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ORIGINAL ARTICLE **OPEN ACCESS**

A Study on Seasonal Variation in Chlorophyll Content of Different Plant species aroundStone Crusher Industrial Area of Bharatkoop, Chitrakoot (UP)

Anjani Gupta
Department of Energy and Environment, Faculty of Science and Environment, Mahatma GandhiChitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Satna, Madhya Pradesh, India

ABSTRACT
The present study reveals the hazardous conditions of vegetation at Bharatkoop town due to air pollution of stone crusher industries. In this study monitoring of ambient air quality of this town is done during summer, rainy season and winter which include measurement of PM_{10}, $PM_{2.5}$, SO_2, NO_2 and CO as well as photosynthetic pigments (chlorophyll content) of some selected plant species around the industrial area of Bharatkoop town. Selected plant species are of common occurrence namely, Azadirachta indica, Butea monosperma, Dalbergia sissoo andFicus benghelensis. Value of PM_{10} and $PM_{2.5}$ are found very high level from NAAQS limit that causes maximum deposition of stone crusher dust on leaves of different plants in winter followedby summer and rainy season and inhibit the process of photosynthesis.
Keywords: *Air pollution, PM_{10}, $PM_{2.5}$, Photosynthetic pigment, NAAQS*

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INTRODUCTION

Air pollution has a diverse effect on much metabolic process in plants such as photosynthetic activities, mitochondrial respiration and stomatal clogging of plants [1]. Industries are emitting toxic substances which adversely affect man‟s food supply by polluting nearby growing plants. Rapid industrialization and addition of the toxic substances to the environment are responsible for altering the ecosystem [2, 3]. The reduction inchlorophyll content due to degradation of chlorophyll into phaeophytin by the loss of magnesium ions [4]. The suspended particulate matter (SPM), depending on the size and weight of particles, remain in the air for varying length of time. Those larger than 10 μm in size settle under forces of gravity on surfaces of vegetations and soil but the smaller ones remain suspended in air for longer periods of time, get dispersed and diffused by the wind, and eventually deposited on various surfaces including foliar ones [5]**.** Suspended particulate matter, sulphur oxide (SOx), nitrogen oxide (NOx) and CO pollution cause a risk for human health [6-7] and exposure of these pollutants also affect vegetation growth due to adsorption of above pollutants on leaf, which prevented the process of respiration and photosynthesis [8]. Atmospheric particulate matter is a mixture of diverse elements. Fine particulate matter is of great concern including dust and smoke as they are respirable, resulting in detrimental effect on human health and vegetation. Dust may affect photosynthesis, respiration, transpiration and allow the penetration of phytotoxic gaseous pollutants [9-11]. Content of chlorophyll varies in different seasons under different conditions of pollution stress and different meteorological conditions [12]**.** Stone crushing Industry is an important industrial sector in the country engaged in producing crushed stone of various sizes depending upon the requirement which acts as raw material for various construction activities such as construction ofroads, highways, bridges, buildings, canals etc. It is estimated that there are over 12,000 stone crusher units in India. These stone crushers though socio-economically are important sectors yet give rise to substantial quantity of fine fugitive dust emissions which create health hazards to the workers as well as surrounding population by way of causing respiratory diseases [13]. Stone dust is a primary aerosol and it is released directly from the source. It has a detrimental effect on people and environment including flora and fauna, for example, changed soil pH and productivity, formation of haze reducing visibility in the surrounding areas, destruction of habitat, damage of natural resources like valuable vegetations and wild lives, promotion of spreading of many diseases etc. [14-16]**.** The dust emitted from stone crushers contains high percentage of respirable particulate matter having silica causing serious health problems [17]**.**

MATERIAL AND METHODS

Five sampling sites of Bharatkoop region were selected for the study. These were Bharatkoop East (BKE), Bharatkoop West (BKW), Bharatkoop Central (BKC), Bharatkoop North (BKN), Bharatkoop South (BKS). The ambient air sampling was done for 24 hours summer, rainy and winter season respectively in year 2017-18 .

Fine particulate sampler model APM 550, Envirotech, New Delhi and Gaseous pollutant sampler, model APM 433, Envirotech were used for particulate and gaseous sampling. Whatman glass microfiber and PTFE filters were used for PM_{10} and $PM_{2.5}$. Toxic Indicator gaZguard, model Tx, Envirotech was used to monitor CO. All parameters were analyzed as per standard methods of National Ambient Air Quality Standard (NAAQS) prescribed by CPCB (Central

Pollution Control Board). Bharatkoop village of district Chitrakoot is predominantly consisting of tropical dry and deciduous type of forest. The Plant leaves samples were collected from two different sites around Bharatkoop region viz. Site I (control site): This site includes areas 10-12 km away from the core stone crusher industrial belt. Site II (polluted site): This site includes areas within 1-2 km radius from the most major stone crusher industries. Selected plant species are of common occurrence namely, *Azadirachta indica, Butea monosperma, Dalbergia sissoo* and *Ficus benghelensis*. Total chlorophyll of leaf was estimated by Arnon [1] method. Chlorophyll a and chlorophyll b was calculated according to modification of the original equation of Arnon [1]. The entire procedure was carried out in a dark room avoiding contact with light.

(a) Chlorophyll extraction- 1 gm (fresh weight) of small pieces of leaf material was taken intoa clean mortar. 10 ml of 80% acetone was added and ground the tissue to a fine pulp (grind for 2 to 3 minute). Carefully the green liquid was transferred into a test tube, covered by aluminum foil and centrifuged the liquid at 4000 rpm for about 10 minutes.

(b) Chlorophyll determination- Separated liquid is taken, read and recorded the absorbance of the chlorophyll extract with a spectrophotometer set at 663 nm & 645 nm. The amount ofchlorophyll present in extract was calculated by Arnon‟s equations mentioned below: Calculations:

Chl a (mg gm^{-1}) = [(12.7 × A663) – (2.6 × A645)] × V (ml acetone)/W (mg leaf tissue) (i)

Chl b (mg gm^{-1}) = [(22.9 × A645) – (4.68 × A663)] ×V (ml acetone) /W (mg leaf tissue) (ii)

Total Chl = Chl a + Chl b (iii)

where V= adjusted volume of chlorophyll extract, W= Fresh wt of leaf sample, A_{663}= absorbancein nm at 663 nm wavelength, A_{645}= absorbance in nm at 645 nm wavelength

RESULTS AND DISCUSSION

The results of ambient air quality monitoring were compared with the prescribed values of National ambient air quality standard (NAAQS) 2009 recommended by Central Pollution Control Board (CPCB) are shown in Tables 1, Table 2, Table3, Table4 and Table5.

The maximum and minimum concentrations of PM_{10} were 1025.63 µg/m^3 S_3 site and 471.33µg/m^3at S_5 site respectively during summer. The maximum and minimum concentrations of

$PM_{2.5}$ were 726.10 µg/m^3 S_3 site and 282.71 µg/m^3 at S_5 site respectively during summer. The maximum and minimum average values of SO_2 were17.11 µg/m^3 at S_4 site and 8.01µg/m^3 at S_5 site respectively during summer. The maximum and minimum average values of NO_2 were 28.49µg/m^3 at S_3 site and 16.87 µg/m^3 at S_5 site respectively during summer .The concentration of CO was not detectable in most of the sampling sites and the concentration of CO was found 2 µg/m^3 at S_4 site which is within the limit of NAAQS during summer.

The maximum and minimum concentrations of PM_{10} were 1435.80 µg/m^3 S_3 site and 546.47 µg/m^3 at S_5 site respectively during rainy season. The maximum and minimum concentrations of $PM_{2.5}$ were 397.41 µg/m^3 S_2 site and 201.29 µg/m^3 at S_4 site respectively during rainy season. The maximum and minimum average values of SO_2 were 26.80 µg/m^3 at S_4 site and 13.02 µg/m^3 at S_5 site respectively during rainy season. The maximum and minimum average values ofNO_2 were 26.68 µg/m^3 at S_3 site and 18.90 µg/m^3 at S_5 site respectively during rainy season. The concentration of CO was not detectable in most of the sampling sites and the concentration of CO was 1.75µg/m^3 at S_4 site which was not more than the limit of NAAQS during rainy season.

The maximum and minimum concentrations of PM_{10} were 1480.63 µg/m^3 S_4 site and 855.80 µg/m^3 at S_5 site respectively during winter. The maximum and minimum concentrations of $PM_{2.5}$were 1374.03 µg/m^3 S_3 site and 549.39 µg/m^3 at S_5 site respectively during winter. The maximumand minimum average values of SO_2 were 13.74 µg/m^3at S_4 site and 8.85µg/m^3 at S_5 site respectively during winter. The maximum and minimum average values of NO_2 were 29.92 µg/m^3 at S_3 site and 20.01 µg/m^3 at S_5 site respectively during winter. The concentration of CO was not detectable in most of the sampling sites and the

concentration of CO was within the limitof NAAQS during winter.

Variations in physiological characteristics of selected plant species exposed to stone crusher industrial pollutants are shown in Table3. The results obtained with polluted and non polluted *Azadirachta indica, Butea monosperma, Dalbergia sissoo* and *Ficus benghelensis* were compared. In general, plants showed a decrease in photosynthetic pigments due to stone crusher dust pollution. *Azadirachta indica, Butea monosperma, Dalbergia sissoo* and Ficus benghelensisshowed a significant reduction in total chlorophyll content (chlorophyll „a" and chlorophyll „b") in the study period.

The concentration of total chlorophyll in the leaves of *Azadirachta indica* at polluted site was recorded as 0.495mg/g which was 0.838 mg/g at control site (Table 3). Thus reduction of 40.6% in total chlorophyll was recorded in the samples from the polluted sites in comparison to control sites during summer. The concentration of total chlorophyll in the leaves of *Azadirachta indica* at polluted site was recorded as 1.426mg/g which was 1.701 mg/g at control site (Table 3). Thus reduction of 16.1% in total chlorophyll was recorded in the samples from the polluted sites in comparison to control sites during rainy season.The concentration of total chlorophyll in the leaves of *Azadirachta indica* at polluted site was recorded as 0.261mg/g which was 0.791mg/g atcontrol site (Table 3). Thus reduction of 67.0% in total chlorophyll was recorded in the samples from the polluted sites in comparison to control sites during winter.

Table 1: National Ambient Air Quality Standard (2009)

Pollutants	**Time Weighted Average**	**Concentration in Ambient Air**		**Methods of Measurement**
		Industrial, Residential, Rural and other Areas	**Ecologically Sensitive Area (Notified by Central Government)**	
Sulphur Dioxide	Annual	50	20	Improved West and Gaeke
(SO_2), µg/m³	24 Hours	80	80	Method
Nitrogen Dioxide	Annual	40	30	Jacob and Hochheiser
(NO_2), µg/m³	24 Hours	80	80	modified (NaOH
				$NaAsO_2$) Method
Particulate	Annual	60	60	Gravimetric
Matter (Size less	24 Hours	100	100	
than 10 µm) or				
PM_{10}, µg/m³				
Particulate	Annual	40	40	Gravimetric
Matter (Size less	24 Hours	60	60	
than 2.5 µm) or				
$PM_{2.5}$, µg/m³				
Carbon	8 Hours	02	02	NDIR
Monoxide (CO),	1 Hours	04	04	
mg/m³				

Table-2 Measurement of Air Pollutants during Summer

S. No.	**Sampling sites**	**PM_{10} (µg/m³)**	**PM2.5 (µg/m³)**	**SO_x (µg/m³)**	**NO_x (µg/m³)**	**CO (mg/m³)**
1	BKE (S_1)	601.18	389.19	11.43	20.03	ND
2	BKW (S_2)	931.87	636.69	10.23	17.33	ND
3	BKC (S_3)	1025.63	726.10	12.56	28.49	ND
4	BKN (S_4)	875.76	504.17	17.11	23.26	2
5	BKS (S_5)	471.33	282.71	8.01	16.87	ND

(ND- Non detectable)

The concentration of total chlorophyll in the leaves of *Butea monosperma* at polluted site was recorded as 1.230mg/g which was 0.682 mg/g at control site (Table 3). Thus reduction of 44.6% in total chlorophyll was recorded in the samples from the polluted sites in comparison to control sites during summer. The concentration of total chlorophyll in the leaves of *Butea monosperma* at polluted site was recorded as

1.906mg/g which was 2.060 mg/g at control site (Table 3). Thus reduction of 7.47% in total chlorophyll was recorded in the samples from the polluted sites in comparison to control sites during rainy season. The concentration of total chlorophyll in the leaves of *Butea monosperma* at polluted site was recorded as 0.235mg/g which was 0.863mg/g atcontrol site (Table 3). Thus reduction of 61.18% in total chlorophyll was recorded in the samplesfrom the polluted sites in comparison to control sites during winter.
The concentration of total chlorophyll in the leaves of *Dalbergia sissoo* at polluted site was recorded as 0.312mg/g which was 0.312mg/g at control site (Table 3). Thus reduction of 49.21% in total chlorophyll was recorded in the samples from the polluted sites in comparison to control sites during **summer .** The concentration of total chlorophyll in the leaves of *Dalbergia sissoo* at polluted site was recorded as 1.526mg/g which was 0.507mg/g at control site (Table 3). Thus reduction of 23.27% in total chlorophyll was recorded in the samples from the polluted sites in comparison to control sites during **rainy** season.The concentration of total chlorophyll in the leaves of *Dalbergia sissoo* at polluted site was recorded as 0.116mg/g which was 0.507mg/g at control site (Table 3). Thus reduction of 77.12% in total chlorophyll was recorded in the samples from the polluted sites in comparison to control sites during **winter season**. The concentration of total chlorophyll in the leaves of Ficus benghelensis at polluted site was recorded as 0.587mg/g which was 0.894mg/g at control site (Table 3). Thus reduction of 34.34% in total chlorophyll was recorded in the samples from the polluted sites in comparison to control sites during summer .The concentration of total chlorophyll in the leaves of Ficus benghelensis at polluted site was recorded as 0.697mg/g which was 1.843mg/g at control site (Table 3). Thus reduction of 7.92 % in total chlorophyll was recorded in the samples from the polluted sites in comparison to control sites during rainy season. The concentration of total chlorophyll in the leaves of Ficus benghelensis at polluted site was recorded as 0.391mg/g which was 0.622mg/g at control site (Table 3). Thus reduction of 37.13% in total chlorophyll was recorded in the samples from the polluted sites in comparison to control sites during winter.

Table-3 Measurement of Air Pollutants during Rainy season

S. No.	Sampling sites	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	SO_x ($\mu g/m^3$)	NO_x ($\mu g/m^3$)	CO (mg/m^3)
1	BKE (S_1)	854.92	380.55	17.01	22.41	ND
2	BKW (S_2)	707.31	397.41	14.68	23.38	ND
3	BKC (S_3)	1435.80	242.95	25.08	26.68	ND
4	BKN (S_4)	1067.12	201.29	26.80	25.83	1.75
5	BKS (S_5)	546.47	391.66	13.02	18.90	ND

(ND- Non detectable)

Table-4 Measurement of Air Pollutants during Winter

S. No.	Sampling sites	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	SO_x ($\mu g/m^3$)	NO_x ($\mu g/m^3$)	CO (mg/m^3)
1	BKE (S_1)	1074.58	710.39	11.79	22.63	ND
2	BKW (S_2)	1332.67	675.19	12.02	22.43	ND
3	BKC (S_3)	1448.53	1374.03	12.49	28.27	ND
4	BKN (S_4)	1480.63	1256.58	13.74	29.92	2.75
5	BKS (S_5)	855.80	549.39	8.85	20.01	ND

(ND- Non detectable)

Table-5: Concentration of Total Chlorophyll (mg g-1) in the Leaves of Polluted and Control Sites during Summer, Rainy season and Winter

		Summer		Rainy		Winter	
S. No.	Plant species	Control site (mg g^{-1})	Polluted site (mg g^{-1})	Control site (mg g^{-1})	Polluted site (mg g^{-1})	Control sites (mg g^{-1})	Polluted site (mg g^{-1})
1	*Azadirachta indica*	0.838	0.495	1.701	1.426	0.791	0.261
2	*Butea monosperma*	1.230	0.682	2.060	1.906	0.863	0.235
3	*Dalbergia sissoo*	0.634	0.312	1.989	1.526	0.507	0.116
4	Ficus benghelensis	0.894	0.587	1.843	0.697	0.622	0.391

CONCLUSION

This paper concluded that chlorophyll is a photosynthetic pigment and reduction in chlorophyll content is

an indicator of air pollution in local area. Stone crusher dust pollution causes maximum of reduction in chlorophyll due to degradation of chlorophyll into pheophytin due to loss of magnesium ion. This study records very high level of PM_{10} and $PM_{2.5}$ that crosses the limit of NAAQS (National ambient air quality standard). The maximum and minimum concentrations of SO_2, NO_2 and CO were found within the permissible limit of NAAQS prescribed by CPCB. Maximum deposition of particulate matter in leaves of plants in winter followed by summer and rainy season. Maximum level of reduction in chlorophyll content is
recorded in Dalbergia sissoo than *Azadirachta indica, Butea monosperma* Ficus benghelensis in winter season. This study shows stone crusher industrial dust pollution highly affects the quality of our environment. So establishment of stone crusher industries should be away from local human communities and development of green belt around the stone crusher industries is very necessary because Plants has capacity to absorb pollutants and noise. They reduce the stress of pollution and maintain ecological balance.

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