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, Tamarindus indica Linn., Tectona grandis L.f, Vitex negundo L., Thevetia peruviana (Pers.) K. Schum., Tecoma stans(L) Juss. ex Kunth, Nerium oleander L., Ficus.sp L, Muntingia calabura L., Ricinus communis L., Erythrostemon gilliesii (Hook) Link & al. 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 has comparatively high APTI values. So, these plants can be used for plantation on the road sides as pollution scavengers.

Keywords: *dust particles, plantation, pollution scavengers, air pollution tolerance index*

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, Lucknow, 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 (SOx) and Nitrogen oxides (NOx) are absorbed into mesophyll of leaves through stomata (Lohe *et* *al*., 2015). 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).

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) Sensitive species are more useful as bioindicators of pollution.

In the present study, in order to determine the tolerance or sensitivity of different plant species like *Tamarindus indica* Linn., *Tectona grandis* L.f, *Vitex negundo* L., *Thevetia peruviana* (Pers.)K.Schum., *Tecoma stans*(L) Juss. ex Kunth, *Nerium oleande*r L., *Ficus.sp* L, *Muntingia calabura* L., *Ricinus communis* L., *Erythrostemon gilliesii (*Hook) Link & al. plants are collected from road sides of Selvapuram, 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 Method

Sample Collection

The leaf samples of roadside plants were collected from Selavapuram, Coimbatore and further analysis has been performed for determining impact of dust deposition on biochemical aspect of leaves. The plant species studied were like *Tamarindus indica* Linn., *Tectona grandis* L.f, *Vitex negundo* L., *Thevetia peruviana* (Pers.)K.Schum., *Tecoma stans*(L) Juss. ex Kunth, *Nerium oleande*r L., *Ficus.sp* L, *Muntingia calabura* L., *Ricinus communis* L., *Erythrostemon gilliesii* (Hook) Link & al. Their controls are collected from non polluted areas.

PLANTS NAME	FAMILY
*Tamarindus indica*Linn.	Fabaceae
Tectona grandis L. f	Lamiaceae
Vitex negundo L.	Lamiaceae
Thevetia peruviana (Pers.)K.Schum	Apocynaceae
Tecoma stans(L) Juss. ex Kunth	Bignoniaceae
Nerium oleander L.	Apocynaceae
Ficus.sp L	Moraceae
Ricinus communis L.	Euphorbiaceae
Erythrostemon gilliesii (Hook) Link & al.	Fabaceae
Muntingia calabura L.	Muntingiceae

Determination of Dust Deposition

Bitopan *et al* (2017), 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 by Devendra *et al.*, 2018. 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:

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

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

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

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 indicates 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) as follows

A = Ascorbic Acid (mg/gm)

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

T = Total Chlorophyll (mg/gm)

P = pH R = Relative Water Content (RWC) (%)

RESULTS 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.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 controls. Dust collection efficiency is maximum for *Tecoma stans*(L) Juss. ex Kunth Sample and minimum for *Nerium oleander* L.

TABLE-1 Determination of dust desposition

S.no	Plant Species	Dust deposition (mg/cm)	
		sample	control
1	*Tamarindus indica Linn.*	2.46	1.09
2	*Tectona grandis* L.f	2.25	2.12
3	*Vitex negundo*.L.	1.33	2.10
4	*Thevetia peruviana* (Pers.)K.Schum.	1.54	1.69
5	*Tecoma stans* (L) Juss. ex Kunth	2.60	0.98
6	*Nerium oleander* L.	0.53	0.56
7	*Ficus.sp* L	1.54	0.36
8	*Muntingia calabura* L.	1.21	1.56
9	*Ricinus communis* L.	0.59	1.43
10	*Erythrostemon gilliesii* (Hook) Link & al.	0.78	0.98

TABLE :2 Leaf pH estimation

S.no	Plant Species	Leaf pH	
		Sample	**control**
1	*Tamarindus indica Linn.*	6.68(alkaline)	7.20(alkaline)
2	*Tectona grandis* L.f	9.18(alkaline)	9.10(alkaline)
3	*Vitex negundo.*L.	8.25(alkaline)	8.10(alkaline)
4	*Thevetia peruviana* (Pers.)K.Schum.	3.20 (acidic)	3.8(acidic
5	*Tecoma stans* (L) Juss. ex Kunth	7.36 (neutral)	7.17 (neutral)
6	*Nerium oleander* L.	6.25(acidic)	6.08(acidic)
7	*Ficus.sp* L	9.22(alkaline)	9.15(alkaline)
8	*Muntingia calabura* L.	8.15(alkaline)	8.5 (alkaline)
9	*Ricinus communis* L.	5.08 (acidic)	5(acidic)
10	*Erythrostemon gilliesii* (Hook) Link & al.	7.25(neutral)	7.10 (neutral)

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 ten plants pH value is maximum for since its dust deposition *Tectona grandis* L.f, *Ficus.sp* L is high. Value of pH is minimum for *Ricinus communis* L. in which dust deposition is minimum.

TABLE :3 Relative water content

S.no	Plant species	Relative water content(%)	
		Sample	**Content**
1	*Tamarindus indica Linn.*	52.39	48.45
2	*Tectona grandis* L.f	59.60	45.36
3	*Vitex negundo.*L.	49.73	33.38
4	*Thevetia peruviana* (Pers.)K.Schum.	44.72	63.48
5	*Tecoma stans* (L) Juss. ex Kunth	51.57	46.68
6	*Nerium oleander* L.	63.74	55.46
7	*Ficus.sp* L	33.23	19.22
8	*Muntingia calabura* L.	46.77	35.55
9	*Ricinus communis* L.	55.38	40.22
10	*Erythrostemon gilliesii* (Hook) Link & al.	46.77	40.22

From table 3 it is observed that relative water content is maximum for *Nerium oleander* L; 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

S.no	Plant species	Total chlorophyll content	
		Sample	Control
1	*Tamarindus indica Linn.*	0.123	0.098
2	*Tectona grandis* L.f	0.142	0.012
3	*Vitex negundo.*L.	0.148	0.016
4	*Thevetia peruviana* (Pers.)K.Schum.	153.4	123,6
5	*Tecoma stans* (L) Juss. ex Kunth	143.8	136.4
6	*Nerium oleander* L.	163.2	146.5
7	*Ficus.sp* L	135.6	112.8
8	*Muntingia calabura* L.	145.8	138.5
9	*Ricinus communis* L.	164.7	111.1
10	*Erythrostemon gilliesii* (Hook) Link & al.	172.8	153.5

Chlorophyll content is highest in *Tamarindus indica* Linn. and lowest in *Nerium oleander L.*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 4)

TABLE: 5 Estimation of ascorbic acid content

S.no	Plant species	Ascorbic acid content(mg/gm)	
		Sample	Control
1	*Tamarindus indica Linn.*	7.99	3.99
2	*Tectona grandis* L.f	22.3	18.8
3	*Vitex negundo.*L.	19.3	13.7
4	*Thevetia peruviana* (Pers.)K.Schum.	23.6	20.4
5	*Tecoma stans* (L) Juss. ex Kunth	47.95	23.97
6	*Nerium oleander* L.	16.8	12.4
7	*Ficus.sp* L	33.5	25.5
8	*Muntingia calabura* L.	26.6	20.5
9	*Ricinus communis* L.	25.3	18.8
10	*Erythrostemon gilliesii* (Hook) Link & al.	32.4	26.8

Here, ascorbic acid content is maximum in *Tecoma stans* (L) Juss. ex Kunth hence it was collected from most polluted area. Ascorbic acid content is minimum in *Tamarindus indica Linn.* (Table 5)

TABLE 6: Determination of air pollution tolerance

S.no	Plant species	Air pollution Tolerance (APTI)	
		Sample	Control
1	*Tamarindus indica Linn.*	10.18	7.50l
2	*Tectona grandis* L.f	7.28	5.47
3	*Vitex negundo*.L.	6.09	7.73
4	*Thevetia peruviana* (Pers.)K.Schum.	358.9	249
5	*Tecoma stans* (L) Juss. ex Kunth	39.38	23.54
6	*Nerium oleander* L.	270.45	179.04
7	*Ficus.sp* L	430	266
8	*Muntingia calabura* L.	363	266.8
9	*Ricinus communis* L.	403.3	203
10	*Erythrostemon gilliesii* (Hook) Link & al.	449.3	356

Air Pollution Tolerance Index (APTI)

Air Pollution Tolerance Index **(**APTI) is the measure of tolerance level of plants to atmospheric pollution. From the table-6, APTI value is maximum for sample of *Erythrostemon gilliesii* (Hook) Link & al., *Ficus.sp* L , *Ricinus communis* L., *Thevetia peruviana* (Pers.)K.Schum., *Muntingia calabura* L. , *Nerium oleander* L., *Tecoma stans* (L) Juss. ex Kunth , *Tamarindus indica Linn.*, *Tectona grandis* L.f, *Vitex negundo*.L. have APTI index above 16 hence they are tolerant .Whereas *Tamarindus indica Linn.* was collected from polluted areas have intermediate tolerance since their APTI value is in between 10 and 16. *Tectona grandis* L.f and *Vitex negundo*.L. have APTI index below 10 hence considered as sensitive species. All the control plants have lower APTI value compared to their samples collected from polluted area. 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 concludes that *Erythrostemon gilliesii* (Hook) Link & al., *Ficus.sp* L , *Ricinus communis* L., *Thevetia peruviana* (Pers.)K.Schum., *Muntingia calabura* L. , *Nerium oleander* L., *Tecoma stans* (L) Juss. ex Kunth , *Tamarindus indica Linn.*, *Tectona grandis* L.f, *Vitex negundo*.L.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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