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REVIEW ARTICLE

INFLUENCE OF LEAF DUST DEPOSITION ON CHLOROPHYLL CONTENT OF *BOUGAINVILLEA SPECTABILIS* AND *LANATANA CAMARA* GROWING IN VICINITY OF JAYPEE CEMENT PLANT, REWA (M.P.)

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ABSTRACT

The aim of this study was to assess the seasonal variation in accumulation of cement dust and its impact on chlorophyll content of leaves in two shrub species with different types of leaves – *Bougainvillea spectabilis* and *Lanatana camara* growing in and around Jaypee cement plant Rewa (M.P.). Results showed that *Lanatana camara* accumulated higher amounts of dust that resulted in a reduction of the efficiency of the photosynthetic pigments whereas less dust accumulation with more photosynthetic efficiency in the leaves of *Bougainvillea spectabilis* growing in polluted site as compared to non-polluted ones in all three seasons. A strong negative correlation was found between the amount of dust accumulation and the efficiency of the photosynthetic apparatus in both the species. Thus shrubs can help significantly in reducing the adverse effect of cement dust pollution by acting as natural filters.

INTRODUCTION

The quality of air is the most alarming issues related to the environment. There is increase in the pollutants which are detoriating the quality of air that we breathe in. Pollutants from automobiles, industries have created a brown cloud zone over many cities. Apart from causing respiratory disorders in humans the air pollutants have caused various effects on the plants. Cement industry caused environmental pollution problems, and the pollutants of the cement industry produced the undesirable impact on air, water and land. Cement industry is recognized as one of the most important industries besides steel and power, and its consumption pattern reflects the economic development of any nation. From the point of view of air pollution, the cement, all over the world, is placed in a unique and somewhat contradictory situation. The cement related activities – crushing, grinding, handling, conveying and calcinating of raw material and finished products in various stages of fineness lead to unavoidable generation of pollutants in the form of gases and particulate matter emissions. The dust produced in the process is a mixture of calcium, potassium, aluminum, silicon, iron and sodium oxides and its particle size ranges from 0.1-1 μ.

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This dust is actually a heterogeneous substance whose constituents and concentrations vary with time and location. It has the property of setting into a hardened mass which forms a thick impervious crust in contact with water. The Cement industry responsible for a vital role in the imbalances of the environment and produce air pollution hazards. In comparison with gaseous air pollutants, many of which are readily recognized as being the cause of injury to various types of vegetation, relatively little is known and limited studies have been carried out on the effects of cement dust pollution on the growth of plants. Cement industry is inherently characterized by particulate air pollution and essentially the dust. Plants growing in the polluted environment can improe the air quality of that area by acting as natural filters. The dust is produced during blasting of raw materials, grinding of cement clinker and packaging and loading of finished cement (Gbadebo and Bankole, 2007). The dust produced during various processes are highly alkaline, have wide range of sizes and varied in chemistry. Leaves are highly exposed parts of a plant act as persistent absorbers in a polluted environment (Maiti, 1993; Samal and Santra, 2002; Farzadkia *et al*; 2016; Nirbhay, 2017). They act as pollution receptors and reduce dust concentration of the air. The leaves capacity as dust receptors depends upon leaf structure, leaf surface geometry and height and canopy of trees (Nowak, 1994; Singh, 2000; Singh *et al*., 2002). The selective response of leaves toward dust may be used for monitoring air dust pollution.

Chlorophyll is a green pigment found in leaves and stems of plant. It gives green colour to leaves and assimilate light that is used in photosynthesis. Chlorophyll is found in high concentrations in the chloroplasts of plant cells. Verma and Chandra, 2015 revealed that chlorophyll measurement is an important tool to evaluate the effects of air pollutants on plants as it plays an important role in plant metabolism and any reduction in chlorophyll relates directly to plant growth. Darweesh and Sayed, 2014 also concluded that due to the cement dust accumulation on exposed parts of the plant, there were decrease in height, productivity, and chlorophyll content of the plant. This research work was undertaken to study the impact of leaf dust deposition on chlorophyll content of two tree species viz; *Bougainvillea spectabilis* and *Lanatana camara* growing in the vicinity of Jaypee Cement Plant, Rewa (M.P.) and to evaluate the relationship between dust deposition and chlorophyll content of leaves.

MATERIALS AND METHODS

Selection of Site-The campus of Jaypee Cement Plant, Rewa (M.P.) was selected as polluted site for the present study. The cement plant (JRP) is located about 15 km from Rewa city.

Selection and sample collection of plant- Two common tree species viz. *Bougainvillea spectabilis* and *Lanatana camara* growing in the vicinity of JP Cement plant, Rewa and APS University campus as control site were selected for the study during November 2017 to July 2018 for their dust deposition and Chlorophyll estimation of leaves.

Dust load deposition: For the estimation of dust load and total leaf area 10 leaves were taken from each tree species. These leaf samples were washed in pre weighed empty petri plates containing 50ml of distilled water with the help of brush & forceps. The amount of dust was calculated by taking the initial and final weight of petri plates in which the leaf samples were washed. Dust load was calculated by using the formula –

$$\text{Dust content (mg/cm}^2\text{)} = \frac{W_2 - W_1}{A}$$

Where, W_1 = Weight of petridish without dust
W_2 = Weight of petridish with dust
A = Total area of leaf in cm^2

Extraction of chlorophyll: This was done according to the method described by Arnon, 1949One gram of fresh leaves were blended and then extracted with 20 – 40 ml of 80% acetone and left for 15 minutes. The liquid portion was taken into another tubes and was then centrifuged at 5000 – 10000 rpm for 5 minutes. The supernatant of the sample was transferred and the absorbance was then taken at 645 nm and 663 nm using a spectrophotometer. The absorbance at 645nm and 663nm against the solvent (acetone) blank was also taken.

Estimation of chlorophyll content: The concentrations of chlorophyll 'a', chlorophyll 'b' and total chlorophyll were calculated using the following equation:

Chlorophyll 'a': $12.7 (A_{663}) – 2.69 (A_{645})$
Chlorophyll 'b': $22.9 (A_{645}) – 4.68 (A_{663})$
Total Chlorophyll: $20.2 (A_{645}) + 8.02 (A_{663})$

RESULTS

The present study was conducted to assess the impact of cement dust deposition and Chlorophyll estimation of leaves of two selected tree species viz., *Bougainvillea spectabilis* and *Lanatana camara* growing under ambient field conditions at various sites located at different distances from the cement kiln of Jaypee Cement plant, Rewa (M.P.). Similar observations were also made for the respective tree species growing in the campus of A.P.S University, Rewa, a control site. The results of dust deposition on the leaves of two shrub species under study, growing at polluted and controlled sites during analysis are summarized in figure 1 and figure 2. It was observed both the shrub species showed higher dust deposition in winter followed by summer and lowest in rainy season. The average seasonal dust accumulation in two shrub species under study is presented in Table 1. It shows *Bougainvillea spectabilis* (0.404 ± 0.194mg/cm^2) to have minimum and *Lanatana camara* (0.623 ± 0.316 mg/cm^2) to have maximum dust accumulation. Figure (1-2) shows that dust fall on the leaves of tree species growing in polluted sites was high compared to those growing in the control site in all the seasons.

Seasonal variation in the chlorophyll pigments i.e. total chlorophyll, chlorophyll 'a' and chlorophyll 'b' in the leaves *Bougainvillea spectabilis* and *Lanatana camara* are presented in Table 2 and 3. The results showed that both the tree species exhibited maximum pigment contents during rainy season followed by summer and winter season. In general in all plants chlorophyll a is present in the highest quantity more than chlorophyll b. The present investigation showed changes in the levels of total chlorophyll content in the trees exposed to atmospheric dust fall. In both tree species chlorophyll a, chlorophyll b, and total chlorophyll, were lower in exposed leaves than in control leaves in all seasons. Maximum concentration of chlorophyll pigments was found in *Bougainvillea spectabilis* (20.703 mg/g) and minimum in *Lanatana camara* (7.802 mg/g) in rainy season at polluted site. The Pearson correlation coefficient (r) values of dust deposit with total chlorophyll content in polluted and controlled site are presented in Table 4. The table shows significant negative correlations between dust load and pigment content i.e. -0.99487at polluted site and -0.99953 at controlled site for *Bougainvillea spectabilis*. Similarly; -0.98173 at polluted site and -0.99947 at controlled site for *Lanatana camara*.

DISCUSSION

Dust accumulation in a particular area depends on its topography, climatic and weather conditions, and direction and speed of wind and human activities. The lower dust accumulation in the rainy season may be due to wash-off by rain. In the study area high wind speed in summer may be the reason for the relatively lower dust accumulation than in winter. The selective response of leaves toward dust may be used for monitoring air dust pollution. All the shrub species exhibited maximum chlorophyll content during rainy season followed by summer and winter season. Higher dust accumulation in *Lantana camara* may also be due to their slightly rough leaf surfaces with depressions in the middle of the leaves and shortness of the plants also must be taken into account.

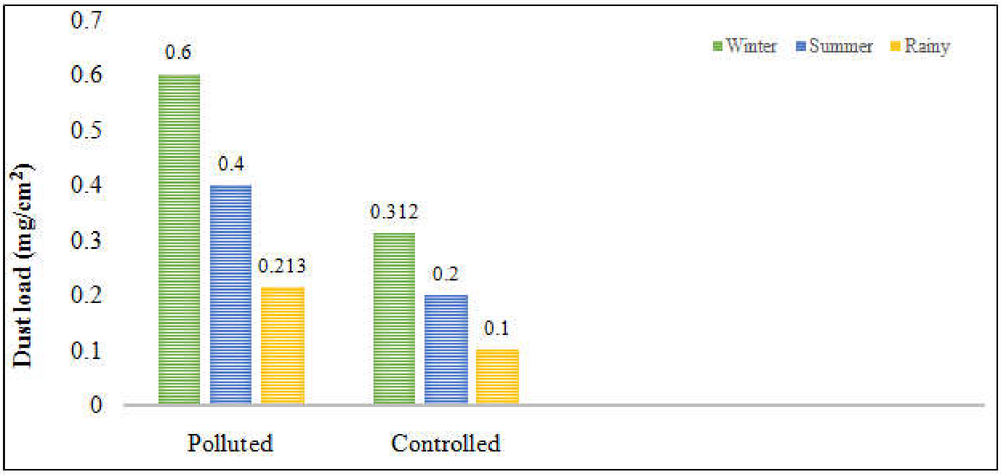

Figure 1. Seasonal Variation of Dust Accumulation (mg/cm^2) in *Bougainvillea spectabilis*

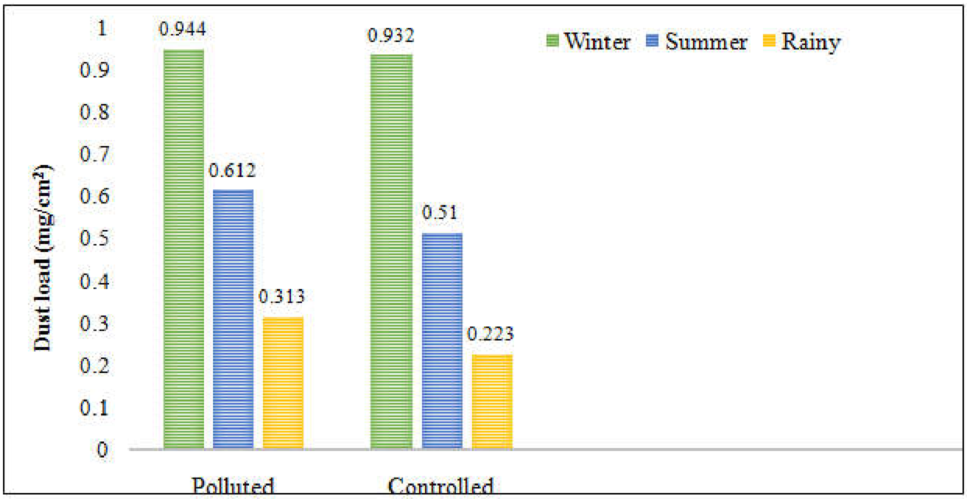

Figure 2. Seasonal Variation of Dust Accumulation(mg/cm^2) in *Lanatana camara*

Table-1 Seasonal Average of Dust Accumulation (mg/cm^2) in selected shrub species under study

Tree Species	Dust Deposited (mg/cm^2 leaf area)	
	Polluted	Controlled
Bougainvillea spectabilis	0.404 ± 0.194	0.204 ± 0.106
Lanatanacamara	0.623 ± 0.316	0.555 ± 0.357

Table-2 Seasonal contents of Chlorophyll 'a' , 'b' , total Chlorophyll(mg/g) in leaves of *Bougainvillea spectabilis* growing at polluted and controlled sites

SeasonsSites	Winter			Summer			Rainy		
	Chl 'a'	Chl 'b'	TC	Chl 'a'	Chl 'b'	TC	Chl 'a'	Chl 'b'	TC
Polluted	14.52	2.798	17.318	15.567	3.799	19.366	16.667	4.899	20.703
Controlled	17.254	4.329	21.583	18.365	5.439	23.804	19.475	6.539	26.009

Table 3. Seasonal contents of Chlorophyll 'a' , 'b' , total Chlorophyll (mg/g) in leaves of *Lanatana camara* growing at polluted and controlled sites

Seasons Sites	Winter			Summer			Rainy		
	Chl 'a'	Chl 'b'	TC	Chl 'a'	Chl 'b'	TC	Chl 'a'	Chl 'b'	TC
Polluted	3.624	0.894	4.518	4.753	2.052	6.805	5.735	2.071	7.802
Controlled	11.411	2.602	14.013	12.511	3.762	16.273	13.614	4.953	18.558

Chl 'a'- Chlorophll a
Chl 'b' – Chlorophyll b
TC – Total Chlorophyll

Table 4. Correlation of dust load with total chlorophyll content (r) in selected tree species

Name of Species	Polluted Site	Controlled Site
Bougainvillea spectabilis	-0.99487	-0.99953
Lanatanacamara	-0.98173	-0.99947

Lower dust accumulation in *Bougainvillea spectabilis* may be due to the thin lamina of their leaves and smooth leaf surfaces. Leaves which grow in polluted area shows reduced photosynthetic activity and thereby show reduction in the chlorophyll content (Kalyani and Singaracharya, 1995). Chlorophyll measurement is an important tool to evaluate the effects of air pollutants on plants as it plays an important role in plant metabolism and any reduction in chlorophyll content corresponds directly to plant growth (Joshi and Swami, 2009).
The variation in chlorophyll content of selected plants may be due to the dust particles. The present study showed significant variation of pigment (total chlorophyll, chlorophyll a and chlorophyll b), content from species to species and season to season in the plants exposed to polluted sites. It is evident from the present investigation that chlorophyll content showed variable responses to dust. Similar results demonstrating that the total chlorophyll content of polluted leaves was lower than that of control leaves were also reported by Darley (1966), Eller (1977), Somashekar *et al*. (1999), Mandal and Mukherji (2000), Samal and Santra (2002), Masahiro and Takeshi (2016)observed a similar type of response in some plants. The Total Chlorophyll Content showed significant negative correlation with dust load.

Conclusion

The present investigation showed changes in the levels of pigment (total chlorophyll) content in the plants exposed to cement dust fall.The study concludes that cement 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 rough surface 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 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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