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Study of the impact of contaminated soil with cement kiln dust of *Zea mays*

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Abstract

This study was undertaken to study the effect of different concentration of cement kiln dust mixed with soil on Zea mays. Cement kiln dust was mixed with soil in the pots to make six different treatment and one control (no cement kiln dust added)100g/5kg, 200g/5kg, 300g/5kg, 400g/5kg and 500g/5kg cement kiln dust was added in soil. The germination percentage, fresh and dry weight of seedling showed gradually decrease with the increase in the cement kiln dust weight. The sets treated with cement kiln dust showed several effects of cyto-toxicity. Similarly Stomatal index, Size of stomata and epidermal cell were found to be reduced in Zea mays grown in the pots mixed mixed with varing amount of cement kiln dust mixed soil.

Keywords: Soil pollution, cement kiln dust, germination, cyto-morphology, micro-morphology, *Zea mays.*

Introduction

Pollution is defined as any undesirable change in the physical, chemical and biological characteristics of air, water and soil that may adversely affect the life or create a probability health risk for any living organism. Pollutants released form industries are the major origin of environment pollution. The cement industry has been significantly contributing in the generation of dust pollution. It also causes the pollution in soil where cement industries are situated. The manufacturing process of cement is one of the chief source which contribute heavy metals in environment.

In the cement dust polluted areas, cement dust compositions plays a major role for the growth of plants. Economically *Zea mays* is very important crop because it is used as a food and fodder for animals and human being. The present research paper carried out the impact of cement kiln dust contaminated soil on germination behavior, micro-morphological study and cyto-morphological studies of *Zea mays.*

Materials and methods

Seed germination studies: Cement kiln dust was mixed with garden soil of the botanic garden of Botany department, S. P. C Government College, Ajmer. Seeds of *Zea mays were* procured from research institute Ajmer. The seeds were surface sterilized with 0.01% $Hgcl_2$ for 10 min then soaked for overnight before sowing. Cement dust mixed with soil was kept in germination cups in the ratio of 1:50g, 2:50g, 3:50g, 4:50g and 5:50g soil, without cement kiln dust as a control.

Triplicate samples were maintained (each containing 10 seeds) under natural photo period of day and night T^0 25 - 27^0 C and 21 - 23^0 C respectively.

On the second day of germination test the seeds were found germinating through the breakage of seed coat. On the 5 day seedling growth parameters such as a germination percentage, seedling length (cm/seedling), fresh and dry weight of seedling (g/seedling) were measured and recorded.

The effect of cement kiln dust on crop pot culture was set in botanic garden, Government College, Ajmer (Raj.). Seeds of *Zea mays* were sown in first week of July in the pots filled with mixture of kiln dust and soil. 6 new pots were set up and each was filled with 5kg of soil. A soil was dried and then mixes with particulate pollutant in different ratio separately. Pots were watered once in a day.

Cyto-morphological studies: Young floral buds were collected from the plants which grown in different concentration of cement kiln dust mixed soil. Aceto-carmine method was for cytological observations.

Micro-morphological studies: For the study of the stomatal characteristics, a 2cm piece of the leaves from the leaf base along the midrib of *Zea mays* was taken and kept in formalin acetic alcohol solution for long term storage. Permanent slides were prepared by free hand sectioning technique and observed under (10×40) a microscope. Observations were taken in upper, middle and lower regions of leaf lamina. Three observations were made in each region for upper and lower epidermis. Number, size of stomata, epidermal cell and stomatal index was noted with the help of occular and stage micrometer.

Results and discussion

Seed germination studies: The effects of cement dust pollution on seed germination of Z. mays are recorded in Table-1. The better results of germination were observed in control seeds.

Germination percentage, growth and their weight were found higher in control seeds as compared to seeds grown in treated soils. The higher germination percentage was noted in untreated seeds. In control, seedling length was 6cm/seedling was in *Z. mays*. Fresh weight of seedling in *Z. mays* was 1.739 /seedling. Dry weight of seedling was 0.345g/seedling in *Z. mays* in the control sets.

Germination percentage was recorded to be only 10% in soil contaminated with 5g/50gm cement kiln dust. Seedling length in *Z. mays* was 1.7cm/seedling. Fresh weight was only 1.115 g/seedling in *Z. mays* treated with 5/50gm cement kiln dust. Dry weight of seedling was 0.285g/seedling in the sets which grew in 5g/50gm cement kiln dust mixed soil. The germination percentage, fresh and dry weight of seedling was constantly recorded to be decreasing with the increase in the cement kiln dust similar observations have also been observed by Raajasubramanian *et al.*[1] and Prasad and Inamdar[2]. The results obtained showed that cement kiln dust had significant effect on the germination of seeds of *Z. mays.*

Cyto-morphological studies: Effect of cement kiln dust on meiotic divisions of *Zea mays* was studied. Zea mays has 2n=20 numbers of chromosomes. When the seeds of *Zea mays* were germinated in different concentration of cement kiln dust, the cells exhibited various distortions showing its toxic effect on meiotic divisions.

(A) (B)

Figure-1(A,B): Photograph of *Zea mays* depicting germination behavior of seedling up to 5th day in petridish, containing with CKD accumulated (A) and control soils (B).

Table-1: Seed germination behaviour of *Zea mays* sown in pots containing cement kiln dust.

Conc. of cement kiln dust (gm) in soil	Total no. of seeds	Total germinated seeds	Length of Seedling (cm/seedling)	Fresh Weight of seeds (g/seedling)	Dry Weight of seeds (g/seedling)
Control	10	10	6	1.739	0.345
1/50 g	10	8	5	1.614	0.342
2/50 g	10	5	4.5	1.599	0.340
3/50 g	10	3	2.1	1.422	0.315
4/50 g	10	2	2.1	1.305	0.300
5/50 g	10	1	1.7	1.115	0.285

Meiosis was normal in all the control sets (no cement kiln dust added) showing 20 univalent and 10 bivalents at metaphase were seen in *Zea mays* (Figure-2A, B). The sets treated with cement kiln dust showed several effects of cyto-toxicity. According to Kumar and Pandey[3] heavy metals present in higher concentration in cement kiln dust affect cyto-morphological features. Chain formation (Figure-2C) and group formation (Figure-2D) at metaphase was recorded in *Zea mays* cells grown on higher concentration of cement kiln dust contaminated soil.

The chromosomal distortions observed in the study confirms the finding of Yahaya *et al.*[4] who reported that chromosomal distortions observed in the test groups are stickiness, c-mitosis, chromosome bridge, chromosome fragmentation, vagrant chromosome, bi-nucleus chromosome and multipolar anaphase. The chromosomal distortions identified in the study confirms the findings of Calistus *et al.*[5] who observed that exposure to cement kiln dust may increase the frequency of sister chromatid exchanges, decreased cell kinetics and significantly increased the frequency of chromosomal distortions in men environmentally and occupationally exposed to cement dust.

Chromium VI has been implicated to cause c-mitosis, chromosome stickiness, chromosomal bridge, decrease in mitotic index, anuploid and sister chromatid exchange in plant and animals Zou *et al.*[6] Aluminum has also been observed to cause chromosome stickiness, occurrence of micronuclei, bi-nucleated and multi-nucleated cells, sticky bridge, laggards Mohanty *et al.*[7].

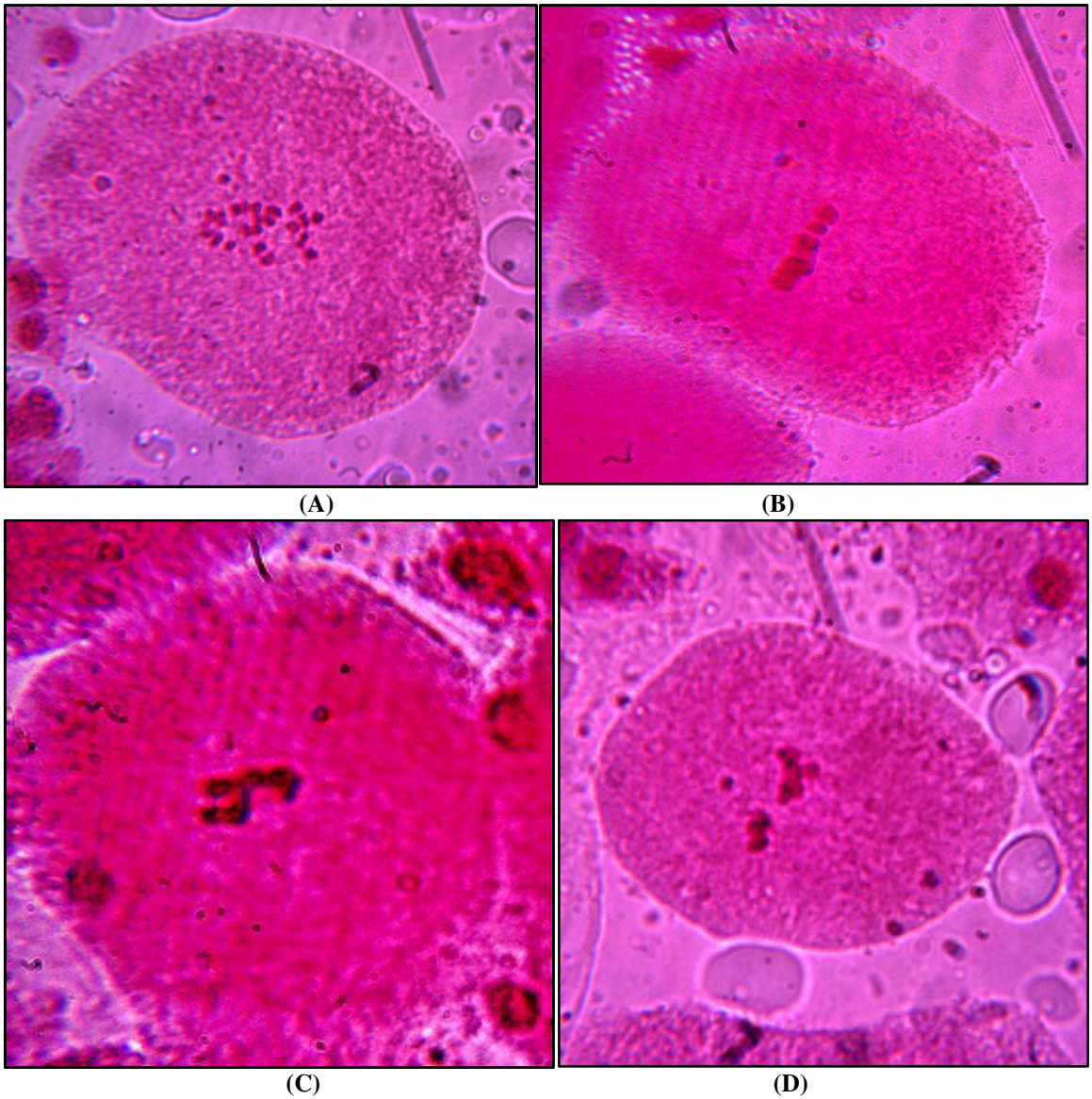

Figure-2(A-D): Effect of cement kiln dust meiotic cell division of *Zea mays*. (A) 20 univalent chromosome at metaphase, (B) 10 bivalent chromosome at metaphase (C) chain formation at metaphase (D) chromosomes divided in 2 groups at metaphase.

Stomatal response: The present study on *Zea mays* growing at different concentration of cement kiln dust contaminated soil shows that soil pollution causes significant changes in structure of leaves. Epidermal cell, Size of stomata and stomatal index was found to be reduced in *Zea mays* growing at cement kiln dust contaminated soil.

Observations on size of stomata, epidermal cell and stomatal index of *Zea mays* growing as control and in polluted sets with cement kiln dust are presented in Tables-2-4. It is clear from the data recorded in these tables that maximum size of epidermal cell was noted in upper surface (length 60.9µm and breadth 15.75µm) and lower surface (length 61.95µm and breadth 10.5µm) maximum stomata size was observed in upper surface (length 25µm and breadth 15.39µm) and lower surface (length 22.75µm and breadth 14.45µm) and maximum stomatal index was seen in upper surface (19%) and lower surface (22.8%) in the control Zea mays plants.

Degradation in length of epidermal cell was observed in upper surface (length 33.6µm and breadth 10.5µm) and lower surface (length 33.6µm and breadth 12.5µm) of *Zea mays* leaves grown at high concentration (500g/5kg) cement kiln dust mixed soil. Degradation in length and breadth of stomata was noted in upper surface (length 15.75µm and breadth 10.5µm) and lower surface (length 15.75µm and breadth 11.37µm) of *Zea mays* leaves which grew at high concentration (500g/5kg) of cement kiln dust contaminated soil. Degradation in Stomatal index upper (8.7%) and lower (16.9%) stomata was seen in *Zea mays.* The stomatal index reduced considerably on both the lower and upper surface of leaves.

Figure--3 (A-D) shows normal stomata on *Zea mays* plant leaves, which grow in normal (no cement kiln dust added) soils, while abnormal shapes of stomata and fusion of two stomata was observed on adaxial and abaxial surface of *Zea mays,* was grown in high concentration of cement kiln dust mixed soil. According to Gupta and Sharma[8] and Princewill[9] heavy metals present in cement kiln dust on affect degradation in stomata and epidermal cell structure and function on *Zea mays*. Similar results have been obtained by Solanki and Parihar[10], Mukhtar *et al.*[11] and Ghelich and Zarinkamar[12] in plants exposed to heavy metals like Cadimum and Lead.

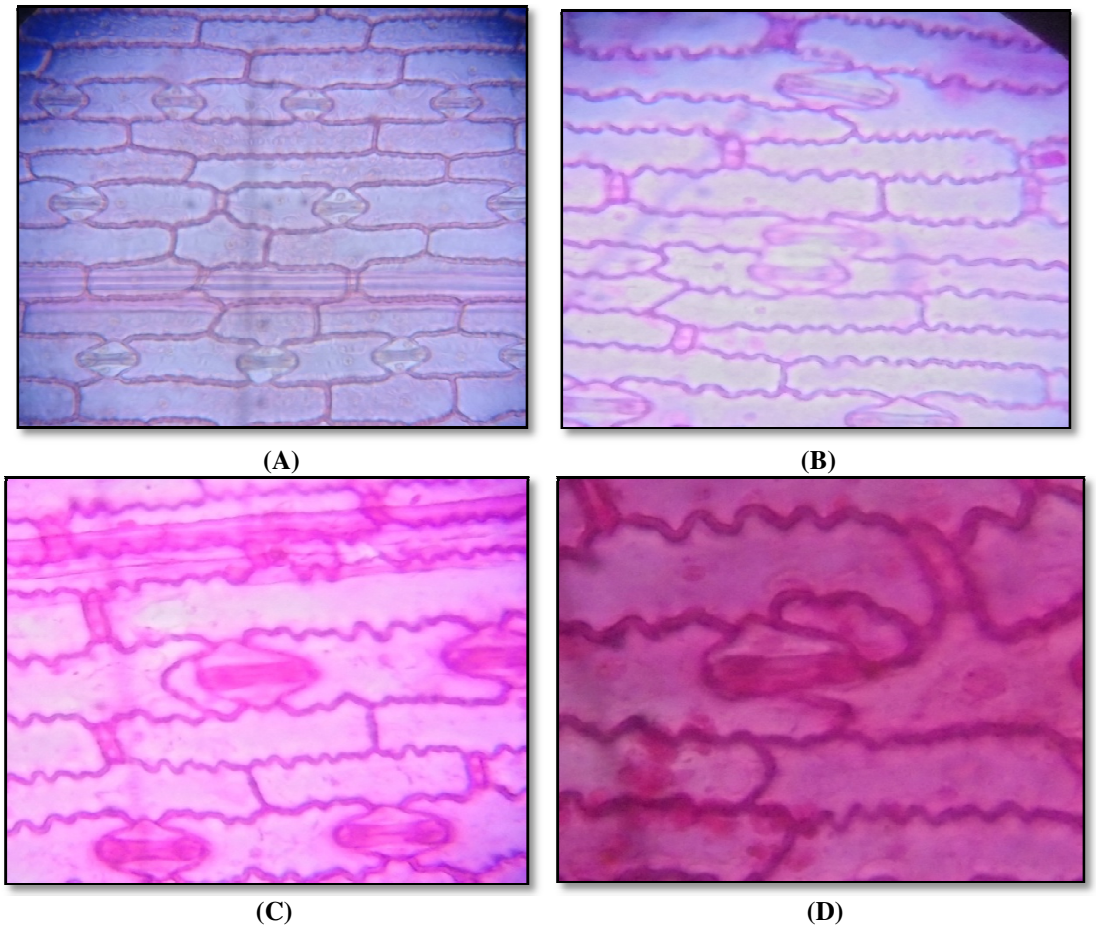

Figure-3: (A) Normal stomatal cell of *Zea mays* plant leaves which grow in normal (no cement kiln dust added) soil. (B, C) fusion of two stomatal cell and (D) abnormal shape of stomata were observed on adaxial and abaxial surface of *Zea mays* which grow in high concentration of cement kiln dust contaminated soil.

Table-2: Observation of epidermal size (Upper and Lower) in different concentration of cement kiln dust on *Zea mays.*

Concentration of cement kiln dust in soil (gm)/5kg	Length of epidermal cell (µm)		Breadth of epidermal cell (µm)	
	Adaxial surface of leaves	Abaxial surface of leaves	Adaxial surface of leaves	Abaxial surface of leaves
Control	60.9	61.95	15.75	10.5
100gm/5kg	50.1	56.7	13.65	12.6
200gm/5kg	40.95	45.25	12.94	10.6
300gm/5kg	39.9	39.9	10.5	10.5
400gm/5kg	34.65	36.75	10.5	10.5
500gm/5kg	33.6	33.6	10.5	12.6

Table-3: Observation of stomatal size (Upper and Lower) in different concentration of cement kiln dust on *Zea mays*.

Concentration of cement kiln dust in soil (gm)/5kg	Length of stomatal cell (µm)		Breadth of stomatal cell (µm)	
	Adaxial surface of leaves	Abaxial surface of leaves	Adaxial surface of leaves	Abaxial surface of leaves
Control	25	22.75	15.39	14.45
100gm/5kg	21	19.75	15.39	13.65
200gm/5kg	18.9	18.9	15.04	10.5
300gm/5kg	18.9	16.8	14.34	11.55
400gm/5kg	17.49	15.75	12.6	11.55
500gm/5kg	15.75	15.75	10.5	11.37

Table-4: Observation of stomatal index (Upper and Lower) in different concentration of cement kiln dust on *Zea mays.*

Stomatal index (%) of *Zea mays*		
Concentration of cement kiln dust in soil (gm/5kg)	Adaxial surface of leaves	Abaxial surface of leaves
Control	19%	22.8%
100gm/5kg	18.8%	21.2%
200gm/5kg	17%	20.5%
300gm/5kg	15.7%	18.7%
400gm/5kg	10%	18.4%
500gm/5kg	8.7%	16.9%

Conclusion

The result have clearly shown that cement dust contains high amount of heavy metals, which cause degradation of germination, degradation of epidermal and stomatal cell size, alteration in the structure of stomatal cell. The effects of cement kiln dust have shown chromosomal distortions in the *Zea mays*. These changes somehow affect the life of plant.

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