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Biological monitoring of roadside plants exposed to vehicular pollution in Jalgaon city

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Abstract: *Experiments on air and biomonitoring were conducted to evaluate pollution impact on the vegetation along the road in Jalgaon City, Maharashtra. The plantation along the roads and mainly includes neem (Aadirachta indica), peepal (Ficus religiosa), banyan (Ficus benghalensis), almond (Terminalia catapa). For biomonitoring, leaf area, total chlorophyll, plant protein were analyzed to study the impact of air pollutants.It was observed that vegetation at roadside with heavy traffic and markets was much affected by vehicular emission. Significant decrease in total chlorophyll and protein content was observed with reduced leaf area. It is concluded that plants can be used as indicators for urban air pollution, and there is need to protect the roadside plants from air pollution.*

Key words: *Biomonitoring, Air quality index, Chlorophyll, Leaf area, Plant protein.*

Introduction

Air pollution is influenced by four major factors, namely industrialized expansion of the cities, increase in traffic, rapid economic development, and higher level of energy consumption. The growth of, both, an industrial and residential area is unplanned in many developing cities of India, thus, contributing to the air pollution problems. In urban areas, the mobile or vehicular population is predominant and significantly contributes to air quality problems. Automobiles produces volatile organic compounds (VOC), suspended particulate matter (SPM), oxides of sulfur (SOx), oxides of nitrogen (NOx) and carbon monoxide (CO), which have adverse effects on surrounding ecosystem.

Regional impact of air pollution on different local plant species is one of the major ecological issues. The climatic conditions, the physico-chemical properties of air pollutants and their residence time in the atmosphere have the impact on surrounding plants and animals.

Monitoring of air pollutants is a prerequisite to air quality control. Their impact on the chemical composition of plants is often used as an indicator of and a tool for monitoring environmental pollution (Rao, 1977; Posthumus, 1984, 1985; Agrawal and Agrawal, 1989; Kulump *et al.,* 1994; Dmuchowski and Bytnerowicz, 1995). Monitoring with the help of biological indicators is simple, cheap, and convenient method to ensure the state of local environment. The effects of environmental factors on plants increase with exposure time. Plant response to air pollution can be used to assess the quality of air that may provide early warning signals of air pollution trends. The dying rates, changes with respect to apparent injury, chlorophyll reduction, and cell size reduction and reduction in leaf area are used as parameters for monitoring air pollution impacts on plant metabolism (LeBlanc and Rao, 1975).

Jalgaon city is the trade and commercial center of North Maharashtra region, India. The population of Jalgaon city had grown by 23% during 1981-1991 and by 19% during 1991-2001. Current population of the city stands at 4 lacs. With the population, vehicular number is also increasing in the city. The native vegetation is a typical dry deciduous forest. The plantation along the road includes neem (*Aadirachta indica*), peepal (*Ficus religiosa*), banyan (*Ficus benghalensis*) and almond (*Terminalia catapa*). Also the factors that there are all indigenous species supported their selection. The study summarizes the results on bimonitoring of local plant species along various sites on the roadside of city exposed to vehicular emission. All the study sites were located in Jalgaon city only.

Materials and Methods

Study area: The study sites included residential, market and high vehicular traffic area in Jalgaon city. The mean monthly temperature during the study period ranges between 12 to 38 °C. The annual average rainfall was 700 mm; with 70-75% relative humidity during the study period (December 2003 to March 2004). The local vegetation is typically mixed deciduous. Study sites include residential area, market area and high vehicular traffic area. Of all the sampling locations the traffic density is very high on the roads. The plants near these locations are continuously exposed to vehicular pollution. University area was considered as a controlled site. The ambient air quality of this location is good and there are very less chances of exposure of plants to the vehicular pollution.

Air quality: The ambient air quality data was processed for air quality index (AQI). AQI was calculated for winter season. The average of the three samples in each month was used for calculating of AQI (Bhaskaran and Rajan, 2001). 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 according to CPCB (1996).

Bio-monitoring: Monitoring with the help of biological indicators can sometimes be a simple, cheap and convenient method to

evaluate the effect of air pollution on plant. Plant growth characteristics such as leaf area (Khanam, *et al.,* 1990), total chlorophyll (Jayaraman, 2000) and total proteins in leaves (Lowary *et al.,* 1951) were recorded to study the impact of air pollutant on plants.

Statistical analysis: The data was subjected to one-way analysis of variance (ANOVA) (Armitage and Berry, 1994). Multicomparison of analysis of variance at 95% confidence interval was carried out for all the plant species on all characteristics.

Results and Discussion

Air quality index at different selected locations in the Jalgaon city is shown in Table 1. Nearly all the sampling locations showed poor air quality (104 - 256) status throughout the study period (December. 2003 – March 2004).

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, as compared to University area where vehicular traffic is low. This shows clearly the effect of vehicular exhaust on the roadside vegetation in the city. Several laboratory and field experiments with cultivated (Davis, 1980) and field studies of native plants showed reduction in leaf area (Rao *et al.,* 1990) due to the inferior air quality. Reduced photosynthetic capacity of plants

Table – 1: Air quality index at study locations during study period (Dec. 03 to March 04).

S. No.	Study location	Dec. 03	Jan. 04	Feb. 04	March 04	Avg. AQI	AQI status
1	Residential area	105	98	109	105	104	Moderate
2	Market area	211	204	212	200	207	Very poor
3	Traffic area	246	265	232	269	258	Very poor
4	Control	60	55	58	40	53	Good

Table – 2: Leaf area (cm^2) of the selected plant species along roadside in study area. (Number of sample at each location =10).

S. No.	Sampling location	Plant species				p-value
		Aadirachta indica*	***Ficus religiosa****	***Ficus benghalensis****	***Terminalia catapa****	
1	Residential	10.1	134	188	216	6.1×10^{-11}
2	Market area	8.3	127	172	215	
3	Traffic area	7.33	122	163	203	
4	Control	12.66	142	210	217	

* Overall difference is based on one-way ANOVA. Test was performed for comparison of leaf area of all plant species at their respective locations, where F values in ANOVA are significant. Significant difference at $p<0.05$ by multiple comparison tests.

Table – 3: Plant protein (μg/mg) of the selected plant species along roadside in study area. (Number of sample at each location =10).

S. No.	Sampling location	Plant species				p-value
		Aadirachta indica*	***Ficus religiosa****	***Ficus benghalensis****	***Terminalia catapa****	
1	Residential	8.3	7.75	12.25	10.5	6.68×10^{-8}
2	Market area	5.25	6.55	8.4	7.9	
3	Traffic area	3.45	4.65	Not Available	6.45	
4	Control	14.3	12.0	155	14.55	

*Overall difference is based on one-way ANOVA. Test was performed for comparison of leaf area of all plant species at their respective locations, where F values in ANOVA are significant. Significant difference at $p<0.05$ by multiple comparison tests.

Table – 4: Total chlorophyll (mg/gm) of the selected plant species along roadside in study area. (Number of sample at each location =10).

S. No.	Sampling location	Plant species				p-value
		Aadirachta indica*	***Ficus religiosa****	***Ficus benghalensis****	***Terminalia catapa****	
1	Residential	2.05	1.62	2.15	2.45	0.000636
2	Market area	1.85	1.46	1.95	2.25	
3	Traffic area	1.26	1.4	1.55	1.9	
4	Control	2.37	2.4	2.55	2.9	

*Overall difference is based on one-way ANOVA. Test was performed for comparison of leaf area of all plant species at their respective locations, where F values in ANOVA are significant. Significant difference at $p<0.05$ by multiple comparison tests.

exposed to air pollutants has been linked to decrease in leaf area (Steubing and Fangmeier, 1987; Byers *et al.,* 1992).

Plant protein is an essential component for the plant growth. Significantly lower concentration of total proteins in leaves of plants was recorded in the traffic area as compared to other locations. Plant protein in all plant species located in residential areas showed moderate decrease, and University area showed the highest concentration of total proteins in leaves.

Significant reduction in total chlorophyll content at traffic area was recorded in all plant species. *Ficus benghalensis* (Table 4) showed much reduction in total chlorophyll content as compared to total chlorophyll observed at University. Chlorophyll measurement is an important tool to evaluate the effect of air pollutants on plants. Chlorophyll plays an important role in plant metabolism. The reductions in chlorophyll concentration correspond directly to the reduction in plant growth.

Biomonitoring of plants is an important tool to evaluate the impact of air pollution on plants. The present study suggests that plants have the potential to serve as excellent quantitative and qualitative indices of pollution level. Present study with all the selected plant species showed reduction in the concentration of chlorophyll and plant protein. Plant species also showed reduction in leaf area particularly at heavy traffic area. The air pollutants effects on the cell elongation mechanism and reduced photosynthetic capacity, which is responsible for the decrease in leaf area (Steubing and Fangmeier, 1987; Byers *et al.,* 1992).

The rapid urbanization imparts more stress on the vehicular use, which release toxic air pollutants in the urban atmosphere in the developing countries. Monitoring of air pollution, biomonitoring of plants is an important tool to evaluate the impact air pollution on plants.

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