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EFFECTS OF VEHICULAR EXHAUST ON BIOCHEMICAL CONSTITUENTS OF LEAVES OF ROADSIDE VEGETATION

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ABSTRACT

Air pollution is one of the serious environmental concern of the urban Asian cities including India where majority of the population is exposed to poor air quality. The health related problems such as respiratory diseases, risk of developing cancers and other serious problems due to poor air quality are known and well documented. Motor vehicles are the major source of a number of these pollutants, in particular, carbon monoxide, nitrogen oxides, unburnt hydrocarbons and lead and, in smaller proportions, suspended particulate matter, sulphur dioxide and volatile organic compounds, and via atmospheric transformation of ozone and other photochemical oxidants.With growing urbanization and increase in vehicle density, and the great expense of pollution control, urban air pollution has become a crucial problem and it is now urgent to undertake risk assessments in order to evaluate and prioritize control strategies. In the present work effect of air pollution on three different plant species selected for the study at three sampling sites. Plant species namely were Dahlia x hybrid, Bougainvillea spectabilis and Leucaena leucocephala were studied in three zones having low, medium & high traffic density. The parameter studied were chlorophyll content, total carotenoid, relative moisture content, leaf area total sugar and protein. The results revealed that reduction in chlorophyll content, sugar and protein, relative water content and APTI was recorded in the leaf samples of all selected plants collected from polluted site area. A significant negative correlation was found between ambient air quality and biochemical parameters which exhibited significant positive correlation with pollution load.

KEYWORDS: ***Air pollution, biomonitoring, total chlorophyll, carotenoid, vehicular emission.***

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INTRODUCTION

Currently in India, air pollution is widespread in urban areas where vehicles are the major contributors and in a few other areas with a high concentration of industries and thermal power plants.[1] Vehicular emissions are of particular concern since these are ground level sources and thus have the maximum impact on the general population.[2] Also vehicles contribute significantly to the total air pollution load in many urban areas.[3-4] A recent study reports that in Delhi one out of every 10 school children suffers from asthma that is worsening due to vehicular pollution. Similarly, two of the three most important health related problems in Bangkok are caused by air pollution and lead contamination, both of which are contributed greatly by motor vehicles. As per Pollution Conservation Research Association, the transport sector alone consumes more than 50% of the total oil consumption in the country. Delhi has experienced an exponential growth in the number of personalized vehicles over the last two decades. The rising trend in air pollution load from vehicular exhaust can also be noticed from the rise in the consumption of both major auto fuels i.e. petrol and diesel. The main source of vehicular pollution is the fuel itself. The way it undergoes combustion inside the engine determines the amount of pollutant emissions from the engine.[4] In the last 25 years the number of registered vehicles increased over 10 times from a mere 2.1 million in 1973 to 25.2 million in 19 73. In the next 5-10 years, the number of vehicles is expected to double. All vehicles burn petrol or diesel.[5] Often this fuel is of poor quality due to illegal contamination and engines of Indian vehicles are not very efficient leading to pollution.[6] Air pollutants enter into the atmosphere by various natural and man-made activities such as dust, storm, volcanic eruptions, and industrial pollution etc.[7] They may be present in any form viz. solid, liquid and gas based on the mode of generation of pollutants, the sources are classified as (i) Natural and (ii) man-made sources. Its impacts economic productivity reduces agricultural productivity, damages property and causes ecological changes that increase the risk of environmental disasters.[8] Total suspended particulate matter, especially those particles that are less than 10 microns in diameter (PM 10) and which can easily penetrate the lungs, cause death from both respiratory illness and cardio-vascular diseases. High levels of atmospheric lead contribute to both hypertension and neurological damage, including the loss of intelligence quotient (IQ) in children. CO reduces the amount oxygen carried by the blood, but dissipates rapidly in the environment and its effects are reversible. Exposure to indoor air pollutants also causes serious health problems like acute respiratory infections, chronic obstructive lung disease, lung cancer and possibly blindness and heart disease in women, children less than 5 years of age, and senior citizens who spend long periods indoors are particularly susceptibility. Certain roads in Noida and East Delhi are always seen with heavy vehicular traffic and the plants that grow in such areas always face vehicular stress at higher level. These plants are constantly exposed to tremendous vehicular pollutants. As these segments consists of many important signal areas, lots of vehicles park for road signals therefore the plants are daily exposed to the exhaust smoke pollutants of vehicles from morning to night.[10-11]Deposited materials on the leaves have some effect on the overall biochemical and physiological aspects of plants like reduce the plants development. By analyzing these parameters, an early diagnosis of the extent of pollution can be done and air quality can also be assessed. The changed ambient environment due to the air pollutants in several areas has exerted a profound influence on the morphological, biochemical and physiological status of plants, and its responses. The objective of the present investigation is firstly to estimate and analyze air quality and classify it according to the Air Pollution Index. Secondly to study the foliar traits based on biochemical responses of some common roadside plant species growing in the selected study sites.

METHODS & MATERIALS

Study area: The study sites included residential, park and higher vehicular traffic area in Sector-18, 44 & 45, Noida. During the study period, temperature ranges from 32 to 36 ºC. The entire area under the study has been divided into three sites in order to assess the status of air pollution on the biochemical and physiological parameters of plant growth along with morphological changes. A detailed description of the selected sites is described below.

Site-A: Site- is a rural area, mainly agricultural fields, few educational institutes and few colonies. It experiences less traffic load.

Site B: Sector-16 & 18. This area comprises of the experience heavy load of traffic. It is also a commercial area.

Site-C: Sector 44 & 45 area is a residential area with medium traffic. It is a semi urban area with recreational areas etc.

Site-D: Garden area with no traffic.

Ambient air quality monitoring

The ambient air quality data was processed for air quality index (AQI). AQI was calculated for summer season. The average of the three samples in each month was used for calculating of AQI.[12] The ambient air monitoring was conducted at the sampling locations, particulate matter, oxides of sulphur (SOx), oxides of nitrogen (NOx), and carbon monoxide (CO) was monitored during study period. The classification of air quality index was carried out.[13] Ambient air quality for SPM, RSPM, SO2 and NO2 were done twice in a month of summer season, 2013. The representative months considered were March,April and May**.** High Volume Air Sampler (Envirotech model, APM-460NL) was used to monitor the air quality and SPM were collected in the separate containers at average air flow rate of 1.5 m3 /min. The sampler was run hourly basis and triplicate samples were collected at each time.

Plant sampling and biochemical parameters assessed

Three plant species name, Dahlia x hybrid, Bougainvillea spectabilis and Leucaena leucocephala were selected for this study, as they were common along roadside. The above species were collected from both polluted and non-polluted sites. Three samples from healthy and mature leaves of each plant were plucked through random selection in early hours of morning and brought in polythene bags, kept in ice box to the laboratory till analyzed for various morphological and biochemical parameters within twenty four hour of their harvesting.

Biomonitoring

Monitoring with the help of biological indicators can sometimes be a simple, cheap & convient method to evaluate the effects of air pollution on plant. During experiments, non-destructive measurements of plant growth characteristic such as leaf area measured with the help of manual planimeter[14], fresh and dry weight, total chlorophyll[15], total protein in leaves[16] Carotenoid, total sugar ,regular counts of the total numbers of live, dead and chlorotic leaves, stomata size, for each plant. A 4 µl droplet of distilled water was placed on the leaf surface, using a syringe, and a picture taken of the droplet within 30 seconds, using a camera.[17]

RESULT AND DISCUSSION

The leaf area was smaller in the plants growing in the vicinity of the emission sources or other heavily polluted sites than in those growing at less polluted sites. The present study revealed a decrease in leaf area in all plant species, growing at sites with heavy vehicular traffic (Site B), as compared to residential area (Site C) where vehicular traffic is low. This shows clearly in the Table-1& 2 the effect of vehicular exhaust on the roadside vegetation in the city and field studies of native plants showed reduction in leaf area due to the inferior air quality.

Table – 1

Air quality index at study locations during study period

Study location	*March*	*April*	*May*	*Avg. AQI*	*AQI status*
Site A	102	104	107	104.3	Moderate
Site B	246	249	273	256	Very poor
Site C	212	204	213	209.6	Very Poor
Control	58	55	57	56.6	Good

Table 2

Rating scale of AQI values at polluted and control sites

Index Value Remarks	Polluted sites			Control sites		
0-25 Clean Air CA	March	April	May	March	April	May
26-50 Light air pollution (LAP)	SAP	MAP	SAP	LAP	LAP	LAP
51-75 Moderate air pollution (MAP)						
76-100 Heavy air pollution (HAP)						
>100 Severe air pollution (SAP)						

Air pollutant concentration

On the basis of air pollution index, site B was categorized as heavy air pollution site, site C as moderately air pollution site respectively and site A as light air pollution site. The values of all the three air pollutants were lowest at site A because it is a rural area with less number of vehicles and highest at site B as it is an industrial area with some commercial complexes and ample no of heavy vehicle passes throughout the day.

Biochemical characteristic

The concentration of chlorophyll pigment in leaves of plant is given in Table-3. The experimental data indicates that the depletion in chlorophyll concentration is due to vehicle pollution. When any change in chlorophyll concentration or composition may results changes in physiological, biochemical and morphological change in leaves of plants. Thus plants having high chlorophyll content in natural conditions are generally tolerance to air pollution in plants while decreases in foliar chlorophyll amount in leaves might be due to depletion of chlorophyll in leaves. The parameter like carenoid, relative moisture content affects the physiology of plants. Plant protein is an essential component for the plant growth & development. Significant lowering of the protein content was recorded in all plant species at the different sites in comparison to the control shown in Table-5. Soluble sugar is an important constituent and source of energy for all living beings. Plants manufacture this organic substance during photosynthesis and breakdown during respiration. Reduction in soluble sugar content which shows in Table-6 in polluted site may correspond with a lower photosynthetic rate and higher energy requirements due to airborne heavy metal stress.[18-20] Pollutants like SO2, NO2 and H2S under hardening condition can cause more depletion of soluble sugar in the leaves of plant grown in polluted area.[21]

Table 3
Changes in the physical and bio-chemical characteristics of tree species due to auto exhaust emission

Parameters	Dahlia x hybrid		Bougainvillea spectabilis		Leucaena leucocephala	
	Control	Pollution	Control	Pollution	Control	Pollution
Chlorophyll a (mg/g)	1.43±0.08	0.81±0.06	2.71±0.07	1.99±0.05	1.33±0.17	0.96±0.44
Chlorophyll b (mg/g)	2.03±0.09	1.63±0.12	1.01±0.15	1.63±0.12	0.84±0.12	0.59±0.06
Total chlorophyll (mg/g)	2.56±0.48	1.42±0.09	2.65±0.14	3.62±0.58	2.17±0.22	1.55±0.28
Carotenoid (mg/gm)	1.42±0.14	0.98±0.16	1.30±0.08	2.17±0.19	1.49±0.14	1.03±0.06
Relative moisture content (%)	70.56±4.15	59.12±4.16	66.99±3.17	52.03±3.99	58.50±2.86	48.12±3.77

Table – 4
Leaf area (cm2) of the selected plant species along roadside in study area.

Sampling location/ Plant species	*Dahliax hybrid*	*Bougainvillea spectabilis*	*Leucaena leucocephala*
Control	13.2	93	85
Residential Area	10.3	88	80
Market Area	8.3	76	69
Traffic area	5.5	S 45	48

Table – 5
Plant protein (µg/mg) of the selected plant species along roadside in study area.

Sampling location/ Plant species	*Dahliax hybrid*	*Bougainvillea spectabilis*	*Leucaena leucocephala*
Control	16.2	13.6	13.9
Residential Area	7.23	6.68	11.05
Market Area	3.15	2.2	1.78
Traffic area	2.14	2.38	1.98

Table -6
Plant total sugar (mg/g ft.wt) of the selected plant species along roadside in study area.

Sampling location/ Plant species	*Dahliax hybrid*	*Bougainvillea spectabilis*	*Leucaena leucocephala*
Control	18.62±0.062	18.69±0.070	11.19 ±0.012
Residential Area	12.90±0.010	10.84±0.026	6.58±0.032
Market Area	6.23±0.066	5.29±0.098	7.21±0.054
Traffic area	4.01 ±0.042	4.01 ±0.032	4.68±0.021

Leaf surface waxes

The change in surface waxes are a very general sign of alteration in surface properties, including chemistry or surface roughness can result from a range of natural & anthropogenic.[22-25] Pollutant may also descript metabolic process & this could potentially affect leaf wax composition & structure indirectly. A number of small organic plant molecules can be stimulated by plants stress & may provide a potential route for the indirect effects of pollutants & react with surface waxes. Many studies have reported surface wax degradation due to exhaust gas exposure.[26-28] Changes in surface waxes are a very general sign of alteration in surface properties, surface roughness etc. Foliar absorption may descript metabolic processes including leaf wax composition & structure of leaf. Urban plant communities are already affected by anthropogenic influences such as disturbance & the urban heat effect; traffic derived pollution & creates stress on urban ecosystem. In a field study, it was observed that reduction in leaf area of plants growing in polluted atmosphere. [29] Such reduction in

leaf area and growth under stressed environmental conditions has been observed which is shown in Table 4.

CONCLUSION

The above study concluded that the common road side plant species growing at site B and site A of Noida city suffers maximum vehicular pollution because of heavy pollution compared to Site D.

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CONFLICT OF INTEREST

Conflict of interest declared none.

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