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Pigment profile and chlorophyll degradation of selected road side plant species

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ABSTRACT

Urban air pollution is rapidly becoming an environmental problem of public concern worldwide. It can influence public health and local/regional weather and climate. Photosynthetic pigments in plants were shown to be very sensitive to various environmental influences. Changes in chlorophylls and carotenoid content were investigated in the selected plant species on the road side area. Pigments were extracted by the absolute acetone and quantified spectrophotometrically. All the measured pigments were reduced in polluted site compared to control. This was due to deceleration of biosynthetic process rather than degradation of pigments. The percentage of reduction in chlorophyll 'a' was maximum at the polluted sites in *Ficus religiosa* L. (34.71%) and minimum in *Pongamia pinnata* L. (22.42%) from 15- days to 75- days interval in comparison with control. The most sensitive pigments of chlorophyll 'b' was reduced at maximum percentage at the polluted sites in *Delonex regia* L. (37.72%) and minimum in *Azhadirachta indica* L. (20.42%) compared to control in the study period. There was a maximum and minimum percentage of reduction in total carotenoid in *Ficus religiosa* L. and *Polyalthiya longifolia* L. are 35.68 per cent and 14.14 per cent, respectively at various days. Total carotenoids needed a longer period of time to reach nearly the same level as in control. The concentration of total chlorophyll in the selected plant species at the polluted sites were maximum reduction in *Delonex regia* L. 34.46 per cent and minimum in *Pongamia pinnata* (20.86%) compared to control in the study period. It might thus be concluded that the *Azhadirachta indica* L. and *Pongamia pinnata* L. had sufficient biosynthetic capacity to prevent irreversible damage by the air pollution. Chlorophyll degradation measurements were intended as a parameter of air pollution experiment. From the result, it was found that chlorophyll degradation was highest in all the plant species after exposure to air pollutant for 30-days.

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Key Words : Air pollution, Assimilating pigments, Carotenoids, Chlorophyll degradation, Pigment profile, Photosynthetic pigments, Total chlorophyll

INTRODUCTION

The use of plants as monitors of air pollution has long been established as plants are the initial acceptors of air pollution. They act as the scavengers for many air borne particulates in the atmosphere. Demand of rapid modes of transportation has increase many folds during the last few decades because of the continuous rise in the human population. This in turn has led a tremendous increase in the number of different types of vehicles, which now has become a major source of air pollution throughout the world. Motor vehicles account for 70 per cent of the pollution found in an urban environment (Singh *et al.*, 1995; Dwivedi *et al.,* 2008). The combustion of fuel in engines of motor gives rise to sulphur dioxide, nitrogen oxides and carbon monoxide as well as suspended particulate matter. These pollutants when absorbed by the leaves because a reduction in the concentration of photosynthetic pigments *viz.,* chlorophyll and carotenoids which directly affect to the plant productivity. Chlorophyll is the principal photoreceptor in photosynthesis, the light-driven process in which carbon dioxide is fixed to yield carbohydrates and oxygen. Carotenoids are a class of natural fat-soluble pigments found principally in plants, algae and photosynthetic bacteria, where they play a critical role in the photosynthetic process (Ong and Tee, 1992; Britton, 1995) and also protect chlorophyll from photoxidative destruction (Siefemann-Harms, 1987). According to a study by Dwivedi and Tripathi (2007), the distribution of plant diversity is highly dependent on presence of air pollutants in the ambient air and sensitivity of the plants. During the last few decades' increased human interference, urbanization and heavy vehicular activity in Madurai city has resulted the changes air quality. Air pollution can directly affect plants via leaves or indirectly via soil acidification. It has also been reported that when exposed to air pollutants, most plant experience physiological changes before exhibiting visual damage to leaves (Dohmen *et al*., 1990). Air pollution has become

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a major threat to the survival of plants in the industrial areas (Gupta and Mishra, 1994). A number of paramenters are used to estimate the effect of air pollution on plants (Ronen and Galun, 1984). Chlorophyll contents and chlorophyll degradation are parameters commonly used to assess the impact of air pollution on plants. The aim of this study was to investigate damage to chlorophyll in selected plant species in relation to different levels of air pollution at selected monitoring site.

RESEARCH METHODOLOGY

Study area description:

Madurai city has grown on both sides of river Vaigai and its terrain is mostly flat. 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 30,41,038 persons (Census 2011). 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 studies were conducted on *Azhadirachta indica* L., *Pongamia pinnata* L., *Delonex regia* L., *Polyalthia longifolia* L. and *Ficus religiosa* L. plants growing under natural conditions. The plant samples were collected from 20-150 cm height from the ground in the roadside of the study area and control site of the selected plant species and analyzed at every 15-days of interval. Leaves were carefully removed from the bark, using a snapper blade and washed with water to remove the dust on the surface of the leaf samples. About 1g of leaves, torn into small pieces in a mortar grounded with a pinch of quartz sand and a total of 10 ml of absolute acetone. Initially, only a small amount of acetone to begin the grinding process was added. It is much easier to grind the leaves if the extract is a pasty consistency. Added 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. Poured the extract into a 15ml centrifuge tube and centrifuged in the bench top centrifuged at 5000 rpm for 3 to 5 min. Removed the extract to a 10ml graduated cylinder using a Pasteur pipette. Transferred an aliquot of the clear leaf extract (supernatant) with a pipette to a 1-cm-pathlength cuvette and taken absorbance readings against a solvent blank in a UV-VIS spectrophotometer at 662,645,435,415,470 nm wavelength.

The concentrations of photosynthetic pigments like chlorophyll-a, chlorophyll-b and carotenoids (mg/g fresh weight) were obtained by using the following formula given by Lichanthaler (1987). The ratio of absorbance 435nm to 415nm are the parameter for chlorophyll degradation in the experiment (Ronen and Galun, 1984).

Quantification of pigments (For 100% acetone)

Chlorophyll 'a' = $11.24\ A_{661.6} - 2.04\ A_{644.8}$

Chlorophyll 'b' = $20.13\ A_{644.8} - 4.19\ A_{661.6}$

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

Chlorophyll degradation = OD 435/OD 415 (OD= Optical Density)

Statistical analysis:

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

The present investigation has been undertaken to study the effect of atmospheric pollutant on total chlorophyll, chlorophyll degradation, total 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 pigment content decreased significantly in response to automobile exhaust pollutants in polluted plant leaves compared with control plant leaves of *Azhadirachta indica* L., *Pongamia pinnata* L., *Delonex regia* L., *Polyalthia longifolia* L. and *Ficus religiosa* L. which is shown in Table 1, 2, 3, 4 and 5.

RESEARCH FINDINGS AND ANALYSIS

The results obtained with polluted and control sites of selected plant species such as *Azhadirachta indica* L., *Pongamia pinnata* L., *Delonex regia* L., *Polyalthia longifolia* L. and *Ficus religiosa* L. were compared (Table 1 to 5). In general, plants showed a decrease in photosynthetic pigments due to atmospheric pollution. All the selected plant species showed the significant reduction ($p<0.01$ and $p<0.05$) in pigment content in the study period which were related to air pollution (Table 6). Results observed that the concentration of photosynthetic pigments is affected by the traffic load and chlorophyll content may vary in all the selected plant species during the sampling period depending on their habitat, climatic condition and pollution level. It may vary depending on the air quality of that area. The vehicular emissions had a profound impact on the concentration of different photosynthetic pigments. The shading effects due to deposition of suspended particulate matter on the leaf surface might be responsible for this decrease in the concentration of chlorophyll in polluted area. It might clog the stomata thus interfering with the gaseous exchange, which leads to increase in leaf temperature which may consequently retard chlorophyll synthesis (Mark, 1963; Singh and Rao, 1981). The reason for degradation of chlorophyll pigments can also be attributed to action of SO_2 and NO_2 on the metabolism of chlorophyll (Lauenorth and Dodd, 1981), both of these gases are the constituents of vehicular emissions.

The present study revealed a decrease in photosynthetic pigments in all the selected plant species, growing at sites with heavy vehicular traffic area as compared to control area where vehicular traffic was low. This showed clearly the effect of vehicular exhaust on the roadside vegetation in the city. Significant reduction in chlorophyll and carotenoid content at traffic area was recorded in all plant species (Table 6, Fig. 1, 2 3 and 4). *Delonex regia* L. showed much reduction in total chlorophyll content as compared to control. Chlorophyll measurement is an important tool to evaluate the effect of air pollutants on plants. Chlorophyll plays an important

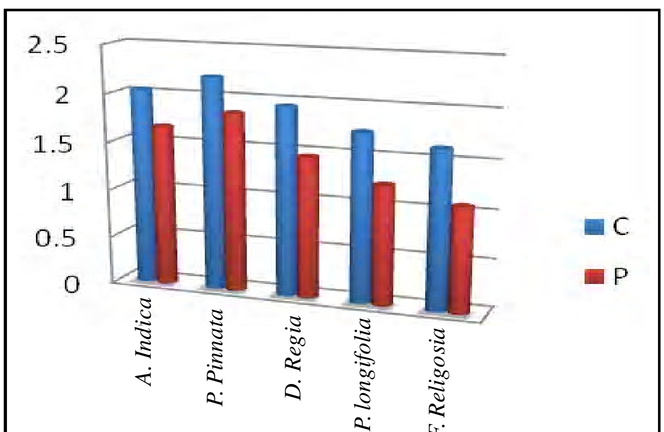

Fig. 1 : Changes in chlorophyll 'a' of selected plant species at control and polluted sites

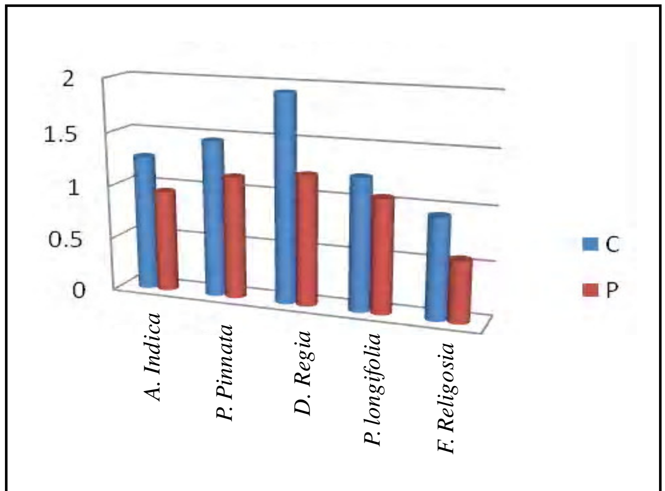

Fig. 2 : Changes in chlorophyll 'b' of selected plant species at control and polluted sites

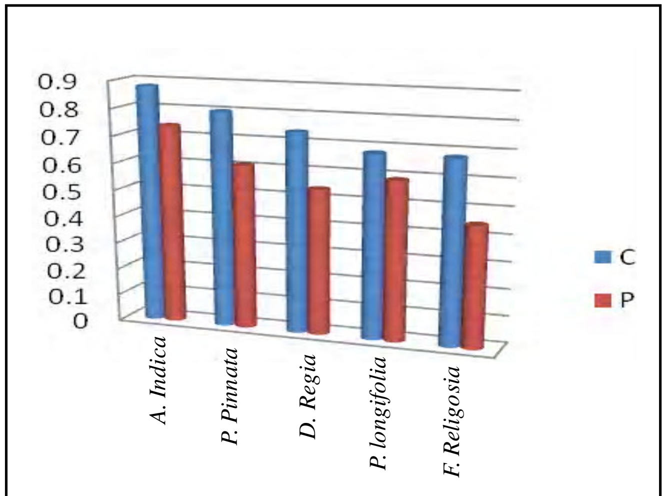

Fig. 3 : Changes in total carotenoids of selected plant species at control and polluted sites

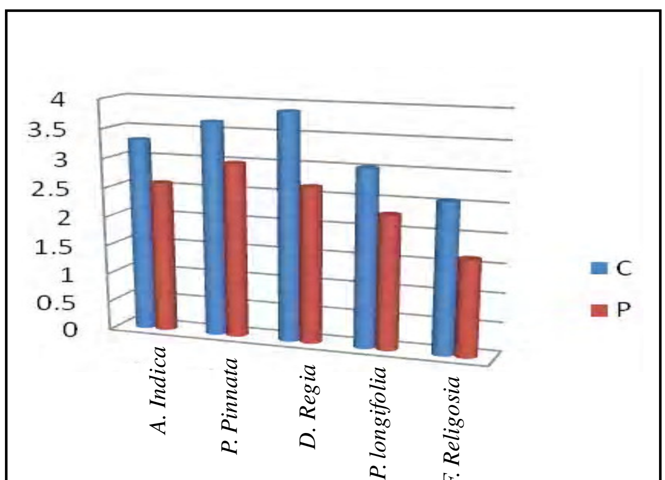

Fig. 4 : Changes in total chlorophyll of selected plant species at control and polluted sites

role in plant metabolism. The reduction in chlorophyll concentration corresponds directly to the reduction in plant growth and chlorophyll degradation measurements were intended as a parameter of air pollution experiment. The present study suggests that plants have the potential to serve as excellent quantitative and qualitative indices of pollution level. Present study with all the selected plant species showed reduction in the concentration of chlorophyll at heavy traffic area. The rapid urbanization imparts more stress on the vehicular use, which release toxic air pollutants in the urban atmosphere in the developing countries. Monitoring of air pollution, bio-monitoring of plants is an important tool to evaluate the impact air pollution on plants.

Chlorophyll degradation:

From the result it was found that chlorophyll degradation was highest in polluted area than control which received clean air, no traffic and other smoke producing activities were also absent. It means that if there is less chlorophyll degradation, the amount of chlorophyll content will be more. However, the lowest degree of chlorophyll degradation was observed at control sites while the highest were observed at polluted sites.

The amount of chlorophyll degradation was recorded in *Azhadirachta indica* L. at polluted sites varied from 1.06mg g^{-1} to 1.19 mg g^{-1} in comparison with control site (1.05 mg g^{-1} to 1.13 mg g^{-1}) from 15 days to 75 days interval (Table 1). There was maximum degradation in *Azhadirachta indica* L. was 1.19mg g^{-1} at 30 days interval. The average amount of chlorophyll degradation was observed in *Azhadirachta indica* L. was 1.0845 mg g^{-1} in control site and in polluted site 1.0978 mg g^{-1} in the study period. This is due to *Azhadirachta indica* L. has greater pollution retaining capacity the lower amount of chlorophyll degradation was monitored at polluted sites during the study period.

In *Pongamia pinnata* L. the average amount of chlorophyll degradation was observed in control site and polluted site were 1.0812 mg g^{-1} and 1.1435 mg g^{-1}, respectively (Table 2). The amount of chlorophyll degradation increased drastically from 1.06 mg g^{-1} to 1.35 mg g^{-1} in polluted sites at various days. There was maximum chlorophyll degradation in *Pongamia pinnata* L. leaf samples at polluted site (1.35 mg g^{-1}) due to heavy traffic load compared to control. It indicates *Pongamia pinnata* L. suffered by automobile exhaust pollution.

The average concentration of chlorophyll degradation in control site and polluted site in *Delonex regia* L. were 1.09 mg g^{-1} and 1.1849 mg g^{-1}, respectively at various days (Table 3). The highest concentration of pigment degradation in *Delonex regia* L. at polluted site was 1.34 mg g^{-1} at 30-days. This is due to less concentration of chlorophyll 'a' in *Delonex regia* L. at polluted site on that days. The chlorophyll degradation was minimum in control site of *Polyalthia longifolia* L. (1.1036 mg g^{-1}) compared to polluted site (1.1168 mg g^{-1}).The average amount of chlorophyll degradation in *Ficus religiosa* L. was recorded 1.068 mg g^{-1} in control compared to polluted (1.1698 mg g^{-1}) (Table 4 and 5).

Photosynthetic pigment analysis:

Azhadirachta indica L.:

Azhadirachta indica(L) showed the reduction in chlorophyll 'a' for the exposure to air pollution as 36.48 per cent, 54.69 per cent , 22.65 per cent, 6.92per cent and 1.58 per cent for 15,30,45,60 and 75 days, respectively (Table 1). After 30-days there was significant reduction in chlorophyll 'a'. It showed that air pollutants inhibited the photosynthetic factor. The pigment chlorophyll 'b' for *Azhadirachta indica* L. showed the reduction as 4.36%, 11.21 per cent , 41.86 per cent , 17.05 per cent and 27.62 per cent for 15,30,45,60 and 75 days, respectively. It was observed that there was maximum reduction for chlorophyll 'b' after 45-days interval. Total carotenoid for *Azhadirachta indica* L. showed the significant reduction after 15-days (48.24%). The significant reduction of the total carotenoid was observed in the polluted plant, that the reduction varied from 4.54 per cent to 48.24 per cent . 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 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 stomata 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 concentration of chlorophyll 'a' content in the leaves of *Azhadirachta indica* L. at polluted sites was recorded as 1.64±0.49 mg g^{-1} which was 2.05±0.39 mg g^{-1} at the control site. Thus a reduction of 26.11 per cent in chlorophyll 'a' content was recorded in the samples from the polluted sites in comparison to control. The concentration of chlorophyll 'b' content was 0.95±0.24 mg g^{-1} in the leaf samples collected from polluted sites while it was 1.27±0.36 mg g^{-1} in the samples from control site. The polluted sites sample thus had 20.42 per cent less chlorophyll 'b' content. Total chlorophyll content was 2.59±0.72 mg g^{-1} and 3.31±0.73 mg g^{-1} in the leaf samples collected from polluted and control site, respectively. Thus there was a reduction of 24.94 per cent in the concentration of total chlorophyll content in the samples from polluted site. The concentration of total carotenoid in the leaf samples from polluted and control site was recorded as 0.74±0.19 mg g^{-1} and 0.88±0.17 mg g^{-1}, respectively with a reduction of 21.53 per cent in leaf samples from polluted sites.

Pongamia pinnata L.:

The concentration of chlorophyll 'a' content in the leaves of *Pongamia pinnata* L. at polluted sites was recorded as 1.85±0.53 mg g^{-1} which was 2.2±0.48 mg g^{-1} at the control site (Table 6). Thus a reduction of 22.42 per cent in chlorophyll content was recorded in the samples from the polluted sites in comparison to control. The concentration of chlorophyll 'b' was 1.14±0.27 mg g^{-1} in the leaf samples collected from polluted sites while it was 1.46±0.3 mg g^{-1} in the samples from control site. The polluted sites sample thus had 21.20 per cent less chlorophyll 'b' content. Total chlorophyll content was 2.99±0.78 mg g^{-1} and 3.66±0.76 mg g^{-1} in the leaf samples collected from polluted and control site, respectively. Thus there was a reduction of 20.86 per cent in the concentration of total chlorophyll content in the samples from polluted site. The concentration of total carotenoid in the leaf samples from polluted and control site was recorded as 0.61±0.18 mg g^{-1} and 0.8±0.18 mg g^{-1}, respectively with a reduction of 28.84 per cent in leaf samples from polluted sites.

Delonex regia L.:

Variations in physiological characteristics of selected plant species exposed to automobile pollutants are given in Table 6. The concentration of chlorophyll 'a' content in the leaves of *Delonex regia* L. at polluted sites was recorded as 1.46±0.57 mg g^{-1} which was 1.96±0.48 mg g^{-1} at the control site. Thus, a reduction of 33.37 per cent in chlorophyll 'a' content was recorded in the samples from the polluted sites in comparison to control. The concentration of chlorophyll 'b' content was 1.21±0.38 mg g^{-1} in the leaf samples collected from polluted sites while it was 1.93±0.42 mg g^{-1} in the samples from control site. The polluted sites sample thus had 37.72 per cent less chlorophyll 'b' content. Total chlorophyll content was 2.67±0.87 mg g^{-1} and 3.88±0.8 mg g^{-1} in the leaf samples collected from polluted and control site, respectively. There was a reduction of 34.46 per cent in the concentration of total chlorophyll content in the samples from polluted site. The concentration of total carotenoid in the leaf samples from polluted and control site was recorded as 0.55±0.23 mg g^{-1} and 0.75±0.25 mg g^{-1}, respectively with a reduction of 31.56 per cent in leaf samples from polluted sites.

Polyalthia longifolia (L.):

The adverse effect of vehicular pollution on the *Polyalthia longifolia* L. resulted in about 42.53 per cent, 32.47 per cent, 43.26 per cent, 24.79 per cent and 20.38 per cent, reduction in chlorophyll 'a' for 15,30,45,60 and 75 days, respectively (Table 4). There was marked reduction in chlorophyll 'a' after 75 days. The chlorophyll 'b' for *Polyalthia longifolia*(L.) which was exposed to the air pollution showed the significant reduction of 41.03 per cent, 11.26 per cent, 2.27 per cent, 44.24 per cent and 7.87 per cent for 15, 30, 45, 60 and 75 days, respectively. The total amount of total chlorophyll for *Polyalthia longifolia* L. showed the reduction between 15 to 75 days with the range of 0.8717 mg g^{-1} to 2.2874 mg g^{-1}. The lowest value for the reduction of total chlorophyll was found for 75-days.

The concentration of chlorophyll 'a' content in the leaves of *Polyalthia longifolia* L. at polluted sites was recorded as 1.23±0.35 mg g^{-1} which was 1.74±0.4 mg g^{-1} at the control site. Thus a reduction of 32.68 per cent in chlorophyll 'a' content was recorded in the samples from the polluted sites in comparison to control. The concentration of chlorophyl 'b' content was 1.06±0.23 mg g^{-1} in the leaf samples collected from polluted sites while it was 1.29±0.18 mg g^{-1} in the samples from control site. The polluted sites sample thus had 21.33 per cent less chlorophyll 'b' content. Total chlorophyll content was 2.29±0.45 mg g^{-1} and 3.03±0.5 mg g^{-1} in the leaf samples collected from polluted and control site, respectively. Thus, there was a reduction of 26.29 per cent in the concentration of total chlorophyll content in the samples from polluted site. The concentration of total carotenoids in the leaf samples from polluted and control site was recorded as 0.59±0.14 mg g^{-1} and 0.68±0.16 mg g^{-1}, respectively with a reduction of 14.14 per cent in leaf samples from polluted sites.

Ficus religiosa (L.):

The concentration of chlorophyll 'a' content in the leaves of *Ficus religiosa* L. at polluted sites was recorded as 1.074±0.23 mg g^{-1} which was 1.63±0.31 mg g^{-1} at the control site. Thus a reduction of 34.71 per cent in chlorophyll 'a' content was recorded in the samples from the polluted sites in comparison to control. The concentration of chlorophyll 'b' content was 0.57±0.05 mg g^{-1} in the leaf samples collected from polluted sites while it was 0.93±0.15 mg g^{-1} in the samples from control

Table 1 : Changes in the pigment content of *Azhadirachta indica* (L) at different time intervals exposed to air pollution

Days	Chloropyll 'a'			Chlorophyll 'b'			Total carotenoids (x c)			Total chlorophyll (a b)			Chlorophyll degradation		
	Parameters in (mg/g fresh weight)														
	Control	Polluted	% of R	Control	Polluted	%ofR	Control	Polluted	% of R	Control	Polluted	%ofR	Control	Polluted	% of R
15	0.9636	0.6121	36.48	0.6097	0.5831	4.36	0.2983	0.1544	48.24	1.5733	1.1952	24.03	1.0608	1.0899	2.74
30	1.5529	0.7036	54.69	0.6377	0.5662	11.21	0.7116	0.5652	20.58	2.1906	1.2698	42.03	1.1333	1.1853	4.59
45	1.9849	1.5353	22.65	1.3715	0.7974	41.86	1.0241	0.7689	24.92	3.3564	2.1689	35.38	1.0565	1.0753	1.78
60	2.4983	2.3254	6.92	1.1239	0.9323	17.05	1.0390	0.9417	9.36	3.6222	3.2577	10.06	1.0845	1.0858	0.11
75	3.2262	3.1753	1.58	2.6024	1.8835	27.62	1.3499	1.2887	4.54	5.8286	5.0588	13.21	1.0584	1.0822	2.24
Avg	2.0452	1.6376	26.11	1.2690	0.9525	20.42	0.8846	0.7438	21.53	3.3142	2.5900	24.94	1.0845	1.0978	1.21

% of R Percentage of reduction, Avg. Average

Table 2 : Changes in the pigment content of *Pongamia pinnata* (L) at different time intervals exposed to air pollution

Days	Chloropyll 'a'			Chlorophyll 'b'			Total carotenoids (x c)			Total chlorophyll (a b)			Chlorophyll degradation		
	Parameters in (mg/g fresh weight)														
	Control	Polluted	% of R	Control	Polluted	%ofR	Control	Polluted	% of R	Control	Polluted	%ofR	Control	Polluted	% of R
15	0.5863	0.3504	40.24	0.7061	0.6576	6.87	0.2250	0.1449	35.59	1.2924	1.008	22.01	1.0564	1.0572	0.07
30	1.7339	0.8455	51.24	1.2665	0.5622	55.61	0.6378	0.2571	59.68	3.0004	1.4077	53.08	1.0753	1.3525	25.77
45	2.3967	2.391	0.24	1.0095	0.9427	6.62	0.8542	0.7891	7.62	3.4062	3.3337	2.13	1.0974	1.1024	0.45
60	3.083	2.4828	19.47	2.1162	1.5795	25.36	1.0912	0.7233	33.71	5.1992	4.0623	21.87	1.0813	1.1092	2.58
75	3.2097	3.1793	0.95	2.201	1.9466	11.56	1.2393	1.1450	7.61	5.4107	5.1259	5.26	1.0954	1.0963	0.08
Avg	2.2019	1.8498	22.42	1.4598	1.1377	21.20	0.8095	0.6119	28.84	3.6617	2.9875	20.87	1.0812	1.1435	5.79

% of R Percentage of reduction, Avg. Average

Table 3 : Changes in the pigment content of *Delonex regia* (L.) at different time intervals exposed to air pollution

Days	Chloropyll 'a'			Chlorophyll 'b'			Total carotenoids (x + c)			Total chlorophyll (a + b)			Chlorophyll degradation		
	Parameters in (mg/g fresh weight)														
	Control	Polluted	% of R	Control	Polluted	%of R	Control	Polluted	% of R	Control	Polluted	%of R	Control	Polluted	% of R
15	0.7382	0.5268	28.64	0.9913	0.6049	38.98	0.3079	0.1169	62.02	1.7294	1.1317	34.56	1.1009	1.2341	12.10
30	1.2763	0.1279	89.98	1.9591	0.4243	78.34	0.2367	0.2091	11.65	3.2354	0.5522	82.93	1.0829	1.3436	24.07
45	2.1503	2.1345	0.73	0.9775	0.7643	21.81	0.8954	0.8942	0.13	3.1278	2.8988	7.32	1.0591	1.0894	2.86
60	2.0012	1.2466	37.70	3.0174	2.0234	32.94	0.6709	0.2435	63.69	5.0186	3.27	34.84	1.0939	1.1253	2.87
75	3.6232	3.2682	9.80	2.6842	2.2404	16.53	1.6340	1.3026	20.28	6.3074	5.5086	12.66	1.0936	1.1322	3.53
Avg	1.9578	1.4608	33.37	1.9259	1.2114	37.12	0.7490	0.5533	31.55	3.8837	2.6722	34.46	1.0861	1.1849	9.09

% of R = Percentage of reduction, Avg. = Average

Table 4 : Changes in the pigment content of *Polyalthia longifolia* (L.) at different time intervals exposed to air pollution

Days	Chloropyll 'a'			Chlorophyll 'b'			Total carotenoids (x + c)			Total chlorophyll (a + b)			Chlorophyll degradation		
	Parameters in (mg/g fresh weight)														
	Control	Polluted	% of R	Control	Polluted	%of R	Control	Polluted	% of R	Control	Polluted	%of R	Control	Polluted	% of R
15	0.8911	0.5121	42.53	0.6098	0.3596	41.03	0.3340	0.2463	26.26	1.5009	0.8717	41.92	1.2289	1.2324	0.28
30	0.9056	0.6115	32.47	1.3649	1.2112	11.26	0.4199	0.4104	2.27	2.2705	1.8227	19.72	1.1145	1.1545	0.83
45	1.5789	0.8959	43.26	1.7147	1.6758	2.27	0.5407	0.4556	15.72	3.2936	2.5717	21.92	1.0131	1.0325	1.91
60	2.4659	1.8545	24.79	1.3483	0.7518	44.24	0.9474	0.9050	4.47	3.8142	2.6063	31.67	1.0738	1.0758	0.19
75	2.8401	2.2613	20.38	1.4147	1.3033	7.87	1.2127	0.9464	21.96	4.2548	3.5646	16.22	1.0575	1.0888	2.96
Avg	1.7363	1.2270	32.69	1.2905	1.0603	21.33	0.6825	0.5927	14.14	3.0268	2.2874	26.29	1.1036	1.1168	1.23

% of R = Percentage of reduction, Avg. = Average

Table 5 : Changes in the pigment content of *Ficus religiosa* (L) at different time intervals exposed to air pollution

Days	Chloropyll 'a'			Chlorophyll 'b'			Total carotenoids (x + c)			Total chlorophyll (a + b)			Chlorophyll degradation		
	Parameters in (mg/g fresh weight)														
	Control	Polluted	% of R	Control	Polluted	%ofR	Control	Polluted	% of R	Control	Polluted	%ofR	Control	Polluted	% of R
15	0.9413	0.4183	55.56	0.7667	0.743	3.09	0.4721	0.1753	62.85	1.708	1.1613	32.00	1.0084	1.1364	12.69
30	1.1348	0.7799	31.27	1.2299	0.4635	62.31	0.4755	0.3025	36.38	2.3647	1.2434	47.41	1.0802	1.2545	16.13
45	1.7455	0.997	42.88	0.5378	0.4633	13.85	0.5079	0.3692	27.32	2.2833	1.4603	36.04	1.0995	1.2472	13.43
60	1.6312	1.5605	4.33	0.7993	0.5687	28.85	0.7816	0.7125	8.84	2.4305	2.1292	12.40	1.0808	1.1248	4.07
75	2.6978	1.6313	39.53	1.3572	0.6342	53.27	1.1963	0.6816	43.02	4.055	2.2655	44.13	1.0706	1.0862	1.46
Avg	1.6301	1.0774	34.72	0.9381	0.5745	32.27	0.6867	0.4482	35.68	2.5683	1.6519	34.40	1.0679	1.1698	9.55

% of R = Percentage of reduction, Avg. = Average

Table 6 : Changes in the photosynthetic pigments of selected plant species due to air pollution

Plant species	Chlorophyll 'a'			Chlorophyll 'b'			Total Cartenoids (x + c)			Total chlorophyll (a + b)		
	Parameters in (mg/g fresh weight)											
	Control	polluted	% R	Control	Polluted	% R	Control	polluted	% R	Control	Polluted	% R
Azhadirachta indica(L.)	2.05 ± .039	1.64 ns ± 0.49	26.11	1.277 ± 0.36	0.95** ± .024	20.42	0.88 ± 0.17	0.74* ± 0.19	21.53	3.31 ± 0.73	2.59** ± 0.72	24.94
Pongamia pinnata(L.)	2.2 ± 0.48	1.85** ± 0.53	22.42	1.46 ± 0.3	1.14** ± 0.27	21.20	0.8 ± 0.18	0.61* ± 0.18	28.84	3.66 ± 0.76	2.99** ± 0.78	20.86
Delonex regia(L.)	1.96 ± 0.48	1.46** ± 0.57	33.37	1.93 ± 0.42	1.21* ± 0.38	37.72	0.74 ± 0.25	0.54ns ± 0.23	31.56	3.88 ± 0.8	2.67* ± 0.87	34.46
Polyalthia longifolia(L.)	1.74 ± 0.4	1.23** ± 0.35	32.68	1.29 ± 0.18	1.060** ± 0.23	21.33	0.68 ± 0.16	0.59 ns ± 0.14	14.14	3.03 ± 0.5	2.29** ± 0.45	26.29
Ficus religiosa (L.)	1.63 ± 0.31	1.07** ± 0.23	34.71	0.93 ± 0.15	0.57** ± 0.05	32.27	0.68 ± 0.13	0.45 * ± 0.11	35.68	2.57 ± 0.39	1.65* ± 0.23	34.39

* and ** indicate significance of values at P < 0.05 and 0.01, respectively and NS = Non significant

site. The polluted sites sample thus had 32.27 per cent less chlorophyll 'b' content. Total chlorophyll content was 1.65.±0.23 mg g^{-1} and 2.57±0.39 mg g^{-1} in the leaf samples collected from polluted and control site, respectively. Thus, there was a reduction of 34.39 per cent in the concentration of total chlorophyll content in the samples from polluted site. The concentration of total carotenoids in the leaf samples from polluted and control site was recorded as 0.45±0.11 mg g^{-1} and 0.68±0.13 mg g^{-1}, respectively with a reduction of 35.68 per cent in leaf samples from polluted sites.

In the present study the highest decrease in chlorophyll 'a' was in *Delonex regia* L. (89.98%) in 30-days followed by *Ficus religiosa* L. (55.56%) in 15-days, *Azhadirachta indica* L. in 30-days (54.69%), *Pongamia pinnata* L. (51.24%) in 30-days and *Polyalthia longifolia* L. in 45-days (43.26%). The highest reduction of chlorophyll 'b' was in *Delonex regia* L. (78.34%) in 30-days followed by *Ficus religiosa* L. (62.31%) in 30-days, *Pongamia pinnata* L. (55.61%) in 30-days, *Polyalthia longifolia* L. (44.24%) in 60-days and *Azhadirachta indica* L. (41.86%) in 45-days. The maximum percentage of reduction in total carotenoid was in *Delonex regia* (L.) (63.69%) in 60-days and minimum percentage of reduction was in *Polyalthia longifolia* L. (26.26%) in 15- days. There was highest reduction of total chlorophyll content in *Delonex religia* L. (82.93%) in 30-days followed by *Pongamia pinnata*, *Ficus religiosa, Azhadirachta indica* and *Polyalthia longifolia* were 53.08 per cent, 47.41 per cent, 42.03 per cent and 41.92 per cent, respectively at various days.

The plant species were affected by lot of smoke, dust and dirt from heavy traffic exposure. Since, the plants were analyzed consequently for 15,30,45,60 and 75 days. It had received heavy traffic pollutant and may be due to domestic garbage were thrown in road side. The area became polluted after a period of time; chlorophyll degradation was the highest at the polluted site and lowest in the residential area. Residential area is undisturbed habitat, which received clean air, no traffic and other smoke producing activities are present. If there is less chlorophyll degradation, the amount of chlorophyll content will be more. In the present study, the chlorophyll degradation was found maximum at the polluted site due to total chlorophyll was decreased maximum by the air pollutant of automobile exhaust. The amount of chlorophyll 'a', chlorophyll 'b', total chlorophyll and total carotenoid were inversely proportional to the SO_2 concentration. It is a baseline records for carrying out future studies related with the ambient air in the area. Chlorophyll degradation was measured as a parameter of air pollution experiment.

Conclusion:

The study reveals that evaluation of anticipated performance of plants might be very useful in the selection of appropriate tree species for urban green belts in the area. Sensitive species are early indicators of pollution and the tolerant species help in reducing the overall pollution load. The results of this study indicated a decline in chlorophyll content in trees growing in industrial area. The reduction in chlorophyll content is due to degradation of chlorophyll into phaeophytin by the loss of magnesium ions. Chlorophyll content may differ in different period of time under different conditions of pollution stress and different meteorological conditions. Thus it is concluded that in the study area there is need to develop green belt for the betterment of environment and human being and also will provide a baseline data for further impact assessment program related on ambient air quality in the area.

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