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Study of plants in relation to ambient air quality in Lucknow city, Uttar Pradesh

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Abstract: Rapid industrialization and urbanization has led to continuous deterioration of air quality which is a major environmental problem in many urban centres in both developed and developing countries. Air pollution is characterized by high concentration of suspended particulate matter, oxides of nitrogen and sulphur. If their concentration beyond tolerance limits in plants. They diversely affect the plants , human health , animals and even the meteorology of the globe. The experiment was performed to study the effect of air pollution load in *Lycopersicon esculentum,*, *Solanum melongena* and *Capsicum annum*. The total chlorophyll and carotenoids were found to be reduced at Site 1 and Site 2 as compared to the control. The catalase and peroxidase activity were increased with increase in different air pollutants concentration.

Key words: Total chlorophyll, Carotenoid, Catalase, Peroxidase

Introduction

A number of harmful gases are added to the atmosphere as the result of emission from industries and other wastes. They adversely affect air quality and make it unfit for living organisms. In our country data on air quality have been collected by National Environmental Engeenering Research Institute (NEERI). Although, there are several parameters to evaluate the air quality. Generally SO_2, NO_X and SPM are used to have a fair idea of pollution load carried by the air (Persily, 2007). NEERI collect data to assess the extent and nature of deterioration of air quality due to industrialization and Urbanization. The industrialization is the need of modern world, but its increasing pace has resulted into serious environmental hazards (Kim, 2004). Auto exhaust contribute significantly 70% to the air pollution in urban area (Parker, 1977; Zhu *et al* ., 2002). Zielinska *et al*. (2004) reported that the composition of emissions from automobile highly depend on the ambient air quality conditions. Air pollutants cause large scale damage to the plants. Research needs to be expanded to encompass a greater variety of plant responses to interactive stresses caused by air pollutants in more realistic field conditions.

In view of the above facts, it is important to assess the ambient air quality of cities and its effect on plants (Klumpp , 2003) as it essential for over all sustainable and eco-friendly development . An attempt has been made to evaluate the automobile pollution in an urban city , Lucknow .

Materials and Methods

Species like *Lycopersicon esculentum* Mill, *Solanum melongena* L. and *Capsicum annum* L. were selected to use their biochemical parameters as indicators of air pollution and were grown in polybags. Three plants of each species were exposed to air pollution for three months (October to December- 2006) at selected polluted sites.

Polluted site: In Lucknow city total three polluted sites including Urban and Suburban sites, close to heavy and light pollution load were identified and Mahanagar was treated as control site. Details of sites are:

Polluted Site 1-Aminabad
Polluted Site 2-Talkatora
Control Site -Mahanagar

Air quality status (SO_2, NO_X and SPM): During the exposure period, ambient air quality of some common air pollutants like SO_2 , NOx and SPM were analysed at polluted sites. Sampling was done 24 hr and twice a week during the exposure period. Average of 24 hr such sampling was taken for final calculation. Collection of samples for SPM from ambient air, GF/A whatman filter paper was used in high volume samapler (HVS) at the flow rate of 1.1. M3/MIN. SPM was analysed as standard method. Filter paper was weighed before and after sampling. West and Geake method (1956) and modified Jacob and Hochheiser (1958) were used for analysis of SO_2 and NO_x respectively.

Air pollution Index (API): The average of the sum of the ratios of three major pollutant concentrations to their respective air quality standards were obtained. The average was then multiplied by 100 to get the index (Rao and Rao, 1989).

$$API = 1/3 \; \frac{SPM \quad + \quad (SO_2) \quad + \quad (NO_X)}{(^{S}SPM) \qquad (^{S}SO_2) \qquad (^{s}NO_X)} \times 100$$

Where $S_{SPM,} S_{so\,2}$ and S_{NOX} represent the ambient air quality standards for SPM, SO_2 and $No_{x.}$

Air pollution index of polluted sites were developed on the basis of ambient air quality analysed at specific polluted sites through instrumental monitoring of SPM, SO_2 and NO_x and correlated with the variation in biochemical parameters. On the basis of air pollution index, Site 1 was categorized as moderate air pollution site (air pollution index 119.00) and Site 2 as heavy air pollution site (air pollution index 122.33) (Table 1).

Biochemical parameters: After three months of the exposure, plants were brought back to the laboratory and leaf samples were analysed for different biochemical parameters. For the chlorophyll and carotenoid analysis leaves were ground with a mortar and pestle (Arnon, 1949). Aliquots of 100 mg were extracted in 10 ml of 80% acetone at 4^0C, centrifuged at 3000 X g for 3 min, and the absorbance at 645 and 663 nm wavelength was measured using a spectrophotometer.

Chlorophyll activity was expressed as mg g^{-1} fresh wt of tissue. Catalase activity in leaves was estimated by the method given by Euller and Josephson (1927). 0.25 g of fresh tissue was homogenised in assay mixture and reaction was initiated by adding enzyme extract. After 5 min reaction was stopped by adding H_2SO_4. Corresponding blanks were also run simultaneously with H_2SO_4 prior to the addition of enzyme. The amount of H_2O_2 reduced by enzyme was determined by titrating the reaction mixture with 0.1N $KMnO_4$. The enzyme activity was expressed as µmoles H_2O_2 decomposed. For peroxidase (Luck, 1963), 0.25 g of fresh tissue was homogenised in assay mixture at 25^0C and reaction was initiated by adding enzyme extract. After 5 min reaction was stopped by adding H_2SO_4. Corresponding blanks were also run simultaneously with enzyme prior to the addition of H_2SO_4 . The absorbance at 485 nm wavelength was measured on a spectrophotometer. The activity was expressed as change in O.D per 40 sec per gram.

Results and Discussion

After three months of exposure, leaf samples of plant species were analysed for chlorophyll, carotenoid, and some of the enzymes like catalase and peroxidase. All the biochemical parameters exhibited insignificant variation ($p>0.05$) from species to species and site to site (Table 2).

***Lycopersicon esculentum* Mill:** At Site1, *Lycopersicon esculentum* Mill exhibited 4.44% reduction in chlorophyll content while increase of 10.36% was observed at Site 2. Carotenoid contents were observed 0.57% low at Site l , followed by a gain of 16.45% at Site2 in comparison to control . Stimulation in catalase activity was observed at all the sites as compared to control *i.e.* 20% at Site 2. Peroxidase activity was also found to be increased at all the sites.

Table - 1: Ambient air quality and air pollution index for different polluted sites

Sites	Pollutants (µg m^{-3})			Air pollution index
	SPM	SO_2	NO_X	
Site1	407.9	10.5	29.4	119.00
Site2	419.9	10.8	29.5	122.33

(Ambiant air quality standards taken for calculating of air pollution index 140 µg m^{-3} for SPM, 60 µg m^{-3} for SO_2 and 60 µg m^{-3} for NOx)

Maximum reduction of 2.91% was observed at Site l, followed by increase of 59.37% at Site 2 (Table 2 and Fig. 1).

***Solanum melongena* L.:** Biochemical parameters of *Solanum melongena* L. at all the polluted sites varied insignificantly ($p>0.05$) (Table 2 and Fig. 3) . Maximum reduction 12.84% was observed in Chlorophyll content while it increased to 30.53% at Site 2. Carotenoid contents showed reduction trend of 21.83% at Site 1 while increase of 23.14% at Site 2 respectively. Peroxidase activity was also found to be increased at all the sites. Maximum reduction of 46.54% was exhibited at Site 1, followed by increase of 183.66% at Site 2. Catalase activity was also found to be increasing at all the sites. At Site 1, there was no loss in catalase activity, whereas gain of 17.64% at Site 2 was evident.

***Capsicum annum* L.:** Chlorophyll content at Site 1 showed increase of 50.79%, followed by reduction 41.16% at Site 2 , as compared to control. Reduction of 6.85% in carotenoid contents was observed at Site l , followed by increase of 8.15% at Site 2. Peroxidase activity was also found to be increased at all the sites. Maximum gain of 97.10% was evident at Site2 followed by 64.05% at Site 1. Catalase activity was also found to be increased at all the sites. Maximum reduction 9.07% was observed at Site 1, followed by 145.40% at Site 2 (Table2 and Fig. 2).

Almost all the species showed maximum variation in biochemical parameters at Site 1, which was found to be moderate air pollution site. A considerable loss in chlorophyll, in the leaves of plants exposed at Site 1 (moderate air pollution site) supports the argument that the chloroplast is the primary site of attack by air pollutants such as SPM, SO_2 and NOx. Air pollutants make their entrance in to the tissues through the stomata and cause partial

Table - 2: Biochemical parameters of different species at different polluted sites

Species	Sites	Chlorophyll (mg g^{-1})	Carotenoid (mg g^{-1})	Catalase (µmole g^{-1})	Peroxidase (O.D/40/sec)
L. esculentum	Control	1.621	5.763	20.00	8.59
	Site1	1.549	5.730	20.00	8.84
	Site2	1.453	4.815	24.00	13.69
S. melongena	Control	2.211	5.488	22.67	3.61
	Site1	1.927	4.290	26.67	5.29
	Site2	1.536	4.218	26.67	10.24
C. annum	Control	2.087	5.077	14.67	5.87
	Site1	1.207	4.729	16.00	9.63
	Site2	1.192	4.663	36.00	11.57

Data represent mean of three replicates. Results are in significant at 5% ($p>0.05\%$)

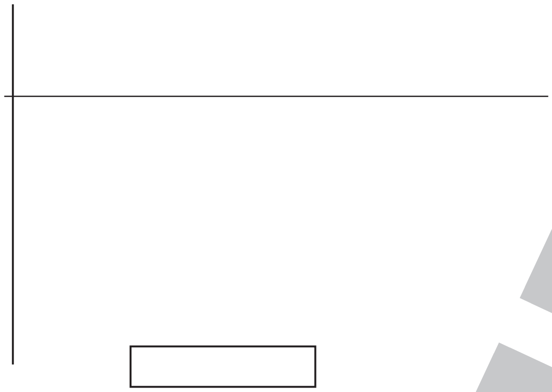

Fig. 1: Variation in biochemical parameters of *Lycopersicon esculentum* at different polluted sites as compared to control

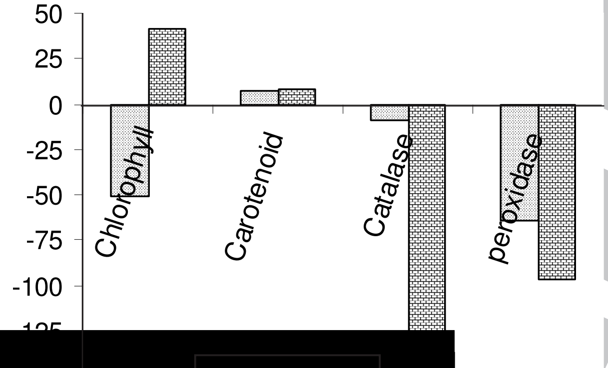

Fig. 2: Variation in biochemical parameters of *Capsicum annum* at different polluted sites as as compared to control

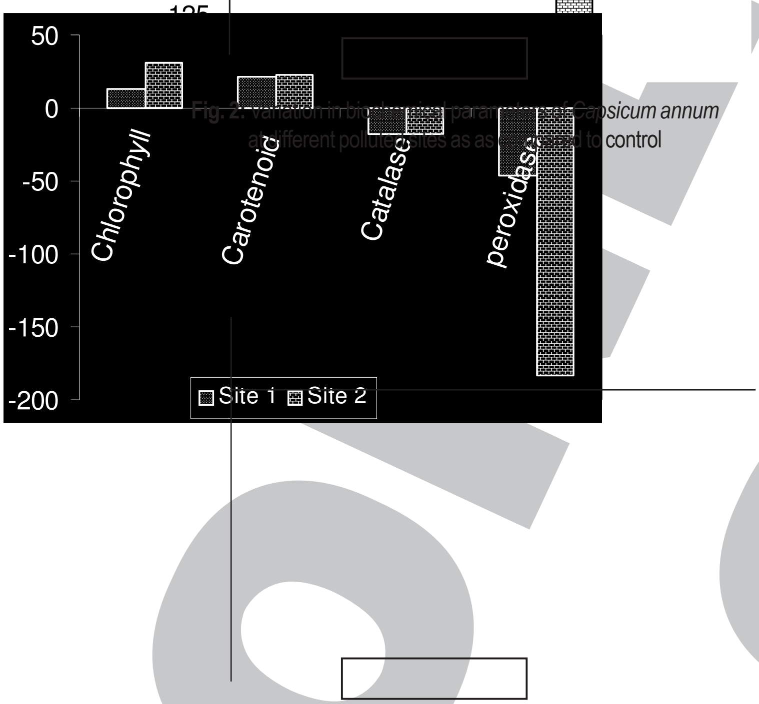

Fig. 3: Variation in biochemical parameters of *Solanum melongena* at different polluted sites as as compared to control

denaturation of the chloroplast and decreases pigment contents in the cells of polluted leaves. Rao and Leblanc (1966) mentinod that high amount of SO_2 causes destruction of chlorophyll and carotenoid and that might be due to the replacement of Mg^{++} by two hydrogen atoms and degradation of chlorophyll, carotenoid molecules to phaeophytin. In *Solanum melongena* L. and *Capsicum annum* L., maximum depletion in chlorophyll, carotenoid content at Site 1 may be due to the maximum pollution load at this site whereas Site 2 showed less depletion due to lower pollution load.

Catalase and peroxidase serve in interlinked primary protection mechanism. Catalase and peroxidase act on the end product (H_2O_2) (Bennett *et al.,* 1984). Catalase and peroxidase reduced H_2O_2 catalysing by air pollutants (Scandalios, 1993).

$$2H_2O_2 = 2H_2O + O_2$$

They were maximum at moderate air pollution site than other sites. This may be due to primary protection mechanism offered bhy catalase and peroxidase in plants to protect themselves at moderate air pollution site as compared to the less air polluted sites (Tanaka *et al.*, 1982).

In view of the data obtained in present investigation, Varshney and Varshney (1985) reported increase in peroxidase and catalase activity in plant cells under a variety of stresses, such as mechanical injury and attack by pathogens or an influence of environmental pollution. The increase in catalase and peroxidase activity varies with the plant species and the concentration of pollutants. Khan and Malhatora (1982) reported that leaves of the resistant plants might have high catalase and peroxidase activity.

Data on ambient pollutant concentrations do not allow direct conclusions to be drawn on potential impacts on plants and the environment. Evidence of effect can only be provided by using plants itself as monitors. These types of plant indicators integrate the effects of all environmental factors including interactions with other pollutants or climatic conditions. This permits the risk of complex pollutant mixtures and chronic effects occurring even below threshold value to be assessed. Therefore use of plants, as indicators in inexpensive technique. The present parameters analyzing, an early diagnosis of the extent of pollution can be done in the absence of visible injury.

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