Assessment of Ambient Air Pollution and its Impact on Biochemical Properties of Selected Plant Species in Haridwar India

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Abstract: The present study was conducted to assess the ambient air quality of Haridwar city, Uttarakhand, India. Dust load and biochemical characteristics of plants (pH, ascorbic acid, relative water content and total chlorophyll) were analyzed in order to determine air pollution tolerance index. Ambient air quality was analyzed in terms of suspended particulate matter (72-202 µg/m^3), respirable particulate matter (67-135 µg/m^3), SO_2 (4-6 µg/m^3) and NO_2 (4-12 µg/m^3). The dust load of the leaf surface of *Polyalthia longifolia* was 0.048-0.47gm/m^2 and in *Mangifera indica* was 0.07-0.68gm/m^2. Biochemical parameters of *Polyalthia longifolia* were recorded as pH (5.73-6.77), relative water content (53.12-69.07%), chlorophyll (1.35-2.53mg/gm), ascorbic acid (1.39-3.80 mg/gm). However in case of *Mangifera indica* biochemical properties were observed as pH (6.03-6.86), relative water content (61.32-74.39%), chlorophyll (2.02-3.52mg/gm), ascorbic acid (2.32-4.83mg/gm). Air pollution tolerance index for *Polyalthia longifolia* was observed as 6.98-10.25 and 8-12.45 for *Mangifera indica*.
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1. Introduction

The atmosphere of earth is the layer of gases, commonly known as air (Sharma, 2014). The rapid growing human population, rapid urbanization, intensive agriculture and industrialization together with human activities resulted in the environmental pollution (Veni et al., 2014). Air pollution may be defined as any atmospheric condition in which certain substances are present in such amount that they can produce undesirable effects on man and his environment (Rao, 2015).

Plants are known to play a major role in removing pollution from the environment as part of their normal functioning. Plants therefore increase the quality of air as a way of a natural air cycle (Agbarie et al., 2015). Air pollution can directly affect plants via leaves or indirectly via soil acidification. It has also been reported that when plant exposed to air pollutants, most plant experience physiological changes before exhibiting visible damage to leaves (Joshi and Bora 2011). The symptoms of plant or any biochemical changes in the plants acts as an indicator of the polluted environment. Thus regular monitoring of certain parameters of the plant physiology and biochemical parameters in plant indicates air pollution in terms of the severity and degree (Choudhury and Banerjee 2009). The present study was conducted to assess the air pollution in Haridwar city and its impact on biochemical properties of selected plant species. Response of plants towards air pollutants was assessed by air pollution tolerance index (APTI).

2. Material and Methods

Haridwar is one of the important holy cities of India, located at an elevation of $29^0 58^{'}$N-$78^0 13^{'}$E in the state of Uttarakhand. It attracts a lot of tourists throughout the year. With rapid development of human civilization and industrialization the number of automobile has also increased, which are responsible for almost 65% of air pollution. Ambient air quality was monitored from October 2015-April 2016 at four different zones (industrial, heavy traffic, moderately traffic and institutional) of Haridwar city. Ambient air samples were collected by using Respirable Dust Sampler (APM 460). Fresh leaf samples of *Polyalthia longifolia* (Ashok) and *Mangifera indica* (Mango) were randomly collected to assess the impact of air pollutants on dust load of leaf and biochemical parameters (pH, ascorbic acid, relative water content and total chlorophyll).

SPM, RPM and dust load of leaf were measured by gravimetric method. Concentration of SO_x and NO_x were measured by Modified West and Geake method and Modified Jacobs and Hochheiser method respectively. Relative water content of plant leaf samples was determined by method followed by Singh (1977). The estimation of chlorophyll content was assessed by the method followed by Arnon (1949) and ascorbic acid was determined by referring the method prescribed by Sadasivam and Manickam (1992). Air Pollution Tolerance Index was calculated by using following formula (Singh and Rao, 1983):

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

Whereas; A= ascorbic acid, T= total chlorophyll, P= pH and R= relative water content.

3. Results

Ambient air quality

Small solid particles and liquid droplets are collectively known as particulates. They are present in atmosphere in fairly large amount and poses a serious air pollution problem. Particulate pollutants are classified according to their partical size and nature into fumes, dust, ash, smoke, lead, asbestos, mist, spray etc (Sharma 2012). Perusal from the data given in table 1 the concentration of suspended particulate matter in ambient air of Haridwar city was observed in the range of 72-202 µg/m^3. However the concentration of respirable particulate matter was varied from 67-135 µg/m^3 (Table 1). Highest concentration of SPM and RPM was found in the heavy traffic zone while the minimum was observed in institutional zone.

The most important oxide emitted by pollution source is SO_2, a colourless gas with a characteristics sharp, pungent odour. It is moderately soluble in water forming weakly acidic sulphurous acid. It is oxidized slowly in clean air to sulphuric trioxide. In a polluted atmosphere, sulphur dioxide reacts photochemically or catalytically with other pollutants or normal atmospheric constituents to form sulphur trioxide, sulphuric acid and salts of sulphuric acid (Rao, 2015). Nitrogen oxide, a highly reactive gas is formed in the ambient air through the oxidation of NO. Nitrogen oxide occurs in atmosphere by burning of fossil fuels. This result from a chemical reaction between atmospheric N_2 and O_2 in the presence of heat to form NO which then reacts again with O_2 to form NO_2 (Rai et al., 2011). According to the data prescribed in table 1the concentration of SO_2 was found in the range of 4-6 µg/m^3 while NO_2 was observed as 4-12 µg/m^3. SO_2 was found below detectable limit in institutional area while observed at maximum concentration in heavy traffic zone. Though, NO_2 concentration was found as highest in heavy traffic zone and lowest in institutional zone. Similar obtained result of particulate matter, SO_2 and NO_2 are in agreement with Chauhan (2010) in the study of tree as bio-indicator of air pollution.

Effect of air pollution on plants

Dust load

Dust from highways, roads and industries can greatly affects the road and industry side vegetation communities. Dust load have been observed to cause change in pH and water availability, species composition and diversity of plant. Dust is a mixture of toxic substances which covers the entire leaf surface. Dust may clog the stomatal pore and interferes with the photosynthetic activity (Smith, 1971). Perusal from the data given in table 2 the dust load on the leaf of *Polyalthia longifolia* was ranged from 0.048-0.47 gm/m^2 while in case of *Mangifera indica* dust load on leaf surface was observed in the range of 0.07-0.68 gm/m^2 (Table 2). The highest dust load was observed at heavy traffic zone however lowest value of dust load was recorded at institutional zone. Similar values of dust load were also observed by Joshi and Bora (2011) in study of the impact of air quality on physiological attributes of certain plants.

pH

pH is a biochemical parameter that acts as an indicator of air pollution because it affects the conversion of hexose sugar of ascorbic acid. pH also indicates the type of pollutants, acidic pollutants would give a lower (more acidic) pH values (Agbaire et al., 2015). In present study the pH value of *Polyalthia longifolia* leaf was found to be ranged as 6.77- 5.72 however in case of *Mangifera indica* the pH of leaf sample was recorded as 6.86-6.03. Values depicted in table 2 showed a significant decrease in pH of leaf samples on moving from polluted to unpolluted. The highest value of pH in the leaf samples was observed at institutional zone while lowest was at heavy traffic zone in case of both the plant species. Similar results of plant leaf pH were also observed by Veni et al. (2014) in study of air pollution tolerance index of plants.

Table 1. Ambient air quality of Haridwar city

Primary pollutants	Institutional Zone	Low traffic zone	Industrial zone	High traffic zone
SPM	72	144	145	202
RPM	67	94	100	135
SO_2	BDL	4	4	6
NO_2	4	7	7	12

Relative water content

Water is necessary for the physiological activities in the plant. RWC is the appropriate measure of plant water status in terms of physiological consequence of cellular water deficit. It also serves as an indicator of drought resistance in plants (Swami and Joshi, 2004). Relative water content in leaf of *Polyalthia longifolia* was ranged from 53.12-69.07 %

while in case of *Mangifera indica* relative water content in leaf was observed in the range of 61.32-74.39% (Table 2). The highest value of relative water content was observed at institutional zone however lowest value of relative water content was recorded at heavy traffic zone. similar values of relative water content of plant leaf was also recorded by Lakshmi et al.(2008) in study of air pollution tolerance index of plant species growing in industrial area.

Chlorophyll content

Chlorophyll content is an indicator of their photosynthetic activity. It signifies the growth and development of biomass (Agbaire et al., 2009). It is well known that chlorophyll content of plant varies species to species, depending upon the age of leaf, pollution level as well as with other biotic and abiotic condition (Katiyar and Dubey, 2000). In present study the chlorophyll content of *Polyalthia longifolia* leaf was found to be ranged as 1.18-2.53 mg/gm however in case of *Mangifera indica* the chlorophyll content of leaf sample was recorded as 2.02-3.52 mg/gm (Table 2). The highest value of chlorophyll content in the leaf samples was observed at institutional zone while lowest was at heavy traffic zone in case of both the plant species. The obtained results of are in agreement with Bakiyaraj and Ayyappan (2014) in the study of air pollution tolerance index of some plant around industrial area.

Ascorbic acid

Ascorbic acid is 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 et al., 2015). In present study the ascorbic acid concentration in *Polyalthia longifolia* leaf was found to be ranged as 1.39-3.80 mg/gm however in case of *Mangifera indica* the ascorbic acid concentration in leaf sample was recorded as 2.32-4.83 mg/gm (Table 2). The highest value of ascorbic acid content in the leaf samples was observed at institutional zone while lowest was at heavy traffic zone in case of both the plant species. The obtained values of ascorbic acid for plant leaf samples are in agreement with Agbaire et al. (2015) in the comparative study of air quality in urban and sub urban city.

Air pollution tolerance index

APTI is an index of tolerance capacity of plants against air pollution. Plants 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 (Bakiyaraj and Ayyappan, 2014). In present study the APTI value of *Polyalthia longifolia* was calculated in the range of 6.27-10.25. However in case of *Mangifera indica* the APTI value was in the range of 8-12.45 (Table 2). The highest value of APTI was recorded at institutional zone and lowest at heavy traffic zone.

The plants having a high APTI score showed a low acidic pH in their leaves with a high chlorophyll content and maximum RWC. Reduction in APTI value at polluted site as compare to other three sites may be due to high concentration of air pollutants. APTI value ranged between 1 to 16 among the sensitive plants. Thus both the plant species studied were sensitive to air pollution.. Similar values of air pollution tolerance index of leaf sample were also recorded by Mate and Deshmukh (2015) in the study to control the effect of air pollution by using roadside trees.

Table 2. Dust load and biochemical parameters along with APTI value of selected plant species

Parameters	Plant Species							
	Polyalthia longifolia				*Mangifera indica*			
	Institutional Zone	Low Traffic Zone	Industrial Zone	High Traffic Zone	Institutional Zone	Low Traffic Zone	Industrial Zone	High Traffic Zone
Dust load(gm/m^2)	0.048 ±0.06	0.11 ±0.03	0.38 ±0.04	0.47±0.10	0.07±0.03	0.16±0.04	0.50±0.02	0.68±0.12
pH	6.77±0.11	6.32±0.10	6.07±0.10	5.72±0.98	6.86±0.11	6.63±0.11	6.29±0.12	6.03±1.16
Relative Water Content (%)	69.07±1.39	61.67±1.06	57.63±0.99	53.12±0.91	74.39±1.28	67.77±1.16	65.03±1.12	61.32±1.05
Total chlorophyll (mg/gm)	2.53±0.43	1.83±0.03	1.35±0.16	1.18±0.22	3.52±0.67	2.79±0.53	2.29±0.28	2.02±0.38
Ascorbic acid (mg/gm)	3.80±0.06	2.04±0.03	1.65±0.21	1.39±0.23	4.83±0.08	3.30±0.44	2.46±0.04	2.32±0.03
APTI	10.25	7.83	6.98	6.27	12.45	9.88	8.61	8.00

4. Discussion

The present study revealed that different plant species respond differently to air pollution. Thus it

can be concluded that both the plant species were sensitive toward air pollution. Plants in the heavy traffic zone were found to be more sensitive than other studied zones due to heavy vehicular pollution load. Sensitive plants can be used as a bio-indicator and also as an assessment tool for air quality. Development of green belt around an industrial and nearby road sides should consist of both tolerant and sensitive species. So that a self-cleansing environment can be developed and in turn other benefit like carbon sequestration could be obtained.

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