Air Pollution Tolerance Index of Some Tree Species of Kathmandu Valley

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Received September 2000; accepted August 2001

Abstract
Plant species show striking variation in their sensitivity to air pollution. Leaves are generally used for analysis because of their absorbance of largest amount of air pollution. Air pollution tolerance index (APTI) value represents the tolerance level of plants to air pollution. Ascorbic acid, Relative water content, Total chlorophyll and pH level from plant leaves are known as the most responsive to air pollution and they are the index of APTI. APTI value is calculated by the estimation of above given parameters. APTI value helps in the selection of the plant species for plantation at the polluted areas, whereas plants with lower level of APTI value can be used in bio monitoring works. From the investigation the APTI value of Cinnamomum camphora was highest while Grevellia robusta has the lowest value.

Keywords: Ascorbic acid, Relative water content, Chlorophyll

Introduction
Plant species show a striking variation in their sensitivity to air pollution (Teshow 1984). Leaves are generally used for analysis because of its absorbance of largest amount of air pollutants. Air pollution decreases the photosysnthetic capacity of plants by affecting stomatal appearance and photosynthetic tissue (Darley & Middleton 1966).

Damage to vegetation due to industrial air pollutant has been reported by Rao (1981). Since plants are stationary and are continuously exposed to air pollutants, air pollution injury to plants are proportional to the intensity of pollution. Hence use of plants is often suggested for air quality monitoring (Chaphekar 1982).

Air pollution has direct harmful impact on plant leaves. Leaves are generally used, as they take up the largest amounts of pollutant (Teshow 1984). A decrease in chlorophyll content has often been suggested as an indicator of air pollution injury (Malhotra & Khan 1984). Chlorophyll is relatively sensitive but rather non specific to air pollution and can be used as bio indicator along with such metabolites as ascorbic acid and protein (Varshney 1982).

In earlier work, attempts have been made to evaluate the responses of higher plants to air pollution with a view to determine the tolerant species by studying the changes in chlorophyll, (Syratt & Wanstall 1969, Prasad & Rao 1982), ascorbic acid contents (Rao 1981, Keller & Schwager 1977) and plant pH (Kumawat & Dubey 1989). From the analysis of the above parameters it has been revealed that the chlorophyll, relative water content and ascorbic acid content may be termed as the most responsive to pollution (Datta & Sinha-Ray 1995).

Air pollution tolerance index represents the tolerance level of plants to air pollution, therefore it helps to categorise the air pollution sensitive and tolerant plants.

Four plant species Cinnamomum camphora, Grevellia robusta, Callistemon citrinus and Jackaranda mimosifolia were selected for the investigation, APTI value was calculated for all the tree species by the estimation of ascorbic acid, pH, relative water content and total chlorophyll from leaves.

Significance of tolerant plant species in combating the air pollution problems is very high. A knowledge of the tolerance of a tree, shrub or herb assumes significance when preparing plans for the abatement of pollution as well as management of the environment quality (Datta & Sinha-Ray 1995).

Methodology
Field experiments were conducted in Kathmandu valley during the month of March – June. According to the concentration of air pollutants (Table 1) Kalanki (Site 1), Chabahil (Site 2) and Sat dobato (Site 3) were selected as the polluted areas. Kirtipur Campus garden area (Site 4) which is located quite far from the city area, with relatively minimal of pollutants was selected as the control. For the observation of APTI value four plant species C. camphora (Lauraceae), G.
robusta (Proteaceae) J. Mimosifolia (Mimosaceae) and C. citrinus (Myrtaceae) common in all the study areas were selected.

Mature leaf samples were analyzed for Ascorbic acid, Total chlorophyll, Relative water content and pH. For each parameter five different samples from each species were taken into account.

**Table 1. Air pollutant concentration of various sites of Kathmandu Valley**

<table>
<thead>
<tr>
<th>Site</th>
<th>NOx mg/m³</th>
<th>SO₂ mg/m³</th>
<th>TSS mg/m³</th>
<th>CO mg/m³</th>
<th>Dust Particles mg/m³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kalanki</td>
<td>137</td>
<td>46.6</td>
<td>1.636</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Kirtipur</td>
<td>18.2</td>
<td>1.2</td>
<td>43</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Lagankhel</td>
<td>477</td>
<td>261</td>
<td>-</td>
<td>2,280</td>
<td>1,967</td>
</tr>
<tr>
<td>Chabahil</td>
<td>188</td>
<td>653</td>
<td>-</td>
<td>14,820</td>
<td>5,917</td>
</tr>
</tbody>
</table>

1 Source: BIONI - 1996

2 Source: Nepal Scientific Services Radio Sagarmatha

**Estimation of Chlorophyll**

0.5 g of leaves were grounded with 20 mL of acetone 80%. The solution was filtered (Wattman filter), the remaining pulp was again ground with 15 mL of 80% acetone and filtered. Then 80% acetone was added to the filtrate to make a volume of 50 mL. The extract was then recorded against acetone 80% by a spectrophotometer at 645 nm and 663 nm (Arnon 1949, Zobel et al. 1987).

Total chlorophyll mg/L = (20.2 × OD645 + 8.02 × OD663) V/(1000 × W)

Where, OD = Optical Density

V = Volume of acetone chlorophyll extract

W = Fresh weight of the sample

**Relative water Content**

Moisture content of plant material can be expressed in terms of relative water content. Leaves were washed and fresh weight of leaves were taken. Then the leaves were dipped in distilled water for 24 hours. After taking the turgid weight of the leaves were oven dried for 24 hours at 80°C and dry weight was taken (Singh 1977).

Relative water content (%) = \( \frac{F - D}{T - D} \times 100 \)

F = Fresh weight of leaves.

D = Dry weight of leaves.

T = Turgid weight of leaves.

**Leaf extract pH**

5 g of fresh leaves were washed and homogenized with 25 mL of distilled water. pH of the leaf extract was measured with pH meter, (Datta & Sinha – Ray 1995).

**Ascorbic Acid Content**

2.5 g sample leaves were homogenized with 25 mL of distilled water and centrifuged. Solution of standard dye was prepared from dichlorophenol indophenol (Bajracharya 1999). Test solution was prepared in a conical flask taking 2 mL of leaf extract, 2 mL glacial acetic acid, 2.5 mL of chloroform and 8 mL of distilled water. Standard solution with known amount of ascorbic acid and blank solution were also prepared.

Then Test solution, Standard solution and Blank solution were titrated against the standard dye solution. Titre value of test solution (T) standard solution (S) and Blank solution (B) were noted.

Now, Ascorbic acid of test solution (mg/100mL) =\( \frac{T - B \times 4 \times \text{dilution}}{S - B} \)

**Air Pollution Tolerance Index (APTI)**

APTI is an empirical value representing the tolerance level of a plant species to air pollution. It is calculated by the following formula, (Datta & Sinha – Ray 1995).

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

Where, A = Ascorbic Acid Content of leaf

P = pH of leaf extract

R = Relative Water Content of leaf

T = Total Chlorophyll level of leaf extract.

**Results**

**J. mimosifolia**

Total chlorophyll level, Relative water content and leaf pH were highest at the control than the other polluted sites (Table 2). Ascorbic acid content of leaves was highest at site 1 and found lowest at site 3 and site 4 (control). The air pollution tolerance Index value ranged from 8.91 (site 1) to 9.41 at the control.

**Table 2. Total Chlorophyll, Relative water content, Ascorbic acid and pH of J. mimosifolia**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Site 1 S.D.</th>
<th>Site 2 S.D.</th>
<th>Site 3 S.D.</th>
<th>Site 4 S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total chlorophyll mg/L</td>
<td>1.98</td>
<td>0.121</td>
<td>2.24</td>
<td>0.22</td>
</tr>
<tr>
<td>Relative water content %</td>
<td>87.27</td>
<td>2.38</td>
<td>88.96</td>
<td>2.08</td>
</tr>
<tr>
<td>Ascorbic Acid mg/100mL</td>
<td>0.26</td>
<td>0.02</td>
<td>0.17</td>
<td>0.02</td>
</tr>
<tr>
<td>pH</td>
<td>4.96</td>
<td>0.045</td>
<td>4.75</td>
<td>0.0254</td>
</tr>
</tbody>
</table>

S.D.: Standard Deviation
C. camphora

All the parameters Total chlorophyll, Relative water content, Leaf pH and Ascorbic acid level were highest at Site 4 (control) as given in Table 3. The range of air pollution tolerance Index was 9.27 to 9.79.

Table 3. Total Chlorophyll, Relative water content, Ascorbic acid and pH of C. camphora.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Site 1</th>
<th>S.D.</th>
<th>Site 2</th>
<th>S.D.</th>
<th>Site 3</th>
<th>S.D.</th>
<th>Site 4</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total chlorophyll mg/L</td>
<td>1.78</td>
<td>0.113</td>
<td>1.63</td>
<td>0.301</td>
<td>1.67</td>
<td>0.24</td>
<td>2.88</td>
<td>0.149</td>
</tr>
<tr>
<td>Relative water content %</td>
<td>91.54</td>
<td>1.04</td>
<td>90.12</td>
<td>1.8</td>
<td>91.52</td>
<td>0.98</td>
<td>95.98</td>
<td>1.5</td>
</tr>
<tr>
<td>Ascorbic Acid mg/100 mL</td>
<td>0.15</td>
<td>0.01</td>
<td>0.15</td>
<td>0.02</td>
<td>0.02</td>
<td>0.03</td>
<td>0.2</td>
<td>0.02</td>
</tr>
<tr>
<td>pH</td>
<td>6.2</td>
<td>0.03</td>
<td>6.00</td>
<td>0.009</td>
<td>6.06</td>
<td>0.04</td>
<td>6.5</td>
<td>0.01</td>
</tr>
</tbody>
</table>

S.D.: Standard Deviation

G. robusta

Total chlorophyll, Relative water content and leaf pH level was highest at site 4 (control). Ascorbic acid level was lowest at site 4 (control) and highest at site 1 (Table 4). The air pollution Tolerance Index value ranged from 7.71 (Site 2) to 9.04 at Site 4.

Table 4. Total Chlorophyll, Relative water content, Ascorbic acid and pH of G. robusta.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Site 1</th>
<th>S.D.</th>
<th>Site 2</th>
<th>S.D.</th>
<th>Site 3</th>
<th>S.D.</th>
<th>Site 4</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total chlorophyll mg/L</td>
<td>1.46</td>
<td>0.03</td>
<td>1.24</td>
<td>0.30</td>
<td>2.04</td>
<td>0.50</td>
<td>2.51</td>
<td>0.207</td>
</tr>
<tr>
<td>Relative water content %</td>
<td>82.58</td>
<td>1.52</td>
<td>74.34</td>
<td>2.1</td>
<td>83.34</td>
<td>1.2</td>
<td>87.24</td>
<td>0.87</td>
</tr>
<tr>
<td>Ascorbic Acid mg/100 mL</td>
<td>0.50</td>
<td>0.05</td>
<td>0.4</td>
<td>0.007</td>
<td>0.4</td>
<td>0.013</td>
<td>0.35</td>
<td>0.02</td>
</tr>
<tr>
<td>pH</td>
<td>5.64</td>
<td>0.1</td>
<td>5.75</td>
<td>0.12</td>
<td>5.15</td>
<td>0.05</td>
<td>6.56</td>
<td>0.65</td>
</tr>
</tbody>
</table>

S.D.: Standard Deviation

C. citrinus

Total chlorophyll level, Relative water content and leaf pH values were highest at Site 4 (control), whereas Ascorbic acid level was highest at Site 1 and lowest at Site 4 (control) as mentioned in Table 5. The range of APTI value was highest at Site 4 (Control) with 9.34 and lowest at Site 2 with 8.84.

Table 5. Total Chlorophyll, Relative water content, Ascorbic acid and pH of C. citrinus.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Site 1</th>
<th>S.D.</th>
<th>Site 2</th>
<th>S.D.</th>
<th>Site 3</th>
<th>S.D.</th>
<th>Site 4</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total chlorophyll mg/L</td>
<td>1.63</td>
<td>0.15</td>
<td>1.64</td>
<td>0.088</td>
<td>0.71</td>
<td>0.044</td>
<td>1.86</td>
<td>0.01</td>
</tr>
<tr>
<td>Relative water content %</td>
<td>89.06</td>
<td>1.60</td>
<td>87.54</td>
<td>2.01</td>
<td>89.75</td>
<td>1.03</td>
<td>92.16</td>
<td>1.71</td>
</tr>
<tr>
<td>Ascorbic Acid mg/100 mL</td>
<td>0.22</td>
<td>0.008</td>
<td>0.12</td>
<td>0.025</td>
<td>0.12</td>
<td>0.02</td>
<td>0.17</td>
<td>0.01</td>
</tr>
<tr>
<td>pH</td>
<td>5.30</td>
<td>0.095</td>
<td>5.26</td>
<td>0.2</td>
<td>4.53</td>
<td>0.21</td>
<td>5.76</td>
<td>0.08</td>
</tr>
</tbody>
</table>

S.D.: Standard Deviation

Discussion and Conclusion

The APTI values of all the species are given in Table 6. Site 1, 2 and 3 were polluted areas and site 4, less polluted area, which was used as a control. Chlorophyll level, Relative water content and pH level were highest at site 4. According to Farooq et al. (1995), the amount of Chlorophyll a, b and total chlorophyll exhibited significant reductions under pollution stress. Similar loss in Chlorophyll due to air pollution has also been reported by Gupta and Ghouse (1987). A decrease in chlorophyll content has often been suggested as an indicator of air pollution (mainly SO2) injury (Treshow 1984). The injurious effects of SO2 on chlorophyll pigment and consequent reductions in production potential of plants have been reported by Rao (1985).

Table 6. Air Pollution Tolerance Index of J. mimosifolia, C. camphora, G. robusta and C. citrinus from the study sites.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Site 1</th>
<th>Site 2</th>
<th>Site 3</th>
<th>Site 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>J. mimosifolia</td>
<td>8.91</td>
<td>9.01</td>
<td>9.04</td>
<td>9.41</td>
</tr>
<tr>
<td>C. camphora</td>
<td>9.27</td>
<td>9.13</td>
<td>9.23</td>
<td>9.79</td>
</tr>
<tr>
<td>G. robusta</td>
<td>8.61</td>
<td>7.71</td>
<td>8.62</td>
<td>9.04</td>
</tr>
<tr>
<td>C. citrinus</td>
<td>9.04</td>
<td>8.84</td>
<td>9.04</td>
<td>9.34</td>
</tr>
</tbody>
</table>

Site 1 = Kalanki, Site 2 = Chabahil, Site 3 = Satdobato, Site 4 = Kirtipur (Control)

The range of APTI values of all the species at different sites are revealed from Table 6. G. robusta has lowest index value 7.71 to 9.04 while highest index value was found in C. camphora with 9.27 to 9.79. According to Datta and Sinha-Ray (1995) that populations having low index value were more sensitive to air pollution than those having high index value.

Chlorophyll level, Relative water content, ascorbic acid content are termed as the most responsive to air pollution. APTI values are based on the above parameters and it is possible to arrange the various populations of plant species with minimum APTI value in low polluted locality and the maximum APTI value in a highly polluted locality.

APTI value helps in the selection of the plant species for plantation at the polluted areas. It is also suggested that APTI can help in the selection of plant species for growing in industrial and urban zones where air pollution is predominant (Datta & Sinha-Ray 1995).

Thus the present study shows that C. camphora is the most air pollution tolerant plant among the four tree species, then J. mimosifolia, C. citrinus and G. robusta lie on the degree of tolerance. Therefore, C.
camphora is recommended for plantation at the polluted areas.

References


