Original Article

Determination of Heavy Metal in Agricultural Soils near and Far From the Cement Factory in Tehran, Iran

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ABSTRACT

Background: Heavy metals (HMs) are one of the most important polluting substances emitted to the environment during cement production. Tehran Cement Factory located in the southeastern of Tehran, Iran, closer to agricultural lands cultivates alfalfa, barley, and maize as feed. The objective of the study was to determine the concentration of HMs in agricultural soils.

Methods: Thirty six soil samples were collected from two regions of Aminabad (close to the cement factory) and Varamin (far from cement factory) in 2015. The samples were taken from a depth of 0-15 cm and analyzed to determine their HM (zinc, lead, cadmium and chromium) by atomic absorption spectrophotometry. Other relevant parameters of soil were evaluated, such as; pH, EC, TOM.

Results: The concentration of HMs in both regions was as follows: Pb> Zn > Cr > Cd. Generally, the soil alfalfa, barley and maize, there was no significant difference.

Conclusion: These data provide information on HM accumulations in agricultural soils and allow us to identify sources of pollution. In the industrial area due to the proximity to cement factory, concentration of zinc, lead, chromium, pH and EC were more than non-contaminated areas.

Keywords: Agricultural Soils, Cement Factory, Heavy Metal, Iran.

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INTRODUCTION

Industrial and agricultural development has been largely responsible for pollution of the environment with heavy metals (HMs).The mobilization of metals from industrial regions by transport with seepage waters or by windblown dust may also be an important source of soil contamination [1-3].Cement industry is one of the sources for environmental pollution. Cement dust contains HMs pollutants hazardous to the biotic environment with impact for vegetation, human health, animal health and ecosystem [4-6].

The main concern of HMs in livestock is dietary exposure, in agricultural regions diet isthe main source of HMs for animals. When evaluating livestock exposure to HMs it is important to consider that dietary exposure will be highly conditioned by husbandry practices, dietary ingredients, soil ingestion or spurious soil contamination in foliage being responsible for the main HM exposure [7-9].The HM contamination soils has become serious environmental issue around the world for various reasons, including industrial activities, solid waste disposal, fertilizers, pesticides, sludge application, irrigation with wastewater, and automobile exhausts [10-13].Beside, anthropogenic and geologic materials, soil character, mobility of the elements, weathering processes and environmental factors have remarkable effects on distribution [14,15]. It is important to have in mind how management practices can contribute to enhancing livestock metal exposures in order to minimize their toxic effect on animals, as well as to limit metal transfer to human feeds as much as possible. In addition to ensure safe quality of the food chain products, it is useful to standardize the allowable loadings of contaminants to agricultural land.

The aim of this study was to evaluate the effect of cement factory activities on agricultural soils. Overall, the objective was to determine the elements in the soil plants (alfalfa, barley, maize) and evaluation of the average of these elements in the area based on where it is located.

MATERIAL AND METHODS

Tehran Cement Factory is located in the southeast Tehran, Iran in Aminabad region. The investigated area has a Mediterranean climate characterized by a little hot in summer and nearly cool, rainy winters. In this study, two regions were compared; first region which was the polluted one is located 2.4 km far from the cement factory. This area has a semi-arid climate and average rainfall is 200 mm per year, altitude from the sea level is 1036 m, and between 35°34′ N, 51°29 E, as contaminated area (CA).The other region was

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Varamin, where is65 km far from cement factory, that has an arid climate and average rainfall 124 mm per year, with an altitude from the sea level 941 m, and between $35^{\circ}21^{/}$ N, $51^{\circ}36^{/}$ E, as non-contaminated area (NCA).

In total, 36 samples of agricultural soils were selected before harvest of the crops from NCA, and CA. Soil samples were taken from a depth of 0-15 cm with a shovel from three farms, including alfalfa, barley and maize, each composite soil sample from the farms consisted of five subsamples. Subsamples selected randomly from farm soil, after mixing them, and creating a composite sample, were taken two kg from it for test (quartile method) and were analyzed in triplicate. Composite soil samples were placed in plastic bags and transported to the laboratory. Samples dried in oven and passed through a two mm sieve before analysis. Each sample was digested with nitric, Sulfuric and Perchloric acid (wet digestion method) and Pb, Zn, Cd and Cr were determined by atomic absorption spectrophotometer. Other parameters such as pH, electrical conductivity (EC) and total organic matter (TOM) were analyzed with standard methods.

The data were statistically analyzed using SPSS 18.0 software (Chicago, IL, USA). For comparison between the mean concentration of heavy metals in the agricultural soils, alfalfa, barley and maize in the CA and NCA areas were carried out using analysis of variance (ANOA) and standard *t*- test. Moreover, Pearson's correlation was used to measure the correlation between the metals and chemical properties. $P<0.05$ was considered significant.

RESULTS

There was no significant difference between the concentrations of HMs in agricultural farms, which cultivates alfalfa, barley and maize in two regions, although the concentrations of HMs in soil of maize were higher than soil of alfalfa and barley in CA. The measurement of HMs in the soil of alfalfa and barley showed that the amount of zinc in CA was more than NCA. The measurement of HMs in the soil of maize and barley showed that the amount of lead in CA was more than NCA (Table 1).

Table 1. Total heavy metal Concentration and Chemical properties in agricultural soils.

Metal ($mg.kg^{-1}$).	Treat.	soil of alfalfa	soil of maize	soil of barley
Pb	CA	331.8±48.19	356.4±40.17^{a}	332±21.16^{a}
	NCA	239±34.8	216.3±13.40^{b}	216.3±13.40^{b}
Zn	CA	95.5±0.19^{a}	100±9.42	100.9±0.98^{a}
	NCA	83.2±0.50^{b}	78.6±11.22	84.7±0.60^{b}
Cd	CA	4.1±2.39	5.3±3.29	4.3±3.29
	NCA	5.1±1.30	5.8±3.30	6.1±1.54
Cr	CA	20.2±0.94	20.6±0.94	20.1±0.32
	NCA	19.3±0.31	19±0.00	19.2±0.31
pH	CA	8.8±0.04	9.1±0.04^{a}	8.7±0.00
	NCA	8.6±0.10	8.5±0.04^{b}	8.5±0.09
EC($ds.m^{-1}$)	CA	1.2±0.04	1.1±0.02^{a}	1.2±0.03^{a}
	NCA	1±0.07	0.87±0.00^{b}	0.97±0.02^{b}
TOM (%)	CA	7.9±0.18	6.9±0.73	7.5±0.06^{a}
	NCA	6.5±0.00	6.8±2.39	6.7±0.07^{b}

CA: contaminated areas; NCA: non-contaminated areas
±, standard deviation
a, b: Significant difference between the samples. Significant at $P<0.05$.

Table 2. Comparison of mean concentrations HMs and Chemical properties of soils in two regions.

Metal ($mg.kg^{-1}$)	CA	NCA
Pb	340.1±32.20^{a}	223.9±21.25^{b}
Zn	98.8±4.96^{a}	82.2±5.78^{b}
Cd	4.6±2.41	5.7±1.78
Cr	20.3±0.65^{a}	19.2±0.23^{b}
pH	8.9±0.17^{a}	8.5±0.05^{b}
EC($ds.m^{-1}$)	1.2±0.04^{a}	0.95±0.07^{b}
TOM (%)	7.4±0.57	6.7±1.22

CA: contaminated areas; NCA: non-contaminated areas.
±, standard deviation.
a, b: Significant difference between the samples. Significant at $P<0.05$.

Table 3. Pearson's correlation between the metals and chemical properties in agricultural soils.

Metal	Pb	Zn	Cr	Cd	pH	EC
Pb	1					
Zn	0.880**	1				
Cr	0.719**	0.808**	1			
Cd	-0.266	-0.526	-0.441	1		
pH	-0.848**	-0.688*	-0.611*	0.208	1	
EC	-0.779**	-0.792**	-0.699*	0.274	0.679*	1
TOM	-.203	-0.268	-0.135	0.273	0.236	0.270

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

The concentration of Pb, Zn, and Cr in the CA was more than soil of NCA ($P\leq$ 0.05) (Table2). Generally, there was no significant difference between the concentrations of Cd in agricultural soils in two regions, but the concentrations of Cd in the NCA were higher compared to the CA. The measurement of chemical characteristics of pH, EC, and organic materials (TOM) in the soil of maize, barley and alfalfa in noted regions did not show any significant difference. The measurement of chemical characteristics of two regions in barley soil showed that the amount of EC and TOM in CA were more than NCA and therefore of no significant difference.

The measurement of chemical characteristics of two regions in maize soil showed that the amount of pH and EC in CA were more than NCA one and therefore, significant difference does exist (Table 1). The results of the chemical compound in two regions of CA and NCA showed that there was significant difference between pH and EC, meaning that the amount of pH and EC in CA is more than NCA (P<0.05) (Table 2).Table 3 indicated that, the agricultural soil Zn and Cr concentrations showed a strong positively significant correlation with Pb and Zn, Pb respectively (P<0.05). The chemical properties of soil contain pH and EC amounts showed a significant and negative correlation with Pb, Zn and Cr, except for Cd. There was positive correlation between EC and pH and very weak correlation between the TOM and the HMs concentration in the agricultural soil.

DISCUSSION

According to Table 4, the comparison of the results of this study with other studies [1-4, 7, 11, 14-16] showed that the Pb concentration in the study area was higher than the concentrations of that metal in other cities, CCEM and MAC. Due to the achieved concentration for Pb, it can be assumed that the anthropogenic sources of pollution, such as industrial activities, in the area. The comparison of Cr concentration with other places, indicate that its concentration is lowest. As well as, the Cr concentration was lower as MAC [7].

Table 4. Comparison of average the concentration of heavy metals (mg\kg) in soils of different cities in the world.

country	location	Pb	Zn	Cd	Cr
Greece	Argolida basin	19.74	74.88	0.54	83.12
Jordan	Qadissiya	55	44.51	5	22.18
China	Guangzhou	14.95	-	62.09	285.07
China	Yangtze Delta	33.9	94.9	0.221	87.8
Egypt	Aswan	31.69	1390	19.69	133.1
Iran	Tabriz	10.86	98.27	1.69	87.40
Iran	Isfahan	34.6	111.5	0.43	89.5
MAC*		20-300	100-300	1-5	50-200
CCME**		70	200	1.4	64
Iran	Tehran	340.1	98.8	4.6	20.3

*MAC= Ranges of Maximum Allowable Concentrations.
**CCME= Canadian Council of Minister of the Environment.

The concentration of Cd has a mild changing; however, it increases in Jordan, China (Guangzhou), and Egypt [2, 4, 14]. The Cd concentration is higher than CCEM. Anthropogenic sources of Cd in soils are related to application of manure, or phosphate fertilizers can lead increasing cadmium in the soil [1-4, 14, 15]. The mean Zn concentration in this study compared with some citiesis similar; in this study is: 98.8, in the Iran (Tabriz and Isfahan) is 98.27 and 111.5 respectively, in the China is 94.9 (mg\kg) [1, 3, 15]. The Zn concentration was lower than CCEM [16]. In addition, in this study Zn, Cr and Cd concentrations were inferior to MAC [7].

CONCLUSION

These data provide information on HM accumulations in agricultural soils and allow us to identify sources of pollution which will be helpful in order to control and prevent of HM entering the soil and consequently being transferred to the feed and food chain.

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