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Impact of Cement Industries Dust on Soil Nutritional Attributes and Microbial Population of Agriculture Fields

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Abstract

The present study investigates the effect of cement industries dust on nutrients and microbial population of agriculture soils of surrounding cement industries. Microbial population includes bacteria, actinomycetes and fungi were studied from the agriculture fields surrounding three different cement industries such as Kalaburagi cement industries, Chettinad cement industries and Shree cement industries. Microorganisms were isolated and population was calculated from the surface and subsurface soils, both with and without crops (redgram and sorghum). pH 8.4 was recorded in CNS1, nutrients Ca and Mg were recorded highest in CNR2 and SRS1 is 38.8 and 23.0 respectively. Highest bacterial count 74×10^5 is recorded in control field and lowest bacterial count 14×10^5 is recorded in shree cement field of redgram field. Surface soil has highest microbial counts than subsurface soil of redgram and sorghum field. A significant higher count of microbial population was observed in the soils of control field. The variations in the microbial population and soil properties are discussed in detail.

Key words: Cement industrial dust, Soil nutrients, Microbial population, Pollution

Cement is the most widely used building material all over the world [1]. Cement is the most common material that is used for construction of buildings, houses, offices, roads, bridges and dams [2]. Cement industries are considered as one of the principal environmental polluting industries in the world [3, 4]. Cement industries takes 17 ranks of environmental polluting industries listed by Central Pollution Control Board (CPCB), India [5,6]. The main impacts of cement production on the environment are the broadcasts of dust particles and gases into the atmosphere from the cement industries are easily transported and disperse over large areas through wind and rain, accumulating in soils and plants [7]. Cement contains 3-8% aluminium oxide, 0-5 to 0.6% iron oxide, 60-70% calcium oxide, 17-25% silicon oxide, 0.1-4% magnesium oxide and 1-3% sulphur trioxide [8].

Soil is the outer layer of the earth surface. Soil is composed of five components such as mineral matter, water, air, organic matter and living organisms [9]. Soil is an active habitat for biological interactions [10]. In industrial areas soil pollution is a major problem which impacts on the nutritional properties of surrounding agriculture [11]. Cement industries dust contains particulate matter, SO_2, NO_2 and CO_2 and heavy metals like nickel, cobalt, lead, and chromium these pollutants harmful to the soil nutrients and living organisms [12]. Short term exposure to cement dust may not cause serious problem, but prolonged exposure can cause serious problem to soil, plant, and living beings [13].

Cement dust causes alkalization of the soil by changing electrical conductivity, pH and chemical composition of the soil [14]. Accumulation of cement dust pollutants can cause reduction in the photosynthetic ability of leaves, closes of leaf stomata and reduction in growth and productivity of crops [15]. Soil microbial activity is important for the nutrient cycling of carbon, nitrogen, sulfur and phosphor elements and it is adversely affected by cement dust pollution [16]. Soil biological and enzyme activities affected by increasing soil pH values [17]. Cement dust pollution leads to considerable decrease in microbial population and microbial biomass in soil [18]. Soil microbial biomass can regulate nutrient availability for terrestrial plants [19].

Therefore, this study was carried out to assess the impact of cement dust pollution on the soil nutritional properties and diversity of soil microorganisms in agriculture fields surrounding of cement industries.

MATERIALS AND METHODS

Study area

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Study was conducted in the Kalaburagi district of Karanataka India, where the area has maximum limestone deposits. At present study three sampling sites were selected near to Kalaburgi District. Samples were collected from Kalaburagi cement industry, Chatrasala., Shree cement industry, Benakanhalli, Sedam taluk and Chettinad cement industry Kallur, Chincholi taluk and Control sample was collected from the field located at Nilhalli village of Sedam taluk.

Collection of soil samples

In Kalaburagi district major crops are red gram and sorghum, these two crops were selected for study. Soil sampling was carried out during crop season in the month of November 2018 and also without crop season in the month of May 2019 in the areas surrounding the cement industry. Samples were collected in farmland covered with cement dust next to the company's fence. Keeping in view the altitudinal variations and feasibility of collection of samples, soil sampling was carried at different locations from the three randomly selected cement plants.

Control soil samples were collected at a distance of about 20 km from the cement industry where there was no record of cement dust pollution. At each cement industry two crops were selected for study i.e., red gram and sorghum and from each sampling location, known amount of soil samples were collected from surface and sub-surface at different spots of selected field. From all sampling sites were collected total no of 16 soil samples, including surface and sub-surface. The soil samples were collected in clean polythene bags, neatly labeled and brought to the laboratory for analysis.

Analysis of physico-chemical properties of soil

a. *Soil pH*

Soil pH was determined in 1:2.5 ratio soil water suspensions. This suspension was stirred intermittently for half an hour and pH was measured by potentiometric method using glass electrode [20].

b. *Electrical conductivity*

The Electrical Conductivity (EC) of soil was determined in the supernatant solution of 1:2.5 soils to water suspension using Conductivity Bridge and the results were expressed in dS/m [20].

c. *Organic carbon*

The organic carbon of the collected soils was determined by Wet Oxidation method and same was expressed in percentage [21].

Analysis of nutritional properties of soil

a. *Available nitrogen*

Available nitrogen was determined by alkaline potassium permanganate method using Kjeldhal flasks and calculated as Kg/ha [22].

b. *Available phosphorus*

Available phosphorus was determined by using Spectrophotometer at 660 nm wave length and calculated as Kg/ha [23].

c. *Available potassium*

Available Potassium was extracted with neutral normal ammonium acetate (pH 7.0). The quantity of potassium in the extractant was determined by flame photometry and calculated as Kg/ha [20].

d. *Available sulphur*

Available sulphur was estimated by Turbidometrically using UV spectrophotometer and calculated as mg/Kg [20].

e. *Calcium and magnesium*

Calcium and magnesium were estimated by Versanate titration EDTA (Ethylene diamine tetra acetic acid) method and expressed in Meq/100g [24].

f. *Micronutrients*

Iron, manganese, zinc and copper were determined using DTPA (Diethylenetriaminepentaacetic acid) extractant. The concentration of these elements in solution was determined by using atomic absorption spectrophotometer and expressed in ppm [25].

Isolation of microorganisms

Microbial communities in soils were typically assessed using plate count method for counting colony form of bacteria, actinobacteria and fungi by using serial dilution plate count technique [26].

Estimation of microbial population

After the incubation, the average colony forming units (CFU) per gram of soil sample from three replicate plates of bacteria, actinobacteria and fungi were counted and calculated by using the formula given below [26].

$$\text{Colony forming units (CFU)/gm. of soil} = \frac{\text{Average colony count} \times \text{Dilution factor}}{\text{Volume of inoculant}}$$

Table 1 Physico-chemical properties of cement industries dust polluted soil with redgram and sorghum crop

Plot No.	pH [1:2:5]	EC dS/m	OC%
CR1	7.8	0.3	0.72
CR2	8.0	0.4	0.60
CS1	7.8	0.3	0.72
CS2	8.0	0.4	0.69
KLR1	7.9	0.3	0.69
KLR2	8.4	0.3	0.63
KLS1	8.3	0.3	0.48
KLS2	8.2	0.3	0.57
CNR1	8.3	0.3	0.48
CNR2	8.3	0.3	0.60
CNS1	8.4	0.3	0.54
CNS2	8.1	0.2	0.78
SRR1	8.3	0.3	0.54
SRR2	8.3	0.3	0.69
SRS1	8.1	0.3	0.51
SRS2	8.0	0.4	0.81

EC- Electrtical Conductivity; OC-Organic Carbon; CR- Control redgram soil; CS- control sorghum soil; Cement industries names with crop field: KLR- Kalaburagi redgram soil; KLS- Kalaburagi sorghum soil; CNR- Chettinad redgram soil; CNS- Chettinad sorghum soil; SRR- Shree redgram soil; SRS- shree sorghum soil; 1-Surface soil; 2-Subsurface soil

RESULTS AND DISCUSSION

Physico-chemical and nutritional properties of cement industries dust polluted soil with redgram and sorghum crop

The study of physicochemical, nutritional and microbiological properties of selected agriculture field around cement industries has shown influence of cement dust on soil

[27]. Cement dust pollutants hardens the soil when mixed with water and it increases soil pH and it becomes alkaline [28]. The results of the physico-chemical analysis are represented in (Table 1). High pH was recorded in all cement dust polluted soils and ranged from 8.1 to 8.4. Ca in the cement dust in the form of oxide, hydroxide and carbonate formed lime that increased the soil pH. Similar findings were also reported by workers like [29-32]. Less pH was recorded in the soils of control field Nilahalli village 7.8 to 8.0, which is away from cement industry.

Table 2 Nutritional properties of cement industries dust polluted soil with redgram and sorghum crop

Plot No.	N Kg/ha	P Kg/ha	K Kg/ha	S Kg/ha	Ca Meq/100g	Mg Meq/10g	Zn PPM	Fe PPM	Cu PPM	Mn PPM
CR1	370	15.0	749	3.12	29.8	13.6	0.277	5.337	0.789	6.5177
CR2	370	25.0	614	5.47	26.4	19.4	0.276	4.865	0.751	5.866
CS1	381	42.0	724	3.25	29.6	14.6	0.303	5.332	0.746	6.744
CS2	358	25.0	647	4.56	35.0	9.8	0.245	5.050	0.578	5.950
KLR1	347	15.0	430	1.56	28.0	15.4	0.699	5.568	0.747	7.330
KLR2	314	15.0	486	7.81	35.16	13.0	0.586	5.558	0.746	6.986
KLS1	224	18.0	759	11.07	32.2	9.6	1.737	5.655	0.830	8.940
KLS2	336	19.0	430	4.69	26.0	14.2	0.304	6.614	0.854	7.888
CNR1	246	21.0	556	9.38	24.80	19.0	1.054	5.647	0.818	7.990
CNR2	360	42.0	437	6.12	38.8	7.0	0.298	5.608	0.777	7.551
CNS1	314	25.0	512	5.60	29.8	18.6	0.346	6.219	0.863	8.410
CNS2	414	22.0	590	6.77	25.6	17.0	0.352	5.785	0.789	7.762
SRR1	302	18.0	540	6.77	36.4	12.0	0.276	5.350	0.595	5.706
SRR2	369	19.0	664	6.25	32.8	14.0	0.306	5.431	0.745	6.661
SRS1	314	19.0	612	8.08	35.2	23.0	0.238	5.737	0.621	6.330
SRS2	571	19.0	560	6.77	35.6	6.40	0.224	5.514	0.590	5.896

N- Nitrogen; P- Phosphorous; K- Potassium, S- Sulphur; Ca- Calcium; Mg- Magnesium, Zn- Zinc; Fe- Iron; Cu- Copper; Mn- Manganese; CR-Control redgram soil; CS- control sorghum soil; Cement industries names with crop field: KLR- Kalaburagi redgram soil; KLS- Kalaburagi sorghum soil; CNR- Chettinad redgram soil; CNS- Chettinad sorghum soil; SRR- Shree redgram soil; SRS- Shree sorghum soil; 1- Surface soil; 2-Subsurface soil

The Electrical Conductivity determined in all soils ranged from 0.2 to 0.4 dS/m. High Organic Carbon was recorded in soils of control field in the ranged from 0.60 to 0.72%, whereas less was recorded in all cement polluted soils ranged from 0.48 to 0.81%.

The result of nutritional properties of soil is represented in (Table 2). The Nitrogen content of control field and cement polluted soils was within the permissible limit i.e., from 224 to 571 Kg/ha, followed by Phosphorus range from 15 to 42 Kg/ha. Content of potassium was high in control field soils i.e.; 614 to 724 Kg/ha and remaining soils were in the range of 430 to 759 Kg/ha. Calcium and magnesium these two elements shown maximum results in all soils from 24.80 to 38.8 Meq/100g and 7.0 to 23.0 Meq/100g respectively.

Zinc (Zn), iron (Fe), copper (Cu) and manganese (Mn) are micronutrients. Among these, zinc was found to be less in all the soil samples and ranged from 0.224 to 1.737 ppm. Iron, copper and manganese were recorded as maximum value in all soil samples of control field soils and cement polluted soils in the range from 4.865 to 6.614 ppm; 0.578 to 0.863 ppm and 5.706 to 8.940 ppm respectively.

Secondary nutrients calcium, magnesium and trace elements such as Cu, Fe, Mn was recorded as above the permissible limit [20-25] in the cement polluted soils. Calcium and Magnesium were recorded above the permissible limit and remaining elements were within the permissible limits.

Table 3 Physico-chemical properties of cement industries dust polluted soil without crop

Plot No.	pH [1:2:5]	EC dS/m	OC%
CR1	7.1	0.3	0.45
CR2	8.2	0.3	0.51
CS1	7.6	0.3	0.45
CS2	7.7	0.2	0.39
KLR1	7.6	0.2	0.57
KLR2	7.8	0.2	0.18
KLS1	8.0	0.5	0.39
KLS2	7.4	0.4	0.42
CNR1	7.5	0.4	0.57
CNR2	7.7	0.4	0.36
CNS1	7.7	0.4	0.39
CNS2	7.6	0.3	0.42
SRR1	7.7	0.4	0.30
SRR2	7.7	0.3	0.30
SRS1	8.1	0.3	0.87
SRS2	7.9	0.3	0.33

EC- Electrical Conductivity; OC-Organic Carbon; CR- Control redgram soil; CS- control sorghum soil; Cement industries names with crop field: KLR- Kalaburagi redgram soil; KLS- Kalaburagi sorghum soil; CNR- Chettinad redgram soil; CNS- Chettinad sorghum soil; SRR- Shree redgram soil; SRS- shree sorghum soil; 1-Surface soil; 2-Subsurface soil

Table 4 Nutritional properties of cement industries dust polluted soil without crop

Plot No.	N Kg/ha	P Kg/ha	K Kg/ha	S Kg/ha	Ca Meq/100g	Mg Meq/10g	Zn PPM	Fe PPM	Cu PPM	Mn PPM
CR1	246	52.0	244	8.86	48.0	18.6	0.060	5.970	1.865	8.519
CR2	358	59.0	335	7.55	48.6	9.60	0.124	1.727	0.780	2.624
CS1	224	45.0	295	5.99	48.4	15.8	0.027	1.530	0.677	2.481
CS2	246	16.0	268	9.25	61.8	5.20	0.058	1.572	0.932	1.782
KLR1	314	33.0	253	9.51	54.2	11.8	0.040	1.414	0.972	2.291
KLR2	202	58.0	259	19.54	47.0	18.6	0.065	1.480	1.172	3.621

KLS1	235	59.0	307	6.64	32.0	26.4	0.051	5.581	0.775	6.761
KLS2	258	30.0	247	7.55	26.8	32.2	0.041	5.669	0.751	5.536
CNR1	347	31.0	241	11.07	21.2	39.8	0.036	5.600	0.705	6.045
CNR2	235	45.0	242	5.73	23.0	31.8	0.030	5.708	0.674	4.679
CNS1	179	80.0	289	8.08	51.0	7.20	0.096	5.334	0.784	7.377
CNS2	414	56.0	277	12.12	51.8	6.00	0.045	5.872	0.674	5.304
SRR1	190	79.0	286	7.81	50.0	5.20	0.109	5.138	0.870	8.179
SRR2	213	50.0	257	5.47	48.2	14.4	0.079	5.801	0.871	7.570
SRS1	627	58.0	311	9.90	50.8	15.0	0.070	5.653	0.796	7.010
SRS2	235	52.0	322	9.90	53.6	12.4	0.056	6.069	0.852	8.210

N- Nitrogen; P- Phosphorous; K- Potassium, S- Sulphur; Ca- Calcium; Mg- Magnesium, Zn- Zinc; Fe- Iron; Cu- Copper; Mn- Manganese; CR- Control redgram soil; CS- control sorghum soil; Cement industries names with crop field: KLR- Kalaburagi redgram soil; KLS- Kalaburagi sorghum soil; CNR- Chettinad redgram soil; CNS- Chettinad sorghum soil; SRR- Shree redgram soil; SRS- shree sorghum soil; 1- Surface soil; 2-Subsurface soil

Microbial population

Data in (Table 5-6) shows the microbial counts of surface and subsurface soil of different cement industries and control field with crop of redgram and sorghum and without crop of redgram and sorghum. Microbial counts of bacteria, actinobacteria and fungi were high in surface soil than in subsurface soil. The control soils samples showed higher microbial population than from the cement dust polluted soils and our findings shown that surface soil has more microbial population compared with subsurface soil. This is concordance with the works of Maier [33] who reported that Surface soils have more microbial population than subsurface soils. This may be because of availability of nutrients and favorable conditions to the surface soil than the subsurface soil. Cement dust deposited surface soil causes unfavorable environment to the microbes and reduces the chances of survival of microbes. Fierer [34], reported that soil microbial population depleted as we dug deep into the soil. This may be because of quality and quantity of carbon substrate deplete as we go deep into the soil. Some previous studies reported that high mortality in both plants and animals which is exposed to cement dust. Toxic elements released from the burning process of cement production have been implicated a lot of health issues, multi-organ injuries and deaths [35].

Table 5 Microbial population of cement industries dust polluted soil with and without redgram crop

Cement industries	Surface soil (microbial count)						Subsurface soil (microbial count)					
	Bacterial count…x10^5		Actinobacteria count…x10^4		Fungi count…x10^3		Bacterial count…x10^5		Actinobacteria count…x10^4		Fungi count…x10^3	
	With and without crop		With and without crop		With and without crop		With and without crop		With and without crop		With and without crop	
Kalaburagi	49	2	11	1	7	2	51	5	26	6	-	1
Chettinad	68	3	3	3	7	2	38	8	10	4	-	2
Shree	51	6	11	3	-	5	14	2	4	4	-	5
Control	74	36	3	5	10	7	>50	6	-	5	<30	6

Table 6 Microbial population of cement industries dust polluted soil with and without sorghum crop

Cement industries	Surface soil (microbial count)						Subsurface soil (microbial count)					
	Bacterial count…x10^5		Actinobacteria count…x10^4		Fungi count…x10^3		Bacterial count…x10^5		Actinobacteria count…x10^4		Fungi count…x10^3	
	With and without crop		With and without crop		With and without crop		With and without crop		With and without crop		With and without crop	
Kalaburagi	45	6	2	2	2	6	27	5	-	-	2	1
Chettinad	59	4	3	-	5	3	68	7	8	1	6	2
Shree	5	6	2	2	-	6	2	6	14	6	-	4
Control	86	30	8	4	17	-	19	17	7	-	9	-

CONCLUSION

In the present investigation, the impact of cement industries dust on the properties of soil and the microbial population of agriculture fields, around three different industries were analyzed. The investigation revealed less microbial population in the cement industries dust influenced soil. The natural addition of cement industries dust in the nearby agriculture fields can be the cause for the adverse effect on microbial population. The chemical components of cement industries dust could be the major attribute to affect the microbial population of soil. It is concluded that cement industries dust can reduce the soil fertility by altering the important physico-chemical and nutritional properties of soil. Further research should be carried out effect of cement dust on rhizosphere microorganisms need to be conducted.

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