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Assessment of air pollution sensitivity of some selected tree species of busiest roads of Lahore city

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Key words: Relative leaf water content, Relative pH, Ascorbic acid content, Total leaf chlorophyll content, Air pollution tolerance index (APTI).

Abstract

The research includes Air Pollution Tolerance Index (APTI) of commonly occurring tree of Mall road and Jail road of Lahore, Pakistan. In order to find out APTI, four species were selected i.e. *Alstonia scholaris* (L.) R.Br., *Callistemon citrinus* (Curtis) Skeels, *Ficus religiosa* L. and *Morus alba* L. The experiment was carried out by taking four aspects viz. pH, ascorbic acid, total chlorophyll and leaf water content (%) of leaf samples of these tree species. It was found that the *Ficus religiosa* was the most tolerant having APTI value 9.09, while *Callistemon citrinus* showed lowest value of 7.86 which indicated that it was most sensitive to air pollution.

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Introduction

Air pollution mainly occur due to anthropogenic activities like industrial processes, transportation, burning of coal or other fossil fuels for energy production, chemicals introduction in agriculture and facilities like landfills for waste deposition, power production, incinerators which brings abrupt changes in atmospheric chemistry (Daly and Zanetti, 2007; Prinn *et al.*, 2005). Rapid increase in vehicle population in Lahore city is creating environmental hazards. Along with this unplanned plantation along road sides and least interest by the authorities is also generating the pressure of pollution day by day in Lahore. WHO studies also confirmed the exceeding levels of pollutants especially the lead (Pb) levels. According to ambient air quality data, levels of primary and secondary pollutants in Lahore and Karachi considerably exceed WHO recommended levels. It was found that main industrial areas of Punjab are exceeding the levels of lead (Pb) as compared to the World Health Organization (WHO) levels (Khwaja and Khan, 2005).

Moreover, accumulation of particulate matter (PM) on road side plants is causing injury to plants. The chief sources for particulate matter are cars, buses, wagons, minibuses rickshaws, trucks and motorcycles which are liberating variety of pollutants in the air (Leghari and Zaidi, 2013). Thus Lahore city once known as the city of Gardens which is under immense pressure of haze around the city in most parts of the year, causing sever health issues to the people of and plants Lahore and due to this tremendous increase in pollution, Lahore know considered as one of the most polluted cities of Asia (Khan, 2015).

Present research work was planned to investigate air pollution tolerance index (APTI) of the planted trees along the two busiest roads i.e., Mall road and Jail road of the Lahore city. The main purpose of this study was to develop a list of plants which are having good tolerance capabilities against air pollution and also help to beautify the road sides of Lahore city by adopting better landscape strategies in form of good sensitive plants.

Unfortunately in Lahore, Pakistan no such work has been carried out yet. So, this study carries uniqueness of its own kind for the city. Moreover, in following lines the related research work of various scientists is presented in order to highlight the importance of this study. Das and Prasad (2010) examined seasonal variation in APTI of 20 plant species, 14 trees and 6 shrubs, growing in and around steel mills and concluded that *Acacia mangium* and *Swietenia mahagonia* were tolerant, *Anthocephelu sindicus, Caesalpinia Pulcherrima* and *Grevillearo busta* were moderately tolerant while *Albizialebbeck* and *Alastonia scholaris* were sensitive. Kuddus *et al.* (2011) determined APTI of 7 economically important plant species growing in industrial area and examined that *Mangifera indica* was tolerant while *Artocarpus* sp. was sensitive. Radhapriya *et al.* (2012) evaluated APTI of 27 selected plants growing around cement industry and observed that *Mangifera indica, Bougainvillea sp.* and *Psidum guajava* showed maximum tolerance. Babu *et al.* (2013) assessed APTI of seven different plant species growing around cement industry and observed that *Aegle marmelos, Cassia auriculata* and *Bougainvillea spectabilis* were tolerant plant species. Nwadinigwe (2014) evaluated air pollution tolerance index of some plant species around the industrial area and observed that *Duranta erecta* was the most tolerant while *Anacardium occidentale* was the most sensitive. After reviewing the literature, it was concluded that such lists of plants, who are tolerant to air pollution should be prepared and with the help of such lists, the road side plantation should be maintained in light of these recommended plants.

Materials and methods

Study area

Lahore is cosmopolitan city of Pakistan and it is burdened with increasing vehicles on the roads, so in order to find out tolerance of plants four tree species viz., 1. *Alstonia scholaris* L. 2. *Callistemon citrinus* (Curtis) Skeel 3. *Ficus religiosa* L. 4. *Morus alba* L. were selected from two busiest roads of Lahore city i.e. Mall road and Jail road.

Sampling of tree species

The samples were collected randomly and minimum five leaf samples of each tree species were collected and tested for various parameters like Total Chlorophyll Content (mg/g), Ascorbic Acid content, percentage of relative water content and Leaf extract pH.

Total Chlorophyll Content (mg/g)

Total chlorophyll content of the sampled tree species were calculated by following Singh *et al.* (1991).

Total chlorophyll (mg/g) = (20.2 X A645 + 8.02 X A663) × V/1000 × W

Where,

A645 = Absorbance at 645nm

V = Total volume of extract

A663 = Absorbance at 663nm

W = Weight of leaf material in gram

Ascorbic Acid content

Ascorbic acid content of the samples were find out after Keller & Schwager (1977)

$$\text{Ascorbic acid (mg/g)} = \frac{[\text{Eo-(Es-Et)}] \times V}{W \times V1 \times 1000}$$

Where,

W = Weight of the fresh leaf taken

V = Total volume of the mixture

V1 = Volume of the supernatant taken

Relative water content (%)

% relative content of the leaf samples were evaluated after Sivakumaran and Hall (1978)

$$\text{RWC (\%)} = \frac{\text{Initial weight-Dryweight}}{\text{Saturate weight-Dry weight}} \times 100$$

pH of leaf extract

For determination of leaf pH, 1 g of leaf sample was well homogenized with 50 ml distilled water and pH of the extract was measured with a digital pH meter (Hussain, 1989).

Air Pollution Tolerance Index (APTI)

The calculations for air pollution tolerance index level of all these four selected species of plants were performed after Singh & Rao (1983) which is as follows:

$$\text{Air Pollution Tolerance Index (APTI)} \frac{[A\ (T + P)] + R}{10}$$

A = Ascorbic acid content

P = pH of leaf extract

R = Relative water content of leaf (%)

T = Total chlorophyll content

Results and discussion

In order to find out the sensitivity of the plants against air pollution pressure, above four parameters were selected for the four tree species of Mall road and Jail road. In total four plant species, three replicated of each plant species were collected from both roadsides of Lahore city. These plant species are *Alstonia scholaris* (L.) R.Br., *Callistemon citrinus* (Curtis) Skeels, *Ficus religiosa* L. and *Morus alba* L. The results are as follows:

Total leaf chlorophyll content (mg/g)

Total chlorophyll content values of plants collected from Jail road and Mall road varied significantly and are represented in Table 1. Among plants collected from Mall road, *Morus alba* had the highest value of chlorophyll content i.e. 0.99 mg/g and *Alstonia scholaris* had the lowest chlorophyll value i.e. 0.31 mg/g. *Ficus religiosa* and *Callistemon citrinus* contains 0.67 mg/g and 0.50 mg/g of chlorophyll content respectively. Among Jail road plants, *A. scholaris* showed the highest chlorophyll content of about 0.44 mg/g followed by *M. alba* with chlorophyll value of 0.19 mg/g, *F. religiosa* 0.18 mg/g and *C. citrinus* with the lowest value i.e. 0.04 mg/g.

Total leaf ascorbic acid content (mg/g)

Total ascorbic acid content was highest in *C. citrinus* and lowest in *F. religiosa* among Mall road plants. *C. citrinus* consist of 0.0096 mg/g ascorbic acid content followed by *A. scholaris* with 0.0068 mg/g ascorbic acid value, *M. alba* 0.0056 mg/g and *F. religiosa* with the lowest value of 0.0050 mg/g. Among plants of Jail road, *A. scholaris* contains 0.0065 mg/g of ascorbic acid content followed by *C. citrinus* with ascorbic acid value of 0.0064 mg/g, *F. religiosa* 0.0056 mg/g and *M. alba* had the lowest value of 0.0045 mg/g.

The observed variations in ascorbic acid content of different plant samples of Jail road and Mall road was recorded in Table 1.

Table 1. Air pollution tolerance index of selected tree species of Mall road (S_1) and Jail road (S_2).

Tree species	Relative Leaf Water Content (%)		Total Chlorophyll Content (mg/g)		Total Ascorbic Acid Content (mg/g)		Relative pH		Air Pollution Tolerance Index (APTI)		Mean APTI
	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	
Alstonia scholaris (L.) R.Br.	86 ±2.70	81.9 ±5.31	0.31 ±0.04	0.44 ±0.41	0.0069 ±0.0029	0.0065 ±0.0002	7.20 ±0.06	6.73 ±0.02	8.19 ±.015	8.60 ±0.02	8.40 ±0.28
Callistemon citrinus (Curtis) Skeels.	85.4 ±3.30	71.8 ±1.57	0.50 ±0.12	0.04 ±0.01	0.0096 ±0.0015	0.0064 ±0.0006	6.50 ±0.09	7.26 ±0.03	7.18 ±.012	8.54 ±0.018	7.86 ±0.96
Ficu sreligiosa L.	89.8 ±0.15	92 ±4.64	0.67 ±0.14	0.18 ±0.04	0.0050 ±0.0016	0.0056 ±0.0002	7.13 ±0.05	6.76 ±0.03	9.20 ±0.021	8.98 ±0.019	9.09 ±0.15
Morus alba L.	89.9 ±2.48	84.8 ±1.66	0.99 ±0.16	0.19 ±1.96	0.0056 ±0.0013	0.0045 ±0.0004	6.64 ±0.07	7.25 ±0.05	8.48 ±0.015	8.99 ±0.021	8.73 ±0.41

± = Standard Error

Relative leaf water content (%)

Relative water content does not varied considerably among two different roadsides and in between the plant samples of each roadside. Relative water content (%) of Mall road and Jail road plants are recorded in Table 1. Amongst Mall road plants, *M. alba* contains 89.9% water content, *F. religiosa* 89.8%, *A. scholaris* 86% and *C. citrinus* 85.4%. In Jail road plants, *F. religiosa* had 92% water content, *M. alba* 84.8%, *A. scholaris* 81.9% and *C. citrinus* 71.8%.

Relative leaf pH

Among all four plants of Mall road, *A. scholaris* had the highest pH i.e. 7.20 followed by *F. religiosa* with 7.13 pH value. They both have basic pH. Other two plant species i.e *M. alba* and *C. Citrinus* with pH value 6.64 and 6.50 respectively are acidic. Within Jail road plants, *M. alba* and *C. citrinus* had basic pH i.e. 7.25 and 7.26 respectively and *A. scholaris* and *F. religiosa* had acidic pH i.e. 6.73 and 6.76 respectively. The variations of leaf relative pH value are shown in Table 1.

Air Pollution Tolerance Index (APTI)

This phenomenon does not varied significantly among Mall road plants. *M. alba* showed the highest level of air pollution tolerance index with a value of 8.99 followed by *F. religiosa* with an air pollution tolerance index of 8.98 and *A. scholaris* 8.60. *C. citrinus* had the lowest value of air pollution tolerance index i.e. 8.54.

Among Jail road plants air pollution tolerance index values varied significantly. *F. religiosa* had the highest value i.e. 9.20 followed by *M. alba* with second highest value i.e. 8.48.

Air pollution tolerance index for *A. scholaris* and *C. citrinus* was 8.19 and 7.18 respectively. All four parameters namely ascorbic acid content, chlorophyll content, relative water content and leaf extract pH along with the value of air pollution tolerance index are shown in Table 1 and the comparison of air pollution tolerance index of Mall road and Jail road depicted in Fig. 1, while the mean value of air pollution tolerance index of both the roads (Mall road and Jail road) is depicted in Fig. 2.

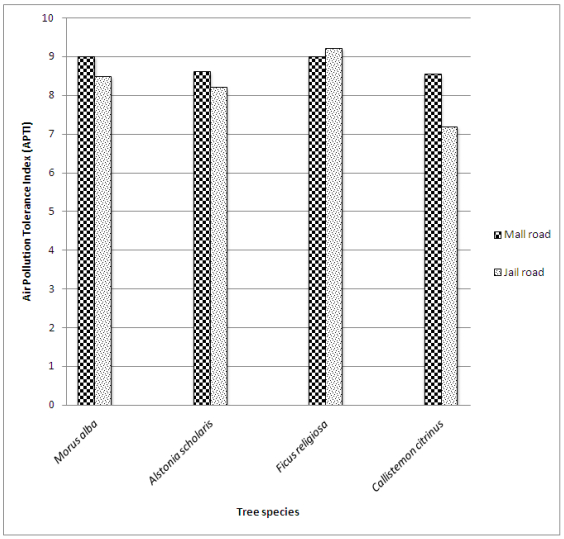

Fig. 1. Comparative values of air pollution tolerance index of selected tree species of two road locations.

Discussion

Urbanized cities like Lahore has tremendous pressure of air pollution which is ultimately causing injuries to the plants through various means and thus the effects of these injuries are found less in tolerant plant species. These tolerant plant species showed great role in biomonitering of air pollution (Seyyednjad, 2011).

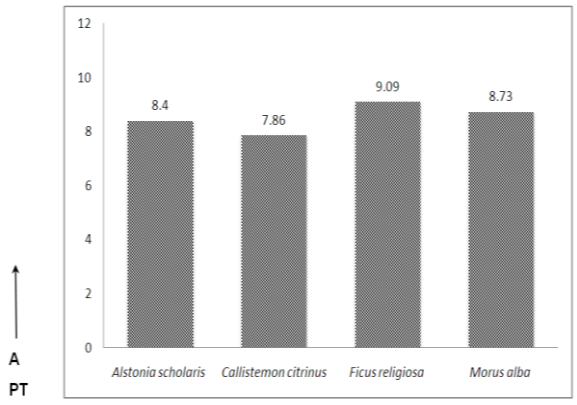

Fig. 2. Comparative Air Pollution Tolerance Index (APTI) of selected tree species.

The results showed that total chlorophyll content values were lesser in all four selected plant species of both Jail road and Mall road. It was in range of 0.99 to 0.31mg/g among plant species of Mall road and 0.44 to 0.04 mg/g among plant species of Jail road. Photosynthetic process of plant mainly depends upon the chlorophyll content of the plant and development of biomass; it varies from plant to plant due to leaf age, biotic, abiotic conditions and pollution levels (Katiyar and Dubey, 2001). Disintegration of these pigments in urbanized plants may occur due to atmospheric pollutants (Ninave *et al.*, 2001). Moreover, it is also found that pollution generated through automobiles is one of the biggest reason in decreasing chlorophyll content in plant growing along road sides (Tripathi and Gautam, 2007; Mir *et al.*, 2008). Thus the decrease in chlorophyll content of both roadsides plants may be due to the high levels of air pollution mainly automobile exhausts.

Along with this ascorbic acid content values were also less in all four selected plant species of both Mall road and Jail road. It ranged 0.0065 to 0.0045 mg/g among plant species of Jail road and 0.0096 to 0.0050 among plant species of Mall road. Ascorbic acid plays a pivotal role as reducing agent in synthesis of cell wall, cell division and defense (Conklin, 2001). Ascorbic acid act as an antioxidant and develops the mechanism of a plant to resist against the adverse atmospheric conditions (Keller and Schwager, 1977; Lima *et al.*, 2000).

Moreover, its high level in plants indicated high tolerance level of plant species against pollutions and its lower values rank the plants in sensitive category against air pollution (Chaudhary and Rao, 1977; Varshney and Varshney, 1984). Thus the results indicated the decrease in ascorbic acid content and high pollution stress on all four plant species of Mall road and Jail road due to automobile exhausts.

Amount of water content was found to be higher in all selected plant species of Mall road and Jail road. It was in the range of 85.4 to 89.9 in selected plants of Mall road and 71.8 to 92 in Jail road plants. Availability of water in plant cells is associated with protoplasmic permeability of cells and thus loss in water content and nutrients from the cells resulted in senescence of leaf in very early stage of plant life (Agrawal and Tiwari, 1997). The relation of water may decide the tolerance towards air pollution. As one study indicated that plants with greater RWC will have greater drought resistance, so it can be concluded that high water content in plants may lead the tree species as tolerant one (Verma, 2003; Dedio, 1975). Thus all the studied plants of Mall road and Jail road showed tolerance to air pollution with respect to relative water content.

Results showed that half of the plant species of Mall road and Jail road exhibited a pH towards acidic site and half towards basic side. The pH ranges between 6.50 to 7.20 in Mall road plants and 6.73 to 7.26 in Jail road plants. Scholz and Reck (1977) indicated that pollutants of acidic nature can lower the leaf pH and sensitivity of plant species as it was observed that low leaf pH will have sensitivity of the plants towards air pollution. Low leaf pH extract showed good correlation with sensitivity to air pollution and also reduce photosynthetic process in plants (Yan-Ju and Hui, 2008; Thakar and Mishra, 2010).

Plants having higher APTI values are found tolerant to air pollution as compared to the plants with lesser values (Singh and Rao, 1983). Moreover sensitivity of a plant species varies from area to area as they behave different atmospheric conditions (Raza *et al.,* 1985).
So the overall work of the present study indicates that all the selected plant species i.e *Alstonia scholaris* (L.) R.Br., *Ficus religiosa* L., *Callistemon citrinus* (Curtis) Skeels and *Morus alba* L. planted on Mall road and Jail road are sensitive to air pollution and thus plants served as best bio indicators/ bio monitors of pollution as one the selected plant (*Alstonia scholaris*) proved to be the best bio indicator capabilities around various roads of Lahore city (Muhammad, 2014).

Conclusion

It is obvious from the study that the automobile pollution of the Lahore city is creating problem not for the human life but also for the plants, apart from it plants are playing major role in combating the matters of the air pollution. Plants absorbed these pollutants and thus altering the chemistry of the plants and causes injuries to plants and plants become sensitive to pollution. This sensitivity of plant species can be measured through APTI and in our studies all four tree species were found sensitive according to categorization of Kalyani and Singaracharya (1995). Such studies should be carried out in urbanized cities in order to develop the list of appropriate plants for the mitigation and management of pollution through well develop landscape corridors of the city.

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