American-Eurasian J. Agric. & Environ. Sci., 11 (6): 840-846, 2011
ISSN 1818-6769

Impact of Cement Dust on Some Soil Properties Around the Cement Factory in Al-Hasa Oasis, Saudi Arabia

Abdulrasoul M. Al-Omran, Salem E. El-Maghraby,
Mahmoud E.A. Nadeem, Ali M. El-Eter and Salem M.I. Al-Qahtani

Department of Soil Sciences, King Saud University,
College of Food and Agricultural Sciences, P.O. Box 2460, Riyadh 11451, Kingdom of Saudi Arabia

Abstract: Eighty composite soil samples were collected from a transect of 6 km long (50 -100 m apart). The study area comprises the vicinity of cement factory in Al-Hasa Oasis, Saudi Arabia (emissions source) up to the Al Oyoun City which is located at (25° 41' 08° N), (49° 31'29.9° E). At each site, samples were collected at two soil depths (0- 5 and 20-30 cm). The collected soil samples were analyzed for their chemical properties as well as their heavy metals content. The results indicated that the soils of the studying area are calcareous in nature having 22.1 to 35.5% $CaCO_3$, sandy loam to loamy sand in texture and moderately to slightly alkaline (with mean pH 7.8). Exchangeable calcium contents ranged from (1.47 to 5.44 c.mol.kg^{-1}) while the mean values of exchangeable potassium reached 0.32 cmol.kg^{-1}. The effective cation exchange capacity (CEC) was low to medium (1.94 to 8.14 cmol.kg^{-1}). The CaO percentages were found to be higher (37.7%) especially in the surface soil samples taken near the cement factory. Based on the geo- accumulation index, the soils of the study area could be classified as moderately to heavily contaminated with (As, Cd, Pb and Ni) and heavily contaminated with Cr while the soils of study area were moderately polluted with Zn. On the other hand, based on the Enrichment factor (EF) the soils of the study area are a significantly contaminated with As, Cd and Cu (5> EF >20). The most contaminated sites area found within the 0 to 2 km of the cement factory.

Key words: Cement factory · Enrichment factor (EF) · Geo-accumulation index · Heavy metals pollution · Physiochemical properties of the Soil and Pollution index

INTRODUCTION

Al-Hasa Oasis is located in eastern - south of Saudi Arabia about 65 km from the Arabian Gulf with an area of about 120 km^2 with a population of more than one million person. It is bounded by the Ad-Dahna deserts. Agriculture remains the central economic activity of the people of oasis and irrigated with more than 60 artesian wells and more than 1000 pumped wells. Around three million date palms produce wide ranges of varieties of high quality of date. Among the other crops rice, citrus and other fruits and alfalfa are preeminent. Farmers of the area are also involved in rising of livestock like sheep, goats, cattle and camels. Egg farms also, make Al-Hasa one of the major Saudi food producers. Al-Hasa also has some industries producing cement and plastics, in addition to more traditional small-scale industries.

Air pollution has become a serious problem in recent times due to rapid growth of thermal power stations, cement factories, steel and coal industries. In comparison to gaseous pollutants, relatively little is known about the effects of particulate pollutants on vegetation, soil microbial population and other soil properties [1-4]. The impact of the cement dust on soil properties and plant production has been investigated by some researchers [5-9]. The determination of soil chemical and physical properties and heavy metals component are very important parameters in monitoring environmental pollution. In this respect, Ibanga *et al.*, [9] reported that moderately to slightly acidic (pH 5.8) was found on the cement affected sites. Exchangeable Ca contents were moderate to high (3.02-7.44 cmol.kg^{-1}) and medium to high exchangeable Na (0.27-138 cmol.kg^{-1}) in the soils around the cement factory in Nigeria. Also Asadu and Agada,

Corresponding Author: Abdulrasoul M. Al-Omran, Department of Soil Sciences, King Saud University, College of Food and Agricultural Sciences, P.O. Box. 2460, Riyadh 11451, Kingdom of Saudi Arabia.

[10] studied the effect of cement dust after a period of 25 years of cement production on soil physiochemical properties. This study showed that exchangeable Ca, Na, H, Mg as well as soil organic matter were significantly higher in the affected soils than in the non-affected soils. In Tunis, Morghom *et al.,* [11] reported an increase of Ca, K and Fe on the surface of the surrounding soils of the cement factory and they suggest that the values of Si, K and Ca could be used as an indication of environment pollution in the vicinity of the cement factory. Zerrouqi *et al.*, [7] reported on their study on soil surrounding cement factory on Morocco that calcium oxide and sulfur oxide are the principal component of pollution. While Al-Khashman and Shawabkeh, [8] revealed that lead, zinc and cadmium have the highest level in area close to cement factory in southern Jordan.

The Saudi cement factory was founded in 1955, therefore it is believed that a large quantity of dust, commonly known as cement kiln dust has been produced during the production of cement in the last 56 years, making it necessary to evaluate the effect of cement dust on the environment. With the main objective to evaluate the environmental impact and determine soil physiochemical properties caused by the cement dust over 56 year of cement factory in Al-Hasa oasis, Saudi Arabia, present study was undertaken.

MATERIALS AND METHODS

Soil Samples Collection and Analysis: In February 2010, eighty composite soil samples were collected from a transect of 6 km long (50 -100 m apart) the sampling site comprises the area around the cement factory (emissions source points) to the Al Oyoun City which located at (25° 41ˉ 08˭ N), (49° 31ˉ29.9˭ E). At each site, samples were collected at two soil depths (0- 5 and 20-30 cm). The collected soil samples were stored in plastic bags. Date and features of the collection points were written on the plastic bags and sent to the laboratory.

Soil samples were air-dried and gently crushed and sieved through a 2 mm sieve and stored for chemical and physical analysis. Calcium carbonate was determined according to [12]. Soil pH and EC values were determined in soil paste extract using a pH - meter according to [13]. Particle size distributions were analyzed according to [14]. Organic matter was measured according to the methods described by [15]. The concentrations of soluble cations and anions (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, CO_3^{2-}, HCO_3^{-}, Cl^{-} and $SO_4$2-) were determined according to the method described by [13]. Also, total concentrations of Fe, Cu, Zn, Pd, Cd, As, Cr, Ni and Hg in soil samples were determined by H_2SO_4-HF-$HCLO_4$ mixture according to [16]. Following extractions the content of the studied metals in the solutions were determined by the ICP (Perkin Elmer, Model 4300 DV).

Moreover, geo-accumulation index was calculated from the formula:

$$I_{geo}= log_2\,(C_n/1.5B_n)\text{, described by [17]} \quad (1)$$

Where C_n is the concentration of element in urban soil, B_n is the background value. Furthermore the pollution index (PI) of each metal was calculated from the following formula:

$$\mathrm{PI}=C_n/B_n \quad (2)$$

Where C_n and B_n are the measured and the background concentrations of element *n* respectively in road dust according to [18-20]. On the other hand the Enrichment Factor (EF) was calculated from the following formula:

EF = ((Cx/CFe) soil) / ((Cx/CFe) Earth's crust) as described by [21] (3)

Where (Cx / CFe) soil) = (the concentration of a metal in the studying soil / the concentration of Fe in the studying soil) divided by ((Cx / CFe) Earth's crust which equal to (the concentration of a metal in the Earth crust / the concentration of Fe in the Earth crust).

Quality Control and Data Analyses: Due care was taken to avoid metal contamination in the process of sampling, extracting and analysis. Before analysis, the devices were rinsed with acidified water (10% HNO_3) and weighted to dissolve metals. Also, all equipments and containers were soaked in 10% NHO_3 for 24 h then rinsed thoroughly in de-ionized water before use. Moreover, quality control was assured by performing duplicate analyses on all samples and by using reagent blanks and standards. Also the values of the studying metals below the detection limits of the ICP were refused. Finally, descriptive statistics (range, median, SD, max, min, etc…) were calculated using SPSS [22, 23].

RESULTS AND DISCUSSION

Physiochemical Properties of the Soil: The basic physiochemical properties of the collected soil samples are statistically summarized in Table (1). The texture class

Table 1: Statistical summary for the major physical and chemical properties of the study area around the cement factory at Al - Hasa region, Saudi Arabia

	0- 5 cm depth				20 - 30 cm depth			
Parameter	Max	Min	Average	S.D	Max	Min	Average	S.D
Sand (%)	93.10	33.10	73.10	13.60	79.20	25.2	61.10	11.6
Silt (%)	44.00	2.00	14.90	8.40	34.40	1.70	11.70	7.12
Clay (%)	42.90	4.90	12.00	7.10	36.50	4.18	10.10	6.01
pH	8.30	7.10	7.90	1.60	7.10	6.06	6.60	1.32
EC ($dS.m^{-1}$)	343.60	4.71	112.00	21.00	292.10	4.02	95.20	17.8
Ca^{2+} ($meq.l^{-1}$)	2696.10	74.40	498.00	93.00	2291.70	63.4	402.30	79.0
Mg^{2+} ($meq.l^{-1}$)	16.50	1.00	8.00	1.50	14.00	0.85	6.80	1.27
Na^{+} ($meq.l^{-1}$)	90.50	1.90	40.00	7.50	76.90	1.62	34.00	6.35
K^{+} ($meq.l^{-1}$)	12.50	0.50	8.00	1.50	10.60	0.34	6.80	1.27
HCO_3^- ($meq.l^{-1}$)	20.50	1.10	12.00	2.20	17.40	0.92	10.20	1.90
Cl^- ($meq.l^{-1}$)	72.20	2.10	48.00	9.00	61.40	1.79	40.80	7.62
SO_4^{2-} ($meq.l^{-1}$)	55.50	6.60	27.70	5.20	47.20	5.58	23.50	4.39
$CaCO_3$ (%)	35.30	22.70	25.90	4.80	30.00	19.3	22.00	4.11
Exc. Na ($cmol.kg^{-1}$)	2.90	0.02	0.34	0.50	2.50	0.02	0.29	0.43
Exc.K ($cmol.kg^{-1}$)	0.70	0.16	0.32	0.13	0.63	0.14	0.27	0.11
Exc. Ca ($cmol.kg^{-1}$)	5.40	1.47	3.14	1.20	4.62	1.25	2.67	0.98
CEC ($cmol.kg^{-1}$)	8.10	1.91	3.96	1.40	6.92	1.65	3.36	1.19
Total Ca %	27.00	6.10	10.10	5.20	22.90	5.18	8.56	4.39
Total CaO %	37.70	8.50	14.10	7.20	30.10	7.25	11.00	6.15

Table 2: Heavy metals contents in soil around the cement factory at Al- Hasa city compared to common ranges in soil

	0 - 5 cm depth Total Concentration $mg.kg^{-1}$			20 - 30 cm depth Total Concentration $mg.kg^{-1}$)			Common range in soil[a] ($mg.kg^{-1}$) reported by (Lindsay, 1979)		
Metal ($mg.kg^{-1}$)	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average
As	22.5	0.1	5.07	15.2	0.04	2.028	50	1	5
Cd	0.75	0.02	0.35	0.52	0.008	0.14	0.7	0.01	0.06
Fe	14970	3276	503	6988	1310	251	55000	7000	38000
Cr	98.4	0.3	22.7	39.4	0.12	9.06	1000	1	100
Cu	20.1	1.0	7.91	8.04	0.4	3.164	100	2	30
Ni	27	0.2	8.22	10.8	0.08	3.29	500	5	40
Pb	20.7	0.1	5.41	12.3	0.04	4.16	200	2	10
Zn	92.2	1.2	22.6	46.9	0.48	14.0	300	10	50

of soil was generally, ranged from sandy loam, to loamy sand in most cases. In the surface soil samples (0 - 5 cm depth), the maximum percentages of sand, silt and clay were 93.1, 44.0 and 42.9 %, while the respective minimum percentages reached 33.1, 2.0 and 4.88 % respectively. The studying soils were calcareous in nature as the $CaCO_3$ content in such soils average at 25.9%. On the other hand, the pH values ranged from 7.06 to 8.30, while the EC_e values ranged from 4.72 to 343.6 $dS.m^{-1}$ with a general mean 12.0 $dS.m^{-1}$. This means that the studying soils were saline to alkaline affected soils. On the other hand, the Ca and Na ions were the most dominant cations, meanwhile the Cl and SO_4 ions were the most dominant anions. Also, the cation exchange capacity of the studying soil ranged from 1.94 to 8.14 $cmol.kg^{-1}$, while the exchangeable Na, K, Ca and total CaO % ranged from (0.02 to 2.91), (0.16 to 0.74), (1.47 to 5.44) $cmolkg^{-1}$ and (8.53 to 37.7 %), respectively. It is worth to mention that the highest values of such parameters were detected in the surface soil samples taken at the 2 km far from the cement factory, followed by a gradual decrease with increasing the distances from the cement factory (Fig. 1, 2 and 3). Such results were stood in agreement with the results reported by (Zerrouqi *et al.,* [7]. It is interesting to note that all the previously results were found in the subsurface soil samples (20 - 30 cm) with relatively lower values than the respective values detected in the surface soil samples (0 -5 cm).

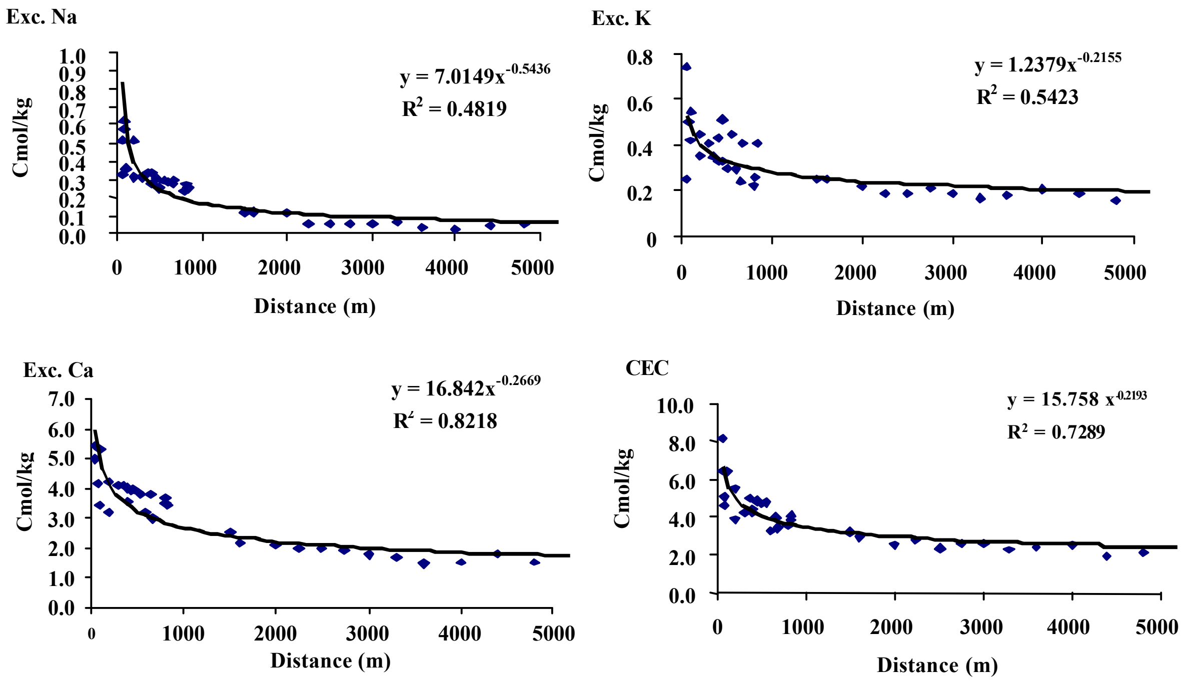

Fig. 1: Distribution of exchangeable Na, K, Ca and CEC in surface soil (0- 5 cm) with the distance far from the cement factory

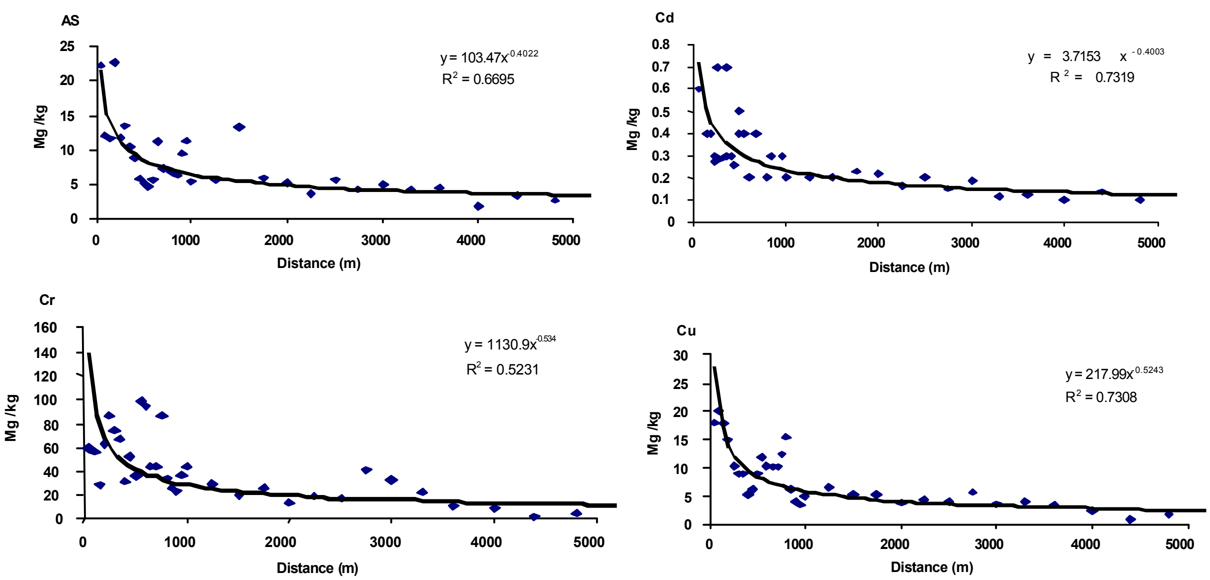

Fig. 2: Distribution of total elements As, Cd, Cr and Cu in surface soil (0- 5 cm) with the distance far from the cement factory

Heavy Metals Content in the Soil: The values in Table (2) shows the descriptive statistics, maximum, minimum and average concentrations of heavy metals of soil samples around the cement factory compared to the average concentrations and the normal ranges in soils reported by [24]. The mean values of the metals content in both studied soil depth could be arranged in the following descending order: Fe > Cr > Zn > Ni > Cu > Pb > As > Cd. Obviously, the levels of Fe, Zn and Cr were higher, whereas the Cd values were the lowest observed. Although, the concentrations of Cd were relatively lower than the other metals, the maximum Cd concentrations

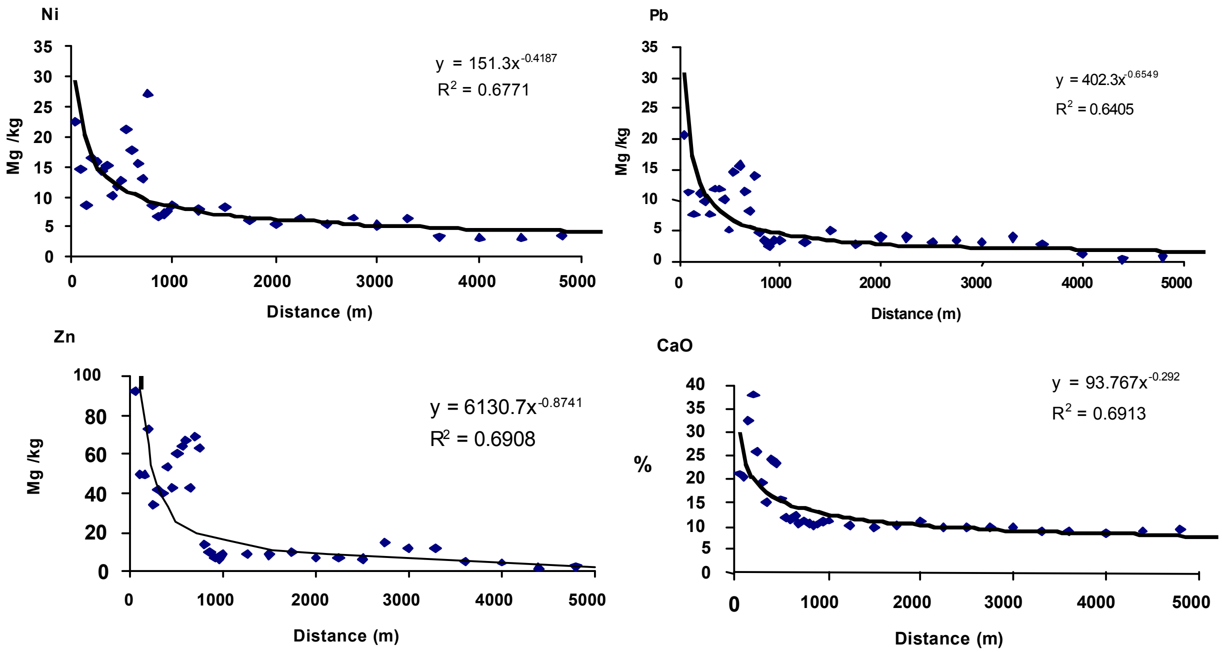

Fig. 3: Distribution of total elements Ni, P, Zn and CaO in surface soil (0- 5 cm) with distance far from the cement factory

Table 3: Heavy metals contents ($mg.kg^{-1}$), geo-accumulation and pollution indexes of surface soil (0 - 5 cm) around the cement factory at Al- Hasa region, Saudi Arabia

		Total Concentration $Mg.kg^{-1}$			EF[(a)]		Geo-accumulation index [(b)] (I_{geo})			Pollution Index [(c)] (PI)		
Metal	Back Ground $mg.kg^{-1}$ (**)	Max	Min	Aver.	Max	Min	Max	Min	Aver.	Max	Min	Aver.
As	2.12	22.5	0.1	5.07	6.24	0.15	2.82	-4.99	0.67	10.61	0.05	2.39
Cd	0.12	0.75	0.02	0.35	5.20	0	2.06	-3.17	0.96	6.25	0.17	2.92
Cr	4.29	98.4	0.3	22.66	0.68	0.42	3.94	-4.42	1.82	22.94	0.07	5.28
Cu	19.66	20.1	1.0	7.91	5.57	0.69	-0.55	-4.88	-1.90	1.02	0.05	0.40
Ni	4.18	27	0.2	8.22	0.37	0.06	2.11	-4.97	0.39	6.46	0.05	1.97
Pb	2.24	20.7	0.1	5.41	1.79	0.05	2.62	-5.07	0.69	9.24	0.04	2.42
Zn	18.23	92.2	1.2	22.57	1.6	0	1.75	-4.51	-0.28	5.06	0.07	1.24

(a) EF = ((Cx / CFe) soil) / ((Cx / CFe) Earth's crust) after (Dragovic *et al.* [21]; while [(b)]$=I_{geo}=log_2 (C_n/1.5B_n)$, [17] and [(C)] PI= C_n/B_n [18 19, 20]

(**) The background values were obtained by analyzing soil samples taken at 20 km far from the cement factory

Table 4: Pearson coefficients between heavy metals and some soil properties and among metals in the study area

	As	Cd	Cr	Cu	Ni	Pb	Zn	Clay	Silt	Sand	O.M	P	EC	$CaCO_3$
Cd	0.07	1.00												
Cr	0.42[a]	0.14	1.00											
Cu	0.17	0.66[a]	0.35[a]	1.00										
Hg	-0.08	0.32[a]	- 0.24[b]	- 0.02										
Ni	0.31[a]	0.31[a]	0.72[a]	0.51[a]	1.00									
Pb	0.27[a]	0.46[a]	0.70[a]	0.60[a]	0.69[a]	1.00								
Zn	0.28[a]	0.49[a]	0.62[a]	0.53[a]	0.63[a]	0.76[a]	1.00							
Clay%	0.08	0.20[b]	0.15	0.02	0.15	0.23[b]	0.27[a]	1.00						
Silt %	0.17	0.15	0.30[a]	0.16	0.27[a]	0.06	0.07	0.55[a]	1.00					
Sand %	-0.14	0.19	-0.12	- 0.09	-0.11	0.08	0.17	-0.85[a]	-0.91[a]	1.00				
O.M %	0.43[a]	0.32[a]	0.49[a]	0.64[a]	0.41[a]	0.49[a]	0.52[a]	-0.01	0.17	-0.10	1.00			
P ($mg.kg^{-1}$)	0.26[a]	0.30[a]	0.59[a]	0.61[a]	0.51[a]	0.51[a]	0.51[a]	-0.04	0.24[b]	-0.14	0.64[a]	1.00		
EC (dSm^{-1})	-0.25[a]	-0.14	-0.45[a]	-0.19	-0.36[a]	-0.43[a]	-0.41[a]	0.52[a]	0.11	-0.33[a]	-0.27[a]	-0.18	1.00	
$CaCO_3$%	-0.20[b]	0.64[a]	0.45[a]	-0.15	-0.19	-0.08	-0.06	0.25[a]	0.52[a]	-0.46[a]	0.12	0.27[a]	-0.29[a]	1.00
pH	0.07	0.22[b]	0.07	0.03	0.03	0.20[b]	0.36[a]	-0.37[a]	-0.34[a]	0.38[a]	0.08	0.08	-0.51	-0.07

[a]Correlation is significant at the 0.01 level (two - tailed) and [b]Correlation is significant at the 0.05 level (two - tailed)

(especially in the 0 -5 cm depth) were very close to the common Cd range reported by [24]. This may be referring to the higher $CaCO_3$ content in the studying soils (Table 1). In this respect, Lindsay [24] reported that Octavite ($CdCO_3$) controls Cd^{2+} activity at values of pH = 7.84. Holm *et al.,* [25] Concluded that precipitation of $CdCO_3$ is not very likely to occur except under very extreme conditions. So, they suggested that Cd concentrations in calcareous soils (like the studying soils) are controlled primarily by sorption processes. It is worth to mention that most of the heavy metals contaminated soil samples were situated more closed to the cement factory (Figure 2). This finding is in agreement with the result reported by Al-Khashman and Shawabkeh [8] for the soil around cement factory in Jordon.

The Geo-Accumulation Index and Enrichment Factor: Data in Table (3) shows the maximum, minimum and average values of geo-accumulation and pollution indexes of studying soil around the cement factory. Apparently, the soil of the studying area could be classified as moderately to heavily contaminated with (As, Cd, Pb and Ni) and heavily contaminated with Cr, while the studying soil were moderately polluted with Zn (based on the geo- accumulation index). The most contaminated sites were situated in the 0 to 1000 m far from the cement factory. On the other hand, based on the (EF) the studying soils have a significant contamination with As, Cd and Cu (5 > EF >20).

Correlation Analysis Between Metal Contents and Soil Properties and among Metals: Data in Table (4) clearly appear that, the pH values were correlated positively with the studying heavy metals. The limited range of pH values in the soils of the studying area may cause such effect, as indicated by the low standard deviation. Although not very high, the relationship between pH and heavy metals in basic and alkaline soils is usually significant [2] and [26]. Data also revel that, except for Cd and Cr the $CaCO_3$ was negatively correlated with the rest of studying metals. This means that $CaCO_3$ may control the activity of Cd as previously mentioned. On the other hand, the (silt and clay) content exhibited a positive correlation with all studying metals; this may be render to the role of clay in increasing the capacity of the soil to bind elements [27, 28]. Such results suggest that the adsorption and retention of the studying metals in the soils at Al- Hasa soils are influenced mainly by clay and carbonate contents. Respecting the correlation between the studying metals, data in Table (4) indicated that, most of the correlations between the studying metals were significant. The correlation between Cr and other metals were strong. The strongest correlations was found also between Ni and Cr ($r = 0.718$, $p <0.01$), followed by Pb and Cr ($r = 0.703$, $p <0.01$),Zn and Cr ($r = 0.617$, $p< 0.01$), Cu and Cd ($r = 0.648$, $p < 0.01$), Zn and Cu ($r = 0.527$, $p <0.01$), Ni and Cu ($r = 0.507$, $p< 0.01$).

CONCLUSION

From the aforementioned results it could be concluded that the soil of the studying area could be classified as moderately to heavily contaminated with (As, Cd, Pb and Ni) and heavily contaminated with Cr, while the studying soil were moderately polluted with Zn. On the other hand, based on the (EF) the studying soils have a significant contamination with As, Cd and Cu (5 > EF >20). The most contaminated sites were situated in the 0 to 2 km far from the cement factory. Results also suggest that the metals content in the studying soil around the cement factory were positively correlated with the soil pH, soil organic matter and silt and clay contents. Moreover the Cd and Cr were also positively correlated with soil $CaCO_3$ content.

ACKNOWLEDGEMENT

The authors wish to express their deep thanks and gratitude to the Saudi Society for Agricultural Sciences, who kindly participated in sponsoring this work.

REFERENCES

1. Iqbal, M.Z. and M. Shafig, 2001. Periodical effect of cement dust pollution on the growth of some plant species. Turk. J. Bot., 25: 19-24.
2. Rodriguez Martin, J.A., M. Lopez, Arias and J.M. Grau Corbi, 2006. Heavy metals contents in agricultural top soils in the Ebro basin (Spain). Application of multivariate geo statistical methods to study special variations. Environ. Poll., 144: 1001-1012.
3. Kaea, O. and L. Bolat, 2007. Impact of alkaline dust pollution on soil microbial biomass carbon. Turk. J. Agric., 31: 181-187.
4. Zargari, F. and H.H. Shoar, 2008. Effect of various levels of cement dust on seed germination and early seedling growth in 2 cultivars of Helianthus annuus L. Reser. J. Biol. Sci., 3: 1189-1193.

5. Saralabai, V.C. and M. Vivekanadau, 1995. Effect of application cement kiln -exhaust or selected soil phyico-chemical and biological properties. Fert. Res., 40: 193-196.
6. Schuhmacher, M., J.L. Domingo and J. Garreta, 2004. Pollutants emitted by a cement plant: health risks for the population living in the neighborhood. Environ. Res., 95: 198-206.
7. Zerrouqi, Z., M. Sbaa, M. Oujidi, M. Elkharmouz, S. Bengamra and A. Zerrouqi, 2008. Assessment of cement's dust impact on the soil using principal component analysis and GIS. Int. J. Environ. Sci. Tec., 5: 125-134.
8. Al-Khashman, O.A. and R.A. Shawabkeh, 2006. Metals distribution in soils around the cement factory in southern Jordan. Environ. Poll., 140: 387-394.
9. Ibanga, I.J., N.B. Umoh and O.B. Iren, 2008. Effects of cement dust on soil chemical properties in Calabar environment, southeastern Nigeria. Comm. Soil Sci. and Plant Analysis, 39: 551-558.
10. Asadu, C.L. and C. Agada, 2008. The impact of cement kiln dust on soil physico- chemical properties at Gboko, east central Nigeria. Nigerian J. Soil and Environ. Res., 8: 1595-6121.
11. Morghom, L.O., N.A. Darid, H.A. Sreiweel and A. Soliman, 2000. Effect of volatile cement dust on the soil properties surrounding the area around cement factories. 11th Inter. Cement Conf., Tunis, pp: 800.
12. Loeppert, R.H. and D.L. Suarez, 1996. Carbonate and Gypsum: Manometer Method. In Methods of Soil Analysis. Part 3: Chemical Methods. 3rd Edition. Soil Sci. Soc. Am., Madison, WI., pp: 437-474.
13. Sparks, D.L., A.L. Page, R.H. Miller and D.R. Keeney, Eds., 1996. Methods of Soil Analysis, Part 3. Chemical Methods. 3rd Edition. Am. Soc. Agron. and Soil Sci. Soc. Am., Madison, WI.
14. Gee, G.W. and J.W. Bauder, 1996. Particle Size Analysis. In: Methods of Soil Analysis. Part 1, 3rd Edition. Physical and Mineralogical Methods. Edited by Sparks, D. L. et. al. Am. Soc. Agron. and Soil Sci. Soc. Am., Madison, WI., pp: 377-382.
15. Nelson, D.W. and L.E. Sommers, 1982. Total Carbon, Organic Carbon and Organic Matter, pp: 539-579. In: A.L. Page *et al*., (eds.) In: Methods of Soil Analysis, Argon. Monograph 9, Part 2, 2nd Edition, Am. Soc. Agron. Inc., Madison, WI, USA.
16. Hossner, L.R., 1996. Dissolution for Total Elemental Analysis. In: Methods of Soil Analysis. Part 3, 3rd Edition. Chemical Methods. Edited by D.L. Sparks, *et al*., Soil Sci. Soc. Am. and Am. Soc. Agron., Madison, WI., pp: 46-64.
17. Ji, Y.Q., Y.C. Feng, J.H. Wu, T. Zhu, Z.P. Bai and C.Q. Duan, 2008. Using geo-accumulation index to study source profiles of soil dust in China, J. Environ. Sci., 20: 571-578.
18. Chen, T.B., Y.M. Zheng, M. Lei, C.H. Huang, H. Wu, H. Chen, K.K. Fan, K. Yu, X. Wu and Q.Z. Tian, 2005. Assessment of heavy metal pollution in surface soils of urban parks in Beijing, China. Chemosphere., 60: 542-551.
19. Lue, X., L. Wang, K. Lei, J. Huang and Y. Zhai, 2008. Contamination assessment of copper, lead, zinc, manganese and nickel in street dust of Baoji, NW China, J. Hazard. Mater., 4: 52-??.
20. Faiz, Y., M. Tufail, M.T. Javed, M.T. Chaudhary and N. Siddique, 2009. Road dust pollution of Cd, Cu, Ni, Pb and Zn along Islamabad Expressway, Pakistan, Micro Chem. J., 92: 186-192.
21. Dragovic, S., N. Mihailovic and B. Gajic, 2008. Heavy metals in soils: distribution, relationship with soil characteristics and radionuclide and multivariate assessment of contamination sources. Chemosphere, 72: 491-495.
22. SPSS, User manual. Chicago, Illmois; SPSS, 2000.
23. Manugistics, STATGRAPHIC plus. User Manual Maryland. Manugistics Inc., 2000.
24. Lindsay, W., 1979. Chemical Equilibrium in Soils.1st Edition. A Wiley Inter. Sci. Pub.. John Wiley and Sons, New York.
25. Holm, P.E., B.B. Andersen and T.H. Christensen, 1996. Cadmium solubility in aerobic soils. Soil Sci. Soc. Am. J., 60: 775-780.
26. Nan, Z., C. Zhao, L. Jijun, F. Chen and W. Sun, 2002. Relation between soil properties and selected heavy metal concentration in spring wheat (*Triticum aestivum* L.) grown in contaminated soil. Water, Air and Soil Pollution, 133: 205-213.
27. Nicholson, F.A., S.R. Smith, B.J. Alloway, Carlton-C. Smith and B.J. Chambers, 2003. An inventory of heavy metals inputs to agricultural soils in England and Wales. Sci. Total Environ., 311: 205-219.
28. Bech, J., P. Tume, L. Logan, F. Reverter, J. Bech, L. Tume and M. Tempio, 2007. Concentrations of Cd, Cu, Pb, Zn, Al and Fe in soils of Manresa, NE Spain. Environ. Monit. Assess. DOI 10 1007s 10661 - 007-0035-2 Springer Science – Business Media B.V. 2007.