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Impact of air pollution and leaf dust deposition on biochemical parameters and air pollution tolerance index (APTI) of some road side plants

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Abstract
Plants growing in cities and near major roads absorb the pollutants and dust particles at their foliar surface. Biochemical parameters like leaf pH, relative water content, total chlorophyll content are used for analyzing impact of dust deposition on plant leaves and Air Pollution Tolerance Index (APTI). In the present study, leaf samples of different plant species like, *Bougainvillaea spectabils,* Willd.; *Ficus relegiosa,* Linn.; *Polyalthia longifolia,* Hook. F. & Thoms.; *Tamarindus indica,* Linn.; and *Tecoma stans,* (L) Juss. ex. Kunth.; were taken from road sides which has a heavy load of vehicles. Changes in biochemical parameters of plants were evaluated and determined Air Pollution Tolerance Index (APTI). Results show *Tecoma stans* (L.) Juss. ex.Kunth.; and *Bougainvillaea spectabilis,* Willd.; have comparatively high APTI values. So these plants can be used for plantation on the road sides as pollution scavengers.

Keywords: major, plantation, scavengers, growing, Tolerance

Introduction

Air pollution is a major anthropogenic threat in modern society. Air pollution is the human introduction of particulate matter, gases, chemicals or any other substances in to air, that is harmful to all organisms and environment. Dust is the fine solid particle of any materials present in air. It also has a role in contaminating air. Motor vehicle emission is another major source of pollutants. Government of India has instituted Bharat Stage Emission Standards (BSES) to control emissions from vehicles (Bansal *et al.*, 2013).

India is one of the difficult countries in the world to breathe. 11 of 12 cities with the highest level of pollution are located in India. Kanpur tops the list with a yearly average of 319 micrograms per cubic meter of most harmful pollutants. Kanpur followed by Faridabad, Varanasi, Gaya, Patna, Delhi, Lacknow, Bamenda (Cameroon), Agra, Muzaffarpur, Srinagar, and Gurgaon (Umair *et al.*, 2018). Air pollution has a range of negative impacts, including human health and damage to ecosystems. It is the cause of seven million premature deaths every year (Deepak *et al.*, 2018).

Trees reduce the concentration of pollutants in atmosphere by absorbing pollutants on their foliar surface. High concentration of pollutants causes inactivation of plant cells. Hence, effects of air pollution are visible on the leaves. Pollutant gases like Sulphur dioxide (SO_x) and Nitrogen oxides (NO_x) are absorbed into mesophyll of leaves through stomata (Lohe *et al.*, 2015) [4]. The plant species which are more sensitive act as biological indicators of air pollution.

Presence of pollutants and dust in the atmosphere causes many variations in plant properties. Changes in biochemical parameters like total chlorophyll content, relative water content, leaf pH and ascorbic acid content acts as key indicators of tolerance level of plants with respect to air pollution (Uka *et al.*, 2017) [7].

In order to estimate susceptible limit of plants to air pollutants, Air Pollution Tolerance Index (APTI) is used. It is determined by parameters such as Leaf extract pH, Relative water contents (RWC), Ascorbic acid content and Total Chlorophyll content. Plants are classified into three categories of sensitivity: APTI < 10, sensitive, APTI 10- 16, intermediate, APTI ≥ 16 tolerant, (Agarwal *et al.*, 1991) [1]. Sensitive species are more useful as bioindicators of pollution.

In the present study, in order to determine the tolerance or sensitivity of different plants (*Tamarindus indica*, Linn,; *Bougainvillaea spectabils*, Willd.; *Polyalthia longifolia*, Hook. F. & Thoms.; and *Tecoma stans*, (L.) Juss. ex. Kunth.; *Ficus relegiosa*, Linn.;) are collected from road sides of Ramanathapuram, Coimbatore. Changes in biochemical parameters like ascorbic acid content, relative water content, pH and total chlorophyll content with leaf dust deposition were analyzed and Air Pollution Tolerance Index (APTI) is determined.

Materials and Methods

Study area

This study was done in Ramanathapuram, Coimbatore, a major city in Indian state of Tamil Nadu. Coimbator is surrounded by the Western Ghats mountain range on the west and north, with reserve forests on the northern side. Coimbatore is the second largest city after Chennai in the state of Tamil Nadu, India. The air pollution level of Coimbatore city in Tamil Nadu increases year after year due to its rapid industrial development and growth of automobile usages. Increase in number of vehicles is the main reason for this.

Sample Collection

The leaf samples of roadside plants were collected from Ramanthapuram, Coimbatore and further analysis has been performed for determining impact of dust deposition on biochemical aspect of leaves. The plant species studied were *Bougainvillaea spectabilis*, Willd.; *Ficus religiosa*, Linn.; *Polyalthia longifolia*, Hook. F. & Thoms.; *Tamarindus* *indica*, Linn.; and *Tecoma stans, (L.) Juss. ex.Kunth.;*. Their controls are collected from non polluted areas.

Determination of Dust Deposition

Bitopan *et.,al* (2017) [2, 8] method is used for the determination of dust deposition. Leaves from the plant species were collected. The leaf samples are washed and that water with dust is filtered through pre weighed Whatman filter paper to collect the dust. The filter papers is dried to remove the water and weighed later to calculate the dust deposition in mg/cm² of the leaf. Washed leaves were blotted dry and then traced on graph paper to measure the total leaf area in cm². Amount of dust was calculated using the formula:

$$W = \frac{W2 - W1}{A}$$

Where, W = dust content (g/ cm−2), w1 = initial weight of tracing paper, w2 = final weight of tracing paper with dust, and A = total area of the leaf (cm2). Area of leaves is determined by graphical method.

Biochemical Analysis

1. **Leaf pH Estimation**
   For determination of pH of leaf samples (Njagi *et al.*, 2012) [5] the leaves were washed with distilled water and then sun dried for three days. 5g of leaves of each plant were weighed and soaked in 250ml of distilled water. The pH of this water (where leaves were soaked) was determined using a pH meter.
2. **Relative Water Content (RWC) Estimation**
   Relative water content of the leaf samples were determined by methods of Devendra *et al.*, (2017) For estimation, the fresh weight of the leaf samples were taken. The leaves were soaked in water to get saturated weight, then dried in shade to obtain the dry weight and determined the RWC as follows:

$$RWC\% = \frac{fresh\ weight - dry\ weight}{saturated\ weight - dry\ weight} \times 100$$

3. **Total Chlorophyll Content Estimation**
   Total Chlorophyll was determined by the spectrophotometric method (Devendra *et al.*, 2018) [3]. 1gm of the fresh leaf sample was blended and then extracted with 20mlof 80% acetone, and centrifuged at 5000 RPM for 5 minutes. The supernatant was collected and its absorbance was measured at 645nm and 663nm using spectrophotometer. Calculations were made using the formula below:

$$\text{Chlorophyll a} = 12.7 \times DX_{663} - 2.69 \times DX_{645} \times V/1000W \text{ mg/g}$$

$$\text{Chlorophyll b} = 22.9 \times DX_{645} - 4.68 \times DX_{663} \times V/1000W \text{ mg/g}$$

$$\text{TCh} = \text{chlorophyll a} + \text{b mg/DX}$$

   Where, DX= Absorbance of the extract at the Wave length Xnm , V= total volume of the chlorophyll solution (ml), W = weight of the tissue extract (g)

4. **Ascorbic acid content estimation**
   Ascorbic acid was determined by titrimetric method (Prabath *et al.*, 2014). 5 ml Ascorbic acid working standard and 10 ml of 4% oxalic acid and titrated against the dye 2, 6- Dichloro phenol indophenol solution for getting V1 (ml). Appearance of a pale pink colour persistant for a few minutes indicate the end point of the reaction. Ascorbic acid working standard is prepared by diluting 10 ml ascorbic acid stock standard in 4% oxalic acid. Similarly 5 ml sample extracted with oxalic acid and then titrated with the dye solution for sample reading (V2 ml). Amount of ascorbic acid in the sample was calculated as:

$$Ascorbic\ acid (mg/100gm) = \frac{0.5mg}{V1ml} \times \frac{V2\ ml}{5ml} \times \frac{100ml}{weight\ of\ the\ sample} \times 100$$

Determination of air Pollution Tolerance Index (APTI)

Air Pollution Tolerance Index (APTI) was calculated using the formula of (Devendra *et al.*, 2018) [3] as follows:

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

A = Ascorbic Acid (mg/gm)
T = Total Chlorophyll (mg/gm)
P = pH
R = Relative Water Content (RWC) (%)

Result and Discussion

The present study shows variation in dust accumulation, biochemical characters of leaves and APTI of different plants collected from polluted areas from their controls. This variation is the impact of air pollution.

Table 1: Determination of dust Deposition

Specimen	Dust Deposition (mg/cm²)	
	Sample	Control
Bougainvillaea spectabilis, Willd.;	*4.47*	*0.61*
Ficus religiosa,Linn.;	0.88	0.37
Polyalthia longifolia, Hook. F. &Thoms.;	0.72	0.61
Tamarindus indica, Linn.;	2.46	1.09
Tecoma stans, (L.) Juss.ex.Kunth.;	2.60	0.98

Dust content in the leaves of selected plants at polluted area and at control area is given in table 1. From table 1, it is observed that dust deposition is high in all samples than their controls. Dust collection efficiency is maximum for *Bougainvillaea spectabilis*, Willd.; sample and minimum for *Polyalthia longoifolia*, Hook. F. &Thoms.;. The dust deposition among samples decreases in the order *Bougainvillaea spectabilis,* Willd.; *Tecoma stans,* (L.) Juss. ex. Kunth.; *Tamarindus indica,* Linn.; *Ficus religiosa,* Linn.; *Polyalthia longoifolia,* Hook. F. &Thoms.;. Dust deposition capacity depends on characters like amount of dust present in atmosphere, surface area of leaf, morphological and anatomical characters of leaf, climate, direction and speed of wind. Highest dust accumulation in *Bougainvillaea spectabilis,* Willd.; may be due to their waxy coating. Lower dust accumulation in *Polyalthia longoifolia,* Hook. F. & Thoms.; may be due to its smooth, flat surface.

Table 2: Leaf pH Estimation

Specimen	Leaf pH	
	Sample	Control
Bougainvillaea spectabilis, Willd.;	7.76 (alkaline)	7.20 (alkaline)
Ficus religiosa, Linn.;	6.62 (acidic)	6.55 (acidic)
Polyalthia longifolia, Hook. F. &Thoms.;	5.15 (acidic)	5.11 (acidic)
Tamarindus indica, Linn.;	6.68 (acidic)	6.62 (acidic)
Tecoma stans, (L.) Juss.ex.Kunth.;	7.63 (alkaline)	7.17 (alkaline)

Table-2 shows, pH of leaves collected from polluted site is lower than that from controlled site in all the selected plants. Variation of pH may be due to the influence of dust deposition on the plant leaves. High dust deposition is may be due to highest pH value that causes dissolution of dust particles in the cell sap resulting in an alkaline condition. Among these five plants pH value is maximum for *Bougainvillaea spectabilis,* Willd.; since its dust deposition is high. Value of pH is minimum for *Polyalthia longifolia,* Hook. F. &Thoms.; in which dust deposition is minimum.

Table 3: Relative Water Content (Rwc) Estimation

Specimen	Relative Water Content (%)	
	Sample	Control
Bougainvillaea spectabilis, Willd;	58.70	36.39
Ficus religiosa, Linn;	69.34	64.47
Polyalthia longifolia, Hook. F. &Thoms;	64.14	56.15
Tamarindus indica, Linn;	52.39	48.45
Tecoma stans, (L.) Juss.ex.Kunth;	51.57	46.68

From table 3 it is observed that relative water content is maximum for *Ficus religiosa,* Linn; and minimum for *Tecoma stans,* (L.) Juss. ex. Kunth;. More water content in leaf helps to maintain its physiological balance under stress conditions of air pollution. Higher relative water content increases drought resistance capacity in plants. Hence plants having more relative water content indicate dry area.

Table 4: Estimation of Total Chlorophyll Content

Specimen	Total Chlorophyll Content (mg/gm)	
	Sample	Control
Bougainvillaea spectabilis, Willd;	-0.001	0.039
Ficus religiosa, Linn;	0.427	0.085
Polyalthia longifolia, Hook. F. &Thoms;	0.138	0.273
Tamarindus indica, Linn;	0.213	0.025
Tecoma stans, (L.) Juss.ex.Kunth;	-0.031	0.245

Chlorophyll content is highest in *Ficus religiosa,* Linn; and lowest in *Polyalthia longifolia,* Hook. F. & Thoms; The reduction in the total chlorophyll content mainly occurs due to the deposition of particulate matter on the leaf surface. The loss in the total chlorophyll content of the leaves support the fact that, chloroplasts are the major site for the attack of air pollutants in plants. The reduction in chlorophyll content may be due to maximum dust accumulation on the leaf surface.

Table 5: Estimation of ascorbic acid Content

Specimen	Ascorbic acid Content (mg/gm)	
	Sample	Control
Bougainvillaea spectabilis, Willd;	13.98	3.99
*Ficus religiosa,*Linn;	9.99	5.99
Polyalthia longifolia, Hook. F. &Thoms;	9.08	4.62
Tamarindus indica, Linn;	7.99	3.99
Tecoma stans, (L.) Juss.ex.Kunth;	47.95	23.97

Here, ascorbic acid content is maximum in *Tecoma stans,* Linn, hence it was collected from most polluted area. Ascorbic acid content is minimum in *Tamarindus indica,* Linn;.

Air Pollution Tolerance Index (APTI)

Air Pollution Tolerance Index (APTI) is the measure of tolerance level of plants to atmospheric pollution.

Table 6: Determination of air Pollution Tolerance Index

Specimen	Air Pollution Tolerance Index (APTI)	
	Sample	**Control**
Bougainvillaea spectabilis, Willd;	16.12	6.84
Ficus religiosa, Linn;	13.69	10.46
Polyalthia longifolia, Hook. F. & Thoms;	11.05	8.01
Tamarindus indica, Linn;	10.18	7.50
Tecoma stans, (L.) Juss.ex.Kunth;	39.38	23.54

From the table-6, APTI value is maximum for sample of *Tecoma stans,* (L.) Juss.ex.Kunth;. It decreases in the order *Bougainvillaea spectabilis,* Willd; *Ficus religiosa,* Linn; *Polyalthia longifolia,* Hook. F. &Thoms.; *Tamarindus indica,* Linn; *Bougainvillaea spectabilis,* Willd*; Ficus religiosa,* Linn. *Polyalthia longifolia,* Hook. F. &Thoms*;* and *Tamarindus indica,* Linn*;* collected from polluted areas have intermediate tolerance since their APTI value is in between 10 and 16. For *Tecoma stans* (L.) Juss. ex.Kunth*.;* collected from polluted area have APTI value greater than 16 hence it is tolerant. All the control plants have lower APTI value compared to their samples collected from polluted area. Among control plants collected from non polluted areas *Tecoma stans* (L.) Juss. ex. Kunth*;* show high APTI, it is tolerant. *Ficus religiosa,* Linn; have intermediate tolerance and all other controls are sensitive. In this study *Tecoma stans* (L.) Juss. ex. Kunth*;* and *Bougainvillaea spectabilis,* Willd*.;* show comparatively high APTI values. So these plants can be planted in the roadsides and polluted areas for trapping the air pollutants and control air pollution.
In the present study, leaf samples are collected from roadsides and their controls are collected from non polluted area (control). *Bougainvillaea spectabilis,* Willd*;* show highest dust deposition and *Polyalthia longifolia,* Hook. F. &Thoms*.;* shows least dust deposition. Highest dust accumulation in *Bougainvillaea spectabilis,* Willd*.;* may be due to their waxy coating. Lower dust accumulation in *Polyalthia longoifolia,* Hook. F. &Thoms.; may be due to its smooth, flat surface. Changes in biochemical parameters of plants were evaluated to determine Air Pollution Tolerance Index (APTI). Biochemical parameters like leaf pH, relative water content, total chlorophyll content, and ascorbic acid content were evaluated.
Air pollution statuses of plants from the cities were estimated by APTI has already studied (Devendra *et al.,* 2017). Changes in parameters such as total chlorophyll content, ascorbic acid, pH, and relative water content of leaf extracts were evaluated to know the tolerance level of plants to air pollution in *Eucalyptus, Mangifera indica, Azardiracta indica, Calotropis procera* are very much tolerant and they can be used for reducing air pollution.
Leaf dust deposition and its impact on biochemical aspects of some roadside plants were also studied (Prabath *et al.,* 2014). In this study season wise dust deposition of six different plants of selected roadsides were evaluated. The result showed significant negative and positive correlation between dust deposition, relative water content, total chlorophyll content, and pH respectively. The highest and lowest dust deposition rates were observed in *Ficus bengalensis* and *Artocarpus integrifolia* respectively. This study concluded that plants can be used in the abatement of dust pollution by acting as natural filters without determining the tolerance level of plants.

Conclusion
Increased amount of air pollutants in atmosphere, absorbed by plant leaves causes some changes in characters and functions of plants. Hence determination of changes in biochemical parameters and APTI of plants have great importance in present scenario. In this study impact of dust and air pollutants on biochemical changes in plants and APTI were determined. Result of APTI estimation shows *Tecoma stans*, (L.) Juss. ex. Kunth; and *Bougainvillaea spectabilis,* Willd.; are more tolerant to air pollution. Hence these plants can be recommended for plantation on the roadsides and polluted areas for reducing the amount of air pollutants in atmosphere.

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