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Foliar response of two species of heavy air pollution load at Indore city

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Abstract
Plants are constantly exposed to air, they absorb, accumulate and integrate pollutants confining on their foliar surfaces and show specific response too. The use of plants as monitors of air pollution has long been established, as plants are the initial acceptors of air pollution. Present study was carried out to find out the effect of air pollutants on morphology, physiology and biochemistry of Bauhinia Purpurea Lamk. and Eucalyptus Citriodora var. Maculata Hook. growing at two different sites of Indore city viz. Scheme No. 78 (Site-I), considered as Low Polluted Area (LPA), in this area there is very low traffic frequency and industries are absent and MR-10 (Site-II) which is Major Road No. 10 of Indore city. There are large number of Industries and heavy traffic frequency in this area, so it is considered as a polluted area. The two species growing at polluted site showed reduction in size of leaf, number of stomata and leaf biomass. Variations in biochemical parameters like chlorophyll in the leaves were found to be pollution load dependent.

Keywords: Air pollution, Low polluted area (LPA), Heavy polluted area (HPA), Foliar morphology

Introduction
Pollution has posed a very vital question for our survival as we are continuously altering the environment to satisfy our needs. Unplanned industrialization, faster means of transportation, urbanization and ruthless exploitation of natural resources have caused severe environmental crisis by polluting air, water and soil.

Air pollution on morphology, physiology and biochemistry of plants. Leaf is the plant part which is most sensitive and constantly exposed to air pollution. The pollution indicator value of the leaf has been studied by a large number of workers.1

Air pollution leads to reduction in plant growth and yield resulting in great damage to economic crops all over the world. Air pollutants adversely affect the plant. Different plant species react differently when exposed to air pollution. Plants provide an enormous leaf area for impingement, adsorption and accumulation of air pollutants. Plants are efficient bioindicators of the type and load of pollution in an area and can be used as a convenient source for environmental monitoring. Air pollution may lead to blocked stomata, increased leaf temperature, reduced photosynthesis, fruit setting, leaf growth, pollen growth and tree growth, leaf necrosis, chlorosis and bark peeling in plants.

Air pollution is one of the most severe environmental problems of the world today. Clean air is a mixture of gases such as 78% Nitrogen, 21% Oxygen, 1% Argon, 0.03% Carbon dioxide, very minor traces of helium, methane, krypton and 1.3% of water vapours by volume. Any rise in its component is considered as a kind of air pollution which may have widespread ecological implication on global scale.

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 atmosphere is a dynamic system that continuously absorbs a wide range of solids, liquids and gases. These substances travel through air, disperse and react with one another both physically and chemically. When their rate of formation is faster than rate of dispersion, they enter into the atmosphere and accumulate in air causing environmental decay. The combustion of fuels add substantial quantities of oxides of nitrogen and sulphur into atmosphere. These primary pollutants react photo chemically in the atmosphere forming Ozone, Peroxy Acetyl Nitrate (PAN) and acid rain as by product. This creates ecotoxic effects on terrestrial and aquatic flora and fauna, especially on endangered species and sensitive ecosystems.

To know the impact of air pollution on these plant Species various parameters were studied. These were Fresh weight, Dry weight, L/B ratio, Specific Leaf Area, Stomatal Size,

Stomatal index, Dust deposition, Leaf wash pH and conductivity, Leaf extract pH and conductivity, Photosynthetic pigment analysis, Ascorbic acid content, Protein content and Enzyme activity. The three sampling stations selected for the present research work were Scheme No. 78 (Low Polluted Area), which was experimental control area, Polo ground area (Industrial Polluted Area) and part of A.B. Road (Vehicular Polluted Area).

Materials and methods

Indore, the biggest city and commercial Capital of Madhya Pradesh is credited to have very dense population, highest growth rate, heavy vehicular density and many industries. Thus having large amount of pollutants which detenovate the quality of ambient air. Plants being constantly exposed to polluted environment absorb and accumulate pollutants, impinging on their leaf surface. Damaging effects of air pollutants on plants have long been recognized and are therefore used as indicators.

Sampling Stations

In order to study the air pollution on plants of Indore city a survey was carried out and sampling stations were selected on the basis of type of pollution, i.e. Industrial and Vehicular pollution. Availability of monitoring facilities and presence of common tree species were also taken into consideration. Thus, overall, three sampling sites were selected as mentioned below:

Low Pollution Area (LPA)

This area is located in Scheme No. 78, Aranya and Indore; where Regional Office of M.P. Pollution Control Board is also situated. This area was taken as the reference for comparison from other sampling stations, as there is absence of any industrial activity and also vehicular traffic is very low.

Vehicular Pollution Area (VPA)

This sampling station is situated near Palasia Square. This particular square has been selected as maximum traffic flows from this intersection. This is also connecting the national highway NH-3 Agra-Bombay Road.

Industrial Pollution Area (IPA)

This area is situated near Pologround, Indore. Here, there are many plastic, pharmaceutical and other polluting industries are located. This is our second sampling station for comparison. Besides this area also has a heavy traffic.

Leaf area

Mature leaves of selected plant species were sampled in leaf area measurements. Leaves were collected from polluted and low polluted areas. Leaves were kept in polythene bags and brought to laboratory for measurements.

Length/ breadth ratio of leaf

Length and breadth of leaf parts were measured with the help of thread and measuring scale. Leaf breadth was measured in upper, middle and lower part and average of three was taken as final breadth.

Fresh and dry weight of leaf

To find out fresh and dry weight of leaves sampling was done in control and both the polluted areas. Leaf samples were collected from the sampling station between 9-10am in polythene bags, kept in ice box and brought to the laboratory. Fresh weight and dry weight of the leaves were taken with the help of Digital Pan Balance and leaves were placed in oven at 80˚C for 24 hrs.

Structure and size of stomata

Mature leaves of selected plant species were sampled. Number and size of stomata were measured with the help of occular and stage micrometer. Mature leaves of the plants from polluted as well as low polluted area were plucked and brought to laboratory in polythene bags kept in ice box. Leaves were washed for stomatal studies.

Stomatal index

Leaves of each species were washed carefully with water and boiled in conc. nitric acid for 2-3min. Boiled leaves were washed thoroughly with water in watch glass and lower and upper epidermis were peeled. Each epidermal surface was then stained with saffranin, mounted in glycerin on a slide and observed under (10×40) × in a microscope. Observations were taken in upper, middle and lower region of leaf lamina. Three observations were made in each region for upper and lower epidermis. Stomatal index was measured after calculating field area using stage and occular scale.

The formula used to calculate stomatal index is as follows

Stomatal index = [S/(S+E)] X 100

Where, $S_=$ number of stomatal cells per unit area

$E_=$ number of epidermal cells per unit area

Dust deposition

The dust deposited on each leaf was carefully brushed off on a butter paper and weight of leaf dust was measured using electronic balance {Keroy, K-200}. Average dust deposition of 10 leaves was then calculated. The obtained amount was divided by the area of leaf and finally deposition was expressed as μgcm^{-2}. The average leaf area was determined using manual planimeter.

Leaf wash pH and conductivity

Ten fully mature leaves of each selected plant were plucked carefully from a height of 1 to 2 meters and placed in polythene bags. Samples were brought to laboratory and leaves were washed in separate beakers with 50ml of distilled water and each polythene bag was also washed with distilled water to remove dust remaining inside polythene bags. The pH and conductivity of leaf wash was measured by digital pH meter model 111E and conductivity meter deluxe model 601E.

Two species of *Bauhinia Purpurea Lamk.* and *Eucalyptus Citriodora var. Maculata Hook.* Were studied for their response to a mixture of air pollutants in a heavily polluted area of Indore city in October 2010-January 2011.

The study was conducted at two sampling stations of Indore city viz. Site-1 (Scheme No. 78), considered as low polluted area (LPA), in this area there is very low traffic frequency and industries are absent. This area was taken as reference site. Site-2 (MR-10) which is Major road no. 10 of Indore city, 8.71 km. long, runs from Vijay Nagar via Sukhliya to Sanwer and joins Ujjain City road, taken as a polluted site due to large number of Industries (Textiles and Fabrics, Pharmaceutical Industry, Steel re- rolling mills, Fertilizer and Chemical Industry etc.). Heavy traffic frequency in this area further added to the pollution load.

Leaf Samples were collected from both the sampling station

during study period in polybags from the height of 3-4 meter, kept in cool kit and brought to the laboratory. Fresh and dry weight of the samples was recorded with the help of digital pan balance (Keroy, K-200). The leaf area was measured by planimeter. Number and size of stomata were measured with the help ocular and stage micrometer and stomatal index was calculated as per Salisbury (1932).

The dust deposition of leaf surface was calculated by dry technique of Das and pattanayak (1977), pH and conductivity of leaf extract was recorded with the help of digital pH meter and conductivity meter. Chlorophyll and carotenoid content were estimated following Arnon (1949) and Duxbury and Yentsc (1956) respectively.

Site Map

Results and discussion

The present study on two species of growing at two different sites in Indore city indicates that air pollution causes significant changes in foliar morphology.

Considerable reduction in fresh and dry weight of leaf was observed in both the species. More reduction in dry weight of leaf was recorded in *Eucalyptus Citriodora var. Maculata Hook.* than in *Bauhinia Purpurea Lamk.* at polluted site. Marked reduction in leaf area, L/B ratio and L/D ratio was recorded in *Eucalyptus Citriodora var. Maculata Hook.*than *Bauhinia Purpurea Lamk.* Similar Reduction in leaf area of *Cassia siamea*, *Azadirachta indica* and *Dalbergia sissoo* due to SPM has been reported by 2.

Table 1: Average fresh and dry weight of 50 leaves (gm.), L/B ratio, L/D ratio, area of leaf (cm²), Stomatal size (µm) and stomatal index of leaves of *Bauhinia Purpurea Lamk.* and *Eucalyptus Citriodora var. Maculata Hook.* Collected from two study area of Indore city.

S. No.	Parameter	*Bauhinia Purpurea Lamk.*		*Eucalyptus Citriodora var. Maculata Hook.*	
		Site-l(LPA)	Site-2(HPA)	Site-l(LPA)	Site-2(HPA)
1.	Fresh weight of Leaves	70.75±0.349	63.89±0.354 (12.35%)	50.47±0.590	43.98±0.277 (12.84%)
2.	Dry weight of Leaves	30.36±0.147	28.58±0.118 (5.86%)	17.37±0.210	15.11±0.058 (13.01%)
3.	Leaf area	1638±4.121	1088±4.005 (33.59%)	1183±8.921	688±3.631 (41.80%)
4.	L/B ratio	109±0.532	87±0.322 (20.37%)	101±0.300	65±0.162 (32.55%)
5.	L/D ratio	6289±23.87	5079±21.56 (19.23%)	4715±20.69	3095±23.57 (34.35%)
6.	Size of stomata	100.1	72.3 (27.77%)	98.9	68.4 (30.83%)
7.	Stomatal index (abaxial surface)	32.53	20.98	28.84	19.8
8.	Stomatal index (adaxial surface)	34.19	22.53	30.18	18.35

Values in the parenthesis represent percentage reduction.
LPA- Low polluted area.
HPA- Highly polluted area

Size of stomata and stomatal index was found to be reduced in both the species growing at polluted site. More reduction is stomatal size and index was observed in *Eucalyptus Citriodora* than in *Bauhinia Purpurea*. Reduction in stomatal size due to air pollution. 3, 4, 5 Low stomatal frequency has been observed 6, 1 in response to polluted air.

Table 2: Dust deposition (mg/cm^2), Leaf pH and Conductivity (µmhos/cm^2) of leaves *Bauhinia Purpurea Lamk.* and *Eucalyptus Citriodora var. Maculata Hook.* collected from two different areas of Indore city.

S. No.	Parameters	*Bauhinia Purpurea Lamk.*		*Eucalyptus Citriodora var. Maculata Hook.*	
		Site-1(LPA)	Site-2(HPA)	Site-1(LPA)	Site-2(HPA)
1	Leaf Wash pH	7.5	6.0	7.4	5.9
2	Leaf Wash conductivity	68	198	55	95
3	Leaf extract – pH	7.0	5.2	6.7	6.0
4	Leaf extract-conductivity	79	122	69	192

LPA – Low polluted area.
HPA – Highly polluted area.

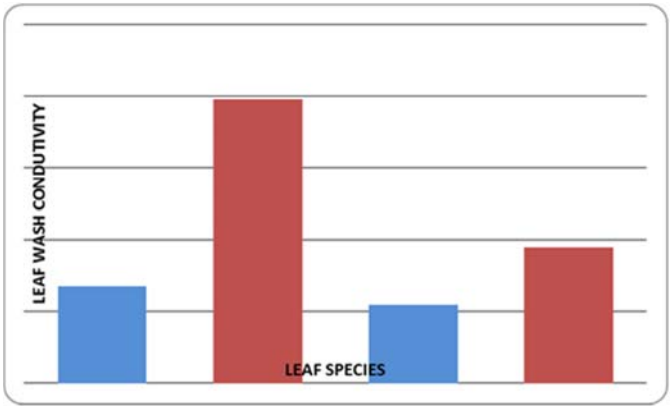

Fig 1: Showing leaf wash conductivity of leaves *Bauhinia Purpurea Lamk.* and *Eucalyptus Citriodora var. Maculata Hook.* collected from two study areas of Indore City.

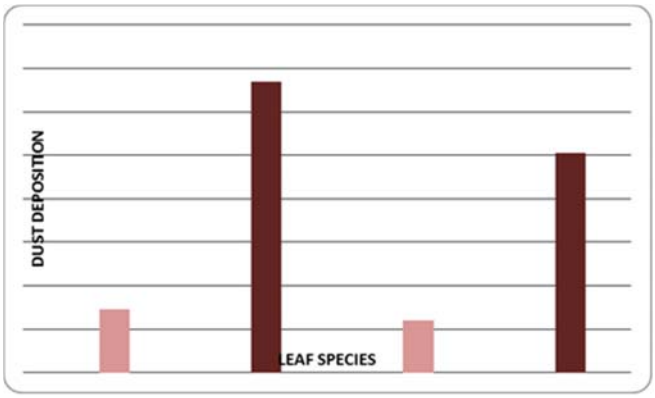

Fig 2: Showing dust deposition of leaves *Bauhinia Purpurea Lamk.* and *Eucalyptus Citriodora var. Maculata Hook.* collected from two study areas of Indore City.

Heavy dust deposition was observed in both the plant species at polluted site. Maximum dust deposition was found in *Bauhinia Purpurea Lamk.* Deleterious effect of dust on the morphology of leaves as expressed by the reduction is size, necrosis, damaged leaf margin and change of colour.7

pH of leaf wash and leaf extract was found to be acidic in both the species at polluted site. Conductivity of Leaf wash and extract was more at polluted site.

The result clearly indicated entry of noxious gases like SOx and NOx through cuticle and stomata. Thus altering the pH of leaf surface and that of extract, which is highly damaging and is primary cause of reduction in chlorophyll contents.

Total chlorophyll, carotenoid content of both the species were reduced at polluted site, maximum reduction was found in *Bauhinia Purpurea Lamk.* Reduction in chlorophyll contents due to air pollutants such as SOx, NOx, and CO has been reported by many earlier workers. 8, 9, 10

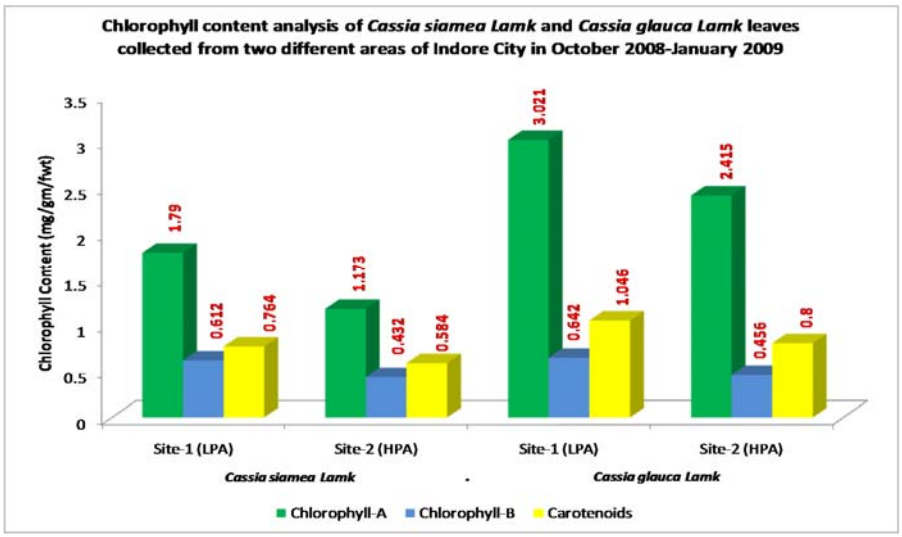

Fig 3: Showing photosynthetic pigment analysis of *Bauhinia Purpurea Lamk.* and *Eucalyptus Citriodora var. Maculata Hook.* collected from two different areas of Indore City (October 2008-January 2009

Conclusion

It is evident from the present study that the air pollutants such as SPM, SOx, NO_x and gl.O_3 from automobile exhaust and industries along with many other unknown pollutants are responsible for bad air quality. These pollutants not only affect the morphology of plants but also alter the physiology and biochemistry. Reduction in various parameters of two plant species studied at two sites clearly indicates the deleterious effect of air pollution on plant health.

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