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Assessment of Toxic Levels for Lead in Soil of Al-Waziriya Region, Baghdad

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ABSTRACT

Lead (Pb) concentration in urban soils was measured in AL-Waziriya District in Baghdad city for both; an industrial area of batteries industry and the residential area around it which may be affected by the emissions caused by production processes of the industrial activities.

A hundred samples were collected from the top soil and analyzed for Pb concentration using Adsorption Spectrometry method.

Geostatistical methods were used to study spatial structure distribution of Pb in this area besides using environmental indices (Geoaccumulation index I*geo* and single potential ecological risk factor Ei) to evaluate contamination degree in the region. Results showed that the examined sites are quite large in which Pb concentration values higher than the world regulatory values regarding soil pollution with it and identifying hot-spot areas. These polluted areas could create a significant health risk for human beings and vegetation in the near future.

Keywords: Lead, Geo-Accumulation Index, Single Ecological Risk Factor.

تقييم مستوى السمية للرصاص في التربة لمنطقة الوزيرية – بغداد

الخلاصة

تم قياس تركيز عنصر الرصاص في التربة الحضرية لمنطقة الوزيرية ببغداد منطقة معمل صناعة البطاريات والمنطقة السكنية التي من الممكن ان تتأثر بالأنبعاثات الناتجة عن هذه الصناعة.جمعت 100 عينة من التربة لغرض فحص تركيز الرصاص فيها باسخدام جهاز الامتزاز الذري .اعتمدت طريقة الرسم الاحصائي لتوضيح توزيع تراكيز هذا العنصر على منطقة الدراسة واعتماد بعض المؤشرات البيئية الحيوية لتقييم نوعية التلوث الذي تعاني منه التربة مثل مؤشر التجميع التراكمي ومؤشر الخطورة على النظام الايكولوجي .اظهرت النتائج ارتفاع تركيز عنصر الرصاص عن محدادته العالمية ولمنطقة واسعة ووجود مناطق تعتبر ساخنة مما يؤثر مستقبلا على صحة الانسان وعلى النظام الخضري.

INTRODUCTION

Industrial pollution has been and continues to be a major cause of environmental degradation. Numerous studies have already demonstrated that areas in close proximity to industrial activities are marked by noticeable contamination of air, soil, and water [1-3]. Hence, such activities can affect the air we breathe, the water we use, and the soil we stand on and can ultimately lead to various health disorders and/or harm to the residents in the affected area. Among various toxic substances released by industrial activities, heavy metals which have been seen as a key marker because they may be analyzed effectively and consistently in most environmental matrices. Unlike organic pollutants which may degrade to less harmful components as a result of biological or chemical processes, metals are not degradable by natural processes especially when elemental metallic content is considered. [4]

Protection and improvement of the environmental conditions are a matter of great importance that affects the life of the people and economical development of the countries around the world. Environment protection complies with the needs and interests of peoples, and simultaneously represents a duty for every government [5].

Pb that presents in a concentration of 44mg/kg for unpolluted soil [6]consider the major row material for batteries industries, so for long term emissions and deposition from atmosphere; leaching and migration of it from these factories can result in pollution of soil and ground water. As Pb does not biodegrade and is not rapidly absorbed by plants, it remains in the soil at elevated levels or removed to local drainage systems through soil disturbance and erosion which both have potentially harmful effects on human health.

The present work deals with studying the contamination degree for Pb in soils for; the industrial area (two factories, Babil (1&2) that related to the State Company for Batteries Industry which were constructed since 1953, 1975 respectively and the residential area around it (al-Mustansiriya and al-Waziriya sections)) by geo-accumulation index (I*geo*) method and to assess the single potential ecological risk (Ei) posed by Pb, with the aid of potential ecological risk index method (Ri).

Materials and Methods

The Study Area:

The study as shown in fig. (1) area is located at Al-Waziriya industrial region in the eighborhood of Waziriya and AL-Aadhamiya sectors, north east of Baghdad city and covers an area of 1.57 km^2 surrounding by Al-Waziriya district and Muhammad Al-Kasim highway from the north, with district of Cairo to the south and east, and Al-Mustansiriya district to the west, that mean it is in the midst of residential areas.

Sample Collection

For the purpose of sample collection, the study area was divided in two main types of land use vis; Industrial, and residential. In this research, 100 locations have been taken from the top soil and selected to cover nearly all the study area. In order to be more specified in calculating amount of pollution by the means of factors, the studying area were divide into four zones as describe below:

1. The first zone A1 is within and around Babil1 factory for 19 samples.
2. The second zone (A2) is within Babil 2 factory and around it for 24 samples.
3. The third zone (A3) is within Al- Mustansiriya residential area for 41 samples in order to cover large part of the most probably residential affected area.
4. The fourth zone (A4) is within Al- Waziriya residential area for 16 samples. Figure (1) shows the studying area boundaries with the four zones and samples distributions that were taken.

Sample Pretreatment and Analysis

All soil samples were taken with a stainless steel spade. Soil samples were placed in clean plastic bags and homogenized. They were, then, air-dried and passed through a mesh sieve with 2 mm openings, after they had been disaggregated with a porcelain pestle and mortar.

The selected test period prolonged the whole month of December 2011. The soil samples were taken from 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. The coordinates of all locations for samples were also taken by using a geographic position system (GPS) instrument type GARMIN.

0.2g each of the dried sieved samples was picked by the aid of a high precision analytical balance. Subsequently, the samples were placed in polytetra-flouroethylene vessels and digested at 100℃ for about 2hrs using 40ml of a mixture of conc. HCl and conc. HNO3 in the ratio of 3:1. The digested samples were left to cool and filtered. The filtrates were made up to $100cm^3$ with distilled water. The total metal levels in the digested samples were determined using Atomic Absorption Spectro-photometer. The blanks and duplicates were similarly determined [7]. All samples were tested at the Environmental Research Center at the University of Technology / Iraq.

Data Analysis

The results obtained were analysis to determine the Geo-accumulation Index (I*geo*) and Single Potential Ecological Risk Index (Ei) of Pb in the environment.

2.4.1. Geo-Accumulation Index (Igeo)

The Geo-accumulation Index (Igeo), was introduced by Muller [8] for determining the extent of metal accumulation in sediments, and has been used by various workers for their studies. Igeo is mathematically expressed as:

$$I_{geo} = \log_2 \left[C_n / (k \times B_n) \right] \quad \text{..................(1)}$$

Where:

Cn: is the concentration of heavy metal (n) in the soil sample,

Bn: is the geochemical background value of (n) in the soil,

k : is the calibration coefficient considering variations of the background value due to the rock resource difference (commonly, *k*= 1.5) [9]. The geo-accumulation index (Igeo) scale consists of seven grades (0 –6) ranging from unpolluted to highly polluted (Table 1).

Potential Ecological Risk Index

The Potential Ecological Risk Index (Ri) was originally introduced by Hakanson [10] to assess the degree for overall heavy metals pollution in soil, according to the toxicity of metals and the response of the environment. For single metal it can be expressed by the single index of ecological risk factor (Ei). The calculating methods of ***Ei*** and ***Ri*** are as follows:

$$Ei = Ti * \frac{Ci}{Bi} \quad \ldots\ldots\ \ldots\ \ldots\ldots (2)$$

$$Ri = \sum_{i}^{n} Ei \quad \ldots\ \ldots\ \ldots (3)$$

Where:

n- the count of heavy metal species, ***Ci***–the measured concentration of metal i in the soil,

Bi-the geochemical background concentration of the metal ***i***, and

Ti* -**The toxic-response factor and values of ***Ti for different heavy metals by Hakanson are given as follows: ***Ti(***Cd)= 30; ***Ti***(Cu)=5; ***Ti***(Pb)=5; ***Ti***(Zn)=1. There are four categories of ***Ri*** and five categories of ***Ei*** as shown in Table(2).

Results and Discussion

The ranges of mean concentration of Pb for the whole studying area is (3291.3 mg/kg) and for the four zones are listed in Tables (3, 4, 5 and 6) and Figure (2) shows Pb concentration distribution within the studying area.

Contamination Degree Based On *Igeo* and *Ei*

The degree of pollution in soil samples can be assessed by the determination of indices such as I*geo* index. The calculated I*geo* indices and ***Ei*** factors values for Pb mean concentrations of the whole studying area and for the four zones according to equation (1,2) are summarized in Table(7) which indicate that the whole area and the industrial zones

(A1&A2) were extremely polluted with I*geo* index > 5 and suffering a very high potential ecological risk with ***Ei*** > 320 while the residential zones within the studying area (A3&A4) showing a moderately polluted with Pb as I*geo* index (1-2) with low potential ecological risk as ***Ei*** factor < 40.

Table (1): Pollution Grades of Geo-Accumulation Index of Metals

Igeo class	**Igeo value**	**RDS quality**
0	Igeo ≤0	uncontaminated
1	0 < Igeo <1	uncontaminated to moderately contaminated
2	1 < Igeo <2	moderately contaminated
3	2 < Igeo < 3	moderately to heavily contaminated
4	3 < Igeo < 4	heavily contaminated
5	4 < Igeo < 5	heavily to extremely contaminated
6	5 < Igeo	extremely contaminated

Table (2): Classification of the potential ecological risk index

Single Index Of Ecological Risk factor(Ei)	Potential Ecological Risk Index(Ri)	Degree of Potential ecological Risk
< 40	< 150	Low potential ecological risk
40-80	150-300	Moderate potential ecological risk
80-160	300-600	Considerable potential ecological risk
160-320	≥ 600	High potential ecological risk
≥ 320	-	Very high potential ecological risk

Table (3): Mean Concentrations (mg/kg) of Pb in soil samples for A_1 zone

Sample no.	Conce. (mg/kg)	Sample no.	Conce. (mg/kg)	Sample no.	Conce. (mg/kg)	Sample no.	Conce. (mg/kg)
1	2561.5	6	19813.8	11	442.5	16	946.5
2	10331.5	7	4259.8	12	427.2	17	462.55
3	18917	8	3521.95	13	23364.7	18	283.1
4	10939.9	9	8249	14	352.75	19	819.55
5	8131.9	10	378.55	15	505.5	20	
Mean Pb concentration for A1zone = 6037.36 mg/kg							

Table (4): Mean Concentrations (mg/kg) of Pb in soil samples for A_2 zone

Sample no.	Conce. (mg/kg)	Sample no.	Conce. (mg/kg)	Sample no.	Conce. (mg/kg)	Sample no.	Conce. (mg/kg)
1	2400.5	7	9789.7	13	11910.7	19	1423
2	5621	8	9335.2	14	4581.5	20	510.2
3	1948.8	9	7757.4	15	16431.6	21	2871.1
4	423.4	10	19845	16	16685	22	528.4
5	25069.6	11	9303.8	17	11855.4	23	246.8
6	18871.5	12	12652.6	18	16504.8	24	185.7
Mean Pb concentration for A2zone = 8614.7 mg/kg							

Table (5):Mean Concentrations (mg/kg) of Pb in soil samples for A_3 zone

Sample no.	Conce. (mg/kg)	Sample no.	Conce. (mg/kg)	Sample no.	Conce. (mg/kg)	Sample no.	Conce. (mg/kg)
1	62.1	12	51.4	23	85.9	34	90
2	104.5	13	57.15	24	42.3	35	76.8
3	59.6	14	99.85	25	57.85	36	47.3
4	104.8	15	657.55	26	105.6	37	58.5
5	677.3	16	54.7	27	89.2	38	47.3
6	476.8	17	209.6	28	72.65	39	56.4
7	92.4	18	40.75	29	67.8	40	38.76
8	205.8	19	170.5	30	59.9	41	71.9
9	228.6	20	50.6	31	63.5		
10	454.9	21	117.9	32	61		
11	88.35	22	62.9	33	176.2		
Mean Pb concentration for A3zone = 135.1mg/kg							

Table (6): Mean Concentrations (mg/kg) of Pb in soil samples for A_4 zone

Sample no.	Conce. (mg/kg)	Sample no.	Conce. (mg/kg)	Sample no.	Conce. (mg/kg)	Sample no.	Conce (mg/kg)
1	77.7	5	212.4	9	370.9	13	36.6
2	53.8	6	49.7	10	175.2	14	62.9
3	79.3	7	263.05	11	80.95	15	178.1
4	161.85	8	232.5	12	44	16	55.7
Mean Pb concentration for A4zone = 133.4 mg/kg							

Table (7): *Igeo* and *Ei* indices for Pb mean concentration in the studying area and its grades.

	Whole studying area	A1 zone	A2 zone	A3 zone	A4 zone
Mean Pb conc.(mg/kg)	3291.3	6037.3	8614.7	135.1	133.4
I*geo* index	5.64	6	7.02	1.02	1.01
Pollution degree	extremely contaminated	extremely contaminat ed	extremely contaminated	moderately contaminated	moderately contaminated
Ei factor	374.01	686	978.9	14.86	15.15
Pollution degree	Very high potential ecological risk	Very high potential ecological risk	Very high potential ecological risk	Low potential ecological risk	Low potential ecological risk

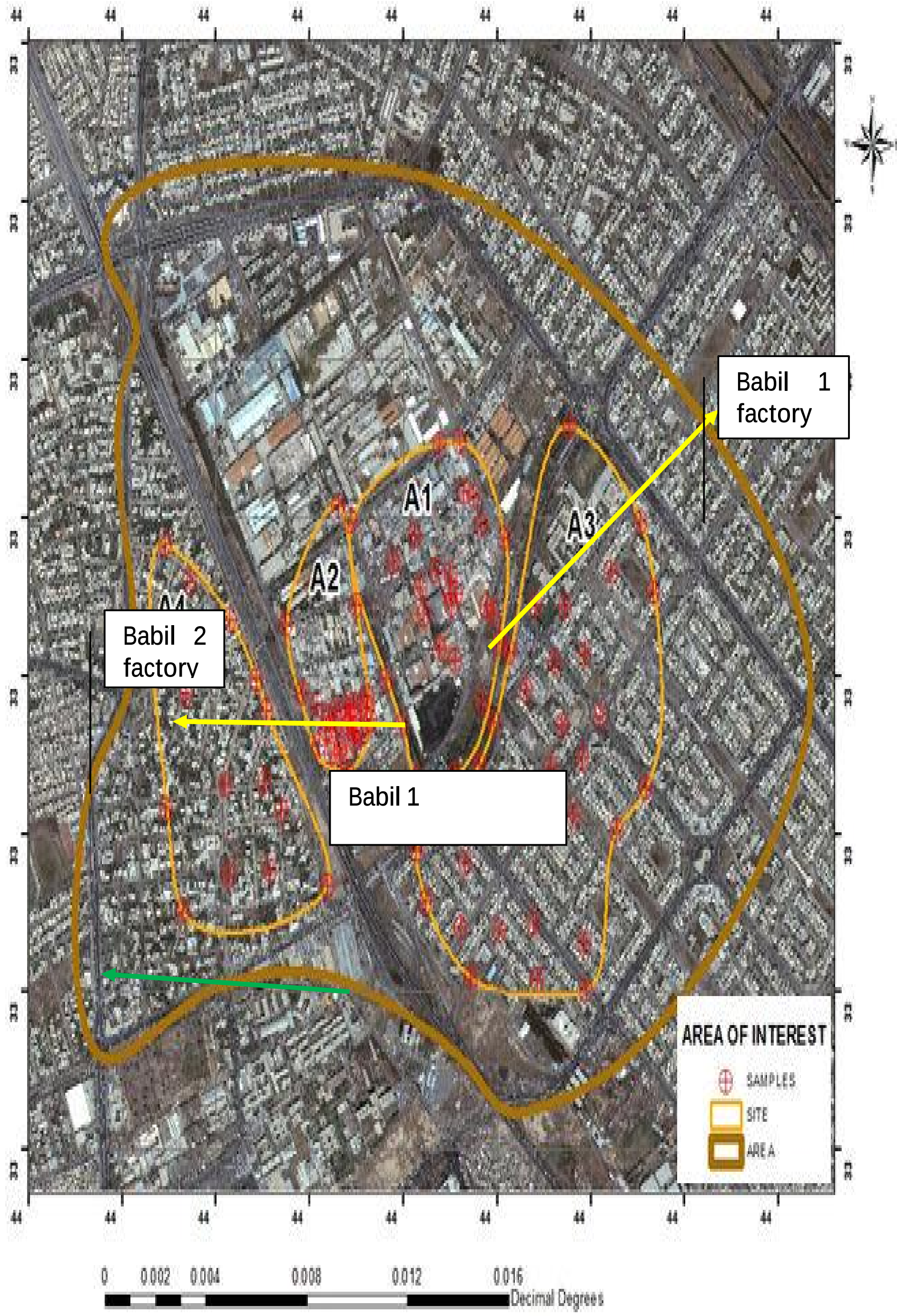

Figure (1) the four zones within the studying area boundaries.

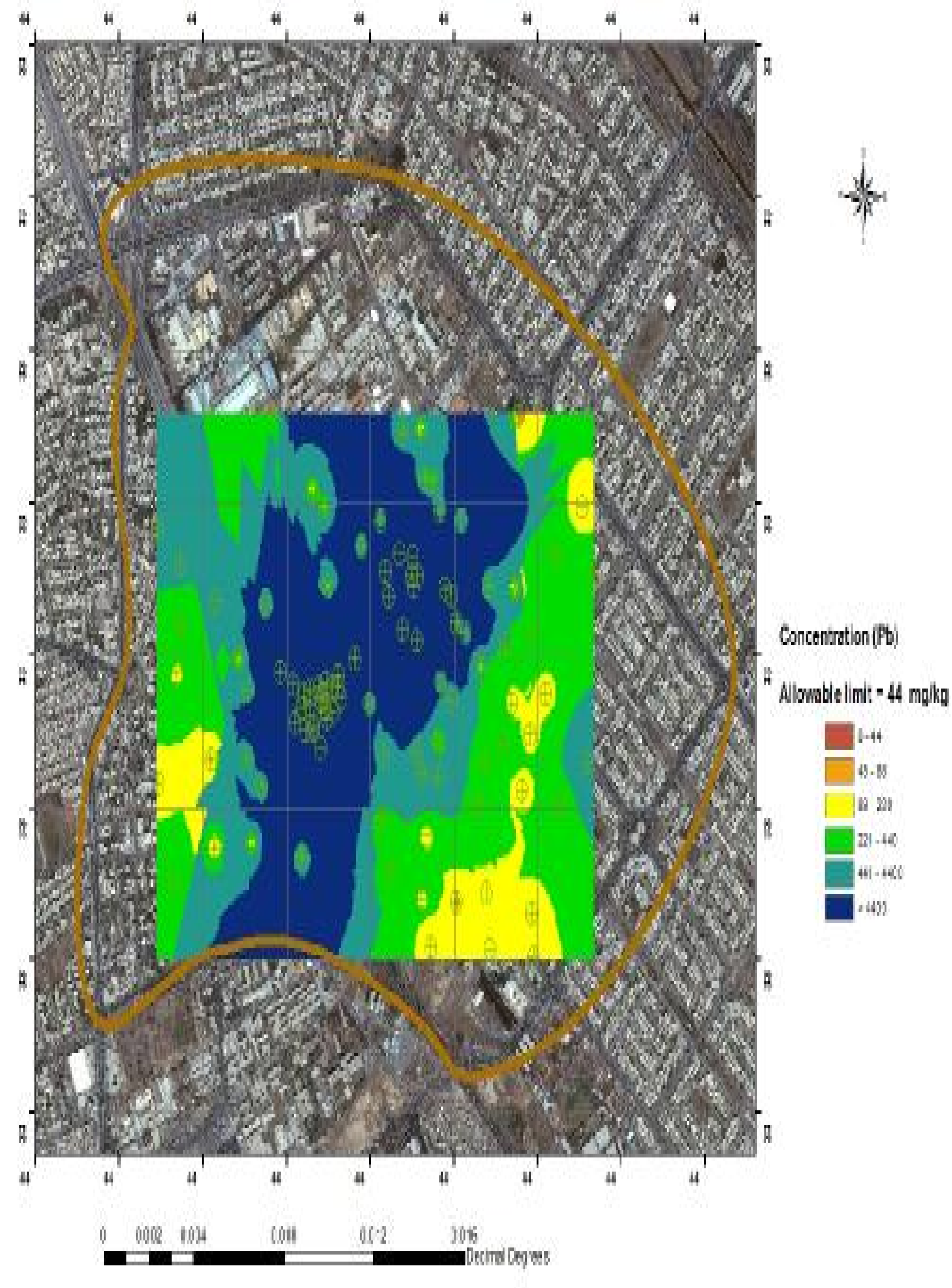

Figure (2) Distribution of Pb at top soil

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