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RESEARCH ARTICLE

STUDY ON CEMENT INDUSTRY POLLUTION AND MORPHOLOGICAL ATTRIBUTES OF TIL (*Sesamum indicum*), KODINAR, GUJRAT, INDIA

[1,*]Sadhana Chaurasia, [2]Ashwani Karwaria and [3]Anand Dev Gupta

[1,3]Department of Energy and Environment, MGCGV Chitrakoot Satna M.P., 485 780, India
[2]Manager- EHS, Reliance Cement Company Pvt. Ltd, Maihar Satna M.P., 485 772, India

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ABSTRACT

Increased concentration of cement industry pollutants causes invisible injuries like progressive decline in the physiological process such as photosynthetic ability and respiration rate of leaves. Similarly, visible injuries such as closure leaf stomata, a marked reduction in growth and productivity were observed due to cement industry pollution. The present study particularly discriminate the effect of cement industry pollution on *sesemum indicum* which is popularly grown in and around the vicinity of the cement industry and its consequence effect on production of crop. The present work focused on growth and yield response of Til due to cement industry pollution. All the morphological and yield parameters were analyzed for the industrial plants and compared with control plants. Ambient air quality was also monitored for PM_{10} and $PM_{2.5}$ at the entire selected site.

INTRODUCTION

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 20^0 54' 45" and longitude 70^0 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 a most important industrial place. Air borne emissions emitted from various industries are a cause of major concern. These emissions are of two forms, viz. solid particles PM_{10} and $PM_{2.5}$. *Sesamum indicum* (Til) 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 yield varies from 200 kg to 800 kg per acre.

MATERIAL AND METHOD

The study area was confined around the cement factory i.e. Ambuja cement. Til plants was selected for field study. The plant samples were collected from various sampling stations (0.5, 1.0 and 2.0 km distance from industry) and were compared with control sites Pransli near Gir forest. At control site the cement dust deposition on the plant was almost negligible. After properly cleaning the plant, root, stem and leaves are separated and average length of root and shoot of plants were measured.

***Corresponding author:** sadhana chaurasia
Department of Energy and Environment, MGCGV Chitrakoot Satna M.P., 485 780, India

Also, average numbers of leaves, branches, flowers, and seeds were counted. The fresh underground and above ground plant parts were dried in oven at 80^0C for 24 hrs and then weighted to estimate the biomass (gm/plant) for 100 days at 20 days intervals. Concentration of chlorophyll was determined using the formula given in (Machlachlan and Zalik, 1963). For measuring transpiration rate, a simple photometer was devised following the standard physiological technique. For this purpose, the lower end of 25ml burette was attached with rubber tubing to a glass tube of 0.5 cm diameter and 12cm length. The test plant was inserted into the open mouth of the glass tube which was then sealed with wax. The set was fixed to a stand and filled with tap water. The exposed water surface in the burette was covered with oil to check evaporation. The airtight set up was kept in sunlight for one hour and the amount of water transpired was recorded to compute the transpiration rate as ml. water transpired/100g fresh plant weight/hour.

RESULT AND DISCUSSION

The PM_{10} lowest concentration was found at control site. At 0.5 km distance PM_{10} was observed 176.70 µg/m^3 which decrease 157.37 at 1 km distance and further decreases 146.27 µg/m^3 at 2 km distance. PM_{10} was found beyond the standard limit (100µg/m^3) at all different site except control site the Pransli. $PM_{2.5}$ was found highest 68.20 µg/m^{3}at 0.5 km distances from plant which decrease 54.77 at 1 km distance and further decreases 51.17 µg/m^3 at 2 km distance. $PM_{2.5}$ was found beyond the standard limit (60µg/m^3) at Vadnagar. (Table-1, Fig-1).

Table 1: Average particulate pollutants at different distance from plants

S. No.	Parameters	Standard limit ($\mu g/m^3$)	Control	Distance from cement plant		
				0.5 km	1.0 km	2.0 km
			Pransli	Vadnagar	Marodia	Facharia
1.	PM_{10} ($\mu g/m^3$)	100	76.23	176.70	157.37	146.27
2.	$PM_{2.5}$ ($\mu g/m^3$)	60	47.7	68.20	54.77	51.17

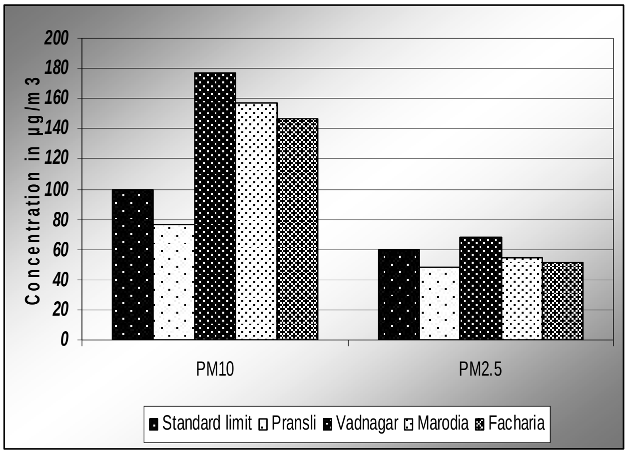

Fig.1: PM_{10} and $PM_{2.5}$ at various stations

Morphological characteristics

Shoot length- Table-2 shows that the shoot length was found higher at control site (average 26.04 cm). The plant growing at 0.5 km distance from industry have less growth average 19.54 cm and as the distance increases from the industry the shoot length also increases at 2 km distance shoot length was found higher average 22.82 cm. Similar results were observed by Chauhan and Joshi 2010.

Number of branches- Number of branches has no significant difference in control and polluted site. The plants growing at 0.5-2 km distance from industry have same number branches 3 at all site.

Number of leaves- Number of leaves increases as the plant grows old the maximum leaves were found in 100 days of age. At control site the numbers of leaves were found 22. The numbers of leaves were significantly low 14 in plants nearest to the industry as the distance from industry increases the number of leaves also increases.

Root length- From the Table-2 it is evident that the root length was found higher 5.60 cm at control site. The plant growing at 0.5 km distance from industry have lesser growth 3.40 cm and as the distance increases from the industry the root length also increases at 2 km distance root length was found higher 3.92 cm (Chauhan and Joshi 2010).

Number of flowers- Till the age of 40 days no flowers were observed after 40 day**s.** Maximum numbers of flowers was observed at control site. The plants growing at 0.5 km distance were having minimum number of flowers 8 and the number of flowers increases as the distance of plant from industry increases.

Number of Pods- Number of pods- Maximum number of pods was observed 23 at control site. The plants growing at

Table 2: Morphological parameter of *Sesamum Indicum* at various distances from industry in 2011-12

S. No.	Morphological Parameter	Distance from Industry (km)	Age in Days					Avg.
			20	40	60	80	100	
1.	Shoot Length (cm)	Control	15.7	20.8	25.2	31.4	37.1	26.04
		0.5	10.4	14.6	17.2	23.3	32.2	19.54
		1	11.8	16.1	18.6	25.7	32.8	21.00
		2	12.4	17.4	19.6	28.9	35.8	22.82
2.	No. of Branches	Control	-	1	2	4	6	3
		0.5	-	-	2	3	4	3
		1	-	-	1	3	4	3
		2	-	-	1	4	5	3
3.	No. of Leaf	Control	9	16	24	29	32	22
		0.5	7	12	14	18	22	14
		1	6	12	14	17	22	14
		2	6	12	14	17	28	15
4.	Root Length (cm)	Control	3.6	4.2	6	6.5	6.7	5.40
		0.5	2.5	3.1	3.2	4.3	4.9	3.60
		1	2.5	3.1	3.4	4.6	5.1	3.74
		2	2.5	3.2	3.7	4.8	5.4	3.92
5.	No. of Flowers	Control		2	7	17		8.67
		0.5	-	-	6	10	-	8.00
		1	-	-	5	11	-	8.00
		2	-	-	6	13	-	8.50
6.	No. of Pods	Control	-	-	-	16	30	23.00
		0.5	-	-	-	9	21	15.00
		1	-	-	-	10	27	18.50
		2	-	-	-	12	29	20.50
7	Wt. of 1000 grains (gm)	Control	-	-	-	-	3.1	3.10
		0.5	-	-	-	-	2.2	2.20
		1	-	-	-	-	2.7	2.70
		2	-	-	-	-	2.8	2.80

0.5 km distance were having minimum number of flowers 15 Table-2 and number of pods increases as the distance of plant from industry increases.

Weight of grain– 1000 oven dried seeds were weight in physical balance to determine the grain weight maximum weight of 1000 seeds was observed in control plant 3.10 gm. The significant reduction in grain weight 2.20 gm was observed in the plant growing at 0.5km distance from the industry (Parthasarathy *et al*. 1975). Grain weight also increases 2.80 gm at the distance increases from industry. Such reduction cud occurs because of the reduced photosynthetic potential of dusted plant as affected by decrease absorption of light (Perice 1910, Sagar *et al.*, 1982). The reduction in numbers was explained due to failures of pollen grains germination on dust laden stigma and failure of fertilization (Rao 1971, Chauhan and Joshi 2010). Significant reductions in yield have also been observed as a result of SO_2 pollution in many cereals and pulses by Thomas (1961); Singh and Rao, (1983). Ozone, SO_2 and NO_2 individually and in combustion are known to reduce the yield of many crop plants (Heggested and Lesser, 1990). Yield losses have often been attributed to reduction in photosynthetic activity and assimilate supplies to support reproductive development and seed growth (Krupa and Lickert, 1989; Agrawal, 2005). Agrawal *et al*., (2003) have reported significant yield reduction in wheat, mug bean, and mustard plants growing along a gradient of air pollution.

Dry biomass of *Sesamum indicum* root

Dry biomass of root of *Sesamum indicum* was observed in control and at various distances from industry in various age group of plant. The data are in given in Table-3. The average dry biomass of root in control plant was observed higher 0.28 gm. The dry biomass of root increases as the age of plant increases and the distance from industry increases (Fig-2).

Dry biomass of *Sesamum indicum* shoots

Dry biomass of shoot of *Sesamum indicum* was observed in control and at various distances from industry in various age group of plant. The data are in given in Table-3. The average dry biomass of shoot in control plant was observed higher 1.91 gm. The dry biomass of shoot increases as the age of plant increases and the distance from industry increases (Fig-3).

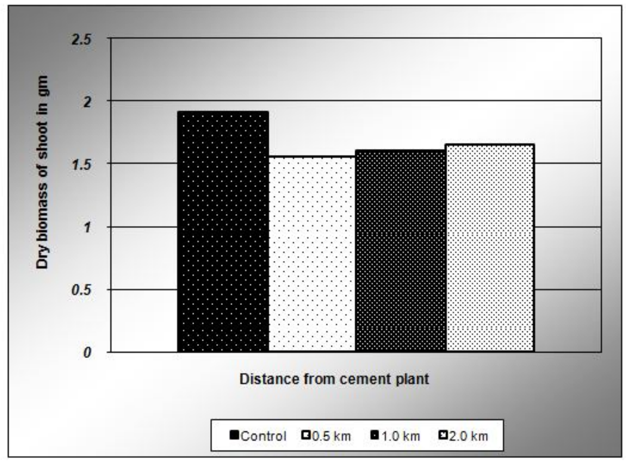

Fig. 3: Average dry Biomass of Til shoots in 2011-12

Transpiration in *Sesamum indicum*

The transpiration rate of *Sesamum indicum* plant was observed higher in control plant 19.10 Table-4. The rate of transpiration increases as the age of plant increases and the distance from industry increases. At 0.5 km distance average transpiration rate was observed 8.36 which increase 8.90 at 1 km distance and further increases 10.22 ml at 2 km distance from industry (Fig-4).

Table 3: Dry biomass (gm/plant) of *Sesamum indicum* (Til) plant in control and industrial area in 2011-12

Age of plant days	Dry biomass of root (gm)				Dry biomass of shoot (gm)			
		Industrial area				Industrial area		
	Control	0.5km	1.0km	2.0km	Control	0.5km	1.0km	2.0km
20	0.09	0.07	0.07	0.08	0.17	0.14	0.15	0.17
40	0.10	0.08	0.08	0.09	1.12	0.96	0.98	0.99
60	0.22	0.13	0.17	0.15	1.27	1.10	1.13	1.13
80	0.35	0.21	0.22	0.24	2.40	2.16	2.28	2.32
100	0.64	0.48	0.50	0.52	4.60	3.43	3.53	3.63
Average	0.28	0.19	0.21	0.22	1.91	1.56	1.61	1.65

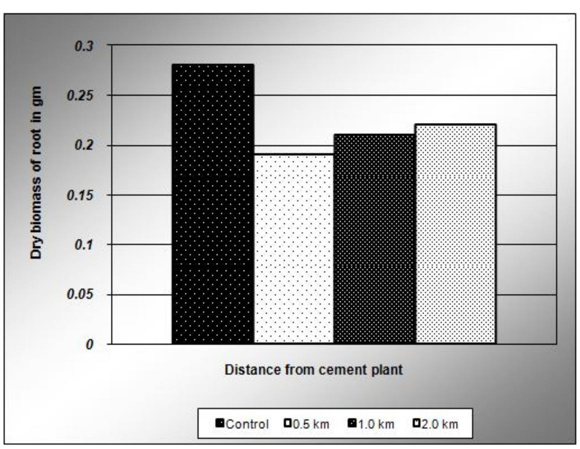

Fig. 2: Average dry Biomass of Til root in 2011-12

Total Chlorophyll

The total chlorophyll concentration in unit weight of control and plants from various distances from industry was observed for *Sesamum indicum* the results are given in Table-5.

Table 4: Transpiration rate (ml. water loss/100 g fresh wt./hour) of *Sesamum indicum* (Til) plant in control and industrial area in 2011-12

S. No.	Plant age in days	Control	Distance		
			0.5 Km	1.00 Km	2.00 Km
1.	20	16.90	7.30	7.90	8.50
2.	40	17.90	7.50	8.30	9.70
3.	60	19.10	8.10	8.60	9.80
4.	80	19.80	9.20	9.40	10.40
5.	100	21.80	9.70	10.30	12.70
Avg.		19.10	8.36	8.90	10.22

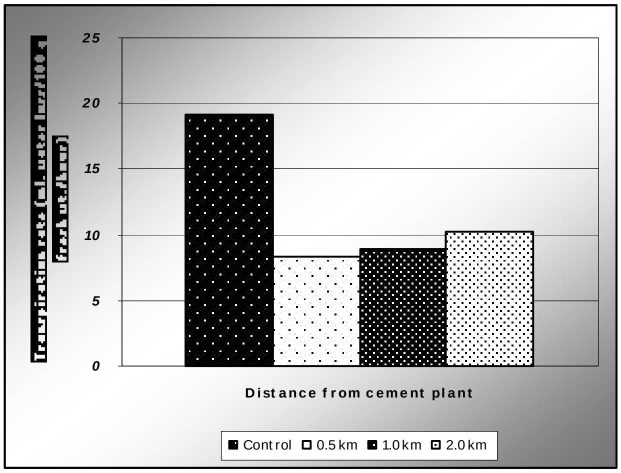

Fig. 4: Transpiration rate in Til in 2011-12

Table 5: Total chlorophyll content (mg g^{-1} dry wt. of leaves) of leaves on control and industrial area in 2011-12

S. No.	Name of Plant	Plant age in days	Control	Distance 0.5 Km	1.00 Km	2.00 Km
1.	*Seasamum indicum* (Til)	20	3.22	1.23	1.20	1.42
		40	3.49	1.42	1.32	1.54
		60	3.98	1.34	1.34	1.58
		80	4.62	1.24	1.28	1.78
		100	4.36	1.01	1.34	1.14
	Avg.		3.93	1.25	1.30	1.50

The maximum average chlorophyll concentration was observed in control plant 3.93. The chlorophyll concentration increases as the age of plant increases and the distance from industry increases. At 0.5 km distance chlorophyll concentration was observed 1.25 mg/gm. which increase 1.30 at 1 km distance and further increases 1.50 at 2 km distance from industry (Fig-5).

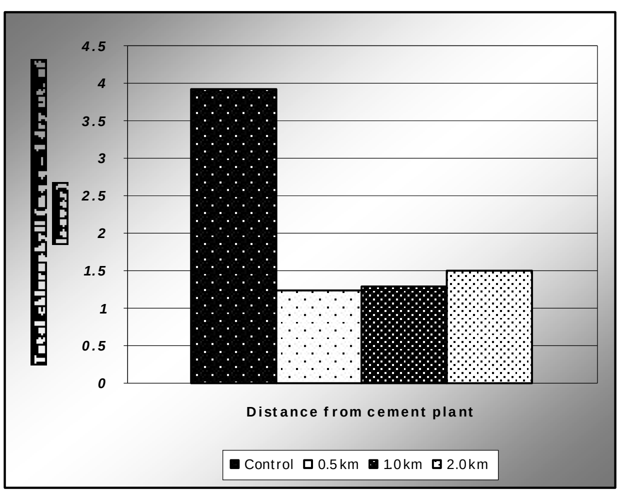

Fig. 5: Chloropyll in Til leaves in 2011-12

Conclusion

Morphological characters of *Sesamum indicum* was studied at different distance from the industry and compared with the control plant. The data obtained at different stage of development indicate that shoot length, root length, number of branches, number of leaves, number of flower, number of seed and weight of seeds were affected by cement industry pollution. The plant growing in control site were healthy than the plant growing near the cement industry. As the distance from the industry increases the plant also improves. The yield in term of seed weight regarding unpolluted plant may be attributed to the photosynthetic potential as against the dusted plant and assimilate supplies to support reproductive development and seed growth. Yield reduction was observed along the gradient of air pollution. A loss in total chlorophyll in the leaves of plants exposed in severe air pollution supports the argument that the chloroplast is the primary site of attack by air pollutants and decreases pigment content in the cells of polluted leaves. The transpiration rate, dry weight, chlorophyll content also shows the similar pattern.

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