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Leaf dust deposition and its impact on Biochemical aspect of some Roadside Plants of Aizawl, Mizoram, North East India

Prabhat Kumar Rai and Lalita L.S. Panda
Department of Environmental Science, Mizoram University, Tanhril, Aizawl- 796004, Mizoram, INDIA

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Abstract

Foliar surface of plants is continuously exposed to the surrounding atmosphere and is therefore the main receptor of dust. This physical trait can be used to determine the level of dust in the surroundings as well as the ability of individual plant species to intercept and mitigate with it. The present research was undertaken to study the dust deposition efficiency of selected common roadside plant species and the response of dust deposition on the biochemical aspect of leaves such as pH, Relative water content and Total chlorophyll content. The result showed maximum dust deposition in winter followed by summer and rainy for all plant species. It was seen that total chlorophyll and relative water content decreased whereas pH of leaf extract increased with the increasing dust load. The result shows significant negative and positive correlation between dust deposition and RWC, Total chlorophyll and pH respectively. The highest and the lowest dust deposition rates were observed in Ficus bengalensis and Artocarpus heterophyllus, respectively. Thus plants can be used in the abatement of dust pollution by acting as natural filters.

Keywords: Dust, RWC, total chlorophyll, pH.

Introduction

Atmospheric particulate matter is a mixture of diverse elements. Fine particulate matter is of great concern including dust and smoke as they are respirable, resulting in detrimental effect on human health and vegetation. Dust mayaffect photosynthesis, respiration, transpiration and allow the penetration of phytotoxic gaseous pollutants[1,2]. Dust from highways and roads greatly affect the roadside vegetation communities by inducing changes in pH, Relative Water Content and species diversity[3]. In India, 40% of the total pollution problem is caused by dust pollution[4]. Vegetation act as natural filters by depositing dust particles on their leaf surface, Susceptible and highly exposed part of a plant and thus makes an important contribution in the improvement of air quality. Leaves act as pollution receptors and decrease dust load of the air. A large no of trees and shrubs have been identified and leaves[5]and leaf traits can be used as a tool as dust filter to check the rising urban dust pollution. The use of vegetation to Combat dust pollution has been accepted in many developed countries such as London[6], Russia[7], Ohio, USA[8]. Plants used for Bio monitoring of dust load are studied by a few workers such as Shetey and Chaphekar[9] and Varsney and Mitra[10]. In Aizawl, factors such as crustal materials from fragile rock, resuspended road dust, vehicular emission and agricultural activity like shifting cultivation propel voluminous dust into the atmosphere. Roadside vegetation particularly trees, shrubs and intense hedge can help significantly in reducing the adverse effect of gaseous and particulate pollutants[11]. The changed ambient environment due to increased dust deposition in Aizawl has influenced the physiological and biochemical aspect of roadside plants and its response.

Present research was undertaken to study the impact of dust deposition on biochemical parameters of roadside plants such as pH, RWC and Total chlorophyll content so that the future effect of dust pollution can be controlled by finding the tolerant species and to know the existence of any relationship with dust deposition and biochemical parameters of plant leaves so that future research can help in abatement of dust pollution by selecting the suitable tolerant plant species. Our goal was to evaluate the relationship between dust deposition and various physiological parameters of six roadside plant species i.e. *Ficus bengalensis, Psidium guajava, Bougainvillea spectabilis, Mangifera indica, Lantana camara* and *Artocarpus heterophyllus.*

Material and Methods

Study Site: The research work was done in Aizawl, Mizoram ($21^0$58'- $21^0$85' N and $90^0$30'- $90^0$60'E), the capital of the state is 1132 meter ASL (figure-1). The altitude in Aizawl district varies from 800 to 1200 meters. The climate of the area is typically monsoonal. The annual average rainfall is amounting to 2350 mm. The area experiences distinct seasons. The site for sampling of dust and leaves was selected near the center of city, an important city road with high anthropogenic activities.

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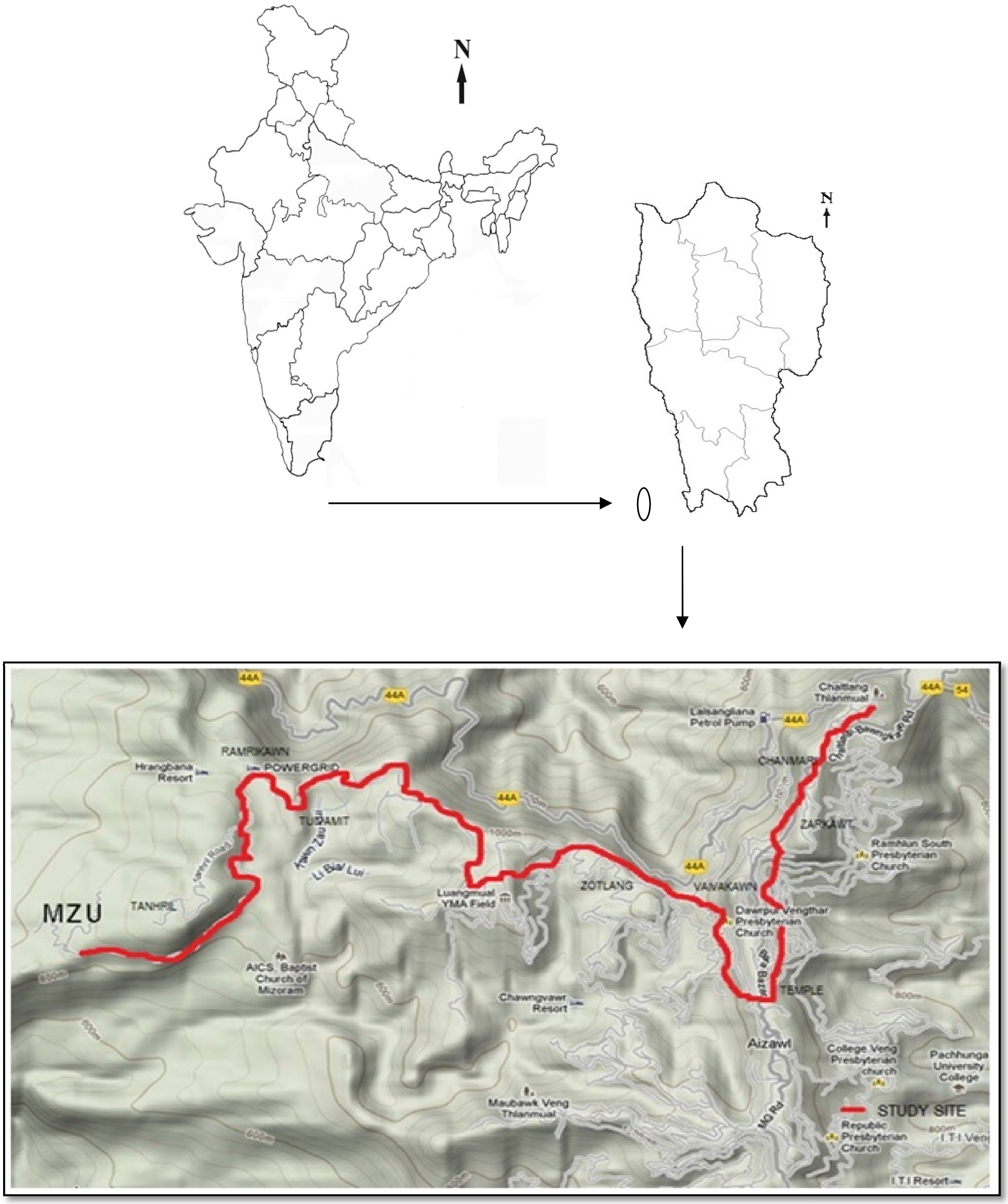

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Figure-1
Map showing the study site

Plants: *Ficus bengalensis, Psidium guajava, Bougainvillea spectabilis, Mangifera indica, Lantana camara* and *Artocarpus heterophyllus.*

Leaf Sampling and Biochemical Analysis: Six plants of common occurrence along the roadside were selected for the study during November 2011 to February 2012 for their dust deposition and biochemical studies. Three replicates of fully matured leaves of each species were randomly collected in early morning from the lower branches (at a height of 2-4 m) and were quickly transferred to the laboratory in polythene bag kept in ice box for further analysis within 24hrs of their harvesting. The amount of dust was calculated by taking the initial and final weight of beaker in which the leaf samples were washed. It was calculated by using the formula:

$$W = \frac{W_2 - W_1}{A}$$

Where, W = Dust content (mg/cm^2), W_1 = Weight of beaker without dust, W_2 = Weight of beaker with dust
A = Total area of leaf in cm^2

Leaf Extract pH: Leaf sample (0.5 g) was crushed and homogenised in 50ml deionised water, the mixture was centrifuged and supernatant was collected for detection of pH using pH meter.

Relative Leaf Water Content (RWC): The method described by Liu and Ding[12], was followed to determine RWC based on the formula, RWC= (wf – wd) x 100 / (wt – wd) Where, wf-fresh wt of the leaf, wt-turgid weight of the leaf after immersing into water overnight and wd-dry weight of the leaf. Fresh weight (wf) of the leaf was increased when leaf pieces were weighed after immersing in water overnight to get turgid (wt). The leaf pieces were then blotted to dryness and placed in a dryer at 1150C (for 2 hr.) and reweighed to get dry weight.

Total Chlorophyll Content (TCH): This was done according to the method described by Arnon[13], 0.3 g of fresh leaves were blended and then extracted with 10 ml of80% acetone and left for 15 min. The liquid portion was decanted into another text-tube and centrifuged at 2,500 rpm for 3 min. The supernatant was then collected and the absorbance was then taken at 645 nm and 663 nm using a spectrophotometer. Calculations were made using the formula below: Chlorophyll a = 12.7DX663 – 2.69DX645 x V/1000W mg/g, Chlorophyll b = 22.9DX645 – 4.68DX663 x V/1000W mg/g, TCh = chlorophyll a + b mg/Dx = Absorbance of the extract at the Wave length Xnm, V = total volume of the chlorophyll solution (ml),and W = weight of the tissue extract (g).

Results and Discussion

Dust Deposition: Season wise dust collection potential of six different plants under study is presented in figure-2. From the figure it was observed that the dust collection efficiency was highest in winter followed by summer and lowest in rainy season. Dust deposition capacity varied from a maximum in *Ficus bengalensis* to a minimum in *Artocarpusheterophyllus.* The trend of dust deposition among the species was *Ficus bengalensis> Psidium guajava> Bougainvillea spectabilis> Mangifera indica> Lantana camara >Artocarpus heterophyllus.* Dust deposition capacity of plants depends on their surface geometry, phyllotaxy and leaf external characteristics such as presence/absence of hairs, cuticle, length of petiole, height and canopy[14-17].Weather condition, direction and speed of wind also affect the dust interception capacity of plants. Highest dust accumulation in *Ficus bengalensis* may be due to its shiny , waxy coating and rough surface with short petiole whereas in case of *Psidium guajava ,Bougainvillea spectabilis* and *Mangifera indica* may be due to their waxy coating, rough surface with slightly folded margin. Lower dust accumulation in *Artocarpus heterophyllus* may be due to its smooth, flat surface and absence of folded margin. The maximum dust deposition in winter may be due to wet surface of leaves that help in dust capturing, preventing particulate dispersion. Washing of leaves due to rain accounts for least dust accumulation in rainy season.

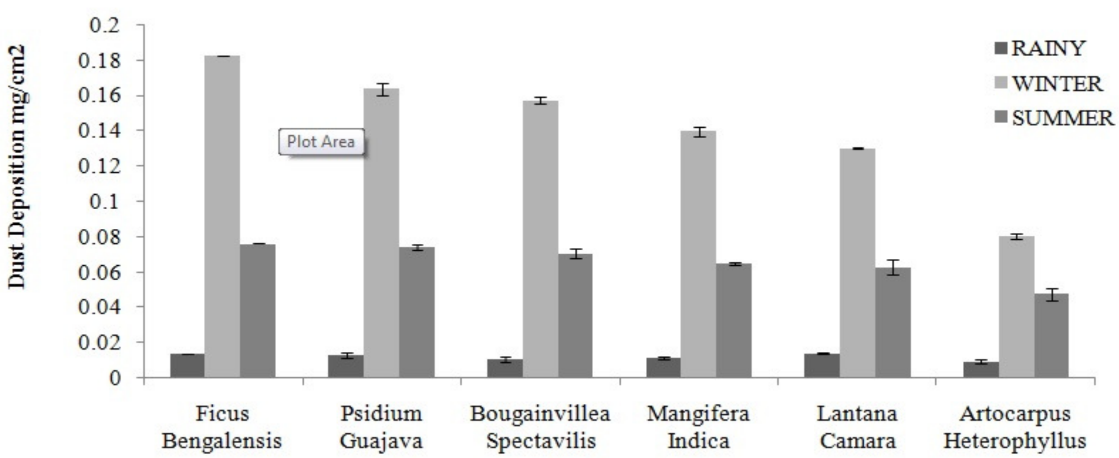

Figure-2
Seasonal variation of Dust accumulation in selected plant species under study

Biochemical Analysis: The seasonal variation in pH of different plant species studied is shown in figure-3. The leaf extract pH of all plants showed higher pH value in rainy followed by summer and lowest in winter season. A variation in the leaf pH was observed among the plant species studied with respect to season. The seasonal variation of pH may be due to the influence of dust deposition on the plant leaves. High dust deposition may be the reason for highest pH value in winter season that cause dissolution of dust particles in the cell sap resulting in an alkaline condition .Among the tree species, *Ficus bengalensis* showed higher leaf pH level i.e. the alkaline condition caused by highest dust deposition and *Artocarpus heterophyllus* showed lower leaf pH level i.e. acidic condition may be due to presence of an acidic pollutant that shift the cell sap pH towards the acidic side.

The result exhibited high leaf Relative Water Content during rainy season, low in winter and least in summer season (figure-4). Leaf water status is related to several leaf physiological variables, such as leaf turgor, growth, stomatal conductance, transpiration, photosynthesis and respiration[18, 19]. All the plant species showed high RWC during rainy season when dust deposition was low and low Relative Water Content was recorded in winter may due to high dust deposition on leaves that clog stomatal opening, severely affecting the transpiration rate. Dust may also absorb water through non-cutinized plant surface such as leaves, stems, and branches along with increased evaporation from the plants because of high temperature would contribute to decreased water content. In summer Relative Water Content is least may be due to lower availability of water in soil along with high transpiration rate.

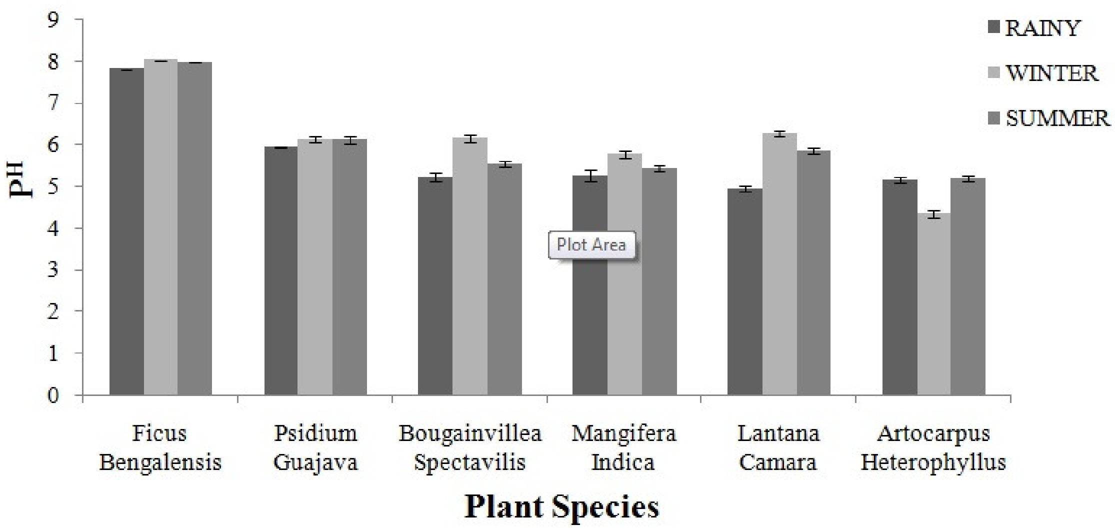

Figure-3
Seasonal variation in pH of selected plant species

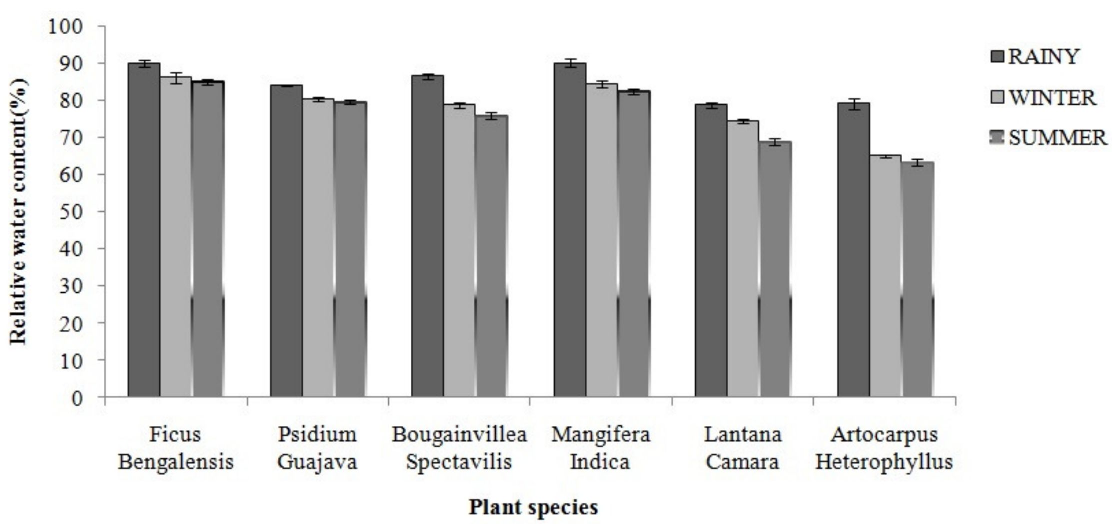

Figure-4
Seasonal variation in Relative Water Content of selected plant species

Season wise variation of Total chlorophyll content of selected plant species under study is shown in figure-5. All the plant species exhibited maximum chlorophyll content during rainy season followed by summer and winter season. The variation in chlorophyll content of selected plants may be due to the dust particles. Dust accumulation causes severe damage in the photosynthetic apparatus[20]. Deposited dust on the surface of leaf alters its optical properties particularly the surface reflectance in the visible and short wave infrared radiation range[21-23] and the amount light available for photosynthesis. The reduction in chlorophyll content during winter season may be due to maximum dust accumulation on the leaf surface and its interference with incident light intensity, leading to a reduction in net photosynthesis. Dust deposition also interferes with gas diffusion between the leaf and air by blocking the stomatal pores. Further the decline in chlorophyll content in the leaves may be due to the alkaline condition created by dissolution of chemicals present in the dust particles, responsible for chlorophyll degradation. Dusted leaf surface causing reduction in chlorophyll content is responsible for reduced photosynthesis[24].The highest chlorophyll content of leaf may be due to least dust accumulation during rainy season.

Correlation of dust load with biochemical parameters such as pH, Relative Water Content and Total Chlorophyll Content is shown in table-1. The biochemical parameter such as pH showed significant positive correlation with dust load except for *Artocarpus heterophyllus* which was negatively correlated which may be due to less dust accumulation whereas Relative Water Content and Total Chlorophyll Content showed significant negative correlation with dust load.

Conclusion

The study concludes that atmospheric dust accumulation varies with structure, geometry, height, size of petiole, presence/ absence of hairs and presence of wax on leaf surface of selected plants. Plants with waxy coating, rough surface with folded margin accumulate more dust than plants with smooth, flat surface without folded margin. Dust depositions induce changes in the biochemical parameters by increasing and decreasing

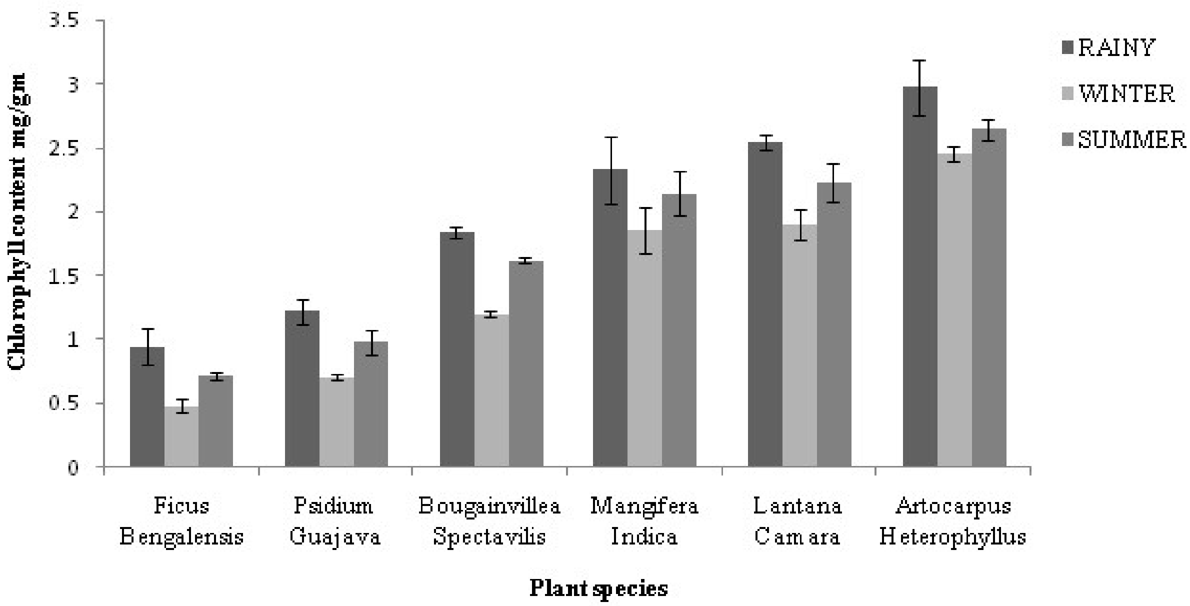

Figure-5
Seasonal variation in Total Chlorophyll Content of selected plant species

Table-1
Correlations of dust load with pH (r1), RWC (r2) and Total Chlorophyll (r3) in selected plant species

Plant Species	PH (r1)	RWC(r2)	Chlorophyll(r3)
Ficus bengalensis	0.851893	-0.66018	-0.99564
Psidium guajava	0.985584	-0.77004	-0.99946
Bougainvillea spectabilis	0.997586	-0.65606	-0.99515
Mangifera indica	0.957836	-0.68247	-0.99637
Lantana camara	0.95887	-0.40657	-0.9997
Artocarpus heterophyllus	-0.97573	-0.83127	-0.98439

their level in the plant leaves. The extent of such changes depends on plant tolerance towards dust and on the chemical nature of the dust. All these changes exert stress on plant physiology and can serve as an indicator of dust pollution.

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