Heavy Metal Contamination and Distribution in the Parks City of Islam Shahr, SW Tehran, Iran

Mohammad Yazdi[1,*] and Narges Behzad[2]

[1]*Dept. of Geology, Shahid Beheshti University, Tehran-Iran*

[2]*Dept. of Geology, Islamic Azad University, Islam Shahr, Iran*

Abstract: Islam Shahr is relatively small city in the south of Tehran (10km), Iran. It is located within the Recent Alluvium Formation of Tehran alluvial. This formation is associated with heterogeneous to poorly sorted clays and silts. The overall objective of this study was to better understand the nature of soil contamination in this area. Such information should be useful for enhancing safe parks city in the Islam Shahr urban area while minimizing adverse effects of soil contamination on human health.

In this research, 25 soil samples were analyzed by ICP for Al, Co, Cr, Cu, Pb, Zn, Ag, Cd, Hg, As, Se. The concentration of Ag, Cd, Hg, As, Se was less than detection limit. Since early work on soil geochemistry of Islam Shahr is not available, the elemental compositions of these soils were normalized using average upper continental crust values. Data processing shows the average concentrations of Cu, Cr, Co, Pb and Zn were higher than the upper continental crust background levels. Also, when the Chinese National Soil Standard values were used as a reference, Co, Cr, Cu, Pb and Zn contaminations in the city park soils of Islam Shahr were similar to Grade I of contamination. Most of the contaminated sites are located in the Vavan areas, where urbanization, heavy traffic, agricultural and industrial activities are high, but it does not pose an immediate threat to the environment. The Islam Shahr is new developed city during the 15 years ago, thus such contaminations are so high and to be worrying for this short period.

Keywords: Park city soil pollution, Islam Shahr urban area, Iran.

1. INTRODUCTION

Soil originates from the weathering of minerals and rocks. Soils are usually considered as a sink for trace metals. Then, trace metals are able to move towards the water column or accumulate in plants and consequently contaminate the food chain. Of major concern about the presence of some metal ions in the environment are the negative health effect that they may cause in humans, animals, and plants. Heavy metal mobility, bioavailability and toxicity depend largely on the chemical state of the metals and determine the potential for environmental pollution. Metal distribution depends on the characteristics of the soils being studied and corresponds to the place of origin, such as the amount and type of organic and inorganic matter, redox properties, pH and oxygen are among the most important chemical factors that affect the mobility of soil-bound metals [1-4].

The overall objective of this study was to better understand the nature of soil contamination in the Islam Shahr area, including three aspects: (1) to investigate the main sources of heavy metal contamination in the area; (2) to determine contamination trends and pollutant types in the area; and (3) to find a proper evaluation approach to metal contamination in this area. Such information should be useful for enhancing safe park areas in the Islam Shahr urban area while minimizing adverse effects of soil contamination on human health.

The Islam Shahr is a small city which located in the south of Tehran, Iran. Its coordinates are: 51°27′30" E, 35°27′30" N. It has an extension of approximately 10 km from Tehran in the south of Alborz range. It is located within the Recent Alluvium Formation of Tehran alluvial. This formation is associated with heterogeneous to poorly sorted clays and silts. The Islam Shahr area is situated in the subtropical region, with hot summers (April–September) and relatively cool and dry winters (October–March). The annual mean temperature is 17.1°C.An annual total rainfall amounts to approximately 231 mm, most of which falls between September and April.

The Islam Shahr city is a relatively contaminated area, and is getting gradually pollutant due to highly urban growth, and for that reason it is more feasible for the soils to interact with the population that lives in the city. However, no systematic study has been made on this city to assess the distribution of the heavy metals in soils of Islam Shahr urban area. The occurrence of trace metals in surface horizon of soils originates from the vegetation, atmospheric deposition and adsorption by soil organic matter. The soils in the Islam Shahr parks city environments have constructed with anthropogenic activities. In such soils metal content varied greatly between sampling sites and was independent of soil depth due to mixing, moving and back filling of soil masses, as well as clean soil having been mixed with polluted soil. High spatial variation was also found in a study on urban soil

*Address correspondence to this author at the Dept. of Geology, Shahid Beheshti University, Tehran-Iran; Tel: +98-21-22431690; Fax: +98-21-29902643; E-mail: m-yazdi@sbu.ac.ir

1876-3979/09

metal contents in several European city parks [5]. Urban soils commonly receive a higher load of metals than corresponding rural soils, and because metals are rather immobile once they reach the soil, hazardous elements derived from industrial activities dating back to the beginning of the industrial revolution can still be found in the soil. The long-term input of metals to the soils has negative effects on human health upon repeated exposure. Children in particular are more susceptible to the negative health effects of metals due to their small body size, developing nervous system and common behavior of putting dirty objects and hands in their mouths. For children up to the age of six, ingestion of soil represents a significant route of contaminant exposure due to this behavior. In a study on 2-year old children carried out in UK by Thornton (1993) [6], it was found that ingestion of dust as a result of hand-to-mouth behavior accounted for up to 50% of a child's daily Pb intake [5]. For these reasons, the subject of metal contents in urban soils of Islam Shahr has received much attention in this research. Soil samples were collected from playgrounds located in parks city since children are playing there. Results from this research would be used in city planning to identify pollution sources and locate polluted areas. Islam Shahr urban area is today subject to affect due to high local pollutant industrial activities close to giant city of Tehran.

2. ANALYTICAL METHODS

All reagents were analytical grade, obtained from Merck (Darmstadt, Germany). Hydrochloric acid, fluoric acid and nitric acid for solution acidification were ultra pure quality. Calibration standards of elements were prepared by appropriate dilution of the 1000 mg L−1 stock solutions (Merck). All solutions were prepared with ultra pure water. All glassware and polyethylene bottles were cleaned by soaking in 10% (v/v) HNO3 (Merck) followed by three rinses with deionizer water. Soil reference material (Iranian Internal standard) was used for validation of the methodology for carbonates, silica, total organic matter and total concentrations of these elements.

Surface soils (10 to 20 cm depth) were collected from the urban area in the season of spring. 25 samples from five sampling sites were selected from main parks of the city, at the following places: Shahrak Mostafa Khomini (A), Nouri Str. (B), Mahdieh Str. (C), Vavan Entrance (D) and Shahrak Vavan (E). Sediments were collected with plastic collectors, returned to the laboratory in polyethylene bottles, and stored at 4 °C. Prior to analysis, the soils samples were dried at 105 °C for 48 h and then sieved (<2 mm) using stainless steel sieves to remove large debris, gravel sized materials and plant roots. 10 gr of sample were taken in 50 mL distilled water and agitated for 10 min. The solution was left undisturbed for 1 h with occasional shaking before measuring the pH. A combined glass electrode connected to a pH-meter was used for pH measurements. The pH in these samples was 7 to 8.

The sieved samples were homogenized and ground with a pestle and a mortar and kept in desiccators prior to chemical digestion. A strong acid digestion method was applied to dissolve the samples and their inorganic contents in solution. In detail, 0.2 gr of dried samples was digested in 2 ml HNO_3 and 1 ml HF acids in a Teflon bottle at 180 °C for 2 days. After the samples had been brought to complete dryness, 1 ml HNO_3 acid and 1 ml internal standard were added and the solutions kept overnight at 180 °C. They were then diluted by HBO_3 and deionizer water, and kept in refrigerator prior to analysis. The sample was filtered, washed with deionizer water, and received in 50.0 mL volumetric flasks. For quality control, blanks and replicates were included in the sample batches. Additionally, international standard reference material from the National Standards (Montana Soil type) was used to evaluate the efficiency of the analytical procedure, particularly for the heavy metals Cd, Co, Cr, Cu, Pb and Zn. Standard solutions of analyzed elements were prepared by diluting a commercial standard containing 1000 μg mL−1, Merck (Darmstadt, Germany). Inductively coupled plasma spectrometry (ICP) was used to determine strong-acid extractable elemental concentrations of the samples in the chemical laboratory of Iran Department of Environment (IRDOE). In this study, 25 samples were analyzed by ICP for Al, Co, Cr, Cu, Pb, Zn, Ag, Cd, Hg, As, Se. The concentration of Ag, Cd, Hg, As, Se was less than detection limit. The results are given in Table **1**. Metal quantification was based on calibration curves which were determined several times during the period of analysis. The statistical analyses were conducted using SPSS software package.

3. RESULTS AND DISCUSSIONS

Information gathered from a geological map of Tehran shows that the Islam Shahr city is located within the Recent Alluvium Formation of Tehran alluvial. This formation is associated with heterogeneous to poorly sorted clays and silts. The relatively high sand content observed in the top layers of some sites indicates that soil material originates from elsewhere. This is in accordance with the common practice of removing the topsoil and replacing it with foreign. The lack of depth distribution for many parameters also indicates that the original soil has been disturbed. However, the agreement between enriched bedrock metal contents and parks soil metal contents implies that the foreign soil in urban Islam Shahr is derived from the surrounding rural area.

The accuracy of the results, minimum, maximum and median contents of the metals measured in parks soil of Islam Shahr are presented in Tables **1** and **2**. Among the 25 soil samples, the highest concentrations of Zn (162.7ppm), Pb (65.3ppm), Cu (42.2ppm), Cr (117.2ppm) and Co (21.2ppm) are found in E-3 and D-1 (parks city in Vavan area), where the traffic density and population is high, and is industrialized side of the city. Similarly, the contents of Pb and Zn in the soil samples collected from park city near the bus station on Mahdeieh Str. (C-3), is also high. Urbanization and the accompanying industrial and agricultural activities result in the release and the subsequent deposition of pollutants and other persistent toxic substances, thereby leading to degradation of environmental conditions in these parts of the city. Correlation analysis provides useful information with respect to the genesis of any contamination. This analysis was carried out on the parks city soil samples of the Islam Shahr urban area. Table **5** contains the Pearson correlation coefficients among the measured elements. The heavy metals (Cd, Cr, Cu, Pb and Zn) displayed significant linear correlations. This correlation is chemically plausible and points to genetic similarities between the groups of metals.

Table 1. Elemental Concentrations of Soils in Urban Area of Islam Shahr (ppm)

Sample No	Al	Co	Cr	Cu	Pb	Zn
A-1	58507	11.87	71.6	35	24.25	120.6
A-2	61460	11.13	73.75	32	26.25	102.87
A-3	60702	11.62	80.12	32.75	22.75	109
A-4	68390	12.37	72.62	33.12	26.12	111.6
A-5	58547	10.25	72.87	33.12	62	129.5
B-1	65251	14.75	67.7	38.75	21	100.5
B-2	59159	14.12	71	35	20.5	93
B-3	60079	14.25	73.25	34.75	20.5	93.25
B-4	58838	14	68.87	34.75	21.37	104.87
B-5	59513	14.12	72.37	34.25	29.87	122.25
C-1	72821	15.3	60.3	36.6	52.2	94.6
C-2	60445	12.7	71.7	35.1	19.6	111.7
C-3	61355	16	87	33.5	65.3	105.6
C-4	62300	15.6	85.6	32.6	25.7	101.8
C-5	58213	14.8	81	29.6	22	89
D-1	78785	21.2	117.2	36.5	27.6	95
D-2	63146	14.6	69.7	31.2	22.1	85.5
D-3	62777	14.7	69.1	29.6	20.6	78.2
D-4	69794	16.6	85.7	30.7	22.8	83.3
D-5	62550	14.3	72.2	31.1	23.8	90.5
E-1	60489	13.25	62.3	32.25	27.6	122.5
E-2	61411	14.6	65.3	35.8	23.6	97.3
E-3	58159	13.3	66.7	42.2	53.8	162.7
E-4	65472	15.1	73	33.5	22.1	87
E-5	62218	14.7	71.8	32.1	26	143

Background levels and guideline values have been established in many countries indicating the concentration of metals of natural origin and a maximum tolerable metal level, respectively. The Iranian Environmental Protection Agency has not defined yet urban background levels of natural soil metal contents. Unfortunately, no previous studies have been carried out on soil metal contents in Islam Shahr urban area, also. For these reasons average upper continental crust values [7] and Chinese National Soil Standard values [8] were used as references to compare our data (Tables **3** and **4**). Zn, Pb, Cu, Cr and Co is slightly enriched in the studied samples compared to the upper continental crust values. However, Al contents show a marked depletion (because of foreign soils) in all samples compared to the upper continental crust values (Table **4**). When the Chinese National Soil Standard values were used as a reference, Co, Cr, Cu, Pb and Zn contaminations in the city park soils of Islam Shahr were not so high evident (Grade I). The level of contamination on the Vavan side of the city is relatively high (Grade I), where heavy traffic and industrial activities are high, but it does not pose an immediate threat to the environment. The Islam Shahr is new developed city during the 15 years ago, thus such contaminations are so high for this short period. However, the levels of Cr, Pb and Zn contaminations on the industrialized side of the city going to be worrying. This study concluded that the parks city soils contents of Cr and Co were mainly derived from geological sources. Contents of Cu, Zn and Pb are mainly derived from anthropogenic sources, with the Islam Shahr urbanization, agricultural and industrial activities as main sources. Traffic is another main source that particularly affects the Pb content of the soil. The Islam Shahr is new developed city during the 15 years ago, thus such contaminations are so high for this short period.

Table 2. Minimum, Mean, Maximum as ppm and Standard Error of Elemental Concentrations of Parks Soils in Islam Shahr (n=25 for Average pH of 7-8)

Standard Deviation	Maximum	Mean	Minimum	Element
4989	78785	62815	5815	Al
2.1	16.6	14	10.25	Co
11.2	87	75	60.3	Cr
2.8	42.2	34	29.6	Cu
13.4	62	29	19.6	Pb
19.6	162.7	105	78.2	Zn

Table 3. Chinese National Soil Quality Standards (mg kg^{-1}) [8] Which Used to Compare Elemental Concentrations of Parks Soils in Islam Shahr

Grade III(pH>6.5)	Grade II(pH 6.5–7.5)	Grade I	Elements
300	150	90	Cr
400	100	35	Cu
500	300	35	Pb
200	50	40	Ni
500	250	100	Zn

Table 4. The Enrichment Factors (EF) for the Elemental Concentrations of Parks Soils in Islam Shahr. The EF is Calculated as the Ratio of the Average Abundance of an Element in these Samples to its Average Content in the Upper Continental Crust [7]

Al	Co	Cr	Cu	Pb	Zn	Element
62815	14	75	34	29	105	Islam Shahr Soils
77440	11.6	35	14.3	17	52	Upper Continental Crust
-0.19	1.2	2.14	2.38	1.71	2.02	Enrichment Factors

Table 5. Pearson Correlation Coefficients for Parks Soils in Islam Shahr

Zn	Pb	Cu	Cr	Co	Al	Correlation
-0.36	-0.005	0.8	0.5	0.68	1	Al
-0.4	-0.08	0.06	0.64	1	0.68	Co
-0.2	-0.002	-0.1	1	0.64	0.5	Cr
0.47	0.31	1	-0.1	0.06	0.8	Cu
0.44	1	0.31	-0.002	-0.08	-0.005	Pb
1	0.44	0.47	-0.2	-0.4	-0.36	Zn

4. CONCLUSIONS

Islam Shahr is relatively new developed city in the south of Tehran. It is located within the heterogeneous to poorly sorted clays and silts Recent Alluvium Formation of Tehran. The main objective of this study was to measure the total concentrations of heavy metals and apply the ecotoxic potential of these metals. The results from this study showed that Zn, Pb, Cu, Cr and Co is slightly enriched in the studied samples compared to the upper continental crust values. Also, when the Chinese National Soil Standard values were used as a reference, Co, Cr, Cu, Pb and Zn contaminations in the city park soils of Islam Shahr were similar to Grade I of contamination. Most of the contaminated sites are located in the Vavan areas, where urbanization, heavy traffic, agricul-

tural and industrial activities are high, but it does not pose an immediate threat to the environment. The Islam Shahr is new developed city during the 15 years ago, thus such contaminations are so high and to be worrying for this short period.

ACKNOWLEDGMENTS

The authors would like to express their thanks to the Islam Shahr Islamic Azad University that provided the funding for this project. Also, we would like to acknowledge the sponsors of the Islam Shahr municipality that provided the sites for data collection. This research benefits the kindly helps of staffs of chemical laboratory in Iranian Environmental Protection Agency.

REFERENCES

[1] Duris M. Geochemical and ecological survey of the Prague urban area. Geochim summer school, internal report 2002.

[2] Guo GL, Zhou QX. Evaluation of heavy metal contamination in Phaeozem of Northeast China. Environ Geochem Health 2006; 28: 331-40.

[3] Pandey PK, Sharma R, Roy M, Roy S, Pandey M. Arsenic contamination in the Kanker district of central-east India: geology and health. Environ Geochem Health 2006; 28: 409-20.

[4] Winfield A. Environmental Chemistry. Cambridge University Press 2001; p. 60.

[5] Ljung K, Otabbong E, Selinus O. Natural and anthropogenic metal inputs to soils in urban Uppsala, Sweden. Environ Geochem Health 2006; 28: 353-64.

[6] Thornton I. Environmental geochemistry and health in the 1990s: a global perspective. Appl Geochem 1993; 2: 203-10.

[7] Wedepohl KH. The composition of the continental crust. J Geochem Cosmochem Acta 1995; 59: 1217-32.

[8] Duzgoren-Aydin NS, Wong CSC, Aydin A, Song Z, You M, Li XD. Heavy metal contamination and distribution in the urban environment of Guangzhou, SE China. Environ Geochem Health 2006; 28: 375-91.

Received: October 30, 2008 Revised: January 21, 2009 Accepted: February 23, 2009