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Assessment of air pollution tolerance index of some trees in Haridwar City, Uttarakhand

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Abstract

Three different plant species *i.e.*, *Ficus religiosa, Polyalthia longifolia and Azadirachta indica* were collected from residential (S1), commercial (S2), industrial (S3) and control areas of the city to study the relative tolerance of plant species. Variation in biochemical parameters like relative water content, leaf pH, ascorbic acid, total chlorophyll, carotenoids and dust interception efficiency were found to be pollution load dependent. These variations can be used as indicators of air pollution for early diagnosis of stress or as a marker for physiological damage to trees prior to the onset of visible injury symptoms. The present findings showed that maximum APTI was observed in *Azadirachta indica* and minimum in *Ficus religiosa.*

Key words

Air pollution tolerance index, Ascorbic acid, Carotenoid, Total chlorophyll

Introduction

Increase in industrialization, unplanned urbanization, alarming increase in vehicles fleet, population growth and underestimated future plan of city development are the major triggers for increase in air pollution level in the city (Jayanthi and Krishnamoorthy, 2006). Plants are affected physically and chemically by air pollutants. Dust settles on leaves and can interfere with pollination and photosynthetic function if their accumulation is significant. Plants are the only living organism which have to suffer a lot from automobile exhaust pollution as they remain static at their habitat (Chauhan *et al*., 2012). The particulates and gaseous pollutants alone and in combination can cause serious setback to the overall physiology of plants. It has been reported that gaseous forms are absorbed by leaves while the particulate forms are absorbed through the outer surface of plants. The affected plants show common symptoms such as reduced content chlorophyll necrosis and inhibition in photosynthesis and decrease is plant growth. Road side plants can easily avoid the effects of air pollution by altering their physiological pathways pertaining to photosynthesis and respiration. Stomatal clogging and closure help these plants in preventing the entry of poisonous gases. Responses of plants towards air pollutants are assessed by Air Pollution Tolerance Index (APTI). It is an index which denotes the capability of plant to combat against air pollution (Mandal, 2000).

Plants play an important role in maintaining the ecological balance by actively participating in the cycling of nutrients and gases like CO_2 (Carbon dioxide), O_2 (Oxygen) and providing enormous leaf area for impingement, absorption and accumulation of air pollutants to reduce the pollution level in atmosphere (Escobedo *et al*., 2008). The use of plants as monitors of air pollution has long been established, as plants are the initial acceptors of air pollution. (Joshi and Swami, 2009). They act as scavengers for many air born particulates in atmosphere. Presence of trees in urban environment can improve air quality through enhancing uptake of gases and particles.

Vehicular load in Haridwar has increased to several folds due to its pilgrimage significance and industrial establishment. The present study was therefore undertaken to evaluate the air pollution tolerance index (APTI) of certain plant species.

Materials and Methods

Haridwar is located in Uttarakhand (India).The total number of four sampling sites were selected as S1- Kankhal (residential area), S2- Jwalapur (commercial area), S3- Sidcul (industrial area) and Sureshwaridevi (Control Site). Plant leaves of *Azadirachta indica*, *Ficus religiosa* and *Polyalthia longifolia* were collected on monthly basis during January-March, 2013 from all the four sites to assess variation in their biochemical properties.

Plant leaves were cut into small pieces and the major veins were discarded. One gram of leaf material was weighed and the material was put into mortar and 10 ml of 80% acetone was added. Tissue was ground with the help of pestle and the extract was centrifuged at 1500rpm for 10-15 min. The extract was decanted into a volumetric flask and the volume was made up to 25ml using 80 % acetone. The volume was made up to 100ml, if the solution was dark green and then the absorbance was taken at different wave lengths for different parameters mentioned below. Biochemical properties of leaves were analysed in terms of chlorophyll content (Arnon, 1949), ascorbic acid concentration (Agrawal, 1985), pH, caretenoid (Kirk and Allen, 1965) and relative water content (Weatherly, 1965). The observed data were presented as mean of three replicates ± SD. APTI was also calculated by using the formula of Singh and Rao (1983).

Results and Discussion

Plants with lower pH are more susceptible while those with higher pH are known to improve tolerance to air pollution (Singh and Verma, 2007). All the plant samples collected from polluted site exhibited pH towards the acidic side, which may be due to the presence of SO_2 and NO_x in the ambient air causing a change in pH of leaf sap towards the acidic site (Swami *et al*., 2004). In the present study, pH varied from 5.1 to 6.7. The minimum pH was recorded in *Polyalthia longifolia* at site-1 while maximum was recorded in *Azadirachta indica* at control site as shown in Table-1. High pH may increase the efficiency of conversion from hexose sugar to ascorbic acid (Escobedo *et al*., 2008), while low leaf pH extract showed good correlation with sensitivity to air pollution and also reduced photosynthesis process in plants. The photosynthetic efficiency has been reported to be strongly dependent on leaf pH (Liu and Ding, 2008).

Relative water content associated with protoplasmic permeability in cells causes loss of water and dissolved nutrients, resulting in early senescence of leaves (Agrawal and Tiwari, 1997). In the present study, the relative water content varied from 46.40% to 55.47%. The minimum relative water content was recorded in *Ficus religiosa* at site-3 while maximum was recorded in *Polyalthia longifolia* at control site in (Table 1).

Dust interception capacity of plants depends on their surface geometry, phyllotaxy and external characteristics of leaves such as hair, cuticle and length of petiole, height and canopy of trees etc., weather conditions with direction and speed of wind. The dust collection varied from 0.53gm m^{-2} to 0.82gm m^{-2}. In the present study, highest dust accumulation was found in *Ficus religiosa* at site-3 and minimum was found in *Azadirachta indica* at the control site (Table 1). Trees having compact branching and closely arranged leaves has shown to possess more dust and collecting ability. Trees having broad leaves of simple elliptical and hairy structure collect a lot of dust from air. Height and size of plants should also be considered as one of the criteria to trap or reduce dust effectively (Prajapati, 2008).

The chlorophyll content of plants signify their photo synthetic activity as well as growth and development of biomass. It is well evident that chlorophyll content of plants varies from species to species, age of leaf and also with pollution level as well as with other biotic and abiotic conditions (Katiyar and Dubey, 2001). Variation in leaf pigment (Chlorophyll and ascorbic acid) content in plants is because of various environmental factors such as air, water and soil (Katiyar and Dubey, 2000). Chlorophyll is the principal photoreceptor in photosynthesis, its measurement is an important tool to evaluate the effect of air pollutants on plants, as it plays an important role in plant metabolism and any reduction in chlorophyll content corresponds directly to plant growth (Joshi and Swami, 2009). In the present study, total chlorophyll content in plant species varied from 4.03 mg gm^{-1} to 5.71 mg gm^{-1}. *Ficus religiosa* showed highest chlorophyll content at control site and lowest chlorophyll content showed in *Ficus religiosa* at site-1. Decrease in chlorophyll content of leaves may be due to alkaline condition created by dissolution of chemicals present in dust particles *i.e.*, metals and polycyclic hydrocarbons in cell sap which block stomatal spores for diffusion of air and thus, put stress on plant metabolism resulting in chlorophyll degradation (Anthony, 2001).

Ascorbic acid plays a vital role in cell wall synthesis, defense and cell division (Conklin, 2001). In the present study,

Table 1 : pH, relative water content and dust load of leaf samples in studied plants at all sites

Sampling sites	pH			Relative water content			Dust load		
	F. religiosa	*A. indica*	*P. longifolia*	*F. religiosa*	*A. indica*	*P. longifolia*	*F. religiosa*	*A. indica*	*P. longifolia*
Control	6.6+0.17	6.7+0.18	6.5+0.15	51.97+0.60	52.38+0.61	55.47+0.62	0.57	0.53	0.55
S1	6.2+0.16	6.0+0.70	5.1+0.65	51.65+0.59	51.95+0.59	52.31+0.60	0.69	0.66	0.68
S2	6.3+0.72	5.7+0.68	6.4+0.72	52.38+0.60	47.85+0.57	51.33+0.59	0.72	0.73	0.75
S3	6.1+0.71	5.8+0.69	6.0+0.71	46.40+0.56	47.01+0.57	47.65+0.57	0.82	0.8	0.78

Whereas: RWC=relative water content

Table 2 : Ascorbic acid, chlorophyll and carotenoid concentration in leaf samples of studied plants at all sites

Sampling sites	Ascorbic acid			Chlorophyll content			Carotenoid content		
	F. religiosa	*A. indica*	*P. longifolia*	*F. religiosa*	*A. indica*	*P. longifolia*	*F. religiosa*	*A. indica*	*P. longifolia*
Control	5.97+0.02	7.46+0.03	6.71+0.02	5.71+0.20	5.56+0.19	5.41+0.19	0.213+0.12	0.268+0.13	0.198+0.11
S1	9.70+0.03	8.20+0.02	8.95+0.02	4.03+0.17	5.40+0.20	5.33+0.19	0.140+0.34	0.158+0.38	0.138+0.33
S2	6.71+0.03	7.08+0.03	6.11+0.02	4.93+0.18	4.68+0.15	4.83+0.15	0.146+0.35	0.165+0.71	0.159+0.36
S3	4.47+0.20	5.97+0.02	5.22+0.02	4.17+0.16	4.25+0.18	4.20+0.17	0.156+0.34	0.139+0.35	0.157+0.31

ascorbic acid content ranged between 4.47 mg gm^{-1} to 9.70 mg gm^{-1}. Highest ascorbic acid was recorded in *Ficus religiosa* at site-1 and lowest was recorded in *Ficus religiosa* at site-3 (Table 2). High pH may increase the efficiency of conversion of hexose sugar to ascorbic acid and it is related with tolerance to pollution (Lui and Ding, 2008).The increased level of ascorbic acid content reported may be due to defense mechanism of the respective plants (Tripathi and Gautam, 2007).

Different pollutants play a significant role in inhibition of photosynthetic activity that may result in depletion of chlorophyll and carotenoid content in leaves of various plants (Chauhan and Joshi, 2008). In the present study, carotenoid content varied between 0.138 mg gm^{-1} to 0.268 mg gm^{-1}. Least carotenoid content was recorded in *Polyalthia longifolia* at site-1, while highest carotenoid content was recorded in *Azadirachta indica* at control site (Table 1). Significant reduction in carotenoid content was also observed in different plants grown at polluted sites (Prajapati, 2008).

Table 3 : Air pollution tolerance index of studied plants at all sites

Tree species	Air pollution tolerance index			
	Control	S1	S2	S3
F. religiosa	12.54	14.54	12.77	9.2
A. indica	14.38	14.56	12.84	10.7
P. longifolia	13.53	14.55	11.99	10.11

APTI plays a significant role in determining resistivity and susceptibility of plant species against pollution level. In the present study, APTI values varied from 9.20 to 14.56. Highest APTI was recorded in *Azadirachta indica* at site-1 and lowest APTI was recorded in *Ficus religiosa* at site-3 in (Table 3). Plants with higher APTI can be effectively used as scavengers (Santoshkumar and Paulsamy, 2006). The level of APTI varies from species to species, depending on the capacity of the plants to tilerate the effect of pollutants without showing any external damage. Thus in the present study, some species were sensitive and some were intermediately tolerant species.

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