AIR POLLUTION TOLERANCE OF SELECTED TREE SPECIES ALONG ROADSIDES IN KANNUR, KERALA.

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ABSTRACT

A study was conducted to understand the air pollution tolerance as well as sensitiveness of selected avenue tree species along the roadsides in Kannur, Kerala. Four dicotyledonous trees such as *Mangifera indica* L., *Polyalthia longifolia* (Sonner) Thw., *Psidium guajava* L. and *Terminalia catappa* L. were selected for the study. Air Pollution Tolerance Index (APTI) was calculated by analyzing the total chlorophyll content, leaf extract pH, ascorbic acid content and relative water content. The study showed that the total chlorophyll content, leaf extract pH and relative water content were low for the trees at polluted site whereas the ascorbic acid in the leaves were high at the polluted sites than the non-polluted sites. *Polyalthia longifolia* is the most tolerant species since it has the least percentage change in APTI value between polluted and non polluted sites whereas *Psidium guajava* is highly sensitive to air pollution. *Terminalia catappa* and *Mangifera indica* are moderately sensitive to air pollution. The trees can be arranged in the order of their tolerance to air pollution as *Polyalthia longifolia* > *Terminalia catappa* > *Mangifera indica* > *Psidium guajava*.

Key words: Air pollution, APTI, Avenue trees

INTRODUCTION

Air pollution is defined as the discharge in to the atmosphere of foreign gases, vapors, droplets, particulates, or of excessive amount of normal constituents either from natural sources such as volcanoes or from man activities (WHO). India is seventh biggest country in the world. In India, being a developing country, the rapid industrialization and urbanization leads to different problems. Pollution is one such menace which is very difficult to tackle.

Air pollutant may originate from one or more variety of sources. The sources are mainly divided in to two types ie, natural sources and anthropogenic sources. The natural pollution sources are oceanic aerosol, volcanic emission, biogenic sources etc. Anthropogenic pollution originates from human activities. There are stationary sources and mobile sources. Stationary source refers to those sources which have relatively fixed location. It includes stacks and chimneys of power plants, steel plants and industries, surface mines, construction sites etc. A mobile source refers to the sources that emit air pollutants while moving state eg: Automobile train engines, airplanes and vehicle exhaust.

Air pollution is a major problem arising mainly from industrialization (Odilara et al., 2006). Man-made urban air pollution, which is derived largely from combustion processes, is a complex mixture containing many toxic components (Cohen, *et. al,* 2004). It is known fact that 60 % of air pollution in cities is caused by automobiles only (Gaikwad et al., 2004). Air pollutions can directly affect plants via leaves or indirectly via soil acidification (Steubing, et al., 1989). The resistance and susceptibility of plants to air pollutants can be determined by its physiological and bio-chemical levels (Randhi and

Reddy, 2012). It has also been reported that when exposed to air pollutants, most of the plants experience physiological changes before exhibiting visible damage to leaves (Dohmen et al., 1990). Therefore, plants can be effectively used as bioindicators of urban air quality (Mondal et al., 2011). The usefulness of evaluating Air Pollution Tolerance Index (APTI) for the determination of tolerance as well as sensitiveness of plant species were followed by several authors (Agrawal and Tiwari, 1997; Dwivedi and Tripathi, 2007; Liu and Ding, 2008). Plant selection criteria for avenue planting should not only be limited to colourful flower and leaves, robustness, watering issues and space but it should also be able to help improve air quality (Nugrahari et al., 2012).

The studies on avenue trees may help the planners to select the suitable tree species for roadside planting. However, a firsthand knowledge about the tolerance and sensitiveness of avenue trees towards air pollution is still lacking. Though there are some sparse studies already been carried out in the western countries, the information regarding the air pollution tolerance of avenue trees in India, especially in Kerala is meagre. Hence, the present study was conducted to understand air pollution tolerance as well as sensitiveness of selected avenue tree species along the roadsides in Kannur, Kerala.

MATERIALS AND METHODS

The present study was conducted along the roadsides from Dharmashala to Taliparamba of Kannur district, Kerala state. A site inside Sir Syed college campus, Taliparamba was selected as control station which is a benign environment. The study was carried out during January 2014 to May 2014.

Four dicotyledonous trees such as *Mangifera indica* L., *Polyalthia longifolia* (Sonner) Thw., *Psidium guajava* L. and *Terminalia catappa* L. were selected for the study. Fully mature leaves in triplicates were collected in morning hours from the selected trees of almost same diameter at breast height (DBH) and immediately taken to the laboratory for analysis. A site inside Sir Syed College campus with similar ecological conditions was selected as the control site. The fresh leaf samples were analyzed for total chlorophyll, ascorbic acid, leaf extract pH and relative water content using the standard procedures of Arnon (1949), Sadasivam and Manickam (1996), Varshney (1992) and Barr and Weatherly (1962) respectively for the evaluation of air pollution tolerance index.

Estimation of total chlorophyll content was carried out according to the method described by Arnon (1949). Fresh leaves (1g) were blended and then extracted with 25 ml of 80% acetone and left for 15 minutes for thorough extraction. The liquid portion was decanted into another test-tube and centrifuged for 3 minutes. The supernatant was then collected and the absorbance taken at 645nm and 663nm using a spectrophotometer. Calculations were done using the formulae given below

Chlorophyll a = 12.7(OD at 663) - 2.69(OD at 645) x V/1000W mg/g leaf tissue

Chlorophyll b = 22.9 (OD at 645) - 4.68(OD 663)x V/1000W mg/g leaf tissue

Total chlorophyll = 20.2(OD at 645) + 8.02(OD at 663) x V/1000W mg/g leaf tissue

Where, V = Total volume of the chlorophyll solution (ml)

W = Weight of the tissue extracted (g)

The percentage relative water content was calculated by using the initial weight, turgid weight and dry weights of leaf samples as explained by Barr and Weatherly (1962).

$$RWC = \frac{FW - DW}{TW - DW} \times 100$$

Where, FW = Fresh weight, DW = Dry weight, TW = Turgid weight

Fresh weight was obtained by weighing the fresh leaves. The leaves were then immersed in water over night, blotted dry and then weighed to get the turgid weight. The leaves were then dried overnight in an oven at 70°C and reweighed to obtain the dry weight.

Fresh leaf (0.5g) sample was homogenized using 50ml deionised water and the supernatant obtained after centrifugation was collected for detection of pH using a digital pH meter after calibrating the pH meter with buffer solution of pH 4 and 9.

For the determination of ascorbic acid content, 1 g of fresh sample were weighed and homogenized with 4% oxalic acid, and was dehydrogenated by bromination. The solution was centrifuged for 5 minutes and supernatant was collected. The dehydroascorbic acid was then reacted with 2, 4-dinitrophenyl hydrazine to form osazone crystals and dissolved in sulphuric acid to give an orange-red colour solution. This was then incubated at 37°C for 3 hrs. followed with the addition of concentrated conc. H_2SO_4. The absorbance of the solution was finally measured at 540nm using a spectrophotometer and compared against a standard ascorbic acid curve to find out the amount of ascorbic acid present in the test sample.

Finally, Air Pollution Tolerance Index (APTI) of all the species were calculated following the method of Singh and Rao, 1983. The formula of APTI is given as

$$APTI = \frac{A(T+P) + R}{10}$$

Where, A = Ascorbic acid content (mg/g)

T = Total chlorophyll (mg/g)

P = pH of leaf extract

R = Relative water content of leaf %

RESULTS

The present study analysed four biochemical parameters such as the total chlorophyll, leaf extract pH, relative water content and ascorbic acid content to determine the Air Pollution Tolerance Index (APTI) value. The results are shown in Table 1.

Table 1. Total Chlorophyll Content (TCh), Leaf extract pH, Relative Water Content (RWC), Ascorbic Acid content (AA) and Air Pollution Tolerance Index (APTI) of tree species studied

Species	Site	TCh (mg/g)	pH	RWC (%)	AA (mg/g)	APTI	% change in APTI
Mangifera indica	ES	2.03	5.31	61.8	10.22	13.68	14.6
	CS	3.24	6.85	81.5	7.80	16.02	
Terminalia catappa	ES	2.08	4.65	60.5	9.30	12.31	10.6
	CS	2.36	4.90	75.0	5.00	11.13	
Polyalthia longifolia	ES	1.28	5.81	67.3	8.13	12.49	3.5
	CS	1.37	5.94	78.9	6.92	12.95	
Psidium guajava	ES	2.33	4.90	47.9	8.37	10.84	27
	CS	4.20	5.65	70.8	7.89	14.85	

Total chlorophyll content was highest for *Psidium guajava* in the control site (4.2 mg/g leaf tissue) and lowest for *Polyalthia longifolia* in the experimental site (1.28 mg/g leaf tissue). All tree species studied showed a decrease in total chlorophyll content in the experimental sites when compared to the control sites (fig. 1).

The leaf extract pH showed decrease in the experimental sites when compared to the control sites for all the trees studied. This means that the leaves exposed to the polluted sites are more acidic than the leaves of the plants in non-polluted site. Lower most pH was observed in *Terminalia catappa* in the experimental site (4.65) whereas the pH value was highest for *Mangifera indica* in the control site (6.85). The same is depicted in fig. 2

Relative Water Content was highest for *Mangifera indica* in the control site (81.5%) and lowest for *Psidium guajava* in the experimental site (47.9%). All tree species showed a decrease in Relative Water Content in the experimental sites when compared to the control sites. The variation is more observed in the case of *Psidium guajava*. A comparison of relative water content in the leaves of the trees between the experimental and control sites is shown in figure 3.

All tree species studied showed an increase in the Ascorbic Acid content in the experimental sites when compared to the control sites. Ascorbic Acid content was highest for *Mangifera indica* in the experimental site (10.22 mg/g leaf tissue) and lowest for *Terminalia catappa* in the control site (5.0 mg/g leaf tissue). A comparison of ascorbic acid content in the leaves of the trees between the experimental and control sites is shown in figure 4.

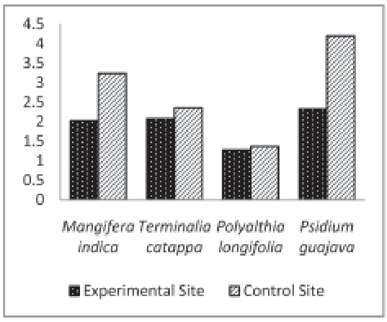


Figure 1. Comparative data on chlorophyll content of the trees between the experimental and control sites

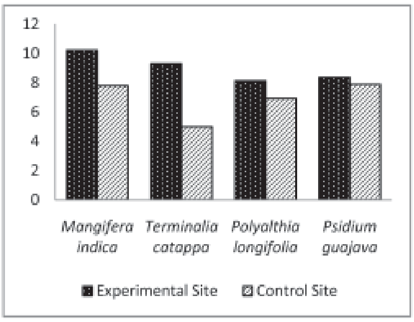
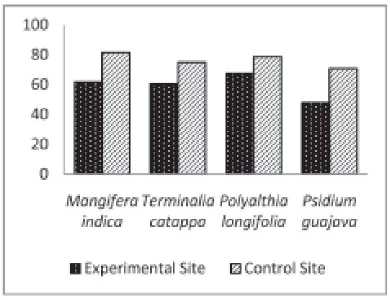


Figure 2. Comparative data on leaf extract pH of the trees between the experimental and control sites

Figure 3. Comparative data on relative water content in the leaves of the trees between the experimental and control sites



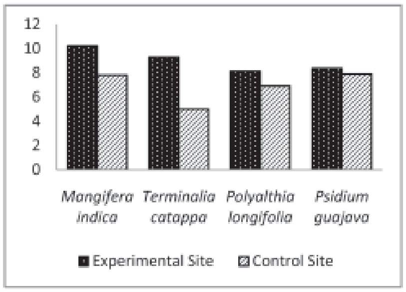


Figure 4. Comparative data on ascorbic acid content in the leaves of the trees between the experimental and control sites

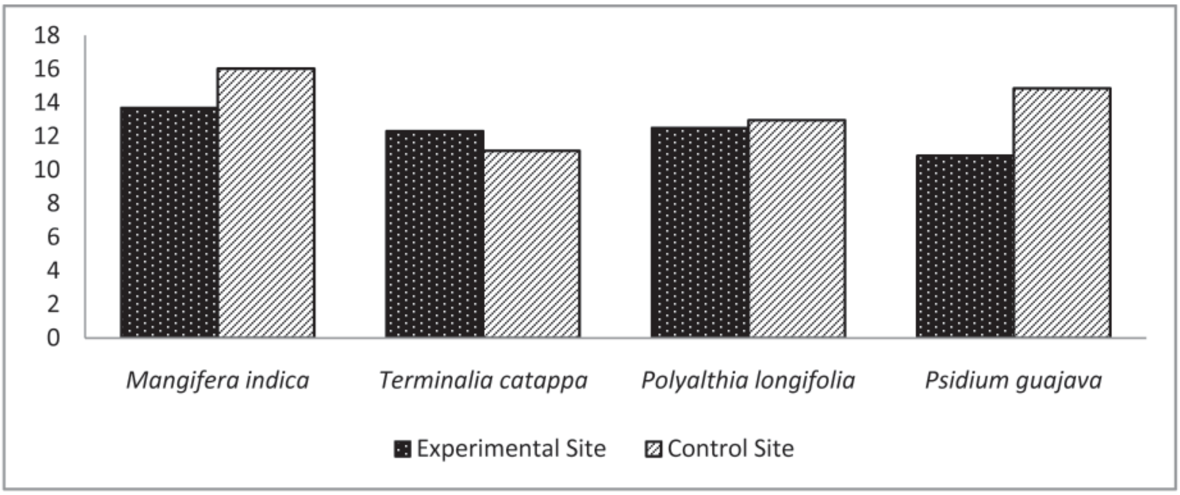


Figure 5. Comparative data on Air Pollution Tolerance Index (APTI) of the trees between the experimental and control sites

The APTI value showed a decrease in the experimental site when compared to the control site in the case of *Mangifera indica*, *Polyalthia longifolia* and *Psidium guajava* whereas for *Terminalia catappa*, the value was found increasing in the experimental site when compared to the control site. In the experimental sites, APTI value was highest for *Mangifera indica* (13.68) and lowest for *Psidium guajava* (10.84). A comparison of APTI values between the experimental and control sites for all the three species is graphically shown in fig. 5.

The percentage change in the APTI value shows sensitiveness as well as tolerance nature of the trees to air pollution (Table 1). Here, *Psidium guajava* showed more change in value between the experimental and control sites. This shows that this species is more sensitive to air pollution. This was followed by *Terminalia catappa* and *Mangifera indica* which are moderately sensitive to air pollution. However, the percentage change in APTI was observed very less in the case of *Polyalthia longifolia*. This means that *Polyalthia longifolia* is highly tolerant to air pollution.

DISCUSSIONS

The present study observed a decrease in the total chlorophyll content in the trees at the polluted site when compared to the trees of the non-polluted site. The same was observed by Jyothi and Jaya (2010). Chlorophyll content of plants signifies its photosynthetic activity as well as the growth and development of biomass. It is well evident that chlorophyll content of plants varies from species to species; age of leaf and also with the pollution level as well as with other biotic and abiotic conditions (Katiyar and Dubey, 2001). Degradation of photosynthetic pigment has been widely used as an indication of air pollution (Ninave et al., 2001). Air pollutants make their entrance into the tissues through the stomata and cause partial denaturation of the chloroplast and decreases pigment content in the cells of polluted leaves (Tripathi et al.,2009; Mandal and Mukherji, 2000; Wang and Lu, 2006).

The present study revealed that the pH level in leaves is less in the case of trees subjected to vehicular pollution. This may be due to the presence of some acidic pollutants in the area. Scholz and Reck (1977) have reported that in presence of an acidic pollutant, the leaf pH is lowered and the decline is greater in sensitive species. A shift in cell sap pH towards the acid side in presence of an acidic pollutant might decrease the efficiency of conversion of hexose sugar to ascorbic acid. However, the reducing activity of ascorbic acid is pH dependent being more at higher pH and lesser at lower pH.

Hence, the leaf extract pH on the higher side gives tolerance to plants against pollution (Agrawal, 1988).

Relative Water Content (RWC) of a leaf is the water present in it relative to its full turgidity. The present study shows that the RWC in the leaves is more at non-polluted site and it is less at the polluted site. The relative water content in a plant body helps in maintaining it's physiological balance under stress conditions of air pollution (Dedio, 1975). It is associated with protoplasmic permeability in cells resulting loss of water and dissolved nutrients, thereby early senescence of leaves (Agrawal and Tiwari, 1997). Therefore the plants with high relative water content under polluted conditions may be tolerant to pollutants.

The present study showed an increase in the amount of ascorbic acid in the leaves of the trees at the polluted site whereas it is less in non-polluted site. Increase in the concentration of ascorbic acid in the leaves of trees near roadsides due to enhanced pollution loads of automobiles was also reported by several other studies (Jyothi and Jaya, 2010; Tripathi and Gautam, 2007). Lower ascorbic acid contents in the leaves of tree species studied supports the sensitive nature of these trees towards pollutants particularly automobile exhausts. Cheng et al., (2007) opined that the increased level of ascorbic acid reported may be due to the defence mechanism of the respective plants.

Different plant species shows considerable variation in their susceptibility to air pollution. The change in the APTI value between the polluted and non-polluted sites shows sensitiveness as well as tolerance nature of the trees to air pollution. If the value changes in high rate, that species may be highly sensitive to air pollution. Similarly if there is no considerable change in the APTI value between the polluted and non-polluted sites, that species may be tolerant to air pollution. Hence, in the present study, the trees can be arranged in order of their tolerance to air pollution as *Polyalthia longifolia* > *Terminalia catappa* > *Mangifera indica* > *Psidium guajava*. High dust collecting capacity may be one of the reasons for the sensitive plant species studied to become highly susceptible to the auto-exhaust pollutants, making reduction or increase of different biochemical and physiological parameters (Singh, 2005). Sharma and Butler (1975) reported that plants that are constantly exposed to environmental pollutants absorb, accumulate and integrate these pollutants into their systems. They further reported that depending on their sensitivity level, plants show visible changes which would include alteration in the biochemical processes or accumulation of certain metabolites. From the result obtained, it has been observed that *Polyalthia longifolia* is the more tolerant species since it has the least percentage change in APTI values between polluted and non-polluted sites whereas *Psidium guajava* is highly sensitive to air pollution. *Terminalia catappa* and *Mangifera indica* are moderately sensitive species.

Conclusion

The findings of the present study may be helpful while selecting species for roadside planting and also when constructing greenbelts in cities and industrial areas. However, more studies are required in this line on other species as well to get more choice of selection. The present study recommends *Polyalthia longifolia* for road side planting since it is the most tolerant species to air pollution whereas *Terminalia catappa* and *Mangifera indica* can be used for planting in avenues and parks with comparatively less vehicular and other kind of air pollution. *Psidium guajava* can be used for biomonitoring of air pollution since it is very sensitive to air pollution.

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