Article

Effect of cement industry pollution on chlorophyll content of some crops at Kodinar, Gujarat, India

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Abstract

Study was carried out to assess the impact of cement industry pollution on some selected plant species around cement industry. Effect of cement dust on chlorophyll was studied in *Arachis hypogaea*, *Sesamum indicum and Triticum species*. Sampling was done at different distance like 0.5 km, 1.0 km and 2.0 km from the cement industry. The Chlorophyll pigments were reduced in dust-exposed plant species compared with control site Pransli (15 km away from the cement industry). Changes in chlorophyll content were investigated in selected plant species exposed to dust emitted by the cement industry. The concentration of chlorophyll in all the selected plant species i.e. *Arachis hypogaea, Sesamum indicum and Triticum species* were investigated and noted that amount of chlorophyll in all plants that are away from cement plant have more chlorophyll than that of near to the industry. Control plants were found always with higher chlorophyll content in comparison to dusted plants. Up to 74.69% reduction was observed in studied plants. In general, pollution by the cement dust has caused adverse effects on the photosynthetic pigments.

Keywords chlorophyll; groundnut; cement; pollution; crops.

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1 Introduction

Cement industry caused environmental pollution problems, and the pollutants of the cement industry produced the adverse impact on air water and land. Cement industry is the one of the 17 most pollutant industries listed by central pollution control board. During the last decades the emission of dust from cement factories has been increased alarmingly due to expansion of more cement plant to meet the requirement of cement materials for construction of building. In comparison with gaseous air pollutant many of which are readily recognized as being the cause of injury to various type of vegetation. Increasing concentration of cement dust pollutant causes in visible injuries like progressive decline in physiological process such as photosynthetic ability and respiration rate of leaves. Similarly visible injury such as reduction in growth and productivity were observed due to cement dust (Raajasubramanian et al., 2011). Satao et al. (1993) also reported that due to cement dust decreased the productivity and concentration of chlorophyll in number of crops. Cement dust are potentially harmful to the environment. The direct effects of the cement dust pollution are alkalization of the ecosystem and the changing of the chemical composition of the soil. The pollutant particles can enter the soil as dry, humid or occult deposits and can undermine the physico-chemical properties. Hence contaminated soil can adversely affect plant survival and growth (Addo et al., 2013).

The typical gaseous emissions to air from cement manufacturing plants include nitrogen oxide (NOx), sulphur dioxide (SO_2), carbon oxides (CO & CO_2) and dust (Pregger and Friedrich, 2009; Kampa and Castanas, 2008). The dust escaping from cement factories is often transported by wind and deposited in areas close and far away from the factory. These include agricultural lands, natural vegetation, towns and villages, such depositions of particulate matter and other pollutants interfere with normal metabolic activities of plants, causing direct injury and impairment of growth and quality and may ultimately lead to decrease in plant yield (Ediagbonya et al., 2013; Prajapati, 2012). The cement kiln dust, containing oxides of calcium, potassium and sodium is a common air pollutant affecting plants in various ways i.e. cement dust and cement crust on leaves plug stomata and interrupt absorption of light and diffusion of gases, lowering starch formation, reducing fruit setting (Lerman, 1972; Shrivastava, 1999), inducing premature leaf fall (Czaja, 1962; Tiwari et al., 2011) and leading to stunted growth (Darley, 1966). Besides causing suppression of plant growth, cement dust induces the change in the physico-chemical properties of soil, which are generally unfavorable to plant growth (Parthasarthy et al., 1975; Singh and Rao, 1978). In comparison to gaseous air pollutants, only limited studies have been carried out on the effect of particulates air pollutants on plant as reported with respect to fluoride dust (McCune et al., 1965), soot (Miller and Rich, 1967), lead particles, cement dust (Darley, 1966; Singh, 1979; Pandey and Simba, 1988, 1990) and coal dust (Rao, 1971).

The present study was carried out to assess the impact of cement industry pollution on some selected plant species around cement industry. Effect of cement dust on chlorophyll was studied in *Arachis hypogaea, Sesamum indicum and Triticum species*. Sampling was done at different distance like 0.5 km, 1.0 km and 2.0 km from the cement industry.

2 Material and Method

The Study area was Kodinar in the Shaurashtra region of Gujrat state forms a part of a bay in the Arabian Sea. It is located approximately 30 km. from famous temple Somnath (Veraval) on the Veraval–Una National Highway No. NH-8E. The area has co-ordinates with latitude, N 20^{o} 54' 45" and longitude 70^{o} 30' 41”. In this area there are total 04 cement plant units namely Ambuja Cement, Gajambuja -1, Gajambuja-2 and Siddhi Cement Ltd with capacity 2–2.5 MTPA. It is the most important industrial place.

The chlorophyll is the essential components for photosynthesis, and occurs in chloroplasts as green pigments in all photosynthetic plant tissues. They are bound loosely to proteins but are readily extracted in organic solvents such as acetone and ether. Chemically, each chlorophyll molecule contains a porphyrin (tetrapyrol) nucleus with a chelated magnesium atom at the centre and a long chain hydrocarbon (phytyl) side chain attached through a carboxylic acid group. The study area was confined around the cement factory. Groundnut, Til and Wheat plants were selected for field study. The plants samples were collected from 0.5, 1.0 and 2.0 km distance from cement factory. Control site was selected 15 km away from cement factory. The plant samples of all the three species were collected from both control and polluted site on 20, 40, 60, 80 and 100 days. The photo synthetic pigment were extracted from leaves in 80% acetone and centrifuged at 3000 RPM for 15 minutes to remove the debris. The volume of clear extract was made up to 100 ml by the addition of 80% acetone and its absorbance at 645 and 663 nm measured with a spectrophotometer. Concentration of chlorophyll a and b were determined using the formulae given by Arnon, 1949. The total chlorophyll content was obtained by addition chlorophyll a and b values.

Some calculations were listed as follows:

mg chlorophyll a/g tissue = 12.7 (A663) – 2.69 (A645) × 1000 × W / V

mg chlorophyll b/g tissue = 22.9 (A645) – 4.68 (A663) × 1000 × W / V

and

mg chlorophyll/g tissue = 20.2 (A645) + 8.02 (A663) × 1000 × W / V

where A = Absorbance at specific wavelengths, V = Final volume of chlorophyll extract in 80 % acetone, and W = Fresh weight of tissue extracted

3 Result and Discussion

The chlorophyll concentration in unit weight of control and plants from various distances from industry was observed for *Arachis hypogaea, Sesamum indicum and Triticum species* the results are given in Table 1, 2 and 3. The chloroplast damaged by incorporation of cement dust on leaf caused reduction in chlorophyll concentration in the plants which are near the industry was also reported by Czaja (1962), Lerman (1972), Singh and Rao (1978). The shading effects of such layer Peirce (1910), Czaja (1962). The similar results were observed in maize crop (Pandey et al., 1999) and gram leaves (Pandey and Simba, 1989). These were sample of evidence concerning the detrimental effects of gaseous pollutants, such as SO_2 at higher concentrations, degrades chlorophyll to a photosynthetically inactive phaeophytin and Mg^{++}.

Table 1 Total chlorophyll content (mg g^{-1} dry wt.) and percentage decrease over control in study area's *Arachis hypogaea* (2011-12).

Plant age in days		Control	Distance		
			0.5 Km	**1.00 Km**	**2.0 Km**
20	Chlorophyll a	1.84	1.16	1.39	1.44
	Chlorophyll b	0.61	0.39	0.46	0.48
	Total chlorophyll	2.45	1.54	1.85	1.92
	Percentage decrease of total chlorophyll over control		37.14	24.49	21.63
40	Chlorophyll a	2.44	1.81	1.93	1.99
	Chlorophyll b	0.81	0.61	0.64	0.66
	Total chlorophyll	3.25	2.42	2.58	2.66
	Percentage decrease of total chlorophyll over control		25.54	20.61	18.15
60	Chlorophyll a	2.99	1.90	2.00	2.05
	Chlorophyll b	0.99	0.63	0.67	0.68
	Total chlorophyll	3.99	2.54	2.67	2.74
	Percentage decrease of total chlorophyll over control		36.34	33.08	31.33
80	Chlorophyll a	3.3	1.81	1.82	2.01
	Chlorophyll b	1.10	0.61	0.61	0.67
	Total chlorophyll	4.40	2.42	2.43	2.68
	Percentage decrease of total chlorophyll over control		45	44.77	39.09
100	Chlorophyll a	2.95	1.51	1.59	1.66
	Chlorophyll b	0.98	0.50	0.53	0.55
	Total chlorophyll	3.94	2.01	2.12	2.22
	Percentage decrease of total chlorophyll over control		48.98	46.19	43.65

Table 2 Total chlorophyll content (mg g $^{-1}$ dry wt.) and percentage decrease over control in *Sesamum indicum* (2011-12).

Plant age in days		Control	Distance		
			0.5 Km	**1.00 Km**	**3.0 Km**
20	Chlorophyll a	2.43	0.88	0.92	0.99
	Chlorophyll b	0.81	0.29	0.30	0.33
	Total chlorophyll	3.24	1.18	1.22	1.32
	Percentage decrease of total chlorophyll over control		63.58	62.34	59.26
40	Chlorophyll a	2.67	0.94	1.03	1.08
	Chlorophyll b	0.89	0.31	0.34	0.36
	Total chlorophyll	3.56	1.26	1.38	1.44
	Percentage decrease of total chlorophyll over control		64.61	61.23	59.55
60	Chlorophyll a	2.99	1.02	1.06	1.17
	Chlorophyll b	0.99	0.34	0.35	0.39
	Total chlorophyll	3.99	1.36	1.41	1.56
	Percentage decrease of total chlorophyll over control		65.91	64.66	60.90
80	Chlorophyll a	3.61	0.92	0.98	1.06
	Chlorophyll b	1.20	0.30	0.32	0.35
	Total chlorophyll	4.82	1.22	1.31	1.41
	Percentage decrease of total chlorophyll over control		74.69	72.82	70.75
100	Chlorophyll a	2.86	0.76	0.83	0.99
	Chlorophyll b	0.95	0.25	0.28	0.33
	Total chlorophyll	3.81	1.01	1.11	1.32
	Percentage decrease of total chlorophyll over control		73.49	70.87	65.35

Table 3 Total chlorophyll content (mg g $^{-1}$ dry wt.) and percentage decrease over control in study area's *Triticum species* (2011-12).

Plant age in days		Control	Distance		
			0.5 Km	**1.00 Km**	**4.0 Km**
20	Chlorophyll a	2.01	0.83	0.85	0.92
	Chlorophyll b	0.67	0.28	0.28	0.31
	Total chlorophyll	2.68	1.11	1.13	1.23
	Percentage decrease of total chlorophyll over control		58.58	57.83	54.10
40	Chlorophyll a	2.49	1.59	1.61	1.75
	Chlorophyll b	0.83	0.53	0.54	0.58
	Total chlorophyll	3.32	2.12	2.15	2.33
	Percentage decrease of total chlorophyll over control		36.14	35.24	29.82
60	Chlorophyll a	3.25	1.61	1.66	1.89
	Chlorophyll b	1.08	0.53	0.55	0.63
	Total chlorophyll	4.34	2.14	2.21	2.52
	Percentage decrease of total chlorophyll over control		50.69	49.07	41.93
80	Chlorophyll a	3.54	1.68	1.71	1.72
	Chlorophyll b	1.18	0.56	0.57	0.57
	Total chlorophyll	4.72	2.24	2.28	2.29
	Percentage decrease of total chlorophyll over control		52.54	51.69	51.48
100	Chlorophyll a	1.82	1.59	1.64	1.76
	Chlorophyll b	0.60	0.53	0.55	0.58
	Total chlorophyll	2.42	2.12	2.19	2.34
	Percentage decrease of total chlorophyll over control		12.39	9.50	3.30

It is evident from Table 1 that was a gradual increase in total chlorophyll content as the distance from industry increases. The reduced photosynthetic potential of dusted plants as affected by decreased absorption of light (Peirce, 1910; Czaja, 1962), internal damage to leaf tissue (Rehman and Mohamed, 2012), interruption in CO_2 exchange (Czaja, 1962; Darley, 1966), reduced photosynthetic area. The chlorophyll concentration in unit weight of dry dusted leaf was always lower than control in all the three selected plant species. The maximum chlorophyll values for all the 3 plant species was found in 60 days in 2011-12.

3.1 Total chlorophyll in *Arachis hypogaea*

Groundnut is sown with the onset of monsoon in the area. The black cotton soil makes it suitable to grow groundnuts in the area. Being a cash crop is grown all over the area. However the yield depends mostly on the conditions of monsoon.

The maximum total chlorophyll value of Groundnut was found 4.40 mg g^{-1} dry wt. control plants in 80 days and 2.74 mg g^{-1} dry wt. dusted plants in 60 days at 2 km distance from industry and minimum was found 1.54 mg g^{-1} dry wt. in 20 days at 0.5 km distance from the industry.

The maximum decrease in total chlorophyll in comparison to control was observed at 0.5 km distance in all the age group of plants. As the distance increases percent decrease of total chlorophyll reduces Fig. 1.

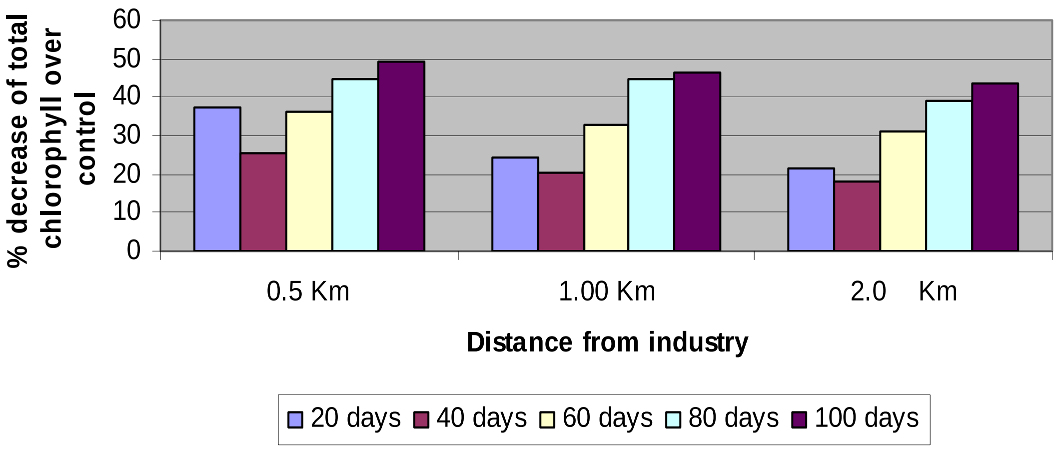

Fig. 1 Percent decrease in chlorophyll content at various distance and age (*Arachis hypogaea*).

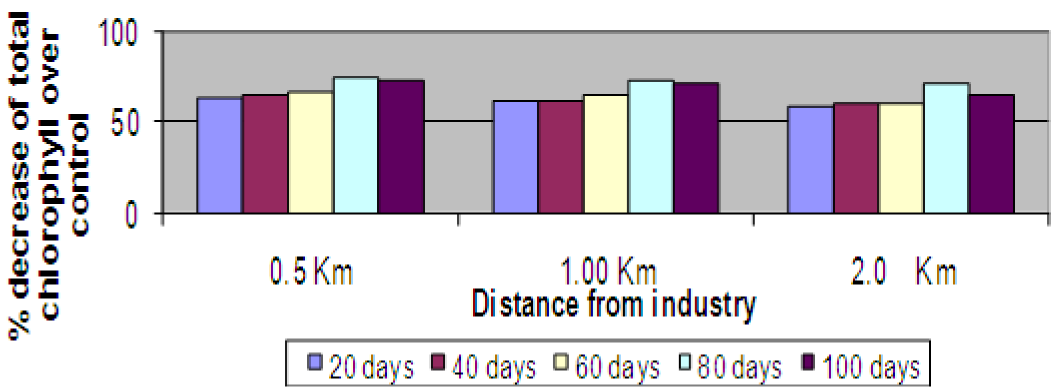

Fig. 2 Percent decrease in chlorophyll content at various distance and age (*Sesamum indicum*).

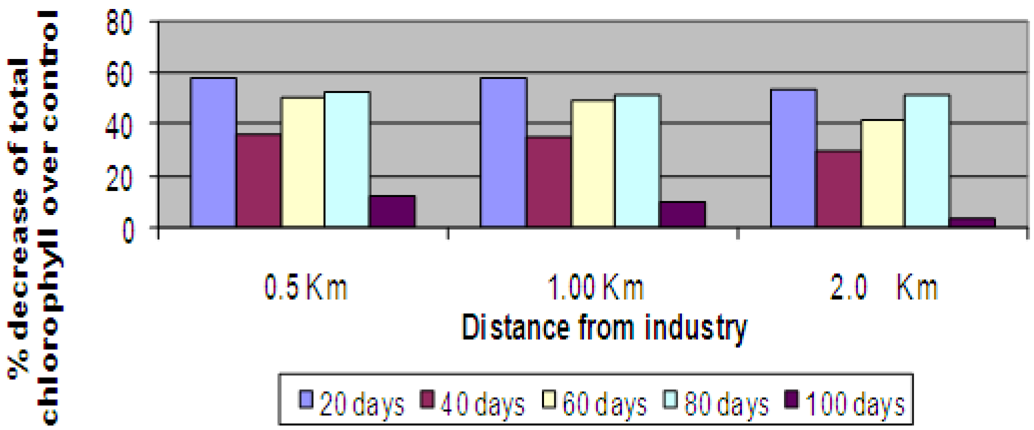

Fig. 3 Percent decrease in chlorophyll content at various distance and age (*Triticum species*).

3.2 Total chlorophyll in *Sesamum indicum*

Till is the main millets crop of Kharif season. These crops are preferred due to suitability of soil in the area. Being a cash crop is growing all over the area.

The maximum total chlorophyll value of Til was found 4.82 mg g^{-1} dry wt. control plants in 80 days and 1.56 mg g^{-1} dry wt. dusted plants in 60 days at 2 km distance from industry and minimum was found 1.01 mg g^{-1} dry wt. in 100 days at 0.5 km distance from the industry. Percent decrease of total chlorophyll is shown in Fig. 2.

3.3 Total chlorophyll in *Triticum sp.*

Wheat is the main Rabi crop grown in the area. Farming of Wheat is also conditional due to suitability of soil as well as availability of irrigation.

The maximum total chlorophyll value of Wheat was observed 4.72 mg g^{-1} dry wt. control plants in 80 days and 2.52 mg g^{-1} dry wt. dusted plants in 60 days at 2 km distance from industry and minimum was found 1.11 mg g^{-1} dry wt. in 20 days at 0.5 km distance from the industry. Percent decrease of total chlorophyll is shown in Fig. 3.

4 Conclusion

This study indicates that the total chlorophyll in control plants was always higher and maximum chlorophyll was observed in 80 days of age while in dusted plants maximum chlorophyll was found in 60 days of age. Exposure to particulate deposition may alter plant growth without physical damage to the plant. Moreover, accumulation of dust particulates on studied plant leaves could be a major problem in their production. It was proposed that the pigments content of the light harvesting complex is an important aspect related to the tolerance of plants to dust pollution. Chlorophyll content is essential for the photosynthetic activity and reduction in chlorophyll content has been used as indicator of air pollution it is fairly sensitive to air pollutants. The continuous cement industry pollution closes the stomata so interfering with gaseous exchange. In all the three plants species growing near the industry were having lesser quantity of chlorophyll and the distance increases the quantity of total chlorophyll also increases. In the present study *Sesamum indicum* was more sensitive to dust pollution followed by *Arachis hypogaea* and *Triticum species.* It clearly indicates that cement industry pollution affect the photo synthetic activity and chlorophyll content adversely.

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