RESEARCH ARTICLE

Assessment for Variation of Air Pollution Tolerance Index of Selected Plants in Bengaluru Urban

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Received: 05 August 2017/Revised: 23 August 2017/Accepted: 19 October 2017

ABSTRACT- To develop the usefulness of *Caesalpinia pulcherrima* and *Catharanthus roseus* plants as bioindicators, which entail an utmost importance for a particular situation. This study focuses on the assessment of air pollution tolerance index (APTI) of two selected plant species commonly found along roadsides in Bengaluru, India. The plant species selected for the study were *C. pulcherrima* and *C. roseus*. The plants were evaluated in terms of APTI by analyzing four different biochemical parameters: Leaf relative water content (RWC), Ascorbic acid content (AA), Total leaf chlorophyll (TCh), and pH of leaf extract. Based on APTI *C. pulcherrima* was found to be more tolerant compared to *C. roseus*. Species with lower APTI value are considered sensitive species, which can be used as a biological indicator for further monitoring of air quality. Species with higher APTI value are tolerant species and thus, can be planted for pollution abatement in order to control and reduce environmental pollution.

Key-words- Air pollution tolerance index (APTI), biochemical parameters, Biomonitors roadside plants

INTRODUCTION

Air Pollution can be simply defined as an undesirable change in the physical, chemical and biological properties of air due to anthropogenic or any other cause. An air pollutant is a substance in the air that can have adverse effects on humans and the ecosystem. The substance can be solid particles, liquid droplets, or gases. Air pollution is a serious problem throughout the world. Rapid industrialization and vehicular traffic, especially in the urban areas of India lead to the deterioration of air quality by adding toxic gases and other substances to the atmosphere. All combustion releases gases and particulate matter into the air, which includes SO_2, NO_2, CO and soot particles as well as smaller quantities of toxic metals, organic molecules, and radioactive isotopes etc. The degradation of air quality is the major environmental problem that affects many urban and industrial sites and the surrounding regions worldwide. Although various efforts have been done for environmental restoration in India still it seems to be a formidable task. A pollutant can be of natural origin or man-made. Air Pollution results in huge harm to the living organisms.

Access this article online	
Quick Response Code	Website: www.ijlssr.com
	crossref DOI: 10.21276/ijlssr.2017.3.6.16

There are several morphological, behavioral, physiological and anatomical changes in plants and animals due to air pollution. But the effect is different in different organisms depending on the chemical the substance causing the pollution [1-3].

The responses of plants to the severity of their environment have attracted the attention of a man long before the establishment of the science of Biology. To a lay man, plants that survive in a harsh environment are 'hardy'; those, which are not 'tender'. Biologists have adopted the term stress for any environmental factor potentially unfavorable to living organisms and stress resistance for the ability of the plant to survive the unfavorable factor and even to grow in its presence. A biological stress can be defined as any environmental factor capable of inducing a potential, injurious strain in living organisms. The living organisms may show a physical strain or change or a chemical strain [4].

Air pollutions can directly affect plants via leaves or indirectly via soil acidification. It has also been reported that when exposed to air pollutants, most plants experience physiological changes before exhibiting visible damage to leaves. Studies have also shown the impacts of air pollution of Ascorbic acid content chlorophyll content, leaf extract pH, and relative water content. These separate parameters gave conflicting results for the same species. However, the APTI based on all four parameters has been used for identifying tolerance levels of plant species. Several contributors agree that air pollutants affect plant growth adversely. These urban air pollutants not only represent a threat to human health and the urban environment but it can also contribute to serious regional and global atmospheric pollution problem. Among the air pollutants, air-borne particulates specifically trace elements and heavy metals constitute the major pollutant burden in the urban environment, which needs to be monitored, filtered and regulated. With regard to the mitigation of these severe problems, policy should be adopted to control the pollution burden by means of monitoring, filtering and regulating the pollutants and their proper management. One of the important technique is the urban plantation and green belt development with suitable plant species in an appropriate manner, which is highly imperative to biofilter the toxic pollutants as well as other economic value. It is an established fact that vegetation plays an important role by cleaning the atmosphere by absorbing certain toxic air pollutants from its surroundings and also abatement of noise pollution. Thus Green belts are recommended for containment of air pollution in the human environment, especially in the urban and industrial environment. Model for green belt, development is recently developed in relation to pollution around industrial premises. In addition, there were the numbers of other benefits like an aesthetic improvement, climatic amelioration, biomass generation, enhancement of biodiversity etc. are the bonus derived through the presence of greenery in the areas. In an urban region of Iran, it has become mandatory for large-scale polluting industry to plant appropriate green belts in and around its unit to protect surrounding ecology. Plants remove air pollutants primarily by uptake via leaf stomata and once inside the leaf, gases diffuse into intercellular spaces and absorbed by water films. Plants, grown in such a way as to function as pollutant sinks are collectively referred to as greenbelts which have limits to their tolerance towards air pollutants. Greening by plantation, which makes use of vegetation to remove, detoxify or stabilize persistent pollutants is a green and environment friendly tool for a clean environment. The screening of effective plants in the particulate sink is essential for air pollution abatement in an urban environment. The routine analysis of elements, thus needs from the foliage of urban trees are essential to understanding the level of metal bioaccumulation and its consequent effect on the plant. Increased urbanization, industrialization, and heavy vehicular traffic have resulted in deterioration of air quality. However, no major attempt has been taken to assess about bioaccumulation of urban plant specifically to assess the tolerance of atmospheric pollutants in an appropriate manner [5,22-25]. Hence, the present study is concerned with the establishment of air pollution biomonitoring capacity with special reference to biochemical and study in a critically polluted region of Bangalore. The air Pollution Tolerance Index is a measure of tolerance level in the plants for air pollution.

Researchers related to Air Pollution Tolerance Index have been done in many places. Air pollution is one of the leading topics of discussion these days due to the pollutants created or generated by our modern life. So, the current topic is been researched in many places in India, as well as other countries. The methods of screening of plants for their tolerance level in air pollutants are important because the sensitive plants can serve as bio-indicator and the tolerant plants as a sink for controlling air pollution in urban and industrial areas. So, in order to evaluate the susceptibility level of plants to air pollutants, four parameters namely leaf extract pH, Relative Water Content, Ascorbic acid and chlorophyll content were determined and computed together in a formulation signifying the APTI of grown plant species in polluted and non-polluted areas of Bangalore. The plant species can be identified as tolerant or sensitive ones using APTI scale method, which is based upon the variation of selected biochemical parameters. It is a very useful index and can classify plant species in various scales like very sensitive, sensitive, intermediate, and tolerant. The tolerant ones can serve as sinks for the abatement of air pollution in urban and industrial habitats and sensitive ones can be used as bio-indicators. APTI value was calculated based on the biochemical parameters as described in the methodology and variation of APTI among the plant species with respect to polluted site and control sites are been presented. The APTI values obtained from different plants were compared to find out the sensitivity/tolerance of these plants. It was reported that plants with relatively low index value are generally sensitive to air pollutants and vice versa. The APTI determination provides a reliable method for screening a large number of plants with respect to their susceptibility to air pollutants. The method is simple and convenient to adopt field conditions without adopting any costly environmental monitoring gadgets. The sensitive species can be used as bio-indicators and tolerant species can be used as a sink for air pollutants. Plants have been categorized into groups according to their degree of sensitivity toward and tolerance of various air pollutants on the basis of experiment and available data. Levels of tolerance to air pollution vary from species to species, depending on the capacity of plants to withstand the effect of pollutants without showing any external damage [6].

MATERIALS AND METHODS

Sampling site- The non-polluted zone, Christ University grounds is situated on the Hosur main road, inverse to dairy circle, Bangalore, India. The place is located at the height of 900 m above the sea level. The coordinates on the globe correspond to 12º 56'North and 77º 36' in the East. The range is loaded with the greenery thus zone is less inclined to Air Pollution. Consequently, this site is considered as a Control site for the study. The polluted zone for the under study was the Hosur highway, which is situated in Bengaluru, Karnataka. This place is also located at the height of 900 m above the sea level. The coordinates on the globe correspond to 12º 56'North and 77º 36' in the East. The area was highly polluted due to the industries and a huge amount of vehicles due to daily traffic.

Sampling Procedure- Plants were selected from one of the major Highway in Hosur, which has high levels of vehicular emissions and industrial emissions. The criterion for the selection of these plants was mainly on their availability and abundance of these two species *C. pulcherrima* and *C. roseus* in parts of the Bengaluru urban area. Six replicates of fully matured plants from both control and polluted zone were taken and immediately taken to the laboratory in a heatproof container for the analysis.

Air Pollution Tolerance Index Technique- To calculate APTI the following four parameters of the samples were analyzed:

Total Chlorophyll Content (TCh)- Total chlorophyll content of the leaf samples were done using the spectrophotometric method described by Arnon [7]. Leaf samples were macerated with 30 mL of distilled water and left aside for 15 min for through extraction. The leaf extract was decanted into centrifuge tubes and centrifuged at 2500 rpm for 10 min. Absorbance was read at 645 nm, 663 nm, and 75 nm using UV-Visible Spectrophotometer. The calculation of the total chlorophyll content was done using the formula:

$$TCh = [20.2(A645) + 8.02(A663)] \times [V/ (1000 \text{ x } W)]$$

Where,
TCh= Total chlorophyll (mg/g)
A645= Absorbance at 645 nm minus the absorbance at 750 nm
A663= Absorbance at 663 nm minus the absorbance at 750 nm
V= Total volume of the extract (mL)
W= Weight of the sample (g)

Ascorbic Acid (AA) Content analysis- Ascorbic acid content (expressed in mg/g) was measured using a spectrophotometric method [8,14,21]. One gram of the fresh foliage was put in a test-tube, 4 ml oxalic acid EDTA extracting solution was added, them 1 ml of Orthophosphoric acid and then 1 ml 5% tetraoxosulphate (vi) acid added to this mixture, 2 ml of ammonium molybdate was added and then 3ml of water. The solution was then allowed to stand for 15 minutes after which the absorbance at 760 nm was measured with a spectrophotometer. The concentrations of ascorbic acid in the sample were then extrapolated from a standard ascorbic.

Leaf Extract pH- This was done following the method adopted by Agbaire *et al.* [8]. The total 5 g weight of the fresh leaves was homogenized in 10ml deionized water. This was filtered and the pH of the leaf extract determined after calibrating pH water with buffer solution of pH 4 and 9.

Relative Leaf Water Content (RWC)- To calculate RWC method described by Agbaire *et al.* [8] and Singh [23] were applied to the leaf samples of both plant species. Fresh weight was obtained by weighing the fresh leaves. The leaves were then immersed in water overnight at 70°C and re-weighed to obtain the dry weight.

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

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

Air Pollution Tolerance Index Determination- This was done following the method of Singh [24]. The formula of APTI is given as:

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

A = Ascorbic acid content (mg/g)
T = Total Chlorophyll (mg/g)
P = pH of leaf extract
R = Relative water content of leaf (%)

RESULTS AND DISCUSSION

Changes in total chlorophyll content- The chlorophyll value was relatively low in polluted site when compared to control. Chlorophyll content of plants signifies its photosynthetic activity as well as the growth and development of biomass. It is well evident that the chlorophyll content of plants varies from species to species; the age of leaf, and also with the pollution level as well as with other biotic and abiotic conditions [9]. Degradation of photosynthetic pigment has been widely used as an indication of air pollution [10]. The present study revealed that chlorophyll content in all the plants varies with the pollution status of the area i.e. higher the pollution level in the form of vehicular exhausts lower the chlorophyll content. It also varies with the tolerance as well as the sensitivity of the plant species i.e. higher the sensitive nature of the plant species lower the chlorophyll content. Studies [11,12,22-24] also suggest that high levels of automobile pollution, decrease chlorophyll content in higher plants near roadside. In all the plant species, chlorophyll content was higher in monsoon season, which might be due to the washout of dust particles from the leaf surface (which will increase photosynthetic activity), low level of pollution and water content of soil as suggested by Shyam *et al.* [13].

Table 1: Comparison of total chlorophyll content

Plant species	Control Site	Polluted Site
C. pulcherrima	6.042 mg/g	5.84 mg/g
C. roseus	1.81 mg/g	1.73 mg/g

Changes in ascorbic acid content- Values of the ascorbic acid content were relatively high in polluted site, when compared to control. Ascorbic acid is a very important reducing agent i.e. ascorbic acid also plays a vital role in cell wall synthesis, defense and cell division [14]. The present study showed elevation in the concentration of ascorbic acid with respect to the control zone in all the plant species selected. Pollution load dependent increase in the ascorbic acid content of all the plant species may be due to the increased rate of production of reactive oxygen species (ROS) during photo-oxidation of SO_2 to SO_3, where sulfites are generated from SO_2 absorbed. Previous reports suggest that the higher ascorbic acid content of the plant is a sign of its tolerance against sulphur dioxide pollution [15,16]. In the present lower ascorbic acid contents in the leaves of other plant species studied supports the sensitive nature of these plants towards pollutants particularly automobile exhausts. Previous study also confirmed an increase in the concentration of ascorbic acid in the leaves of near roadsides plants due to enhanced pollution loads of automobiles [12].

Table 2: Comparison of ascorbic acid content

Plant species	Control Site	Polluted Site
C. pulcherrima	8 mg/g	9 mg/g
C. roseus	6 mg/g	7 mg/g

Changes in leaf extract pH- There was a slight reduction in leaf pH among the plant species studied with respect to the control. Previous studies have reported that in the presence of an acidic pollutant, the leaf pH is lowered and the decline is greater in sensitive species [17-21]. A shift in cell sap pH towards the acid side in the 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 and lesser at lower pH. Hence the leaf extract pH on the higher side gives tolerance to plants against pollution [22-25].

Table 3: Comparison of pH

Plant species	Control Site	Polluted Site
C. pulcherrima	5.76	5.81
C. roseus	6.15	6.2

Changes in relative water content- The relative water content was high among the plant species in polluted site when compared to control. Relative water content is associated with protoplasmic permeability in cells causing loss of water and dissolved nutrients, resulting in early senescence of leaves [3,18-21]. Therefore the plants with high relative water content under polluted conditions may be tolerant to pollutants.

Table 4: Comparison of relative water content

Plant species	Control Site	Polluted Site
C. pulcherrima	53.84%	63.93%
C. roseus	75.43%	85.18%

Air Pollution Tolerance Index- From this study, it was found that the plant species *C. pulcherrima* had higher APTI as compared to *C. roseus*, showed that *C. pulcherrima* in a better condition. Nonetheless, the APTI values of the plants at control locations showed that there was only a slight difference in the values, indicating that they were adapting well to the environment. However, they still fell under the sensitive group based on the APTI scale. According to the APTI scale, any plant species with the value less than 1 is considered as very sensitive, plant with value from 1 to 16 is considered as sensitive, plant with value in the range of 17 to 29 is considered as intermittently tolerant and plant with value from 30 to 100 is considered as tolerant. From the overall results obtained, it was observed that the *C. roseus* was less sensitive in comparison with *C. pulcherrima*. The APTI value of the *C. pulcherrima* was much higher than the value of *C. roseus*.

Table 5: Observed value of Air Pollution Tolerance Index (APTI)

Plant species	Control Site	Polluted Site
C. pulcherrima	14.82	16.87
C. roseus	12.27	14.12

CONCLUSIONS

In conclusion, it appears that to increase in industrialization and urbanization, there is an increase threat of deforestation and hence such type of APTI determinations will gain significant importance for future planning. Firstly, this study revealed the impact of air pollution in terms of changes took place in various biochemical parameters of the study species. Secondly, this work threw light on the selection of air pollution tolerant species in terms of their APTI values. The study provided useful information for selecting tolerant species for landscaping and urban heat island reduction. The plant species *Catharanthus roseus* was less sensitive in comparison with *Caesalpinia pulcherrima*. *Caesalpinia pulcherrima* APTI value was found to be moderately tolerant with respect to APTI classification which could be considered for biocontrol strategy against air pollution. Thus, this study provides useful information for selecting tolerant species for landscaping and urban heat island reduction and for future planning. The present study recommended various tree species for urban planting so that a wider usage of local, as well as exotic tree species, can be explored for controlling air born pollution in urban climate.

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How to cite this article:
Manjunath B.T, Reddy J: Assessment for Variation of Air Pollution Tolerance Index of Selected Plants in Bengaluru Urban. Int. J. Life Sci. Scienti. Res., 2017; 3(6):1522-1526. DOI:10.21276/ijlssr.2017.3.6.16

Source of Financial Support: Nil, **Conflict of interest:** Nil