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Research Paper :

Induced changes of photosynthetic pigments in selected plant species due to cement dust pollution

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ABSTRACT

Plants are the only living organisms which have to suffer a lot from cement dust pollution, because they remain static at their habitat. In the present study, the estimation of Chlorophyll 'a', Chlorophyll 'b' and total carotenoid pigments were studied in three different species such as *Azhadirachta indica*(L), *Polyalthia longifolia*(L) and *Ficus religiosa*(L). Extraction was made using 100 per cent acetone and spectrophotometric determination was carried out. The selected plant species was exposed to the cement dust pollution. Variation in Chl'a', Chl'b' and carotenoid were found out from the plant species which were exposed to the cement dust pollution on various days such as 30, 60, 90, 120, 150 and 180 days. *Ficus religiosa*(L) was found to be more affected compared to the remaining species. This variation can be used as indicators of the air pollution for early diagnosis of stress caused by the pollution. The findings implied that cement dust pollution reduced the photosynthetic capacity of the plants. The reduction in photosynthetic pigments corresponds directly to the reduction in plant growth.

KEY WORDS : Cement dust, Bio-indicators, Photosynthetic pigments, Chlorophyll, Carotenoids, Leaf extraction, Spectrophotometric determination and acetone

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The impact of the atmospheric pollution on the ecosystems was demonstrated at several times (Bliefert and Perraud, 2001; Grantz, *et al.,* 2003). Otherwise, this form of pollution is caused by industrial activities including the cement industry. The main impact of the cement activity on the environment is the broadcasts of dust and gases. These particles or dust are very numerous and varied. This diversity is assigned to different sources of broadcast (Laj and Sellegri, 2003). Plant response to air pollution can be used to assess the quality of air that may provide early warning signals of air that may provide early warning signals of air pollution trends (Wagh *et al.,* 2006). Plants enormous provide an enormous leaf area for impingement, absorption and accumulation of air pollutants to reduce the pollution level in the air environment (Escobedo *et al.,* 2008), with a various extent for different species (Hove *et al.,* 1999). Presence of trees in the urban environment can thus improve air quality through enhancing the uptake of gases and particles (McPherson *et al*., 1994; Beckett *et al.,* 1998, Smith *et al.,* 2005). Of all the plant parts, the leaf is the most sensitive part to air pollutants and several other such external factors (Lalman and Singh, 1990). Removal of pollutants by plant from air by three processes, namely deposition of particulates, absorption by leaves and aerosols over leaf surface (Prajapti and Tripathi, 2008).

The chlorophylls, Chl 'a' and Chl '*b*', are virtually essential pigments for the conversion of light energy to stored chemical energy. The amount of solar radiation absorbed by a leaf is a function of the photosynthetic pigment content; thus, chlorophyll content can directly determine photosynthetic potential and primary production (Curran *et al.,* 1990, Filella *et al.,* 1995). In addition, Chlorophyll gives an indirect estimation of the nutrient status because much of leaf nitrogen is incorporated in chlorophyll (Filella *et al.,* 1995, Moran *et al.,* 2000). Furthermore, leaf chlorophyll content is closely related to plant stress (Hendry 1987, Merzlyak and Gitelson 1995, Peñuelas and Filella 1998, Merzlyak *et al.,* 1999). Traditionally, leaf extraction with organic solvents and spectrophotometric determination in solution is required for pigment analysis with wet chemical methods (e.g., Lichtenthaler 1987). Recently, alternative solutions of leaf pigment analysis (*i.e.*, chlorophyll, carotenoids and anthocyanins) with non-destructive optical methods have been developed. These newer methods are non-destructive, inexpensive, quick and now possible in the field (Buschmann and Nagel, 1993, Gitelson and Merzlyak, 1994 a, b, Markwell *et al.,* 1995, Gamon and Surfus, 1999, Gitelson *et al.,* 2001, 2002).

It is a common observation that none of the plant has been found to be uniformly distributed around the globe; similarly no particular region in the world has been reported to lodge all the plants of the plant kingdom. This disparity of plant distribution depends on interaction of a plant with its surrounding (Kumar and Soodan, 2006). Interaction and establishment of plants in any area also depends upon the sensitivity or resistance of plants to air pollutants (Tripathi and Dwivede, 2002). The effect of the pollutants in combination is quite apparently of paramount importance rather than the individual pollutant. Study of the effects of pollutant mixtures on single plant type and vegetation has now become a major area of research. (Ormred, 1982; Kondo, 1984). Moving over to questions related to the animal kingdom and human health, the impact of air pollutants on them is well known (Dean, 1968; Stern, 1962). The pollutants affect the organisms directly and indirectly (Srivastava, 1989).

EXPERIMENTAL METHODOLOGY

Study area description:

Madurai city has grown on both sides of river Vaigai and its terrain is mostly flat. The ground rises from the city, towards outward, on all sides except the south, which is a gradually sloping terrain. It is surrounded on the outskirts by small and prominent hills. The city is about 100 meters above mean sea level and it is situated on $9^0$55' north latitude and $78^0$7' east longitude and the city is covering 51.96 sq.kms that comprises of a total population of 25,78,201 persons (Census 2011). Whereas the Madurai Urban agglomeration comprising the city and surrounding settlements accommodates a population of 12,03,095 persons. The climate of Madurai town is hot and dry and the temperature range between a maximum and minimum of 42^0C and 21^0C, respectively. April and May are the hottest months and rainfall is irregular and intermittent, with an average of approximately 85 cm per annum. The wind blows from northeast direction during January– February and from southwest direction during May to July. The phenomenal growth in population coupled with the growth of vehicles and increasing transport demand have created numerous transportation problems in the city, particularly deterioration of environmental quality, resulting in an increased air pollution and traffic noise (Sivacoumar, 2000).

Experimental procedure:

The experiment was conducted in pots under natural conditions. Mature ripe seeds of three plant species like Azhadirachta indica(L), Polyalthia longifolia(L) and Ficus religiosa(L) were collected. The seeds of all the three species were sown in medium sized clay pots with three parts fine sand and one part of natural manure. When the seedlings reached a suitable height, they were transferred to pots, 23.0 cm in diameter and 21.0 cm in depth and the five plants were planted in three replicates. One gram of cement dust was sprinkled regularly on the aerial parts of each plant twice a week, except the control and all the plants were watered daily with tap water.

Chlorophyll analysis:

Photosynthetic pigments:

Chlorophyll a and b impart the green color that one associate with plant leaves. Carotenoids, which are yellow pigments, are also present in leaves but are usually masked by the chlorophylls. It is only in the fall when the chlorophylls are degraded faster than the carotenoids that the yellow color becomes visible to us. The chlorophyll and carotenoid contents of plants can vary markedly with its age or depend on environmental factors such as light intensity or quality during growth. Carotenoids and chlorophylls are found in the chloroplasts and are associated with the thylakoids, the internal membrane network of these organelles. It is now established that all chlorophylls are organized as discrete chlorophyll-protein complexes within the lipid matrix of the photosynthetic membrane.

The majority of chlorophyll 'a' molecules (and all chlorophyll 'b' and carotenoid molecules) functions as antenna pigments. In combination with proteins, they form the light-harvesting complexes, which absorb and funnel light energy to the reaction center chlorophylls, thereby allowing the plant to utilize a broad spectrum of wavelengths for photosynthesis. Some of the chlorophyll 'a' molecules serve specialized functions in the reaction centers of photo systems I and II, where the light energy is used to drive the reduction of components of the electron transport chain.

Extraction of photosynthetic pigments:

Extract photosynthetic pigments by grinding 1g of leaves, torn into small pieces, in a mortar with a pinch of clean sand and a total of 10 ml of 100 per cent acetone. Initially, add only a small amount of acetone to begin the grinding process. It is much easier to grind the leaves if the extract is a pasty consistency. Add more solvent in small increments while continuing to grind the leaves. For some species may need to add more than the suggested 10ml of acetone. Pour the extract into a 15ml centrifuge tube and centrifuge in the bench top centrifuge for 3 to 5 min. Remove the extract to a 10ml graduated cylinder using a Pasteur pipette. Transfer an aliquot of the clear leaf extract (supernatant) with a pipette to a 1-cm-pathlength cuvette and take absorbance readings against a solvent blank in a UV-VIS spectrophotometer at four different wavelengths.

750 nm ($A750 = 0$ for clear extract)

662 nm (chlorophyll *a* maximum using 100 per cent acetone)

645 nm (chlorophyll *b* maximum using 100 per cent acetone)

470 nm (carotenoids).

Apply measured absorbance values to equations given by Lichtenthaler (1987) for acetone to determine pigment content (ìg/ml extract solution).Once the baseline has been run from 700-400nm using acetone in the cuvette, run an absorption spectrum for each pigment, rinsing the sample cuvette with acetone between readings. The peaks and valleys will be adjusted automatically by the spectrophotometer, by changing the range of percentage absorbance on the y-axis. We can use the cursor to obtain the wavelengths of the spectral peaks, or estimate them from the printed spectra. These peak wavelengths will be useful for determining the identities of the pigments associated with the spectra.The studies were conducted on *Azhadirachta indica*(L), *Polyalthia longifolia*(L) and *Ficus religiosa* (L) plants growing under natural conditions. The plant samples were analyzed at every 30-day of intervals. The concentrations of photosynthetic pigments like chlorophyll-a, chlorophyll-b and carotenoids (mg/g fresh weight) we obtained using the following formula given by Lichanthaler 1987.

Quantification of pigments (For 100% Acetone)

Chl-a (µg/ml) = $11.24\ A_{661.6} - 2.04\ A_{644.8}$

Chl-b (µg/ml) = $20.13\ A_{644.8} - 4.19\ A_{661.6}$

Carotenoids = $(1000\ A_{470} - 1.90\ C_a - 63.14\ C_b)/214$

Statistical analysis:

Data from the two selected sites for the plant materials were subjected to the two way analysis of variance (ANOVA). Using ANOVA the comparison made between control plant species and polluted plant species, significance difference was calculated at 0.05 per cent , 0.01 per cent and 0.001 per cent level as per standard method of Gomez and Gomez (1984).

The present investigation has been undertaken to study the effect of cement dust pollutant on total chlorophyll, carotenoids, chlorophyll 'a' and chlorophyll 'b' of selected plant species. In the present study, the pollution effects on the performance of selected plant species was observed and the total chlorophyll content decreased significantly in response to cement dust pollutants in polluted plant leaves compared with control of *Azhadirachta indica* (L), *Polyalthia longifolia*(L) and *Ficus religiosa* (L) which is shown in Table 1, 2 and 3 (Fig. 1, 2, 3 and 4).

Interpretation of chlorophyll and carotenoid content:

The concentration of Chl 'a' and 'b' in plant material can be quantified with different reference systems. Reference systems currently in use include mg Chl a+b/ m^2 leaf area (or µg/cm^2 leaf area), µg Chl a+b/g dry weight and mg Chl a+b/g fresh weight (less suitable than dry weight). The weight ratio of Chl 'a' and Chl 'b' (Chl a/b ratio) is an indicator of the functional pigment equipment and light adaptation of photosynthetic apparatus (Lichtenthaler *et al.*, 1981). Chl 'b' is found exclusively in the pigment antenna system, whereas chl 'a' is present in the reaction centers of photo systems I and II and in the pigment antenna, whereas the light-harvesting pigment protein LHC-I of the photosynthetic pigment system PS I has an a/b ratio of 3, that of LHC-II of PS II exhibits a/b ratio of 1.1 to 1.3. The level of LHC-II of PS II is variable and shows a light adaptation response. Thus a

Table 1 : Changes of chlorophyll content of *Azhadirachta indica* (L) at different time intervals exposed to cement dust pollution

Days	Parameters in (mg/g fresh weight)											
	Chloropyll 'a'			Chlorophyll 'b'			Total Carotenoids (x + c)			Total chlorophyll (a + b)		
	Control	Polluted	% of R	Control	Polluted	%of R	Control	Polluted	% of R	Control	Polluted	%of R
30	0.6028	0.4922	18.35	0.5423	0.3355	38.13	0.1220	0.0394	67.62	1.1452	0.8278	27.71
60	0.6832	0.5997	12.22	0.5662	0.3895	31.20	0.2572	0.1558	39.40	1.2495	0.9892	20.82
90	1.5529	0.9246	40.45	0.6963	0.5985	14.04	0.4096	0.1659	59.48	2.2492	1.5231	32.28
120	1.9849	1.8363	7.48	0.9163	0.6067	33.78	0.5510	0.2894	47.47	2.9012	2.4431	15.79
150	2.8908	1.8763	35.09	1.3715	1.2404	9.55	0.6603	0.6441	2.45	4.2623	3.1167	26.87
180	2.994	2.2784	23.90	1.7493	1.3009	25.63	1.0655	0.6832	35.88	4.7433	3.5793	24.53

% of R = Percentage of reduction

Table 2 : Changes in chlorophyll content of polyalthia longifolia(L) at different time intervals exposed to cement dust pollution

Days	Chloropyll 'a'			Chlorophyll 'b'			Total carotenoids (x + c)			Total chlorophyll (a + b)		
	Parameters in (mg/g fresh weight)											
	Control	Polluted	% of R	Control	Polluted	%of R	Control	Polluted	% of R	Control	Polluted	%of R
30	0.5021	0.4432	11.73	0.9345	0.6397	31.53	0.0839	-0.0540	164.41	1.4367	1.0829	24.62
60	0.9056	0.6084	32.81	1.0731	0.7249	32.44	0.1314	0.0503	63.31	1.9787	1.3333	32.61
90	0.9593	0.6115	36.25	1.3649	1.0339	24.24	0.1531	0.0729	52.38	2.3243	1.6455	29.20
120	1.5366	0.8120	47.15	1.4147	1.2006	15.13	0.2742	0.1757	35.90	2.9514	2.0127	31.80
150	1.6446	1.3517	17.80	1.8696	1.2112	35.21	0.5088	0.3520	30.81	3.5142	2.5629	27.06
180	2.8401	2.3214	18.26	1.9198	1.2850	33.06	0.8143	0.6508	20.08	.7599	3.6064	24.23

% of R = Percentage of reduction

Table 3 : Changes in chlorophyll content of Ficus religiosa(L) at different time intervals exposed to cement dust pollution

Days	Chloropyll 'a'			Chlorophyll 'b'			Total carotenoids (x + c)			Total chlorophyll (a + b)		
	Parameters in (mg/g fresh weight)											
	Control	Polluted	% of R	Control	Polluted	%of R	Control	Polluted	% of R	Control	Polluted	%of R
30	0.3943	0.3127	20.67	0.5615	0.3104	44.70	0.0934	0.0834	10.77	0.9558	0.6232	34.79
60	0.7799	0.4183	46.35	0.5687	0.4345	23.59	0.1070	0.0903	15.61	1.3487	0.8529	36.75
90	1.0263	0.4418	56.94	0.5969	0.4437	25.66	0.1368	0.1282	6.32	1.6233	0.8856	45.44
120	1.5605	0.5068	67.52	0.7993	0.5374	32.76	0.4810	0.1967	59.09	2.3598	1.0442	55.74
150	1.6312	1.0491	35.68	1.0991	0.7667	30.23	0.4834	0.2846	41.12	2.7304	1.8158	33.49
180	1.6829	1.1326	32.69	1.2299	0.7702	37.37	0.6243	0.3678	41.08	2.9128	1.9029	34.67

% of R = Percentage of reduction

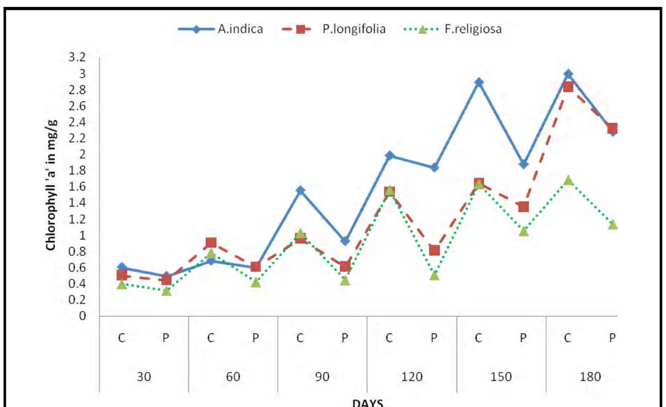

Fig. 1 : Content of chlorophyll 'a' of cement dusted and non-dusted of selected plant species at various Days duration

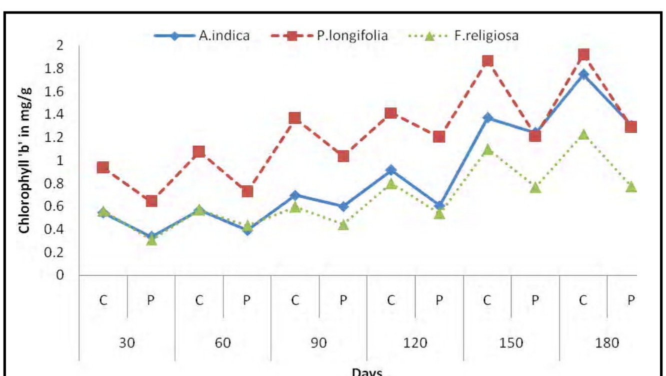

Fig. 2 : Content of chlorophyll 'b' of cement dusted and non-dusted of selected plant species at various days duration

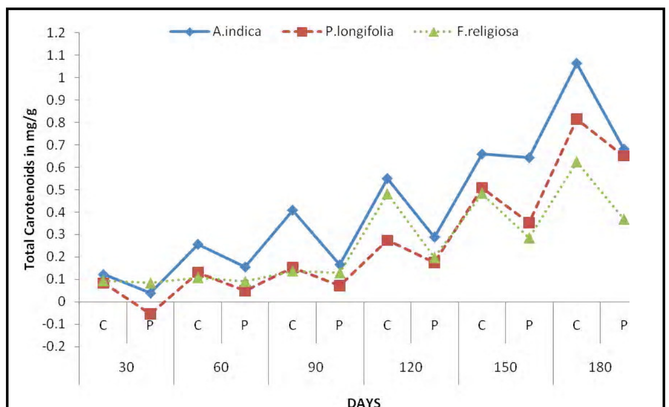

Fig. 3 : Content of total carotenoids of cement dusted and non-dusted of selected plant species at various days duration

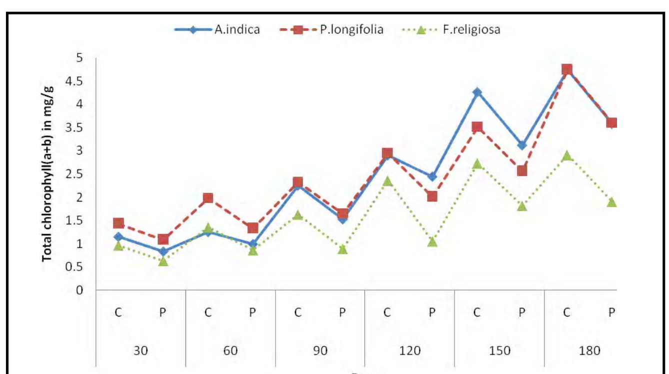

Fig. 4 : Content of total chlorophyll (a+b) of cement dusted and non-dusted selected Plant species at various days duration

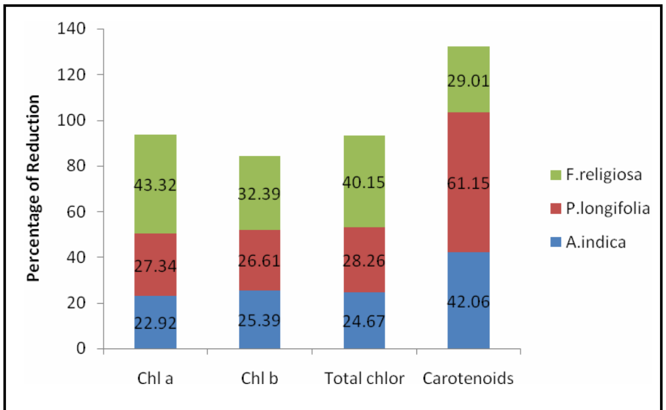

Fig. 5 : The Significant reduction of all the photosynthetic pigments in the selected plant species

decrease in the Chl a/b ratio may be interpreted as an enlargement of the antenna system of PS II.

The weight ratio of Chls 'a' and 'b' to total carotenoids (a+b)/(x+c) is an indicator of the greenness of plants. The ratio (a+b)/(x+c) normally lies between 4.2 and 5 in sun leaves and sun-exposed plants, and between 5.5 and 7 in shade leaves and shade-exposed plants. Lower values of the ratio (a+b)/(x+c) are an indicator of senescence, stress, and damage to the plant and photosynthetic apparatus, which is expressed by a faster breakdown of Chlorophylls than carotenoids. Leaves become more yellowish-green and exhibit values for (a+b)/(x+c) of 3.5, or even as low as 2.5 to 3.0 as senescence progresses. Also during chromoplost development in ripening fruits or fruit scales, which turn from green to yellow or orange or red, the ratio (a+b)/(x+c) decreases continuously and reaches values below 1.0.

EXPERIMENTAL FINDINGS AND ANALYSIS

Plants are very sensitive to atmospheric changes if closely monitored. Gaikwad *et al.*, 2006, conducted study on plant bio-indicators, and observed that they are very sensitive and affected by increased atmospheric pollution. The relatively reduction in Chl 'a', Chl 'b', total chlorophyll and total carotenoids for the selected species such as *Azhadirachta indica* (L.), *Polyalthia longifolia* (L.) and *Ficus religiosa* (L.) were related to cement dust pollution. The following observations were made.

Azhadirachta indica (L.):

Azhadirachta indica (L) showed the reduction in Chl 'a' for the exposure to cement dust pollution as 18.35 per cent , 12.22 per cent , 40.45 per cent , 7.48 per cent , 35.09 per cent and 23.90 per cent for 30, 60,90,120,150 and 180 days, respectively. After 90-days there was significant reduction in Chl 'a'. It shows that cement dust inhibited the photosynthetic factor. The pigment Chlorophyll 'b' for *Azhadirachta indica* (L.) showed the reduction as 38.13 per cent , 31.20 per cent , 14.04 per cent , 33.78 per cent , 9.55 per cent and 25.63 per cent for 30, 60, 90, 120, 150 and 180 days, respectively. It was observed that there was maximum reduction for Chl'b' after 30-days it and the variation of reduction in Chl 'b' varied between 60, 90, 120, 150 and 180 days. *Azhadirachta indica* (L.) showed the maximum reduction in total chlorophyll (Chl 'a'+Chl 'b') at 90-days. The reduction in the total chlorophyll for 30, 60, 90, 120, 150 and 180 days are 27.71 per cent , 20.82 per cent , 32.28 per cent , 15.79 per cent , 26.87 per cent and 24.53 per cent , respectively.

Total carotenoid for *Azhadirachta indica* (L.) showed the significant reduction after 30-days (67.62%). The significant reduction of the total carotenoid was observed in the polluted plant, that the reduction was varied from 2.45 per cent to 67.62 per cent . The variation was varied for the various days. The significant reduction in photosynthetic pigments of the *Azhadirachta indica* (L.) may be an indication of a reduction in photosynthesis of polluted plants which could be

Table 4 : Changes in the photosynthetic pigments of selected plant species due to cement dust pollution

Plant species	Chlorophyll A			Chlorophyll B			Total carotenoids			Total chlorophyll		
	Control	Polluted	% R	Control	Polluted	% R	Control	Polluted	% R	Control	Polluted	% R
A. indica (L.)	1.78 0.42	1.33* 0.31	22.92	0.97 0.20	0.75** .017	25.39	0.51 0.14	0.33* 0.11	42.06	2.76 0.62	2.08** 0.47	24.67
P. longifolia (L.)	1.40 0.34	1.02** 0.29	27.34	1.43 0.16	1.02** 0.11	26.61	0.33 0.12	0.21 0.10 NS	61.15	2.83 0.49	2.04** 0.38	28.26
F. religiosa (L.)	1.18 0.22	0.64** 0.14	43.32	0.81 0.12	0.54** 0.08	32.39	0.32 0.09	0.19 0.05 NS	29.01	1.99 0.32	1.19** 0.22	40.15

Significant at: $**p<0.01$, $*p<0.05$ and NS - non significant explained on the basis of quantitative as well as qualitative changes in the incident light available for photosynthesis in cement encrusted leaves (Bhone,1963), of interruption in gaseous through stomatal clogging (Darley *et al.*, 1966; Lerman, 1972), of reduction in transpiration in terms of the absorption of minerals from soil and inhibition of intracellular process (Singh and Rao, 1981).

The weight ratio of Chl 'a' and Chl 'b' indicates the functional characters of photosynthetic pigments. The ratio of Chl 'a' and Chl 'b' was found to be higher for the polluted environement exposed to the Azhadirachta indica(L) compared to the control species of Azhadirachta indica(L). Similarly, the weight ratio of Chl 'a' and Chl 'b' to total carotenoids indicates the stress experienced by the plant species. The ratio said to be decreasing from 30-days to 180-days drastically from 20.96 to 5.24 which is shown in the Table 5.

***Polyalthia longifolia* (L.):**

The adverse effect of cement dust pollution on the Polyalthia longifolia(L) resulted in about 11.73 per cent , 32.81 per cent , 36.25 per cent , 47.15 per cent , 17.80 and 18.26 per cent reduction in Chl 'a' for 30, 60, 90, 120, 150 and 180 days, respectively. There was marked reduction in Chl 'a' after 120 days. And also it was surprising to note that the percentage of reduction in Chl 'a' increased from 30 to 180 days. The Chl 'b' for *Polyalthia longifolia*(L.) which was exposed to the cement dust pollution showed the significant reduction of 31.53 per cent , 32.44 per cent , 24.24 per cent , 15.13 per cent , 35.21 per cent and 33.06 per cent for 30, 60, 90, 120, 150 and 180 days, respectively. It has been found that the cement dust pollution before the pollution 0.9345 (mg/g fw) to 0.6397 (mg/g fw) at the end of pollution. The total amount of total chlorophyll for *Polyalthia longifolia* (L.) showed the reduction between 30 to 180 days with the range of 1.0829 (mg/g fw) to 3.6064 (mg/g fw). The lowest value for the reduction of total chlorophyll was found for 30-days.

The amount of carotenoid pigment for the polluted species for 30, 60, 90,120,150 and 180 days are -0.0540 (mg/g fw), 0.0503 (mg/g fw), 0.0729 (mg/g fw), 0.1757 (mg/g fw), 0.3520 (mg/g fw) and 0.6508 (mg/g fw), respectively. The percentage of reduction of carotenoids varied from 30 to 180 days. The total photosynthetic pigments (Chl 'a'+ Chl 'b'+ carotenoid) were found to be minimum compared to the control plant species. The total photosynthetic pigments were dropped after 120-days extensively compared to the remaining days. The reduction in total pigments is mostly caused by Chl 'a' and Chl 'b' which have significant value and also the low carotenoid pigments. The ratio of Chl 'a' to Chl 'b' from the polluted plant species was very less compared to the control area species. The ratio was said to be between 0.5915 (mg/g fw) to 1.8065 (mg/g fw). The low ratio value indicates the plant species subjected to the dust pollution. The ratio of Chl 'a' and Chl 'b' to carotenoid showed the variation between 30-days to 180 days (Table 6). Cement dust had a significant negative effect on the photosynthetic pigments. This finding coincides with the

Table 5 : Variation of assimilating pigments in *Azhadirachta indica* (L.)

Days	(Chl-a + Chl-b + Carotenoid)			Chlorophyll a/b ratio			Chl (a + b)/Carotenoid		
	Control	Polluted	%of R	Control	Polluted	% of R	Control	Polluted	% of R
30	1.2673	0.8673	31.56	1.1115	1.4669	-31.97	9.3860	20.9576	-123.28
60	1.5067	1.1451	23.99	1.2066	1.5395	-27.58	4.8568	6.3461	-30.66
90	2.6588	1.6891	36.47	2.2301	1.5449	30.72	5.4910	9.1786	-67.15
120	3.4522	2.7325	20.84	2.1662	3.0263	-39.70	5.2652	8.4415	-60.32
150	4.9226	3.7609	23.60	2.1077	1.5126	28.23	6.4548	4.8389	25.03
180	5.8088	4.2625	26.62	1.7115	1.7513	-2.32	4.4514	5.2390	-17.69

Table 6 : Variation of assimilating pigments in *Polyalthia longifolia* (L.)

Days	(Chl-a+ Chl-b + Carotenoid)			Chlorophyll (a/b) ratio			Chl (a + b)/Carotenoid		
	Control	Polluted	%ofR	Control	Polluted	% of R	Control	Polluted	% of R
30	1.5206	1.0288	32.33	0.5373	0.6928	-28.94	17.1162	-20.0297	217.02
60	2.1159	1.3836	34.60	0.8439	0.8393	0.548	14.4318	26.5052	-83.65
90	2.4774	1.7184	30.63	0.7028	0.5914	15.85	15.1785	22.5680	-48.68
120	3.2256	2.1885	32.15	1.0861	0.6763	37.73	10.7616	11.4506	-6.40
150	4.0231	2.9150	27.54	0.8796	1.1160	-26.87	6.9060	7.2799	-5.41
180	5.5743	4.2573	23.62	1.4793	1.8065	-22.11	5.8449	5.5412	5.19

Table 7 : Variation of assimilating pigments in *Ficus religiosa* (L)

Days	(Chl-a+Chl-b+Carotenoid)			Chlorophyll a/b ratio			Chl (a + b)/Carotenoid		
	Control	Polluted	% of R	Control	Polluted	% of R	Control	Polluted	% of R
30	1.0493	0.7066	32.65	0.7021	1.0073	-43.46	10.2253	7.4725	26.92
60	1.4557	0.9433	35.20	1.3712	0.9627	29.79	12.6025	9.4448	25.05
90	1.7602	1.0138	42.40	1.7192	0.9957	42.08	11.8598	6.9070	41.76
120	2.8408	1.2410	56.31	1.9523	0.9431	51.69	4.9060	5.3078	-8.19
150	3.2139	2.1005	34.64	1.4841	1.3681	7.813	5.6472	6.3794	-12.96
180	3.5372	2.2707	35.80	1.3682	1.4704	-7.462	4.6656	5.1736	-10.88

results of the earlier studies made (Rauk, 1995). The rather large dust load and its long-term effect have brought about alkalization of the growth environment. This complicates mineral nutrition and misbalances the content of micro- and macro elements in the organisms. Changes in the primary metabolism and mineral nutrition of trees are accompanied by changes in secondary metabolism and growth processes (Mandre, 1995c).

Ficus religiosa (L.):

The biochemical indicator such as Chl 'a' of *Ficus religiosa*(L.) at all the study period such as 30, 60, 90, 120, 150 and 180 days varied significantly ($p< 0.01$). Maximum reduction in Chl'a' was observed at 120 days(67.52%) while at 30, 60, 90, 150 and 180 days, loss of 20.67 per cent , 46.35 per cent , 56.94 per cent , 35.68 per cent and 32.69 per cent , respectively was observed. At all the study period Chl'b' showed significant reduction. Maximum loss of 44.70 per cent was exhibited at 30-days followed by 23.59 per cent , 25.66 per cent , 32.76 per cent , 30.23 per cent and 37.37 per cent for 60, 90, 120, 150 and 180 days, respectively. Ficus religiosa(L) showed the decreasing trend of total chlorophyll at all the study period as compared to control values. 120-days dusted plant species dust exhibited maximum reduction (55.74%) in total chlorophyll followed by 30, 60 and 90 days, respectively. Maximum decrease (59.09%) was observed at 120-days of total carotenoid. All the study period showed significant reduction in carotenoid ($p<0.01$). The reduction of total carotenoid varied from 6.32 per cent to 59.09 per cent for 30 to 180-days.

The total photosynthetic pigment such as Chl'a', Chl'b' and total carotenoid for the polluted plant species was very much less compared to the control area. The reduction of total photosynthetic pigments for *Ficus religiosa* (L.) which was exposed to the cement dust was found to be 32.65 per cent , 35.20 per cent , 42.40 per cent , 56.31 per cent , 34.64 per cent and 35.80 per cent for 30, 60, 90, 120, 150 and 180 days, respectively. The ratio of Chl'a' to Chl'b' was found to be minimum compared to the control species. After 120-days, the ratio of Chl'a' and Chl'b' was found to be below 0.95 (mg/gfw). The ratio of Chl'a' and Chl'b' to carotenoid was found to be 7.47(mg/g), 9.44(mg/g), 6.91(mg/g), 5.31(mg/g), 6.38(mg/g) and 5.17(mg/g) compared to the control species 10.23(mg/g) 12.60(mg/g), 11.86(mg/g), 4.91(mg/g), 5.65(mg/g) and 4.67(mg/g), respectively for 30, 60, 90, 120, 150 and 180 days, respectively (Table 7). The observed variation in photosynthetic pigment was contributed due to the air pollutant and sensitivity of the plant.

Conclusion:

The cement dust had a significant effect on the photosynthetic pigments such as Chl'a',Chl'b' and total carotenoid. Plant response varies between plant species of a given genus and between varities within a given species. Plants do not necessarily showed similar susceptibility to different pollutants. Major variations in response to different species to air pollutants have been documented by Jacobson and Hill (1970). Studies of biochemical changes and pollution effects on the plant metabolism, that is, reduction in chlorophyll and completely clogged stomates (Ahmed and Qadir, 1975) reveals that these parameters are important in regulating the productivity and also the number of flowers and seeds produced. Although all the species showed significant reduction in the photosynthetic pigments, the extent up to which the plant species were affected varied from species to species and days to days. Almost all the species showed maximum variation in photosynthetic pigments. *Ficus religiosa*(L.) was found to be significantly affect was found to be significantly affected in Chl'a'(43.32%) reduction, Chl'b' (32.39%) reduction and total chlorophyll (40.15%) reduction followed by *Polyalthia longifolia* (L.) 27.34 per cent , 26.61 per cent and 28.26 per cent and *Azhadirachta indica* (L.) are 22.92 per cent ,25.39 per cent and 24.67 per cent (Table 4 and Fig. 5) The results presented in the paper shows that cement dust pollution significantly reduced the photosynthetic pigments of *Ficus religiosa* (L.) compared to other two species. It is also clear that *Ficus religiosa*(L.) is very sensitive species compared to the other two species.

It is concluded that the presence of toxic pollutants in cement dust might be responsible for the reduction in plant species pigments. Traces of toxic metals such as Chromium and Copper are common in some varieties of Portland cement and are harmful to human beings and other living systems (Omar and Jasim, 1990). Cement dust pollution imparts more stress on the plant species. Bio-monitoring of the plants is an important tool to evaluate the impact of cement dust pollutants on pollution.

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REFERENCES

1. **Ahmed, Z.** and Qadir, S.A. (1975). The effects of air pollution on stomatal clogging. Carbohydrate and chlorophyll contents in certain roadside plants. *Pakistan J. Bot.,* **7**: 81-84.
2. **Beckett, K.P.,** Freer-Smith, P.H. and Taylor, G. (1998). Urban woodlands: Their role in reducing the effects of particulate pollution. *Environ. Pollution,* **99**: 347-360.
3. **Bliefert, C.** and Perraud R. (2001), Climate de I' environment air, eau, sols, dechets. De Boeck Diffusion, Paris, 359-365.
4. **Bohne, H.** (1963). Schadichkeit von Staub aus Zementwerken fur waldbestande. *Allg. Forstz,* **18**: 107-111.
5. **Buschmann, C.** and Nagel, E. (1993). *In vivo* spectroscopy and internal optics of leaves as basis for remote sensing of vegetation. *Internat. J. Remote Sens,* **14**: 711–722.
6. *Crop Sci.,* **35**: 1400–1405.
7. **Curran, P.J.**, Dungan, J.L. and Gholz, H.L. (1990). Exploring the relationship between reflectance red edge and chlorophyll content in slash pine. *Tree Physiol.,* **7**: 33–48.
8. **Darley, G.D.E.F.,** Drugger, W.M., Mudd, J.B., Ordin, L., Taylor, O.C. and Steph, E.R. (1966). Plant damage by pollution derived from automobiles. *Arch. Environ. Health,* **6**(4): 700-761.
9. **Dean, G.** (1968). Air pollution and health. *Royal Soc.Hlth. J.,* **68** : 31-38.
10. **Escobedo, F.J.,** Wagner, J.E. and Newyork, D.J. (2008). Analyzing the cost effectiveness of Santiago, Chiles policy of using urban fores to improve air quality. *J. Environ. Mangament,* **86**: 148-157.
11. **Filella, I.,** Serrano, I., Serra, J. and Peñuelas, J. (1995). Evaluating wheat nitrogen status with canopy reflectance indices and discriminate analysis.
12. **Gaikwad, U.S.,** Ranade, C.D. and Gadgil, G.M. (2006). Plants as bio indicators of automobile exhaust pollution a case study of Sangli city. *J. Instrumentation Eng.*, **86**: 26-28.
13. **Gamon, J.A.** and Surfus, J.S. (1999). Assessing leaf pigment content and activity with a reflectometer. New Phytol 143: 105–117 Moran JA, Mitchell AK, Goodmanson G, Stockburger KA (2000) Differentiation among effects of nitrogen fertilization treatments on conifer seedlings by foliar reflectance: a comparison of methods. *Tree Physiol.*, **20**: 1113–1120.
14. **Gitelson, A.A.** and Merzlyak, M.N. (1994 a). Quantitative estimation of chlorophyll *a* using reflectance spectra: Experiments with autumn chestnut and maple leaves. *J. Photochem. Photobiol.,* (B) **22**: 247–252.
15. **Gitelson, A.A.** and Merzlyak, M.N. (1994 b). Spectral reflectance changes associated with autumn senescence of *Aesculus hippocastanum* and *Acer platanoides* leaves. Spectral features and relation to chlorophyll estimation. *J. Plant Physiol.,* **143** : 286–292.
16. **Gitelson, A.A.**, Merzlyak, M.N. and Chivkunova, O.B. (2001). Optical properties and non-destructive estimation of anthocyanin content in plant leaves. *Photochem. Photobiol.,* **74**: 38–45.
17. **Gitelson, A.A.**, Zur, Y., Chivkunova, O.B. and Merzlyak, M.N. (2002) Assessing carotenoid content in plant leaves with reflectance spectroscopy. *Photochem. Photobiol.,* **75**: 272–281.
18. **Gomez, K.A.** and Gomez, A.A. (1984). *Statistical procedures for agricultural research* (2nd Ed.. New York: John Wiley and Sons.
19. **Grantz, D.A.**, Garner, J.H.B. and Johnson, D.W. (2003). Ecological effects of particulate matter. *Environ. Int.,* **29** : 213-239.
20. **Hendry, G.A.F.**, Houghton, J.D. and Brown, S.B. (1987). The degradation of chlorophyll – biological enigma. *New Phytol.,* **107**: 255–302
21. **Hove, L.W.**, Bossen, M.E. and Bok, F.A.M. (1999). The uptake of O_3 by poplar leave: the impact of a long term exposure to low O_3 concentration. *Atmospheric Environemtnt,* **33**: 907-917.
22. **Jacobson, JS.** and Hill, A.C. (1970). Recognition of Air Pollution injury to Vegetations: A Pictorial Atlas. Air Pollution Control Association Pittsburgh. Pennsyvania.
23. **Kondo, J**. (1984). Studies on effects of air pollutant mixture on plants. Res.rep. Nat.Inst. Environ. Studies. Japan 66.
24. **Kumar, R.** and Soodan, A.S. (2006). A biodiversity approach to check *Parthenium hysterophorous*(L). *J. Environ. Biol.,* **27**(2), 349-353.
25. **Laj, P.** and Sellegri, K. (2003). Les aerosols atmosphericques: impacts locaux, effects globaux. *Revue francaise des Laboratories*, **349** : 23-34.

26. **Lalman** and Singh, B. (1990). Phytotoxic influence of SO_2 pollution on leaf growth of Vigina mungo L. *J. Environmental Biology,* **11**(2): 111-120.

27. **Lerman, S.** (1972). Cement Kiln dust and the bean plant (Phaseolus vulgaris L. Black valentine var): In-depth investigation into plant morphology, physiology and pathology. Ph.D Thesis, University of California, Reverside.

28. **Lichtenthaler, H.K.** (1987). Chlorophyll and carotenoids: Pigments of photosynthetic biomembranes. *Meth Enzym.,* **148**: 331–382

29. **Lichtenthaler, H.K.,** Buschemann, C., Doll, M., Fietz, H.-J., Bach, T., Kozel, U., Meier, D., and Rahmsdorf, U. (1981). Photosynthetic activity, chloroplast ultrastructure, and leaf characteristics of high-light and low-light plants and of sun and shade leaves. *Photosynthesis Res.,* **2**:115-141.

30. **Mandre, M**. (1995c). Changes in the nutrient composition of trees. In Dust Pollution and Forest Ecosystems. A Study of Conifers in an Alkalized Environment (Mandre, M., ed), pp. 44-65. *Publ. Inst. Ecol.,* **3**. Tallinn.

31. **Markwell, J.,** Osterman, J.C. and Mitchell, J.L. (1995). Calibration of the Minolta SPAD-502 leaf chlorophyll meter. *Photosynth Res.,* **46** : 467–472

32. **McPherson, E.G.,** Nowak, D.J. and Rowntree, R.E. (1994). Chicago's urban forest climate project USDA General Technical Rep; NE-186. USDA, Washington DC.

33. **Merzlyak, M.N.** and Gitelson, A.A. (1995). Why and what for the leaves are yellow in autumn? On the interpretation of optical spectra of senescing leaves (*Acer platanoides* L.). *J. Plant Physiol.,* **145** : 315–320

34. **Omar, J.M.** and Jasim, F. (1990). Some observations on the use of electrothermal atomic absorption spectrophotometry for the determination of Chromium and Copper in portland cement. *Micro Chem. J.,* **41**(3): 348-355.

35. **Ormred, D.P**. (1982). Air pollutant interaction in mixtures effect of gaseous air pollution in agriculture and horticulture. (Eds: M.H. unsworth and D.P. Ormred). Butterworth, London. pp. 307-331.

36. **Prajapati, S.K.** and Tripathi, B.D. (2008). Seasonal variation of leaf dust accumulation and pigment content in plant species exposed to urban particulates pollution. *J. Environ. Quality*, **37**: 865-870.

37. **Rauk, J.** (1995). Radial increment of trees. In Dust Pollution and Forest Ecosystems. A Study of Conifers in an Alkalized Environement (Mandre, M., ed.), pp. 112-116. *Publ. Inst. Ecol.,* **3**. Tallinn.

38. **Singh, S.N.** and Rao, R.N. (1981). Certain responses of wheat plants to cement dust pollution. *Environ. Pollut.,* **24**(1): 75-81.

39. **Smith, W.H.** (1971). Lead contamination of road side white pine. *Forest Sci.,* **17**: 195-198.

40. **Srivastava, Y.N.** (1989). *Environmental pollution*, Ashish Publishin House, New Delhi 101-104 (1989).

41. **Stern, A.C.** (1962). *Air pollution*. Vol 1. Academic Press, pp. 95-98 N.Y.

42. **Tripathi, B.D**. and Dwivedi, A.K. (2002). Atmospheric pollution and its outcome-An analysis. *The Botanica*, **52** : 88-92.

43. **URL**: http//www.madurai maps of india.

44. **Wagh, N.D.,** Shukla, P.V., Tambe, S.B., Ingle, S.T. (2006). Biological monitoring of roadside plants exposed to vehicular pollution in Jalgaon city. *J.Environ.Biol..*, **27**(2): 419-421.

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