The Ecoscan 2 (2) : 203 - 206, 2008
AN INTERNATIONAL BIANNUAL JOURNAL OF ENVIRONMENTAL SCIENCES

AIR POLLUTION TOLERANCE INDEX OF VARIOUS PLANT SPECIES GROWING IN INDUSTRIAL AREAS

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ABSTRACT

Air Pollution Tolerance Index (APTI) was calculated for various plant species growing in industrial areas of Visakhapatnam. The leaf samples collected from 24 tree species in industrial areas of Visakhapatnam city were used to determine their Air Pollution Tolerance Index (APTI) by calculating the ascorbic acid, chlorophyll, pH, and relative water contents. In the present study, the APTI values of less than 16 are reported in 20 species and they can be used as indicators of air pollution. The species *Ficus religiosa* (25.77), *Zizypus jujuba* (22.32), *Phyllanthus emblica* (18.88) *and Cassia fistula* (18.69) showed their moderate response by changing their biochemical contents and are identified as moderately tolerant to air pollution.

KEY WORDS
Air pollution
Tolerance Index
Indicator Species

Received : 15.05.2008
Revised : 12.10.2008
Accepted : 17.11.2008

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INTRODUCTION

Plants 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 also provide enormous leaf area for impingement, absorption and accumulation of air pollutants to reduce the pollution level in the air environment (Escobedo *et al.,* 2008). Sensitivity and response of plants to air pollutants is variable. The plant species which are more sensitive act as biological indicators of air pollution. The response of plants to air pollution at physiological and biochemical levels can be understood by analyzing the factors that determine resistance and susceptibility. Using plants, as indicator of air pollution is the possibility of synergistic action of pollutants. The ambient environment of an urban area may be contaminated with several pollutants such as SO_2, CO, NOx and heavy metals and the plants growing there would be exposed not only to one but to many pollutants and their different conditions. It is possible to estimate the overall effect of a large number of pollutants as total pollution by measuring changes in the plants (Agarwal, 1985; Tiwari *et al.,* 1993). Plants were assessed for their tolerance index to establish the air pollution level. Air pollution effects on plants have long been known. Singh and Rao (1983) have suggested a method of determining Air Pollution Tolerance Index (APTI) by synthesizing the values of four different biochemical parameters i.e. leaf extract pH, ascorbic acid, total chlorophyll and relative water contents. In the present study tolerant species to air pollution have been identified in respect to the above four biochemical parameters which may help in proper selection of species in urban plantation programme at Visakhapatnam.

MATERIALS AND METHODS

Visakhapatnam is situated in North coastal Andhra Pradesh. It lies between 17° 43 N latitude and 83° 0 E longitude. The climate in Visakhapatnam is generally tropical humid with mean daily maximum temperatures being in the range of 27°C to 34°C and mean daily minimum temperatures varies between 14°C to 28°C. The annual mean humidity is 77% and the wind direction is generally from the South west towards North West.

Visakhapatnam is selected for the case study since numerous sources emit air pollutants including several major and minor industries located with in the city. The study was carried out in industrial and urban areas characterized by heavy industrial activity. Leaf samples were obtained from 24 tree species of different locations in industrial areas of Visakhapatnam. The Air Pollution Tolerance Index (APTI) was determined by calculating the ascorbic acid, chlorophyll, pH and relative water contents in leaf samples. Ascorbic acid

was estimated by 2, 6 - dichlorophenol indophenol dye following the method suggested by Agarwal (1985). Chlorophyll was calculated by spectrophotometer and pH was determined by digital pH meter. Relative water content of leaf material was estimated by taking the initial weight and dry weight of leaf material. The APTI was calculated by using the following formula (Singh and Rao, 1983).

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

Where, **A** = Ascorbic acid (mg/g dry wt.)

T = Total Chlorophyll (mg/g dry wt.)

P = pH of leaf extract.

R = Relative water content of leaf tissue (%).

The Entire sum was divided by 10 to obtain a small manageable figure.

RESULTS AND DISCUSSION

Air Pollution Tolerance Index (APTI) is calculated for 24 plant species growing in industrial areas of Visakhapatnam and the data is presented in Table 1. All biochemical parameters that are analyzed for APTI plays significant role to determine resistivity and susceptibility of plant species. Ascorbic acid is important in cell wall synthesis, photosynthetic carbon fixation and cell division (Conklin, 2001), pH as an indicator for sensitivity to air pollution (Scholz and Reck, 1977), total chlorophyll is also related to ascorbic acid productivity. Air pollution in urban and industrial areas may get adsorbed, absorbed, accumulated or integrated in the plant body and if toxic, may injure them in various ways. The level of injury will be high in sensitive species and low in tolerant ones. The sensitive species help in indicating air pollution and tolerant one help in abatement of air pollution. (Subrahmanyam *et al.,* 1985).

The tolerant species of plants function as pollution "sink" and therefore a number of environmental benefits can be desired by planting tolerant species in polluted areas. For this purpose, evaluation of plants with respect to their tolerance level to air pollution may be essential. To evaluate the tolerance level of plant species to air pollution, Singh and Rao, (1983) used four leaf parameters to drive an empirical number indicating the Air Pollution Tolerance Index (APTI). From the table it was evident that the plants showed varied degree of tolerance index to air pollution. Based on the APTI values the plants were conveniently grouped as follows (Kalyani and Singaracharya, 1995):

APTI value	Response
30 to100	Tolerant
29 to17	Intermediate
16 to 1	Sensitive
< 1	Very sensitive

In the present study out of twenty four species studied four species such as *Ficus relgiosa* (25.77), *Zizypus jujuba* (22.32), *Phyllanthus emblica* (18.88) and *Cassia fistula*

Table 1: Air Pollution Tolerance Index (APTI) of various plant species growing in industrial areas of Visakhapatnam

S. No.	Name of plant species	Totalchlorophyll (mg/g)	pH	Ascorbic acid (mg/g)	R.W.C (%)	APTI
1.	*Ficus religiosa* (Peepal)	16.12	8.5	7.52	72.63	25.77
2.	*Zizypus jujube* (Jujube)	8.90	6.5	9.82	72.00	22.32
3.	*Phyllanthus emblica* (Amla)	9.28	6.1	8.12	64.00	18.88
4.	*Cassia fistula* (Indian laburnum)	4.57	7.1	11.05	58.00	18.69
5.	*Tamarindus indica* (Tamarind)	6.75	4.4	8.23	70.00	16.24
6.	*Anacardium occidentalis* (Cashew)	9.38	4.7	7.16	56.10	15.69
7.	*Nerium odorum* (Sweet scented oleander)	2.52	6.0	8.18	84.00	15.36
8.	*Polyalthia longifolia* (Ashoka)	6.70	5.6	7.27	61.66	15.10
9.	*Acacia melanoxylon* (Blackwood)	3.89	7.2	7.76	61.34	14.73
10.	*Psidium guava* (Guava)	6.12	6.4	5.50	72.00	14.08
11.	*Azadirachta indica* (Neem)	6.89	6.2	5.36	65.39	13.55
12.	*Helianthus* spp. (Sunflower)	6.38	7.5	4.23	72.07	13.07
13.	*Morus alba* (Mulberry)	1.841	6.5	6.45	74.45	12.82
14.	*Mangifera indica* (Mango)	5.80	5.8	4.32	68.12	11.82
15.	*Ficus bengalensis* (Banyan)	5.38	8.8	3.33	69.80	11.70
16.	*Eucalyptus* spp.(Eucalyptus)	4.25	5.0	6.16	56.46	11.34
17.	*Pongamia pinnata* (Indian beach)	6.17	6.8	3.33	63.27	10.64
18.	*Anona squamosa* (Custard apple)	4.66	5.3	4.00	61.10	10.09
19.	*Syzygium* spp. (Black plum)	7.00	6.1	2.29	63.45	9.34
20.	*Artocarpus* spp. (Jack fruit)	6.42	6.1	3.15	51.30	9.07
21.	*Acacia arabica* (Babool)	2.50	6.1	3.85	55.00	8.81
22.	*Achras sapota* (Sapota)	2.00	6.4	3.77	53.27	8.49
23.	*Delonix regia* (Gulmohar)	5.90	7.4	1.161	68.80	8.42
24.	*Casuarina equisitifolia* (Casuarina)	0.90	5.2	1.62	55.23	6.51

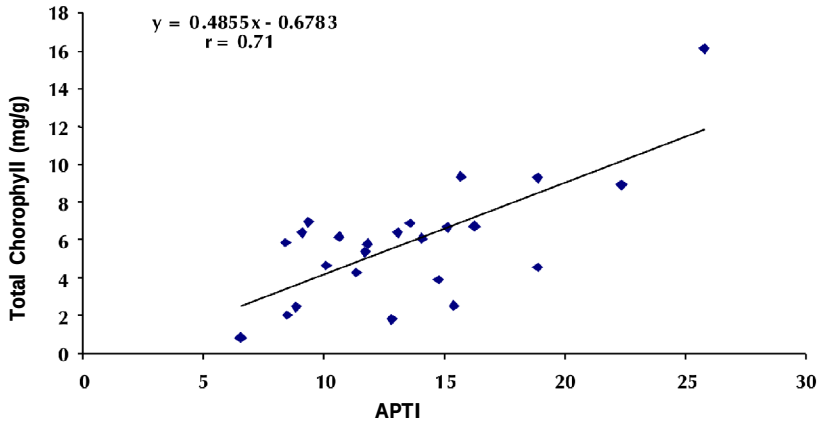

Figure 1: Correlation between total chlorophyll content and APTI

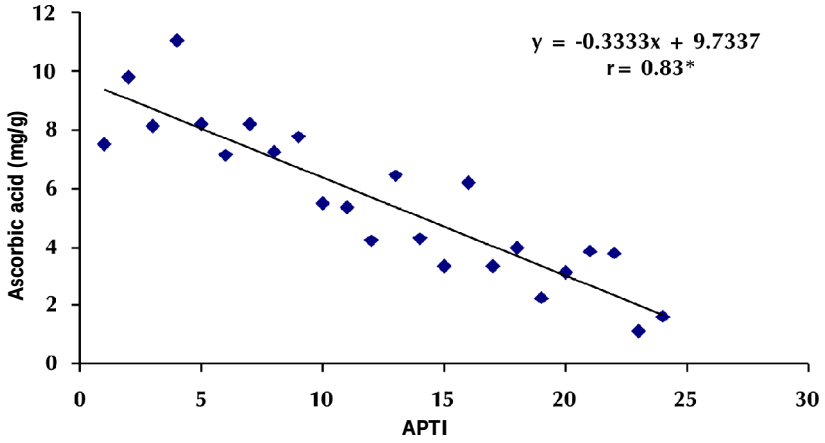

Figure 2: Correlation between ascorbic acid content and APTI

(18.69) showed their moderate / intermediate response by changing their biochemical characters. The remaining twenty species showed APTI values of less than 16 which were designated as sensitive range.

The analysis of biochemical parameters showed a marked variation between tolerant and sensitive species. The Ascorbic acid content ranged between 7.52 to 11.05 mg in intermediately tolerant species and 1.161 to 8.23 mg among the sensitive plant species. Relative water content ranged between 58% to 73 % in intermediately tolerant species and 51.3% to 84% in sensitive plant species. Chlorophyll content ranged between 4mg to 16mg in intermediately tolerant plants and 0.90 to 9.38mg in sensitive plants. The pH ranged between 4.4 to 8.8 in both intermediately tolerant and sensitive plant species.

Correlation coefficient was calculated between APTI and biochemical parameters such as Ascorbic acid, total chlorophyll, leaf pH and Relative water content. The total chlorophyll content was significantly correlated with APTI ($r = 0.71$, $y = 0.485x - 0.678$) and where as the leaf pH did not show any significant correlation with APTI (Fig. 1). High pH may increase the efficiency of conversion from hexose sugar to ascorbic acid (Escobedo et al, 2008) while low leaf pH extract showed good correlation with sensitivity to air pollution and also reduce photosynthesis process in plants. The photosynthetic efficiency has been reported to be strongly dependent on leaf pH (Yan-ju liu and Hui ding. 2008) the photosynthesis was reduced in plants with low leaf pH (Turk and Wirth 1975). In the present study the leaf p^H values are higher than 5.0 in all the species except *Tamarindus indica* (4.4) and *Anacardium occidentalis* (4.7). The Ascorbic acid content was also significantly correlated ($r = 0.83$, $y = -0.33x + 9.73$) with APTI (Fig. 2) and where as the Relative Water Content did not show any significant relation. High water content within plant body helps to maintain its physiological balance under stress conditions such as exposure to air pollution when the transpiration rates are usually high. It also serves as an indicator of drought resistance in plants (Dedio, 1975). In the present study ascorbic acid content was not correlated with relative water content and it is an indication that the plant species responded to the dry weather by a relative water content drop. Thus out of the 24 species of plants only 4 species can serve as indicator of industrial air pollution namely *Ficus religiosa, Zizypus jujuba, Phyllanthus emblica and Cassia fistula*.

ACKNOWLEDGEMENT

Authors are thankful to GITAM University for providing facilities and encouragement.

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