Plant Archives Volume 20 No. 2, 2020 pp. 8183-8188 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

ESTIMATION OF AIR POLLUTION TOLERANCE INDEX (APTI) AND ANTICIPATED PERFORMANCE INDEX (API) OF SELECTED TREE SPECIES IN SANTINIKETAN, BIRBHUM, WEST BENGAL, INDIA

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Abstract

Air pollution is one of the most serious problems around the world. Certain plants are capable to tolerate this pollution and can control it by filtering the air through their aerial elements viz. stems, leaves etc. To reduce the chances of air pollution afforestation programme is the best way and prior to afforestation, selection and screening of pollution sensitive and pollution tolerant plant species should be the primary objective. Present study estimated the Air Pollution Tolerance Index (APTI) and Anticipated Performance Index (API) of 15 tree species commonly found in Santiniketan. Anticipated Performance Index (API) was calculated based on the Air Pollution Tolerance Index (APTI) and some other economical, social and biological factors. APTI was analyzed by determining the Total chlorophyll, pH, Relative water content and Ascorbic acid. Highest APTI was observed in *Cassia fistula* (9.67) and lowest in *Holorrhena pubescens* (6.17). Most of the recorded plants species were very sensitive to air pollution. API was higher in *Alstonia scholaris, Anacardium occidentale, Azadirachta indica* and *Mangifera indica* and therefore recommended for plantation along the road side and around the industrial belt.

Key words: Afforestation, Air Pollution Tolerance Index, Anticipated Performance Index, Industrial belt.

Introduction

Air pollution can be defined as the change in quality of air due to increase in concentration of chemicals or introduction of new chemicals which can affect living beings. Motor vehicle, residential heating, power generation and industries release high concentrations of air pollutants to the atmosphere (Kar *et al*., 2010). Industrialization, urbanization and rapid economic growth are the sources of air pollution (Abbas *et al*., 2013). No physical or chemical method is known to improve air pollution. A suitable biological method as suggested by Shannigrahi *et al*., (2004) and Ghose and Majee, (2001) consists growing green plants in and around industrial and urban areas. Trees are initial acceptors of air pollution and are used to monitor air pollution (Abbas *et al*., 2013). Trees provide enormous leaf area for impingement, absorption and accumulation of air pollutants for reducing the pollutant level in the air environment, up to different extent by different species (Liu and Ding, 2008). Trees can improve air quality by taking up gases and particles (Woo and Je, 2006; Kar *et al*., 2013). Prior to recommendation for plantation, selection and screening of plants is an important task. Plants which can tolerate high level of air pollution should be recommended for plantation and the sensitive plants should be avoided.

Sensitivity and tolerance of plants towards air pollutants vary with change in Leaf extract pH, Relative water contents (RWC), ascorbic acid (AA) content and Total Chlorophyll content (Chouhan *et al*., 2012). As the study of single parameter may not provide a clear picture of tolerance level of plant species to the pollution induced changes, Singh and Rao, (1983) used four leaf parameters viz. Leaf extract pH, Relative water contents (RWC), ascorbic acid (AA) content and Total Chlorophyll content to derive an empirical number indicating the air pollution tolerance index (APTI). Relative water content is the amount of water present in a leaf tissue relative to its fully turgid state. It seemed to be higher in polluted areas as compared to control areas (Sharma and Sharma, 2017). pH can be defined as the negative logarithm of H^+ ion concentration in a solution. It is the measurement of acidity or alkalinity. pH is one of the most important properties for a plant to carry out its own metabolic processes and also to tolerate different types of air pollutants (Sabri *et al*., 2015). Ascorbic acid is an anti-oxidant, which the

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growing plant parts possess in large quantity and act as a resisting factor of the plant to adverse condition (Rathore *et al*., 2017). As it is a stress reducing factor, high pollutant stresses make them release high amount of ascorbic acid in polluted area as compared to non-polluted area (Rai *et al*., 2013). Ascorbic acid content of all plant species increases in polluted condition because of the increment in the production rate of reactive oxygen species during the photo-oxidation process and the other opinion regarding the increased level is that higher ascorbic acid is the result of SO_2 pollution (Tripathi and Gautam, 2007; Varshney and Varshney, 1984). Chlorophyll content is one of the most important components for plants to survive. Chlorophyll content of plants varies with respect to different species, age of leaves and pollution level (Katiyar and Dubey, 2001). Decrease of chlorophyll level indicates air pollution (Rathore *et al*., 2017). The loss of total chlorophyll content of the leaves supports the fact that chloroplasts are the major site for the attack of air pollutants in plants (Tripathi and Gautam, 2007). On the basis of air pollution tolerance and some other relevant phyto-socioeconomic characters and biological factors, anticipated performance index (API) of plant species can be calculated (Noor *et al*., 2014). Following Noor *et al*., (2014), gradation of plant species was done based on eight categories of characters. Trees were categorized as best, excellent, very good, good, moderate, poor, very poor and not suggested for plantation. Plant species belonging to first six categories may be recommended for plantation. The main objective of this study was to determine the sensitivity and air pollution tolerance of common plant species growing in Santiniketan of West Bengal.

Materials and Methods

Study area

Present work was done in Santiniketan of Birbhum district of West Bengal, India (23.6776°N, 87.6852°E) (Fig. 1). Santiniketan is a neighborhood of Bolpur city. It was established by Maharshi Devendranath Tagore and later was expanded by his son Rabindranath Tagore. Geographically this area is flanked on two sides by the river Ajoy and Kopai. Earlier, it had an extensive forest cover but continuous soil erosion gave it a barren look and thus the environment of surrounding areas has changed over time. The pollution of this area is very less due to the absence of any heavy industry but increasing number of tourist and private vehicles, dust and pollens are the major threats of pollution now a days. The climate of this area is Sub-tropical type. Summer is much warmer (45°C) than winter (6°C). July and August show heavy rainfall and average annual precipitation is 1287 mm.

Fig. 1: Map showing study area.

Sample collection and Analysis

The study was conducted from August 2018 to April 2019. 15 tree species belonging to 5 families (Table 1) which are frequently found in Santiniketan were chosen. Green mature leaves were collected for the study, immature leaves were avoided. Freshly collected leaf samples were cleaned with distilled water and then refrigerated (22°C) for further biochemical analysis. Various biochemical parameters such as leaf extract pH (Singh and Rao, 1983), relative water content (Singh, 1977), total chlorophyll (Arnon, 1949) and ascorbic acid (Keller and Schwager, 1977) were estimated from the collected leaf samples.

Table 1: List of tree species selected for study.

Family	Name of Plants
Anacardiaceae	*Anacardium occidentale* L. *Mangifera indica* L. *Spondias pinnata* (L. f.) Kurz
Apocynaceae	*Alstonia scholaris* (L.) R. Br. *Holarrhena pubescens* Wall. ex G.Don *Plumeria alba* L.
Fabaceae	*Butea monosperma* (Lam.) Taub. *Cassia fistula* L. *Delonix regia* (Hook.) Raf.
Meliaceae	*Azadirachta indica* A.Juss. *Melia azedarach* L. *Swietenia mahagoni* (L.) Jacq.
Myrtaceae	*Eucalyptus tereticornis* Sm. *Psidium guajava* L. *Syzygium cumini* (L.) Skeels

Calculation of Air Pollution Tolerance Index (APTI) in the studied plant species

The air pollution tolerance index was calculated by using the formula given by Singh *et al*., (1991).

$$APTI = \frac{A(T+P) + R}{10}$$

Where, A = Ascorbic acid content of leaf (mg g^{-1} of fresh weight)

T = Total chlorophyll of leaf (mg g^{-1} of fresh weight);

P = pH of leaf extract

R = relative water content, in percentage.

Calculation of Anticipated Pollution Index (API) in the studied plant species

API was estimated by following Abbas *et al*., (2013), combining the APTI values with some related biological and socio-economic characters (plant habit, canopy structure, type of plant, laminar structure and economic value) for different species; and based on these characters, different grades (+ or -) are allotted to plants (Table 2). Different plants are scored according to their grades. The criteria used for calculating the API of different plant species are given in table 3.

Results and Discussion

The present study evaluated four biochemical

Table 2: Gradation of plant species on the basis of air pollution tolerance index (APTI) and other biological and socioeconomic characters (According to Noor *et al*., (2014) and Abbas *et al*., (2013)).

Site No.	Characteristics assessed (for grading)		Assessment hierarchy	Category	Grades allocated
1	Tolerance		APTI	<7	-
				7-9	+
				9-11	++
				11-13	+++
				13-15	++++
				15-17	+++++
				17-19	++++++
2	Morphological and Ecological feature	Tree habit		Small	-
				Medium	+
				Large	++
		Canopy	Globular/ irregular		-
			Spread crown		+
			Dense canopy		++
		Type of tree	Deciduous		-
			Evergreen		+
		Leaf lamina	Size	Small	-
				Medium	+
				Large	++
			Texture	Smooth	-
				Coriaceous	+
			Hardness	Soft	-
				Hard	+
		Economic value	Frequency	<3 use	-
				3-4 use	+
				5 or more use	++

Table 3: Anticipated performance index (API) of plant species (Noor *et al.*, 2014).

Grade	Score	Assessment category
0	0-30	Not suggestion for plantation
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

properties of 15 trees in relation to pollution tolerance. The values of Relative water content (RWC), pH, Total chlorophyll content (TC) and ascorbic acid content of the leaves sampled from the selected plants were determined for calculating the APTI value of each plant species (Table 4). The APTI was used to establish a hierarchy of species tolerance to air pollution. The APTI calculated for the selected tree species ranged from 6.17 to 9.67. Highest APTI was shown by *Cassia fistula* and *Holarrhena pubescens* showed the lowest APTI. The RWC of the plants were found to range from a maximum of 88.31% (*Spondias pinnata*) to a minimum of 60.39% (*Holarrhena pubescens*). Water is essential for plant. According to Chouhan *et al*., (2012), high water content helps to maintain the physiological balance of plants under stress condition such as exposure to air pollution when the transpiration rates are usually high. *Holarrhena pubescens* generally found along the roadside of Santiniketan, facing the pollutants released by vehicles showed the lowest RWC value (60.39%), whereas *Spondias pinnata* located approximately 250 meters away from the road showed the highest RWC value (88.31%). pH of the leaf extracts ranged from a maximum of 6.52 (*Butea monosperma*) to a minimum of 3.18 (*Spondias pinnata*). Presents study supports the findings of Swami *et al*., (2004). All the trees got leaf extract pH towards acidic side, which may be due to the presence of SO_2 and NOx in the ambient air coming from vehicular exhaust as pointed out by Swami *et al*., (2004). According to Singh and Verma, (2007), tolerant plants have pH around 7, while plants with lower pH are more susceptible. Contrary to this, in our study *Spondias pinnata* had a high APTI (9.09) although pH was very much acidic (3.18). Total chlorophyll contents were found to a range from a maximum of 3.19 mg/g (*Delonix regia)* to a minimum of 0.3 mg/g (*Spondias pinnata).* According to Chouhan *et al*., (2012), leaf pH has a correlation with photosynthetic efficiency and photosynthetic rate was reduced in plants at low leaf pH. Reduction of rate of photosynthesis is due to the loss of Chlorophyll content. In our study also, leaf pH showed significant correlation with total chlorophyll content ($r = 0.73, p<0.002$). Ascorbic acid content ranged from a maximum of 2.7 mg/g (*Cassia fistula*) to a minimum of 0.071 mg/g (*Alstonia scholaris*). Ascorbic acid plays an important role in photosynthesis. High pH may increase the efficiency of conversion of hexose sugar to ascorbic acid (Lui and Ding, 2008); (Escobedo *et al*., 2008).

The scoring percentage and API grades of all tree species are shown in table 5. Anticipated performance index can be used to assess the tolerance index of all higher plants based on social and economic characteristics, air pollution tolerance index and the frequency (Abbas *et al*., 2013). *Alstonia scholaris, Mangifera indica, Anacardium occidentale* and *Azadirachta indica* had a good scoring percentage and hold a good API grade. Scoring percentages of *Cassia fistula, Holarrhena pubescens, Plumeria alba* and *Swietenia mahagoni* were very poor and therefore held the lower position based on API grade. API of most of the studied plant species although belonged to moderate and poor assessment category but the frequency and consistency of species with climate in a particular area can be considered as a criteria of selection for controlling pollution. Five of these species have got better assessment category in polluted city of Varanasi (Prajapati and Tripathi,

Table 4: Air pollution tolerance index of tree species studied in Santiniketan.

Name of Plants	A	P	T	R	APTI
Cassia fistula L.	2.7	6.48	2.54	72.32	9.67
Mangifera indica L.	1.195	5.01	1.78	87.57	9.57
Melia azedarach L.	0.699	6.05	2.91	87.86	9.41
Spondias pinnata (L. f.) Kurz	0.737	3.18	0.3	88.31	9.09
Azadirachta indica A.Juss.	0.718	6.19	1.29	84.79	9.02
Delonix regia (Hook.) Raf.	0.097	5.74	3.19	87.06	8.79
Anacardium occidentale L.	0.098	5.19	1.78	84.89	8.56
Eucalyptus tereticornis Sm.	1.177	4.63	0.56	79.34	8.54
Syzygium cumini (L.) Skeels	0.401	4.72	1.13	76.3	7.86
Butea monosperma (Lam.) Taub.	0.117	6.52	2.58	76.27	7.73
Alstonia scholaris (L.) R. Br.	0.071	5.77	1.21	74.7	7.52
Swietenia mahagoni (L.) Jacq.	0.619	6.02	2.57	69.74	7.51
Psidium guajava L.	0.164	5.51	2.58	72.59	7.39
Plumeria alba L.	0.116	6.41	2.38	68.1	6.91
Holarrhena pubescens Wall. ex G.Don	0.173	5.84	1.88	60.39	6.17
A = Ascorbic Acid, P = pH, T = Total Chlorophyll, R = Relative Water Content (Average mean value).					

Table 5: Scoring percentage and API grades of tree species studied in Santiniketan.

S. No.	Name of Trees	AP TI	Tree habit	Canopy Structure	Type of tree	Lamina Size	Text-ure	Hard-ness	Economic value	Total plus (+)	Sco-ring (%)	API Grade
1	*Alstonia scholaris* (L.) R. Br.	+	++	++	+	+	-	+	++	10	58.82	3
2	*Anacardium occidentale* L.	+	+	++	+	+	-	+	++	9	52.94	3
3	*Azadirachta indica* A.Juss.	++	++	++	-	-	-	-	++	8	47.06	2
4	*Butea monosperma* (Lam.) Taub.	+	+	-	-	++	+	+	+	7	41.18	2
5	*Cassia fistula* L.	++	-	-	-	+	-	+	-	4	23.53	0
6	*Delonix regia* (Hook.) Raf.	+	++	+	+	-	-	-	+	6	35.29	1
7	*Eucalyptus tereticornis* Sm.	+	++	-	+	-	-	+	++	7	41.18	2
8	*Holarrhena pubescens* Wall. ex G.Don	-	+	+	-	+	-	-	+	4	23.53	0
9	*Mangifera indica* L.	++	++	++	+	+	-	+	+	10	58.82	3
10	*Melia azedarach* L.	++	+	+	+	-	-	-	+	6	35.29	1
11	*Plumeria alba* L.	-	-	+	+	++	-	+	-	5	29.41	0
12	*Psidium guajava* L.	+	-	-	+	-	+	+	++	6	35.29	1
13	*Spondias pinnata* (L. f.) Kurz	++	+	++	-	+	-	-	+	7	41.18	2
14	*Swietenia mahagoni* (L.) Jacq.	+	+	-	+	-	-	-	+	4	23.53	0
15	*Syzygium cumini* (L.) Skeels	+	+	+	+	-	-	+	++	7	41.18	2

2008), e.g., *Mangifera indica* was judged as excellent performer. Elsewhere also *Mangifera indica* and *Butea monosperma* are adjudged as best and excellent performers respectively (Yousafzai *et al.*, 2008).

Conclusion

The present study showed that both API and APTI facilitate the selection of tree species for urban green belt development. *Alstonia scholaris, Mangifera indica*, *Anacardium occidentale, Azadirachta indica, Melia azedarach* and *Spondias pinnata* are the plants, recommended for plantation along roadside and are useful in selection of green belt development.

Acknowledgement

Authors thank the UGC-DRS and DST-FIST supported Department of Botany, Visva-Bharati for providing laboratory support.

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