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EVALUATION OF LEAD AND CADMIUM POLLUTION FOR SOME SOILS IN DIWANIYA GOVERNORATE USING THE POLLUTION STANDARDS

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Abstract

Lead and cadmium are ones of the heaviest metals that negatively affect the environment. Soil samples were collected from nine different locations, both civilian and agricultural areas, in Diwaniya Governorate (Shamiya county, Al-Taqiyya neighborhood, Al-Iskan Al-Sinai neighborhood, Al-Furat neighborhood, Nouriya county, Afak Entrance, Afak county, Al-Iskan neighborhood, Al-Sunia county). A soil sample was also taken as a comparison sample, which far from pollution sources, with a single sample for each region with a depth of (0-30) cm for the purpose of detecting the pollution status with lead and cadmium elements. Certain pollution standards were used, such as the Enrichment factor (EF), Contamination Factor (CF), Pollution Load Index (PLI), and Geoaccumulation index (Igeo). The results indicate that the concentration of lead and cadmium ranged between (0.162 - 0.741) mg.Kg $^{-1}$ and (0.0026 - 0.0190) mg.Kg $^{-1}$ for both lead and cadmium, respectively. In general, the results presented a high concentration of lead and cadmium in study soils near the industrial complexes and main streets. The highest lead value was recorded at the last listed site, which is about 20 meters away from the Kashi plant. As for cadmium, it was the highest concentration in Afak entrance. The results also indicate that the average concentrations of lead and cadmium elements in all soils of the study sites were lower than the average concentrations of global soils.

In general, the Enrichment Factor values decreased as we departed from the sources of pollution. It is more than the critical threshold of (1.5) at sites near major streets and industrial parks. The results also showed that the concentration of lead and cadmium elements that were evaluated within the calculation of the CF, EF, PLI, Igeo pollution indicators indicates that their source is human activity, which confirms the hypothesis that those sites are affected by gases emitted from car exhaust and various other industries.

***Keywords*:** pollution standards, heavy metals, lead, cadmium, soil pollution

Introduction

Heavy elements are one of the biggest pollutants of the environment. They continue emitting from their various sources, whether natural or artificial and lead to an increase in their concentration in the atmosphere. Heavy elements include a wide range of elements, which are useful for many vital activities, such as copper and iron, including harmful toxic substances such as lead, cadmium, and nickel, which are highly toxic to neighborhoods, Delibacak *et al*. (2002); Jeber *et al* (2019). Therefore, it is important to recognize the distribution of levels of heavy elements in the soil and the mechanics of controlling their solubility and minerals that control their movement, forms, and availability in the soil, as well as their behavior within plants that can grow in polluted soils.

Mineralization processes contribute to an increase in element contamination, which generally represents a great danger to plants, people, animals, and the environment, and this makes it one of the most serious environmental problems in the world, Zheljazkov and Nielsen, (1996); Khaeim *et al* (2019). Its seriousness is their cumulative quality in the bodies of living organisms, Sadiq *et al*., (2008) and Mohsen *et al*. (2008). Humans and animals need a certain percentage of these elements, which may get part of them in plants through the food chain, Sadiq *et al*. (2008) and Azita *et al*. (2008); Hussein *et al* (2019). Therefore, the higher concentrations of these elements in plants than the permissible limits endanger the life of the consumer, WHO (2003). This increase in concentrations comes as a result of the growth of the plant in its soil contaminated with these elements for reasons due to geological weathering factors of the soil or as a result of excessive use of chemical fertilizers and agricultural pesticides. Most often, it is the result of irrigation with water contaminated with waste from factories sewage waste, Sadiq *et al*. (2008) and Mohsen *et al*. (2008).

The accumulation of heavy elements in the soil surface is affected by many environmental variables, such as the original material, soil properties, human activities, industrial production, agricultural operations, and irrigation. There are wide areas that can be polluted by heavy elements as a result of the application of industrial water, fertilizers, organic fertilizers, and pesticides. Regardless of the sources of soil pollution, the accumulation of heavy elements contributes to low soil productivity, Nagajyoti *et al*. (2010); Khaeim *et al* (2019); Wafaa Sahib Alawsy *et al.* (2018). Heavy elements like lead, cadmium, and zinc are dangerous substances that pollute the soil, water, and air. The most important sources of this pollution are car exhaust, factory waste and waste, fuel combustion and metal smelting. These heavy elements, including those that settle in the place that has been contaminated for a long time without any chemical changes. Including what settles for a short period if it changes chemically due to heat, humidity, microbes, light reactions and other environmental factors. Soil pollution leads to poor fertility and low crop yields, as well as its natural composition, which results in a decrease in its nutritional value, Singh *et al*. (2011); Drebee *et al*. (2018).

The effect of soil pollution is not limited to plants but extends to humans and animals. Contamination of crops with harmful chemicals leads to disease in humans because of eating these contaminated foods, whether they are vegetable or animal foods. There is no doubt that livestock is also affected by soil pollution with harmful chemicals. Poultry and livestock are affected by diseases that lead to low animal production, Majewska *et al*. (2011); Khaeim *et al*. (2019); Drebee *et al*. (2014). Therefore, our current study aims to identify the extent of soil contamination in some areas of

Diwaniya governorate with the elements of lead and cadmium using some of the approved pollution standards such as Enrichment factor (EF), Contamination Factor (CF), Pollution Load Index (PLI), and Geoaccumulation index (Igeo)

Methods and Materials

Study site and sample collection

Soil samples were collected from 9 different civilian and agricultural sites from the Diwaniyah governorate. One sample was approved as a comparison sample as it is far from the source of pollution and they taken in a depth ranged between (0-30) cm. Samples were collected in plastic bags and transferred to the laboratory to perform the necessary analyses.

Laboratory Tests

The samples were dried aerially and crushed with a wooden hammer and divided into two parts. The first part is a sieved with a diameter sieve of (2) mm for the following physical and chemical analyzes:

1- Volumetric distribution of soil particles. The Hydrometer method was used to estimate the volumetric distribution of soil segments and their tissues according to the Day method (1965).

2- The degree of interaction of the study water samples was measured directly by the pH-meter. The electrical conductivity was measured by the electrical conductivity bridge.

3- The organic matter was estimated by the method of wet oxidation (Walkley and Black), described in Jackson, (1958).

In the second part, it was prepared to extract total iron and heavy elements (lead and cadmium) as it was extracted according to Jones and other methods, (2001). They were measured by the Atomic Absorption Spectrometer in the laboratories of the College of the Pharmacy, University of Kufa, and the soil concentrations of the College of Agriculture adopted the comparison soil as far from the sources of pollution shown in Table (1) to determine the extent of pollution.

Table 1 : The total content of iron and heavy elements in the comparison soil.

The element	Concentration (mlg.kg^{-1})
Fe	273.392
Pb	0.139
Cd	0.026

Pollution standards

Some of the pollution standards were used in our study from the principle of identifying the actual sources of soil pollution under study. After that work to distinguish pollutants from geological sources from those resulting from anthropogenic human activity was done.

1. Enrichment factor (EF):

$$EF = \frac{\left[(C)_M / (C_{Fe})\right]_{sampls}}{\left[(C)_M / C_{Fe}\right]_{Background}}$$

Where,

Sample (Cm) = concentration of the element.

Sample (CFe) = concentration of iron in the soil.

Background (Cm) = concentration the same element in the comparison soil

Background (CFe) =concentration of the iron element in the comparison soil

2. Contamination Factor (CF)

CF = (Cm) Sample / (Cm) Background

Where:

Sample (Cm) = concentration of the element studied in the soil.

Background (Cm) = concentration the same element in the comparison soil

Liu *et al* (2005) classified the CF pollution factor into four groups

CF <1 low contamination

1 ≤ CF <3 contamination moderate

3≤ CF <6 significant contamination

CF> 6 very high contamination

3. Pollution Load Index (PLI)

PLI = (CF1 x CF2 x CF3 x ... x CFn) 1 / n

Where,

n = number of items studied

CF = contamination factor

PLI≤ 1= No contamination

PLI> 1 = soil contamination

4. Geoaccumulation index (Igeo)

$$Igeo = \log_2 \left((C_m)\ Sample / (1.5 \times (C_m)\ Background) \right)$$

Where,

Sample (C_m) = concentration of the element studied in the soil.

Background (C_m) = concentration the same element in the comparison soil

1.5 = A determining factor for this equation to reduce the effect of possible changes in

The values of C_m (Background) and related to rock changes in soils. Table (2) shows the levels of geological accumulation index.

Table 2 : Geoaccumulation index (Igeo) levels

Igeo	Levels of pollution
Igeo< 0	unpolluted
Igeo< 1 ≤ 0	Unpolluted - low pollution
1≤Igeo▪ 2	Polluted - Average pollution
2≤Igeo▪ 3	Medium pollution - highly polluted
3≤Igeo▪ 4	Very polluted
4≤Igeo▪ 5	Very Pollution - Very severe pollution
Igeo ≥ 5	Very severe pollution

Results and Discussion

Chemical and physical properties of the soils

Table (3) presents some of the chemical and physical properties of the soils of the study sites. The results indicate that the electrical conductivity (EC) values of the soil of the study sites ranged between (2.21-77.40) dsimmons.m^{-1}. The highest value presented in the Sunnia county and the lowest value was in the second location in the Askan Sinaai, while the values of the degree of soil interaction ranged between (7.21 - 8.19). The lowest value is in the last location, in the Sunnia area, and the highest value is in the second location, in the Askan Sinaai. It is noticeable that the electrical conductivity values are proportional to the soil reaction values backward, and this is what Al-Zubaidi and Qutayba (1978) indicated that there is a gradual and slight increase in the pH values towards the basal level, as the salt concentration in the soil decreases. That is, there is an inverse or near-inverse relationship between the pH and soil salinity values for Iraqi soils.

The results of Table (3) showed the total content of the organic matter as it ranged between (4.100-27.50) g. It is generally low values except for the third and fifth locations, as it reached (23.40 and 27.50) g.Kg^{-1}. The reason for the low values of organic matter in these locations may be due to the lack of vegetation and high temperatures in the summer that lead to the oxidation of the organic matter and its rapid decomposition. The results of Table (3) present that the percentage of sand minutes is more than the rest of the articulations in all locations except for the second site (Al-Taqiyya neighborhood) and the last site (Al-Sunia county), as it was the dominant of the percentage of silt minutes.

Table 3 : Some chemical and physical properties of the studied soils

Location	pH	EC dessem. cm.m^{-1}	O.M g.kg^{-1}	Soil separators g.kg^{-1}			Soil texture	Notes
				Sand	Silt	Clay		
Al-Shamia	8.19	5.21	6.20	516	300	184	Loam	An agricultural area in Al-Shamiya / Al-Salaha
Al-Taqyya	7.41	64.20	16.50	276	520	204	Silty loam	Away from the main street about 5 meters
Al-Iskan Sinaai	8.20	2.18	23.40	496	380	124	Loam	Agricultural land about 50 meters from the rubber plant
Al-Furat	8.18	5.33	11.70	576	220	204	Silty clay loam	Residential area
Al-Nuriah	7.62	40.60	27.50	596	240	164	Silty clay loam	Near the College of Agriculture, about 5 meters away from the main street
Afak entrance	7.86	24.6	4.100	536	300	164	Sandy clay	Away from the center of Afak, about 200 meters
Afak	8.04	4.47	10.70	416	400	184	Clay loam	Agricultural land away from Afak Hospital about 200 meters
Al-Askan	7.40	65.80	15.10	496	380	124	Loam	Away from the power station about 300 m
Al-Sunnia	7.21	77.40	17.10	376	440	184	Loam	Away from the Kashi factory about 20 meters

The total concentration of lead and cadmium

Table (4) presents the concentrations of heavy elements of lead and cadmium in the selected studied soils. They ranged between (0.162 - 0.741) mg.K^{-1} and (0.0026 - 0.0190) mg.K^{-1} for both lead and cadmium, respectively. The highest concentration of lead was recorded in Al-Sunia county, as the study sample is 20 meters away from the Kashi plant. The highest concentration of cadmium was in the Afak entrance. This is what Baird (2001) indicated, the increase in the concentration of heavy elements, such as lead and cadmium in soils, is due to combustion products from factories, factories, and electric power plants available in those areas, as well as transportation and waste burning residues, all of which contributed to increasing the concentration of heavy elements in the soil.

Comparing the average concentration of lead and cadmium elements in the soil of the study sites with the global concentration rate in soils globally according to (Lindsay, 1979). It was found that they did not exceed the global average concentrations and in all study soil samples. Comparing the concentration of lead and cadmium with the highest concentration of them, it can be found in non-polluted soil, it is found that they were not more than the highest concentration of world soil (200 and 0.7) mg.Kg^{-1} in a row.

Table 4 : Concentrations of lead, nickel and zinc elements in the study soils compared with the average and overall extent of soils in the world.

	Location		Pb (mlg.kg^{-1})	Cd (mlg.kg^{-1})
1.	Al-Shamia		0.278	0.0026
2.	Al-Taqyya		0.440	0.0064
3.	Al-Iskan Sinaai		0.626	0.0027
4.	Al-Furat		0.162	0.0180
5.	Al-Nuriah		0.626	0.0141
6.	Afak enterance		0.662	0.0190
7.	Afak		0.580	0.0167
8.	Al-Askan		0.324	0.0090
9.	Al-Sunnia		0.741	0.0095
The average			0.483	0.483
The general range of the sequence in the world, Lindsay, 1979		Heist concentration	200	0.7
		Least concentration	2	0.01
		Global average	10	0.06

Pollution standards for lead and cadmium in study site soils

Some of the pollution criteria were used to determine the source of pollution, whether it was due to human activity or derived from a geological source.

Enrichment factor (EF): The enrichment factor is used to assess the level of pollution caused by human activity by studying the concentrations of heavy elements in different soil samples. Akoto (2008) presented that the values of the enrichment factor range between (1.5 - 0.5) indicate that the presence of the element is a result of natural geological processes, while the values of the enrichment factor that are greater than (1.5) indicate that the sources of heavy elements come from human influences. The results of Table (5) showed the values of the enrichment factor for the study of soil samples for lead and cadmium. It ranged between (1.204 - 5.532) and (0.099 - 0.779), respectively. The lowest value of the enrichment factor for the cadmium element was (0.099) in the Shamiya district, and the highest value of the lead element was (5.532) in the Sunni area. It is noted from the results of Table (5) that the values of the enrichment factor generally decrease as moved away from sources.

These results explain the effect of gases emitted from vehicle exhaust and factory waste, and these results are consistent with a number of researchers, Mafuyai *et al.* (2015); Sam *et al.* (2015); Luma *et al.* (2019). The results showed that the values of the enrichment factor in more than the critical threshold (1.5) had all appeared at sites near the main streets such as the Afak entrance, Taqiyya neighborhood and the factories such as the rubber and Kashi plants and power stations.

Table 5 : Enrichment factor (EF) values for lead and cadmium of the soils

	Location	**EF**	
1.	Al-Shamia	Pb	Cd
2.	Al-Taqyya	1.996	0.099
3.	Al-Iskan Sinaai	3.175	0.246
4.	Al-Furat	4.512	0.104
5.	Al-Nuriah	1.204	0.715
6.	Afak enterance	4.888	0.588
7.	Afak	5.078	0.779
8.	Al-Askan	4.253	0.654
9.	Al-Sunnia	2.387	0.354

Contamination Factor (CF): This factor is used to classify the level of contamination with heavy metals and for certain soils. Table (6) shows the pollution factor values for the study sample soils. The pollution factor values for the lead component ranged between (1.165 - 5.330), which is located between a moderate level of pollution to high pollution. As for the cadmium element, the pollutant factor values for the study soils were between (0.100 - 0.692), which is falls within the low pollution level. The highest pollution factor value for lead and cadmium was (5.330 and 0.692), and the lowest value was (1.165 and 0.100), respectively.

The sites can be arranged according to the pollution factor in relation to the lead element as follows: Al-Furat Neighborhood <Shamiya <Al-Iskan Neighborhood <Al-Taqiyya Neighborhood <Afak <al-iskan alsinai< Al-Nuriya <Afak Entrance <Al-Sunni cunty. The reason for the high values of the pollution factor in the Sunni area and the entrance to Afak can be attributed to its proximity to the Kashi plant and the main streets, which witnesses a large movement of means of transportation. As the lead component is included in the fuel components as it is applied as an anti-crack, the fuel products contain high levels of the lead component, causing an increase in its concentration in the soil after its deposition from the air. This indicates the contribution of gases emitted from car exhaust, cache plant waste, and electric power plants in each of the previously mentioned locations in raising the pollution factor values. These results are consistent with, Mmolawa *et al.* (2011); Rahman *et al.* (2012); Awadh (2013).

Pollution Load Index (PLI): Through this indicator, it is possible to give an estimate of the pollution status of the soil of a specific site. It was known by some researchers as the arithmetic means of the decomposing pollutants, Abrahim (2005), while Mmolawa (2011) defined it as the geometric mean of the studied pollutants. In light of the last definition, the bearish pollution index (PLI) gives a clear visualization of the pollution status of a particular site, as it was classified into two degrees, namely, PLI> 1, the soil is polluted, and PLI> 1 that represent no pollution.

The results of Table (6) show the values of the bearish pollution index for the soil of the study samples was more than (1) in four locations, namely (Afak, Afak entrance, Al-Nouriyah, and Al-Sunnia), as its values were (1.864, 1.636, 1,562 and 1.394), respectively. This indicates the presence of pollution, but in varying degrees, depending on its proximity to the sources of pollution represented by transportation means and industrial complexes. These results were identical to the findings of (Abd & Others, 2017) in the role of human activity in surface soil pollution for study sites in Tikrit city and the increase in the value of the bearish pollution index of (1).

Geoaccumulation index (Igeo): This indicator was used by Muller (1969) to calculate the amount of soil pollution in order to understand the effect of the geological source of the element and to estimate the effect of human intervention on the pollution process. The results of Table (7) show the values of the geological accumulation index (Igeo) for the lead element, which ranged between (0.362--1.832). Comparing to Table (2), it is found that their values fall within the first and third levels of the values of the Igeo Geological Accumulation Index. Thus, the soils of the Al-furat neighborhood, which fall within the first level, are not polluted, while all of the soils of the Shamiya county and the Al-Askan Alsinai are located within the second level that is not polluted - low pollution. There was no geological source to raise lead concentrations in those sites, while the soils of Al-Sunia, the Afak and Nouriya entrance, industrial housing, Afak, and Taqiyya were classified within the third level as polluted - medium pollution. Thus, the contribution of the geological source to the supply of soils with heavy elements is at its lowest levels.

As for the values of Igeo for the element cadmium it ranged between (3.906- 1.115), Table (2), it is noted that when compared with the values of the geological accumulation index falls within the first level as the values of the geological accumulation index were negative. That is, it is below zero and for all soils of the current study, and as such is classified as non-polluting, meaning there is no geological source for raising cadmium concentrations in these soils. These results indicate that the concentrations of the lead and cadmium elements of the study soils whose values appeared in the calculation of other pollution indicators PLI, CF, and EF were their source due to human activity, which confirms the assumption that the soil sites were affected by gases emitted from vehicle exhaust, industrial complexes or other human activities.

Table 6 : Values of the Pollution Factor (CF) and the Load Pollution Index (PLI) of Lead, Nickel, and Zinc in study soils

	Location	CF		PLI
		Pb	Cd	
1.	Al-Shamia	2.00	0.100	0.447
2	Al-Taqyya	3.165	0.246	0.882
3	Al-Iskan Sinaai	4.503	0.103	0.681
4	Al-Furat	1.165	0.692	0.897
5	Al-Nuriah	4.503	0.542	1.562
6	Afak enterance	4.762	0.730	1.864
7	Afak	4.172	0.642	1.636
8	Al-Askan	2.330	0.346	0.897
9	Al-Sunnia	5.330	0.365	1.394

Table 7 : The Geological Accumulation Index (Igeo) was evaluated for lead, nickel, and zinc in the study soils

	Location	Igeo	
1.	Al-Shamia	Pb	Cd
2.	Al-Taqyya	0.417	- 3.906
3.	Al-Iskan Sinaai	1.080	- 2.607
4.	Al-Furat	1.589	- 3.852
5.	Al-Nuriah	- 0.362	- 1.115
6.	Afak entrance	1.589	- 1.467
7.	Afak	1.670	- 1.031
8.	Al-Askan	1.479	- 1.223
9.	Al-Sunnia	0.639	- 2.115

Conclusions

In light of the results of our current research, the soil of Diwaniyah city has been affected in varying degrees by human activity. The results showed that the average concentrations of lead and cadmium in the study site soils were lower than the global average concentration of soils in all study sites. The values of the enrichment factor generally decreased as moved away from the sources of pollution, as they were more than the critical threshold of (1.5) at the sites closed the main roads and industrial complexes. The results indicate that the concentration of lead and cadmium elements that were evaluated in the calculation of the CF, EF, PLI, and Igeo pollution indicators indicates that their source is human activity, which confirms the hypothesis that these sites are affected by gases emitted from car exhaust and various other industries.

Recommendations

The need to monitor soil pollution, especially agricultural lands close to pollution sources, because of its role in plant pollution, and then the transfer of pollutants to the human and animal body through the food chain, causing many diseases. Using high-quality diesel fuel to avoid environmental pollution is necessary. Leave safe distances from public streets and industrial complexes and avoid cultivation to avoid the problem of contamination with heavy elements.

References

Abd, M.F.; Salman, K. and Ghazi, A.Z. (2017). Calculating pollution indicators and health risks of heavy elements in the topsoil of Tikrit city. Kirkuk University Journal. 12(3).

Abrahim, G.M.S. (2005). Holocene sediments of Tamaki Estuary: characterization and impact of recent human activity on an urban estuary in Auckland, New Zealand. Ph.D. thesis, University of Auckland, Auckland, New Zealand, p. 36.

Akoto, O.; Ephraim, J.H. and Darko, G. (2008). Heavy metal pollution in surface soils in the vicinity of abundant railway servicing workshop in Kumasi, Ghana. Int. J. Environ. Res., 2(4): 359–364.

Al-Zubaidi, A. and Qutaiba, M.H. (1978). Washing some of the soil affected by salinity using water from the water. Iraqi Journal of Agricultural Sciences, 13: 332 - 326.

Awadh, S.M. (2013). Assessment of the potential pollution of cadmium, nickel and lead in the road-side Dustin the Karkhdistrict of Baghdad City and along the highway between Ramadi and Rutba, West of Iraq. Merit Research Journal of Environmental Science and Toxicology. 1(7): 126-135.

AZita, B.H. and Seid, A.M. (2008). Investigation of heavy metals uptake by vegetable crops from metal – contaminated soil. World Academy of Science, Engineering and Technology. 43(1): 56-58.

Baird, C. (2001). Environmental Chemistry. University of Western Ontario. W. H., Freeman and Company, New York. (1): 398-401.

Baker, D.A.; Hussein, M.K. and Mustafa, A.M. (2020). Assessment of arbuscular mycorrhizal fungi (Glomus spp.) as potential biocontrol agents against damping-off disease Rhizoctonia solani on cucumber. Journal of Crop Protection. 9(1): 141-147.

Day, P.R. (1965). Particle fractionation and particle size analysis. InC.A. Black (ed). Methods of soil analysis part 1, Agron. Ser. No. 9, Am. Soc. Agron: Madison, Physical and.

Delibacak, S.; Elmaci, O.L.; Secer, M. and Bodur, A. (2002). Trace element and heavy metals concentration in fruit and vegetables of the Gediz River region. International Journal of water. 2(2/3): 196-211.

Drebee, H.A. and Razak, N.A.A. (2018). Measuring the Efficiency of Colleges at the University of Al-Qadisiyah-Iraq: A Data Envelopment Analysis Approach, Jurnal Ekonomi Malaysia, 52(3): 163-179.

Drebee, H.A.; Razak, N.A.A. and Karim, M.Z.A. (2014). Is there an overlapping market between national car producers in Malaysia? Jurnal Ekonomi Malaysia, 48(1): 75-85.

Hussein, M.K.; Bushra, A.J. and Mahmood, A.A. (2019). Winter Wheat Genotypes Response to Different Water Quality. International journal of agricultural and statistical sciences. 15(2): ISSN:0973-1930. eISSN-09763392.

Jackson, M.L. (1958). Soil Chemical Analysis. Prentice Hall, Inc Englewood Cliff, N.J. U.S.A. 225 – 276.

Jeber, B.A. and Khaeim, H.M. (2019). Effect of foliar application of amino acids, organic acids, and naphthalene acetic acid on growth and yield traits of wheat. Plant Archives, 19(2): 824-826.

Joudah, R.A. (2013). Heavy metals pollution in the roadside soil of Bab Al-Muadham city center/Baghdad. Aust. J. Basic & Appl. Sci., 7(12): 35-43.

Khaeim, H.M.; Clark, A.; Pearson, T. and Van Sanford, D. (2019). Methods of Assessing Fusarium Damage to Wheat Kernels. Al-Qadisiyah Journal For Agriculture Sciences (QJAS)(P-ISSN: 2077-5822, E-ISSN: 2617-1479), 9(2): 297-308.

Khaeim, H.M.; Clark, A.; Pearson, T. and Van Sanford, D. (2019). Determining The Effect of Mass Selection for FHB Resistance in Soft Red Winter Wheat Using an Image-Based Optical Sorter. Al-Qadisiyah Journal For Agriculture Sciences (QJAS)(P-ISSN: 2077-5822, E-ISSN: 2617-1479), 9(2): 278-296.

Khaeim, H.M.; Clark, A.; Pearson, T. and Van Sanford, D. (2019). Comparing Genetic Variation within Red Winter Wheat Populations with and without Image-Based Optical Sorter Selection. Al-Qadisiyah Journal For Agriculture Sciences (QJAS)(P-ISSN: 2077-5822, E-ISSN: 2617-1479), 9(2): 266-277.

Lindsay, W. (1979). Chemical Equilibria in soils. 1st edition. A Wiley-Interscience Publication. John Wiley and Sons, New York.

Liu, W.H.; Zhao, J.Z.; Ouyang, Z.Y.; Solderland, L. and Liu, G.H. (2005). Impacts of Sewage Irrigation on Heavy Metal Distribution and Contamination in Beijing, China. Environ. Intl., 32: 805-812.

Maya, G.M.; Kamoh, N.M.; Kangpe, N.S.; Ayuba, S.M. and Eneji, I.S. (2015). Heavy Metals Contamination in Roadside Dust along Major Traffic Roads in Jos Metropolitan Area, Nigeria. European Journal of Earth and Environment. 2(1): 1-14.

Majewska, M.; Kurek, E. and Słomka, A. (2011). Effect of Plant Growth on Total Concentrations of Zn, Pb, and Cd, and Their Distribution between Operational Fractions in the Upper Layer of a 100-Year-Old Zinc-Lead Waste Heap. J. Environ. Stud., 20(3): 591-597.

Mmolawa, K.B.; Likuku, A.S. and Gaboutloeloe, G.K. (2011). Assessment of heavy metal pollution in soils along with major roadside areas in Botswana. African Journal of Environmental Science and Technology, 5(3): 186-196.

Mohsen, B. and Mohsen, S. (2008). Investigation of metals accumulation in Some vegetables irrigated with wastewater in share Ray- Iran and toxicological application. American-Euras-ian. J. Agric. Environ. Sci., 4(1): 86-92.

Muller, G. (1969). Index of accumulation in sediments of the Rhine river. GeologicalJournal, 2(3): 108-118.

Nagajyoti, P.C.; Lee, K.D. and Sreekanth, T.V.M. (2010). Heavy metals, occurrence, and toxicity for plants: a review. Environ Chem Lett., 8(3): 199–216.

Rahman, S.H.; Khanam, D.; Adyel, T.M.; Islam, M.S.; Ahsan, M.A. and Akbor, M.A. (2012). Assessment of heavy metal contamination of agricultural soil around Dhaka Export Processing Zone (DEPZ), Bangladesh: implication of seasonal variation and indices. Applied sciences, 2(3): 584-601.

Sadiq, A.H. and Kamel, K.M. (2008). Monthly changes in concentrations of trace elements in the main river channel of the Al-Gharraf River, the Department of Fish and Livestock. faculty of Agriculture. Albasrah university.

Sam, R.A.; Ofosu, F.G.; Atiemo, S.M.; Aboh, I.J.K.; Gyampo, O.; Ahiamadjie, H.; Aditi, J.P. and Arthur, J.K. (2015). Heavy Metal Contamination Levels in Topsoil at Selected Auto Workshops in Accra. International Journal of Science and Technology (IJST). 4(5): 222-229.

Singh, A.; Kumar, C.S. and Agarwal, A. (2011). Phytotoxicity of cadmium and lead in Hydrilla verticillata (I.F). Royle. Journal of Phytology, 3(8): 1-4.

World Health Organization (2003). The report of using wastewater in agriculture - a guide for planners. Regional Office for the Middle East. Regional Center for Environmental Health Activities. Oman. Jordan.

Zheljazkov, V. and Nielsen, N.E. (1996). Effect of heavy metals on peppermint and cornmint. Plant Soil 178: 59–66.

Wafaa, S.A. and Hussein, M.K. (2018). Effect of Sewage Water Irrigation on Growth Performance, Biomass and Nutrient Accumulation in Maize and Barley. International Journal of Agricultural and Statistics Sciences, 14(2): (ISSN: 0973-1903).

Luma, A.A. and Khaeim, M.H. (2018). Utilization of Treated Wastewater in Irrigation and Growth of Jatropha Plant to Protect the Environment from Pollution and Combating Desetification.yu. Plant Archive Journal. eISSN:2581-6063 (online),ISSN:0972-5210.