

*Full Length Research Paper*

# Selection and identification of air pollution-tolerant plants by air pollution tolerance index (APTI) in urban parks of Isfahan, Iran

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The study examined air pollution tolerance index (APTI) of ten tree species in urban parks of Isfahan, Iran. Four physiological and biochemical parameters namely: leaf relative water content of leaf (RWC), ascorbic acid content, total leaf chlorophyll (TCH) and leaf extract pH were used to determine the APTI. The results show that combining variety of these parameters gave a more reliable result than those of individual parameter. In this method, the leaves of *Nerium oleander*, *Platanus orientalis*, *Morus alba*, *Ulmus carpinifolia*, *Robinia pseudoacacia*, *Pinus eldarica*, *Cupressus sempervirens*, *Ailanthus altissima*, *Cercis siliquastrum* and *Eucalyptus camaldulensis* were extracted and the air pollution tolerance index calculated. The higher values of APTI were recorded for the species, *A. altissima* and *R. pseudoacacia*; they were more tolerant to air pollution while the minimum values of APTI was recorded for *P. orientalis* and *U. carpinifolia* and they were sensitive to air pollution.

**Key Words:** Tolerant plants, ascorbic acid, total chlorophyll, bioindicators.

## 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). Anticipated performance index of some tree species for green belt development to mitigate traffic produced noise was evaluated in Varanasi (Tripathi et al., 2011). Sensitive plant species were suggested to act as bioindicators. Levels of air pollution tolerance vary from species to species, depending on the capacity of plants to withstand the effect of pollutants without showing any external damage. The anticipated performance index (API) of 30 plant species has been evaluated for green belt development in and around an industrial urban area in India. Using air pollution tolerance index (APTI) and this performance rating, the most tolerant

plants have been identified. High values of APTI recorded in *Mangifera indica*, *Moringa pterydosperma*, *Cassia renigera* and *Ailanthus excels* (Shannigrahi et al., 2004). Different plant groups were classified into sensitive, intermediate, moderately tolerant. *Copiapoa gigantea*, *Copiapoa roseus*, were tolerant and *Dalbergia. sissou*, *L. chinensis*, *Copiapoa carandus*, *Copiapoa rottleri* were sensitive to air pollutant (Singh et al., 1991). Physiological responses of some tree species under roadside automobile pollution stress were assessed by finding out some physiological parameters, which included chlorophyll a, and b, total chlorophyll, carotenoids, ascorbic acid, pH and relative water content. Higher value of APTI was recorded for *Shorea robusta* while the minimum value of APTI was recorded for *Mangifera indica* (Joshi and Swami, 2007). 23 plant species growing near a Beijing steel factory, an air pollution point source were collected. Four physiological and biochemical parameters including leaf relative water content (RWC), ascorbic acid (AA) content, total leaf chlorophyll (TCh) and leaf extract pH were used to develop an APTI. Plant species tolerant or moderately tolerant to air pollution under various environmental conditions include non-trees (shrub, herb,

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vine) such as *Metaplexis japonica*, *Ampelopsis aconitifolia* var. *glabra*, *Rhamnus parvifolia*, *Ziziphus jujuba* var. *spinosa*, *Pharbitis purpurea*, *Vitex negundo*, and trees including *Broussonetia papyrifera*, *Robinia pseudoacacia*, and *Ailanthus altissima*. The APTI of species showed to be ideal candidate for landscape planting around polluting industry (Liu and Ding, 2008).

Air pollutants in urban and industrial areas may be accumulated or integrated into the plant body and, if toxic, may injure them to some degree. The level of damage will be high in sensitive species and low in tolerant ones. Sensitive species are useful as early warning indicators of pollution, and the tolerant ones help in reducing the overall pollution load, leaving the air moderately free of pollutants (Rao, 1983).

APTI of many plant species is evaluated by analyzing important biochemical features. The Anticipated Performance Index (API) of these plant species are also calculated by considering their APTI values with other socio-economic and biological parameters. Based on these two indexes, the most suitable plant species for green belt development in urban areas were identified and recommended for long-term air pollution management (Prajapati and Tripathi, 2008). Other studies showed the impacts of air pollutants on the parameters which also included ascorbic acid (Hogue et al., 2007), chlorophyll content (Flowers et al., 2007), leaf-extract pH (Klumpp et al., 2000), and relative water content (Rao, 1979). Some of tree species which are sensitive act as bioindicators of air pollution. APTI of ten plant species around the Erhoike- Kokori oil exploration station of Delta state. Four physiological and biochemical features (RWC, AA, TCh and leaf extract pH) were used to calculate the APTI values. The result showed that combining variety of these parameters gave a more reliable result than those of individual parameter (Agbaire, 2009). APTI was calculated for various plant species growing in the industrial areas of Visakhapatnam. The leaf samples collected from 24 tree species in industrial areas of Visakhapatnam city were used for the APTI by calculating the ascorbic acid, chlorophyll, pH, and relative water contents. Sensitivity and response of plants to air pollutants varied. The plant species which were more sensitive acts 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 determining resistance and susceptibility. Using plants as indicator of air pollution is the possibility of synergistic action of pollutants (Srinivas et al., 2008).

Keeping this fact in mind, the present study was designed to find out the possible air pollution tolerance plants species in and around the urban parks of Isfahan.

## MATERIALS AND METHODS

Isfahan is situated in Iran and lies at 32° 39' 35" N latitude and

51°40' 17" E longitude. The climate of Isfahan is generally semi arid with temperature from 24°C to 39°C on July. In a study carried out over a 30-year period (1966 to 1995), the average temperature of Isfahan province was estimated as 16.3°C, average relative humidity was 54 and 29% at 06.30 and 12.30 h, respectively. At 06:30 h, it was 54% and at 12:30 h, it was 29%; average annual rainfall was 122.7 mm, the maximum amount of rainfall on a single day was 48 mm, average number of days with the temperature below 0°C was 69.1, average number of hours of sunshine over the entire year was 3233.2 and maximum wind speed was 29 m/s; blowing in the direction of 300°. Leaf samples of ten tree species were collected from different streetscape of Isfahan. The samples were taken from the tree species in polluted area. Plants were randomly selected from the immediate vicinity of the station. Three replicates of fully matured leaves were used and then samples were preserved in a refrigerator. The experiments were replicated three times for each biological factor. Samples were quickly transported to the laboratory and leaf fresh weight was taken. Dry weight (DW) was adopted to express AA content and TCh. RWC was determined and calculated with the formula:

$$RWC = (Wf - Wd) \times 100 / (Wt - Wd)$$

Fresh weight was obtained by weighing the fresh leaf pieces on a balance (Wf). Then, these leaf pieces were weighed after immersing in water overnight to get Wt, which is the turgid weight. Next, leaf pieces were blotted to dryness and placed in a dryer at 105°C (2 h) and reweigh to get dry weight (Wd).

For TCh analysis, 0.5 g fresh leaves material were ground and diluted to 10 ml in distilled water. A subsample of 2.5 ml was mixed with 10 ml acetone and filtered. Optical density was read at 645 nm (D645) and 663 nm (D663). Optical density of TCh (CT) is chlorophyll a (D645) density and chlorophyll b (D663) density:

$$CT = 20.2 (D645) + 8.02 (D663).$$

TCh (mg/g DW) was calculated as follows:

$$TCh = 0.1 CT \times (\text{leaf DW}/\text{leaf fresh weight})$$

For Leaf extract pH determination, about 4 g of fresh leaves was homogenized in 40 ml deionized water and centrifuged at 7 000 g. Extract pH was measured with a photovolt pH meter at 25°C. AA content analysed (mg/g DW) was measured by using the colorimetric 2,6-dichlorophenol-indophenol (DIP) method. The air pollution tolerance index of ten tree species was calculated by following the 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, and R = relative water content of leaf tissue (%).

## RESULTS AND DISCUSSION

APTIs were calculated for the ten tree species growing in urban parks of Isfahan and are presented in Table 1. *A. altissima*, among the trees exhibited the highest APTI value of about 10.7076 followed by *R. pseudoacacia*, (9.8435), *Morus alba*, (9.6998) and *Cercis siliquastrum* (9.5242). Different plant species showed considerable variation in their susceptibility to air pollution.

**Table 1.** Air pollution tolerance index (APTI) of some tree species in urban parks of Isfahan.

S/N	Species	Tch	pH	RWC	AA	APTI
1	<i>Ailanthus altissima</i>	2.42	6.61	84.7	2.478	10.7076
2	<i>Robinia pseudoacacia</i>	2.85	6.63	80.3	1.913	9.8435
3	<i>Morus alba</i>	2.26	5.75	85.6	1.423	9.6998
4	<i>Cercis siliquastrum</i>	1.92	6.12	76.3	2.356	9.5242
5	<i>Eucalyptus camaldulensis</i>	2.98	5.63	81.6	0.650	8.7196
6	<i>Cupressus sempervirens</i>	1.76	5.66	72.4	1.568	8.4034
7	<i>Pinus eldarica</i>	1.85	6.23	70.2	1.415	8.1633
8	<i>Nerium oleander</i>	2.83	5.75	67.8	1.465	8.0369
9	<i>Ulmus carpiniifolia</i>	1.53	6.46	67.6	0.935	7.5070
10	<i>Platanus orientalis</i>	1.63	5.46	62.3	0.826	6.8156

AA = ascorbic acid; RWC = relative water content; Tch = total leaf chlorophyll.

The plants with high and low APTI can serve as tolerant and sensitive species, respectively. The APTI values of *A. altissima*, *R. pseudoacacia*, *M. alba* and *C. siliquastrum* were higher than for others and suggest that they were more tolerant to air pollution. Minimum values of APTI were recorded for *Platanus orientalis* and *Ulmus carpiniifolia*; they were sensitive to air pollution.

It is worth noting that combining a diversity of parameters gave a more reliable result than when a single biochemical parameter was used (Agbaire, 2009). Ascorbic acid plays a role in cell wall synthesis, defense and cell division. It is also a strong reducer and plays important roles in photosynthetic carbon fixation, with the reducing power directly proportional to its concentration. So, it was given top priority and used as a multiplication factor in the formula. High pH may increase the effectiveness of conversion from hexose sugar to AA, while low leaf extract pH showed good correlation with sensitivity to air pollution (Escobedo et al., 2008). High water content within a plant will help to maintain its physiological balance under stress condition such as exposure to air pollution when the transpiration rates are usually high. High RWC favors drought resistance in plants. If the leaf transpiration rate reduces because of the air pollution, plant cannot live well due to the inability to pull water up from the roots for photosynthesis (1 to 2% of the total). Then, the plants neither bring minerals from the roots to leaf where biosynthesis occurs, nor cool the leaf. The product of ascorbic acid, sum of leaf extract pH and total chlorophyll was added with the RWC in the APTI formula (Liu and Ding, 2008). Different plants respond in different ways to air pollution; therefore plants growing in actually polluted environment had higher APTI than those from less polluted environment.

The observations in this study suggest that plants have the potential to serve as excellent quantitative and qualitative index of pollution since biomonitoring of plants is an important tool to evaluate the impact of air pollution on plants. Among the different plant species selected

for this study, the tolerant plant species *A. altissima*, *R. pseudoacacia*, *M. alba* and *C. siliquastrum* can effectively be used in the air pollution evaluation. Therefore combining a variety of parameters can give a more reliable result than a single biochemical parameter. Furthermore, air pollution tolerance is affected by natural climate conditions such as temperature and humidity. This study also provides useful information to select tolerant species fit for landscape on sites continuously exposed to air pollutants.

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