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Biochemical Parameters of selected Plants as Air Pollution Indicators

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ABSTRACT

Air pollution is considered to be one of the major issues throughout the globe majorly in many developing cities like Hyderabad. Addressing this kind of pollution is more complicated than other ecological challenges. In present study is aimed at assessing the air pollution tolerant plant species from two different locations in Hyderabad city. The study was carried out by using commonly available eighteen selected plant species from polluted and control areas. Their Air Pollution Tolerance Index (APTI) was determined by using biochemical parameters viz. pH, Ascorbic acid, Total Chlorophyll, and Relative Water Content (RWC) to calculate APTI by using the standard method. The present study reveals that the control site has more APTI than the polluted site. The lowest APTI was found in Hibiscus rosasinencis (5.24) whereas the highest APTI was found in Syzygium cumini (11.83). The minimum APTI reduction percentage compared to the control site was observed in Bougainvillea glabra (3.82%) and maximum in Pdilanthus tithimiloides (28.92%). Percentage of Reduction in APTI at polluted site showed that Pdilanthus tithimiloides (28.92%) > Casia fistula (28.75) > Pongamia pinneta (24.36%) > Senna auriculata (23.55%) > Lantana camara (23.15%) > Hibiscus rosasinencis (22.02%) > Tinospora cardifolia (17.00%) > Psidium guava (15.79%) > Mangifera indica 15.65%) > Albizia lebbeck (14.77%) > Catharanthus roseus (13.55%) >Azadirecta indica (13.00%) > Annona reticulata (12.47%) > Baliospermum solanifolium (6.71%) > Syzygium cumini (5.83%) > Couroupita guianensis (5.52%) > Ficus religiosa (5.65%) > Bougainvillea glabra (3.82%) were more sensitive tree species. The tolerant tree species can be served as a sink, and sensitive tree species can act as an indicator for air pollution moderation. Thus, this study provides valuable insight for selecting tolerant plant species for future planning and greenbelt development in and around the industrial regions of Hyderabad city. For reducing air pollution and improving the health of humans and environment.

Keywords: *Ascorbic acid, Chlorophyll, Relative water content, pH, Air pollution tolerance index, Greenbelt, Air pollution, plants.*

INTRODUCTION

Due to rapid industrialization and urbanization, the cities have made air pollution an extremely major concern, as pollution is considered to be a major issue, which can change metabolic processes in many organisms. Majorly developed metropolitan cities are more vulnerable as these are more prone to increased levels of air pollution. Over the past few decades number of developing cities, witnessed a substantial increase in the population. Moreover, with the expansion of cities, urbanization reached industrial regions. The expanding cities in developing countries like India are at the receiving end as they face the rage of industrial air pollution significantly. Harmful exhaust from the factories is the primary reason for the increase in air pollution in the cities. Generally, trees play a vital role in improving air quality by exchanging gases as they act as a sink for the air pollutants to remove particulate matter by acting as living filters to minimize air pollution [1]. Trees exposed to environmental pollutants absorb, accumulate, and integrate these pollutants into their systems, depending on their sensitivity level. Plants show visible damages, which were due to alteration of the biochemical processes or accumulation of individual metabolites. These changes were considered for the assessment of APTI (Air Pollution Tolerance Index) of different plant species. Various researchers have carried out investigations on air pollutants through plants when they are exposed to air pollution to find out that most of the plants experience physiological changes before revealing visible damage. The plant's reaction was observed, and after the analysis of some biological parameters of each species the tolerance level of the plants was determined. In the present study, four parameters (ascorbic acid, total chlorophyll content, relative water content, and leaf extract pH) were analyzed and expressed together in one formula to evaluate the sensitivity of plants to air pollutants. APTI determines the plant's reaction to air pollution and the plant's ability to fight against air pollution [2-4].

Earlier industries used to be set up quite far from the residential areas. However, rapid urbanization brought both industrial and residential areas so close that now there is no distinct barrier between industrial and residential areas in developing countries. As a result, deterioration of air quality is the major environmental problem in urban areas, as in the case of Hyderabad. Human beings and plants in urban areas are the worst sufferers of air pollution as they are getting affected adversely. All the species of plants tend to respond differently to diverse pollutants and climatic conditions. Hence, the present study was carried out to understand the resistance and adaptability of plants toward air pollution [5-11].

The current study is about the vulnerability levels of commonly growing tree species in the industrial regions based on air pollution tolerance indices. Biological monitoring of plant tolerance towards air pollution helps select tolerant and sensitive plants as a bioindicator of air pollution. The plants with the minimum tolerance index value were sensitive to air pollution. At the same time, plants with high tolerance index values were tolerant to air pollution. Susceptible species help in mitigating air pollution, while less susceptible species act as an indicator. Greenbelt developers can employ the results of the study in managing industrial air pollution [12-15].

MATERIALS AND METHODS

Chemicals and Reagents

All the chemicals and mixtures used were of investigative grade. Acetone, magnesium carbonate, oxalic acid, distilled water, standard pH solution (buffer). 2, 6 dichlorophenol indophenol, acetic acid, sulphuric acid, and standard Ascorbic acid were used.

Study Area and Sampling

Hyderabad city is located in Telangana State and belongs to the Deccan Plateau region, the city lies between 17.3850° N, 78.4867° E and is spread over an area of 650 km^2 and has a population of 6,809,970 making it the fourth most populous city in India. There are 3,500,802 male and 3,309,168 female citizens. The maximum temperature ranges from 39 °C and 43 °C during summer, and the minimum temperature is between 13 °C to 17 °C during the winter months of November-January. The average rainfall is about 136.1 millimeters received during the rainy season from June to the end of September. The climate of the region is hot and humid. Sampling sites are located in Hyderabad. For the present study, the control plant species were selected from Osmania university Botanical garden area and sample plant species were selected from the Balanagar industrial region in the winter season of October in the year 2020.

Collection of plant material

Fresh leaves were collected from each plant species from both the sites (control and polluted). Present work was designed to assess the effects of air pollution on plants; hence, 18 commonly available plants were uncovered in Industrial areas like *Syzygium cumini*, *Bougainvillea glabra*, *Ficus religiosa* , *Couroupita guianensis*, *Catharanthus roseus*, *Baliospermum solanifolium*, *Annona reticulate*, *Mangifera indica*, *Lantana camara*, *Albizia lebbeck*, *Casia fistula*, *Senna auriculata*, *Pongamia pinneta*, *Azadirecta indica*, *Tinospora cardifolia*, *Pdilanthus tithimiloides*, *Psidium guava and Hibiscus rosasinencis.*

All selected plants were recognized with the help of available standard literature and verified with the help of experts in the field of taxonomy from the Department of Botany, Osmania University, Hyderabad, India. Samples from healthy and fully matured leaves of

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each plant were gathered through random selection from the bottommost position. Further analysis was carried out in the Environmental science laboratory. Leaves were used for the study. It was washed with the running tap water, rinsed with distilled water, and then used for further research.

RESULTS

Total Chlorophyll

Total chlorophyll was founda maximum of 8.08 mg/g in *Psidium guava* and minimum 2.15mg/g in *Lantana camara*. The study revealed that total chlorophyll decreased significantly in plant leaves in the polluted industrial area as compared to the control area. A reduction in chlorophyll content was observed is minimum in Cassia fistula (1.98%). Reduction in chlorophyll content found the maximum for *Syzygium cumini* (29.56). the results were depicted in the figure 1. The reduction percentage of total chlorophyll content is seen is *Syzygium cumini* (29.56) > *Annona reticulate* (24.09) > *Hibiscus rosasinencis* (23.46) > *Azadirecta indica* (17.15) > *Bougainvillea glabra* (12.12) > *Mangifera indica* (9.90) > *Tinospora cardifolia* (7.10) > *Lantana camara* (6.97) > *Catharanthus roseus* (6.92) > *Psidium guava* (5.81) > *Senna auriculata* (5.6) > *Baliospermum solanifolium* (4.62) > *Albizia lebbeck* (4.60) > *Couroupita guianensis* (3.2) > *Pongamia pinneta* (2.83) >*Ficus religiosa* (2.77) > *Pdilanthus tithimiloides* (2.17) > *Casia fistula* (1.98).

Leaf extract pH

The pH of leaf extract was found the maximum *Tinospora cardifolia* 8.6 and the minimum in *Pongamia pinneta*, *Baliospermum solanifolium*, *Mangifera indica*, *Azadirecta indica* (7.1). The leaf extract pH plays a significant role in regulating the SO_2 sensitivity of plants. The change observed in leaf extract pH followed the minimum for *Bougainvillea glabra* (1.35). The difference observed in leaf extract pH found the maximum for *Tinospora cardifolia* (20.93%) which is depicted in figure 2.

The reduction percentage of total pH is seen as *Tinospora cardifolia* (20.93) > *Senna auriculata* (15.38) > *Baliospermum solanifolium* (9.85) > *Mangifera indica* (7.14 =) > *Pdilanthus tithimiloides* (6.57) > *Syzygium cumini* (5.40) > *Psidium guava* (4.76) > *Hibiscus rosasinencis* (4.05) > *Annona reticulate* (3.94) >*Albizia lebbeck* (3.57) > *Catharanthus roseus* (2.66) > *Lantana camara* (2.43) > *Couroupita guianensis* (2.43) >*Azadirecta indica* (1.40) > *Pongamia pinneta* (1.40) > *Ficus religiosa* (1.38) > *Casia fistula* (1.36) > *Bougainvillea glabra* (1.35).

Relative water content (RWC)

The RWC was found maximum *Syzygium cumini* (88.90%) and minimum in *Tinospora cardifolia* (31.94%). The study revealed that RWC decreased in plant leaves at the polluted area when compared to the control area. Which is shown in figure 3.

Casia fistula (56.44) > *Lantana camara* (26.29) > *Pongamia pinneta* (24.11) > *Hibiscus rosasinencis* (24.09) > Tinospora cardifolia (14.62) > *Mangifera indica* (13.89) > Psidium guava (13.55) > *Catharanthus roseus* (12.40) > *Senna auriculata* (11.11) > *Annona*

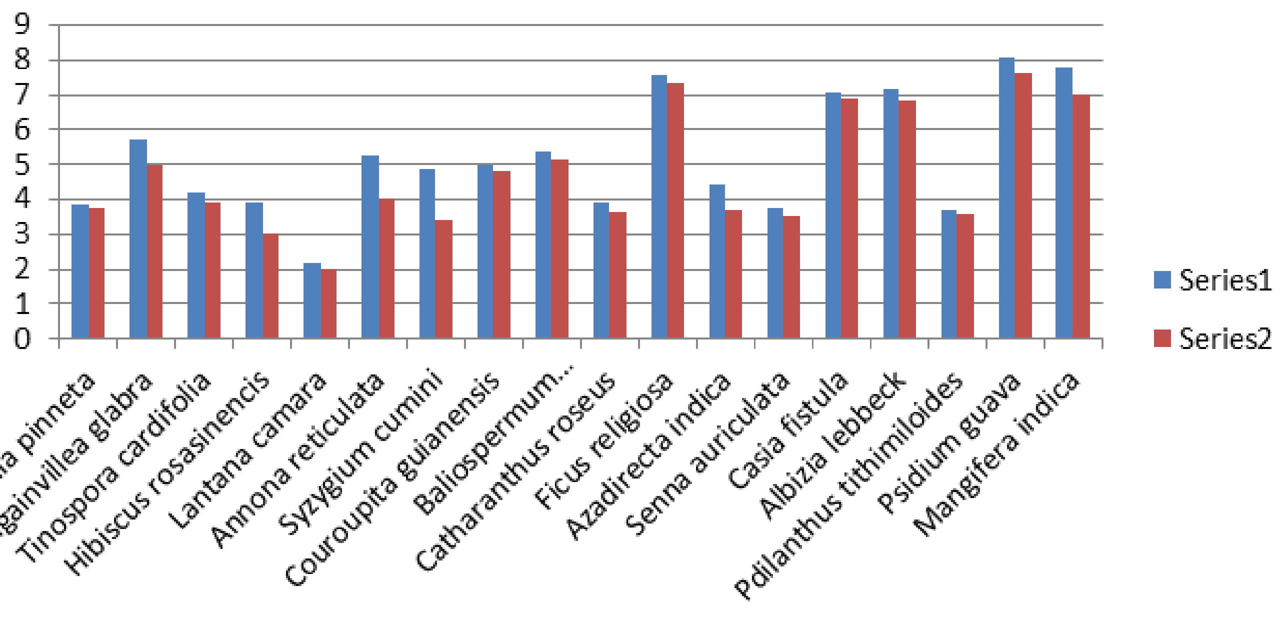

Figure 1: Comparative graph of Total Chlorophyll content of control and industrial region

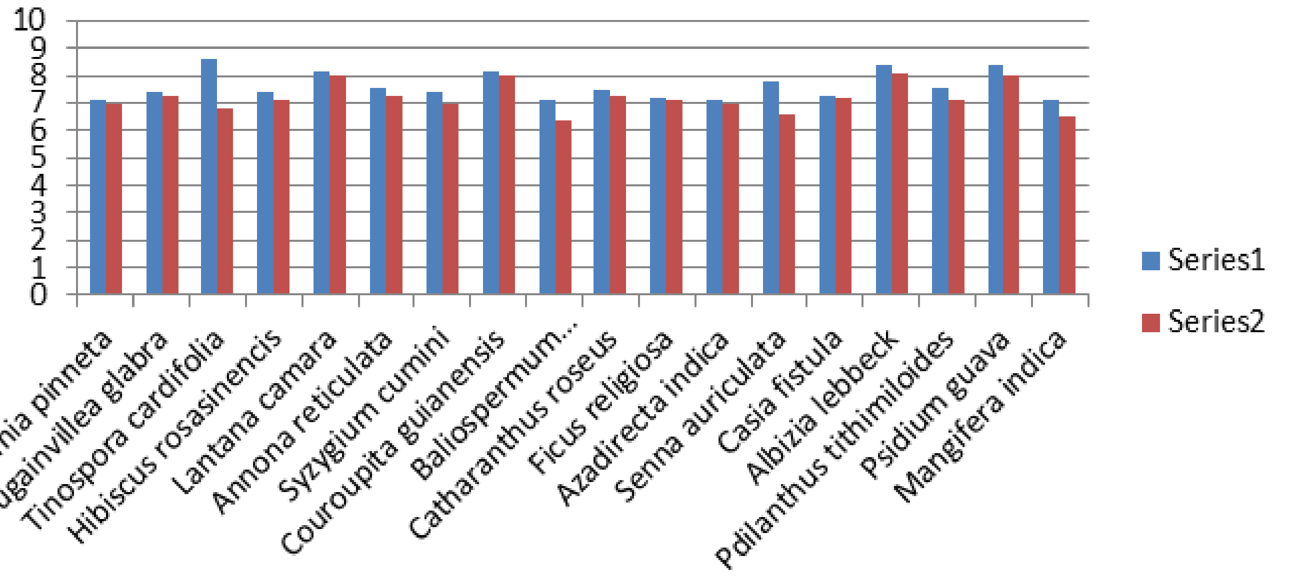

Figure 2: Comparative pH of plant species

reticulate (10.42) > *Pdilanthus tithimiloides* (8.33)> *Azadirecta indica* (7.41) > *Albizia lebbeck* (4.76) > *Bougainvillea glabra* (1.96) > *Syzygium cumini* (1.57) >*Baliospermum solanifolium* (1.56) > *Couroupita guianensis* (1.08) > *Ficus religiosa* (0.87).

0% Reduction in ascorbic acid content was observed in the maximum Senna auriculata (52.38%) shown in figure 4.

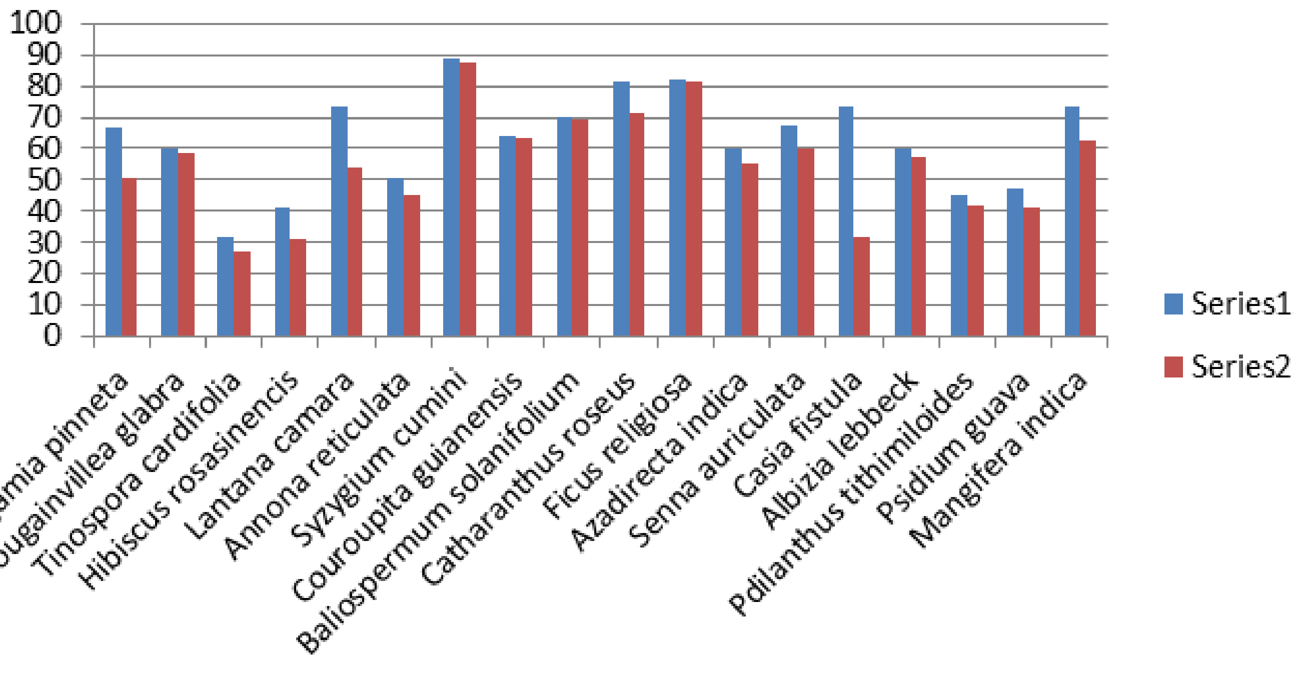

Figure 3: Comparative Relative water content of plant species

Ascorbic acid

The ascorbic acid content found the maximum in Bougainvillea glabra 4 mg/g fr. wt. Whiletheminimum in Catharanthus roseus is 1.2 mg/g fr. wt. Plants were maintaining high ascorbic acid under pollutant conditions considered as tolerant to air pollution. The study revealed that ascorbic acid decreased significantly in plant leaves in the polluted area as compared to the control area. Reduction in ascorbic acid content was found the minimum is Bougainvillea glabra

The reduction percentage of total Ascorbic acid content is seen is

Senna auriculata (52.38%) > *Pdilanthus tithimiloides* (39.28%) > *Azadirecta indica* (28.57%) > *Albizia lebbeck* (25.00%) > *Pongamia pinneta* (23.80%) > *Baliospermum solanifolium* (21.42%) > *Casia fistula* (16.66%) > *Psidium guava* (16.66%) > *Ficus religiosa* (16.66%) > *Catharanthus roseus* (16.66%) > *Mangifera indica* (14.28%) > *Couroupita guianensis* (13.04%) > *Lantana camara* (11.53%) > *Hibiscus*

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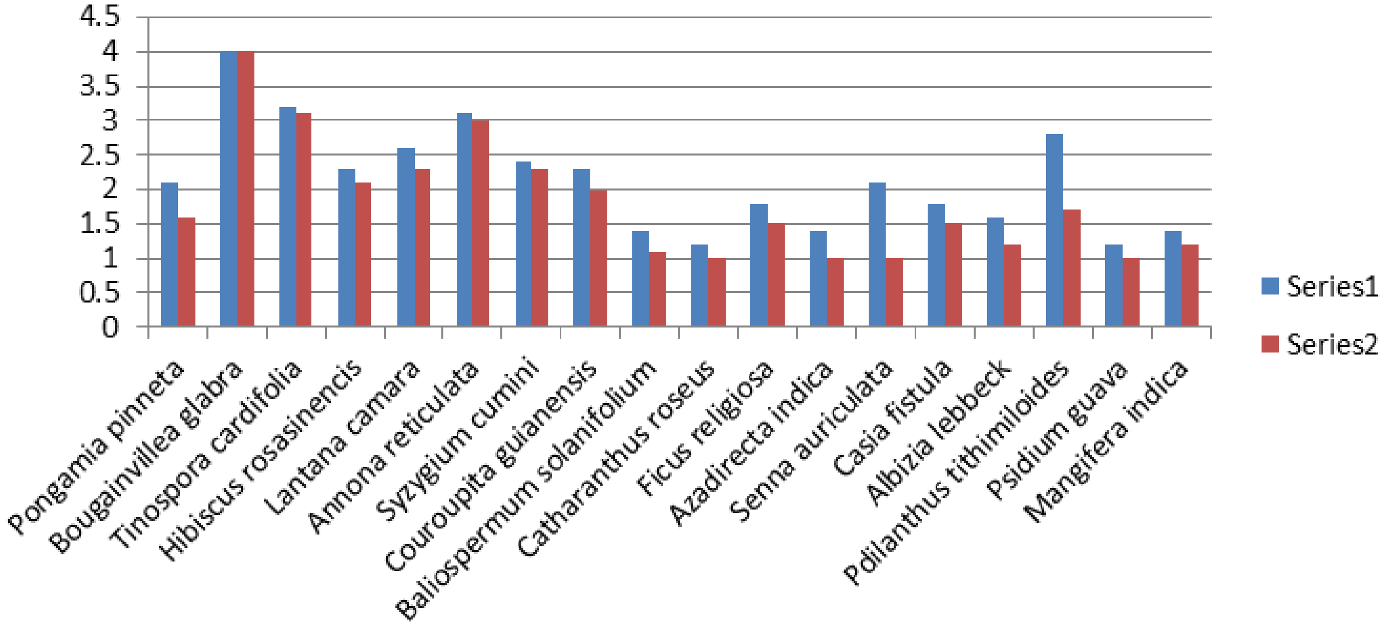

Figure 4: Comparative Ascorbic acid content of plant species

rosasinencis (8.69%) > *Syzygium cumini* (4.16%) > *Annona reticulate* (3.22%) >*Tinospora cardifolia* (3.12%) > *Bougainvillea glabra* (0%).

Air pollution tolerance indices (APTI)

APTI index shows the capability of a plant to fight against air pollution. The APTI was found minimum in *Psidium guava* (6.71) and the maximum in *Syzygium cumini* (11.83). The study reveals that the control site has more APTI than the polluted site. Reduction in APTI was observed the minimum is for *Bougainvillea glabra* (3.82%), Table 1 has shown that decreasing in percentage of APTI was observed as *Pdilanthus tithimiloides* (28.92%). > *Casia fistula* (28.75) > *Pongamia pinneta* (24.36%) > *Senna auriculata* (23.55%) > *Lantana camara* (23.15%) > *Hibiscus rosasinencis* (22.02%) > *Tinospora cardifolia* (17.00%) > *Psidium guava* (15.79%) > *Mangifera indica* 15.65%) > *Albizia lebbeck* (14.77%) > *Catharanthus roseus* (13.55%) > *Azadirecta indica* (13.00%) > *Annona reticulata* (12.47%) > *Baliospermum solanifolium* (6.71%) > *Syzygium cumini* (5.83%) > *Couroupita guianensis* (5.52%) > *Ficus religiosa* (5.65%) > *Bougainvillea glabra (3.82%)* shown in figure 5.

Table 1: APTI decreasing percentage

S. No	Name of the Plant species	Control (OU)	APTI of polluted areas	% Decrease in APTI
1	*Pongamia pinneta*	8.99	6.8	24.36
2	*Bougainvillea glabra*	11.23	10.8	3.82
3	*Tinospora cardifolia*	7.29	6.05	17.00
4	*Hibiscus rosasinencis*	6.72	5.24	22.02
5	*Lantana camara*	10.02	7.7	23.15
6	*Annona reticulata*	9.06	7.93	12.47
7	*Syzygium cumini*	11.83	11.14	5.83
8	*Couroupita guianensis*	9.42	8.9	5.52
9	*Baliospermum solanifolium*	8.78	8.19	6.71
10	*Catharanthus roseus*	9.52	8.23	13.55
11	*Ficus religiosa*	10.89	10.33	5.14
12	*Azadirecta indica*	7.61	6.62	13.00
13	*Senna auriculata*	9.17	7.01	23.55
14	*Casia fistula*	9.91	7.06	28.75
15	*Albizia lebbeck*	8.8	7.5	14.77
16	*Pdilanthus tithimiloides*	7.71	5.98	28.92
17	*Psidium guava*	6.71	5.65	15.79
18	*Mangifera indica*	9.39	7.92	15.65

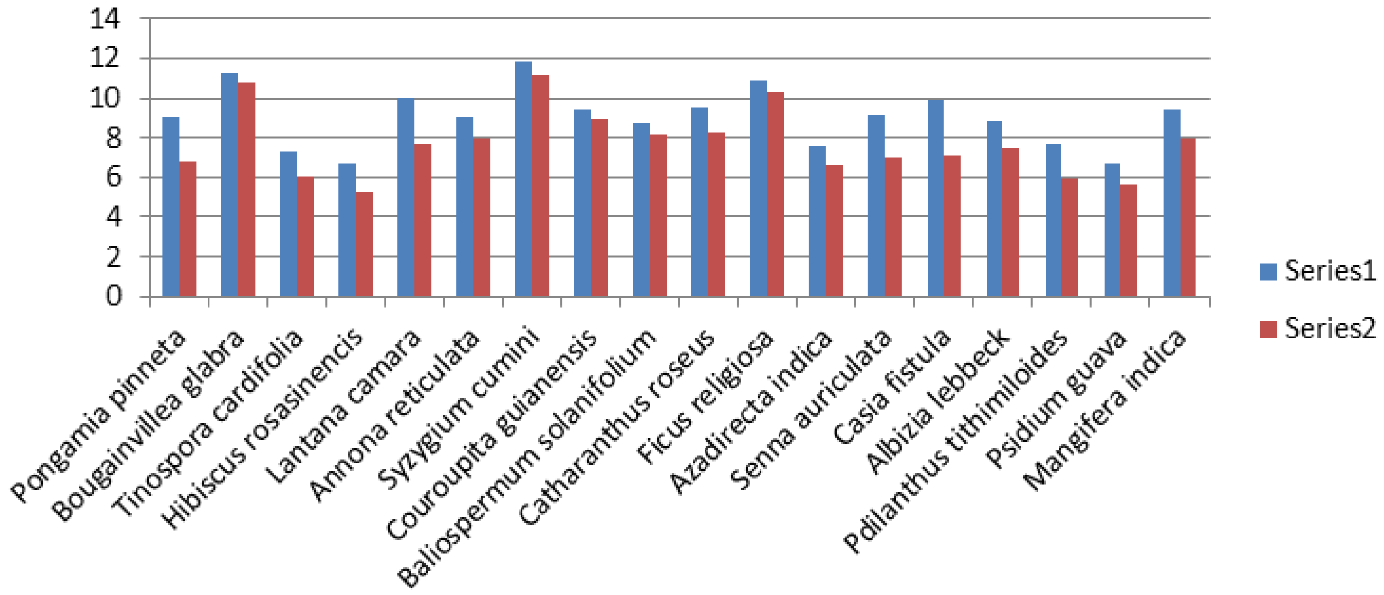

Figure 5: Comparative Air pollution Tolerance indices of plant species

DISCUSSION

Tremendous pressure of air pollution is faced by the Developed cities, which is ultimately causing injuries to the plants through several means, the effects of these injuries were found on less intolerant plant species. These tolerant plant species showed a significant role as bio-indicators of air pollution.

Among the plant species which were selected from the polluted site, the total chlorophyll content values are less than the unpolluted site. The results ranged from a maximum 29.56 mg/g fr. wt. in *Syzygium cumini* and minimum 1.98%mg/g fr. wt. in *Casia fistula*. The photosynthetic process of plants chiefly depends upon the chlorophyll content and development of biomass; it varies from plant to plant due to leaf age, biotic, abiotic conditions, and pollution levels. Atmospheric pollution may have created the disintegration of these pigments in industrial area plants. The air pollutants mainly affect the chloroplast, which is more prone to be attacked. Stomata are the means through which the air pollutants enter directly the tissues and cause partial denaturation of the chloroplasts. Hence the pigment content is decreased in the cells of polluted leaves. The degradation of photosynthetic pigments has been widely used as an indicator of air pollution. The decrease in chlorophyll content of leaves may be due to the alkaline condition created by the dissolution of chemicals present in dust particles *i.e.* metals and polycyclic hydrocarbons in cell sap which block the stomata spores for the diffusion of air and thus put stress on plant metabolism resulting in chlorophyll degradation [16-18].

The content of ascorbic acid is found less in all the species of the plants selected from the polluted site. It ranged maximum in *Bougainvillea glabra 4 mg/g fr. wt* mg/g fr. wt. and minimum in *Catharanthus roseus 1.2 mg/g fr. wt*. Ascorbic acid acts as an antioxidant and develops the mechanism of a plant to resist adverse atmospheric conditions. An important role is played by ascorbic acid in cell wall synthesis, defense, and cell division. It is a strong reducer too, and also plays an important role in photosynthetic carbon fixation. Moreover, its high level in plants indicated a high tolerance level of plant species against pollution, and its lower values rank the plants in a sensitive category against air pollution. Thus, vehicular emissions could be the cause of a decrease in the ascorbic acid content of plant species in the polluted area. The RWC was found higher in all selected plant species of the polluted site. It was the maximum *88.90%in Syzygium cumini* and the minimum 31.94% in *Tinospora cardifolia*. Accessibility of water in plant cells connected with the protoplasmic permeability of cells, thus a loss in water content and nutrients from the cells resulted in senescence of leaf in very early stage of plant life. According to one study, plants with higher RWC would have drought resistance, so it can be concluded that the species of the plants having high water content will be tolerant to the pollution. Thus, all the results of RWC of the polluted roadside area showed tolerance to vehicular air pollution.

Results also revealed that all plant species of the polluted site showed a pH basic in nature. The pH was found maximum in *Tinospora cardifolia (8.6)* and minimum in *Pongamia pinneta, Baliospermum solanifolium, Mangifera indica, Azadirecta indica*

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(7.1). A significant role is played by the leaf extract pH in regulating the SO_2 sensitivity of plants. According to the findings of researchers, in the presence of an acidic pollutant, the leaf pH lowered, and the decline is more remarkable in sensitive species. Low leaf pH extract showed a good correlation with sensitivity to air pollution and reduced photosynthetic process in plants. The plants with high sensitivity to SO_2 and NO_2 closed the stomata faster when they were exposed to pollutants.

The outcome of this study exposes that diverse trees respond differently to air pollution, hence they have different indices. The study reveals that the control site has more APTI than the polluted site. The APTI observed minimum in *Psidium guava (6.71*) and maximum in *Syzygium cumini (11.83)*. Reduction in APTI percentage is found the minimum for Pdilanthus tithimiloides (28.92%) > Casia fistula (28.75) > *Pongamia pinneta* (24.36%) > Senna auriculata (23.55%) > Lantana camara (23.15%) > Hibiscus rosasinencis (22.02%) > *Tinospora cardifolia* (17.00%) > Psidium guava (15.79%) > *Mangifera indica* (15.65%) > Albizia lebbeck (14.77%) > *Catharanthus roseus* (13.55%) > *Azadirecta indica* (13.00%) > *Annona reticulata* (12.47%) > *Baliospermum solanifolium* (6.71%) > *Syzygium cumini* (5.83%) > *Couroupita guianensis* (5.52%) > *Ficus religiosa* (5.65%) > *Bougainvillea glabra* (3.82%).

The result obtained, revealed that *Syzygium cumini* (5.83%) *Couroupita guianensis* (5.52%), Ficus *religiosa* (5.65%) and *Bougainvillea glabra* (3.82%) were found most tolerant since they had the least percentage reduction in APTI values. While *Pdilanthus tithimiloides* (28.92%), Casia fistula (28.75), Pongamia pinneta (24.36%), and Senna auriculata (23.55%) found more sensitive as they had a higher percentage reduction in APTI values.

However, as per some of the researchers, APTI values are higher in the polluted environment than in the controlled environment. This could be due to different environmental conditions. Moreover, it was noticed that the sensitivity of a plant species varies from area to area as they behave differently in other atmospheric conditions [19]. Between the eighteen plant species selected for experimental analysis, the order of plant species tolerant to air pollution with the percentage change in APTI values is as follows.

Pdilanthus tithimiloides (28.92%) > *Casia fistula* (28.75) > *Pongamia pinneta* (24.36%) > *Senna auriculata* (23.55%) > Lantana camara (23.15%) > Hibiscus rosasinencis (22.02%) > *Tinospora cardifolia* (17.00%) > Psidium guava (15.79%) > *Mangifera indica* (15.65%) > Albizia lebbeck (14.77%) > *Catharanthus roseus* (13.55%) > *Azadirecta indica* (13.00%) > *Annona reticulata* (12.47%) > *Baliospermum solanifolium* (6.71%) > *Syzygium cumini* (5.83%) > *Couroupita guianensis* (5.52%) > *Ficus religiosa* (5.65%) > *Bougainvillea glabra* (3.82%).

Tolerant plant species can be used in Greenbelt development, as they tend to serve as barriers and act as a sink for air pollutants. These plant species plays an important role in industrial areas to control the level of air pollution, while sensitive plant species can act as bio-indicators of air pollution. These particular plant species help to mitigate environmental air pollution.

Consent And Ethical Approval

As per university standard guideline, participant consent and ethical approval have been collected and preserved by the authors

Competing interests

Authors have declared that no competing interests exist.

Authors' Contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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