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Assessment of Some Heavy Metals in the Soil from Kut Al-Fadagh and Hamdan at Basrah City

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Abstract

Heavy metal accumulation in agricultural soils degrades soil quality and poses risks to crops and human health. This study aimed to measure the concentration of heavy elements in the agricultural soils of Abu Al-Khasib in the Basrah Governorate. Two sites were selected, the first site is Kut Al-Fadagh and the second site is Hamdan. Their study showed that the concentration of cobalt ranged between (21.77, ND µg. g-1). On the other hand, the concentration of cadmium was (1.700,0.052 µg.g-1) while lead the values were (38.24,3.85 µg.g-1), iron values ranged (11448,463 µg.g-1), zinc values were (117.9,19.5), manganese values were (651.5,248.8 µg.g-1), selenium values ranged (0.4491,0.1011 µg.g-1) and the concentration of heavy elements in the soil varied according to the seasons. As for the average sites, Hamdan's site recorded a higher concentration of cobalt, cadmium, zinc, manganese, and selenium (0.2418,494.4,71.5,0.540,11.52 µg. g-1) than Kut Al-Fadagh's site (0.2232,483.3,65.7,0.402,4.32 µg. g-1). Moreover, Kut Al-Fadagh's site recorded a higher concentration of iron and lead (28.69,3467 µg.g-1) compared to Hamdan's site, which recorded(20.20,3067) .

Keywords: Accumulation, heavy metals, pollution, soil

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Introduction

Food production is necessary for life, and soil is a critical component of the natural environment that promotes plant growth. Since it supports plants, soil, along with water and air, is the basic foundation for agricultural productivity and the continuation of human life (Al-Khatib, 1998).

To conduct optimal exploitation of any natural resources and put in place appropriate management of pollution, it is necessary to identify the nature of pollutants and implement proper management and disposal strategies. Such approaches help direct the use of priceless resources and protect them from deterioration (Youssef, 2005).

Soil contamination poses a serious threat to human health, as it can cause physiological abnormalities in the human body and its organs, which can ultimately lead to the development of deadly diseases. (Zaghloul, 2019).

Soil is exposed to a wide range of pollutants each year, either intentionally or unintentionally. Soil contamination can be classified according to its origin—either natural or anthropogenic—and according to its nature as biological, chemical, or radioactive. Common sources of soil contamination include acid rain, radiation, and both domestic and industrial solid and liquid wastes (Al-Yasiri, 2016).

Natural weathering, such as erosion of parent rocks, atmospheric deposition, volcanic activities, etc. And anthropogenic activities such as wastewater irrigation, addition of manure, fertilizers, pesticides, are responsible for soil and crop contamination with heavy metals (HMs) (Khan *et al.*,2013).

However, one of the most significant sources of heavy metal contamination in field soil is the applied of the chemical fertilizers to promote plant growth, particularly when it used against internationally accepted standards. Additional sources include the excessive use of pesticides, combustion by-products such as charcoal and crop residues, and the application of sewage sludge from water treatment plants (Sadiq and Yousri, 2010). Heavy metals are considered very hazardous pollutants to all organisms because of their harmful impacts on living things and long-term environmental persistence (Cai et al.,2012). Therefore, the aim of the current study is to assess and evaluate the heavy elements in the field soils of two orchard regions—Kut Al-Fadagh and Hamdan—in Abu Al-Khaseeb, located in the southeastern part of Al-Basrah Governorate.

Materials and Methods

Description of The Study Area

The study area is located in Abu Al-Khaseeb, 10 km southeast of Basrah city center. This region has relatively warm winters and scorching, dry summers. Abu Al-Khaseeb was previously well known for its extensive date palm groves and numerous water channels branching from the Shatt Al-Arab River. Soil samples were collected from well-maintained and productive orchards' locations in Kut Al-Fadagh (Site 1) and Hamdan (Site 2) (Fig. 1).

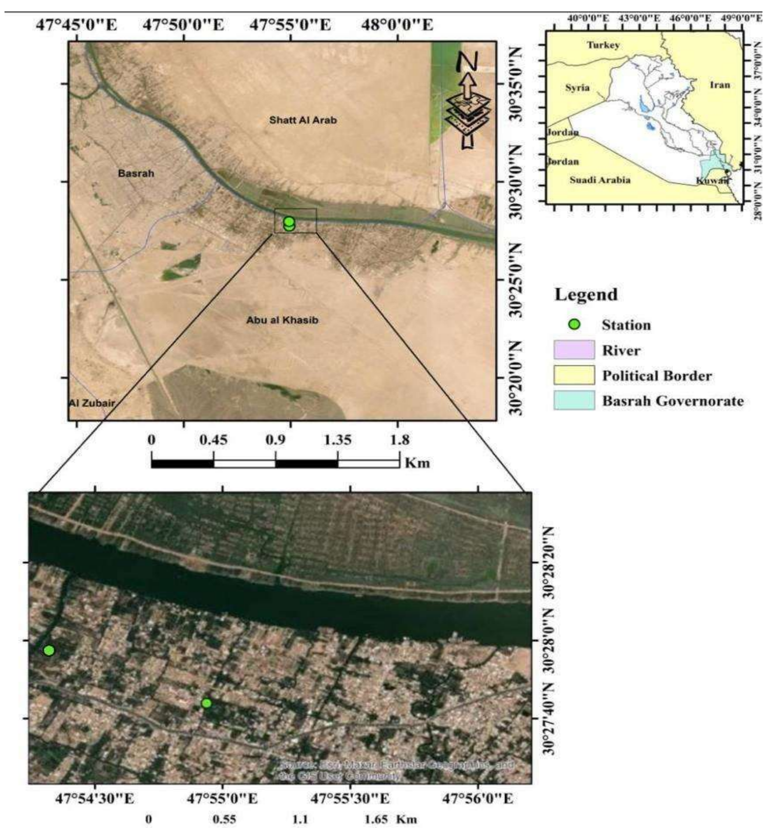

Fig.1: Study stations.

Soil Sample Collection : Samples of the soil were gathered periodically between August 2022 and April 2023 from the study area using an auger. About 1.0 kilogram of soil was gathered from each location and placed in sterile plastic bags, and labeled with the necessary sample data. The soil samples were air-dried at room temperature before being sieved through a 2 mm mesh screen. Soil samples were kept dry until the conduct the further examinations.

Soil digestion: Soil samples were ground gently to conserve particle integrity. Followed, sieved using a 2 µm mesh. Digestion was performed according to standard procedures described by Estefan (2013) . 1 g of soil was placed into digestion tubes, and 3 mL of concentrated nitric acid (HNO_3) was added. The tubes were heated on a hot plate at 145 °C for one hour. Subsequently, 4 mL of concentrated hydrochloric acid (HCl) was added while increasing the temperature. The samples were filtered using fine filter with a pore size of 0.45 µm, and the final volume was made up to 50 mL with deionized water . Samples transferred to the Marine Chemistry Laboratory at the Marine Science Center for the determination of heavy metals using a flame Atomic Absorption Spectrophotometer (Shimadzu AA7000, Japan).

Statistical analysis

Statistical analysis was implemented using GenStat V.7 software, utilizing a randomized complete block design (RCBD) with two factors: site and season. Differences were considered statistically significant at a probability level of $p < 0.05$.

Results

Table 1 presents the outcomes of the statistical analysis of seasonal changes in heavy metal concentrations at two study sites. With regard to all different seasons and sites, the spring season at the second site (Hamdan) had the highest significant concentration of cobalt (Co), at 21.77 $\mu g \cdot g^{-1}$. On the other hand, the fall season at both locations had the lowest cobalt concentration (0.00 $\mu g \cdot g^{-1}$), which was not significantly different from the spring season at the first site (Kut Al-Fadagh).

For cadmium (Cd), the highest significant concentrations were recorded during the winter season at both sites, with values of 1.150 and 1.700 $\mu g \cdot g^{-1}$ at Kut Al-Fadagh and Hamdan, respectively. On the other hand, the lowest concentrations were recorded during the summer season at the same sites, with values of 0.052 and 0.060 $\mu g \cdot g^{-1}$, respectively. These low values did not differ significantly from those recorded in the autumn and spring seasons at both sites. At both study locations, these low values were not much different from those observed in the fall and spring.

Regarding lead (Pb), the highest significant value 53.79 $\mu g \cdot g^{-1}$ was recorded in the fall season at the first Site. While the lowest concentration was recorded during the same season at the same site (3.85 $\mu g \cdot g^{-1}$). In comparison with the first site, Hamadan recorded the highest concentrations of (Pb) in the spring season with a value of (38.24 $\mu g \cdot g^{-1}$) and the lowest at autumn season (4.89 $\mu g \cdot g^{-1}$).

For iron (Fe), the highest significant observation was recorded in the summer season at the first and second sites with a value of (11448 and 9669 $\mu g \cdot g^{-1}$) respectively, while the lowest value occurred in the winter at both sites (463 and 475$\mu g \cdot g^{-1}$) successively.

With regard to zinc (Zn), the spring season at both sites (1 and 2) recorded the highest significant values, with 117.9 $\mu g \cdot g^{-1}$ at the second site and 109.5 $\mu g \cdot g^{-1}$ at the first site, showing no significant difference between them. Compared to the other seasons and sites, the second site's autumnal zinc concentration was noticeably lower (19.5 $\mu g \cdot g^{-1}$).

For manganese (Mn), the greatest value was found at the Kut Al-Fadagh and Hamdan sites (651.5 $\mu g\cdot g^{-1}$ and 631) respectively, While The lower Mn concentration was identified in both sites in the winter season with a value (248.8 $\mu g\cdot g^{-1}$ and 320.2).

In terms of selenium (Se), there was little variation between the two sites' wintertime values, which were the greatest at 0.449 $\mu g\cdot g^{-1}$ at the first site and 0.439 $\mu g\cdot g^{-1}$ at the second. With no discernible difference between the two sites, the autumn season showed the lowest Se values (0.1100 $\mu g\cdot g^{-1}$ at the first site and 0.1011 $\mu g\cdot g^{-1}$ at the second site).

Table (1) Seasonal variations of heavy Metals ($\mu g.g^{-1}$ Dry wight) in soil

Study Area	Seasons	Co	Cd	Pb	Fe	Zn	Mn	Se
Kut Al-Fadagh (First Site)	Summer	7.24	0.052	18.89	11448	91.0	631.0	0.1856
	Autumn	0.00	0.235	53.78	1052	34.4	460.0	0.1100
	Winter	10.05	1.150	3.85	463	28.1	248.8	0.4491
	Spring	0.00	0.172	38.23	904	109.5	593.4	0.1481
Hamdan (Second Site)	Summer	7.20	0.060	24.76	9669	94.9	651.5	0.3040
	Autumn	0.00	0.220	4.89	1226	19.5	422.0	0.1011
	Winter	17.10	1.700	12.90	475	53.5	320.2	0.4390
	Spring	21.77	0.181	38.24	898	117.9	583.8	0.1231
LSD	0.6877	0.687	3.207	370.2	8.90	10.78	0.04561	

Table 2 presents the average levels of heavy elements at the two study sites.

Hamdan site recorded the highest significant level of cobalt (Co) at 11.52 $\mu g\cdot g^{-1}$, compared to 4.32 $\mu g\cdot g^{-1}$ at Kut Al-Fadagh site .

For cadmium (Cd) concentrations, no significant variations were recorded between the two sites, with values of 0.540 $\mu g\cdot g^{-1}$ and 0.402 $\mu g\cdot g^{-1}$, respectively.

For lead (Pb), highest concentration at 28.69 $\mu g\cdot g^{-1}$ was observed in first site, compared to 20.20 $\mu g\cdot g^{-1}$ at the second site. In the same way, iron (Fe) recorded greater value at the first and second sites (3467 $\mu g\cdot g^{-1}$, 3067 $\mu g\cdot g^{-1}$) respectively .

In terms of zinc (Zn) and manganese (Mn), the second site recorded significantly higher concentrations—71.5 $\mu g\cdot g^{-1}$ for Zn and 494.4 $\mu g\cdot g^{-1}$ for Mn—compared to the first site, which recorded 65.7 $\mu g\cdot g^{-1}$ and 483.3 $\mu g\cdot g^{-1}$, respectively. These differences between the two sites were statistically significant.

Ultimately, the selenium (Se) levels did not differ considerably between the two sites, with values of 0.2418 $\mu g\cdot g^{-1}$ at the second site and 0.2232 $\mu g\cdot g^{-1}$ at the first site.

Table(2)The Mean accumulation Heavy metals(µg.g^{-1} Dry wight) in soil in the soil

Study Area	Co	Cd	Pb	Fe	Zn	Mn	Se
Kut Al-Fadagh	4.32	0.402	28.69	3467	65.7	483.3	0.2232
Hamdan	11.52	0.540	20.20	3067	71.5	494.4	0.2418
LSD	**1.252**	**0.3438**	**1.603**	**185.1**	**4.45**	**5.39**	**0.02280**

Discussion

Cobalt (Co)

The elevated levels of cobalt during the winter and spring seasons may be attributed to the release of fertilizers or discharge of wastewater into irrigation channels. These results have been confirmed by Varalakshmi and Ganeshmurthy (2012), who found that fertilizer, fuel combustion, and sewage discharge are common sources of heavy metal pollution like cobalt. These results imply that agricultural fertilization activities are probably responsible for the elevated cobalt concentrations in the winter and spring.

Cadmium (Cd)

The hike of cadmium levels in soil during the winter may be ascribed to several factors, including the use of phosphate fertilizers, the fuel combustion, and the using of contaminated irrigation water. Lower microbial activity and slower decomposition rates in winter may also reduce cadmium immobilization, allowing it to remain bioavailable in the soil. These findings are in line with those reported by Khuwaidem et al. (2009), who found that cadmium levels in Basrah and Baghdad exceeded world averages. Similarly, Huang et al. (2019) noted that the standard limit for cadmium in soil, as set by the National Environmental Quality Standards (NEQS) in China, is 0.3 µg·g^{-1}. Based on this

Lead (Pb)

According to the National Environmental Quality Standards (NEQS), the soil quality standard for lead (Pb) contamination is 60 µg·g^{-1} (Huang et al., 2019). Based on this guideline, both study sites were considered Pb-free across all seasons. These findings are in line with the results of Al-Hawi *et al*., (2024), who obtained same observations within safe limits.

Iron (Fe)

The elevation of iron concentration in the soil of both sites of present investigation during the summer season may be attributed to several factors, including workshops, factories, and vehicle discharges, as well as dust-laden sand from various sources. Additionally, some human contributions, such as the use of soil conditioners and pesticides, along with reduced river water flow during the summer months. These findings are in line withAl-Maliki and Al-Aasadi (2022), who noted similar sources of iron accumulation in soils.

The elevation of iron concentration in the soil of both sites of the present investigation during the summer season may be attributed to several factors, including workshops, factories, and vehicle discharges, as well as dust-laden sand from various sources. Additionally, some human contributions such as the use of soil conditioners and pesticides, along with reduced river water flow during the summer months. These findings are in line with Al-Maliki and Al-Aasadi (2022), who noted similar sources of iron accumulation in soils. In the contrary, the decrease in iron (Fe) concentration during the winter season may be attributed to increased rainfall, which leads to leaching and surface runoff, causing iron and other elements to be washed out of the soil. Wuana and Okieimen (2011) indicated that the concentration and distribution of mineral pollutants across different regions are directly influenced by several factors, including soil properties, element transport mechanisms, and the chemical characteristics of groundwater, industrial inputs, and agricultural practices concentration and distribution of mineral pollutants across different regions are.

Zinc (Zn)

Current results agree with Al-Maliki and Al-Aasadi (2022), who suggested that elevated zinc levels in soil may be due to its deposition in the form of zinc sulfate ($ZnSO_4$) under alkaline conditions, particularly at pH values between 7 and 9.

These results also align with Eisler (1993), who noted earlier that the main sources of zinc contamination are anthropogenic, including industrial and domestic activities, particularly from zinc-based packaging materials.

Manganese (Mn)

The elevated levels of manganese (Mn) at both study sites are consistent with findings reported by Saleh (2024), who observed increased manganese concentrations in the Al-Tannumah region, east of Basrah. Similarly, Al-Bedhany et al. (2013) reported that seasonal and spatial variations significantly influence the contamination levels of various heavy metals—including iron, manganese, nickel, cobalt, copper, and lead—in the soils of Basrah. These variations are largely attributed to anthropogenic activities, industrial processes, and the geological composition of the soil. In support of this, Fosu-Mensah et al. (2017) also emphasized that the distribution and accumulation of heavy metals in soil are affected by a combination of natural factors and human activities, particularly in urban and peri-urban agricultural zones.

Selenium (Se)

According to the present findings, both the first and second sites were free from selenium (Se) contamination during all seasons, as the recorded Se concentrations did not exceed 0.2418 $\mu g \cdot g^{-1}$. Based on the U.S. Environmental Protection Agency (US-EPA) standard, the acceptable limit for selenium in soil is 1.6 $\mu g \cdot g^{-1}$ (Saleem et al., 2012).

However, Sors et al. (2005) revealed that selenium levels in soils are influenced by various factors, including soil type, the presence of sedimentary rocks, organic matter content, and rainfall patterns. Selenium tends to accumulate more in arid and semi-arid regions, where rainfall is limited.

Conclusion

This study revealed significant seasonal and spatial variations in the concentrations of heavy metals in farmland soils at Kut Al-Fadagh and Hamdan in Basrah, Iraq. While most heavy metal levels remained within internationally accepted standards, like cadmium (Cd) concentrations during the winter season exceeded the safe threshold, indicating potential environmental and public health risks. The elevated levels of certain metals were largely attributed to anthropogenic activities, including fertilizer application, waste water irrigation, and atmospheric deposition. These findings emphasize the importance of regular soil monitoring and the adoption of sustainable land management practices to prevent long-term heavy metal accumulation and ensure agricultural and ecological sustainability.

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تقييم بعض المعادن الثقيلة في التربة من كوت الفداغ وحمدان في مدينة البصرة

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الملخص

تعد المعادن الثقيلة خطيرة بسبب ثباتها وسميتها. قد يؤدي التلوث بالمعادن الثقيلة في التربة الزراعية إلى اخلال في وظائف التربة، والتدخل في نمو المحاصيل، وحتى الإضرار بصحة الإنسان من خلال تلوث السلسلة الغذائية. هدفت الدراسة إلى قياس تركيز العناصر الثقيلة في الترب الزراعية لمنطقة أبي الخصيب في محافظة البصرة، وتم اختيار موقعين الموقع الأول هو كوت الفداغ والموقع الثاني حمدان. أظهرت الدراسة أن تركيز الكوبالت تراوح بين (ND. 21.77) مايكروغرام.غرام$^{-1}$ في المقابل بلغ تركيز الكادميوم (1.700.0.052) مايكروغرام.غرام$^{-1}$ فيما بلغت القيم الرصاص (38.24.4.89) مايكروغرام.غرام$^{-1}$ وتراوحت قيم الحديد (11448.463) مايكروغرام.غرام$^{-1}$ وكانت قيم الزنك (117.9.19.5) مايكروغرام.غرام$^{-1}$وكانت قيم المنغنيز (651.5.248.8) مايكروغرام.غرام$^{-1}$. وتراوحت قيم السيلينيوم (0.4491،0.1011) مايكروغرام.غرام$^{-1}$وتباينت تراكيز العناصر الثقيلة في التربة باختلاف الفصول. أما متوسط المواقع فقد سجل موقع حمدان أعلى تركيز لعناصر الكوبالت والكادميوم والزنك والمنجنيز والسيلينيوم (0.2418,494.4,71.5,0.540,11.52) مايكروغرام.غرام$^{-1}$ مقارنة بموقع كوت الفداغ الذي سجل (0.2232,483.3,65.7). ،4.32،0.402) مايكروغرام.غرام$^{-1}$. كما سجل موقع كوت الفداغ تركيزا أعلى للحديد والرصاص (28.69,3467) مايكروغرام.غرام$^{-1}$مقارنة بموقع حمدان الذي سجل (20.20,3067) مايكروغرام.غرام$^{-1}$