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THE STUDY OF CHANGE IN PHYSICO-CHEMICAL PROPERTIES OF SOIL DUE TO CEMENT DUST POLLUTION-AN HAZARDOUS TERRORIZATION TO ECOSYSTEM

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ABSTRACT

The present study implies the impact of dust emitted from a cement works on physico-chemical properties of soil and their impact on the mineral compositions of plants. The soil samples were collected from each plot before sowing and after harvesting and labelled separately. Their physico-chemical properties such as pH, electrical conductivity, available nitrogen, phosphorus, potassium, calcium, magnesium, zinc, copper, iron and manganese were estimated the result as a significant influence due to cement dust. Cement dust as an negative implication on soil and plants.

Keywords: Cement dust pollution, environment, soil, physico-chemical.

INTRODUCTION

Soil is nature's gift to nurture the plants, which intern nourishes the biotic community thus ecosystem. Now a day's this soil as become pool for various, toxins, syntactic non degradable chemicals, heavy metals etc. Soil as been polluted in all possible means, polluted water being reservoirs of chemicals heavy metals lets this chemical percolate into the soil. Polluted air caring all the toxin dust depositing on the soil, Human population explosion, rapid industrialization, increased deforestation, unplanned urbanization, scientific and technological advancement etc. have further hyped all kinds of pollution.

Industrialization, the index of modernization, is believed to cause inevitable problems to air, water and soil based on the type of industry, nature of raw materials used and the manufacturing processes involved (Dolar *et al.*, 1972). Among all kinds of pollution, air pollution has started to be a serious problem with increasing developments in industry and technology in the 21th centuary. It is a social disease generated primarily from the activity of man adversely affecting his health and welfare. With the advent of modern technology in recent years, the emission of air pollutants by various industries has increased alarmingly and constantly poses its impact on environment. The pollutants cut the key links in the web of biological and physical processes, which support ecological system in which man lives. It also destroys man's biological capital such as air, water and other components of the ecosystem.

Air pollution has become a major threat to the survival of plants in the industrial areas. Air pollutants emitted from various industries in particularly damage plant leaves impairs plant growth, and limit primary productivity according to the sensitiveness of the plants to pollutants (Ulrich, 1984). Thus, pollution stress can alter plant growth and quality and the effects are often extensive (Sagar *et al.*, 1982). Generally, the industries are categorized as high polluting industries, less polluting industries and non-polluting industries by the Ministry of Environment and Forest, Government of India, on the basis of their potentials in polluting the environment (David and Fernandes, 1988). Cement industries are regarded to be highly-pollution prone, especially with regard to particulate emission. They also play a vital role in the imbalance of the environment and produces air pollution hazard.

Cement industries pollute their environment in the form of dust in the surrounding areas and their products escape during factory processing (Uma *et al*., 1994; Ayanbamiji and Ogundipe, 2010). India being developing country urbanization is getting centralized thus paving way to

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Table 1. Chemical composition of raw material, cement and cement kiln dust.

S. No.	Chemical composition	Raw material (%)	Cement (%)	Cement kiln dust (%)
1.	Alluminium oxide	3.46	5.70	5.20
2.	Calcium oxide	43.40	66.10	45.10
3.	Ferric oxide	2.26	3.40	2.40
4.	Free lime	Trace	1.5-3.0	Nil
5.	Coal	35-40	Trace	Trace
6.	Magnesium oxide	1.50	1.60	Trace
7.	Manganese oxide	Nil	Nil	Trace
8.	Phosphorus pentoxide	Nil	Nil	Trace
9.	Potassium oxide	Trace	Trace	Trace
10.	Silicon oxide	14-11	24-12	11.00
11.	Sodium oxide	Trace	Trace	Trace
12.	Sulphur trioxide	Trace	0.8-1.2	1.75
13.	Titanic oxide	Nil	Nil	Trace
Gaseous and Liquid component of Cement Kiln Dust				
14.	CO	0.75	-	-
15.	Co_2	25.00	-	-
16.	So_2	1.00	-	-
17.	O_2	4.50	-	-
18.	H_2S	0.15	-	-
19.	Chlorine	Trace	-	-

development of concrete jungles replacing the natural beauty of environment, to meet this ever growing demands, more and more cement industries are established in India. The first Indian cement factory was established in 1914 at Porbundar in Gujarat. At present, there are 155 major cement industries (160 million tonnes per annum) and 300 mini cement plants (9 million tonnes per annum) in India. There are nearly 20 major cement industries located in Tamil Nadu. The main industries such as Alagappa cements (Pudupalayam), Ariyalur Cement Works (Kallankurichi), Chettinad cements (Keelapazhur), Dalmia cements (Thamaraikulam), Dharani cements (Veenakaikatti), Grasim cements (Reddiarpalayam), Ramco cements (Govindapuram) and Sankar cements (Thalavai) are located in and around ariyalur. They produce enormous amount of dust and pollute the surrounding environment. Among them, Ariyalur Cement Works, Ariyalur was established in 1979. It produces as much as 1500 MT/day employing dry process method. During production, it releases a stalk emission of 1,60,000 MT/hr. The emitted dust is carried out to surrounding areas and deposited over the vegetation and soil. The main objective of this research is to assess the impact of the dust given out by a cement factory on the physico chemical characteristics of soil and the mineral content of plant grown there.

Cement dust composition

Cement contains 3-8% aluminum oxide, 0.5-6% iron-oxide, 60-70% calcium oxide, 17-25% silicon oxide, 0.1-4% magnesium oxide and 1-3% sulphur trioxide (Shukla *et al*., 1990; Pandey and Simba 1990a, b). Toxic compounds such as fluoride, magnesium, lead, zinc, copper, beryillium, sulphuric acid and hydrochloric acid were found to be emitted by cement manufacturing plants (Andrzej, 1987). Another study, Prasad *et al.* (1991) have mentioned several biotoxic metals present in and around cement plant area. Adejumo *et al*. (1994) reported that Ca content which is present in the cement dust decreased exponentially with increasing distance from the factory. Some toxic heavy metals like As, Pb, Ni, Co, Zn, Cu, Cr, as well as S, P were found highly enriched in the neighborhood when compared to 5 km away from the cement factory. The emissions from cement industries contained 87– 91% dust and 9–13% gaseous pollutants such as SO_2, NO and CO (Mandre *et al*., 1994). Dusts emitted by the building materials and cement industries are usually conglomerates of chemically heterogeneous substances and they are prevailingly alkaline (Mandre *et al*., 1995). The chemical composition of cement raw material, cement kiln-dust and cement were obtained from the authorities of Ariyalur cement works (TANCEM), Ariyalur. The percentage of composition of these materials is presented in the table 1.

MATERIALS AND METHODS

Cement dust collection

The cement dust samples were collected in plastic bags from nearby Ariyalur cement works (TANCEM), Ariyalur district of Tamil Nadu, India. They were brought to Ecology laboratory, Botany Department to carry out the simulation studies on Black gram (*Vigna mungo* (L.) Hepper var. Vamban 3).

Seed material

The seeds of Blackgram (*Vigna mungo* L. Hepper var. Vamban 3) were procured from National Pulse Research Station, Regional Research Station of Tamil Nadu Agricultural University located at Vamban, Pudukkottai district, Tamil Nadu, India. The healthy seeds were chosen and used for both laboratory and field experiments.

Mineral Contents

Field experiment were conducted in Department of Botany, Botanical garden, Annamalai University, Tamil Nadu, India and was carried out to assess the effect of different levels of cement dust on mineral content of Blackgram var. Vamban 3. Both macronutrients (N, P, K, Ca and Mg) and micronutrients (Zn, Cu, Fe, and Mn) analyzed and recorded at seedling stages figures 1-3.

The field experiment was performed during the months of January to March, 2010.

Soil Analyses

The soil samples were collected from each plot before sowing and after harvesting and labelled separately. Their physico-chemical properties such as pH, electrical conductivity, available nitrogen, available phosphorus, available potassium, available calcium, available magnesium, zinc, copper, iron and manganese were estimated and recorded in table 2.

pH

Twenty grams of soil sample was air-dried and 50 ml of distilled water was added and mixed well. The solutions were taken in beaker and the pH of the soil sample was recorded by using a pH meter (ELICO, LI 120).

Electrical conductivity (dSm^{-1})

Twenty grams of dried soil sample was taken and dissolved in 50 ml of distilled water and mixed well. The solution was used to measure the conductivity with the help of an electrical conductivity meter (ELICO, CM180).

Available nitrogen (Subbiah and Asija, 1976)

Twenty grams of the soil sample was taken in a flask and 20 ml of distilled water, 100 ml of freshly prepared 0.32 per cent potassium permanganate solution and 100 ml of 2.5 per cent sodium hydroxide were added. The flask was heated and 30 ml of distillate was collected in 50 ml of N/50 sulphuric acid. Excess acid was titrated against N/50 NaOH solution using methyl red indicator. The amount of available nitrogen in the soil was calculated by using the following formula:

$$\text{Available nitrogen (mg kg}^{-1}\text{)} = \frac{\text{Volume of 0.02 N } H_2SO_4 - \text{Volume of 0.02 N NaOH consumed} \times 0.28}{\text{Weight of soil in gram}} \times 1000$$

Available phosphorus (Jackson, 1958)

One gram of the soil was suspended in 200 ml of 0.002 N sulphuric acid, shaken well and then filtered through Whatmann No. 42 filter paper. To 10 ml of filtrate, three drops of 0.02 per cent 2,4-dinitrophenol indicator was added. Whenever, the solution became yellow, 2 N sulphuric acid was added until the disappearance of the yellow colour. If the solution was colourless after adding the indicator, 4 N sodium carbonate was added till it became colourless. To that solution, 2 ml of sulphomolybdic acid (ammonium molybdate 25g in 200 ml; 275 ml con. H_2SO_4 diluted to 700 ml both were cooled, mixed and made upto 1000 ml) and 0.5 ml of chlorostannous acid (25g $SnCl_2.2H_2O$ in 50 ml of concentrated HCl diluted to 500 ml with water and made upto one litter with 1.2 N HCl) were added and made upto 50 ml. The solution was shaken well and read in a UV-Spectrophotometer (Hitachi U-2900) at 660 nm after 5 min. Standard graph was prepared using potassium dihydrogen phosphate.

Available potassium (Jackson, 1958)

Ten grams of soil was taken in 250 ml conical flask and 100 ml of 1 N ammonium acetate was added to it. The flask was stoppered, shaken intermittently for 10 min and filtered by suction. Ammonium acetate was poured to the soil to get a volume of 250 ml and then evaporated to dryness. Dried samples were ashed in a muffle furnace at 700-800°C for 20-30 min. To the residue, 50 ml of 0.1 N HCl was added and warmed gently and the extract was fed to Flame photometer (ELICO, CL22D). Potassium chloride was used to prepare the standard solution.

Available calcium (Yoshida *et al.*, 1972)

Five grams of soil was extracted with 50 ml of 1 N ammonium acetate. Two ml of the extract was mixed with 2 ml of 5 per cent lanthanum oxide solution and diluted with 10 ml of 1 N HCl. The solution was fed into an Atomic Absorption Spectrophotometer (ELICO, SL176) at 211.9 nm. Standard solution was prepared using calcium chloride.

Available magnesium (Jackson, 1958)

Ten grams of soil sample was extracted with 50 ml of 1 N ammonium acetate and the extract was filtered and used for the determination of magnesium. The determination procedure adopted was as in the case of calcium. The amount of magnesium was estimated by using Atomic Absorption Spectrophotometer (ELICO, SL176). Magnesium chloride was used for the standard preparation.

Zinc, copper, iron and manganese (Piper, 1966)

Fifty grams of soil was extracted with 100 ml of extraction solution (diethylenetriaminepentaacetic acid – DPTA) and shaken thoroughly for 2 hrs. The solution was filtered through Whatmann No. 42 filter paper. The filtrate was read at 568 nm for iron, 324.6 nm for copper and 214 nm for zinc 530 nm for manganese and 540 nm by using the appropriate hollow cathode lamps in Atomic Absorption Spectrophotometer (ELICO, SL176).

STATISTICAL ANALYSIS

The statistical analysis of experimental results was carried out by **SPSS version 11.0** was used for the statistical analysis. All the data were given as mean of 3 assays. The level of significance was calculated at *p* value < 0.05%.

RESULTS

The impact of various level of cement dust on mineral content changes of blackgram were estimated and presented in figures 1 to 3. The highest content of nitrogen (0.579 %), phosphorus (0.655 %), Zinc (0.801 ppm), copper (0.659 ppm), iron (1.021 ppm), manganese (1.213 ppm) and the lowest amount of potassium (0.624 %), calcium (0.937 %) and magnesium (0.368 %) were recorded in control seedlings. The lowest content of nitrogen (0.351 %), phosphorus (0.363 %), Zinc (0.315 ppm), copper (0.361 ppm), iron (0.424 ppm), manganese (0.429 ppm) and the highest content of potassium (1.401 %), calcium (2.228 %) and magnesium (0.967%) were recorded in the seedlings grown in 25 g of cement dust mixed with 200 g of soil.

The physico-chemical analyses of soil before sowing and after harvesting are presented in table 2. Soil analysis (before

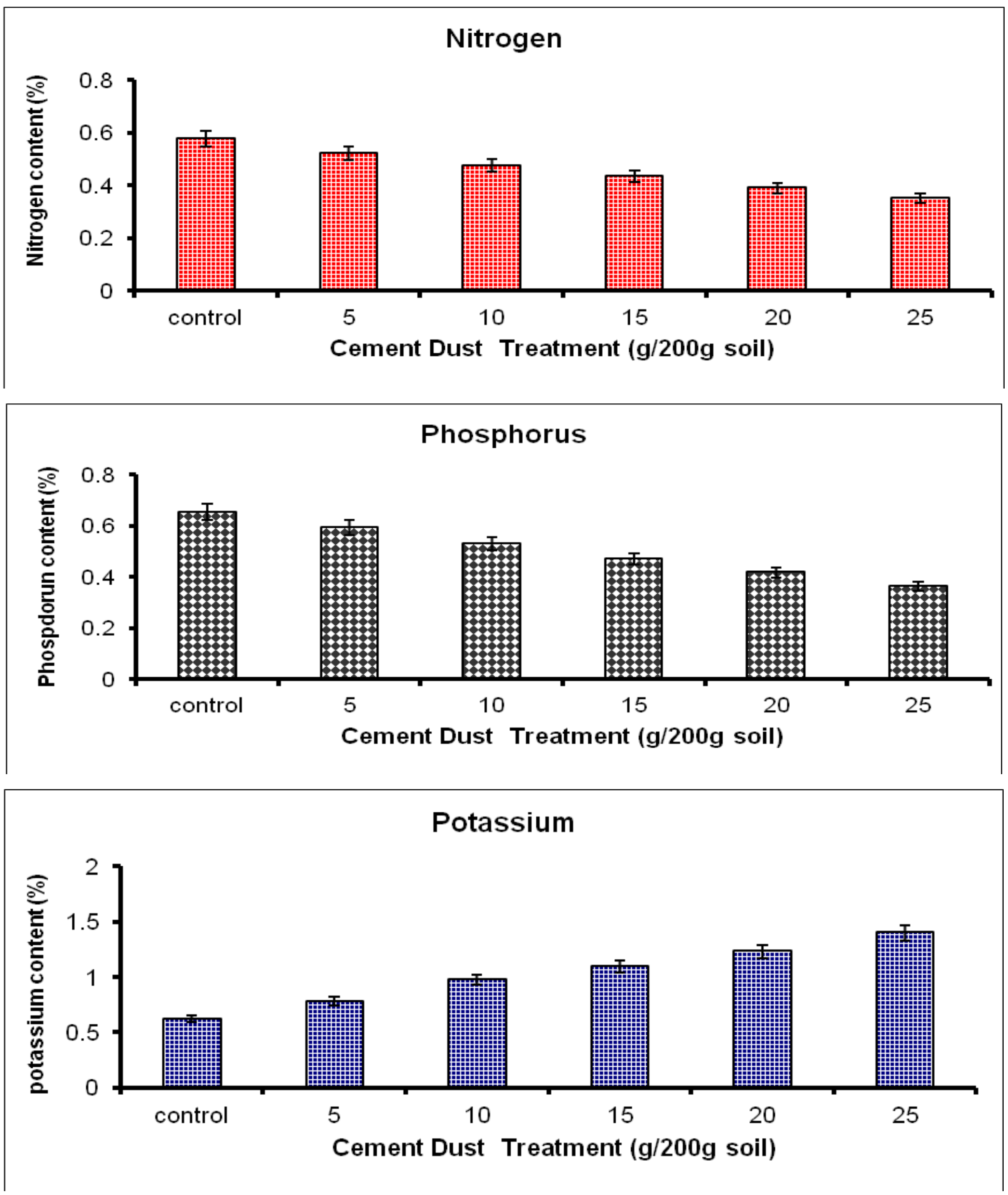

Fig. 1. Effect of cement dust on nitrogen, phosphorus and potassium content (%) of Blackgram seedlings.

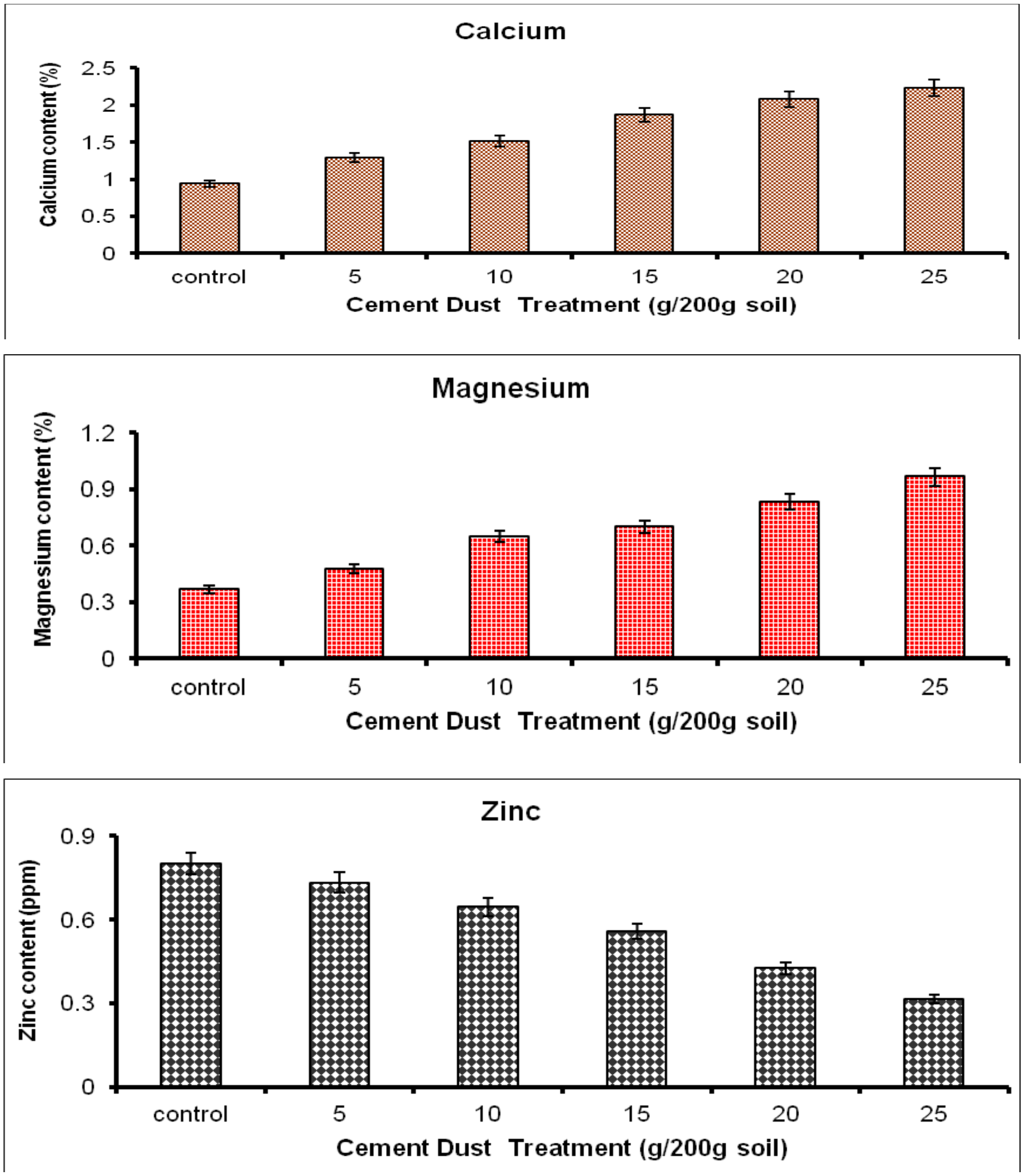

Fig. 2. Effect of cement dust on calcium (%), magnesium (%) and zinc (ppm) content of Blackgram seedlings.

sowing) shows the value of pH (7.1), Electrical conductivity (0.33 d Sm^{-1}) and content such as Available Nitrogen (70.0 kg/acre), Available Phosphorus (14.2 kg/acre), Available Potassium (35.0 kg/acre), Available Calcium (12.6 C Mole $Proton^{+}$/kg), Available Magnesium (10.3 C Mole $Proton^{+}$/kg), Zinc (3.49 ppm), Copper (3.04 ppm), Iron (23.3 ppm) and Manganese (2.16 ppm). Soil analysis (after harvesting), showed the minimum pH (7.4), Electrical conductivity (0.35 d Sm^{-1}) in control soil and maximum value of pH (10.2), Electrical conductivity (0.48 d Sm^{-1}) and the maximum amount of Available Potassium (90.0 kg/acre), Available Calcium (19.2 C Mole $Proton^{+}$/kg), Magnesium (16.3 C Mole $Proton^{+}$/kg), Zinc (2.73 ppm), Copper (2.99 ppm) and Iron (33.65 ppm) were recorded in 20 g m^{-2} day^{-1} cement dusted plants grown soil. The maximum content of minerals Available Nitrogen (39.0 kg/acre), Available Phosphorus (11.0 kg/acre), Available Potassium (50.0 kg/acre), Available calcium (13.2), manganese (10.8 ppm), zinc (1.21ppm), copper (1.31ppm) and iron (24.59 ppm) recorded in control soil and whereas minimum amount of Available Nitrogen (26.0 kg/acre), Available Phosphorus (5.0 kg/acre) and Manganese (1.17) present in the 20 g m^{-2} day^{-1} soil.

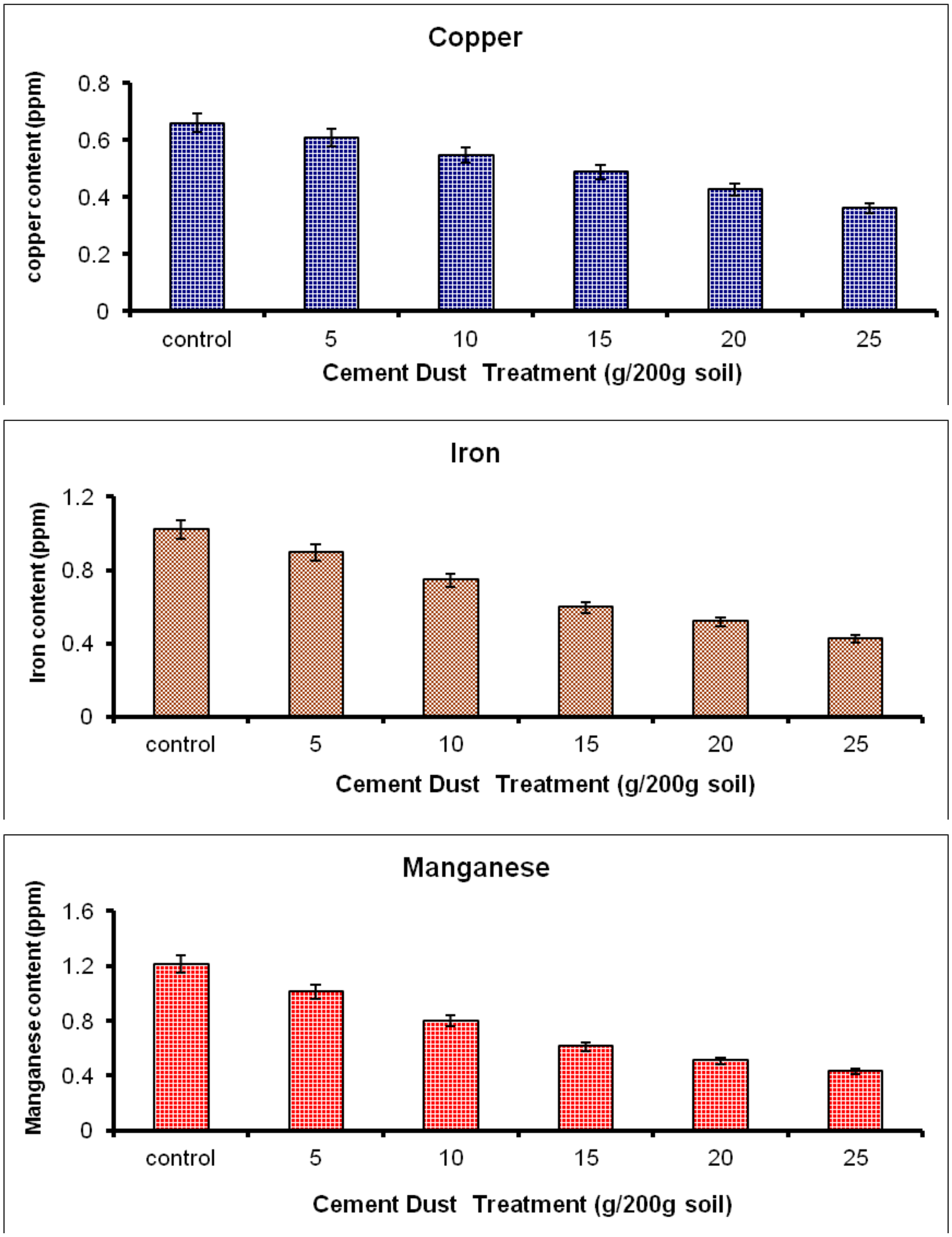

Fig. 3. Effect of cement dust on copper, iron and manganese content (ppm) of Blackgram seedlings.

DISCUSSION

Nature is wonderful engineer and its system works flawlessly until and unless we indulge we use, utilize nature in recent times we have been exploiting nature rather than using it. Air pollution has become a serious environmental problem in recent years due to rapid growth of cement factories, thermal power stations, steel and coal industries. It is physical, chemical and biological agents that modify the natural characteristics of the atmosphere. Air pollution is responsible for vegetation injury, crop yield loss and has become a major threat to the survival of plants in industrial area (Fuji, 1973). It has a fairly long history of damage to agricultural crops, horticultural plants and forest trees. Addition of toxic substances to environment is increasing day by day and they are responsible for altering the ecosystem (Mishra and Pandey, 2011).

The cement industries play a major role in the imbalance of the environment and produces air pollution hazards. In recent years, air pollution due to emission of cement dust is assuming a mammoth proportion due to installation of more and more cement plants to meet the ever-growing

Table 2. Changes in Physico-Chemical properties of soil due to cement dust pollution (before sowing and after harvesting).

Quantity of cement dust (g m^{-2} day^{-1})	Soil properties										
	pH	EC (d Sm^{-1})	Available N (kg/acre)	Available P (kg/acre)	Available K (kg/acre)	Available Ca (C Mole $Proton^{+}$/kg)	Available Mg (C. Mole $Proton^{+}$/kg)	Zn (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)
Before sowing											
Normal soil	7.1	0.33	70.0	14.2	35.0	12.6	10.3	3.49	3.04	23.3	2.16
After harvesting											
Control	7.4	0.35	39.0	11.0	50.0	13.2	10.8	1.21	1.31	24.59	1.95
5	8.9	0.38	35.0	8.0	65.0	15.6	11.5	1.56	1.64	25.1	1.78
10	8.11	0.41	31.0	7.5	72.0	16.1	13.1	1.76	1.72	29.8	1.65
15	9.6	0.44	28.0	6.0	88.0	18.9	14.6	2.09	2.11	32.2	1.43
20	10.2	0.48	26.0	5.0	90.0	19.2	16.3	2.73	2.99	33.65	1.17

needs of the society. They pollute the environment in the form of dust to the surrounding area of cement factories (Uma *et al*., 1994; Ayanbamiji and Ogundipe, 2010). Due to high energy consumption and dust emission potential, cement industry falls under red category (high polluting industries) by Ministry of Environment and Forest, Government of India.

Cement dust coming from the cement factories creates serious pollution problem and cause enormous damage to biotic and abiotic components. The crust is formed over the surfaces of soil and leaves because of the settling dust. It consists of calcium silicates which are typical of the clinkers (Burned lime stone) from which cement is made. In the presence of free moisture, calcium silicate ($CaOSio_2$) and calcium aluminate ($CaOAl_2O_2$) undergoes slow hydration, form a colloidal gel, which crystallize and solidify to form an impervious hard crust over the surface of plant and soil. Cement dust has been reported to be harmful to plants, the dust forms thick crust, which interfere with light absorption that leads to stunted growth and growth of fewer leaves in plants (Borka, 1986).

Cement industry emit a large volume of dust into the atmosphere, spread over a large area and it affects the vegetation and soil. It depends upon the height of cement factory chimney, wind direction, wind velocity and nature of particles emitted from the factory. Dust particles gets deposited over different plant parts, especially on leaf surfaces, on soil and finally cumulative effect of cement dust cause reduction in growth and yield of crops. In addition, it leads to large scale deforestation, destruction of flora, fauna and other natural resources (Singh and Shrivastra, 2002).

The chemical ions present in the cement dust combines with the micro and macro nutrient present in soil forming complexes affecting the absorption of these minerals by plants interfering with their metabolic path ways causing degradation of habitant and ecosystem.

CONCLUSION

The results reveal that Cement dust significantly alters the soil profile and essential parameters for good soil. Chemical, metallic, ions along with various other oxides, cause immense awful affects on the ecosystem and environment on which there should be a scrupulous check and there should be focus of development of clean technology in cement manufacturing.

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