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Effect of Air Pollution on Chlorophyll Content of Leaves

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ABSTRACT

In the present investigation, comparative studies have been done, to find the effect of air pollutants generated from the exhaust of industries and automobiles on the chrorophyll content of leaves. The leaves samples of *Azadirachta indica, Nerium oleander, Mangifera indica* and *Dalbergia sissoo* were collected from areas with potentially higher and lower levels of air pollution Photosynthetic pigments chlorophyll a, chlorophyll b and carotenoids were quantified. A reduction in the photosynthetic pigments of plant leaves growing in higher polluted site as compared to non or less polluted ones.

Key words : Chlorophyll, Carotenoids, Air Pollution, Quantification, Photosynthetic Pigments.

INTRODUCTION

Industrialization, urbanization, economic growth and associated increase in energy demands have resulted in a profound deterioration of air quality in developing countries like India. Oxides of nitrogen and sulphur and fly-ash constitute as the major proportions for the gaseous and particulate emissions from industries and automobile. The exposure of these pollutants to the leaves cause a reduction in the concentration of their photosynthetic pigments viz., chlorophyll and carotenoids, which affects the plant productivity, germination of seeds, length of pedicles, and number of flowers inflorescence[1]. Chlorophyll is the principal photoreceptor in photosynthesis, the light-driven process by which carbon dioxide is "fixed" to yield carbohydrates and oxygen. While carotenoid is a class of natural fat-soluble pigment found principally in plants, algae and photosynthetic bacteria, where they play a critical role in the photosynthetic process[2] and also protect chlorophyll from photoxidative destruction[3]. When plants are exposed to the environmental pollution above the normal physiologically acceptable range, photosynthesis gets inactivated[4]. Since, the plants leaf samples used for this experiment were constantly exposed to air pollutants (polluted area- industrial area, automobile area & less polluted area – jungle, they had absorbed[5], accumulated and integrated pollutants on their surface and showed specific response. Hence, plants can be used as bioindicators in various field of research[6].

Bhopal City of Lakes is an important tourist centre and industrially developing city. It is densely populated and has heavy vehicular traffic. Air pollution has increased tremendously that is affecting the proper growth of plants in its vicinity. The rapid addition of toxic substances to environment is responsible for altering the ecosystem[7]. Plants growing in heavy trafficular area are thus exposed to variety of pollutants such as SMP, RSMP, No_X, & So_2 etc.

MATERIALS AND METHODS

Present investigation deals with comparative study of under heavy trafficular pollution with those growing in less or unpolluted

areas. For this purpose leaf samples of *Azadirachta indica* (Neem)*, Nerium oleander*(Kaner), *Mangifera indica*(Mango) and *Dalbergia sissoo* (Sheeshame) were collected from highly polluted and less or unpolluted area.

Study Area and Sample Collection

Four sites were selected for polluted area as well as for less or non polluted area from Bhopal City district and capital of Madhya Pradesh, situated at 23° 152 03 N, 77° 252 03 E in India. For polluted area samples were collected from Mandideep and Govindpura as industrial area and DIG Banglow (situated near Union Carbide India limited pesticide plant responsible for Bhopal Gas Tragedy), Chetak Bridge as highly traffic area. For non polluted or less polluted area we selected Kaliasot Jungle, VIP Road, Indian Institute of Soil Science & Barkatullah University.

Determination of Chlorophyll Content

50 mg of fresh leaf tissue was weighed accurately; Chlorophyll was extracted by crushing leaf and suspended in test tubes containing 10 ml of dimethyl sulphoxide (DMSO). Test tubes were incubated at 60° C – 65° C for 4 hour in a hot air oven. The supernatant was decanted and the chlorophyll extract was transferred to a cuvette and the absorbance was read in a spectrophotometer at 645 and 663 nm against DMSO blank[8] Chlorophyll a, b, total chlorophyll and chlorophyll a/b ratio were calculated by using formulae given by[9].

RESULTS AND DISCUSSION

Photosynthetic pigment Changes

Variations in physiological characteristics of selected plant species exposed to cement dust pollutants are given in Table 1, 2,3 and 4 (Fig. 1). The results obtained with polluted and non polluted *Azadirachta indica, Nerium oleander, Mangifera indica* and *Dalbergia sissoo* were compared. In general, plants showed a decrease in photosynthetic pigments due to air pollution. *Azadirachta indica, Nerium oleander, Mangifera indica* and *Dalbergia sissoo* showed a significant reduction in total chlorophyll content, chlorophyll 'a' and chlorophyll 'b' in the study period. But there is no significant change in total carotenoids of the selected plant species.

Table 1: Concentration of Different Photosynthetic Pigments (mg g-1) in the Leaves of *Azadirachta Indica* Collected from Polluted and Control Sites

Parameter	P	NP	%R
Chlorophyll a	0.49	1.65	70.30
Chlorophyll b	0.28	0.60	53.78
Total chlorophyll	1.04	2.19	52.40
Caretenoid	0.36	0.56	35.71

Where P= Polluted area, NP= non Polluted area and %R= percent reduction

Table 2: Concentration of Different Photosynthetic Pigments (mg g-1) in the Leaves of *Mangifera Indica* Collected from Polluted and Control Sites

Parameter	P	NP	%R
Chlorophyll a	1.87	2.37	21.14
Chlorophyll b	0.20	0.62	67.48
Total chlorophyll	2.02	2.75	26.55
Caretenoid	0.19	0.32	40.63

Table 3: Concentration of Different Photosynthetic Pigments mg g-1) in the Leaves of *Nerium Oleander* Collected from Polluted and Control Sites

Parameter	P	NP	%R
Chlorophyll a	1.00	2.02	50.37
Chlorophyll b	0.36	0.47	24.51
Total chlorophyll	1.25	2.14	41.71
Caretenoid	0.31	0.49	37.11

Table 4: Concentration of Different Photosynthetic Pigments mg g-1) in the Leaves of *Dalbergia Sissoo* Collected from Polluted and Control Sites

Parameter	P	NP	%R
Chlorophyll a	1.74	2.71	35.98
Chlorophyll b	0.59	0.79	24.66
Total chlorophyll	2.25	3.64	38.32
Caretenoid	0.78	1.22	36.48

Azadirachta indica

The concentration of Chl 'a' in the leaves of *Azadirachta indica* at polluted sites was recorded as 0.49±0.09 mg/g which was 1.65±0.27 mg/g at the control site. Thus a reduction of 70.3% in Chlorophyll 'a' was recorded in the samples from the polluted sites in comparison to control. The concentration of Chl 'b' was 0.28±0.10 mg/g in the leaf samples collected from polluted sites while it was 0.69±0.09 mg/g in the samples from control site. The polluted sites sample thus had 53.78% less Chl 'b' content. Total chlorophyll content was 1.04±0.05 mg/g and 2.19±0.05 in the leaf samples collected from polluted and control site respectively. Thus, there was a reduction of 52.4% in the 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 0.36±0.06 mg/g and 0.56±0.16 mg/g respectively with a reduction of 35.71% in leaf samples from polluted sites.

Mangifera indica

The concentration of Chl 'a' in the leaves of *Mangifera indica* at polluted sites was recorded as 1.87±0.35 mg/g which was 2.37±0.42 mg/g at the control site. Thus a reduction of 21.14% in Chlorophyll 'a' was recorded in the samples from the polluted sites in comparison to control. The concentration of Chl 'b' was 0.20±0.04 mg/g in the leaf samples collected from polluted sites while it was 0.62±0.14 mg/g in the samples from control site. The polluted sites sample thus had 67.48% less Chl 'b' content. Total chlorophyll content was 2.02±0.46 mg/g and 2.75±0.65 in the leaf samples collected from polluted and control site respectively. Thus, there was a reduction of 26.55% in the 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 0.19±0.09 mg/g and 0.32±0.12 mg/g respectively with a reduction of 40.63% in leaf samples from polluted sites.

Nerium oleander

The concentration of Chl 'a' in the leaves of *Nerium oleander* at polluted sites was recorded as 1.00±0.35 mg/g which was 2.02±0.32 mg/g at the control site. Thus a reduction of 50.37% in Chlorophyll 'a' content was recorded in the samples from the polluted sites in comparison to control. The concentration of Chl 'was 0.36±0.14 mg/g in the leaf samples collected from polluted sites while it was 0.47±0.24 mg/g in the samples from control

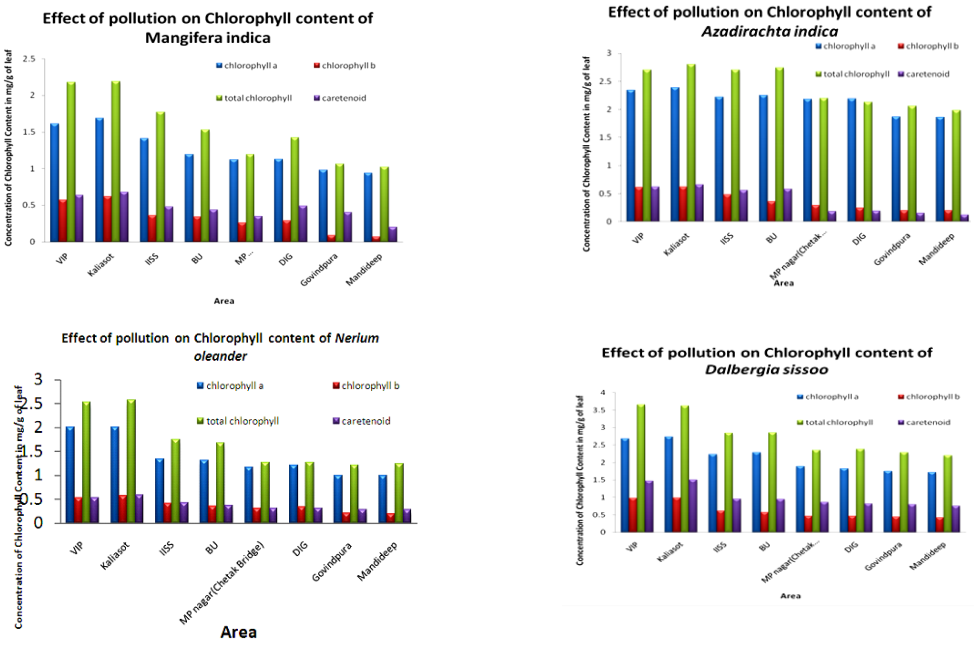

Fig. 1: Concentration of Chlorophyll Content Collected from Polluted or less Polluted area

site. The polluted sites sample thus had 24.51% less Chl 'b' content. Total chlorophyll content was 1.25±0.46 mg/g and 2.14±0.35 in the leaf samples collected from polluted and control site respectively. Thus, there was a reduction of 41.71% in the 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 0.31±0.08 mg/g and 0.49±0.11 mg/g respectively with a reduction of 37.11% in leaf samples from polluted sites.

Dalbergia sissoo

The concentration of Chl 'a' in the leaves of *Dalbergia sissoo* at polluted sites was recorded as 1.74±0.35 mg/g which was 2.71±0.42 mg/g at the control site. Thus a reduction of 35.98% in chl 'a' content was recorded in the samples from the polluted sites in comparison to control. The concentration of Chl 'b' was 0.59±0.14 mg/g in the leaf samples collected from polluted sites while it was 0.79±0.24 mg/g in the samples from control site. The polluted sites sample thus had 24.66% less Chl 'b' content. Total chlorophyll content was 2.25±0.46 mg/g and 3.64±0.65 in the leaf samples collected from polluted and control site respectively. Thus, there was a reduction of 38.32% in the 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 0.78±0.08 mg/g and 1.22±0.11 mg/g respectively with a reduction of 36.48% in leaf samples from polluted sites.

Air pollutants, fly ash and dust emissions have a profound impact on the concentration of different photosynthetic pigments. Polluted and dusted leaf surface is responsible for reduced photosynthetic and thereby causing reduction in chlorophyll content[10]. The similar impact of air pollutants in the concentration of chlorophyll contents have been reported by a number of other works[11-17]. In the present study the highest decrease in total chlorophyllwas in *Azadirachta indica* (52.40%) followed by *Nerium oleander* (41.71%) *Delbergia sissoo* (38.32%) and *Mangifera indica* (26.55%). The two way ANOVA showed that the reduction in chlorophyll content of *Azadirachta indica Nerium oleander Delbergia sissoo* and *Mangifera indica* were significant at 0.05% level.

Total average amount of assimilating pigments

Total average amount of assimilating pigments (a+b+c) in the control plant leaves of *Azadirachta indica* was maximum reduction (53.27%) compared with *Mangifera indica* (43.08%) *Nerium oleander* (37.33%) and *Delbergia sissoo* (31.48%). The chlorophyll a + b, carotenodic pigments, (a +b/c) ratio had extremely low values compared to the control because of significant drop of both types of chlorophyll as well as the increase of carotenoidic pigments. It indicates the plant species are under stress and also had damage due to pollution.

The photosynthetic pigments are the most likely to be damaged by air pollution. Chlorophyll pigments exist in highly organized state, and under stress they may undergo several photochemical reactions such as oxidation, reduction, pheophytinisation and reversible bleaching[18]. Hence any alteration in chlorophyll concentration may change the morphological, physiological and biochemical behaviour of the plant. Air pollution-induced degradation in photosynthetic pigments was also observed by a number of workers[19-21]. In both the plants chlorophyll a and chlorophyll b content were reduced significantly at polluted site.

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. On the basis of this study, it could be concluded that growth of plants was found to be affected by cement dust, which might be due to the presence of different toxic pollutants in cement dust. The phonological behavior of *Azadirachta indica* was found to be highly affected than *Mangifera indica, Nerium oleander* and *Delbergia sissoo* . It is clear that the air pollution caused by industries and automobile smoke are operative ecological factor causing deterioration in the quality of our environment[22]. From the correlated interpretation

of the obtained data, one can conclude that, beside particular manifestations of interactions between atmospheric pollutants (gas and solid) and vegetations, there is a common series of manifestations, as a general response to the stress caused by pollutants aggressions, regardless of their chemical nature. Under the influence of solid and gas polluting agents the average photosynthetic pigment amount drops, the values being most often correlated to the pollutants. Further investigations are necessary, in order to study the variation of these pigments in the control leaves along all vegetative season and to anticipate more accurately the possible 'answers' that the vegetation might have when subjected to a chronic aggression from atmospheric polluting agents.

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