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Evaluation of Air Pollution Tolerance Index (APTI) and Anticipated Performance Index (API) of Some Plants Species in Haridwar City

Nayak, Anjali[1]; Madan, Sangeeta[2] and Matta, Gagan[1]

[1]Department of Zoology and Environmental Science,
[2]Department of Environmental Sciences, Kanya Gurukula Campus,
Gurukula Kangri Vishwavidyalaya, Haridwar, Uttarakhand

Corresponding Author: anjalinayak055@gmail.com

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ABSTRACT

In this modern world the quality of air is getting decline day by day by vehicle emission, rapid industrialization, agricultural practices etc. and the pollution of air is a major of concern throughout the world. Plants play a vital role in controlling the air pollutants as the have potential to tolerate contaminants. In the present study, Air Pollution Tolerance Index (APTI) and Anticipated performance index (API) was calculated to observe the tolerant potential of three plant species in Haridwar area of Uttarakhand. The API not only takes APTI into consideration but also the biological and socio-economic aspect of the species. APTI was recorded highest in Azadirachta indica at site-1 and lowest APTI was recorded in Nerium indicum at site-3. In the present study API % score varies from 54% to 77% the highest API % score was recorded in Azadirachta indica and minimum API % score was recorded in Nerium indicum. The present study revealed that the assessments of above mention index with high APTI are significant in the reduction of urban air pollution and green belt designing.

KEYWORDS

Air Pollution Tolerance Index | Anticipated Performance Index | Carotenoid | Total Chlorophyll Content | Relative Water Content | Ascorbic Acid

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Introduction

Air pollution is threat to environment, especially in developing country like India. A human being of normal health and height, respires 22,00 times in a day and the air utilized in course of such respiration is about 20 times more than the quantity of food consumed Human beings can live for weeks without food, for several days without water, but for only few minutes without air (Sabri, 2015). It deteriorates ecological condition and can be defined as the fluctuation in many atmosphere constituent from the value that would have existed without human activity (Tripathi and Gautam, 2007).

The ever – increasing vehicular traffic density has posed a continuous threat to ambient air quality. In all the major cities of the country about 800 to 1000 tons of pollutants are being emitted into air daily, of which 50% come from automobiles exhaust. It affects the plants through the poisoning of specific parts of the plant tissue. Urbanization is one of the most drastic changes that can be imposed on an environment. Urban air pollution is a serious problem in developing countries.

Plants generally expose direct vehicular and industrial pollution. The particulate and gaseous pollutants, alone and in combination, can cause serious setback to the overall physiology of plants. There are number of plant species which showed maximum variation under stress condition, certain metabolites are found to function as antioxidants. An appreciable enhancement in non enzymatic antioxidants such as ascorbic acid, are a characteristic of plants growing under stress condition. The plants reposes due to air pollution were assessed by air pollution index. Air pollution tolerance level of each plant is different and plants do not show a uniform behaviour. APTI is an index denotes capability of a plant to combat against air pollution (Chauhan, 2010).

Plants with higher APTI values are more tolerant to air pollution than those with low APTI which may act as bio- indicators of pollution. According to their indices, different plants may be categorized into tolerant, moderately tolerant, intermediate and sensitive plants. Ascorbic acid is an antioxidant, which contributes in protecting the plants against oxidative damage resulting from aerobic metabolism, photo-synthesis and a range of pollutants

Thus, keeping the above facts in view, the present study was undertaken to Evaluation of Air Pollution Tolerance Index (APTI) and Anticipated Performance Index (API) of some plants species in Haridwar City, Uttarakhand.

Methodology

Description of study area

Haridwar located in the state of Uttarakhand is one of the important holy cities of India extended from 29°58'N latitude and 78°13'S longitude with a subtropical climate. The present study was conducted at three different sites at Hardwar with heavy and light pollution load. APTI and API was assess from three different zone (moderately traffic (site1), commercial (site2), industrial (site3) of Haridwar city. Three locally available tree species were selected from each sampling location. fresh leaf sample of Azadirachta indica (Neem), Polyalthia longifolia (Ashok), Nerium indicum (kaner) were collected to assess the APTI and API and biochemical parameters (pH, ascorbic acid, relative water content, carotenoid and total chlorophyll). The study was carried out in the period of three months from January 2017. The fresh leaf sample were randomly collected in triplicate of fully matured leaves and brought to the laboratory in polythene for analysis. Samples which, not immediately used were preserved in a refrigerator.

Air Pollution Tolerance Index (APTI)

Air Pollution Tolerance Index (APTI) is an index of the tolerance level of plant species to air pollution was estimated by using the method of Singh and Rao (1983). To evaluate the tolerance level of plant species of plant species of air pollution two leaf parameters use to derive an empirical no. indicating the APTI as shown in the formula.

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

Whereas, R = relative water content in mg/ g, A = ascorbic acid in mg / g,T = total chlorophyll in mg/ g, P = pH of plant leaf

Anticipated Performance Index (API)

Anticipated Performance Index (API) is particularly useful in selection of those species for plantation which can perform a dual function of improving the air quality and providing aesthetic and recreational value. API can be calculated by the formula

$$API = \frac{\text{No.of "+" obtained}}{\text{Total no.of "+"}} \times 100$$

Results and discussion

An overview of the result obtained from this study reveals that different plants respond differently to air pollutants. The variation of the APTI can be attributed to the variation in any of the physiological factors which governs the computation of the index. The physiological and biological characteristics that were considered in the study were- pH, Dust load, Total chlorophyll, Ascorbic acid, Carotenoid and Relative water content (RWC). The results are given in Table 2 to 6

Chlorophyll content

Chlorophyll content of the plant signifies photosynthetic activity as well as the growth and development of biomass. It is known that 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 condition (Katiyar and Dubey, 2001). Chlorophyll content is an indicator of their photosynthetic activity in plant. It signifies the growth and development of biomass (Agbaire and Esiefarienrhe, E. 2009). In the present study total chlorophyll contain in the plant species varied from 3.56mg/gm to 5.96mg/gm. Azadirachta indica showed highest chlorophyll content at Site-1 (Table-2) and lowest chlorophyll content showed in Nerium indicum at site-3 (Table-4). Thus, all the plant species under taken for studies were intermedialy tolerant plants against pollution load and particles

Carotenoid

Carotenoids are a class of natural fat-soluble pigments found principally in plants, algae and photosynthetic bacteria, where they play a critical role in the process of photosynthesis. Chlorophyll and carotenoid both takes part in photosynthetic reaction. Both are plays an important role in photosynthesis activity. The 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 (Chauhan and Joshi, 2010). In the present study the carotenoid varies between 1.34mg/gm to 2.92mg/gm. The least carotenoid content was recorded in Nerium indicum at site-2 (Table-3) while highest carotenoid content was recorded in Azadirachta indica at site-1 (Table-2).

Ascorbic Acid

Ascorbic acid is known to play an important role in cell wall synthesis, photosynthetic carbon fixation and cell division. It is also a natural antioxidant known to be able to prevent the damaging effect of air pollutant in plant tissue. The high amount of ascorbic acid therefore favors pollution tolerance in plants. It is very important indicator of pollution that is given a top priority and so used as a multiplication factor in the APTI formula (Agbaire and Esiefarienrhe, E. (2009). In the present study ascorbic acid content ranged between 4.68 to 7.95mg/gm. The highest ascorbic acid was recorded in Azadirachta indica site-1(Table-2) and lowest was recorded in Nerium indicum at site-3 (Table-4). High pH may increase the efficiency of conversion of hexose sugar to ascorbic acid and it is related to the tolerance to pollution (Lui and Ding, 2008). The increase level of ascorbic acid due to defense mechanism of respective plants (Tripathi and Gautam, 2007).

pH

pH is biochemical parameter that act as an indicator for sensitivity to air pollution. The plants samples collected from polluted site exhibited a pH towards acidic site which may be due to the presence of SO_2 and NO_2 in the ambient air causing a change in pH of the leaf sap towards acidic site. In the present study the pH varies from 7.16 to 5.61. The minimum pH was recorded in Nerium indicum at site-3 (Table-4) while maximum was recorded in Azadirachta indica at site-1 (Table-2). The photosynthetic efficiency has been reported to be strongly dependent on leaf pH (Liu and

Ding, 2008). The pH ranged between 4.4 and 8.8 lies in both intermediately tolerant and sensitive plant species (Lakshmi et al, 2009). Thus all plant species are both intermediately tolerant and sensitive to air pollutants.

RWC (Relative water content)

Water in plant is necessary for the physiological activities in the plant. RWC is the appropriate measure of plants water status in term of physiological consequences of cellular water deficit. A high water content within to air pollution when the transpiration rates are high. It also serves as an indicator of drought resistance in plants. Relative water content of a leaf is the water present in it, relative to its full turgidity. Relative water content is associated with protoplasmic permeability in cells cause loss of water and dissolved nutrients, resulting in early senescence of leaves.In the present study the relative water content varies from 71.40% - 92.27%. The minimum water content was recorded in Nerium indicum at site-3 (Table-4) while maximum was recorded in Azadirachta indica site-1 (Table-2).

Dust load

Dust from roads and railway station can greatly affected road side vegetation communities. They have observed changes in pH, water availability species composition and diversity. Dust is a mixture of toxic substance which covers the entire leaf surface. Particulate matter may clog the stomata pores are interfering with the serious exchange and photosynthetic activities. Dust interception capacity of plants depends on their surface geometry, phyllotaxy and leaf external characteristics such as hairs, cuticle and length of a petioles, height and canopy of trees etc, whether condition with direction and speed of wind. In the present study Dust load ranges from 0.35gm/m² to 0.72 gm/m2, highest accumulation was found in Polyalthia longifolia at site 3 (Table-4) and the minimum accumulation was found in Nerium indicum at Site-1 (Table-2). Madan et al. (2016) observed that the dust load of the leaf surface of Polyalthia longifolia (0.048-0.47 gm/m2). The highest dust accumulation at site 3might be due to very high traffic density and lowest dust accumulation at Site 1 was due to minimal vehicular density.

Air Pollution Tolerance Index (APTI)

APTI plays a significant role to determine resistivity and susceptibility of plant species against pollution level. Plant which have higher index value are tolerant to air pollution, while plants with low index value showed less tolerance and can be used to indicate levels of air pollution. In this present study the APTI value varies from 10.12 to 15.51, the highest APTI was recorded in Azadirachta indica at site-1 (Table-2) and lowest APTI was recorded in Nerium indicum at site-3 (Table-4). Madan and Chauhan (2015) evaluated the maximum APTI value (12.36±0.14) for Mangifera indica and the minimum value (7.94±0.62) for Polyalthia longifolia. Level of APTI varies from species to species depending on the capacity of plants to the effect of pollutants without showing any external damage. The tree having a high having APTI score showed a low acidic pH in their leaves with a high chlorophyll content and maximum RWC. Thus in the present study some species are sensitive and some are intermediately tolerant species.

Anticipated Performance Index (API)

The API value can give a good and logical reason to integrate various plant species for green belt development, afforestation. The API not only takes APTI into consideration but also the biological and socio-economic aspect of the species. The combination of these biochemical and physiological parameters gave a more reliable result than those of individual parameter. In the present study API % score varies from 54% to 77% the highest API % score was recorded in Azadirachta indica and minimum API % score was recorded in Nerium indicum. Acc to API assessment Azadirachta indica was found under very good category and Nerium indicum was found in Moderate category and Polyalthia longifolia was found in good category. On the basis of API the species like Ficus religiosa, Azadirachta indica, Tectona grandis (75%), Saraca indica, Shorea robusta and Tectona grandis (68%) were observed tolerant (Bora and Joshi 2014).

Tables

Grading	Character	Pattern of assessment	Grade allotted
Tolerance	Air Pollution Tolerance Index (APTI)	9.0-12.0 12.1-15.0 15.1-18.0 18.1-20.0 20.1-24.0 24.1-32.0	+ ++ +++ ++++ +++++ ++++++
Biological and socio economic characters	Plant habit	Small Medium Large	- + +
	Canopy structure	Sparse/Irregular/globular Spreading crown/open/semi dense Spreading dense	– + ++
	Type of plant	Deciduous Evergreen	– +
Leminar Structure	Size Texture Hardiness	Small Medium Large Smooth Coriaceous Delineate Hardy	- + ++ - + - +
Socio-economic	Economic value	less than three uses Three or four uses Five or more uses	– + ++

Table 1. Gradation of plant species on the basis of Air Pollution Tolerance Index (APTI) and other biological and socioeconomic characters (Pathak *et al*., 2011)

Plant species	Dust load (g/m^2)	pH	RWC (%)	Total chlorophyll (mg/g)	Carotenoid (mg/g)	Ascorbic acid (mg/g)	APTI
Polyalthia longifolia	0.45±0.09	6.43±0.17	81.24±0.44	5.16±0.04	1.89±0.19	6.74±0.03	12.97
Azadirachta indica	0.37±0.10	7.16±0.19	92..27±0.58	5.96.±0.03	2.92±0.15	7.95±0.02	15.51
Nerium indicum	0.35±0.10	6.56±0.16	78.19±0.37	4.99±0.05	1.43±0.11	5.43±0.02	11.83

Table 2. Biochemical parameters along with APTI of selected plant species at Site-1. (All values are mean ± Standard Error. of 7 observations each)

Plant species	Dust load (g/m^2)	pH	RWC (%)	Total chlorophyll (mg/g)	Carotenoid (mg/g)	Ascorbic acid (mg/g)	APTI
Polyalthia longifolia	0.69±0.11	6.34±0.14	75.70±0.41	4.40±0.03	1.58±0.08	5.60±0.02	11.51
Azadirachta indica	0.55±0.11	6.47±0.18	82.11±0.56	5.05±0.12	1.52±0.06	6.52±0.03	12.93
Nerium indicum	0.49±0.11	5.91±0.12	72.64±0.36	3.64±0.08	1.34±0.02	5.21±0.02	10.70

Table 3. Biochemical parameters along with APTI of selected plant species at Site-2. (All values are mean ± S.E. of 7 observations each)

Plant species	Dust load (g/m^2)	pH	RWC (%)	Total chlorophyll (mg/g)	Carotenoid (mg/g)	Ascorbic acid (mg/g)	APTI
Polyalthia longifolia	0.72±0.12	6.21±0.12	74.41±0.38	3.96±0.06	1.38±0.03	5.34±0.03	11.15
Azadirachta indica	0.62±0.12	6.16±0.14	79.38±0.42	4.98±0.07	1.46±0.03	6.23±0.02	12.27
Nerium indicum	0.58±0.12	5.61±0.10	71.40±0.34	3.56±0.14	1.41±0.04	4.68±0.20	10.12

Table 4. Biochemical parameters along with APTI of selected plant species at Site-3. (All values are mean ± S.E. of 7 observations each)

Plant species	APTI	T.H.	C.S.	T.T.	L.S.	L.T.	H.	E.I.	Total Plus
Polyalthia longi-folia	++	++	+	+	+	+	+	+	10
Azadirachta indica	+++	++	++	+	+	+	+	++	13
Nerium indicum	+	+	+	+	+	+	+	+	8

Table 5. Evaluation of plant species on the basis of APTI and some biological and socio economic parameter .
[Abbreviations: T.H.- Tree habitat, C.S.- Canopy structure, T.T.- Type of trees, L.S.- Laminar size, L.T.- Laminar texture, H.- Hardiness, E.I.- Economic importance]

Plant species	Total Grade	% score	API value	Assessment category
Polyalthia longi-folia	10	62.50	4	Good
Azadirachta indica	13	77	5	Very Good
Nerium indicum	8	54	3	Moderate

Table 6. Anticipated performance index value of selected plant species.

Conclusion

The present study showed that the assessment of APTI and API give significant results. The APTI of Azadiracta indica recorded highest (10.12-15.51) which shows highest tolerance and Nerium indicum showed slightly lower (10.12-11.83) API values. The API % score varies from 54% to 77% the highest API % score was recorded in Azadirachta indica and minimum API % score was recorded in Nerium indicum. API assessment Azadirachta indica was found under very good category and Nerium indicum was found in Moderate category and Polyalthia longifolia was found in good category. This study revealed that these plant can be design to reduce air pollution in urban area.

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