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Selection of Some Plant Species Suitable for Green Belt Expansion in Mumbai Industrial Area - A Baseline to Alleviate Global Air Pollution

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The air quality and global environment is immensely affected due to the industrial as well as urban expansion. The present study aims to identify the natural tolerance of six plant species towards the air pollution, which are growing along the Chembur industrial area of Mumbai. The plant's air pollution tolerance level was identified by evaluating Air Pollution Tolerance Index (APTI) and Anticipated Performance Index (API). The estimation of APTI was done based on the measurement of physico-chemical parameters like pH, ascorbic acid, total chlorophyll content and the relative leaf water content of the fresh leaves of plant species grown along the industrial and non-industrial areas. The higher API values obtained for the *Thespesia populnea* (L.) Sol. *excorrea*, *Polyalthia longifolia* and *Albizia saman* (Jacq.) Merr plant species growing in the industrial zone indicate a good tolerance towards polluted air and hence are suggested for green zone development in the Chembur industrial area. The present work can be extended for the selection of the most air pollution tolerant plant species for the development of green zone along the industrial belt across the world. It will facilitate healthy atmosphere for the nearby population.

Keywords: Relative leaf water, Ascorbic acid, Anticipated performance index, Total chlorophyll, Air pollution tolerance index.

INTRODUCTION

Industrial and urban area expansion deteriorates the air quality and increases the stress on the global environment. The deteriorated air greatly affects the health of plants, animals and humans [1-3]. Air pollution increases the concentration of gases like oxides of sulphur, carbon, nitrogen and also introduces suspended particulate matter into the atmosphere causing environmental degradation [4]. Plants indicate certain symptoms of exposure to air pollutants through respiration, chemical process, membrane disruption, stomata behaviour, catalyst reactions which ultimately results in plant death [5]. A lot of research is going on to find out a simple solution to upgrade global air quality. One of the best, natural and economic ways to improve air quality around the industrial area is green zone expansion.

The Air Pollution Tolerance Index (APTI) and Anticipated Performance Index (API) values can be estimated to analyze the physiological, morphological and biochemical aspects of plants. It helps in the selection of the plant species that are tolerant to air pollution and play a significant part in improving the air quality when used in green belt expansion [6].

In present study, the APTI and API of six plant species were determined in all the three seasons for a duration of two years (April 2017 to March 2019). The outcomes of the current investigation were expected to be useful to identify the sensitive and tolerant plant species contributing to the expansion of the green area in the polluted industrial zone.

EXPERIMENTAL

The present investigation area of Chembur is a north-eastern suburb of Mumbai (19.051ºN 72.894ºE) which is in the proximity of Trombay area of Mumbai city, India. The suburbs near the investigation area were Ghatkopar, Mahul, Chunabhatti, Deonar, Kurla and Govandi. It was recently ranked first in Mumbai and 80th among the polluted industrial clusters of India with a Comprehensive Environment Pollution Index (CEPI) of 54.67 [7,8]. The average concentration values of SO_2, NO_x, respirable suspended particulate matter (RSPM) are 5-6 μg m^{-3}, 77-83 μg m^{-3}, 147-148 μg m^{-3}, respectively as per Maharashtra Pollution Control Board report during the study period (April 2017-March 2019) [9].

Plant species: Three replicates of completely developed leaves of six commonly found plant species were collected from the Chembur industrial zone as experimental samples (ES). The samples of the same plant species collected from the botanical garden of Bhavan's College, Andheri (19.073ºN 72.501°E) were used as the controlled samples (CS) as it was away from traffic and industrial areas. Table-1 contains the species, type and native country of the plants chosen for the current study [10].

Collection and analysis of samples: Experimental samples (ES) and controlled samples (CS) collection, as well as analysis, was done for a period of two years at regular intervals during the summer (April), rainy (August) and winter (December) seasons. Cloth and polythene bags were used to collect the ES and CS, which were instantly taken to the testing room. For further analysis, the samples were preserved in the refrigerator. The ES and CS leaves were analyzed for pH, ascorbic acid (AA), relative water content (RWC) and total chlorophyll (TCh).

pH measurement: The pH meter (Equiptronics, EQ 614A) used for measuring the pH of the leaf extract filtrate was standardized using the buffer solution of pH = 4 and pH = 9 [2,11,12].

Ascorbic acid analysis: Many researchers have analyzed ascorbic acid content by spectrophotometric method and very few have analyzed ascorbic acid by HPLC method. HPLC instrumentation method was used to analyze ascorbic acid content. The concentration of ascorbic acid content was investigated using a Shimadzu LC HPLC instrument isocratic system coupled with a diode array detector and flame-photometric detector. The mobile phase was pumped isocratically at a flow rate of 0.7 mL min^{-1} at 20 ºC and Superspher RP-18 (250 × 4.6 mm, 10 μm particle size) was used as a column (λ = 280 nm). A consistent low column temperature helped in stabilizing the ascorbic acid during the analysis. During the study, the field samples were tested for the routine analysis of method blanks, spiked blanks and sample duplicates. The samples were analyzed in duplicate in order to assess the error during sample extraction and the results showed satisfactory precision. Blanks showed the absence of any target compound [13].

Analysis of relative water content (RWC) content: The electronic weighing balance of accuracy of 0.0001 g was used to measure the weight of leaves (Contech, CA 223). The RWC of leaf samples was calculated from the fresh Weight, turgid weight and dry weight values using the eqn. 1 [10,11,14,15]:

$$\text{RWC (\%)} = \frac{\text{FW} - \text{DW}}{\text{TW} - \text{DW}} \times 100 \quad (1)$$

Total chlorophyll (TCh) analysis: The TCh content of the fresh plant leaves was analyzed by the reported method [11,12,16].

Air Pollution Tolerance Index (APTI) determination: The formula mentioned in eqn. 2 was used to determine APTI [1,4,11,12,16].

$$\text{APTI} = \frac{\text{AA (TCh + pH) + RWC}}{10} \quad (2)$$

Statistical analysis: The correlation analysis was carried out by using a univariate Pearson correlation coefficient for individual species to determine the association of the specific parameters related to species, season and place. The statistical analysis of the outcomes was carried out by using the One-way ANOVA method. The significance of correlation for specific parameters was observed for $p < 0.05$ in most of the cases. It indicates that these parameters were associated to the same species. All the statistical computations were achieved using IBM SPSS statistics version 20.

RESULTS AND DISCUSSION

The season-wise biochemical parameter values acquired in the current investigation are presented in Table-2.

As shown in Table-3, a matrix of correlation coefficients was used to observe the positive association of the parameters. A comprehensive study of the data set exhibited that substantial correlations arise among maximum of the parameters with correlation coefficient values persistently greater than 0.5.

Leaf extract pH: It was observed from the analysis data that the pH values of ES were lower whereas higher for CS. The least mean pH value of 5.22 and the highest mean pH value of 6.38 was observed for S2, S1 experimental samples, respectively. A higher pH value (6.93) was observed for S4 sample in winter 2018-19 whereas the lower pH value (5.05) was observed for S2 experimental sample in winter 2017-18. The industrial release of SO_x, NO_x and acid producing contaminants in the air are responsible for lower pH of leaf extract [16]. The sensitivity of the plant to air pollution shows a good relation with the lower pH of the leaf latex [14].

TABLE-1
TYPE AND NATIVE COUNTRY DETAILS OF THE PLANTS STUDIED IN THE PRESENT WORK

Plant species	Plant type	Native country
Polyalthia longifolia (S1)	Tall evergreen tree with alternate and exstipulate leaves	India, Sri Lanka, Pakistan
Prosopis juliflora (SW.) DC. (S2)	Small tree with deciduous leaves	Mexico, South America, Africa, Asia
Calotropis gigantea (L.) Dryand (S3)	Larger Shrub with oval and light green leaves	India, Cambodia, Malaysia, Sri Lanka
Leucaena leucocephala (Lam.) de wit (S4)	Medium fast-growing mimosoid tree with pinnular leaves	Southern Mexico and northern America, India
Albizia saman (Jacq.) Merr. (S5)	Rain tree with evergreen, feathery foliage	Central and South America Invasive to India
Thespesia populnea (L.) Sol. excorrea (S6)	Evergreen shruby tree with alternate simple leaves	Old world tropics, Pacific-island

TABLE-2
SEASON WISE BIOCHEMICAL PARAMETERS VALUES OF EXPERIMENTAL AND CONTROLLED PLANT SPECIES FROM THE STUDY AREA

Parameter	Sample	Experimental samples								Controlled samples							
		Summer		Rainy		Winter		Mean	SD (±)	Summer		Rainy		Winter		Mean	SD (±)
		2017-18	2018-19	2017-18	2018-19	2017-18	2018-19			2017-18	2018-19	2017-18	2018-19	2017-18	2018-19		
pH	S 1	6.11	6.39	6.37	6.74	6.44	6.20	6.38	0.22	6.88	6.91	7.22	7.42	7.64	7.42	7.25	0.30
	S 2	5.39	5.30	5.05	5.12	5.08	5.35	5.22	0.15	7.12	7.06	7.17	7.38	7.02	6.90	7.11	0.16
	S 3	5.93	6.74	5.16	5.29	5.91	6.10	5.86	0.58	6.14	7.16	6.43	6.92	6.83	7.42	6.82	0.47
	S 4	5.35	5.09	5.75	5.90	6.35	6.93	5.90	0.67	6.97	6.61	6.84	7.10	7.41	7.03	6.99	0.27
	S 5	5.82	5.46	5.96	5.18	5.25	6.81	5.75	0.61	6.40	6.68	7.02	7.39	7.39	7.36	7.04	0.42
	S 6	5.62	5.93	5.09	5.35	5.47	6.67	5.69	0.56	7.38	7.22	7.18	7.50	6.92	7.32	7.25	0.20
AA (mg/g)	S 1	9.72	10.22	9.24	9.31	9.91	9.82	9.70	0.37	3.07	3.13	2.82	3.03	2.32	2.62	2.83	0.31
	S 2	10.44	10.47	10.15	10.31	9.80	9.52	10.12	0.38	3.94	2.85	3.09	3.20	3.18	3.22	3.25	0.37
	S 3	10.98	10.44	10.59	10.73	10.84	10.41	10.67	0.23	4.17	4.03	3.94	4.13	3.92	3.73	3.99	0.16
	S 4	10.23	10.27	10.03	10.26	10.73	10.05	10.26	0.25	3.44	3.27	3.06	3.19	3.38	2.67	3.17	0.28
	S 5	10.77	11.18	10.52	10.82	10.01	10.96	10.71	0.41	4.03	3.83	4.17	4.29	3.36	3.59	3.88	0.36
	S 6	10.30	9.85	10.04	10.14	9.50	10.19	10.00	0.29	3.21	3.35	3.28	3.44	2.91	2.83	3.17	0.25
RWC (%)	S 1	86.18	86.55	88.20	91.34	83.39	84.97	86.77	2.76	59.44	60.13	55.50	56.41	54.93	53.12	56.59	2.71
	S 2	76.41	84.64	93.73	95.35	73.56	72.55	82.71	10.12	47.72	63.38	58.26	60.08	58.91	54.59	57.16	5.43
	S 3	85.17	85.58	73.73	71.97	85.62	80.14	80.37	6.20	57.37	78.56	48.30	50.16	63.90	60.35	59.77	10.96
	S 4	91.02	84.17	79.29	81.49	81.35	85.19	83.75	4.14	42.24	46.38	51.68	53.72	51.20	30.90	46.02	8.50
	S 5	79.98	75.06	74.34	76.22	79.19	72.20	76.17	2.97	57.77	49.33	42.29	48.65	48.96	54.03	50.17	5.28
	S 6	89.71	80.91	83.41	85.19	91.05	87.46	86.29	3.85	41.73	67.40	50.63	53.88	73.09	50.28	56.17	11.76
TCh (mg/g)	S 1	6.75	6.66	6.08	6.54	6.03	6.88	6.49	0.36	7.07	7.73	7.24	7.32	7.55	7.46	7.40	0.24
	S 2	5.92	5.77	5.86	6.11	7.18	6.51	6.23	0.54	6.64	6.77	7.15	7.41	8.68	8.29	7.49	0.83
	S 3	6.11	6.72	6.81	6.74	6.65	6.82	6.64	0.27	7.28	8.25	7.51	7.68	8.03	8.26	7.84	0.41
	S 4	6.68	6.74	6.90	6.43	6.36	6.79	6.65	0.21	8.15	7.87	7.94	7.25	8.61	7.97	7.97	0.44
	S 5	7.65	6.95	6.79	6.74	7.02	6.83	7.00	0.34	9.79	8.21	7.47	7.33	9.59	9.16	8.59	1.07
	S 6	6.63	6.41	6.08	6.27	6.03	6.36	6.30	0.22	7.73	7.35	7.93	7.19	7.76	7.46	7.57	0.28
APTI	S 1	21.12	21.99	20.32	21.50	20.70	21.34	21.16	0.59	10.23	10.60	9.63	10.11	9.02	9.21	9.80	0.62
	S 2	19.45	20.05	20.45	21.13	19.37	18.55	19.83	0.91	10.19	10.28	10.25	10.74	10.88	10.35	10.45	0.29
	S 3	21.74	22.61	20.05	20.11	22.18	21.46	21.36	1.06	11.33	12.55	10.32	11.05	12.22	11.88	11.56	0.82
	S 4	21.41	20.57	20.62	20.80	21.77	22.31	21.25	0.71	9.43	9.37	9.69	9.95	10.54	7.10	9.35	1.18
	S 5	22.51	21.38	20.85	20.52	20.20	22.17	21.27	0.92	10.97	10.64	10.27	11.18	10.60	11.33	10.83	0.40
	S 6	21.59	20.25	19.56	20.30	20.03	22.02	20.63	0.96	9.02	11.62	10.02	10.44	11.58	9.21	10.32	1.12

TABLE-3
SEASONAL CORRELATION BETWEEN VARIOUS BIOCHEMICAL PARAMETERS MEASURED FOR VARIOUS PLANT SPECIES FROM AN INDUSTRIAL ZONE

Sample		Summer					Rainy					Winter				
		pH	AA	RWC	TCh	APTI	pH	AA	RWC	TCh	APTI	pH	AA	RWC	TCh	APTI
S1	pH	1.0000					1.0000					1.0000				
	AA	0.8535[a]	1.0000				0.9054[a]	1.0000				0.9358[a]	1.0000			
	RWC	0.7362[a]	0.9396[a]	1.0000			0.7853[a]	0.8941[a]	1.0000			-0.8795[a]	-0.8150[a]	1.0000		
	TCh	-0.7851	-0.8473[a]	-0.8047[a]	1.0000		0.8275	0.9759[a]	0.7995[a]	1.0000		-0.9470	-0.9603[a]	0.8647[a]	1.0000	
	APTI	0.9787[a]	0.9741[a]	0.7883[a]	-0.9142[a]	1.0000	0.9230[a]	0.9454[a]	0.9766[a]	0.8292[a]	1.0000	-0.9017[a]	-0.9759[a]	0.7773[a]	0.8886[a]	1.0000
S2	pH	1.0000					1.0000					1.0000				
	AA	-0.7410[a]	1.0000				0.8954[a]	1.0000				-0.8240[a]	1.0000			
	RWC	-0.9859[a]	0.9101[a]	1.0000			0.7964[a]	0.8284[a]	1.0000			-0.7601[a]	0.9109[a]	1.0000		
	TCh	0.8400[a]	-0.7692[a]	-0.8157[a]	1.0000		0.8840[a]	0.8429[a]	0.8537[a]	1.0000		-0.7827[a]	0.8961[a]	0.9292[a]	1.0000	
	APTI	-0.9597[a]	0.9749[a]	0.9403[a]	-0.7841[a]	1.0000	0.9156[a]	0.9453[a]	0.7781[a]	0.8905[a]	1.0000	-0.9109[a]	0.9358[a]	0.9205[a]	0.8232[a]	1.0000
S3	pH	1.0000					1.0000					1.0000				
	AA	0.7417[a]	1.0000				0.8471[a]	1.0000				-0.8764[a]	1.0000			
	RWC	0.8704[a]	-0.7540[a]	1.0000			-0.7257[a]	-0.8319[a]	1.0000			-0.9469[a]	0.9531[a]	1.0000		
	TCh	0.9968	-0.8532[a]	0.8850[a]	1.0000		-0.7582[a]	-0.8894[a]	0.7764[a]	1.0000		0.8350[a]	-0.9797[a]	-0.7510[a]	1.0000	
	APTI	0.8964[a]	-0.7751[a]	0.9269[a]	0.8590[a]	1.0000	0.8498[a]	0.9592[a]	-0.9205[a]	0.9757[a]	1.0000	-0.8387[a]	0.8565[a]	0.8153[a]	-0.8956[a]	1.0000
S4	pH	1.0000					1.0000					1.0000				
	AA	-0.7823[a]	1.0000				0.8056[a]	1.0000				-0.9676[a]	1.0000			
	RWC	0.8727[a]	-0.8269[a]	1.0000			0.8897[a]	0.7378[a]	1.0000			0.8268[a]	-0.9245[a]	1.0000		
	TCh	-0.7670[a]	0.9262[a]	-0.9560[a]	1.0000		-0.7741	-0.9119[a]	-0.9927[a]	1.0000		0.8749	-0.7528[a]	0.7848[a]	1.0000	
	APTI	0.9409[a]	-0.9943[a]	0.8824[a]	-0.8153[a]	1.0000	0.9989[a]	0.8319[a]	0.8854[a]	-0.9689[a]	1.0000	0.9721[a]	-0.8859[a]	0.8370[a]	0.9409[a]	1.0000
S5	pH	1.0000					1.0000					1.0000				
	AA	-0.9749[a]	1.0000				-0.7878[a]	1.0000				0.9150[a]	1.0000			
	RWC	0.9198[a]	-0.9198[a]	1.0000			-0.8313[a]	0.8991[a]	1.0000			-0.8797[a]	-0.7904[a]	1.0000		
	TCh	0.9368	-0.9153[a]	0.9924[a]	1.0000		0.9874	-0.8041[a]	-0.8041[a]	1.0000		-0.9687	-0.9740[a]	-0.8851[a]	1.0000	
	APTI	0.9143[a]	-0.9907[a]	0.9103[a]	0.8891[a]	1.0000	0.8295[a]	-0.8510[a]	-0.8579[a]	0.9825[a]	1.0000	0.9132[a]	0.7795[a]	0.8417	-0.9341[a]	1.0000
S6	pH	1.0000					1.0000					1.0000				
	AA	-0.9079[a]	1.0000				0.8518[a]	1.0000				0.9968[a]	1.0000			
	RWC	-0.8823[a]	0.8426[a]	1.0000			-0.9410[a]	-0.9605[a]	1.0000			0.8050[a]	-0.9704[a]	1.0000		
	TCh	-0.9148	0.9567[a]	0.7917[a]	1.0000		0.9436	0.9830[a]	0.8651[a]	1.0000		-0.9376	0.9068[a]	-0.9591[a]	1.0000	
	APTI	-0.9753[a]	0.9071[a]	0.8769[a]	0.7424[a]	1.0000	0.8114[a]	0.8115[a]	0.9225[a]	0.7487[a]	1.0000	0.8491[a]	0.7740[a]	-0.8884[a]	0.9607[a]	1.0000

[a]Correlation is significant at the 0.05 level (two tailed). AA = Ascorbic acid, RWC = Relative water content, TCh = Total chlorophyll.

Table-3 data indicates a strong positive correlation of pH with AA values in most of the ES species. The S6 species has shown highest value (r = 0.9968) in the winter season, which indicates that a rise in the pollution resistance mechanism of plants is correlated to an increase in its pH value. A positive correlation was observed for pH and TCh of S3 sample (r = 0.9968) in the summer season, which shows that the increased pH protects the chlorophyll content in the polluted air. This increases the plant life. A strong positive correlation was observed for pH and APTI of the S4 sample (r = 0.9989) in the rainy season, which directs that the tolerance level of a plant increases with an elevated pH value.

Ascorbic acid content: The ascorbic acid content analysis of foliage samples indicates that the values of the industrial area samples were higher than the non-industrial area. The highest mean ascorbic acid value (10.71 mg g^{-1}) was observed for the S5 sample whereas the lowest mean ascorbic acid value (9.70 mg g^{-1}) was observed for the S1 experimental sample. The highest ascorbic acid value was shown by S5 (11.18 mg g^{-1}) in summer 2018-19 and the least value was shown by S1 (9.24 mg g^{-1}) in rainy 2017-18 among the experimental samples. Ascorbic acid is an antioxidant present in plant leaves and an elevation in its value indicates an improvement in the plant's defence towards the air pollution [27,28]. Table-3 shows a strong positive correlation between ascorbic acid and RWC of the S3 sample (r = 0.9531) sample in the winter season that indicates a rise in the water holding capacity of the leaves with a rise in ascorbic acid content. A strong positive correlation observed for ascorbic acid and APTI of S2 (r = 0.9749) in the summer season. It shows a good association of plant's pollution tolerance with a rise of AA content.

Relative water content (RWC): The highest mean RWC percentage was observed for the S1 (86.77%) experimental sample. It was observed that the RWC values of CS were considerably lower than that of ES due to low exposure of CS to air pollutants. The plant species with high relative leaf water content can show good drought tolerance ability even under pollution stress by maintaining its physiological equilibrium [15].

The highest RWC value of 95.35% was observed for the S2 experimental species in the rainy season of 2018-19. The lowest value of 71.97% was observed for the S3 experimental sample in the rainy season of 2018-19. According to Table-3, a strong positive correlation was observed for RWC and TCh of S5 sample (r = 0.9924) in the winter season. It indicates that an increase in the RWC during the winter season helps the plants to maintain chlorophyll content. A strong positive correlation was observed for RWC and APTI of S1 sample (r = 0.9766) in the rainy season, which indicates that the tolerance capacity of plants can increase with an increase in RWC values in any season.

Total chlorophyll (TCh) content: The investigation reveals that the TCh values were higher for CS whereas lower for the ES. The highest TCh value of 7.00 mg g^{-1} was exhibited by the S5 plant species followed by S4, S3, S1 and S6 samples of the polluted areas. The lowest TCh value of 6.23 mg g^{-1} was exhibited by the S2 experimental sample. The difference between the TCh values of experimental and controlled samples was very small. It indicates that the experimental sample could maintain their total chlorophyll content and productivity even in industrial pollution conditions [15].

The current investigation revealed the maximum TCh value of 7.65 mg g^{-1} for the S5 ES in the summer 2017-18 and the minimum value of 5.77 mg g^{-1} was observed for the S2 experimental sample during the summer 2018-19. The values of Table-3 indicate a strong positive correlation for TCh and APTI of S5 sample (r = 0.9825) in the winter season. It shows that a rise in the TCh value can improve the tolerance level of plants in any period.

Air Pollution Tolerance Index (APTI): It was observed that the APTI values of the industrial area samples were higher as compared to the non-industrial area samples (Table-2). It indicates that the air pollution tolerance of the ES was higher than the CS. The highest mean APTI value of 21.35 was observed for the S3 plant species whereas the least mean value of 19.83 was observed for the S2 plant species. The difference between the lowest and the highest mean APTI values was very small. It shows that the air pollution tolerance capacity of all the six plant species was comparatively good. The highest APTI value of 22.61 was exhibited by the S3 sample in the summer 2018-19 while the lowest value of 18.55 was exhibited by the S2 sample in the winter 2018-19. The results revealed that the APTI values of the same plant species showed seasonal variation. The air pollution susceptibility of the plants varies from species to species [19]. The plants exhibiting high APTI values were observed to be tolerant ones while those with lower APTI values were sensitive ones.

Comparison of the outcomes of the present study with the published research data as shown in Table-4, indicates the enhanced pollution tolerance ability of the plant samples from the present study area.

Anticipated performance index (API) and green belt development: The resulting APTI values were combined with some suitable biological and socio-economic characters to evaluate the API values of plants samples. Considering these characters, + or – grade was given to the plants (Table-5). The percentage scoring was considered to allot API grade to plant samples [3,29]. The API determination of six plant species is presented in Table-5.

By relating the API grade with Table-6, it was seen that the S6 sample revealed the best tolerance whereas the S1 and S5 samples showed excellent tolerance to industrial air pollution stress conditions. The S4 sample reported very good tolerance and the S3 sample showed the good tolerance to air pollution. These five plant samples are recommended for the plantations to develop a green area in the industrial region. The S2 species showed poor API grade and hence suggested for economic and aesthetic interest in the industrial region.

Conclusion

Considering the results of the current study, it can be concluded that the APTI values varied remarkably relating to the sample, season and geographical area. Plants possess natural tolerance towards air pollution, which helps them to survive under pollution stress. *Thespesia populnea* (L.) Sol. *excorrea*, *Polyalthia longifolia*, *Albizia saman* (Jacq.) Merr, *Leucaena leucocephala* (Lam.) de wit and *Calotropis gigantea* (L.). Dryand plant species showed higher API grades as well as higher natural air pollution tolerance levels among all industrial zone samples and are suggested for the development of green zone around the industrial area. *Thespesia populnea* (L.) Sol. *excorrea* and *Polyalthia longifolia* are evergreen plants that can be planted on a huge scale for the green area development the year round in the industrial zone. An equivalent study can be conducted globally for the selection of the tolerant plant species. The green zone development at the global level can ensure the presence of healthy atmosphere. It can enhance as well as preserve the beauty of nature for the next generations.

TABLE-4
COMPARISON OF APTI RELATED PARAMETERS REPORTED GLOBALLY

Name of the plant species	Sampling location/ region/country	Year of sampling	pH	AA (mg g^{-1})	TCh (mg g^{-1})	RWC (%)	APTI	Ref.
Polyalthia longifolia (S1)	South west Nigeria	–	5.00	7.20	0.70	81.50	13.20	[17]
	Ghana, Africa	–	5.73-5.92	12.09-13.65	0.58-0-93	84.49-93.86	16.22-18.92	[18]
	Kerala, India	2006-07	5.70	3.65	5.29	86.83	13.77	[19]
	Mumbai	2017-19	6.38	9.70	6.49	86.77	21.16	Present Study
Prosopis juliflora (SW.) DC. (S2)	Southeast Iran	–	5.40	0.30	6.64	55.00	5.80	[20]
	Tamil Nadu, India	2015- 16	7.00	0.36	29.22	79.77	10.00	[21]
	Coimbatore, India	–	6.1	68.6	0.25	80.00	50.00- 51.00	[22]
	Mumbai	2017-19	5.22	10.12	6.23	82.71	19.83	Present Study
Calotropis gigantea (L.) Dryand (S3)	Tamil Nadu, India	2013	9.00	1.95	0.78	99.85	10-12	[23]
	Tamil Nadu, India	2012	7.86	16.90	15.10	90.40	15.10	[24]
	Mumbai	2017-19	5.86	10.67	6.64	80.37	21.36	Present Study
Leucaena leucocephala (Lam.) de wit (S4)	Indonesia	2015	6.90	15.54	4.60	66.54	24.53	[25]
	Tamil Nadu, India	–	6.29	6.29	1.66	72.78	12.28	[14]
	Mumbai	2017-19	5.90	10.26	6.65	83.75	21.25	Present Study
Albizia saman (Jacq.) Merr. (S5)	Tamil Nadu, India	2015-16	6.00	0.12	36.46	67.93	08.12	[21]
	Tamil Nadu, India	–	5.62	5.62	2.83	81.63	12.91	[14]
	Mumbai	2017-19	5.75	10.71	7.00	76.17	21.27	Present Study
Thespesia populnea (L.) Sol. *excorrea* (S6)	Tamilnadu, India	2018-19	5.68	2.09	1.99	85.31	10.14	[26]
	Tamil Nadu, India	–	5.45	6.50	4.75	91.27	15.76	[14]
	Mumbai	2017-2019	5.69	10.00	6.30	86.29	20.63	Present Study

TABLE-5
API CALCULATION OF PLANT SPECIES BY CONSIDERING THEIR BIOLOGICAL, SOCIO-ECONOMIC CHARACTERS AND APTI

Sample No.	Scientific name	APTI	Tree habit	Canopy structure	Tree type	Laminar size	Laminar texture	Laminar hardness	Economic importance	Total plus	Scoring (%)	API grade
S1	*Polyalthia longifolia*	+++++	++	+	+	++	–	–	++	13	81.25	6
S2	*Prosopis juliflora* (SW.) DC.	+++	+	+	+	–	–	–	++	08	50.00	2
S3	*Calotropis gigantea (L.) Dryand*	+++++	–	–	+	+	–	+	++	10	62.50	4
S4	*Leucaena eucocephala (Lam.) de wit*	+++++	++	++	+	–	–	–	++	12	75.00	5
S5	*Albizia saman (Jacq.) Merr*	+++++	++	++	+	+	–	+	++	14	87.50	6
S6	*Thespesia populnea (L.)* Sol. *excorrea*	++++	++	++	+	++	+	+	++	15	93.75	7

TABLE-6
ASSESSMENT CATEGORY ALLOTMENT CRITERIA OF PLANT SPECIES BASED ON API

Grade	Percentage score	Assessment category
0	Up to 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

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this article.

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