Research Article

Air Pollution Tolerance Index of Plants at Perumalmalai Hills, Salem, Tamil Nadu, India

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ABSTRACT

Air pollution tolerance index is used to select plant species tolerant to air pollution. Four physiological and biochemical parameters namely, leaf extract pH, ascorbic acid, total chlorophyll and relative water content were combined together in a formulation signifying the air pollution tolerance index of plants. Plants present in Perumalmalai hill, which is located at Salem District were studied to identify its tolerance to pollution during the month of February 2013. From our study, Nerium oleander having APTI value of 16.65 was identified as intermediate species tolerant to pollution. Whereas, *Ficus benghalensis, Psidium guajava, Spathodea campanulata, Opuntia ficus indica* having APTI score of 15.92, 15.41, 9.92, 9.74 was identified as a sensitive species. The carotenoid content studied also showed its maximum in *Opuntia ficus indica*.

Keywords: APTI Score, Chlorophyll, Relative water content, Carotenoid, Perumalmalai hills.

INTRODUCTION

The study area Perumalmalai hill is situated in southern Eastern Ghats. It is located between 11°41'39" latitude in North and 78°7'44" longitude in East. Approximate height of perumal malai hill is 1000 feet, located in Salem. This hill is surrounded by a house of more than 100, having plants of total 80,000 approximately, in the area of 100 hectares. Among the plants present, there were roughly 30,000 *Azadirachata indica*, 20,000 *Procetes pusifera*, 15,000 *Anona sekimose*, 12,000 Millettia pinnata and also other trees like *Spathodea campanulata, Ficus benghalensis, Acacia nilotica, Borassus flabellifer, Ficus religiosa, Ziziphus jujuba, Moringa oleifera, Mangifera indica, Psidium guajava*. Industrialization is a major cause of pollution.[1] Pollutants that are pumped into the atmosphere and directly pollute the air are called primary pollutants while those that are formed in the air when primary pollutants react or interact are known as secondary pollutants. Air pollutants can directly affect plants via leaves or indirectly via soil acidification.[2] These pollutants in the atmosphere may impair the health of plants and animals, because plants are the initial acceptors of air pollution and used to monitor the strength of the environment. No physical or chemical method is known to ameliorate air pollution. A suitable alternative is to develop a biological method because plants provide an enormous leaf area for impingement, absorption and accumulation of air pollutants to reduce the pollutants level in the environment, with a various extent.[3] Sensitivity and tolerance nature of plants to air pollutants varies with change in Leaf extract pH, Relative water contents (RWC), Ascorbic acid content and Total Chlorophyll content. Study of single parameter may not provide a clear picture of the pollution induced changes. So, air pollution tolerance index (APTI) which was based on the above said parameters has been used to identify the tolerance levels of plant species. Hence, the present study was done to evaluate the impact of pollution on plants and their tolerance levels and also the need to protect the biodiversity as a citizen of India.

MATERIALS AND METHODS

Sample collection

Fresh leaves were collected during Feb, 2013 from Perumalmalai hill (experimental) site by following necessary precautionary measures were brought to the laboratory for analysis.

Morphological measurements

Leaves brought to the laboratory were weighed with dust and then after washing, width and length of the leaves were also measured.

Biochemical Measurements

Ascorbic acid content (AA)

Ascorbic acid content was measured by Titrimetric method using 2,6,Dichlorophenol indophenol dye.100mg of leaf sample was extracted with 4% oxalic acid and then titrated against the dye until pink colour develops. Similarly, a blank is also developed.[4]

Photosynthetic pigment

Hundred milligram of leaf sample was used for the study. The chlorophyll and carotenoid pigments were analyzed[5] with the help of visible spectro photometer using 645 to 663 nm for chlorophyll and 480 and 510 nm for carotenoids.

Leaf extract pH

Hundred milligram of the leaves were homogenized in 50 ml deionized water, filtered and the pH of filtered leaf extract was determined by using pH meter.[6]

Relative water content (RWC)

Relative water content was determined.[7,8] Fresh weight was obtained by weighing fresh leaves. The leaves were then immersed in water over night, blotted dry and weighed to get turgid weight. Now the leaves were dried in an oven at 70˚C and reweighed to obtain dry weight. Relative water content was calculated by using the formula:

RWC= [FW-DW)/ (TW-DW)] x100 (FW = fresh weight, DW= dry weight and TW= turgid weight).

Calculation of Air Pollution Tolerance Index (APTI)

Air pollution tolerance index was assessed by Singh and Rao[6] to assess the tolerant/ resistance power of plants against air pollution.

The air pollution tolerance index was calculated using the formula:

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

Where:

A =Ascorbic Acid (mg/g)

T =Total Chlorophyll (mg/g)

P = pH of the leaf extract,

R = Relative water content of leaf (%).

RESULTS AND DISCUSSION

The leaves collected from the experimental site were subjected to morphological measurements. The obtained results are shown in table 1.

Morphological Measurements

Morphological measurements will give an idea about the site under study and also the nature of pollutants present in that area. The reduced leaf area results in reduced absorbed radiations and subsequently in reduced photosynthetic rate. The length of the leaf was high for *Borassus flabellifer* whereas leaf length and width was found to be very low for *Acacia nilotica* and *Moringa oleifera*. Similarly, the width of the leaf was high for *Ficus religiosa*. Leaf weight also showed significant changes indicating the deposition of dust due to the presence of polluted environment in the selected site.

Table 1: Morphological measurements of Plants from Perumalmalai hills

S. No.	Name of the plants	Leaf length (cm)	Leaf width (cm)	Leaf weight with Dust (mg)	Leaf weight (after cleaning dust mg)
1	*Azadirachata indica*	5.0	1.0	92	90
2	*Prosobhis juliflora*	4.0	1.5	119	115
3	*Moringa oleifera*	1.5	0.5	35	33
4	*Millettia pinnata*	7.5	5.0	535	525
5	*Ficus religiosa*	17.5	10.5	1460	1380
6	*Anona sekimose*	10.5	4.0	521	492
7	*Spathodea campanulata*	14.0	4.5	738	737
8	*Agave americana*	20.0	3.0	11900	11790
9	*Ziziphus jujuba L.*	3.5	2.2	206	204
10	*Opuntia ficus-indica*	11.0	6.0	14380	14260
11	*Psidium guajava*	9.0	3.5	567	563
12	*Syzygium cumini*	13.0	5.0	1120	1090
13	*Nerium oleander*	21.0	3.1	2300	1990
14	*Calotropis gigantea*	11.0	5.0	1660	1540
15	*Ficus benghalensis*	16.0	9.0	2400	2100
16	*Capparis sepiaria*	3.0`	1.0	56	55
17	*Tecoma stans*	8.0	2.0	248	242
18	*Mongifera indica*	25,0	5.0	2590	2300
19	*Borassus flabellifer*	60.0	4.5	8590	8500
20	*Acacia nilotica*	1.5	0.5	12	9

Biochemical measurements

Bio-chemical measurements were done for the identification of Air Pollution Tolerance Index. The obtained results are shown in Fig.1, Fig.3, Fig.4, Fig.5. Carotenoid content of the plant leaves analysed were depicted in Fig.2.

Ascorbic acid

Ascorbic acid was found to be high in *Psidium guajava* (5.25 mg/g), whereas it was low in *Opuntia ficus indica*. Our results correlate well with previous reports, that plant maintaining high ascorbic acid under pollutant conditions are considered to be tolerant to air pollution.[9]

Total chlorophyll (TC) and Carotenoid

Total chlorophyll was found to be high in *Ziziphus jujube, Nerium oleander, Ficus benghalensis, Acacia nilotica* and it was found to be low in *Ficus religiosa, Agave Americana, Opuntia ficus indica, Calotropis gigantea*. All the other plants showed chlorophyll in moderate amount. Chlorophyll and carotenoid both take part in

photosynthetic reaction. Different pollutants play a significant role in inhibition of photosynthetic activity that may results in depletion of chlorophyll and carotenoid content of the leaves of various plants.[10] Rao and Leblanc have also reported reduction in chlorophyll content brought by acidic pollutants like SO_2 which causes phaeophytin formation by acidification of chlorophyll.[11] The carotenoid content of *Opuntia ficus indica* was found to be high and it was low for *Psidium guajava*. All the other plants studied for carotenoid pigment were in the range of 1.50 to 3.19mg/g. Carotenoids are a class of natural fat-soluble pigments found principally in plants, algae and photosynthetic bacteria, where they play a critical role in photosynthesis.[12] Carotenoid protects chlorophyll from photoxidative destruction.[13] The carotenoid contents of some crop plants were found to decrease in response to SO_2.[14-16]

pH

The pH observed in *Calotropis gigantea, Acacia nilotica* was alkaline but with *Opuntia ficus indica* it was acidic, whereas neutral pH was observed in *Moringa oleifera, Millettia pinnata, Syzygium cumini, Psidium guajava, Borassus flabellifer*. Our results are well supported by earlier reports, that the photo synthetic efficiency of plant species strongly depends upon the leaf pH. The pH value of Ziziphus jujube was found to be 6, which was supported by the result of Krishnaveni et. al.[17] High pH value increases the hexosugar conversion efficiency to ascorbic acid. The development of detoxification mechanism which is necessary for the tolerance in the plant species can be indicated by its alkalinity.[18] Hence, plant species which are neutral and above neutral might be a tolerant species in the experimental site i.e Perumalmalai hill.

Relative Water Content (RWC)

Relative water content of plant is associated with protoplasmic permeability in cells which causes loss of water and dissolved nutrients, resulting in early senescence of leaves.[19] The relative water content was found to be high in *Borassus flabellifer, Ficus benghalensis, Nerium oleander, Tecoma stans, Syzygium cumini, Opuntia ficusindica, Agave Americana, Millettia pinnata;* whereas it was found to be low in *Moringa oleifera*. More water content in leaf in certain plants helps to maintain its physiological balance under stress conditions of air pollution, when the transpiration rates are usually high. Higher relative water content favours drought resistance in plants.[20] So, plants having more relative water content might be grown in drought area.

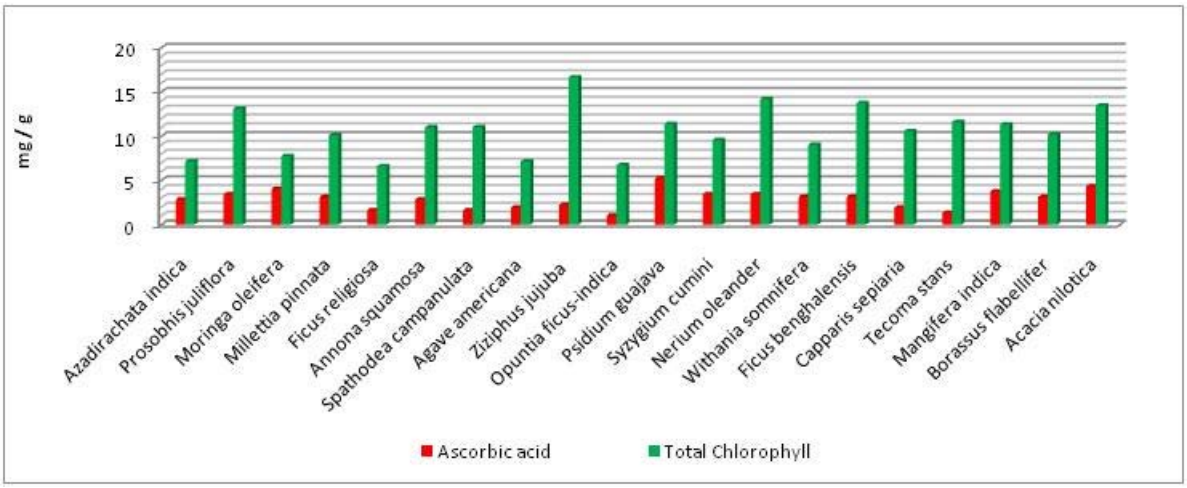

Figure 1: Ascorbic acid, Pigment content of herbal plant leaves

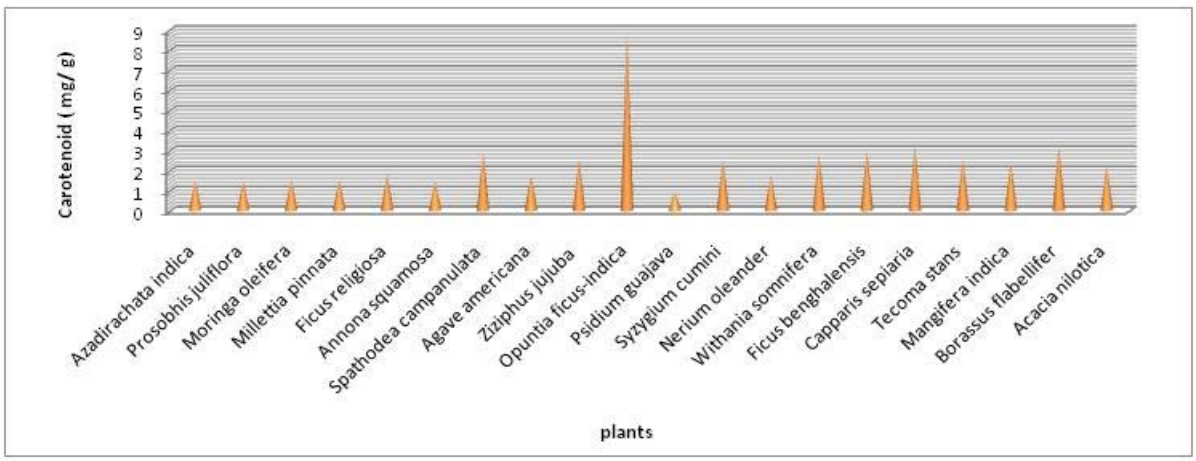

Figure 2: Carotenoid content of plant leaves

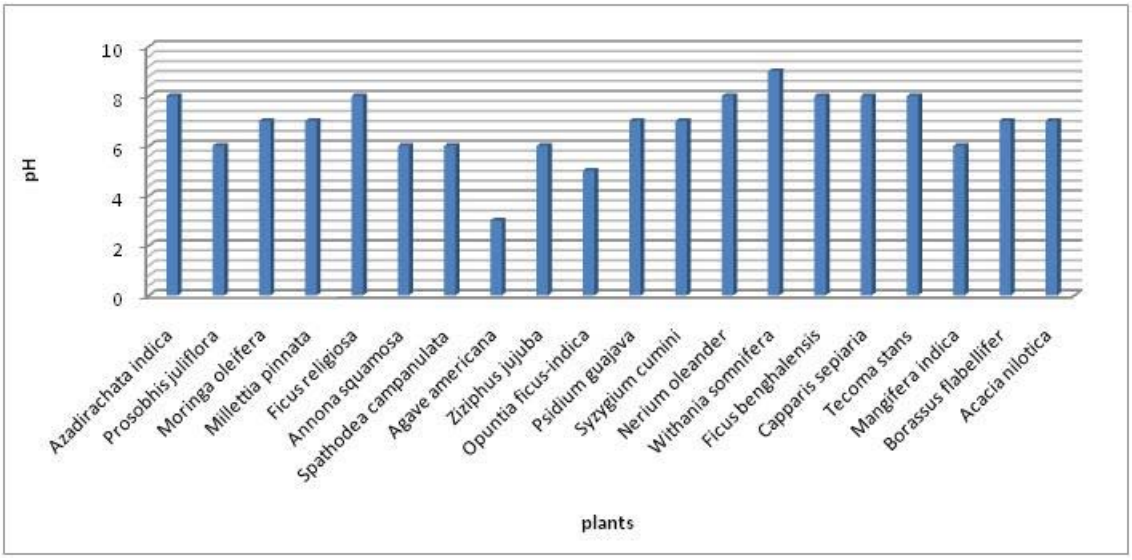

Figure 3: pH of herbal plant leaves

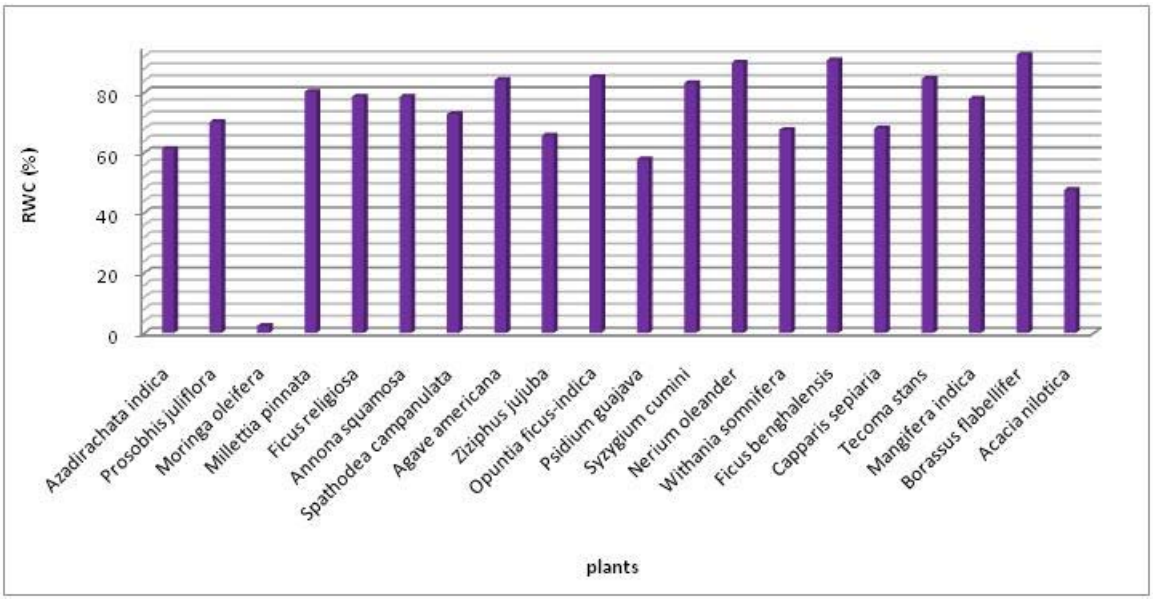

Figure 4: Relative water content of plant leaves

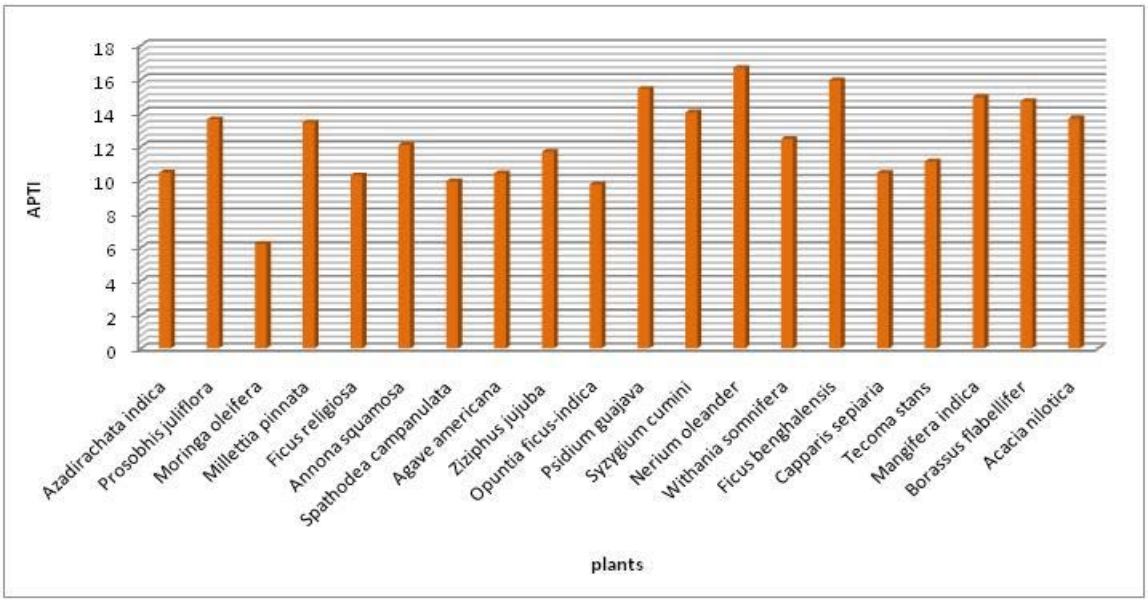

Figure 5: Air Pollution Tolerance Index of plants

Air Pollution Tolerance Index (APTI)

The APTI determination provides a reliable method for screening large number of plants with respect to their susceptibility to air pollutants. This is a simple method and very easy to apply in all type of 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. The APTI was found to be above 16 in Nerium oleander whereas it was 15.92 for *Ficus benghalensis* and 15.41 for *Psidium guajava* whereas APTI value was found to be very low in *Spathodea campanulata, Opuntia ficus indica*. Plants having low index values were generally sensitive to air pollutants. In our study, we could find contradictory result with *Acacia nilotica* having APTI of 13.65.[21] According to Lakshmi et. al.,[22] plants having APTI value in the range of 30-100 were tolerant to pollution and APTI value in the range of 17-29 were intermediate to pollution and below 16 and up to 1 are sensitive and value less than 1 are very sensitive. Implying this in to our results, no plants were found to be very sensitive to pollution. As per this classification, Nerium oleander was the only plant that have the APTI value above 16 and thus serve as a plant intermediate to pollution. All other plants were found to be sensitive and helpful in indicating air pollution.[23]

CONCLUSION

The APTI values obtained for different plants were compared to find out the sensitivity/tolerance nature of plants located. Certain species have the maximum value for a single parameter among the four parameters specific for APTI, and that each parameter plays a distinctive role in the determination of susceptible nature of plants towards pollution and also in identifying the polluted/contaminated area. Thus, the combination of four parameters is suggested as the best index for the identification of susceptibility levels of plants. Thus, from our results, we can conclude that Nerium oleander as intermediately tolerant and *Ficus benghalensis, Psidium guajava, Moringa oleifera* as a sensitive species.

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