Assessment of Trace Metal Distribution and Contamination in Surface Soils of Al-Waziriya, Baghdad

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ABSTRACT

A total of 100 samples from the top soil were collected from four different zones (tow industrial locations, tow residential locations) located in Al-Waziriya, Baghdad. Soil samples were analyzed for their content of Cd, Cu, Pb and Zn. A profile for average content of these selected metals has been determined by taking average values for different zones. The average concentrations of Cd, Cu, Pb and Zn in the whole area were 11.45, 143.3, 3291.38 and 195.2 mg/kg, respectively. Highest concentrations for selected heavy metals were observed in the industrial area. Enrichment factor calculations indicated that Pb, Cu, Cd and Zn are highly enriched. Battery factories, fossil fuel combustion from traffic emissions, wear of brake lining materials, and several industrial processes are considered as major sources of the studied heavy metals.

Keywords: Heavy metals; Soil contamination.

تقيم توزيع تلوث بعض العناصر الثقيلة في الترب السطحية لمنطقة الوزيرية - بغداد

الخلاصة

تم جمع 100 عينة من التربة السطحية من أربع مناطق مختلفة (مواقع صناعية ، مواقع سكنية) تقع في حي الوزيرية في بغداد قرب معمل البطاريات وبعد اجراء عملية الهضم بالحوامض لعينات التربة تم تحليل جميع العينات لفحص محتواها من بعض المعادن الثقيلة (الكادميوم، والنحاس، والرصاص، والزنك.) وقد تم احتساب معدل محتوى عينات التربة من هذه المعادن المختارة وكان متوسط التراكيز من الكادميوم، والنحاس، والرصاص، والزنك في المنطقة كلها 11،45 و143،3 و3291،38 و195،2ملغ / كغ على التوالي.

وقد لوحظ ان أعلى التراكيز لهذه المعادن قد تواجد في المنطقة الصناعية ضمن منطقة الدراسة. وأشارت الحسابات الى ان منطقة الدراسة تعتبر ذات عامل اغناء عالي وانها مشبعة بهذه المعادن وقد يعزى هذا الامر لتواجد مصانع البطاريات والعديد من العمليات الصناعية والتي تشكل المصادر الرئيسية لتوليد هذه العناصر. بالاضافة الى احتراق الوقود والانبعاثات الناتجة من حركة المرور .

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INTRODUCTION

In the recent years; much concern has been addressed over understanding the urban soils, characteristics and contamination which became considerable great concerns due to the rapid industrializations and urbanizations. The upgrading of industry and the presence of intensive human activities in urban areas has worsened the problems of heavy metal contamination in urban soils [1].

Key heavy metals are lead (Pb) from leaded gasoline; copper (Cu);zinc (Zn) and cadmium(Cd)from car components, tire abrasion, lubricants and industrial plus incinerator emissions[2].

Their levels in the environment are not stable and vary according to industrial production, urbanization, climate changes and many other factors [3]. So; there is an increasing interest in studies of critical soil constituents of heavy metals to examine their spatial distribution and identifying the links with factors such as parent material, land use or other human activities[4].The present investigation aims to assess heavy metal contamination in residential and industrial region in Baghdad city and to study their distribution and sources.

Experimental Work

Sampling was carried out in November and December 2011. Table 1 gives an indication of the character of the zones (as seen in Figure 1) from which samples were taken. Samples were collected from (100 points) at the topsoil's (0.20 m) The soil samples were taken on a dry day from various categories of Babil 1 and Babil 2 gardens, civil food factories near Babil 1, gardens on road sides near both factories, casinos, children's playgrounds, schools situated in the residential area, state house for orphans care, squares and public parks and homes gardens to asses several heavy metals content in soil.

In the laboratory, samples were sieved in a 2-mm sieve to remove stones, glass and large plant roots and subsequently dried at room temperature for 3 days. The dried samples were then homogenized with a mortar and a pestle. The procedure described by Page [5] was followed to digest the samples with some modifications. Approximately 0.2 g of the sample was transferred into a Teflon 250 ml beaker. About 30 ml of high purity concentrated HCL and 10 ml of HNO_3 were added and allowed for slow evaporation to near dryness, to about 1 ml. The digest was cooled and diluted with deionized water up to 100 ml and stored in plastic bottles. Concentrations of Cd, Cu, Pb and Zn, were determined by the Flame Atomic Adsorption Spectrometry method.

Table (1): Description of sampling locations

Location	Description	No. of samples
A 1	industrial area at battery factory Babil 1	19
A 2	industrial area at battery factory Babil2	24
A 3	residential area of Al-Mustansiriya	41
A 4	residential area of Al-Waziriya	16

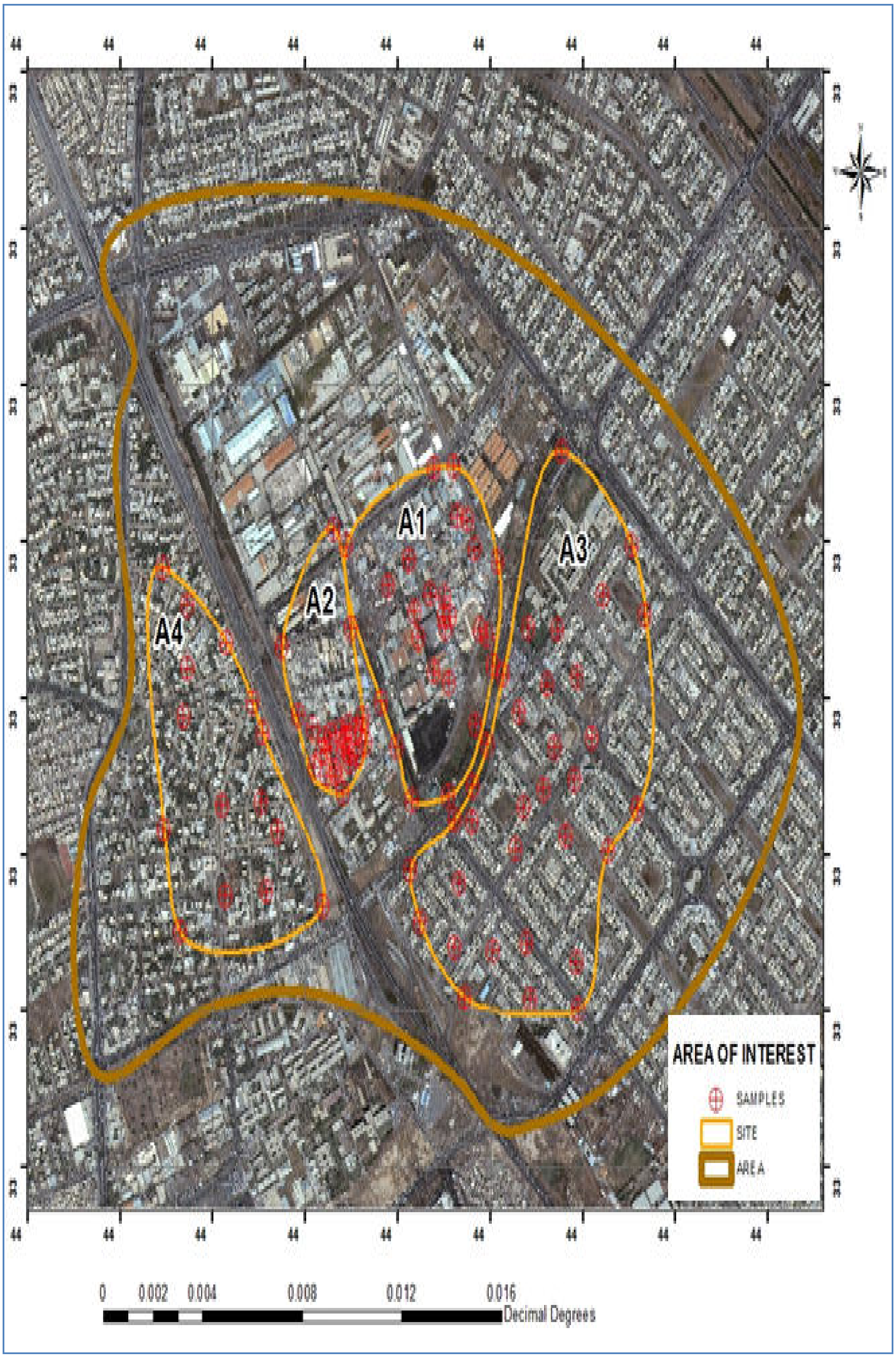

Figure (1) the zones of the studying area.

Results and discussion

1. Total metal concentrations

The maximum and minimum concentrations of the four metals (Cd, Cu, Pb and Zn) in the soil samples are shown in table 2.

Table (2): The measured concentration of contaminants .

Contaminant concentration mg/kg		A 1	A 2	A 3	A 4
Cd	**Max.**	7.85	6.35	151.75	39.6
	Min.	5.2	3.6	0.05	0.05
Cu	**Max.**	2922.9	311.7	167	176.5
	Min.	68.4	75.8	65.3	60.1
Pb	**Max.**	23364.7	25069.6	677.3	370.9
	Min.	283.1	185.7	38.7	36.6
Zn	**Max.**	1017.9	866.2	223.7	207.2
	Min.	34.9	34.3	63.75	68.7

In many cases, large differences in value between samples in the same location are observed. Such results indicate that highly localized events may have a profound effect upon concentration and distribution of metal in soil. In some cases, large differences between metal levels measured in different soil samples taken from the same location may be accounted for by point source contamination due to the presence of battery factories.

The measured values of Cd in A1,A2 and A3 zones are more than its allowable concentration in the unpolluted soil (0.53mg/kg) [6]. The maximum concentrations of Cd were in A3 zone. Cd has been reportedly associated with tyre wear and traffic movement[7] which can be fits with the results that obtained from the high Cd concentration mean of zone A3 with its high traffic activity and different industries.

The concentration of Cu for the whole studying area is greater than its allowable value in the unpolluted soil (24 mg/kg) [6]. The maximum concentration of Cu was in A1 zone. The presence of industrial and commercial activities in this zone such as manufacture process of the plumbing and electrical equipments and mechanical abrasion of vehicles causes this increasing content of Cu. This is committing with the views of [8].

Regarding Pb, maximum concentration was found in zone A2 which exceeds the standard limits more than195 times than its allowable limits in the unpolluted soil (44 mg/kg) [6]. It is so simply to notice the difference between the results of the four zones so, even that the deposition related to the automobile emissions and transportations sector consider as the major source of residential areas high Pb content [9 ,10] it became minor here due to the presence of the two factories in this region which causing the incredible values of Pb amount in soil which might affect harmfully on the safety of both human and soil components and the step decrease in the levels of Pb indicate the point source of Pb from the battery factories, since it is a common observation that contaminant levels in the vicinity of a point source generally decline with distance from that source.

The observed values are more than the allowable Zn concentration in the unpolluted soil (100 mg/kg) [6] in A1, A2 and A4 zones while it was within the limits in A3. There were a significant increase in Zn concentration in zones A1, A2 comparing to zones A3and A4, which is compatible with the increment of Zn content in the industrial area rather than in residential one [11,8].

Comparisons with other studies conducted in other cities worldwide [12] were also made as shown in Table 3. These studies indicate that the results obtained for Al-Waziriya are comparable to the concentrations of metal in urban areas worldwide. However the level of Cu was lower than that reported for London, and Zn was lower than that reported for all cities except for Calcutta, while the content of Cd is higher than its content in Calcutta.

Table (3): Comparison of mean concentrations for the whole study area (mg/kg) of heavy metals in urban soils.

	Studying area(average of four zones)	Calcutta	Hong Kong	London	Oslo	New Zealand
Cd	11.45	3.12	-	-	-	-
Cu	143.3	44	110	191	123	90.8
Pb	3291.38	536	120	2008	180	1223
Zn	195.2	159	3840	1176	412	716

The concentration of Pb in this study has the highest amount among other cities with different industrial activities. This is due to the presence of lead battery factories in this area at which Pb is the main primary raw material used for battery production; deficient in environmental awareness; lack of environmental controls on factories emissions and wastes.

2. Enrichment factor of metals

Due to universality formula and simplicity for assessing enrichment degree and comparing the contamination of different environmental media, Enrichment factor (EF) is widely used to quantify the degree of pollution of urban soil with respect to background soils [13]. Using of uncontaminated background levels for metal concentrations in calculating EF is a common approach used to estimate the relative degree of metal contamination; to differentiate between the metals originating from anthropogenic activities with those from natural procedure and to assess the degree of anthropogenic influence[14]. Its version adapted to assess the contamination of various environmental media is as follows[15] :

$$EF = \left(C_{(\text{urban soil})} \big/ C_{(\text{natural soil})} \right)$$

Where: C content of the examined element.

Five contamination categories are recognized on the basis of the EF:

EF < 2 – depletion to minimal enrichment,

EF = 2-5 – moderate enrichment,

EF = 5-20 – significant enrichment,

EF = 20-40 – very high enrichment,

EF > 40 – extremely high enrichment.

As the EF values increase, the contributions of the anthropogenic origins also increase [16]. In this study EF was used to assess the level of contamination and the possible anthropogenic impact on soils from the battery factories. The results of EF values which are less than 1, suggest a natural source for this element [17].

Enrichment factors for Pb, Cu, Cd and Zn were high which imply the presence of significant contribution of anthropogenic sources. The presence of industrial activities and fossil fuel combustion, traffic emissions and wear of brake lining materials are considered as major emission sources of these elements.

Table (4):Results of EF factors for the whole study area.

	Cd(mg/kg) All. conc. 0.53mg/kg	Cu(mg/kg) All. conc. 24mg/kg	Pb(mg/kg) All. conc. 44mg/kg	Zn(mg/kg) All. conc. 100mg/kg
Mean	11.45	143.3	3291.3	195.2
EF(mean conc./all. conc.)	21.6	5.97	74.79	1.952

The result of selected heavy metals mean content show that Cd and Pb are from anthropogenic and the soils have been contaminated by these metals in the recent years. The difference in EF values may be due to the difference in the magnitude of input for each metal in the soil and/or the difference in the removal rate of each metal from the soil. For the four zones the results are shown in the tables (5, 6,7and 8) respectively.

Table (5): Results of EF factors for A1 zone.

	Cd(mg/kg) All. conc. 0.53mg/kg	Cu(mg/kg) All. conc. 24mg/kg	Pb(mg/kg) All. conc. 44mg/kg	Zn(mg/kg) All. conc. 100mg/kg
Mean	6.5	244.3	6037.3	307.7
EF	12.26	10.18	137.21	3.07

For A1 zone, Table 5 shows that the zone has an extremely high enrichment for Pb as the area consider industrial one by the presence of Babil 1 factory.

Table (6): Results of EF factors for A2 zone.

	Cd(mg/kg) All. conc. 0.53mg/kg	Cu(mg/kg) All. conc. 24mg/kg	Pb(mg/kg) All. conc. 44mg/kg	Zn(mg/kg) All. conc. 100mg/kg
Mean	3.9	31.5	8614.7	331.7
EF	7.35	1.31	195.78	3.31

In accordance to the results shown in Table (6), A2 zone has an extremely high enrichment with Pb as its elevated enrichment factor. The results fit with the fact that enrichment of heavy metals in the region came from anthropological sources rather than natural source.

Table (7): Results of EF factors for A3 zone.

	Cd(mg/kg) All. conc. 0.53mg/kg	Cu(mg/kg) All. conc. 24mg/kg	Pb(mg/kg) All. conc. 44mg/kg	Zn(mg/kg) All. conc. 100mg/kg
Mean	22.7	72.7	130.8	96.9
EF	42.83	3.029	2.97	0.96

Regarding to EF factors for A3 zone (Table 7) the results show that this zone has an elevated enrichment by Cd for its highest EF and it observed to be greater than those of other metals. This was probably to the accumulation process over the years due to the atmospheric deposition which can affect large area, depending on distribution of population and industrial activities in the city.

Table (8): Results of EF factors for A4 zone.

	Cd(mg/kg) All. conc. 0.53mg/kg	Cu(mg/kg) All. conc. 24mg/kg	Pb(mg/kg) All. conc. 44mg/kg	Zn(mg/kg) All. conc. 100mg/kg
Mean	3.4	109	133.4	108.8
EF	6.41	4.54	3.03	1.08

The result of heavy metals content in soil samples at this area seems to be the best between other zones as metals have been found from natural sources rather than from anthropogenic one.

Conclusions

Results of this study indicated that levels of metals in top soil samples in Al-Waziriya is comparable to the other metal levels in urban soil levels worldwide. However, concentrations of Cu and Zn in urban soils are generally lower than those reported for some polluted cities. Enrichment factor data suggest widespread contamination by Pb, Cd and lowest contamination Cu and Zn. Lead levels are significantly higher on industrial area compared to residential one. Maximum concentrations for Cd, Cu and Zn, were observed in the industrial area, certainly due to the various metal processing industries, such as welding, electroplating and galvanizing.

REFERENCES

[1]Suna,Y., Zhoua,Q., Xiea,X., Liu,R.,. (2010). "Spatial, Sources And Risk Assessment Of Heavy Metal Contamination Of Urban Soils In Typical Regions Of Shenyang, China." ELSEVIER/Journal of Hazardous Materials , 455-462.

[2]Fiuza,M.D.L. and Dinis,A. (2011). "Exposure Assessment to Heavy Metals in the Environment: Measures to Eliminate or Reduce the Exposure to Critical Receptors. "Environmental Heavy Metal Pollution and Effects on Child Mental Development: Risk Assessment and Prevention Strategies, DOI 10.1007/978-94-007-0253-0_2 Springer Science+ Business Media B.V

[3]Krystofova,O., Shestivska,V., Galiova,M., Novotny ,K., Kaiser,J., Zehnalek ,J., Babula ,P., Opatrilova ,R., Adam ,V., and Kizek,R.,. (2009). "Sunflower Plants as Bioindicators of Environmental Pollution with Lead (II) Ions. "Senseros ISSN 1424-8220 , 181-193

[4]Okieimen, R., Wuana,A. and Felix,E. (2011). "Heavy Metals in Contaminated Soils: A Review of Sources, Chemistry, Risks and Best Available Strategies for Remediation." ISRN Ecology , 17-25.

[5]Page, A. a. (1986). "Methods Of Soil Analysis, Part 2,Chemical And Microbiological Properties." 2nd Ed,. Madison, Wisconsin,USA: Agronomy,No.9, ASA,SSSA Publ.,.

[6]Kabata-Pendias, A., . (2001). "Trace Elements in soils and plants third edition." Boca Raton London New York Washington, D.C.: CRC Press.

[7]De Miguel, E., LLamas,J.F.,Chacon, E.,Berg,T., Larsson, S.,Royset,O and Vadest, M. (1997). "Origin And Patterns Of Distribution Of Trace Elements In Street Dust: Unleaded Petroland Urban Lead." Atmospheric Environment 31 ,17 , 2733-2740.

[8]Charlesworth, S., Everett,M., McCarthy,R and De Miguel, E. (2003). "A Comparative Study Of Heavy Metal Concentration And Distribution In Deposited Street Dusts In A Large And Small Urban Area: Birmingham Coventry, West Midlands, UK." Environment International,29 , 563-573.

[9]Madrid, L. D.-B. (2002). "Distribution of Heavy Metal Contents of Urban Soils in Parks of Seville." Chemosphere,49 , 1301-1308.

[10]Imperato, M. A. (2003). "Spatial Distribution of Heavy Metals in Urban Soils of Naples City (Italy)." Environmental Pollution", 124 , 247-256.

[11]Banerjee, A.D.K. (2003). "Heavy Metal Levels And Solid Phase Speciation In Street Dust Of Delhi, India." Environmental Pollution, 123 , 95-105.

[12]Ehsanul, K., Sharmila, R., Ki-Hyun, K., Hye-On, Y.,Eui-Chan, J. Y., Shin, K., Yong-Sung ,Ch., Seong-Taek, Y., and Richard ,J. C. B. (2012). "Current Status of TraceMetal Pollution in Soils Affected by Industrial Activities." The Scientific World Journal , 1-18.

[13]ZhaoHong M., Li,Y.Q., Zhang,D.Y. Zhang,Li. (2011). "Pollution And Ecological Risk Assessment Of Heavy Metal Elements In Urban Soil. Harbin,China:" College of Geographical Sciences, Harbin normal university, 150025 Harbin, China

[14]Hernandez, L., Probst, A.and Probsta, J. L., and Ulrich, E. (2003). "Heavy Metal Distribution In Some French Forest Soils: Evidence For Atmospheric

Contamination." The Science of the Total Environment, 312 , 195-219.
[15]Garty, J. (2002). "Deposits As A Medium For Chemical Elements." In J. Garty, Elsevier ,Trace Metals in the Environment 467–563.
[16]Sutherland, R. (2000). "Bed Sediment-Associated Trace Metals In An Urban Stream, Oahu, Hawaii." Environ. Geol., 39 , 611-637.
[17]Manta, D. A. (2002). "Heavy Metals In Urban Soils: A Case Study From The City Of Palermo(Sicily),Italy."The Scince of the Total Environment,300 , 229-243.