AIR POLLUTION TOLERANCE INDEX OF CERTAIN PLANT SPECIES: A STUDY OF NATIONAL HIGHWAY NO-8, INDIA

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Received January 20, 2016 Accepted May 15, 2016

ABSTRACT

Urban air pollutants like particulate matter, sulphur dioxide, nitrogen oxides, ozone etc. can harm the plants. It can absorb through stomata and affects adversely its biochemical constituents and physiological process. The variation in biochemical parameters in the leaves can be used as indicators of air pollution for early diagnosis of stress or as a marker for physiological damage prior to the onset of visible injury symptoms. In this study, four physiological and biochemical parameters, viz., leaf Relative Water Content (RWC), Ascorbic Acid content (AA), Total leaf Chlorophyll (TCh) and leaf extract pH were used to compute the Air Pollution Tolerance India (APTI) values of some plant species in different locations along the National Highway No 8 Kisehanger toll to Bagru toll. The plant species having higher APTI value can be given priority for plantation program in urbanize and industrial areas, so as to reduce the effects of air pollution and to make ambient atmosphere clean and healthy.

Key Words: Air Pollution Tolerance Index, Chlorophyll, Ascorbic acid, Bio-chemical parameters, Physiological process

INTRODUCTION

Air pollution is one of the serious problems faced by the people globally due to its transboundary dispersion of pollutants over the entire world. Ambient air pollution is a growing problem because of increasing urban population causing high density motor-vehicle traffic, local industrial emission, domestic and commercial activities. Motor vehicles account for 60–70% of the pollution loads in urban environment, followed by industries (20–30%) in India. The particulate pollution has always been a matter of great concern because of its adverse effect on human and plant population. In the present Global Environmental Scenario, this problem has become increasingly severe. The particulates and gaseous pollutants, alone and in combination, can cause serious setbacks to the humans and overall physiology of plants. Dust may affect photosynthesis, respiration, transpiration and allow the penetration of phytotoxic gaseous pollutants. As plants are very efficient in trapping atmospheric particles, leaves have been used as monitors of particulate pollution. Deposition of dust depends on the physical characteristics of particles, such as their size, shape and also the plant species. Pollutants gases like sulphur dioxide (SO2), nitrogen oxides (NOx) etc. are absorbed into the mesophyll of the leaves through stomata. Toxicity of gases like SO2 and NOx is depending on its reducing property. When its concentration is increased, the cells are first inactivated with or without plasmolysis, then ruptured and finally tissue collapse and dry up, killed. In response to the particular type and level of air pollution, plants developed characteristic, response and symptoms. They show several type of acute injuries vary in the form of various necrotic lesions ranging from fine steppe to large patches of dead tissues, with white to brown coloration. Trees act as a sink of air pollutants and reduce their concentrations in the air. Vegetation naturally cleans the atmosphere by absorbing gases and particulate matter through leaves as plant leaf may act as a persistent absorber when exposed to the polluted environment. Sensitive plant species are suggested as bio-indicators. Different plant
species showed a different behaviour for different pollutants and any plant part could be indifferently used as biomonitors. To screen plants for their sensitivity/tolerance level to air pollution, a proper selection of plants characteristic is of vital importance. Air pollution tolerance levels of each plant do not show uniform behaviour. The tolerance depending upon topography and pollution condition may be either stress avoidance or stress sensitive. In present study, the susceptibility levels of different plants have been determined on the basis of their Air Pollution Tolerance Indices. The plants with low index value were sensitive to air pollution and vice versa. Where the former can be planted as indicator species and the later as tolerant sink to mitigate pollution.

**AIMS AND OBJECTIVES**

To evaluate the Air Pollution Tolerance Index (APTI) of different plant species growing along the National Highway No-8 (Kishangarh toll to Bagru toll) as to select particular plant species to grow in respective areas and their correlation with respective pollutants.

**MATERIAL AND METHODS**

**Study site**
The area under investigation, Ajmer is centrally situated city of Rajasthan lies between 26°25’ to 26°29’ N latitudes and 74°37’ to 74°42’ E longitudes. Area of Ajmer is 8481.40 sq. km and area of the Ajmer city is 241.56 sq. km. It is represented by Aravalli hill rocks, sand dunes, agricultural fields, different kind of phyto-geographical habitats and floristic biodiversity. The NH-8 is serving the states of Delhi, Rajasthan, Gujarat and Maharashtra. The highway originates in Delhi and ends in Mumbai. National highway – 8 is one of the busiest routes in the country. It forms a part of the golden quadrangle connecting the political capital of India New Delhi with the commercial capital city of India, Mumbai. Total length of the road is 90.385 Km. The existing highway traverses through plain terrain. The road is located between North Latitude 26°35’ to 26°55’ and East longitude 74°50’ to 75°45’. The highway passes through two districts of Rajasthan namely Jaipur and Ajmer. Leaf samples were collected from different sites along the National highway 8, from Kishangarh Toll Plaza to Jaipur Toll Plaza covering major areas of National Highway such as Toll Plazas and major villages like Patan, Bandersindri, Parasoli, Dantri, Ramnagar and Dudu etc. The location of Jaipur - Kishangarh Express Highway is shown in Fig. 1.

![Fig. 1: Location of Jaipur - Kishangarh Express Highway](image-url)
Few plants of common occurrence along the roadside of National Highway were selected for the study for their biochemical studies. Care was taken for all plants undergoing investigation should have so-ecological condition with respect to light, water, soil and pollutant exposure. Three replicates of fully matured leaves of each species were randomly collected in early morning from the lower branches (at a height of 2.4 m). The leaf samples were analysed for total chlorophyll, ascorbic acid, leaf pH and relative water content using the standard procedure. The air pollution tolerance index was computed using the equation:

\[ \text{APTI} = \frac{[A(T+P)] + R}{10} \]

Where A = ascorbic acid (mg/g FW), T = total chlorophyll (mg/g), P = leaf extract pH and R = relative water content (%) of the leaves.

RESULTS AND DISCUSSION

Ascorbic Acid

The ascorbic acid content was maximum 6.84 mg/g dry wt. in Bougainvillea and minimum 1.23 mg/g dry wt. in Pongamia glavaris. Ascorbic acid being a strong reductant protects chloroplasts against SO\(_2\) induced H\(_2\)O\(_2\), O\(_2\) and OH– accumulation and thus protects the enzymes of the CO\(_2\) fixation cycle and chlorophyll for inactivation. Its reducing power is directly proportional to its concentration. However, its reducing activity is pH dependent, being more at higher pH levels because high pH may increase the efficiency of conversion of hexose sugar to ascorbic acid and is related to the tolerance to pollution. Ascorbic acid plays an important role in cell division, defense and cell wall synthesis. It is a natural detoxicant, which may prevent the effects of air pollutants in the plant tissues. Thus, plants maintaining high ascorbic acid under pollutant conditions are considered to be tolerant to air pollution.

Leaf extract pH

The leaf extract pH was found maximum 7.7 and minimum 5.5 in Ficus bengalensis and Terminalia arjuna respectively in polluted area. Plants with lower pH are more susceptible while those with pH around 7 are tolerant. Stomatal activity of the leaves changes due to change in leaf extract pH due to air pollution. Leaf extract pH plays a significant role in regulating SO\(_2\) sensitivity of plants. In presence of an acidic pollutant the leaf pH is lowered and the decline is greater in sensitive species. In presence of an acidic pollutant cell sap pH shifts towards acid which might decrease the efficiency of conversion of hexose sugar to ascorbic acid. However, the reducing activity of ascorbic acid is pH controlled being more at higher and less at lower pH. Hence, the leaf extract pH on the higher side gives tolerance to plants against pollution.

Relative water content

The relative water content was found maximum 78.48 in Bougainvillea and minimum 50.32 in Ficus benjamine. Water is crucial prerequisite for plant life. RWC (Relative Water Content) of a leaf is the amount of water present in it relative to its full turgidity. Relative water content is associated with protoplasmic permeability in cells causes’ loss of water and dissolved nutrients, resulting in early senescence of leaves. Under stress conditions of air pollution when the transpiration rates are usually high, high water content in a leaf will help to maintain its physiological balance.

Total chlorophyll

Total chlorophyll was found maximum 7.13 mg/g fr. wt. in Bougainvillea and minimum 2.64 mg/g fr. wt. in Albizia lebbeck. Chlorophyll is the index of productivity in plants. 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 condition. Thus, plants having high chlorophyll content shows tolerance to air pollution.

Air pollution tolerance indices

Plants that are continuously exposed to pollutants leads to accumulation of pollution, integration of pollutants in to their own system, thereby altering the nature of leaf and make them more sensitive. This sensitivity is measured through various biochemical changes and finally to air pollution tolerance index. APTI gives an empirical value for tolerance level of plants to air pollution. In this study, it found that Bougainvillea shows the
highest APTI value. It was found that plants with high index values are tolerant to air pollutants whereas low index values were generally sensitive to air pollutants.\(^{29-32}\) Cultivation of such species in polluted habitats leads to rapid amelioration of habitats to cope with the polluted environment. From the result obtained (Table 1), it has been observed that Albizia lebbeck, Ficus bengalensis, Alstonia scholaris, Nerium odorum and Golden durenta were the more tolerant species because of high APTI values in polluted areas.\(^{33,34}\) APTI values of plants can be used as indicator of presence of air pollutants and they are also very helpful in green belt development in the urban-industrial areas.\(^{35}\)

<table>
<thead>
<tr>
<th>S/N</th>
<th>Plant species</th>
<th>Total chlorophyll (mg/g)</th>
<th>Leaf extract pH</th>
<th>Ascorbic acid (mg/g)</th>
<th>Relative water content (%)</th>
<th>APTI</th>
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<tbody>
<tr>
<td>1.</td>
<td>Azadirchta indica</td>
<td>3.20</td>
<td>6.3</td>
<td>3.5</td>
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<td>2.</td>
<td>Albizia lebbeck</td>
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<td>6.4</td>
<td>4.4</td>
<td>72.66</td>
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<td>3.</td>
<td>Alstonia scholaris</td>
<td>6.18</td>
<td>6.9</td>
<td>4.38</td>
<td>77.80</td>
<td>13.50</td>
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<td>4.</td>
<td>Bougain villea</td>
<td>7.13</td>
<td>7.2</td>
<td>6.84</td>
<td>78.48</td>
<td>17.64</td>
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<tr>
<td>5.</td>
<td>Cassia siamia</td>
<td>4.57</td>
<td>6.12</td>
<td>3.72</td>
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<td>6.</td>
<td>Ficus bengalensis</td>
<td>4.34</td>
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<td>7.</td>
<td>Ficus benjamine</td>
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<td>7.5</td>
<td>3.12</td>
<td>50.32</td>
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<td>8.</td>
<td>Ficus religiosa</td>
<td>4.45</td>
<td>7.2</td>
<td>3.18</td>
<td>56.50</td>
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<td>9.</td>
<td>Ficus panda</td>
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<td>6.3</td>
<td>3.56</td>
<td>72.32</td>
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<td>11.</td>
<td>Hibiscus rosasines</td>
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<td>3.27</td>
<td>42.11</td>
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<td>15.</td>
<td>Terminalia arjuna</td>
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<td>5.5</td>
<td>5.62</td>
<td>70.31</td>
<td>11.90</td>
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</table>

**CONCLUSION**

Air pollutants such as SPM, SOx, NOx and ozone etc. from automobile exhaust and industries along with many other unknown pollutants are responsible for bad air quality. These pollutants not only affect the morphology of plants but also alter the physiology and biochemistry. To ensure a relatively pollution free environment worth for human habitation along the National Highway following suggestive measures based on the above data can be made. Both types of plants to be grown some with high APTI value (sink) others with low APTI value (bio indicators). Plants with some economic value can be selected. Plants should not have any damaging role to play like release of allergic pollen in large amount.

**REFERENCES**

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