Air Pollution Tolerance Index and Anticipated Performance Index of Selected Plant Species in Haridwar City, India

Sangeeta Madan [1, *], Shivani Chauhan [1]

[1.] Department of Environmental Sciences, Gurukul Kangri University, Haridwar 249401, India
Snmadan21@gmail.com, shivanichauhanjmd@gmail.com

Abstract: The present study was designed to evaluate the variation in biochemical parameters and the air pollution Tolerance Index (APTI) of selected six plant species collected from four different sites of Haridwar city. High value of APTI was recorded in *Mangifera indica* (12.36±0.14) and the lowest APTI was recorded in *Polyalthia longifolia* (7.94±0.62). The Anticipated Performance Index (API) of these plant species was also calculated by considering their APTI values together with other socio-economic and biological parameters. According to API *Ficus religiosa* was found under very good category and *Azadirachta indica, Mangifera indica* and *Syzygium cumini* were categorized as good performer. *Polyalthia longifolia* and *Psidium guajava* to be very poor performer. Based on these results the most tolerant species were *Mangifera indica* and *Ficus religiosa.*
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Key words: air pollution; anticipated performance index; air pollution tolerance index; biochemical parameters

1. Introduction

Air is never found to be absolutely clean in nature. Pollution of air started from the moment when the primitive man knew to make fire, since then it has increased and increasing every moment (Sharma, 2005). Air pollution is one of the serious problems throughout the world. It deteriorates ecological conditions and can be defined as the fluctuations in any atmospheric constitution from the value that would have existed without human activity (Tripathi and Gautam, 2007). The degradation of air quality is major environmental problem that affects many urban and industrial sites and the surrounding regions worldwide (Kuddus et al., 2011). Urbanisation is one of the most drastic changes that can be imposed on an environment. Rapid industrialization and vehicular traffic especially in the urban areas of India lead to the deterioration of air quality by adding toxic gases and other substances to the atmosphere. All combustion releases gases and particulate matter into the air which includes SOx, NOx, CO and soot particles as well as smaller quantities of toxic metals, organic molecules and radioactive isotopes (Bhattacharya et al., 2013; Agbaire, 2009; Chouhan et al., 2011).

Plants are the only living organisms, which have to suffer a lot from pollution as they remains static at their habitat. Air pollutants can directly affect plants via leaves or indirectly via soil acidification. The particulates and gaseous pollutants, alone and in combination can cause serious setbacks to the overall physiology of plants (Ashenden and Williams, 1980; Anda, 1986). Air pollutants when absorbed by the leaves may cause a reduction in the concentration of photosynthetic pigments viz., chlorophyll and carotenoids, which directly affected to the plant productivity (Joshi and Swami, 2009).

Plant play an important role in maintaining and monitoring the ecological balance by actively participating in the cycling of the nutrients and gases like carbon dioxide, oxygen and provide enormous leaf area for impingement, absorption and accumulation of air pollutants to reduce the air pollution level in the environment (Escobedo et al., 2008). Responses of plants towards air were assessed by air pollution tolerance index. Air pollution tolerance level of each is different and plants do not show a uniform behaviour. It is that plants 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. By calculating air pollution tolerance index (APTI) based on four bio-chemical and physiological parameters viz. chlorophyll, ascorbic acid, pH, relative water content the tolerance level of the plants can be evaluated (Singh and Rao, 1983). When this tolerance index of plants combines with some of the socioeconomic and biological characters the anticipated performance index (API) was also determined which gives more stable results than those with single parameter.

Thus the main objective of the study was to evaluate Air Pollution Tolerance Index (APTI) and Anticipated Performance Index (API) of some selected plants species in Haridwar city.

2. Materials and methods

2.1 Study area

The present study was carried out at four

different sites of Haridwar city located in the state of Uttarakhand, is one of the important holy cities of India and is extended from latitude 29° 30' in the north to longitude 78°43' in the east with a subtropical climate. Rapid industrialization and urbanisation in the city increases the density of air pollutants with the development of industrial area, and increase in population and further increased the load of vehicular density. Six locally available plant species were selected for the study were; *Polyalthia longifolia* (Ashok), *Ficus religiosa* (Peepal), *Mangifera indica* (Mango), *Azadirachta indica* (Neem), *Syzygium cumini* (Jamun), *Psidium guajava* (Guava). Matured leaf samples were collected from sites and kept in polythene bags for analysis.

2.2 Methodology

Various biological and physical parameters such as dust load, leaf extract pH (Singh and Rao, 1983), relative water content (Weatherly, 1965), total chlorophyll (Arnon, 1949), Caroteniods ((Kirk and Allen, 1965), ascorbic acid (Sadasivam and Manikam, 1991), Air Pollution Tolerance Index (APTI) (Singh and Rao, 1983) and Anticipated Performance Index (API) (Mondal et al., 2011) were done from collected samples. Standard table for API assessment is given in table 1 and 2.

3. Result Analysis

The results obtained from the analysis are given in table 3 to 8. In present study dust deposition in plants leaves varied between 0.20±0.10 g/m^2 to 0.74±0.10. Highest dust accumulation was found in *Psidium guajava* 0.74±0.10 g/m^2 at site-IV (Table-6) which may be due to waxy coating, slightly folded margins, rough surface and small petioles that reduced the movement of leaves in wind. Secondly trees having broad leaves of simple elliptical and hairy structure collect a lot of dust from air. Dust load of area is also responsible for higher dust accumulation on leaves. Lowest dust accumulation was found in *Ficus religiosa* 0.58±0.10 g/m^{2}at site-I because height and size of plant should also be considered as one of the criteria to reduce dust deposition. pH value of leaf extract ranges between 6.06 ±0.16 mg/gm. *Mangifera indica* showed the maximum chlorophyll content at site-I (Table-3) and minimum was found in *Psidium guajava* at site-IV. The reduction in chlorophyll content of plants at site-IV may be due to higher pollution status of the area. Pollution stress decreases the chlorophyll level in tree species (Paulsamy et al., 2000). Reduction of chlorophyll in plants may be due to the increase of chlorophyllase enzyme activities, which in turn affects the chlorophyll concentration in plants (Mandal and Mukherji, 2000). carotenoid varies between 2.67±0.08mg/g to 0.82±0.05 mg/g. The least carotenoid content was recorded in *Azadirachta indica* at site-III (Table-5) and the maximum was recorded in *Syzygium cumini* at site-I (Table-3). The ascorbic acid content ranged between 1.92±0.17mg/g to 0.84±0.11mg/g. The highest ascorbic acid was recorded in *Mangifera indica* at site-I and the lowest was recorded in *Polyalthia longifolia* at site-IV (Table-6). The reducing activity of ascorbic acid is pH dependent being more at higher and lesser at lower pH (Tsega and Prasad, 2014). APTI values ranging between 7.94±0.62 to 12.36±0.14. The highest APTI was recorded in *Mangifera indica* at site-I (Table-3) and the lowest APTI was recorded in *Polyalthia longifolia* at site-IV (Table-6). The APTI value of *Mangifera indica* and *Ficus religiosa* was higher than 10 at site-I. Acc. to API assessment *Ficus religiosa* was found under very good category and *Azadirachta indica, Mangifera indica* and *Syzygium cumini* were categorized as good performer. These plants have dense plant canopy of evergreen foliage which may afford protection from pollution stress.

Table 1. Gradation of plant species on the basis of air pollution tolerance index (APTI) and other biological and socioeconomic characters.

Grading	Character	Pattern of assessment	Grade alloted
(a) Tolerance	Air Pollution Tolerance Index(APTI)	12.0-16.0	+
		16.1-20.0	++
		20.1-24.0	+++
		24.1-28.0	++++
		28.1-32.0	+++++
		32.1-36.0	+ + + + + +
(b) Biological and Socio economic characters	(i) plant habit	small	-
		medium	+
		large	+
	(ii)canopy structure	Sparse/Irregular/Globular	-
		Spreading crown/Open/Semi dense	+
		Spreading dense	++
	(iii) Type of plant	Deciduous	-
		Evergreen	+

Grading	Character	Pattern of assessment	Grade alloted
	(iv) Laminar structure size	Small	-
		Medium	+
		Large	++
	Texture	Smooth	-
		Coriaceous	+
	Hardiness	Delineate	-
		Hardy	+
	(v) Economic value	Less than three uses	-
		Three or four uses	+
		Five or more uses	++

Table 2. Anticipated performance index (API) of plant species

Grade	Score (%)	Assessment category
0	Up to 30	Not recommended
1	31-40	Very poor
2	41-50	Poor
3	51-60	Moderate
4	61-70	Good
5	71-80	Very good
6	81-90	Excellent
7	91-100	Best

Table 3. Biochemical parameters along with APTI of selected plant species at Site-I

Plant species	dust load (g/m^2)	pH	RWC (%)	T. Chl. (mg/g)	Carotenoids (mg/g)	Ascorbic acid(mg/g)	APTI
Polyalthia longifolia	0.20±0.08	7.36±0.24	79.24±0.46	1.99±0.05	1.77±0.18	1.67±0.08	9.98±0.10
Ficus religiosa	0.26±0.13	8.00±0.17	91.79±0.16	3.33±0.14	1.92±0.15	1.75±0.12	12.06±0.09
Mangifera indica	0.15±0.10	7.16±0.10	92.23±0.25	3.40±0.12	2.53±0.09	1.92±0.17	12.36±0.14
Azadirachta indica	0.13±0.20	7.08±0.32	89.30±0.19	2.19±0.08	1.43±0.12	1.23±0.23	10.07±0.05
Syzygium cumini	0.33±0.15	7.18±0.11	88.27±0.40	2.23±0.15	2.67±0.08	1.32±0.05	10.32±0.10
Psidium guajava	0.18±0.10	7.55±0.13	89.77±0.38	2.56±0.18	1.58±0.17	1.43±0.17	10.65±0.16

Table 4. Biochemical parameters along with APTI of selected plant species at Site-II

Plant species	dust load (g/m^2)	pH	RWC (%)	T.Chl. (mg/g)	Carotenoi-ds (mg/g)	Ascorbic acid(mg/g)	APTI
Polyalthia longifolia	0.33±0.01	6.56±0.10	75.70±0.10	1.96±0.10	1.54±0.04	0.86±0.07	8.30±0.04
Ficus religiosa	0.36±0.05	7.26±0.08	89.11±0.13	3.03±0.05	1.83±0.02	1.30±0.03	10.76±0.12
Mangifera indica	0.50±0.11	7.05±0.03	91.23±0.08	3.12±0.08	2.14±0.08	1.37±0.06	11.33±0.10
Azadirachta indica	0.30±0.04	6.43±0.05	82.11±0.02	2.17±0.05	1.22±0.05	0.99±0.08	9.70±0.05
Syzygium cumini	0.45±0.02	6.83±0.02	85.28±0.05	2.13±0.02	2.20±0.02	1.02±0.10	9.94±0.04
Psidium guajava	0.53±0.10	6.56±0.05	83.60±0.08	2.40±0.08	1.45±0.04	1.07±0.02	10.12±0.06

Table 5. Biochemical parameters along with APTI of selected plant species at Site-III

Plant species	dust load (g/m^2)	pH	RWC (%)	T.Chl. (mg/g)	Carotenoi-ds (mg/g)	Ascorbic acid(mg/g	APTI
Polyalthia longifolia	0.43±0.18	6.5±0.02	74.34±0.18	1.64±0.04	1.37±0.14	0.97±0.08	8.10±0.06
Ficus religiosa	0.40±0.10	7.13±0.00	87.12±0.32	2.1±0.01	1.46±0.10	1.12±0.12	9.75±0.10
Mangifera indica	0.55±0.03	6.97±0.07	88.54±0.25	2.86±0.07	1.95±0.08	1.2±0.05	10.03±0.04
Azadirachta indica	0.45±0.04	6.38±0.03	81.6±0.09	2.06±0.12	1.19±0.13	0.82±0.05	8.99±0.12
Syzygium cumini	0.49±0.04	6.5±0.0	84.85±0.15	1.94±0.04	2.03±0.05	1±0.02	9.33±0.05
Psidium guajava	0.56±0.10	6.45±0.06	82.67±0.20	2.05±0.03	1.33±0.06	1.03±0.07	9.14±0.08

Table 6. Biochemical parameters along with APTI of selected plant species at Site-IV

Plant species	dust load (g/m^2)	pH	RWC (%)	Total Chl. (mg/g)	Carotenoi-ds (mg/g)	Ascorbic acid(mg/g)	APTI
Polyalthia longifolia	0.64±0.02	5.98±0.02	73.12±0.34	1.57±0.14	1.22±0.12	0.84±0.11	7.95±0.12
Ficus religiosa	0.58±0.10	7.08±0.04	85.34±0.20	1.96±0.08	1.18±0.07	1.1±0.09	9.53±0.07
Mangifera indica	0.68±0.12	6.33±0.03	87.65±0.15	2.39±0.05	1.65±0.09	1.02±0.13	9.65±0.13
Azadirachta indica	0.65±0.04	6.06±0.07	80.2±0.19	2±0.10	0.99±0.15	0.92±0.17	8.76±0.17
Syzygium cumini	0.72±0.08	5.77±0.08	82.37±0.22	1.56±0.07	1.87±0.20	0.96±0.14	8.94±0.05
Psidium guajava	0.74±0.10	6.22±0.00	79.66±0.12	1.43±0.05	0.86±0.14	1.01±0.10	8.74±0.15

Table 7. Evaluation of plant species on the basis of APTI and some biological and socio economic parameter

Plant species	APTI	T.H	C.S.	T.T	L.S	L.T	H	E.I	Total plus
Polyalthia longifolia	-	+	+	+	+	+	+	-	6
Ficus religiosa	+	++	++	+	++	+	+		12
Mangifera indica	+	++	+	+	++	+	+	++	11
Azadirachta indica	-	++	++	+	+	+	+	++	10
Syzygium cumini	-	+	++	+	++	+	+	++	10
Psidium guajava	-	+	-	-	+	+	+	++	6

Table 8. Anticipated performance index value of selected plant species.

Plant species	Total Grade	% score	API value	Assessment category
Polyalthia longifolia	6	38	0	Very poor
Ficus religiosa	12	75	4	Very good
Mangifera indica	11	69	2	Good
Azadirachta indica	10	63	2	Good
Syzygium cumini	10	63	2	good
Psidium guajava	6	38	1	Very poor

4. Discussion

By determine APTI and API value of selected plant species it can be concluded that different plants respond differently towards air pollution, hence different APTI value which denotes the capability of a plant to combat against air pollution. So this study is useful for the better understanding and management of air quality as well as in selection of suitable plant species (with high APTI and good performer under API) for plantation at traffic congestion point, market areas and at industrial area and this become one of the strategy for the abatement of city's air pollution because it will have a marked effect on many aspects of the quality of the urban environment and the richness of life in a city. The APTI and API determination provides a reliable method for screening large number of plants with respect to their susceptibility to air pollutants and the methods are simple and do not require any costly environmental monitoring gadgets. Estimation of these indices will be a reliable method for the selection of appropriate species which can be used as bioindicators and mitigators of pollutants in an urban and industrial region. Planting more of tolerant tree species in polluted habitats leads to rapid amelioration of habitat to cope with air pollution.

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Correspondence to:
Sangeeta Madan
Environment Science Department
Gurukul Kangri University, Haridwar 249401, Ind ia
Telephone: +918130596449
Emails: snmadan21@gmail.com

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