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Accumulation Detection of Cadmium in some land-use soil of Baghdad city, Iraq

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Abstract

This study aims to detect cadmium accumulation in the soil of Baghdad. Twenty soil samples were collected randomly during November 2020 to cover the study area, emphasizing the nature of each area (agricultural, commercial, industrial, residential, roadside, and waste dumping sites). All soil samples were subjected to geochemical analysis using atomic absorption spectrometry (ASS) to determine the concentration of cadmium in Baghdad soil. The laboratory data was utilized to design the spatial analysis map using Arc GIS 10.4.1 to investigate the spatial distribution of cadmium. The results demonstrated that the total content of cadmium in the study area ranged from 0.121to 1.78 mg/kg. All results of cadmium concentrations are within the allowable limits of WHO (3 mg/kg), and the mean concentration of cadmium according to the type of land use is shown by the following decreasing order: roadside > agricultural areas > residential areas > industrial areas >waste dumping site> commercial. In addition, the spatial analysis map showed the accumulation of cadmium concentration on the Al-Karkh side than on the Al-Rissafa side of Baghdad city. A comparison between cadmium concentration in the soil of some land- use for the current study and cadmium concentration in previous studies showed that the concentration of cadmium decreased from previous years, except roadside sites recorded a higher cadmium concentration than the cadmium concentration of roadside areas according to [12].

Keywords: Cadmium, Land use, Accumulation Detection, soil, Baghdad

كشف تراكم الكادميوم في تربة بعض الاراضي المستخدمة في مدينة بغداد, العراق

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الخلاصة

ولكشف تراكم الكادميوم في تربة مدينة بغداد، تم جمع 20 عينة من التربة عشوائياً خلال شهر نوفمبر/تشرين الثاني من عام 2020 لتغطية كامل مساحة الدراسة مع التركيز على طبيعة كل منطقة، على سبيل المثال (الزراعية، والتجارية، والصناعية، والسكنية، وعلى جانب الطريق، وموقع إلقاء النفايات). وخضعت جميع عينات التربة للتحليل الجيوكيميائي باستخدام قياس الامتصاص الذري لتحديد تركيز الكادميوم في تربة بغداد، واستخدمت البيانات التي تم الحصول عليها من المختبر في تصميم خريطة التحليل المكاني

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باستخدام برنامج (Arc GIS 10.4.1) بغرض التحقيق في التوزيع المكاني للكادميوم. ويتراوح مجموع محتوى الكادميوم في مجال الدراسة بين 0.121 و1.78 مغ/كغ. وجميع نتائج تركيزات الكادميوم ضمن الحدود المسموح بها لمنظمة الصحة العالمية (3 مغ/كغ). متوسط تركيز الكادميوم وفقا لنوع استخدام الأراضي المبين في التسلسل التالي، جانب الطرق> المناطق الزراعية> المناطق السكنية> المناطق الصناعية> موقع دفن النفايات> التجاري. وبالإضافة إلى ذلك، أظهرت خريطة التحليل المكاني تراكم الكادميوم المتركز في جانب الكرخ أكثر من جانب الرصافة في مدينة بغداد. أظهرت المقارنة بين تركيز الكادميوم في تربة بعض الأراضي المستخدمة للدراسة الحالية وتركيز الكادميوم للدراسات السابقة أن تركيز الكادميوم انخفض عن السنوات السابقة باستثناء الموقع على جانب الطريق حيث سجل تركيز الكادميوم ارتفاعا عن تركيز الكادميوم لموقع على جانب الطريق الذي سجل وفقا لتقرير [12].

1. Introduction

Cadmium (Cd) is considered the most toxic of all heavy metals., which means that the few maxima found are critical values[1,2]. Contamination soils with cadmium is a universal environmental problem resulting from unregulated industrialization, unsustainable urbanization, and intense agricultural practice. Cadmium contamination in soil is produced from natural sources (weathering of minerals) and anthropogenic activities such as human industrial and agricultural activities [3]. Emissions of cadmium to the atmosphere from human activities are fifteen times higher than emissions from natural weathering [4]. Moreover, cadmium has strong chemical activity, such as strong concealment, high mobility and long-lasting toxicity. Because most microorganisms cannot break it down in the soil [5]; therefore, they accumulate in soil and can even be converted into extra toxic alkyl compounds that can be ingested and accumulated by plants and other organisms, thereby accumulating in the food chain and affecting human health [6]. Cadmium (Cd)-contaminated soils have major implications for terrestrial ecosystems, agricultural output, and human health [7].

Therefore, research on the distribution and concentrations of cadmium in soils is critical for developing management strategies to improve environmental quality and reduce the hazard associated with an excessive rise in cadmium in the soil environment [8]. Numerous researchers referred in their research to cadmium pollution cases in Baghdad, expressed in water, plants, and soil. [9] found that the total concentration of cadmium in Agricultural sites was higher than the concentration of cadmium in urban sites. [10] found a high concentration of cadmium in soil and plants, the accumulation of cadmium in the leaf fraction of plant more than fruit fraction. [11] reported a typical concentration of cadmium less than 1 ppm in Baghdad city soil and mentioned there was no abnormal concentration of cadmium in the water of the Tigris river. [12] reached that the concentration of cadmium in roadside and open areas in Baghdad soil exceeds the average mean value of unpolluted soil worldwide. [13] found high cadmium concentration compared with the calculated global average of unpolluted soils.

This work aims to determine the concentration, spatial distributions and cadmium accumulation sites of Baghdad soil.

1.1 Study area

The city of Baghdad is within the UTM coordinates Northing (3672000-3704000), and Easting (428000-456000) lies in the Mesopotamian alluvial plain, which is mainly formed by river sediments (sand, silt, and clay). The Tigris River separated Baghdad into two halves, the right or western side is Al Karkh, and the left or eastern side is Al Rafa. It has an arid to semi-arid climate, with cold and humid winters and hot, dry summers, with an annual rainfall of around 151.8 mm [14]. According to the Ministry of Planning, Baghdad has a land area of 4,555 km^2 and a population density of more than 8 million people.

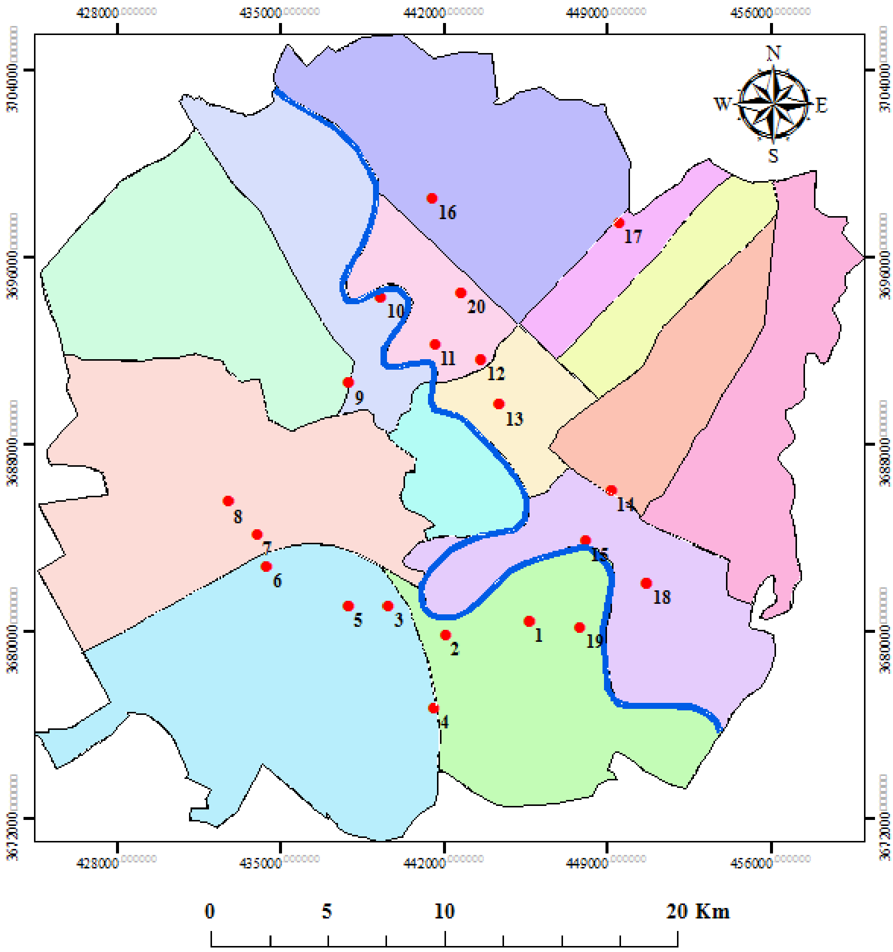

Figure 1- The study area map shows the soil samples' location.

2. Materials and methods

For the sample collection, the investigated area was divided into land-use types: agricultural, industrial, residential, waste dumping site, commercial, and roadside. Twenty samples collected from topsoil at a depth between (5- 30 cm) were randomly distributed to cover the entire study area. All samples were collected during November 2020. Soil samples were saved in clean plastic bags and homogenized. They were transferred to the laboratory, and the wet samples were subjected to dry in an oven at 60C˚. Soil samples were wet digested using a combination of $HClO_4$ and HNO_3 [15]. Metal determination was done by Atomic Absorption Spectrometry (AAS 6300, Shimadzu, Japan). At the Atomic Absorption Spectrometry laboratory of Environmental & Water Research & Technology Directorate, Ministry of Science and Technology. In this manuscript, the Arc GIS 10.4.1 was used to design the spatial analysis map of cadmium element in the study area, Excel 2010 was used for data processing, and the statistical analysis was performed using IBM SPSS statistics 25.

Table 1- Coordinates, land use type, name, and the number of sampling sites.

Sample No.	Site name	Land use type	Coordinates (UTM)	
			Easting	**Northing**
1	Al-Dora (Al-Masafi junction)	Roadside	445637	3680485
2	A-Dora	Agricultural	442041	3679889
3	Sayidia	Agricultural	439595	3681134
4	Al-Salam university college	Agricultural	441565	3676765
5	Al-Bayaa (Industrial District)	Industrial	437871	3681120
6	Jehad	Agricultural	434398	3682802
7	Amirya	Commercial	433959	3684200
8	Abu Ghraib	Waste dumping site	432747	3685586
9	Al-hurriya	Residential	437921	3690662
10	Kadhimiya	Agricultural	439283	3694319
11	Adhamiya	Agricultural	441620	3692327
12	Al-Wazeeria(Battery Manufacturer)	Industrial	443585	3691668
13	Shikh Omer	Industrial	444355	3689755
14	Ziyouna	Residential	449130	3686058
15	Karada	commercial	448043	3683911
16	Shaab	Agricultural	441488	3698587
17	Sadr city	Industrial	449475	3697518
18	Al-Za'franiya	Residential	450674	3682094
19	Al-Dora expressway	Agricultural	447821	3680205
20	Alselikh	Residential	441820	3695015

3. Results and Discussion

The statistical analyses of cadmium concentration in the soil samples are presented in Table 2. In addition, the spatial distribution of cadmium in the soil is shown in Figure 2.

Table 2- The Concentration of Cadmium in mg/kg with descriptive statistics and WHO permissible limit [16].

Sample No.	Site name	Land use	Cadmium Concentration in (mg/kg)
1	Al-Dora (Al-Masafi junction)	Roadside	1.78
2	A-Dora	Agricultural	1.03
3	Sayidia	Agricultural	0.85
4	Al-Salam university college	Agricultural	<0.1
5	Al-Bayaa (Industrial District)	Industrial	0.121
6	Jehad	Agricultural	<0.1
7	Amirya	commercial	<0.1
8	Abu Ghraib	Waste dumping site	0.25
9	Al-hurriya	Residential	<0.1
10	Kadhimiya	Agricultural	0.14
11	Adhamiya	Agricultural	<0.1
12	Al-Wazeeria (Battery Manufacturer)	Industrial	0.485
13	Shikh Omer	Industrial	0.2365
14	Ziyouna	Residential	<0.1
15	Karada	commercial	<0.1
16	Shaab	Agricultural	0.5
17	Sadr city	Industrial	0.4305
18	Al-Za’franiya	Residential	0.35
19	Al-Dora expressway	Agricultural	<0.1
20	Alselikh	Residential	<0.1
	Min		0.121
	Max		1.78
	WHO,2006 [16]		3

WHO: World Health Organization

The total cadmium content in the study area ranged from 0.121to 1.78 mg/kg. However, a lower value was recorded in Al-Bayaa (Industrial District), while a higher value was recorded in Al-Dora (Al-Masafi junction). No elevated level of cadmium in the soil of all sites investigated according to the health world organization (WHO) permissible limit of cadmium [16], All results of cadmium concentrations are within the allowable limits (3 mg/kg). The average total cadmium content of the soil samples formed the following order according to the type of land use: roadside > agricultural areas > residential areas > industrial areas > waste dumping site> commercial. Concentrations of cadmium above 0.5 mg/kg might reflect the influence of human activity [17]. Human activities can contribute to elevated cadmium values due to urban industrial and agricultural activities [7]. In this current study, cadmium accumulation in roadside soil (Al-Dora Al-Masafi junction) mainly originated from automobile traffic, and industrial activities such as Al-Dora refineries might contribute to elevated cadmium concentrations. In addition, the reason for the accumulation of cadmium in agricultural areas is due to the use of cadmium as an impurity in many products such as phosphate fertilizers, and pesticides.

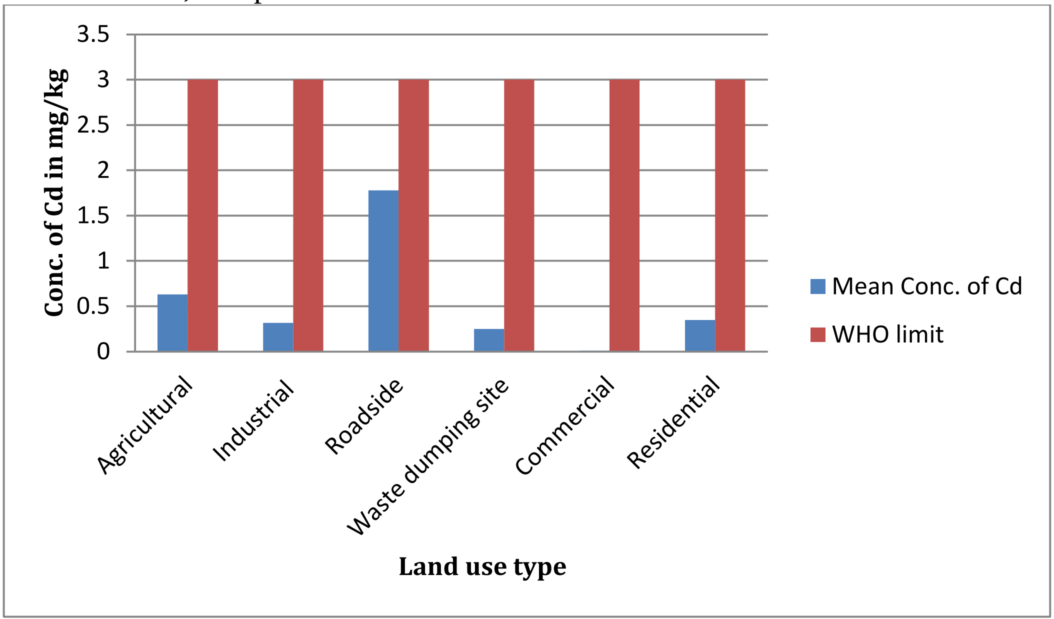

Figure 1- Mean concentrations of cadmium compared with WHO permissible limit for different land use of study area.

The GIS technique uses spatial analyst extension in Arc Map to prepare the map to predict the spatial distribution of cadmium concentrations in Baghdad soil. The map shows that cadmium concentrations increase towards the south and southeast of the study area. Further, the map showed the accumulation of cadmium in the Al-Karkh side slightly higher than on the Al-Rissafa side due to urban sprawl, which decreases vegetation cover and increases traffic emission, anthropogenic activity and economic activity.

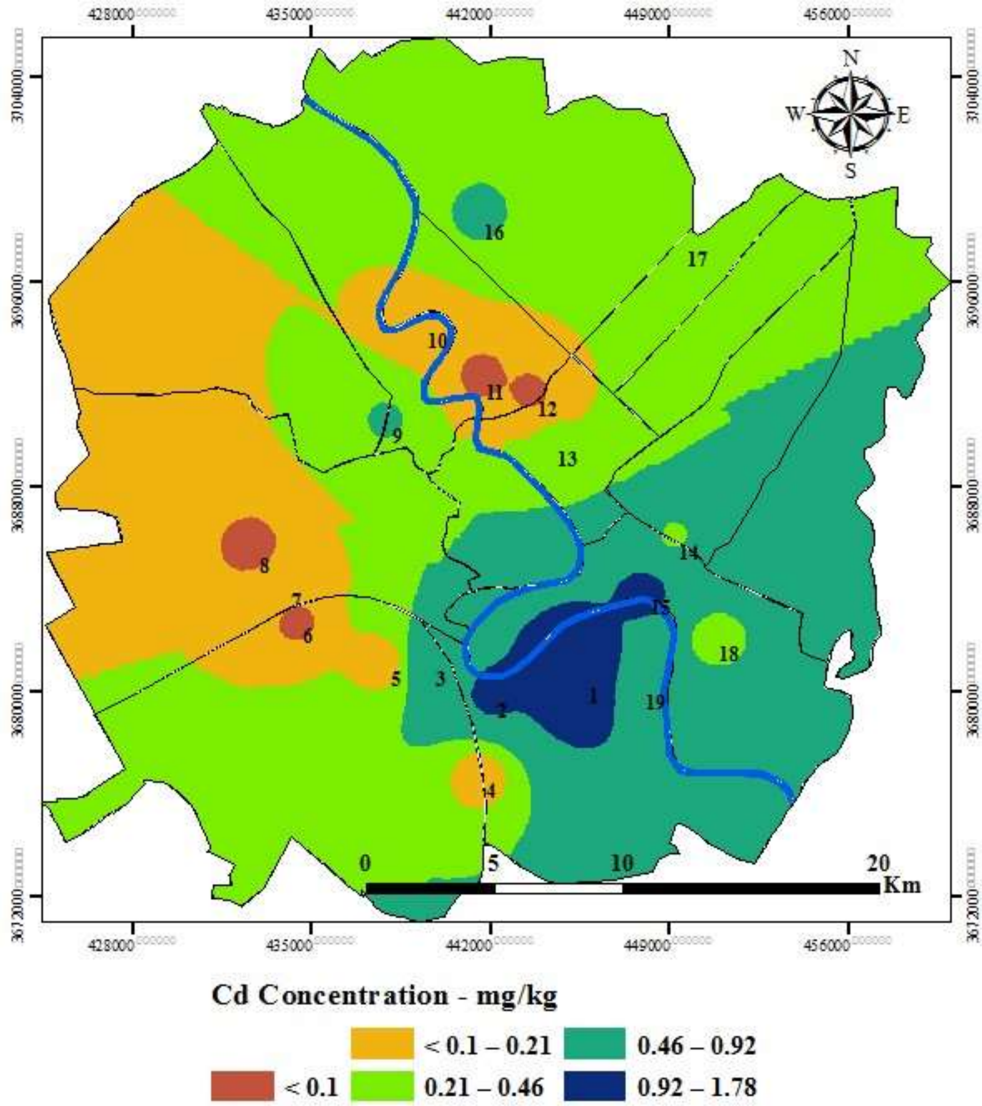

Figure 3- Spatial distribution map of cadmium soils of the study area

Table 3- compression between the mean concentration of cadmium for different land-use of Baghdad soil and other previous studies

The type of land use	Mean Concentration of Pb	References
Urbanization **Agricultura**	3.93 4.42	[9]
All soils	19	[10]
Agricultural **Industrial** **Urbanization**	<1 <1 <1	[11]
Residential **Commercial** **Industrial** **Roadside** **Open area soils**	0.26 0.425 0.935 0.56 0.52	[12]
Residential **Commercial** **Industrial** **Mixed**	2.99 3.42 4 4.18	[13]

All soils	5.25	[18]
Residential	0.35	Present study
Commercial	<0.1	
Industrial	0.318	
Waste dumping site	0.25	
Agricultural	0.63	
Roadside	1.78	

Eventually, the comparison of the mean concentration of Cd in the current study with other previous studies of Baghdad (Table 3) revealed that the concentration of Cd in the current study for all land use was lower than the reported Cd concentration in [7,9,10,13,18] researches. At the same time, there are no significant differences from reported Cd concentration in [11, 12], except the roadside mean Cd concentration of the current study is higher than the roadside mean Cd concentration according to [12]. However, this variety reflects the effect of various variables, such as parent material, traffic density, nature of anthropogenic inputs etc. [19].

4. Conclusion

In conclusion, this research established the accumulation detection of Baghdad soil's cadmium. The geochemical analysis and spatial analysis map of soil samples exhibited that the mean concentration of cadmium according to the type of land-use displayed by the following sequence, roadside > agricultural areas > residential areas > industrial areas >waste dumping site> commercial and all results of cadmium concentrations are within the allowable limits (3 mg/kg). Further, the spatial analysis map showed the accumulation of cadmium concentrated on the Al-Karkh side more than on the Al-Rissafa side of Baghdad city. The anthropogenic activities such as increased traffic emission and application of phosphate fertilizers contribute to higher cadmium accumulations in roadside and agricultural sites. The results of comparison between the mean concentration of cadmium for different land use in the present study and other previous studies of Baghdad soil showed a lower than all the studies except the roadside mean Cd concentration of current study higher than the roadside mean Cd concentration according to [12].

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