J. Environ. Manag. 2008;88:1343–1349.
15. Shannigrahi A, Sharma R, Fukushima T. Air pollution control by optimal green belt development around the Victoria Memorial monument, Kolkata (India). Int. J. Environ. Stud. 2003;60:241–249.
16. Apel K, Hirt H. Reactive oxygen species: metabolism, oxidative stress, and signal transduction. Annual Review Plant Biology. 2004;55:373–399.
17. Swami A, Bhatt D, Joshi PC. Effects of automobile pollution on sal (*Shorea robusta*) and Rohini (*Mallotus phillipinensis*) at Asarori, Dehradun. Himalayan Journal of Environment and Zoology. 2004;18:57-61.
18. Chandawat S, Deepika R. Effects of air pollution on physiology and metabolism in road- side plants growing at Ahmadabad. Ph.D. Thesis, Gujarat University, Gujarat. 2011.
19. Tambussi EA, Bartoli CG, Beltrano J, Guiamet JJ, Araus JL. Oxidative damage to thylakoid proteins in water-stressed

leaves of wheat (*Triticum aestivum*). Physiol. Plant. 2000;108:398-404.
20. Kaur R, Nayyar H. Ascorbic acid: a potent defender against environmental stresses. In: Ahmad, P. (Ed.), Oxidative Damage to Plants. Academic Press, San Diego. 2014; 235-287.
21. Krishnaveni M. Air pollution tolerance index and antioxidant activity of *Parthenium hysterophorus*. J. Pharm. Res. 2013;7:296-298.
22. Deepalakshmi AP, Ramakrishnaiah H, Ramachandara YL, Radhika RN. Roadside plants as bioindicators of Urban air pollution. Journal of Environment Science, Toxicology and Food Technology. 2013; 3:10-14.
