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Seasonal Variation in Air Pollution Tolerance Indices and Selection of Plant Species for Industrial Areas of Rourkela

Sasmita Das and Pramila Prasad

Government (Autonomous) College, P.G. Department of Botany, Rourkela, Sundargarh-769 004

Air pollution tolerance index (APTI) is used to select plant species tolerant to air pollution. Four physiological and biochemical parameters, namely; leaf extract pH, ascorbic acid, total chlorophyll and relative water content, were combined together in a formulation signifying the APTI of plants. Twenty common plant species, 14 trees and 6 shrubs, growing in and around Rourkela Steel Plant, an air pollution point source, were collected during the period from April, 2009 to April, 2010. The plant species, like *Acacia mangium* and *Swietenia mahagoni* are found to be tolerant, *Anthocephalus indicus, Caesalpinea pulcherima* and *Grevillea robusta* are moderately tolerant, while species, like *Albízia lebbeck* and *Alstonia scholarís* and others are sensitive to air pollution with respect to their average APTI values. Analysis of result has suggested the need for APTI measurements to be conducted throughout the growing season, when evaluating pollution tolerance of individual species, an ideal characteristic for planting in the vicinity of polluting industries.

KEYWORD

Air pollution tolerance index, Leaf extract pH, Leaf total chlorophyll, Ascorbic acid, Leaf relative water content.

INTRODUCTION

Rourkela, in the north-western part of the Indian state of Orissa at the heart of a rich mineral belt, is one of the major industrial centres of India. It is located at 84.54 E longitudes and 22.12 N latitude in Sundargarh district of Orissa at an elevation of about 219 m above the mean sea level. The climate of Rourkela is characterized as tropical monsoon climate, where the minimum temperature is 9.4-9.8 °C in December and maximum is 44-44.2 °C in May. There is mainly three seasons, namely summer, rainy and winter. The hot summer lasts from the month of March to the middle of June, rainy season from the middle of June to September with an average rainfall of 20-160 cm. The winter season is of short duration which extends from the middle of November to the middle of February.

The integrated iron and steel unit, the Rourkela Steel Plant (RSP) of the Steel Authority of India Ltd., and a number of ancillary medium and small-scale industries, the thermal power plant, the refractories, the chemical plant and pigments, the cement factory and the engineering and sponge iron industries are major sources of pollution in and around Rourkela. Rourkela is a significant and long-term point source of air pollutants, such as SO_2, CO, NO_2 and heavy metals. Effects of toxic pollutants from industrial emissions and automobile exhaust upon human health and other organisms are many and diverse.

Air pollution has become a serious environmental stress to plants due to increasing industrialization and urbanization during the last few decades (Rajput and Agarwal, 2004). The particulates and gaseous pollutants, alone and in combination, can cause serious setbacks to the overall physiology of plants (Ashenden and Williams, 1980; Mejstrik, 1980; Anda, 1986). It has been an established fact that plants are 'living fil-

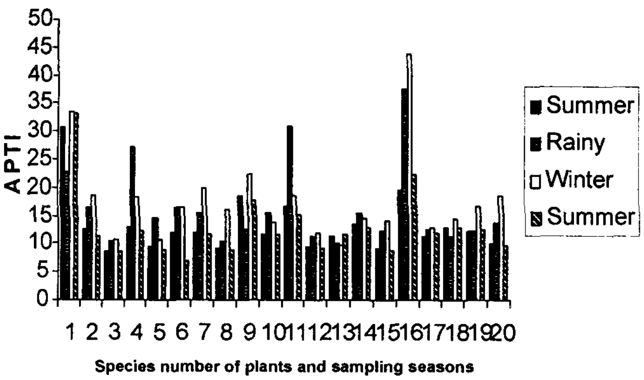

Figure 1. *Variation of air pollution tolerance indices (APTI) of some plant species around industrial complex of Rourkela Township during sampling seasons*

ters', leaves and exposed parts of a plant generally act as persistent absorber in a polluted environment. Plants provide an enormous leaf area for impingement, absorption and accumulation of air pollutants in the air environment (Warren, 1973; Shannigrahi *et al.*, 2004). Trees experience the greatest exposure and are influenced greatly by pollutant concentration due to their perennial nature (Raina and Sharma, 2003). Regional impact of air pollution on local plant species is one of the major ecological issues. The climate condition, the physico-chemical properties of air pollutants and their residence time in the atmosphere have the impact on surrounding plants and animals (Wagh *et al.*, 2006). Tree act as a sink of air pollutants and thus reduce their concentration in the air (Prajapati and Tripathi, 2008). However, this function of pollution abatement is best performed by the pollution-tolerant species (Das and Prasad, 2010). It appears that tree plantation in industrial areas is a site-specific activity and knowledge of tolerance level of plant species to air pollution is necessary (Das *et al.*, 2010). Work has been done in this direction to study the sensitivity of plants based on selected parameters, such as ascorbic acid content (Keller and Schwager, 1977; Rajput and Agrawal, 2005; Chauhan, 2008), relative water content (Falla *et al.*, 2000; Joshi and Chauhan, 2008), chlorophyll content (Bell and Mudd, 1976;

Table 1. *Average air temperature (°C) and humidity (%) of Rourkela Township in sampling seasons*

Sampling season and month	Air temperature, °C	Humidity, %
Summer (April, 2009)	31.2	29.8
Rainy (August, 2009)	27.5	80.7
Winter (December, 2009)	19.0	69.0
Summer (April, 2010)	32.9	31.0

Prasad and Inamdar, 1990; Sabratnam and Gupta, 1988; Rajput and Agrawal, 2005; Petkovšek *et al.*, 2008, Chauhan and Sanjeev, 2008; Chauhan and Joshi, 2008) and leaf extract pH (Chaudhury and Rao, 1977; Joshi and Chauhan, 2008; Chauhan and Joshi, 2008). These four physiological and biochemical parameters, namely; leaf extract pH, ascorbic acid, total chlorophyll and relative water content, were used to calculate APTI (Singh and Rao, 1983) as per their relative significance in identifying the tolerance level of various plant species. In view of this, the present investigation was taken upto evaluate APTI of common avenue tree species of Rourkela Township with respect to the variation of APTI throughout the growing season, in summer, rainy and winter season, under a variety of environmental conditions.

MATERIAL AND METHOD

Survey was done for selection of sites around the steel industrial complex of Rourkela. Plants of common occurrence along the roadsides and other sites were selected for chemical analysis. Leaf samples were collected from 20 plant species, 14 trees and 6 shrubs, from different locations within the township in consecutive summer, rainy, winter and summer season of year 2009-2010. Three replicates of fully-matured leaves of each species were randomly collected in the morning (8 A.M. to 10 A.M.). Samples were quickly transferred to the heat-proof container. The weight of fresh leaves was taken immediately and samples were preserved in a refrigerator for further

Table 2. *Leaf relative water content (RWC) of some plant species around industrial complex of Rourkela Township during sampling seasons*

Plant species	Leaf relative water content (RWC), %			
	Summer (April, 2009)	Rainy (August, 2009)	Winter) (December, 2009	Summer (April, 2010)
Acacia mangium	72.77	81.22	70.07	71.05
Albizia lebbeck	72.66	93.47	74.65	72.00
Alstonia scholaris	79.33	86.09	81.53	77.02
Anthocephalus indicus	81.66	88.77	84.12	82.33
Artocarpus integrifolia	72.98	96.03	86.61	69.76
Azadirachta indica	80.54	91.22	86.27	75.09
Bauhinia variegata	73.92	80.85	77.15	75.78
Bougainvillea spectavillis	86.97	95.23	92.89	85.25
Caesalpinea pulcherima	73.43	81.43	80.76	76.05
Cassia siamea	85.71	94.11	91.09	87.01
Grevillea robusta	63.33	71.96	52.82	62.61
Lagerstroemia speciosa	82.58	98.72	85.51	79.65
Lantana camara	72.74	81.48	75.30	73.61
Mangifera indica	87.22	95.66	91.38	86.62
Pongamia pinnata	68.67	83.33	70.90	63.29
Swietenia mahagoni	66.85	81.08	73.53	63.25
Syzygium cumini	86.08	91.15	89.03	87.29
Tabernaemontana coronaria	83.70	89.92	85.92	81.80
Thevetia nerifolia	77.03	89.69	79.69	76.25
Ziziphus jujuba	69.32	88.66	71.48	69.01

analysis.

Leaf relative water content (RWC)

RWC presents a useful indicator of the state of water balance of a plant, essentially because it expresses the absolute amount of water, which the plant requires to reach artificial full saturation. Following the method described by Singh (1977), leaf RWC was determined and calculated using the formula:

$$RWC = [(FW-DW)/(TW-DW)]x100 \quad \dots (1)$$

where FW is fresh weight, DW is dry weight and TW is turgid weight. Fresh weight was obtained by weighing the fresh leaves on a digital balance. The leaves were then immersed in water overnight, blotted dry and then weighed to get the turgid weight. Next, the leaves were dried overnight in an oven at 70 °C and reweighed to obtain the dry weight.

Leaf extract pH

For pH estimation 0.5 g of leaf material was ground to paste and dissolved in 50 mL of distilled water and the pH of this extract was measured using a calibrated digital pH meter.

Total chlorophyll content (TCH)

Total chlorophyll analysis was done according to the method described by Arnon (1949). For this purpose, 0.5 g of fresh leaves were blended and then extracted with 10 mL of 80% chilled acetone and left for 15 min. The liquid portion was decanted and centrifuged at 2,500 rpm for 15 min. The supernatant was then collected and the absorbance (optical density) was then determined at 645 nm and 663 nm using a spectrophotometer. Calculations were made using the formula

Table 3. *Leaf extract pH of some plant species around industrial complex of Rourkela Township during sampling seasons*

Plant species	Leaf extract pH			
	Summer (April, 2009)	Rainy (August, 2009)	Winter (December, 2009)	Summer (April, 2010)
Acacia mangium	7.1	4.8	6.0	7.1
Albizia lebbeck	6.0	5.2	6.0	6.0
Alstonia scholaris	5.1	4.4	5.2	5.2
Anthocephalus indicus	3.4	2.6	3.9	3.6
Artocarpus integrifolia	6.0	5.3	6.3	6.0
Azadirachta indica	5.9	5.3	6.6	6.0
Bauhinia variegata	6.1	6.0	6.7	6.1
Bougainvillea spectavillis	6.3	5.6	6.6	6.5
Caesalpinea pulcherima	6.6	5.1	6.3	6.6
Cassia siamea	5.1	3.9	6.1	4.8
Grevillea robusta	5.2	4.7	5.6	5.4
Lagerstroemia speciosa	4.6	3.9	4.7	4.6
Lantana camara	8.2	6.1	8.6	8
Mangifera indica	6.1	4.6	5.3	6.0
Pongamia pinnata	6.3	5.2	6.6	6.1
Swietenia mahagoni	5.7	5.5	6.5	5.7
Syzygium cumini	3.6	3.3	4.2	4.0
Tabernaemontana coronaria	5.8	5.6	6.1	6
Thevetia nerifolia	5.8	5.1	6.0	5.6
Ziziphus jujuba	5.8	5.4	6.1	5.8

TCH = (20.2xO.D. at 645 nm) + (8.02x O.D. at 663 nm) ... (2)

where O.D. is optical density.

Ascorbic acid content analysis

Ascorbic acid (AA) content (expressed in mg/g) was measured using the colorimetric 2, 4-dinitrophenyl hydrazine (DNPH) method (Roe and Mills, 1948; Roe and Kuether, 1943). For each sample, 2.0 g of fresh foliage was homogenized in 20 mL of double-distilled water. From the supernatant solution, 2.5 mL of extract solution was taken in a separate test-tube, to which 2.5 mL of 8% trichloro acetic acid was added, followed by a few drops of bromine water. Excess bromine water was removed by aeration. The resultant sample was then centrifuged for 10 min at 2,000 rpm and 0.2 mL of the above supernatant collected was converted to a volume of 2.0 mL by addition of double-distilled water followed by the addition of 1 mL 2, 4-dinitrophenyl hydrazine thio urea reagents. The samples were left for colour development at 57 °C for 1 hr in the incubator. Finally, 5 mL of concentrated H_2SO_4 was added to the experimental sample and optical density was measured at 540 nm by the use of colorimeter. Triplicate readings were taken for each leaf sample. From average of these samples, ascorbic acid concentration was calculated on the standard ascorbic acid curve.

APTI calculation

The air pollution tolerance indices of 20 plants were determined following the method of Singh and Rao (1983). The formula of APTI is given as :

$$APTI = [A(T+P)+R]/10 \quad ... (3)$$

Table 4. *Total chlorophyll content (TCH) of some plant species around industrial complex of Rourkela Township during sampling seasons*

Plant species	Total chlorophyll content (TCH), mg/g			
	Summer (April, 2009)	Rainy (August, 2009)	Winter (December, 2009)	Summer (April, 2010)
Acacia mangium	0.62	1.16	0.25	0.49
Albizia lebbeck	1.47	2.39	1.05	1.60
Alstonia scholaris	0.22	0.88	0.12	0.32
Anthocephalus indicus	1.75	2.21	0.07	1.58
Artocarpus integrifolia	0.32	0.66	0.26	0.33
Azadirachta indica	0.49	2.03	0.39	0.53
Bauhinia variegata	0.35	1.13	0.27	0.54
Bougainvillea spectavillis	0.57	1.57	0.24	0.42
Caesalpinea pulcherima	0.77	2.61	0.64	0.78
Cassia siamea	0.32	0.69	0.27	0.36
Grevillea robusta	0.38	1.70	0.27	0.36
Lagerstroemia speciosa	0.63	2.21	0.14	0.62
Lantana camara	0.85	1.16	0.56	0.99
Mangifera indica	0.46	1.67	0.25	0.4
Pongamia pinnata	1.87	2.59	0.23	1.68
Swietenia mahagoni	1.50	1.89	0.61	1.15
Syzygium cumini	0.63	1.19	0.25	0.86
Tabernaemontana coronaria	0.54	1.59	0.49	1.59
Thevetia nerifolia	1.55	1.95	0.45	0.70
Ziziphus jujuba	0.33	0.79	0.15	0.44

where A is Ascorbic acid content (mg/g), T is total chlorophyll (mg/g), P is pH of leaf extract, and R is relative water content of leaf (%). Based on the APTI values the plants were conveniently grouped as follows (Kalyani and Singaracharya, 1995);

APTI index range: <1 => Very sensitive,
1 to16 => Sensitive,
17 to 29 => Intermediate and
30 to 100 => Tolerant.

Data analysis

Data were analyzed by one way analysis of variance (ANOVA).

RESULT AND DISCUSSON

Air temperature in °C and humidity in % during summer, winter and rainy seasons were measured and their average values are shown in the table 1.

Leaf relative water content (RWC)

The results exhibited high leaf RWC during rainy season, low in winter and least in summer season (Table 2) in all the plant species except in *Acacia mangium* and *Grevellia robusta,* which had their lowest RWC in winter season. Leaf RWC of all the plant species showed significant changes ($\alpha=0.01$ and $\alpha=0.05$) during summer, rainy and winter seasons. Further analysis of leaf relative water content and air humidity exhibited a positive correlation ($r=0.90$) of leaf relative water content and air humidity. High leaf RWC was recorded in all the plant species during August, 2009, when Rourkela was experiencing a pouring and humid weather. The high RWC of the leaf can be explained by the higher rate of availability of water in the soil along with the low rate of transpiration. Leaf water status is intimately related to several leaf physiological variables,

Table 5. *Ascorbic acid (AA) content of some plant species around industrial complex of Rourkela Township during sampling seasons*

Plant species	Ascorbic acid (AA) content, mg/g			
	Summer (April, 2009)	Rainy (August, 2009)	Winter (December, 2009)	Summer (April, 2010)
Acacia mangium	30.33	24.50	40.99	34.33
Albizia lebbeck	7.08	9.33	16.00	5.33
Alstonia scholaris	1.22	3.75	5.16	1.66
Anthocephalus indicus	9.33	40.5	24.66	8.00
Artocarpus integrifolia	3.45	8.50	3.20	3.16
Azadirachta indica	5.91	10.33	11.33	6.83
Bauhinia variegata	7.33	9.33	16.83	6.16
Bougainvillea spectavillis	0.58	1.33	10.08	0.50
Caesalpinea pulcherima	15.50	8.33	20.75	11.83
Cassia siamea	5.74	13.00	7.37	5.66
Grevillea robusta	18.75	37.33	22.83	15.3
Lagerstroemia speciosa	2.16	2.33	7.50	2.61
Lantana camara	4.50	2.66	2.50	5.00
Mangifera indica	7.50	9.33	9.50	6.99
Pongamia pinnata	1.87	2.59	0.23	1.68
Swietenia mahagoni	17.83	41.50	51.16	23.75
Syzygium cumini	6.66	7.66	9.00	7.00
Tabernaemontana coronaria	7.33	3.50	9.00	6.50
Thevetia nerifolia	6.24	4.60	13.53	8.00
Ziziphus jujuba	5.41	8.33	18.33	4.83

such as leaf turgour, growth, stomatal conductance, transpiration, photosynthesis and respiration (Kramer and Boyer, 1995).

Leaf extract pH

Leaf extract pH of different plant species showed significant changes during summer, rainy and winter seasons ($\alpha=0.01$ and $\alpha=0.05$). Most of the observed plant species reach their highest leaf extract pH during winter season followed by summer and rainy season (Table 3). Leaf extract pH value did not exhibit any significant correlation with air humidity and temperature. The high dust accumulation in the winter season may be due to the wet surfaces of leaves which help in capturing dust, with a gentle breeze and foggy condition preventing particle dispersion. This can explain the highest H^+ ion concentration of leaf extract, that is the alkaline condition which is caused by the dissolution of dust particles in the cell sap. Despite high concentration of dust in summer, high wind speed may be the reason for relative lower dust accumulation in the summer than in the winter causing the decreased pH as well. In the rainy season dust accumulation is least due to washing of leaves, which may be the cause of low leaf extract pH.

Total chlorophyll content (TCH)

All the plant species exhibited high TCH content during rainy season followed by summer and winter season (Table 4). Significant difference in chlorophyll content was observed during the said sampling seasons ($\alpha=0.01$ and $\alpha=0.05$). Further analysis showed that chlorophyll content of leaves was positively correlated with leaf relative water content ($r=0.75$) and showed a negative correlation when compared with leaf

Table 6. *Air pollution tolerance indices (APTI) of some plant species around industrial complex of Rourkela Township during each sampling season*

Plant species	Air pollution tolerance index (APTI)				
	Summer (April, 2009)	Rainy (August, 2009)	Winter (December, 2009)	Summer (April, 2010)	Average APTI
Acacia mangium	30.00	21.85	33.53	33.22	30.04
Albizia lebbeck	12.55	16.42	18.74	11.25	14.74
Alstonia scholaris	8.58	10.58	10.90	8.61	9.66
Anthocephalus indicus	12.97	27.36	18.26	12.37	17.74
Artocarpus integrifolia	9.47	14.67	10.76	8.98	10.97
Azadirachta indica	11.93	16.57	16.54	6.83	12.94
Bauhinia variegata	12.05	15.39	19.92	11.66	14.75
Bougainvillea spectavillis	9.09	10.47	16.18	8.87	11.15
Caesalpinea pulcherima	18.78	12.74	22.48	17.81	17. 95
Cassia siamea	11.68	15.37	13.8	11.62	13.11
Grevillea robusta	16.80	31.09	18.68	15.08	20.41
Lagerstroemia speciosa	9.38	11.29	12.18	9.32	10.54
Lantana camara	11.34	10.08	9.82	11.85	10.77
Mangifera indica	13.64	15.42	14.41	13.13	14.15
Pongamia pinnata	9.11	12.35	14.38	8.78	11.15
Swietenia mahagoni	19.52	37.64	43.93	22.60	30.92
Syzygium cumini	11.42	12.56	12.90	12.13	12.25
Tabernaemontana coronaria	13.01	11.51	14.52	13.11	13.03
Thevetia nerifolia	12.28	12.21	16.7	12.66	13.46
Ziziphus jujuba	10.24	14.02	18.81	9.91	13.24

extract pH.

Various environmental factors, like air, water and soil cause variation in plant leaf pigment content through dust accumulation on the leaf surface. The least total chlorophyll content during winter season may be due to the highest amount of dust accumulation on the leaf surface, a factor inhibiting chlorophyll synthesis due to the presence of various metals and polycyclic hydrocarbon, which inhibit the enzyme necessary for chlorophyll synthesis. Dust deposition also affects the light availability for photosynthesis and blocks stomatal pores for diffusion of air and thus puts stress on plant metabolism (Eller, 1977; Hope *et al.*, 1991; Keller and Lamprecht, 1995; Anthony, 2001). The air pollutants make their entrance into the tissues through the stomata and cause partial denaturation of chloroplast and decrease pigment contents in the cells of polluted leaves. Rao and Leblanc (1966) mentioned that high amount of gaseous SO_2 causes destruction of chlorophyll and that might be due to the replacement of Mg^{++} by two hydrogen atoms and degradation of chlorophyll molecule to phaeophytin. Further, the decrease in chlorophyll content in the leaves during summer and winter season may be due to the alkaline condition created by dissolution of chemicals present in the dust particles in the cell sap, which is responsible for chlorophyll degradation. The highest pigment content of leaf can be correlated to the least dust accumulation during rainy season.

Ascorbic acid content analysis

The ascorbic acid content in most of the plant species were maximum in winter followed by rainy and summer season except in *Acacia mangium, Thevetia nerifolia* and

Table 7. *Air pollution tolerance grades of some plant species around industrial complex of Rourkela Township during each sampling season*

Plant species	Air pollution tolerance grade				
	Summer (April, 2009)	Rainy (August, 2009)	Winter (December, 2009)	Summer (April, 2010)	Average Grade
Acacia mangium	T	I	T	T	T
Albizia lebbeck	S	S	I	S	S
Alstonia scholaris	S	S	S	S	S
Anthocephalus indicus	S	I	I	S	I
Artocarpus integrifolia	S	S	S	S	S
Azadirachta indica	S	S	S	S	S
Bauhinia variegata	S	S	I	S	S
Bougainvillea spectavillis	S	S	S	S	S
Caesalpinea pulcherima	I	S	I	I	I
Cassia siamea	S	S	S	S	S
Grevillea robusta	S	T	I	S	I
Lagerstroemia speciosa	S	S	S	S	S
Lantana camara	S	S	S	S	S
Mangifera indica	S	S	S	S	S
Pongamia pinnata	S	S	S	S	S
Swietenia mahagoni	I	T	T	I	T
Syzygium cumini	S	S	S	S	S
Tabernaemontana coronaria	S	S	S	S	S
Thevetia nerifolia	S	S	S	S	S
Ziziphus jujuba	S	S	I	S	S

S-Sensitive, T-Tolerant, I-Intermediate

Tabernaemontana coronaria species (Table 5). These plant species had their maximum ascorbic acid content in winter followed by summer and rainy season. In *Lantana camara* the highest ascorbic acid content was found in summer followed by rainy and winter season. However, the ascorbic acid content showed significant variation ($\alpha = 0.05$) throughout the sampling period, that is; summer, rainy and winter seasons. Ascorbic acid content of plant species showed positive correlation ($r = 0.87$) with air humidity and a negative correlation with air temperature ($r = -0.95$).

Ascorbic acid plays a role in the cell wall synthesis, defense and cell division (Conklin, 2001). It is also a strong reducer and plays important role in photosynthetic carbon fixation (Pasqualini *et al.*, 1980). Ascorbic acid is a strong reductant and it activates many physiological and defense mechanisms. It also influences the resistance of plants to adverse environmental conditions, including air pollution (Keller and Schwager, 1977) and its reducing power is directly proportional to its concentration (Raza and Murthy, 1988). Study of trees and shrubs around Rourkela revealed the highest ascorbic acid content during winter season followed by summer and rainy season. But the study revealed that the ascorbic acid content of plants during rainy season is higher than that of summer season, which may be due to the high chlorophyll content of leaves during rainy season as ascorbic acid is concentrated mainly in chloroplast (Franke and Heber, 1964).

Air pollution tolerance index (APTI)

Air pollution tolerance indices of various plant species did not show significant variations ($\alpha=0.01$ and $\alpha=0.05$) during the sampling seasons, that is; summer, rainy and winter seasons. Most of the plants exhibited their highest APTI during winter season and lowest during summer season (Tables 6,7 and Figure 1). Plant species, like *Acacia mangium, Thevetia nerifolia* and *Tabernaemontana coronaria* showed their highest APTI during winter followed by summer and rainy season, whereas *Lantana camara* showed highest APTI value in summer and lowest in winter season. APTI of plant species showed a positive correlation with ascorbic acid content of leaf ($r=0.1$). Air pollution tolerance indices calculated for various plant species showed positive correlation ($r=0.92$) with air humidity, while a negative correlation with air temperature ($r=-0.95$).

CONCLUSION

In conclusion, it seems that evaluation of plant responses based on single criterion alone may not be feasible in the complex circumstances of an urban industrial environment where a variety of unspecified pollutants are present. So, the combination of a variety of parameters can give a more reliable result than that based only on a single biochemical parameter. Further, air pollution tolerance is affected by natural climatic conditions, such as temperature and humidity. Air pollution tolerance index (APTI) of 20 plant species was calculated. By taking the average of their respective APTI values in different sampling seasons, 2 plant species are found tolerant, 3 are intermediately tolerant, while the rest 15 plants are sensitive to air pollution. Species ranked as tolerant and moderately tolerant and considered as ideal candidates for landscaping in the vicinity of polluting industry are found to be *Acacia mangium, Swietenia mahagoni, Anthocephalus indicus, Caesalpinea pulcherima* and *Grevillea robusta.* Species ranked as sensitive, such as *Albizia lebbeck, Alstonia scholaris, Artocarpus integrifolia, Azadirachta indica, Bauhinia variegata, Bougainvillea spectavillis, Cassia siamea, Lagerstroemia speciosa, Lantana camara, Mangifera indica, Pongamia pinnata, Syzygium cumini, Tabernaemontana coronaria, Thevetia nerifolia* and *Ziziphus jujuba* should be avoided.

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AUTHOR

1. Miss Sasmita Das, P.G. Department of Botany, Government (Autonomus) College, Rourkela, Sundargarh - 769 004.

2*. Dr. (Mrs.) Pramila Prasad, Reader and Head, P.G. Department of Botany, Government (Autonomus) College, Rourkela, Sundargarh - 769 004.