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 0.121 to 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

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

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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.
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 60°C. Soil samples were wet digested using a combination of HClO₄ and HNO₃ [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.

Figure 1- The study area map shows the soil samples' location.
Table 1- Coordinates, land use type, name, and the number of sampling sites.

| Sample No. | Site name                                | Land use type | Coordinates (UTM) |
|------------|------------------------------------------|---------------|-------------------|
| 1          | Al-Dora (Al-Masafi junction)             | Roadside      | Easting 445637 Northing 3680485 |
| 2          | A-Dora                                   | Agricultural  | Easting 442041 Northing 3679889 |
| 3          | Sayidia                                  | Agricultural  | Easting 439595 Northing 3681134 |
| 4          | Al-Salam university college              | Agricultural  | Easting 441565 Northing 3676765 |
| 5          | Al-Bayaa (Industrial District)           | Industrial    | Easting 437871 Northing 3681120 |
| 6          | Jehad                                    | Agricultural  | Easting 434398 Northing 3682802 |
| 7          | Amiriya                                  | Commercial    | Easting 433959 Northing 3684200 |
| 8          | Abu Ghrain                               | Waste dumping site | Easting 432747 Northing 3685586 |
| 9          | Al-Hurriya                               | Residential   | Easting 439721 Northing 3690662 |
| 10         | Kadhimiya                                | Agricultural  | Easting 439283 Northing 3694319 |
| 11         | Adhamiya                                 | Agricultural  | Easting 441620 Northing 3692327 |
| 12         | Al-Wazeeria (Battery Manufacturer)       | Industrial    | Easting 443585 Northing 3691668 |
| 13         | Shikh Omer                               | Industrial    | Easting 444355 Northing 3689755 |
| 14         | Ziyouna                                  | Residential   | Easting 449130 Northing 3686058 |
| 15         | Karada                                   | Commercial    | Easting 448043 Northing 3683911 |
| 16         | Shaab                                    | Agricultural  | Easting 441488 Northing 3698587 |
| 17         | Sadr city                                | Industrial    | Easting 449475 Northing 3697518 |
| 18         | Al-Zafraniya                             | Residential   | Easting 450674 Northing 3682094 |
| 19         | Al-Dora expressway                       | Agricultural  | Easting 447821 Northing 3680205 |
| 20         | Alselikh                                 | Residential   | Easting 441820 Northing 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) | Min | Max | WHO,2006 [16] |
|------------|------------------------------------------|----------|---------------------------------|-----|-----|---------------|
| 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          | Amiriya                                  | commercial | <0.1                        |     |     |               |
| 8          | Abu Ghrain                               | 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-Zafraniya                             | Residential | 0.35                        |     |     |               |
| 19         | Al-Dora expressway                       | Agricultural | <0.1                        |     |     |               |
| 20         | Alselikh                                 | Residential | <0.1                        |     |     |               |
|            | **Min**                                  |           | 0.121                         |     |     |               |
|            | **Max**                                  |           | 1.78                          |     |     |               |

WHO: World Health Organization
The total cadmium content in the study area ranged from 0.121 to 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         | 3.93                      | [9]        |
| Agricultura          | 4.42                      | [10]       |
| All soils            | 19                        | [11]       |
| Agricultural         | <1                        | [12]       |
| Industrial           | <1                        |            |
| Urbanization         | <1                        |            |
| Residential          | 0.26                      |            |
| Commercial           | 0.425                     |            |
| Industrial           | 0.935                     | [13]       |
| Roadside             | 0.56                      |            |
| Open area soils      | 0.52                      |            |
| Residential          | 2.99                      | [14]       |
| Commercial           | 3.42                      | [15]       |
| Industrial           | 4                         |            |
| Mixed                | 4.18                      |            |
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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