

IMPACT OF CEMENT DUST ON PHYSICO-CHEMICAL PROPERTIES OF SOILS AROUND A CEMENT FACTORY IN BAGALKOT, KARNATAKA, INDIA.

ABSTRACT

Aims: To study the physico-chemical properties of soil around the cement factory, to examine the effect of the industrial dust on the soil properties and to analyse the relation between the proportion of pollutants and the distance from the cement factory.

Study design: To achieve the goal, we used simple statistical methods like percentage and graphs. Along with these, Pearson correlation method is made use of to analyse the relation between concentration of different elements in the soil samples and distances in four directions.

Place and Duration of Study: For the purpose of determining physico-chemical properties of the soils, samples have been collected from around the J k Cement factory near Muddhapura of Mudhol Taluk of Bagalkot district in the pre monsoon period at four directions. Further, the samples have been tested by Titration Method, Titrant Method, Flame photometer method, Oslen method is used to determine physico-chemical properties. Along with these, Pearson correlation method is made use of to analyse the relation between concentration of different elements in the soil samples and distances in four directions.

Results: Analysis of these samples showed that there is considerable increase in concentration of many chemicals around the cement factory. It can be observed that majority of correlations are negative implying that their concentration decreases with increasing distances. Major elements, among these are P, Ca, and Mg etc. However, there are some exceptions such as OC, N, S, Na, Zn, and Fe whose concentration in the soil samples increase with increase in distances in all directions. Since their correlation with distance is positive and significant since the P-value is less than 0.05.

Conclusion: In the present study, it has been established that the physico-chemical properties of the soils around the factory have been changed due to the dust deposition as it is adversely affecting the composition of soils. This in turn affects the concentration of nutrients required for plants growth. Further, it may become hazardous to soil, flora and fauna.

Keywords: physico-chemical, proportion, pollutants, correlation

1. INTRODUCTION

Cement industries are considered as highly polluting industries by the Central Pollution Control Board (CPCB) as they are causing all the three types of pollution viz. air, water and soil pollution. The dust emitted from cement plants are of two categories. They are cement and clinker dust which contain cement mineral compounds (Crolius, 1992). The second category is the raw mill and percipitate dust that have not been calcined and they contain calcium carbonates, oxides of iron, sillicon, aluminium, magnesium and other minor elements (Maina, 2013).

The previous studies show that cement dust is major pollutant of soil. The pollutants are emitted at every stage of the manufacturing process, including extraction of the raw materials, crushing, Production etc. (Okoro, Orimolade, Adebayo and Akande, 2017.) The dust emitted from the cement factories is usually deposited around the factories. Concentration of the dust goes on decreasing as we move away from the factory. The concentration of dust is higher corresponding to the dominant direction of wind i.e south-west to north-east in the study area. Cement dust chnages elemental concentration of soil and also changes its physicochemical properties(Khamparia, Chattergee and Sharma, 2012). Change in properties of soils due to deposition of the dust adversely affects not only soils but also plants and animals.

The study area constitutes a part of the Deccan plateau of Karnataka State in India and covered by black soils which are rich in iron, lime and magnesium carbonate but poor in phosphorus, nitrogen and organic matter. But the soils around the factory have lost their original properties due the dust deposition. Therefore, there is a need for monitoring and evaluation of the cement manufacturing industries in order to mitigate the cement dust. Thus, the present study makes an attempt to analyse the impact of cement dust deposition on some elemental physico-chemical properties of soil cover in the vicinity of JK cement factory of Bagalkot district.

2. Material and methods

For the purpose of determining physico-chemical properties of the soils, 16 top soil samples from the depth of 0-15 cm. from various distances such as 0.25 km, 0.5 km, 0.75 km and 1km in four directions viz. South-west, south-east, north-west and north-east have been collected from the study area in the pre

monsoon period in which south-west monsoon winds are dominant. Further, the samples have been tested by Titration Method, technique where a solution of known concentration is used to determine the concentration of an unknown solution. The concentration of the unknown is determined by the volume of titrant. And to determine the concentration of certain metal ions viz. sodium, potassium, lithium, and calcium flame photometer is used. It is a controlled flame test with the intensity of the flame colour quantified by photoelectric circuitry.

While, Oslen method is used to determine the relative bioavailability of ortho-phosphate in soils. Along with these, Pearson correlation method is made use of to analyse the relation between concentration of different elements in the soil samples and distances in four directions.

3. The aim of this paper will be achieved with the following objectives:

1. To study the physico-chemical properties of soil around the cement factory
2. To examine the effect of the industrial dust on the soil properties.
3. To analyse the relation between the proportion of pollutants and the distance from the cement factory

4. Study Area

The district of Bagalkot is situated entirely on the North Karnataka Plateau, which is part of the Deccan Plateau and Located in north-central Karnataka, Bagalkot is surrounded by Belgaum District to the west, Bijapur District and Kalburgi District to the north and north-east, Raichur District to the east and Koppal, Gadag and Dharwad Districts to the south-east, south and south-west respectively.

It is positioned at $16^{\circ}12'N$ $75^{\circ}45'E$ and covers an area of 6593 km². Bagalkot district has six taluks- Bagalkot, Badami, Hunagunda, Mudhol, Jamkhandi, Bilgi. According to the 2011 census Bagalkot district has a population of 18, 90,826, the district has a population density of 288 inhabitants per square kilometre. There are six cement industries in Bagalkot district which are located at various places such as Mudhol, Lokapur, Bilagi and Bagalkot. The JK Company established a cement industry at Muddhapura of Mudhol Taluk In the year 2005. The cement plant is located at the distance of 20 km from taluk head quarters Mudhol.

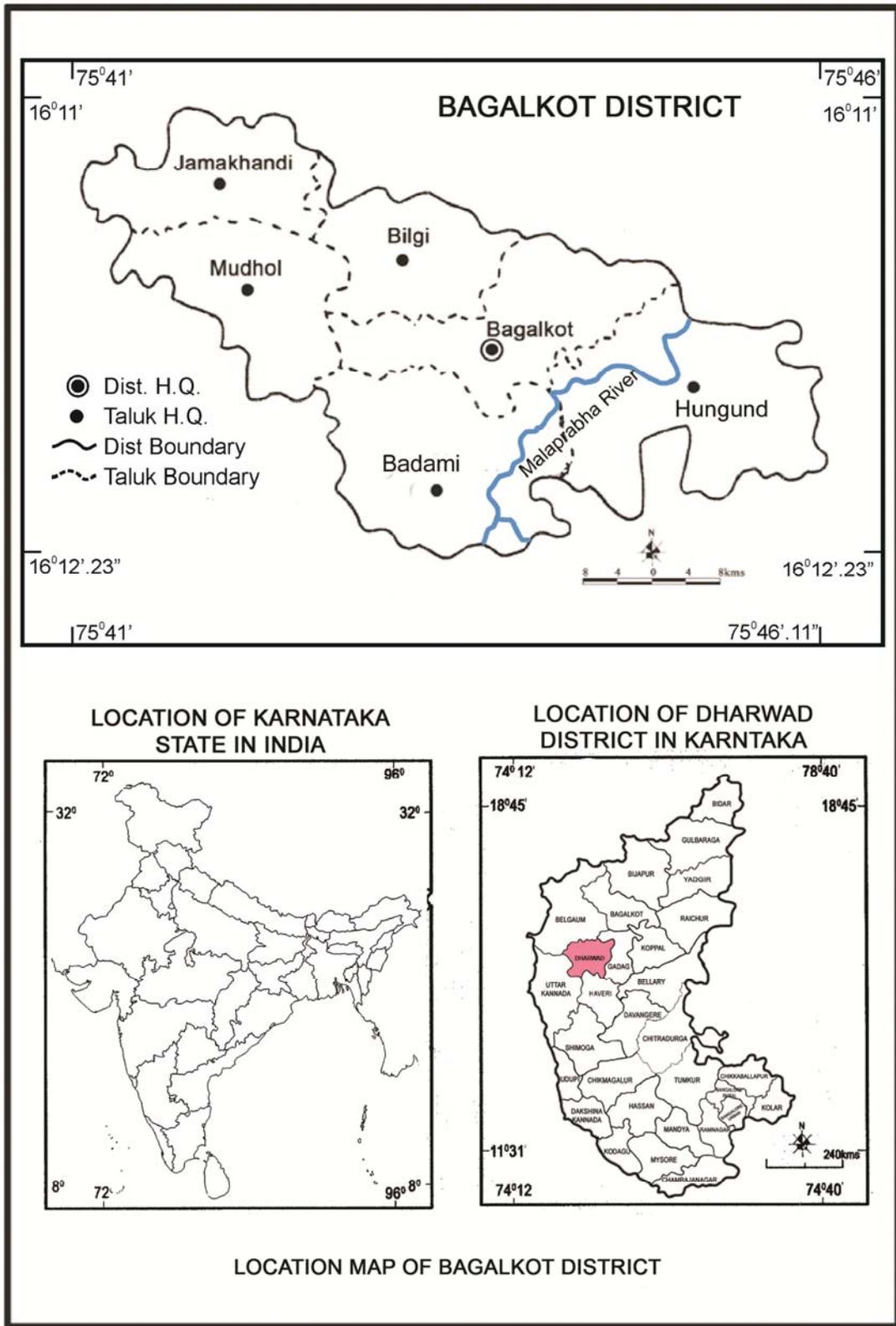


Fig. 1

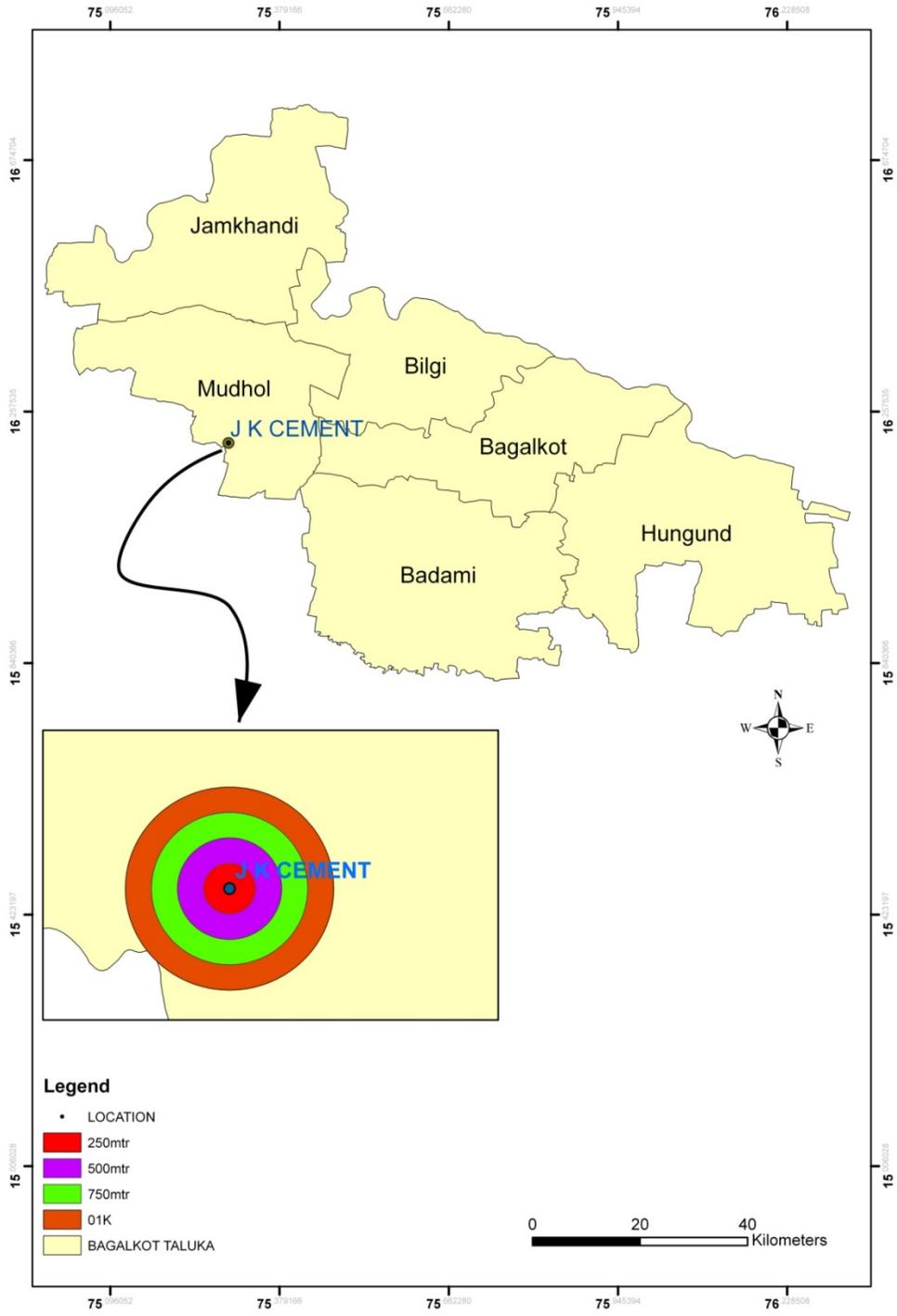


Fig. 02
LOCATION OF JK CEMENT FACTORY, MUDHOL, BAGALKOT DISTRICT

Table 1. Physicochemical properties of soil and Methods

SI No	Elements	Abbreviation of Elements	Methods	Measurements
01	pH	Potential Hydrogen	pH meter	
02	EC	Electrical Conductivity	Conductivity meter	
03	OC	Organic Carbon	Titration Method	g.kg-
04	N	Nitrogen	Kjeldas Method	kg/ha(kilo gram per hectare)
05	P	Phosphorous	Olsen Method	kg/ha(kilo gram per hectare)
06	K	Potassium	Flame photometer	kg/ha(kilo gram per hectare)
07	S	Sulphur	Turbidimetric Method	kg/ha(kilo gram per hectare)
08	Na	Sodium	Flame photometer	me/100gm (milli equivalents per 100 gram)
09	Ca	Calcium	Titration Method	me/100gm (milli equivalents per 100 gram)
10	Mg	Magnesium	Titration Method	me/100gm (milli equivalents per 100 gram)
11	Zn	Zink	DTPA Extract (AAS)	ppm(parts per million)
12	Fe	Iron	DTPA Extract (AAS)	ppm (parts per million)
13	Mn	Manganese	DTPA Extract (AAS)	ppm(parts per million)
14	Cu	Copper	DTPA Extract (AAS)	ppm (parts per million)
15	CaCO3	Calcium Carbonate	Titration Method	me/100gm(milli equivalents per 100 gram)

Source:APHA

Table .02 Physico-chemical properties of the Soils with average distance from the factory

Elements of Soil (Units)		pH	EC	OC g.kg-	N Kg/ha	P Kg/ha	K Kg/ha	S Kg/ha	Na Me/100 gm	Ca Me/100 gm	Mg Me/100gm	Zn ppm	Fe ppm	Mn ppm	Cu ppm	CaCO ₃ Me/100gm
SI No	Directions															
01	SE 0.25 km	8.76	0.826	2.95	175.2	26.17	580	78.25	2.23	60.2	11.2	6.253	1.110	5.365	0.478	7.25
02	NE 0.25 km	9.01	0.868	3.01	178.6	27.08	590	80	2.02	70.1	12.1	5.894	1.235	5.231	0.480	8.82
03	SW 0.25 km	8.90	0.900	2.98	187	34.15	595	79	2.26	69.3	10.5	6.145	1.125	6.125	0.476	9.23
04	NW 0.25 km	8.08	0.896	2.69	168	38.06	585	78	2.01	89.1	12.1	5.985	1.121	6.789	0.470	8.96
Average	0.25 km	8.68	0.872	2.90	177.2	31.36	587.5	78.81	2.13	72.17	11.47	6.06	1.396	5.87	0.476	8.565
05	SE 0.5 km	8.53	0.557	3.25	180.1	15.15	484	98.21	1.21	59.3	9.8	7.213	1.125	6.013	0.414	5.15
06	NE 0.5 km	8.08	0.875	4.23	189.3	28.15	580	95.21	2.01	68.3	10.3	6.868	1.258	6.321	0.344	7.51
07	SW 0.5 km	7.03	0.557	3.12	192	25.15	584	86	2.12	64.2	9.3	7.148	1.236	7.154	0.414	8.12
08	NW 0.5 km	7.5	0.597	4.12	196	37.15	484	94	1.92	70.1	11.5	6.546	1.563	7.125	0.412	8.14
Average	0.5 km	7.78	0.646	3.68	189.27	26.48	533	93.35	1.81	65.47	10.22	7.94	1.35	6.653	0.396	7.23
09	SE 0.75 km	8.58	0.249	4.12	195.1	13.75	528	123.27	1.11	57.8	7.6	8.124	1.564	7.546	0.356	4.12
10	NE 0.75 km	8.03	0.489	4.89	198.1	26.12	576	124.41	1.82	59.1	9.8	7.213	1.564	7.122	0.339	6.23
11	SW 0.75 km	7.65	0.498	3.96	231	16.2	545	102.1	1.78	59.1	8.8	9.123	1.568	8.369	0.400	7.52
12	NW 0.75 km	7.0	0.586	4.23	210	25.12	463	125	1.68	71.2	9.2	7.898	1.894	8.965	0.408	7.36
Average	0.75 km	7.81	0.911	4.3	208	20.29	528	118.69	1.59	61.8	8.85	8.08	1.647	8.005	0.375	6.24
13	SE 1.km	8.01	0.311	4.45	220.3	15.57	480	145.32	0.48	54.1	6.7	9.546	1.989	8.365	0.476	3.05
14	NE 1.km	7.5	0.462	5.32	225.1	22.11	578	156.12	1.52	56.2	7.1	9.258	1.898	9.325	0.441	5.62
15	SW 1.km	7.25	0.451	4.85	245	15.00	456	126	1.63	57.8	7.1	9.895	2.102	9.621	0.368	5.65
16	NW 1.km	6.5	0.559	5.14	245	26.00	459	148	1.52	64.2	7.2	8.986	2.125	9.125	0.396	5.56
Average	1 km	7.31	0.445	4.94	223.25	22.54	520.75	127.53	1.67	62.05	7.02	8.50	2.02	8.32	0.141	6.41

Source: Lab report (This table shows the value of physicochemical properties in soil samples below 15 cm.)

5. RESULTS AND DISCUSSION

Analysis of these samples showed that there is considerable increase in concentration of many chemicals around the cement factory. Table no. 2 shows that mean concentration of different elements at various distances from the cement factory, while the third table reveals the correlation of concentration of elements in the soil samples over different distances in all directions. It can be observed that majority of correlations are negative implying that their concentration decreases with increasing distances. Major elements, among these are P, Ca, Mg etc.

However, there are some exceptions such as OC, N, S, Na, Zn, and Fe whose concentration in the soil samples increase with increase in distances in all directions. Since their correlation with distance is positive and significant since the P-value is less than 0.05

Table No.03 Pearson correlation between concentration of elements and distance

Elements	Distance	
	Pearson Correlations	p-value
pH	-0.882	0.118
EC	-0.606	0.394
OC	0.999	0.001
N	0.997	0.003
P	-0.868	0.132
K	-0.868	0.132
S	0.985	0.015
Na	0.153	0.847
Ca	-0.909	0.091
Mg	-0.983	0.017
Zn	0.889	0.111
Fe	0.803	0.197
Mn	0.977	0.023
Cu	-0.919	0.081
CaCO ₃	-0.907	0.093

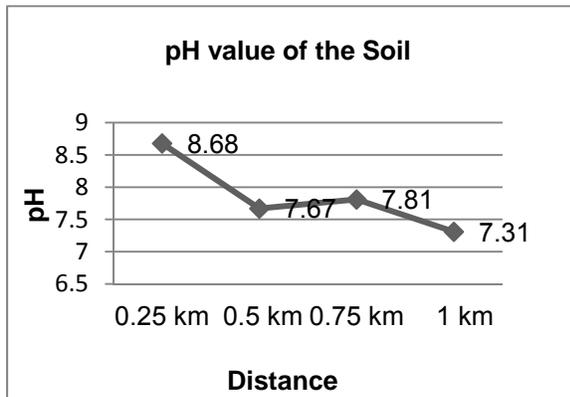


Fig .03

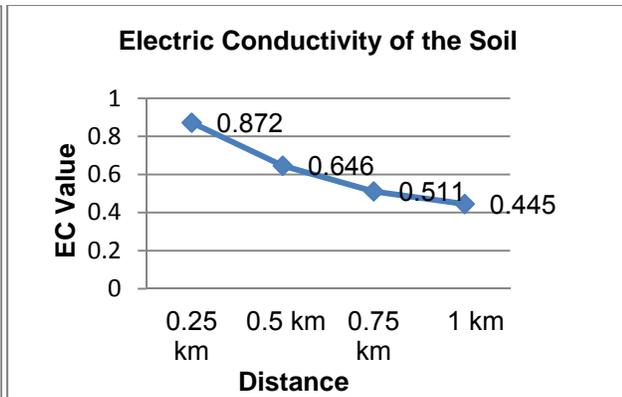


Fig .04

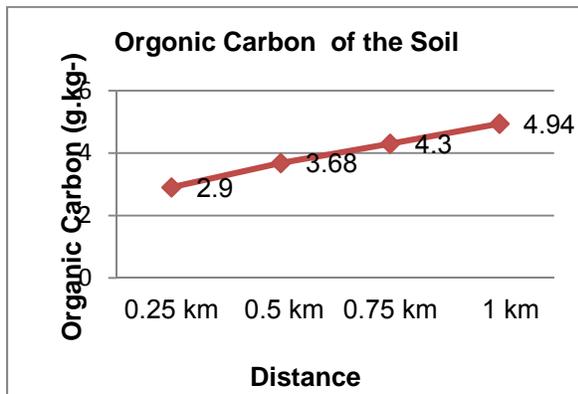


Fig .05

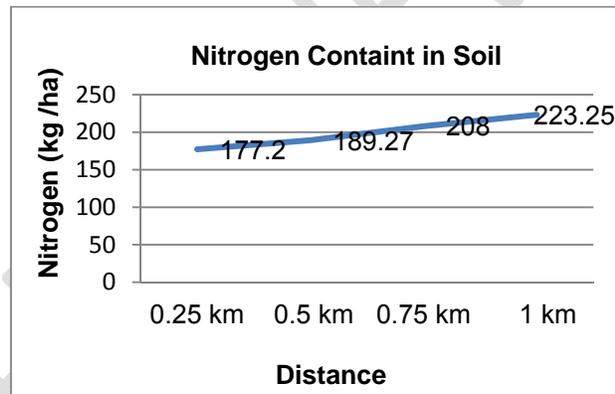


Fig .06

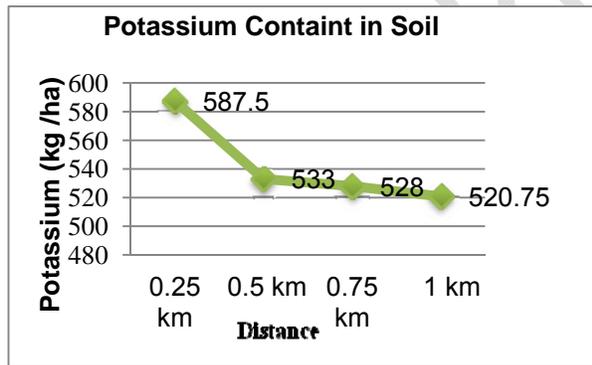


Fig .07

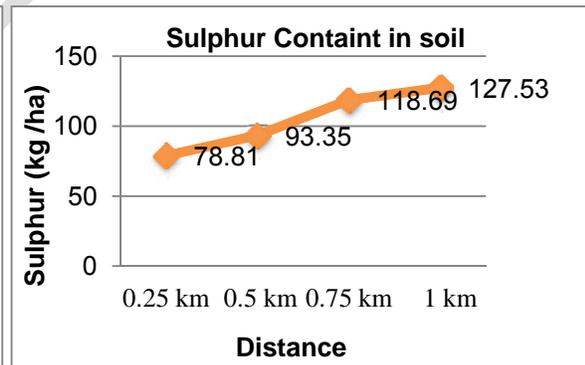


Fig .08

Potential Hydrogen (pH) :

Statistics of the pH analysis of different soil samples are given in table no 2. The most significant of the soil is its pH level. If the pH is less than 6 then it is said to be an acidic soil, the pH range from 6-7 it's a normal soil and greater than 7 then it is said to be alkaline soil. It varied from 7.31 to 8.68 in the

study area. Hence, soil was found to be alkaline type, pH value is declining with the increase of distance. These results indicating that the soils around the cement plant were alkaline in reaction with cement dust. The soil pH was 8.68 at 0.25 km. it decreased gradually to 7.67 at 0.5 km. and it was 7.81 at 750 meter and 7.31 at 1 km. distance (Fig.1). There was significant decrease in the soil pH up to the increasing distance of 1 km from the cement plant. **(Fig. 03)**

The Pearson Correlation between pH and distance is -0.882 with a p-value of 0.118. Even though, the correlation value is strong and it is negative since the p-value is greater than 0.05 we may conclude that the relation is non-significant.

Electric Conductivity (EC):

Electric Conductivity measures the ions present in solution. The electrical conductivity of soil solution increases with the increased concentration of ions. It is used to check the quality of soil. Here Electric Conductivity increased from 0.445, to 0.911 at 1 km to 0.75 km distance from cement factory and 0.646 at 0.5 km and 0.872 at 0.25 km (250 meter) distance from the cement manufacturing unit indicating the effect on soluble salt content of the soil. **(Fig. 04)**

The Pearson Correlation between EC and distances is -0.606 with a p-value of 0.394. Even though the correlation value is strong and it is negative. Since the p-value is greater than 0.05 we may conclude that the relation is non-significant.

Organic Carbon (Oc):

Soil Organic Carbon is a significant property of the soils. If the soil is deficient organic matter it enhances the process of soil erosion. The soil is rich in organic matter is highly useful for the agricultural practices. The data clearly showed continuous decrease in organic carbon content from 4.94 (g.kg-) at 1 km distance, 4.3 (g.kg-) 750 meter, and 3.68 (g.kg-) at 500 meter and finally 2.90 (g.kg-) at 250 meter distance from the cement factory. It confirms the trend of organic carbon content in polluted area. On the basis of above results it can be concluded that the contents of cement dust highly affected the properties of soil. **(Fig. 05)**

The Pearson Correlation between OC and distances is 0.999 with a p-value of 0.001. Since the correlation is positive and it is significant since the p-value is 0.001 which is less than 0.05 we may conclude that there is positive and statistically significant correlation between OC and distances.

Nitrogen (N):

Nitrogen is a most significant manure element in the soils. Plants react quickly to use of nitrogen salts. This component encourages exceeding ground vegetation growth and gives a deep green color to the leaves. It is the most essential nutrient required by plant for proper growth and development.

The result shows that, the availability of Nitrogen in collected soil is 223.25 kg /hectare at the distance of 1 km from the cement industry and its continuously decreasing 208 kg /hectare at 750 meter, 189.27 kg /hectare at 500 meter and finally 177 .2 kg /hectare 250 meter at the distance from the cement factory. It showed a clear trend of reduction in total Nitrogen content in soil with decreasing distance. **(Fig. 06)**

The Pearson Correlation between N and distances is 0.997 with a p-value of 0.003. Since the correlation is positive and it is significant since the p-value is 0.003 which is less than 0.05. We may conclude that there is positive and statistically significant correlation between N and distances. This implies that as the distance from cement factory increases the concentration of N in soil samples also increases.

Potassium (K):

Potassium is also one of the major elements in plants components and it is useful for growth of every plants. The normal preparation of potassium in soils is 110 kg/ha to 280 kg/ha. But more concentration of potassium content found near the cement industry because of cement dust.

Here the total potassium content of the soil is 520.75 kg/hectare at 1 km distance from the cement factory and increasing trend were continued like 528 kg/hectare at 750 meter and 533 kg/hectare at 0.5 km and finally near the factory means at the distance of 0.25 km high potassium were found 587.5 kg/hectare because of cement dust. **(Fig. 07)**

The Correlation between K and distances from the factory is -0.868 with a p-value of 0.132. Even though the correlation value is strong and it is negative. Since the p-value is greater than 0.05. Thus, the relation is non-significant.

Sulphur (S):

The Normal Range of sulphur content in soil is 20 kg/hectare to 40 kg/hectare. Here the samples of soil in the study area show the high sulphur content and we have seen high concentration of sulphur in soils and its increasing trend with increasing distance from the factory.

At the distance of 0.25 km sulphur content of soils is 78.81 kg/hectare and its increases to 93.35 kg/hectare at 0.5 km distance, and 118.69 kg/hectare and 127.53 kg / hectare at the distance of 0.75 km and 1 km distance respectively from the cement factory. **(Fig. 08)**

The Correlation between Sulphur and distances from the factory is 0.985 with a p-value of 0.015. Since the correlation is positive and it is significant since the p-value is 0.001 which is less than 0.05 we may conclude that there is positive and statistically significant correlation between concentration of Sulphur in the soil samples and distances.

Sodium (Na):

The Normal Range of sodium content in the soil is 1.00 me/100gm to 1.5 me/100gm (milli equivalents per 100 gram). As per the lab report, soils of the study area have more sodium content compared to the normal range of sodium content in soils.

Sodium content of soils in the study area is has 2.13 me/100gm at the distance of 0.25 km. It has shown higher concentration of sodium near the cement factory. And its goes on decreasing with the increasing distance. At the distance of 0.5 km and 0.75 km the concentration of sodium is 1.81 me/100gm and 1.59 me/100gm respectively. **(Fig. 09)** Correlation between concentration of Na in the soil samples and distances from the factory is 0.153 with a p-value of 0.847. Even though the correlation value is strong and it is positive as the relationship is non-significant.

Calcium (Ca):

Normally concentration of calcium in the soil ranges from 10 to 30 me/100gm (milli equivalents per 100 gram). Calcium content in soils near the factory is showing high concentration because of cement dust and its continuously decreasing away from cement factory. At the distance of 0.25 km calcium content is 72.17 me/100gm. 65.47 me/100gm calcium content is found at the distance of 0.5 km. At the distance of 0.75 km and 1 km from cement factory calcium content of soils is 61.8 me/100gm and 62.05 me/100gm respectively. **(Fig. 10)**

Correlation between concentration of Ca in soil samples and distances from the factory is -0.909 with a p-value of 0.091. This indicates that the relationship is non-significant.

Magnesium (Mg):

The magnesium content of soils in the study area is having more concentration of magnesium compare to normal range of magnesium content in soils. The normal range of magnesium content in soils is 3 to 10 me/100gm. In study area at the distance of 0.25 km from the cement factory the concentration of magnesium is 11.47 me/100gm and 10.22 me/100gm at the distance of 0.5 km. 8.85 me/100gm and 8.37 me/100gm at the distance of 0.75 and 1 km distance from cement factory respectively. **(Fig. 11)**

Correlation between concentration of Mg in soil samples and distances from the factory is -0.983 with a p-value of 0.017. Since the correlation is positive and it is significant since the p-value is 0.001 which makes it clear that there is negative and statistically significant correlation between concentration of magnesium in the soil samples and distances. This implies that as the distance from cement factory increase the concentration of Mg in soil samples decreases.

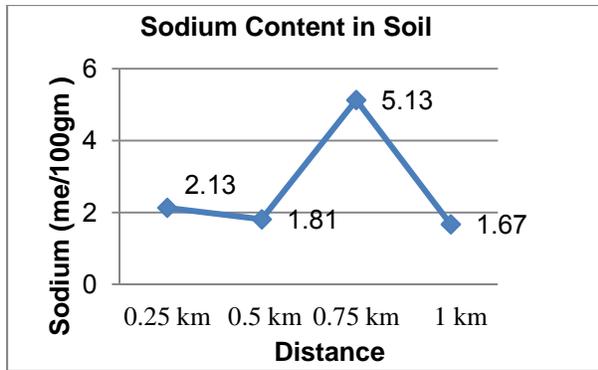


Fig. 09

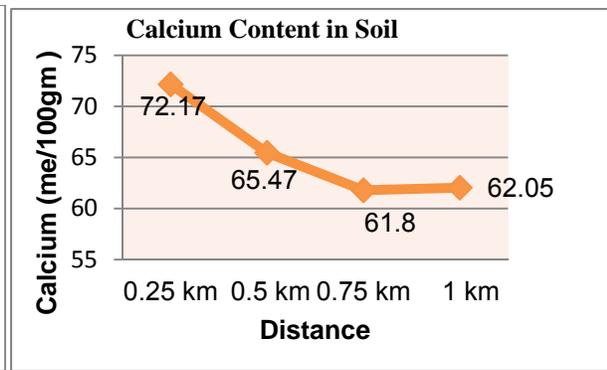


Fig. 10

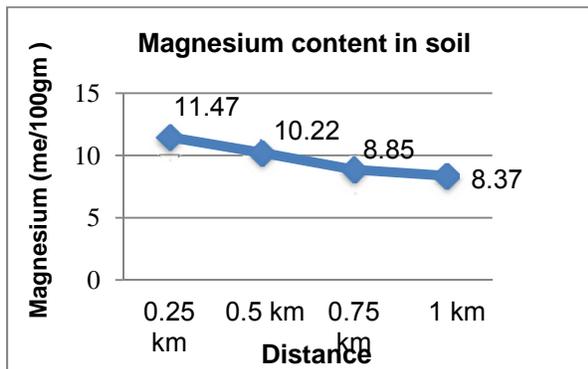


Fig.11

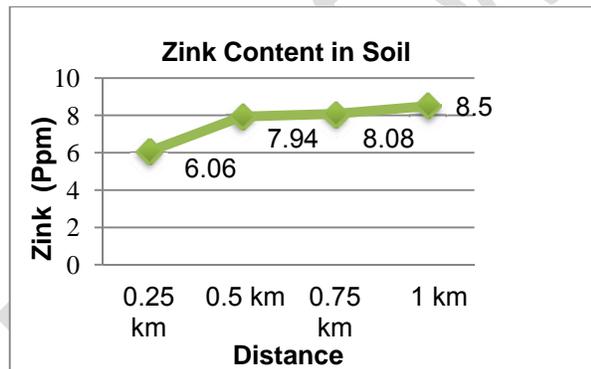


Fig.12

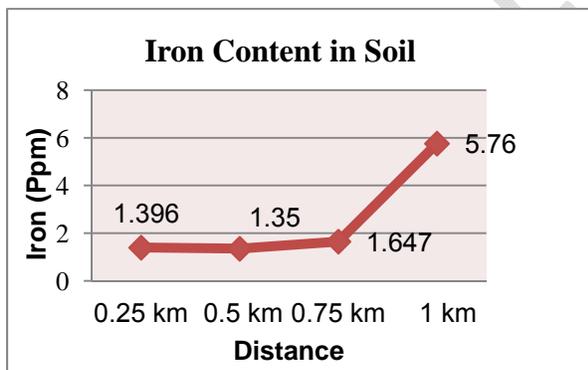


Fig.13

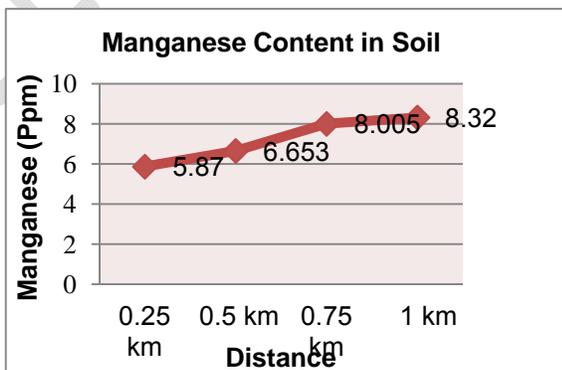


Fig.14

Zink (Zn):

Zink is one of the major micronutrient elements in soils, it is play vital role in plants growth. In the study area soils are having sufficient Zink content. But the soils have lost concentration of Zink near the cement industry. The normal range of Zink content in soils is 0.6 ppm to 6.5 ppm. Ppm (Parts per million).

The Zinc content of soils in study area is 6.06 ppm at the distance of 0.25 km from the cement industry. Here it is showing increasing trend with increasing distance from cement factory. At the distance 0.5 km the concentration of Zinc is 7.94 ppm and 8.08 ppm at the distance of 0.75 km. finally the concentration of Zinc content in soils is 8.50 ppm at the distance of 1 km from factory. **(Fig. 12)**

Correlation between concentration of Zn in the soil samples and distances from the factory is 0.889 with a p-value of 0.111. Though the correlation value is strong and it is positive as the p-value is greater than 0.05 the relationship is non-significant.

Iron (Fe):

Ferrous content is one of most essential micronutrient element for plant development. The moderate concentration of iron is good for plants but the study area soils have lesser concentration of iron. If the concentration of iron in soils less than 2.5 ppm, they are called as Non Calcareous soils and if its concentration is more than 4.5 ppm, they are called Calcareous soils.

The study area has Non Calcareous soils as its concentration of iron is 1.396 ppm at the near the factory 0.25 km distance. At the distance of 0.5 km and 0.75 km the concentration of iron is 1.35 ppm and 1.647 ppm respectively, and finally the concentration of iron in soils is increasing suddenly as 5.76 ppm at the distance of 1 km from cement industry. Correlation between concentration of Fe in the soil samples and distances from the factory is 0.803 with a p-value of 0.197. This is also showing non-significant relationship. **(Fig. 13)**

Manganese (Mn):

Manganese is also one of the major micronutrients in the soil. The soils which have 28.46 ppm are better for growth and development of plants. But the concentration of manganese is lower in the soils of the study area.

Here the manganese concentration of soils is 5.87 ppm at the distance of 0.25 km from the factory and its concentration increases away from the cement industry. At the distance of 0.5 km and 0.75 km the concentration of manganese in soils is 6.653 ppm and 8.005 ppm respectively and 8.32 ppm

concentration of manganese in soils is found at the distance of 1 km from the factory. This implies that as the distance from cement factory increases the concentration of Mn in soil samples also increases (**Fig. 14**)

Correlation between concentration of manganese in soil samples and distances from the factory is 0.977 with a p-value of 0.023. Since the correlation is positive and it is significant since the p-value is 0.023 which is less than 0.05 which shows positive and statistically significant correlation.

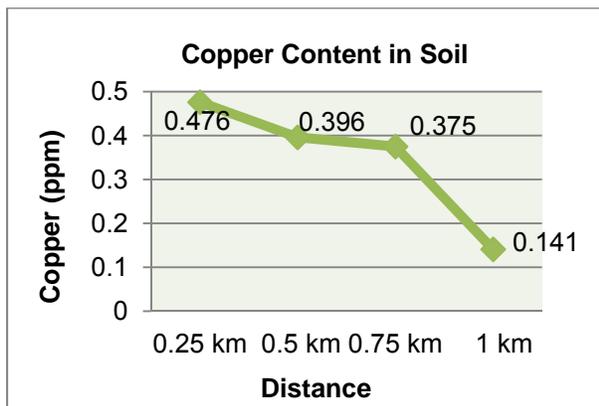


Fig.15

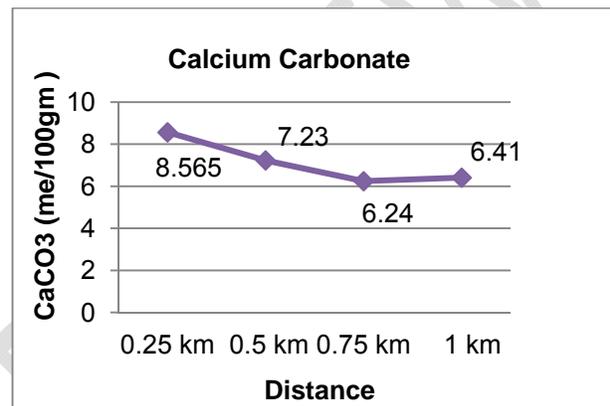


Fig.16

Copper (Cu):

Copper is also one of the essential micronutrients of soils like Zn, Fe, Mn. The concentration of copper in study area soils is 0.476 ppm at the distance of 0.25 km from cement factory. At the distance of 0.5 km and 0.75 km from the cement industry the concentration of copper in soils is 0.396 ppm and 0.375 ppm respectively and finally 0.141 ppm concentration of copper found at the distance of 1 km from cement industry. Thus, it goes on decreasing away from the factory. (**Fig. 15**)

Correlation between concentration of Cu in soil samples and distances from the factory is -0.919 with a p-value of 0.081. This shows non-significant relationship.

Calcium Carbonate (CaCO₃):

Calcium Carbonate is one of the most important elements in soils, it is essential for every plant. But high concentration of Calcium Carbonate in soils results into alkaline soils. Its maximum

concentration is found near the factory due to fall of dust on soils. At the distance of 0.25 km the concentration of CaCO₃ is 8.56me/100gm (milli equivalents per 100 gram). 7.23 me/100gm and 6.24 me/100gm concentration of CaCO₃ is found at the distance of 0.5km and 0.75 km from the cement industry respectively. And 6.41 me/100gm concentration of CaCO₃ is found at the distance of 1 km from cement factory. It shows that concentration of calcium carbonates decreases with increasing distance.

(Fig. 16)

Correlation between concentration of CaCO₃ in soil samples and distances from the factory is - 0.907 with a p-value of 0.093. This is also showing non-significant relationship.

Conclusion

In the present study, it has been established that the physico-chemical properties of the soils around the factory have been changed due to the dust deposition as it is adversely affecting the composition soils. This in turn affecting the concentration of nutrients required for plants growth. Further, it may become hazardous to soil, flora and fauna. As such, the factory management has not initiated any measures to reduce the dust emission. Therefore, government has to take proper action against the factory which may force the management to make efforts to minimise the dust emission. Further, people living around the factory have to be educated about effects of dust deposition on their fields and houses so that they could be cautious about it.

6. References

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