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HEAVY METALS CONCENTRATION IN SOILS AROUND OF LOUSHAN CEMENT FACTORY, GUILAN PROVINCE, IRAN

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ABSTRACT

Soil contamination and accumulation of heavy metals in agricultural products is one of the most important environmental issues that are threatened living plants, animals and human. The purpose of this study is to monitor the status of heavy metals in soils around the cement factory of Loushan. In this study, soil samples in three directions of north-west, south-west and south-east of cement factory and at intervals of 500 meters to 5 km distance from the plant was sampled in three replicates. Concentrations of DTPA-extractable cadmium, iron, manganese, copper and zinc and EDTA extractable chromium concentrations in soil samples were measured. Results showed that the maximum concentration of DTPA-extractable cadmium in the northwest of the plant within 1000 meters (1.4 mg/kg), within 1500 meters in the southwest of the plant (2.16 mg/kg) and within 1000 meters in the southeast of the plant (1.92 mg/kg) was observed. Since the concentration of cadmium in non-polluted soils is less than (1 mg/kg), soil of the studied area had cadmium contamination. Due to intensive deficiency of zinc and copper elements in these soils, copper and zinc concentrations in the 1000 meters of factory space has increased to the desirable extent needed to plants.

Keywords: Cadmium, Chromium, Environment, Loushan, Soil Contamination

INTRODUCTION

However, soil is considered the main source of food production and other raw materials for human, but today is also considered as a place to municipal and industrial waste disposal, particularly in industrialized countries. Soil contamination has increasingly risks to human health and the environment. Heavy elements are

considered as the most important pollutants in the environment that sharply in recent decades have been considered.

Accumulation of heavy metals in soil, especially in agricultural lands is gradual and concentration can reach to levels that threaten the human food security. Annually, thousands of these elements from the activities of municipal, industrial and agricultural imported into the soils. For example, annually, more than 38 thousands tons of cadmium and one million tons lead from various sources is added to soil **[1]**. Soil pollution is a threat to human health and the environment. In recent decades, heavy metals as environmental pollutants and the soil are receive more attention **[2]**. Part of the heavy elements that has been added by environmental pollutants to the soil is absorbed by plants. Solid particles in air can put a negative impact on air quality that the cement factory is one of the producers of aerosols. However, the cement factory to be built away from downtown, the factory dust by wind, rain and other factors are distributed and accumulates in plant, animal and soil context that cause negative effects of heavy elements on human health.

Cement factory is considered as an important source of contamination of both organic and inorganic chemicals and input materials and semimetals such as As, Cd, Co, Cr, Ni, Pb, and Zn. Various types of heavy elements has been studied and these elements are very dangerous because they are toxic **[3]**. Accumulation of heavy metals in soils reduced crop yield. This reduces the quality of the environment, human health and soil fertility **[4]**. Plant tolerance to Cd is varies from 0.2 to 9 mg kg^{-1} soil, but the amount of 3 mg kg^{-1} of cadmium in soil stopped plant growth and makes serious damage to the human body **[5]**. Soil contamination at the plant will cause pollution and pollutants elements are transferred to humans through used plants and domestic animals **[4]**.

Soil, is a place for particles that are deposited by air **[6]**. Isikili *et al.*, **[7]** investigated the chromium concentration in 258 samples of soil and plants around and away from the cement factory of Cocorhesyar, Turkey and conclude that the concentrations of this element in the plant were more than the control area. Heavy metal toxicity in humans, animals and plants are important factors that should be paying more attention to it. Heavy metals such as cadmium, mercury, lead, chromium and aluminum have a role in environmental pollution. This study investigates the concentrations of some heavy metals around cement factory of Loushan, Guilan, Iran.

MATERIALS AND METHODS

Loushan is one of the central cities of Rudbar in the Guilan province and the

neighboring city of Qazvin province. The study area is located at 49°31′ east longitude and 49°39′of North latitude. According to the latest figures seem that definitive population of Loushan is over 22,000. Loushan position is located at 100 km from Rasht and it is arid weather. Cement factory of Loushan is located within the city that due to increased pollution levels, it has been repeatedly criticized by city officials and people.

Measurement of Available Heavy Elements in the Soil

With regard to the satellite image of area, three geographically directions were considered to take soil samples. To evaluate the dispersion of heavy metals around the cement factory of Loushan, 30 soil samples from a depth of 0-30 cm in the Northwest, Southeast and southwest of cement factory were taken every 500 meters and were transported to the laboratory. At first, Soil samples become air-dried and then sieve in 2 mm. Five grams of dried soil was poured in 250 ml Erlenmeyer flask. Amount 20 ml was added to the DTPA and was shacked in 380 rpm for 2 hours and then, samples were centrifuged. And later the samples were filtered and soil extracts was prepared. The concentration of cadmium in soil extracts was measured using DTPA **[8]**. Measurement of the elements concentration was performed using Flame Atomic Absorption Spectrometry **[9]**.

Measurement of Available Cr in the Soil

One gram of dried soil from each sample was extracted with 10 ml EDTA extracts soluble. Chromium concentration measured by Flame Atomic Absorption Spectrometry **[9]**. The pH of Soil sample by extract 2:1 water to soil, soil lime by titration method, soil texture by hydrometer method, soil organic matter by Walkey and Black method **[10]** were measured. Statistical analysis was performed using SPSS software.

RESULTS AND DISCUSSION

Table 1 show that the effect of distance from cement factory on soil heavy metal concentration in all three directions, northwest, southwest and southeast was significant at 1% level.

DTPA-Extractable Fe, Mn, Zn and Cu

Table 2 shows the results of soil iron concentration (mg/kg) in the northwest and at different distances from the cement factory. Results showed that iron concentrations in the 500 meters distance from the cement factory was equal to 13.4 mg/kg and taking away from the factory, at a distance of 1000 meters from the factory the concentration of DTPA-extractable Fe reaches to the highest concentrations (29.6 mg/kg) than the other distances from the cement factory. Iron concentration in the soil around the plant in toxicity was not observed.

According to **Table 2**, the highest concentration of Mn in all geographic distance was observed at 1000 meters from the cement factory. At distances greater than one kilometer, Mn concentrations significantly decreased compared to 1000 meters away from the cement factory. However, the manganese concentration in the southwest at a distance of 2000 m from the factory was more than 1000 meters away, so it was not significant (5.6 mg/kg). Results of a survey conducted by Pais *et al*., **[11]** showed that the toxicity of DTPA-extractable Mn concentration in soil is 850 mg/kg. The visible concentrations in the northwest, southwest, southeast was lower than the extent of the toxicity of this heavy metal.

The highest DTPA-extractable Zinc concentration in all geographic distances was observed at 1000 meters from the cement factory. Zinc toxicity concentration is 125-150 mg/kg **[12]**. A concentration of Zinc in soils around the cement factory was observed lower the extent of toxicity. The highest concentration of copper in all geographic directions was observed at 1000 meters from the cement factory. At distances greater than one kilometer, Cu concentrations significantly decreased compared to 1000 meters away from the cement factory. Since the soil around cement factory was calcareous, Zinc and Copper concentrations were below the critical level, so the zinc concentration in the 1000-meter distance was sufficient. And a Cu concentration in the northwest at a distance of 1000 meters and in the southwest and southeast directions at intervals of 1000 to 1500 meters from the cement factory was considered desirable.

DTPA-Extractable Cadmium Concentrations

According to the results in **Table 3**, the highest concentration of cadmium was observed in northwest in comparison with other intervals in 1000 and 3500-meter distance from the plant (1.40, 1.36 mg/kg). In directions northwest, southwest and southeast, maximum DTPA-extractable Cd concentration within 1000 meters of cement, respectively, 1.4, 2.16, 1.92 mg/kg was observed. Cadmium in most non-contaminated soils has concentrations less than 1 mg/kg and critical concentration in the soil is 1.5 to 2.5 mg/kg **[12]**. The acceptable concentration of Cd in Germany, Britain, Canada and Australia is 2, 1, 8 and 5 mg/kg Soil **[13]**. Based on Britain standard, therefore, soils had been polluted by Cd around the cement factory of Loushan within 1000 meters in three geographical directions. Concentration of this element in both the southwest and southeast was more than the northwest. Wind direction can be effective in the scattering this element.

DTPA-Extractable Chromium Concentrations

According to **Table 3**, the highest concentration of Chromium in all three geographic distance was observed at 1000 meters from the cement factory. At distances greater than one kilometer, Chromium concentrations significantly decreased compared to 1000 meters away from the cement factory. **[7, 14]** examined the Chromium concentrations in 258 soil and plant samples at different distances from the cement plants, Cocorhesyar, in Turkey and concluded that Chromium concentrations at distances closer to the plant was more than from further distances from the cement factory and by a gradual distancing from the factory, the heavy metal concentration declined compared to distances closer to the factory.

In general, results showed that cement factory activity has been caused to soil pollution regarding heavy metals; only Cd concentration in 1000 m distance of plant is approximately more than standard concentration.

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Table 1: Variance Analysis of Heavy Metal Concentration in Soil at Different Distances From the Cement Factory of Loushan in Three Directions Towards the Northwest (NW), Southwest (SW), South-East (SE)

Source	Direction	df	Mean square					
			Fe	Mn	Zn	Cu	Cd	Cr
Distance of factory	NW	9	171.6**	52.4**	1.67**	0.42**	0.87**	0.024**
	SW	9	553.9**	19.5**	2.21**	0.42**	1.01**	0.14**
	SE	9	699.7**	4.13**	5.52**	0.43**	0.85**	0.012**
Eror	NW	18	0.11	0.08	0.02	0.01	0.006	0.003
	SW	18	0.31	0.016	0.026	0.022	0.097	0.031
	SE	18	0.33	0.013	0.003	0.009	0.098	0.001

Table 2: The Concentration of DTPA Extractable Fe, Mn, Zn and Cu in soil (mg/kg) Around Cement Factory of Loushan

Distance	North West				South West				South East			
	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu
500	13.4 d*	0.95 f	0.46 c	0.63 c	10.36 d	2.13 d	0.46 c	0.91 bc	6.3 a	1.26 e	6.33 a	0.49 de
1000	29.6 a	13.61 a	2.53 a	1.50 a	51.60 a	5.36 b	3.23 a	1.26 a	57.5 a	4.23 a	57.50 a	1.40 a
1500	14.7 c	2.16 d	0.96 b	0.92 b	11.83 c	2.13 d	0.83 b	1.13 ab	9.5 de	0.58 f	9.56 de	1.16 b
2000	17.7 b	0.76 f	0.33 d	0.84 b	6.50 f	5.63 a	0.53 c	0.96 bc	8.6 ef	2.23 c	8.60 ef	0.31 fg
2500	7.9 e	2.24 d	0.31 d	0.66 c	8.13 e	0.63 fg	0.66 bc	0.84 cd	10.5 d	0.37 g	10.50 d	0.60 cd
3000	6.5 g	1.10 ef	0.13 d	0.28 d	12.16 c	0.70 fg	0.86 b	0.76 cde	12.7 b	1.73 d	12.73 b	0.36 efg
3500	7.2 f	1.43 e	0.13 d	0.45 d	7.76 e	2.56 c	0.46 c	0.50 e	11.8 bc	0.58 f	11.80 bc	0.26 g
4000	4.5 h	7.96 b	0.17 d	0.35 d	18.13 b	0.83 f	0.43 c	1.39 a	11.8 bc	2.23 c	11.80 bc	0.40 efg
4500	6.5 g	0.71 f	0.12 d	0.34 d	6.73 f	1.56 e	0.41 c	0.71 cde	8.0 f	1.40 e	8.03 f	0.73 c
5000	14.8 c	3.14 c	0.20 d	0.27 d	8.73 e	0.53 g	0.43 c	0.62 de	7.5 f	2.63 b	0.33 fg	0.46 def

NOTE: *LSD (least significant difference) shows the significant difference (ρ = 0.05) among the different treatments. Values followed by the same letters in each column are not significantly different at the 0.05 level (least significant difference)

Table 3: Cd and Cr Concentrations in Soil (mg/kg) at Different Distances from the Cement Factory of Loushan for Three Geographic Directions

Distance	NorthWest		SouthWest		SouthEast	
	Cd	Cr	Cd	Cr	Cd	Cr
500	0.00	0.28 bc	1.23 bc	0.91 bc	1.32 b	0.36 b
1000	1.40 a	0.52 a	1.46 b	1.26 a	1.92 a	0.45 a
1500	0.21 c	0.37 b	2.16 a	1.13 ab	1.26 b	0.36 b
2000	0.00	0.29 bc	1.50 b	0.96 bc	0.58 c	0.34 bc
2500	0.75 b	0.24 c	1.40 b	0.84 cd	0.48 c	0.26 de
3000	0.00	0.21 c	0.66 d	0.76 cde	0.18 c	0.34 bc
3500	1.36 a	0.31 bc	0.83 cd	0.50 e	1.23 b	0.30 cd
4000	0.23 c	0.26 c	0.30 d	1.39 a	0.61 c	0.29 cde
4500	0.29 c	0.27 bc	0.46 d	0.71 cde	1.37 b	0.28 cde
5000	0.23 c	0.23 c	0.63 d	0.23 c	0.66 c	0.23 e