Research Article

Impact of Air Pollution in Plants near Thermal Power Plant, Mettur, Salem, Tamilnadu, India

Krishnaveni M.*, Durairaj S., Madhiyan P., Amsavalli L., Chandrasekar R.,
Department of Biochemistry, Periyar University, Salem-11, Tamilnadu, India.
***Corresponding author's E-mail:** logasarvesh@gmail.com

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ABSTRACT

Among the different variables used to evaluate the condition of an ecosystem, the content of leaf nitrogen, chlorophyll and other pigments are the most important. Since, they are closely related to the photosynthetic capacity and physiological status of plants. The plants act as a sink for the pollutants and thus changes in its essential components indicates stress. Hence, an attempt has been tried to investigate the air pollution tolerance index of plants located near Thermal power plant, Mettur, Salem, Tamil Nadu, India. For the present study, 19 plants were collected from the experimental site. Among the plants studied, *Mangifera indica, Acacia Arabica, Embilica officinalis, Azadirachta indica* having APTI value above 17 are grouped as intermediate to pollution. Other plants having APTI value less than 17 are sensitive to pollution and no plants were found to be less than 1 which is grouped under very sensitive category.

Keywords: Pigments, Tolerance, Thermal power plant, Biochemical changes**.**

INTRODUCTION

Air pollution is the most severe problem world is facing today. Urban air pollution is a threat to both developing and developed countries[1]. The increasing number of industries and automobile vehicles are continuously adding toxic gases and other substances to the environment[2]. Environmental stress, such as air pollution, is among the factors that limit the plant productivity and survivorship[3]. Ambient air pollution in several large cities of India is amongst the highest in the world[4]. According to an estimate, dust pollutants comprise around 40% of total air pollution problem in India [5]. Plant response to air pollution can be used to assess the quality of air that may provide early warning signals of air pollution trends[6]. Plants provide an enormous leaf area for impingement, absorption and accumulation of air pollutants to reduce the pollution level in the air environment[7], with a various extent for different species[8]. Of all the plant parts, leaf is the most sensitive part to air pollutants and several other such external factors[9]. Responses of plants towards air were assessed by air pollution tolerance index. Air pollution tolerance level of each is different and thus all plants do not show a uniform behavior. It is seen that plant having higher index value are tolerant to air pollution and can be used as a filter of sink to mitigate pollution, while plants having low index value show less tolerance and can be used to indicate levels of air pollution. Air pollutants in urban and industrial areas may be accumulated or integrated into the plant body and, if toxic, may injure them to some degree. The level of damage will be high in sensitive species and low in tolerant ones. Sensitive species are useful as early warning indicators of pollution, and the tolerant ones help in reducing the overall pollution load, leaving the air moderately free of pollutants [10].

MATERIALS AND METHODS

Study Sites

The experimental site mettur is located in Salem, Tamil Nadu, India. The Coordinate is 11.80 N 77. 80E, having elevation of 238m. Mettur is known for its huge dam and industries like Mettur Thermal Power Station, which acts as a base load power station for the Tamil Nadu Electricity Board. It is also called Aluminium city of Tamilnadu, havin Aluminium plant Called MALCO-Madras Aluminium Company Ltd, Steel industry, Chemplast Sanmar / Mettur Chemicals. Since, it is a place which is having several industries nearby, there is a possibility of more pollution. Hence, an attempt has been initiated to study the air pollution tolerance index of plants from mettur forest located at 1km distance from Thermal Power Plant, Mettur. There were approximately 1,50,000 plants. Houses surrounding the forest area will be approximately 500. Common plants observed in the mettur forest were *Polyalthia longifolia, Derris Indica, Holepetela integrifolia, Terminalia tomentosa, Pisidium guajava, Nerium indicum, Azadirachta indica, Calotropis gigantea, Ricinus communis, Carica papaya, Ficus religiosa, Embelica officinalis, Tectona grandis, Opuntia ficus indica*. To study the impact of pollution on plants, this site was chosen for the study, as the experimental site is a home of industries.

Sample collection

The fresh leaves collected were brought to the laboratory for morphological and biochemical analysis.

Air pollution induced Changes in biochemical parameters

Change in leaf pH

100mg of fresh leaves was homogenized in deionized water. This was then filtered and the pH of leaf extract was determined after calibrating pH meter with buffer solution of pH 4 to 9[11].

Change in leaf ascorbic acid content

100mg of fresh leaves ground with 4% oxalic acid. The extract was then titrated against 2, 6 dichlorophenol indophenol dye until the appearance of permanent pale pink colour [12].

Change in leaf cholrophyll and carotenoid pigments

100mg of fresh leaf sample was extracted with 80% acetone, pigments were analyzed with the help of visible spectrophotometer using 645 to 663 nm for chlorophyll and 480, 510 nm for carotenoids[13].

Change in leaf relative water content

The method described by Singh[14] and Agbaire[11] was applied to determine, calculate relative leaf water content. Fresh weight was obtained by weighing the fresh leaves. The leaves were then immersed in water over night at 70˚C and reweighed to obtain the dry weight. Relative water content is arrived by using the following formula:

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

Where,

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

APTI ANALYSIS

The APTI was calculated[15] by using the following formula. The Entire sum was divided by 10 to obtain a small manageable figure.

APTI= [A (T+P) + R] /10

Where,

A= Ascorbic acid (mg/g)

T= Total Chlorophyll (mg/g)

P= pH of leaf extract

R= Relative water content of leaf tissue (%).

RESULTS AND DISCUSSION

Morphological characterization

The amount of dust deposited on the leaf surface signifies the measure of pollution. So, in order to have a rough estimate on level of air pollution, leaf weight with dust, after cleaning dust was measured. Leaf length and width were also measured using meter scale and the results were recorded in cm and depicted in Table.1. According to the results obtained, leaf weight with dust was found to be high in *Opuntia ficus indica, Ricinus communis, Carica papaya, Tectona grandis, Holopetela integrifolia*. Likewise, the leaf length was found to be high in *Carica papaya, Ricinus communis, Ficus religosa, Ficus benghalensis* and more wider leaf was observed *in Ficus religosa, Ricinus communis*. This variation may be due to the environment of an industrial area which might be contaminated with several pollutants such as SO_2, CO, NO_x and heavy metals and the plants growing there would be exposed not only to one pollutant but to many pollutants. The ability of each plant species to absorb and adsorb pollutants by their foliar surface varies greatly and depends on several biochemical, physiological and morphological characteristics [16].

Air pollution induced changes on biochemical parameters

Different plant species shows considerable variation in their susceptibility to air pollution. For this study, parameters such as ascorbic acid, total chlorophyll, carotenoid, pH of leaf extract, relative water content were used in evaluating the degree of tolerance to air pollution by the plant species. The results of components involved in APTI such as pH, Ascorbic acid, Chlorphyll, Carotenoids, Relative water content were depicted in Table.2.

Change in leaf pH

The pH was found to be high in *Polyalthia longifolia, Calotropis gigantea, Ficus benghalensis, Tectona grandis*. The pH was acidic for all the other plants having pH5 and 6. Whereas neutral pH was observed with Derris indica, Psidium guajava, Carica papaya, Moringa oleifera. The high dust accumulation in the winter season may be due to the wet surface of leaves which help in capturing dust, with a gentle breeze and foggy condition preventing particle dispersion. This can explain the highest H+ ion concentration of leaf extract, that is the alkaline condition which is caused by the dissolution of dust particles in cell sap. The photosynthetic efficiency has been reported to be strongly dependent on leaf pH[17] and photosynthesis was reduced in plants with low leaf pH[18].

Change in leaf ascorbic acid content

The ascorbic acid content was high in *Opuntia ficus indica* whereas it was low in *Tectona grandis*. All the other plants showed ascorbic acid in the range of 1.35-3.75mg/g. Ascorbic acid is essential for cell wall synthesis, defense and cell division[19]. It is a strong reducer and plays a significant role in photosynthetic carbon fixation[20]. It also influences the resistance of plants to adverse environmental conditions including air pollution[21] and its reducing power is directly proportional to its concentration[22].

Table 1: Morphological characteristics of plants

S.No	Plants	Leaf weight with dust (g, mg)	Leaf Weight after cleaning dust (g, mg)	Leaf length (cm)	Leaf width (cm)
1	*Polyalthia longifolia*	1.27	1.02	9.5	2.0
2	*Derris indica*	0.692	0.611	5.0	2.6
3	*Holopetela integrifolia*	1.256	1.148	4.5	2.5
4	*Tamarindus indica*	0.528	0.498	6.3	2.8
5	*Terminalia tomentosa*	0.667	0.611	4.0	1.6
6	*Psidium guajava*	0.568	0.472	8.0	3.5
7	*Nerium indicum*	0.682	0.610	11.0	3.5
8	*Azadirachta indica*	0.486	0.240	3.0	1.4
9	*Calotropis gigantea*	1.296	1.098	7.5	4.0
10	*Ricinus communis*	8.506	8.010	21.5	8.5
11	*Carica papaya*	2.215	1.978	24.0	6.5
12	*Ficus benghalensis*	0.982	0.784	17.5	5.5
13	*Embilica officinalis*	0.586	0.498	5.0	2.5
14	*Tectona grandis*	1.840	1.700	12.4	6.7
15	*Ficus religosa*	1.058	0.898	17.5	10.5
16	*Mangifera indica*	0.754	0.684	21.0	4.0
17	*Moringa oleifera*	0.380	0.365	1.7	0.8
18	*Acacia arabica*	0.15	0.12	1.5	0.5
19	*Opuntia ficus indica*	20.012	19.972	15.0	6.0

Table 2: Biochemical changes in plants

S.No	Name of plants	Ascorbic acid (mg/g)	Chlorophyll a (mg/g)	Chlorophyll b (mg/g)	Carotenoid (mg/g)	pH	Relative water content (%)
1.	*Polyalthia longifolia*	2.25	1.72	0.59	0.31	8	59.60
2.	*Derris indica*	2.85	0.15	0.05	0.04	7	90.81
3.	*Holopetela integrifolia*	2.55	0.54	0.56	0.35	6	97.52
4.	*Tamarindus indica*	1.65	0.14	5.67	0.47	5	87.33
5.	*Terminalia tomentosa*	1.65	0.26	0.29	0.77	6	80.23
6.	*Psidium guajava*	3.45	1.11	0.21	0.58	7	84.97
7.	*Nerium indicum*	1.95	0.80	0.14	0.49	6	90.16
8.	*Azadirachta indica*	3.75	12.56	7.72	4.54	6	89.78
9.	*Calotropis gigantea*	2.85	9.61	6.88	3.06	8	85.10
10.	*Ricinus communis*	2.85	0.20	9.03	0.79	6	96.69
11.	*Carica papaya*	3.75	2.71	3.33	2.85	7	97.53
12.	*Ficus benghalensis*	1.35	1.27	0.14	0.26	8	98.49
13.	*Embilica officinalis*	2.85	5.14	22.90	5.0	6	89.98
14.	*Tectona grandis*	1.05	12.59	7.36	4.53	8	93.80
15.	*Ficus religosa*	1.65	1.06	0.83	0.19	6	87.09
16.	*Mangifera indica*	3.45	4.28	30.80	2.58	6	90.47
17.	*Moringa oleifera*	1.35	39.74	3.80	2.97	7	73.42
18.	*Acacia arabica*	3.75	17.46	8.26	6.62	6	73.46
19.	*Opuntia ficus indica*	12.08	3.28	3.49	8.67	5	95.47

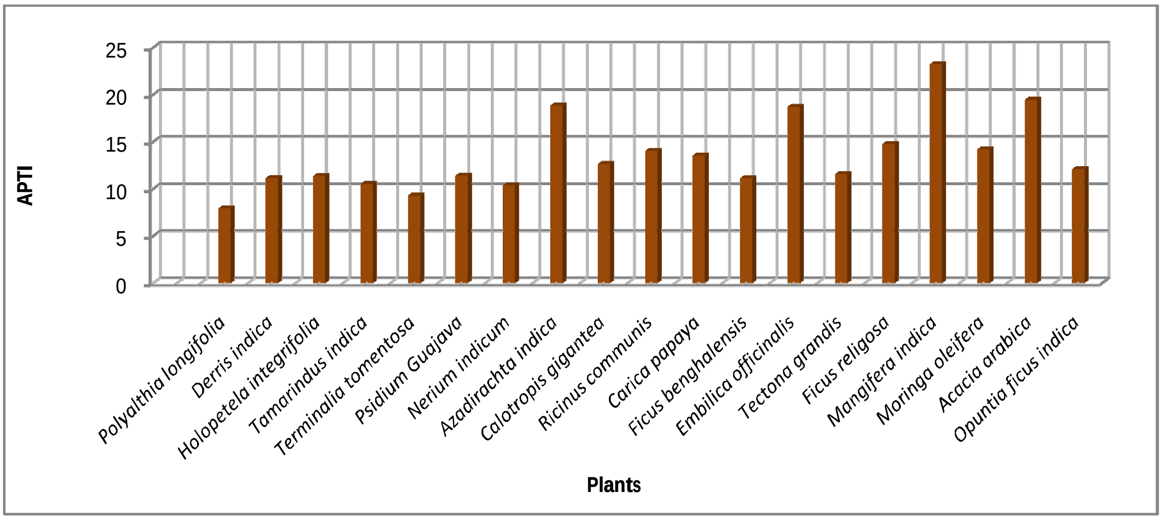

Figure 1: Air Pollution Tolerance Index of plants

Change in leaf chlorophyll and carotenoid pigments

The chlorophyll a content was higher in *Moringa oleifera* (39.74mg/g), *Tectona grandis* (12.59mg/g), *Azadirachta indica* (12.56mg/g) whereas it was low for *Tamarindus indica* having 1.14mg/g. The chlorophyll b content of *Mangifera indica* was 30.80mg/g and 22.90mg/g for *Embilica officinalis*, all other plants showed chlorophyll in the range of 0.05-9.03mg/g. Chlorophyll content of plant is important for its photosynthetic activity as well as for the growth and development of biomass. The chlorophyll content of plant varies from species to species; age of leaf and also with the pollution level as well as with other biotic and abiotic conditions[23]. Various environmental factors like air, water and soil cause variation in plant leaf pigment content through dust accumulation on leaf surface. The least total chlorophyll content during winter season may be due to the highest amount of dust accumulation on the leaf surface, a factor inhibiting chlorophyll synthesis due to the presence of various metals and polycyclic hydrocarbon, which inhibit the enzyme necessary for chlorophyll synthesis. Dust deposition also affects the light availability for photosynthesis and blocks stomatal pores for diffusion of air and thus puts stress on plant metabolism[24-27]. The air pollutants make their entrance into the tissues through the stomata and cause partial denaturation of chloroplast and decreased pigment contents in the cells of polluted leaves. Allen et. al.,[28] demonstrated, that the increasing levels of total chlorophyll by certain pollutants. So, increase in chlorophyll content of the leaves in industrial site may be attributed to the influence of pollutants present in a smoke releasing from the industry.

Change in leaf relative water content

The relative water content was found to be high in *Ficus benghalensis, Carica papaya, Holopetela integrifolia, Ricinus communis*. Whereas, it was in the range of 59 to 90.47% in all other selected plants. Relative water content presents a useful indicator of the state of water balance of a plant, essentially because it expresses the absolute amount of water, which the plant requires to reach artificial full saturation. The high RWC of the leaf can be explained by the higher rate of availability of water in the soil along with the low rate of transpiration. Leaf water status is intimately related to several leaf physiological variables such as leaf turgour, growth, stomatal conductance, transpiration, photosynthesis and respiration[29]. Thus, the higher relative water content in industrial site sample may be responsible for normal functioning of biological processes in plants at industrial site.

Air pollution tolerance index analysis

The present investigation of air pollution tolerance index was carried during Feb, 2013. The results of air pollution tolerance index [APTI] calculated for each plant studied at the experimental sites is mentioned in Fig.1. In the present study, the air pollution tolerance of plants found to decrease in the following order: *Mangifera indica* < *Acacia Arabica* < *Azadirachta indica* < *Embilica officinalis* < *Ficus religosa Moringa oleifera*< *Ricinus communis* <*Carica papaya* <*Calotropis gigantea* < *Opuntia ficus indica* <*Tectona grandis* < *Psidium Guajava* < *Holopetela integrifolia* <*Derris indica*< *Ficus benghalensis* < *Nerium indicum*< *Tamarindus indica*< *Terminalia tomentosa*< *Polyalthia longifolia.* Lakshmi et. al.,[30] classified plants according to their tolerance capacity as follows: APTI value in the range of 30-100 as tolerant to pollution, 17-29 intermediate to pollution and below 16 and up to 1 are sensitive and value less than 1 are very sensitive. Among the 19 plants selected, *Mangifera indica, Acacia Arabica, Embilica officinalis, Azadirachta indica* having APTI value above 17 are grouped as intermediate to pollution. Whereas, other plants having APTI value less than 17 are sensitive to pollution and no plants were found to be less than 1.

CONCLUSION

Plants were assessed for their tolerance index to have an idea about the air pollution level in that locality. This work has indicated the suitability of *Mangifera indica, Acacia*

Arabica, Embilica officinalis, Azadirachta indica as intermediate tolerant species to pollution. It can be utilized for urban plantation and greenbelt development in industrial area to reduce the level of air pollution. Different plants respond in different ways to air pollution, therefore plants growing in actually polluted environment had higher APTI than those from less polluted environment.

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