Research Article

Heavy metals concentrations in selected soil samples of Al-Diwaniyah governorate, Southern Iraq

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Abstract
Heavy metals' origin, accumulation, and distribution in soil samples have been the focus of much attention by many researchers to monitor soil pollution. The objective of this study is to determine the levels of the heavy metals such as lead (Pb), cadmium (Cd), copper (Cu), and zinc (Zn) in the soil samples collected from different areas residential, industrial and agricultural of Al-Diwaniyah governorate southern Iraq using the effective technique of atomic absorption spectroscopy AAS, so that the degree of pollution could be ascertained. The results show that the mean values of Pb, Cd, Cu and Zn concentrations in soil samples are 31.75, 1.804, 18.51 and 29.82 mg/l, respectively. The results show that the heavy metals concentrations were found to be higher in industrial regions than the other locations. Mean values of Pb and Cd in soils studied were generally higher than the acceptable limits, suggesting some degrees of pollution with heavy metals.

Keywords Heavy metals · Soil samples · Pollution · AAS · Al-Diwaniyah

1 Introduction

Human activities in areas with a high proportion of industrial and urban development have contributed in environmental contamination. Soil pollution caused by toxic metals has harmful effects on the human health and environmental balance. Heavy metals such as Pb, Cu, Zn and Cd in urban soils are clear indicators of environmental contamination [1–5]. The main reason for heavy metals contamination in soil samples of urban areas is the human activities which include industrial waste and vehicle emissions among others. Emission of toxic metals as a result of man-made activities exceeds emission from natural sources. Due to the widespread use of heavy metals in a wide range of manufacturing processes so that the exposure to these elements is common in industry [6, 7]. According to the environmental studies, the main source of the contamination by toxic metals in environment is anthropogenic source. The anthropogenic sources of toxic metals in urban soils are traffic emission which includes vehicle exhaust and tire wear particles. Also, industrial emission includes power plants, auto repair shop, metallurgical industry and chemical plant. However, in agricultural soils the anthropogenic sources of toxic metals involve using chemical fertilizers, pesticides and vehicle exhausts and so on [8–11]. Heavy metals can enter into the human body through ingesting food and water which are contamined by toxic elements or by inhaling dust particles containing toxic elements. When the toxic metals enter the human body will transfer through the blood into the different organs, causing several healthy problems for the exposed individuals where these elements are considered as a possible human carcinogen [12, 13]. Availability and distribution of toxic metals in soil samples are important when assessing the environmental quality of an area. The environment in Iraq has been suffered from the increasing levels of toxic elements in a way affecting the ecological balance and Iraqis' health as a result of the human activity, especially in the southern part of the country [14–17]. The chemical analysis of soil samples is the preferred method

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for monitoring the external exposure of toxicological contaminants. There is not adequate information about heavy metal levels in soil samples of Al-Diwaniyah governorate therefor, this study is aimed to determine the concentrations of Pb, Cd, Cu and Zn in soil samples collected from various areas residential, industrial and agricultural of Al-Diwaniyah governorate southern Iraq by using atomic absorption spectroscopy. Results of the investigation are compared with the allowable levels worldwide.

2 Material and method

2.1 Sample collection

The present estimation was based on the study of 20 soil samples collected from differentiated areas in nature residential, industrial and agricultural in Al-Diwaniyah governorate southern Iraq, as shown in Table 1. Al-Diwaniyah governorate has a total area of 8153 km^2 and the population was estimated to be 1,320,000 people [18]. It is located between 31°.73′N, 44°.69′E. About 10 g of soil samples, which are sufficient for getting the required amount for atomic absorption spectroscopy. The samples were stored in plastic vials with the code of the sample to the time of analysis.

2.2 Experimental method

The experimental technique for the estimation of heavy metals contents in soil samples is the same as reported elsewhere [19–21]. Soil samples were dried using an electric oven at 100 °C for 2 h. The samples were grinded using a hand mill, and then the samples were sieved using a fine mesh of 75 µm for homogenization to prepare them for laboratory procedures. The dried soil samples, weighing 1 g in containers were digested by adding 150 ml of HCl with 5 ml of acid nitric HNO_3. The samples were placed on a sandy bath for 60 min. Then, the containers were cooled and added 5 ml of HCl and 50 ml of distilled water to wash the sides of the container from the dissolved sample. The mixture was heated to boiling point for 3 min after that the sample was filtered using a filter sheet and the sample was collected with volume of 100 ml in a special containers. The mineralised samples were stored in a refrigerator at temperature of 4 °C up to the time of analysis. Contents of (Pb, Cd, Cu, and Zn) in soil samples were measured using atomic absorption spectroscopy AAS (Biotech Engineering Management Ltd, UK) which enables elemental analysis at percentage to parts per million (ppm) levels for a wide range of metals. Calibration procedure was undertaken prior the use of the AAS in order to analyse the samples. Standard solutions used in calibration were prepared by

Table 1 Demographic information of the study areas in Al-Diwaniyah governorate

Name of area	Sample code	Coordinates	Area classification
Al-Forat district	S1	32°.03′N, 44°.89′E	Industrial—Electrical power plant
Al-Thaqlin district	S2	31°.96′N, 44°.95′E	Industrial—Factory of plastic and fabric
Al-Askari district	S3	31°.99′N, 44°.94′E	Residential
Al-Wahda district	S4	31°.99′N, 44°.95′E	Residential—Main road and traffic jam
Al-Jameih district	S5	31°.97′N, 44°.95′E	Residential
Al-Nahda district	S6	31°.98′N, 44°.95′E	Residential
Al-Sinaeiu district	S7	31°.98′N, 44°.89′E	Industrial—Car repair garage
Al-jamieih district	S8	31°.99′N, 44°.87′E	Residential
Al-Taamim district	S9	31°.98′N, 44°.93′E	Residential—Main road and traffic jam
Al- Eidharia district	S10	31°.98′N, 44°.91′E	Agricultural
Al-Dagharah city	S11	32°.06′N, 44°.77′E	Agricultural
Al-Saniya city	S12	32°.07′N, 44°.77′E	Agricultural
Al-Hamad village	S13	31°.99′N, 44°.97′E	Industrial—Electrical power plant
Afak city (Al-Rasul district)	S14	32°.03′N, 45°.14′E	Industrial—Car repair garage
Afak city (Or district)	S15	32°.04′N, 45°.18′E	Residential
Afak city (Al-Shurta district)	S16	32°.06′N, 45°.24′E	Residential
Sumer city	S17	32°.14′N, 44°.99′E	Agricultural
Nifar city	S18	32°.12′N, 45°.23′E	Agricultural
Al-Hamza city	S19	31°.73′N, 45°.00′E	Residential
Al-Sahmiya city	S20	31°.97′N, 44°.69′E	Industrial—Electrical power plant

diluting multi-elemental standard solutions of concentration of 100 mg/l.

3 Results and discussion

Table 2 illustrates the concentrations of heavy metals in soil samples of Al-Diwaniyah governorate. From this table, the highest value of Pb concentration is 41 mg/l found in soil sample of Al-Taamim district (S9) where this area is a main road and traffic jam. Therefore, the levels of Pb were higher, whereas the lowest value of Pb concentration obtained is 20 mg/l found in Al-Jameih district (S5) where this area is residential and free from human activities. Thus, the mean value of Pb content in soil samples of Al-Diwaniyah governorate is 31.75 ± 2.65 mg/l. The result of Pb content in studied soil is about threefold higher than the normal level of Pb in soil 10 mg/l [22]. This finding indicates that the soil samples of the study area are polluted by Pb metal as a result of human activities where usage this metal in a wide range of manufacturing and vehicle emissions. On other hand, the concentration of Cd in soil samples ranged from 0.98 mg/l found in soil of Al-jamieih district (S8) of a residential nature to 2.72 mg/l in soil sample of Al-Sinaeiu district (S7), which contains car repair garages, with the mean value of Cd in soil samples of the study area is 1.804 ± 0.43 mg/l. The mean value of Cd concentrations in soil samples exceeds the safety level of Cd 0.12 mg/l as reported elsewhere [22]. These results indicate that the soil samples of the study are polluted by Cd metal due to the industrial activities and absence of the environmental monitoring. The maximum value of Cu concentration in soil samples is 24.12 mg/l found in Al-Sinaeiu district, while the minimum value of Cu level is 13.3 mg/l found in Al-Askari district of a residential nature (S3). The average value of Cu content in the studied soil samples is 18.51 ± 2.77 mg/l, where this value is within the normal level of Cu in soil samples 18.7 mg/l [22]. The concentration of Zn in the samples varied from 22.4 mg/l in Al-Hamza city of residential nature (S19) to 49.45 mg/l in Al-Thaqlin district (S2) of industrial nature near the factory of plastic and fabric. The average value of Zn concentration in the soil samples is 29.82 ± 3.54; this value is about twofold lower than the acceptable limit of Zn in soil samples 57.5 mg/l [22]. These findings indicate that the soil samples of the present study are not polluted by Cu and Zn metals.

According to Table 2, the mean value of Pb levels in soil samples of the study area is 31.75 ± 2.65 mg/l this value is higher than the levels of Cd, Cu and Zn; so that the levels of toxic elements in soil samples of the present study can be arranged in the following sequence (from

Table 2 Heavy metals concentrations in soil samples of Al-Diwaniyah governorate

No	Sample code	Heavy metals concentrations (mg/l)			
		Pb	Cd	Cu	Zn
1	S1	32	1.98	17.65	32
2	S2	34	2.25	19.42	49.54
3	S3	29	2.16	13.3	29.2
4	S4	30	2	22.14	34.46
5	S5	20	1.81	17.12	22.72
6	S6	31	1.3	14.23	23.4
7	S7	33	2.72	24.12	28.8
8	S8	28	0.98	17.3	23.4
9	S9	41	1.2	20	31.68
10	S10	38	1.3	16	33.6
11	S11	31	2.27	16.78	38.8
12	S12	30	2.16	18.6	25.6
13	S13	36	1.84	21.32	28.73
14	S14	40	1.22	20.1	32.4
15	S15	27	1.76	16.6	25.3
16	S16	30	1.83	17	24
17	S17	39	1.7	18	26.77
18	S18	27	1.8	23.3	29.6
19	S19	22	1.7	18.1	22.4
20	S20	37	2.11	19.2	34.12
Mean ± SD		31.75 ± 2.65	1.804 ± 0.43	18.51 ± 2.77	29.82 ± 3.54

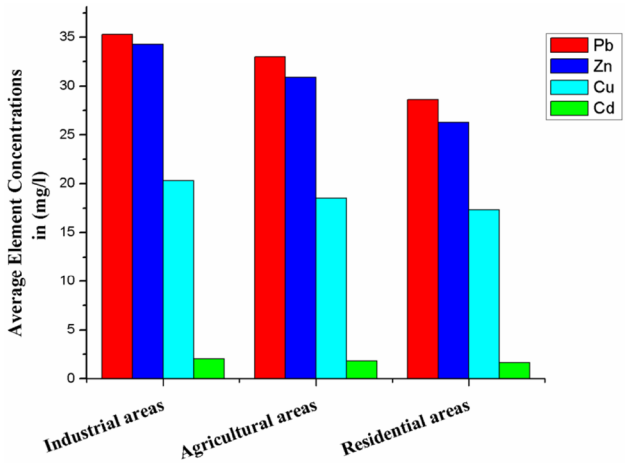

Fig. 1 Average values of elements concentrations in soil samples as a function of the region nature

more available to less available): Pb > Zn > Cu > Cd. The increase in Pb concentration in the soil samples of industrial areas could be ascribed to petrol combustion and industrial activity in and around the study area. This result is in agreement with those of other researchers [1, 17].

Figure 1 illustrates the concentrations of Pb, Cd, Cu and Zn in soil samples of Al-Diwaniyah governorate as a function of the region nature, where the study areas varied in nature, which included residential, agricultural and industrial areas. From this figure the mean values of Pb, Cd, Cu and Zn concentrations in soil samples collected from industrial areas are (35.3, 2.02, 20.31 and 34.26 mg/l) respectively, These mean values are significantly higher than the concentrations of heavy metals in the agricultural and residential areas. These findings indicated that the industrial areas are more polluted than other areas due to the human activities and industrial applications, the degrees of pollution of the toxic elements in soil samples of the study area are ranked as follows: industrial > agricultural > residential where this finding is in agreement with those of other researchers [1, 23–25]. The reason of pollution in industrial areas of Al-Diwaniyah governorate can be attributed to the unchecked wastes of factories, emitted gases form electrical power plants in addition to waste of car repair garages. Whilst the pollution of toxic metals in soil samples of the agricultural areas is attributed to the use of chemical fertilizers and insecticides in agricultural fields. Further the contamination of the residential areas is due to untreated sewage water, motor vehicle exhausts and the use of leaded gasoline.

The concentrations of heavy metals Pb, Cd, Cu and Zn in soil samples of other locations are different and summarised in Table 3. This table shows that the highest records of the heavy metals values are observed in Isfahan, Iran and Tamilnadu, India [1, 26]. The figures of the present study are higher than the levels in Sadat, Egypt and lower than those of Isfahan, Iran; Tamilnadu, India and Birmingham, UK. As the present investigation was the first study ever carried out involving soil samples of different areas of Al-Diwaniyah governorate southern Iraq, the results obtained are now serving as the reference data for future studies.

4 Conclusion

The heavy metals concentrations in soil samples collected from different areas residential, industrial and agricultural of Al-Diwaniyah governorate, southern Iraq have been determined by using AAS technique. The metals Pb and Cd are most abundant in the soil samples of the study area due to human activities. The results indicated that the industrial areas are more polluted than the agricultural and residential regions due to the industrial activities. The results of heavy metals concentrations in the present study show that the soil samples are not polluted by Cu and Zn.

Table 3 Comparison of heavy metals concentration of present work with other countries

No	Locations	Analysed Metals in (mg/l)				References
		Pb	Cd	Cu	Zn	
1	Isfahan, Iran	139.3	–	45.1	118.7	[1]
1	Tamilnadu, India	50	3.5	–	90	[26]
2	Birmingham, UK	48	1.62	64.9	53.4	[27]
3	Beijing, China	28.6	0.15	23.7	65.7	[28]
4	Ottawa, Canada	39.05	0.37	65.84	112.5	[29]
5	Sadat, Egypt	5.89	1.2	14.1	–	[30]
6	Al-Diwaniyah, Iraq	31.75	1.804	18.51	29.82	Present study

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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