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Use Cu and Fe metals as a pollution index for status estimation of some Agricultural Soil in Baghdad city/ Iraq

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ABSTRACT

The presence of heavy metals in the soil in high concentrations is a clear indicator of soil pollution. The research aims to estimate concentrations of iron (Fe) and copper (Cu) in some selected agricultural soil of Baghdad city and to assess the impact of agricultural practices and the sources that lead to an increase in their presence in the soil. Seven sites were selected from the study area that distributed six sites affected by pollution sources and one sample as a control. Copper (Cu) and Iron (Fe) concentrations were measured using XRF technology.

The results show Fe concentrations were higher than the WHO,1996 limit (50,000 mg/kg). Fe ion is one of the dominant metals among the essential elements in agricultural soils and necessary for plants and is classified geochemically among the major elements, as it differs from the rest of the microelements in terms of their quantity in the soil. Fe values in study soil samples follow this pattern: NH. DYL. > BAST.2 > JAZ. > LAT. > > JAD. > BAST.1 > CONT., the increase in Fe concentrations in the soils of the study area is attributed to the fact that the soil of Baghdad city is rich in iron, and to the long-term use of chemical fertilizers containing impurities of these elements, and to the irrigation water which Agricultural lands are irrigated for a long time. Also, current study results of the Cu element in soil samples were below permissible limits (36 mg/kg) according to the WHO, although some soil samples in sites such as Al-Bestna- 2 and AL-JADRIA were Cu concentrations were high or close to the permissible limit. Cu values in study soil samples follow this pattern: JAD. > BAST.2 > NH. DYL. > LAT. > JAZ. > CONT. > BAST.1. The irrigation of agricultural soil by not suitable water such as agricultural drainage water and wastewater for a long time, in addition to what has added pollutants from the ambient environment such as road dust, air pollutants, and dumping or accumulation of solid waste, leads to an increase Cu concentrations and accumulative it in the soil. The pollution of studied soil was assessed using many soil pollution indices; In general, the results indicate a low contamination level or absence of soil pollution, and no environmental risk by copper element, although there was moderate contamination in some sites.

Keywords: *pollution index 1; Cu and Fe metals 2; Agricultural soil; Baghdad city 4.*

INTRODUCTION

The soil bears the greatest burden of environmental pollution. It is getting polluted in some ways. There is an urgency in controlling soil pollution to preserve soil fertility and increase productivity. Generally, most pollutants are introduced into the environment by sewage, waste, or accidental discharge, or else they are by-products or residues from the production of something useful. Due to this, our precious natural resources like air, water, and soil are getting polluted (Ashraf et al., 2014). Heavy metals are currently of much environmental concern. They are harmful to humans, and animals and are susceptible to bioaccumulation in the food chain. Heavy metals may come from many different sources in urban areas. Atmospheric pollution is a major contributor to heavy metal contamination in top soils (Kelly et al., 1996). Human activities such as industrial production, mining, agriculture, and transportation, release high amounts of heavy metals into surface and groundwater, soils, and ultimately to the biosphere. Accumulation of heavy metals in crop plants and agricultural soil is of great concern due to the probability of food contamination through the soil root interface (Nazir, et al., 2015; Rana, et al., 2010). Ingestion of vegetables irrigated with wastewater and grown in soils contaminated with heavy metals possesses a possible risk to human health and wildlife and heavy metal concentration in the soil solution plays an important role in controlling metal bioavailability to plants (Nazir, et al., 2015).

Heavy metals based on their health importance can be classified into four major groups, essential, like Cu, Zn, CO, Cr, Mn, and Fe, which are micronutrients and are toxic when taken in excess (Amin, N. 2014), In recent years many alternative ways for irrigation were found like the use of treated wastewater and well water because of drought and lack of rain season. Most of the studies show that the use of wastewater and well water contaminated with heavy metals for irrigation over a long period may increase the heavy metal contents of soils above the permissible limit (Amin, N. 2014; AL-Jaboobi et al., 2014; Lone, 2013). Ultimately, increasing the heavy metal content in the soil also increases the uptake of heavy metals by plants depending upon the soil type, plant growth stages, and plant species (Amin, N. 2014; AL-Jaboobi, 2014; Lone, 2013). Assessing the ecological risk of contaminated soil, pesticide application, sewage sludge amendment, and other human activities leading to exposure of the terrestrial environment to hazardous substances is a complicated task with numerous associated problems (Ashraf et al., 2014).

Soil is the main sink for metals emitted into the environment from a wide variety of anthropogenic sources (Niragu, 1990; Abdel-Rahman, et al., 2018). The accumulation of heavy metals in agricultural soils is a growing concern due to its relationship to food safety, or its link through Leaching into groundwater, as well as surface water, represented in nearby rivers and water bodies, which may lead to potential health risks. Also, the dangerous heavy metals may come from the rocks that make up the soil itself, or from anthropogenic sources such as solid or liquid sediments, agricultural activities, or from industrial and urban emissions (Wilson and Pyatt, 2007). Heavy metals are considered dangerous environmental pollutants and their danger lies in their bio-cumulative characteristic in the bodies of living organisms that feed on plants cultivated in polluted soils for reasons related to factors of geological weathering of soil because of excessive use of chemical fertilizers and agricultural pesticides, most of the time it is the result of irrigation with water polluted with waste of factories, and sewage wastes (Sadiq, and Muhannad. 2008).

The main objective of this research is to shed light on the possibility of estimation of agricultural soil pollution in Baghdad by Fe and Cu metals using different pollution indices, define environmental risk levels, and determine the sources which are lead to an increase of these metals concentrations, and its presence in the soil.

1.1 The Study Area

Baghdad was divided into ten districts, five districts on the east bank of the Tigris River (Al-Rusafa) and five on the west bank (Al-Karakh), (Al-Kinani, 2017), with geographical coordinates of latitude 33.452°N to 33.184°N and longitude 44.189°E to 44.576°E. Baghdad is Iraq's biggest, and most densely inhabited city, Baghdad as the largest city in Iraq (24% of Iraq) and the second largest city in the Arab home after Cairo, covering a neighborhood of about 205.1 km^2. The Tigris crosses the town and splits it into 2 sections: Karkh (west) and Rusafa (east). The eastern region borders Diyala watercourse that connects the Tigris River to the southwest city (Bukheet, 2016), as shown in Figure (1), https://www.worldmap1 .com /map/iraq/baghdad-map.asp

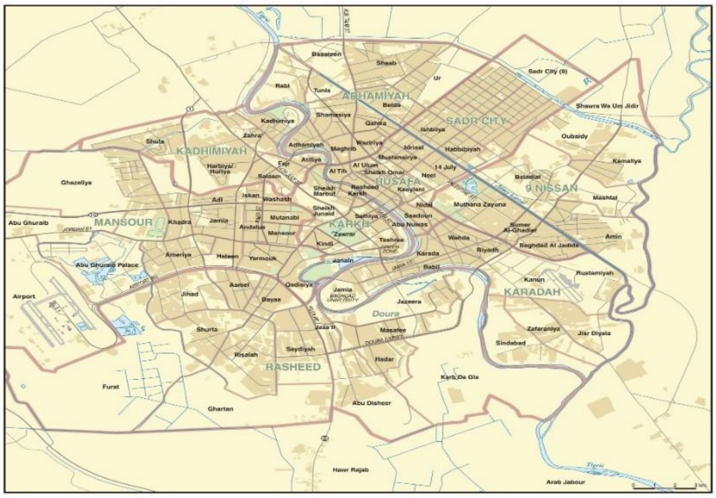

FIGURE 1. Map of Baghdad City

Several publications refer to Baghdad City soil is effecting by anthropogenic activities, wrong farming practices, use of untreated water for irrigation, and what is added to it from pollutants from the surrounding environment. Kadhum and Hussain, 2011 The aim of this research is to study the changes in the chemical properties of the soil (the agricultural soil beside the Army canal in Baghdad city) which has been irrigated for a long period with polluted river water. Also, a comparison was done between the properties of irrigated soil and the properties of non-irrigated soil. Results show that Pb and Ni increased, and Ec and TSS increment has also been found especially in the non-irrigated soil. Habib, et al., 2012 studied the distribution and concentration of heavy metals (Fe, Pb, Cd, Ni, and Co) in the soil in Baghdad city. The concentration of heavy metals in the soil appeared to be higher than in the natural distribution, so the leaves and fruits of plants are also likely. Heavy metals in the Baghdad soil, especially Pb, Cd, and Co had strongly correlated together and distributed in similar patterns which may be originated from sources of diesel and gasoline fuel. Al-Obaidy and Al-Mashhadi, et al., 2013 collected soil samples from three land use types within Baghdad urban areas. Their research indicated a higher concentration of Cd, Cr, Cu, Fe, Ni, Pb, and Zn in the industrial area, while a higher concentration of Mn was observed in the residential areas. However, the concentration of Cd, Ni, and Pb was higher than the calculated worldwide mean of unpolluted soil. Al-Nour et al., 2016 the results of their research showed variation in the concentrations of most of the studied heavy metals (traces) and they exceeded the permissible limit of the World Health Organization in some stations with the exception of the elements cadmium, zinc, and iron. Important in the behavior of trace elements, and thus affect their distribution in the biosphere, except for the first station, the results of the examination matched the permissible limits. Jasim, 2017 He evaluated of the impact of environmental pollution on water and soil south of Baghdad. The presented results revealed different values for physical, and chemical parameters for both the water and soil samples studied. In some polluted soil samples, there is a highly elevated of heavy metals. Also, the results refer to an increase in most of these elements. The aim of this work is to renew data base for the environmental parameters which are very important to study medical problems. Mahdii and Turki, 2020 this study aims to identify soil pollutants from heavy metals, as they were taken 23 soil samples and divided into six regions lies in Baghdad governorate. Heavy metals values compared with standard, as the values of Fe, Zn, Cu, Pb, Ni, Mn, were within the allowed limits in the soil, for as for Cd it was not within limits standard. Fadhel and Abdulhussein, 2022 studied of the contamination of Baghdad Soils with Lead Element. The high Pb concentration in the soils has been related to anthropogenic activities. Further, the spatial analysis map showed the high concentration of Pb distribution in the Al-Rissafa side of Baghdad city. The geoaccumulation factor and contamination factor indicate that all the soil samples are uncontaminated except the industrial sites are very high contamination with Pb. Also, by calculating the potential ecological risk, It has been found there is a very high ecological risk in the industrial sites, while a low ecological risk in other sites in the study area. The results showed that the average concentration of Pb in soil was greater than the global soil average.

MATERIALS AND METHODS

Sampling

Fieldwork was conducted on Nov. 2021 and Feb., June, July, and Aug 2022. Thirty-five soil samples were collected at a depth between 5-30 cm using a hand auger and stored in labeled polyethylene bags. Six locations have been identified, distributed over the city of Baghdad as one random sample for each area to cover the whole study area, which represents agricultural areas irrigated with water of the Tigris, as well as sewage or sewage water with agricultural activity. Where samples were taken by replicate. However, the results were not accurate, so we used the method of collecting composite samples until we got the desired result, Figure (2). In addition, one soil sample was collected as a control. The coordinates of each site have been determined by using the Global Positioning System (GPS), Figure (3), and Table (1).

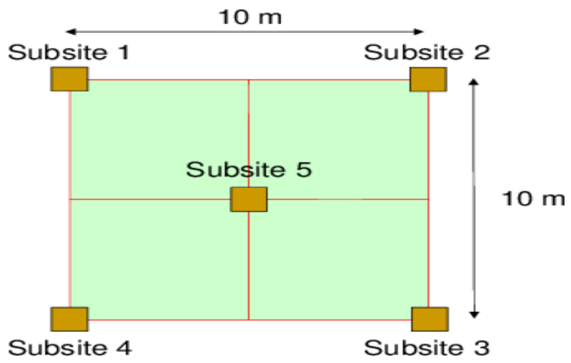

FIGURE 2. Composite soil sampling scheme. Soil samples are composited from 5 subsites from a 10 x 10 m square plot according to the above scheme.

FIGURE 3. Location map of the study area with agricultural soil samples sites.

TABLE 1. Geographic coordinates of the Samples location

Sample No.	Site Name/ District	Soil type	Coordinates	
			Latitude	Longitude
S1	AL-Jazeera/ Al-Rashidyah	Agricultural	33 25 54.01	44 21 18.85
S2	Nahr-Dyala/ Dyala bridge	Agricultural	33 15 04.82	44 31 48.22
S3	Al-Bastna 1/ AL-ZUFRANIA	Agricultural	33 13 38.28	44 30 10.19
S4	Al-Bastna 2/AL-ZUFRANIA	Agricultural	33 13 32.26	44 30 26.65
S5	AL-Latyfia Baghdad Governorate	Agricultural	32 59 55.53	44 21 27.37
S6	Baghdad University/ AL-Jadyria	Agricultural	33 16 03.88	44 23 08.39
S7	Oil houses Garden/ Al-Amel	Agricultural/ Control	33 16 58.43	44 20 23.27

RESULTS AND DISCUSSION

The agricultural use of pesticides and fertilizers adds heavy metals, persistent organic pollutants, excess nutrients, and agrochemicals that are transported downstream by surface runoff; flood events; atmospheric transport and deposition; and/or soil erosion (FAO, 2018). The problem of soil contamination with heavy metals is the possibility to be transported to other parts by wind and runoff water causing an accumulation of these metals. Heavy metals can find their way to the human food chain through enriched plants in agricultural areas. Furthermore, heavy metal accumulation in agricultural soil leads to a limit or even diminishes crop productivity (Issa and Alshatteri, 2021).

Iron (Fe)

Iron comes at the forefront of the microelements which is necessary for plants, and is classified geochemically among the major elements, as it differs from the rest of the microelements in terms of its quantity in the soil (Al-Ghajar, 2022). From Table (2) and Figure (4), the highest mean of the Fe element was (14170.5 mg/kg) in Al-Jazeara site, and the lowest mean of this element was (8941.92 mg/kg) in Bestna- 2, with Std. Deviation mean (1754.668). While the maximum value of Fe was (18607.27 mg/kg) in the NH. DYL. of Nov. month, and the minimum value was (6579.03 mg/kg) in Al-Bestna- 2. of June. month (Table 3).

TABLE 2. Fe concentrations (mg/kg) in Soil samples of the study area

Site name	Abbreviation	Mean	Std. Deviation	Minimum	Maximum
AL-JADRIA	JAD.	10915.2	669.879	10327.6	11644.6
AL-JAZERA	JAZ.	14170.5	4127.83	10069. 7	18324.8
AL-LATIFIA	LAT.	10411.5	1076.75	9705.95	11650.8
BASTNA- 1	BAST.1	11656.7	1038.89	10852.9	12829.8
BASTNA - 2	BAST.2	8941.92	2172.42	6579.03	10852.7
NHR-DYALA	NH. DYL.	10637.8	1513.72	9591.29	12373.5
CONTROL	CONT.	12369.51	1683.19	10615.9	13972.13

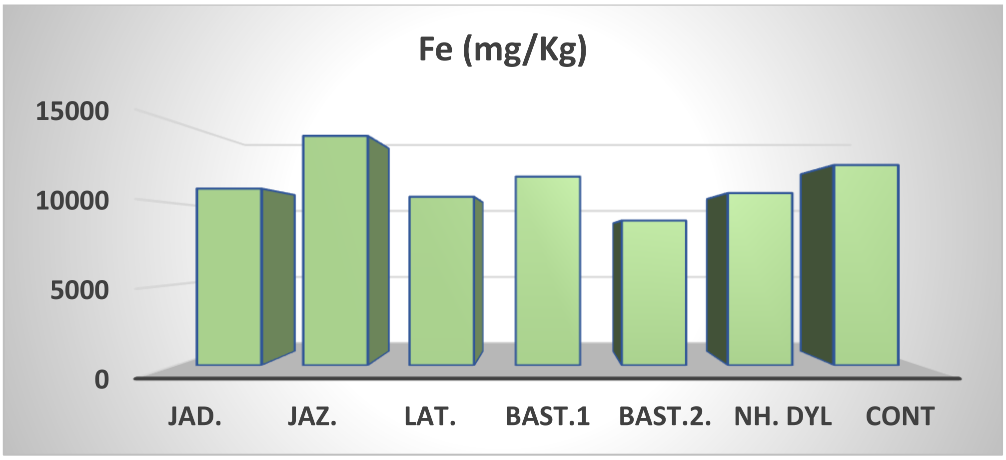

FIGURE 4. Fe concentrations mean in soil samples of the study area

TABLE 3. Monthly variations of Fe values in study soil samples

Months	JAZ.	NH. DYL.	BAST.1	BAST.2	LAT.	JAD.	CONT.
Nov.	**15430.00**	**18607.27**	**16152.36**	**18426.90**	**12164.97**	**16337.16**	**10131.31**
Feb.	**15219.39**	**13149.58**	**13713.84**	**13272.67**	**16686.64**	**16577.58**	**13058.11**
Jun	**14116.95**	**9591.29**	**11287.41**	**9394.02**	**11650.83**	**10773.31**	**13972.13**
July	**10069.67**	**9948.63**	**10852.94**	**6579.03**	**9877.61**	**11644.59**	**10615.92**
Aug.	**18324.80**	**12373.48**	**12829.81**	**10852.72**	**9705.95**	**10327.55**	**12520.48**

Comparing these Fe concentrations results for iron with WHO, the maximum allowable limit for iron is (50,000 mg/kg), and all results were higher than this limit. The iron ion is one of the dominant metals among the essential elements in agricultural soils, and since there are high concentrations of this element in the agricultural soils taken from the study area, it is believed that this is due to an increase in its concentration in irrigation water (with sewage water or agricultural drainage water), which Agricultural lands are irrigated for a long time, in addition to the continuous use of inorganic fertilizers.

To arrange Fe values in study soil samples from highest to lowest, the following is observed: NH. DYL. > BAST.2 > JAZ. > LAT. > JAD. > BAST.1 > CONT., the increase in Fe concentrations in the soils of the study area is attributed to the fact that the soil of Baghdad city is rich in iron, and to the long-term use of chemical fertilizers containing impurities of these elements, and this is consistent with previous studies such as (Habib et al., 2012; Abdul Hameed et al., 2013; Mahdii et al., 2021).

Copper (Cu)

Cu is used in numerous applications because of its physical properties. The toxicity for humans is not very high. Cu normally accumulates typically surface horizons, a phenomenon explained by the bioaccumulation of the metal and recent anthropogenic sources (Chatterjee and Banerjee, 1999). In agricultural soils, Cu contamination arises from the application of Cu-based fungicides, which degrade the quality of soil used for crop cultivation (Fan et al., 2012). The incorrect methods of using pesticides and fertilizers (Subhi, 2012), and minor concentrations of Cu in the soil due to soil base elevation, as in the oxidizing acidic medium or in the acidic oxidizing environment, and Cu has high mobility, therefore agricultural activities may add large amounts of copper element to the soil, (Endale, et al., 2012).

Table (4) and Figure (5), the highest mean of the Cu element was (22.28 mg/kg) in AL-JADRIA site, and the lowest mean of this element was (2.067 mg/kg) in Bestna- 1, with Std. Deviation mean (8.20). While the maximum value of Cu was (34.54 mg/kg) in the Al-Bestna- 2 of Aug. month, and the minimum value was (<1 mg/kg) in Al-Bestna- 1, Al-LATIFIA, and CONTROL in some months (Table 5).

Current study results of the Cu element in soil samples were below permissible limits (36 mg/kg) according to the (WHO, 1996), although some soil samples in sites such as Al-Bestna- 2 and AL-JADRIA were Cu concentrations were high or close to the permissible limit.

TABLE 4. Cu concentrations (mg/kg) in Soil samples of the study area

Site name	Abbreviation	Mean	Std. Dev.	Minimum	Maximum
AL-JADRIA	JAD.	22.280	9.208	11.650	27.790
AL-JAZERA	JAZ.	6.850	2.018	5.200	9.100
AL-LATIFIA	LAT.	11.097	11.686	0.500	23.630
BASTNA- 1	BAST.1	2.067	2.454	0.600	4.900
BASTNA - 2	BAST.2.	21.597	15.018	5.130	34.540
NHR-DYALA	NH. DYL.	18.967	12.356	5.100	28.810
CONTROL	CONT.	3.017	4.099	0.600	7.750

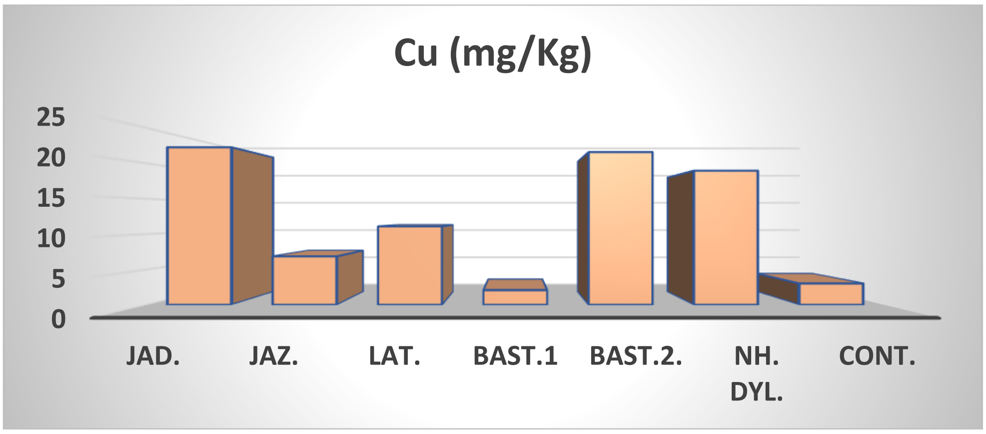

FIGURE 5. Cu concentrations mean in soil samples of the study area

TABLE 5. Monthly variations of Cu values in study soil samples

Months	JAZ.	NH. DYL.	BAST.1	BAST.2	LAT.	JAD.	CONT.
Nov.	**6.33**	**8.2**	**1.25**	**29.45**	**1.40**	**33.18**	**4.0**
Feb.	**8.65**	**22.83**	**< 1***	**8.4**	**< 1**	**25.59**	**6.50**

Jun	**9.10**	**28.81**	**< 1**	**5.13**	**23.63**	**27.79**	**< 1**
July	**5.20**	**5.10**	**< 1**	**25.12**	**< 1**	**27.40**	**< 1**
Aug.	**6.25**	**22.99**	**4.90**	**34.54**	**9.16**	**11.75**	**7.75**

To arrange Cu values in study soil samples from highest to lowest, the following is observed: JAD. > BAST.2 > NH. DYL. > LAT. > JAZ. > CONT. > BAST.1,

The irrigation of agricultural soil with water that is not suitable for cultivation, such as agricultural drainage water and wastewater that are irrigated for a long time, in addition to what has added pollutants from the external environment such as road dust and air pollutants from dumping or accumulation of solid waste leads to increase Cu concentrations and accumulative it in the soil.

Soil pollution indices

The problem of high concentrations of heavy metals, especially in agricultural soils, creates a global environmental issue due to the crucial importance of food production and security (Chen et al. 2015). The key to the effective assessment of soil contamination with heavy metals lies in the use of pollution indices, the comprehensive nature of assessing soil quality through the use of indices is also demonstrated by the opportunity it affords to estimate environmental risk as well as the degree of soil degradation (Kowalska, 2018). The indices help to determine whether the accumulation of heavy metals were due to natural processes or was the result of anthropogenic activities (Elias and Gbadegesin 2011).

To assess the pollution status and to evaluate the impact of anthropogenic activities, we can be employed the pollution indicators, such as geoaccumulation index (Igeo), Degree of Contamination and Contamination Factor, Single Pollution Index (SEPI), and Integrated pollution load index (IPLI) and Potential Ecological Risk Index (Eif). Because Fe is classified geochemically among the major elements, and an essential element for the growth and development of cultivated plants, plants absorb it in relatively large quantities, which made some researchers name iron with major elements such as potassium and magnesium, Therefore, the focus will be only on evaluating the soil of the study area in terms of copper contamination.

geoaccumulation index (Igeo)

The application scope of this index is to the assessment of the pollution levels in the soil of individual heavy metals. Igeo allows the assessment of soil contamination with a heavy metal based on its contents in A or O horizons referenced to a specified GB (Müller 1969).

$$Igeo = \log_2 \left[\frac{Cn}{1.5\ GB}\right] \ldots\ldots\ldots\ldots\ldots (1)$$

where Cn: is the concentration of individual heavy metals, GB: is the value of the geochemical background, and the 1.5 constant, allows for an analysis of the variability of heavy metals as a result of natural processes, (Abrahim and Parker, 2008). The values of this 7-grade index range from subzero to more than 5 (Muller, 1969), as seen in Table (6):

TABLE 6. Geoaccumulation index (I geo) for soil pollution levels

Igeo Class	Igeo value	Pollution level
0	**<0**	practically unpolluted
1	**0-1**	unpolluted to moderately polluted
2	**1-2**	moderately polluted
3	**2-3**	moderately to strongly polluted
4	**3-4**	strongly polluted
5	**4-5**	strongly to extremely polluted
6	**>5**	extremely polluted

I geo values of Cu in soil samples (-1.343), indicating practically unpolluted (Table 7), because the I geo mean values for soil samples were (Igeo value <0).

TABLE 7. Mean value of Geoaccumulation Igeo for soil sample

Site name	I_{geo} value
AL-JADRIA	**-0.014**
AL-JAZERA	**-1.716**
AL-LATIFIA	**-1.020**
BASTNA- 1	**-3.444**
BASTNA - 2	**-0.060**
NHR-DYALA	**-0.246**
CONTROL	**-2.899**
Mean value	**-1.343**

Single Pollution Index (PI)

An index that can be used to determine which heavy metal represents the highest threat to a soil environment is the Single Pollution Index (PI). An assessment index is generally applied to measure the environmental quality of soil and one simple and well-known index is the single-element pollution index (SEPI) which was used as an evaluation method to identify single-element contamination resulting in increased metal toxicity. The formula used to calculate SEPI is as:

$$SEPI = \frac{metal\ content\ in\ soil}{permissible\ level\ of\ metal} \quad ……………(2)$$

The tolerable levels for soil suggested by WHO, 1996 were adopted as permissible levels, and each heavy metal was classified as low contamination (SEPI ≤ 1), moderate contamination (1 < SEPI ≤ 3), or high contamination (SEPI > 3) (Chen, 2005). The SEPI value of Cu in study soils varied from 0.619 to 0.057 (Table 8) which indicated a low contamination level (SEPI ≤ 1), with an average of 0.341 for all soil samples indicating a low contamination level.

TABLE 8. Mean value of SEPI values for soil sample

Site name	SEPI value
AL-JADRIA	0.619
AL-JAZERA	0.190
AL-LATIFIA	0.310
BASTNA- 1	0.057
BASTNA - 2	0.60
NHR-DYALA	0.530
CONTROL	0.084
Mean value	0.341

Contamination Factor (CF) and Contamination Degree (C_{deg})

Håkanson, 1980 proposes the term "contamination factor" (Cf) to indicate the degree to which a lake or sub-basin has been contaminated with a certain toxin, which is calculated by dividing the soil metal concentration by the metal's natural background concentration (concentration in unpolluted soil):

CF = C Heavy metal / C Background………….(-3)

Where Cm: is the mean content of heavy metal from at least five samples of individual metals, and Cp-i: is the preindustrial reference value for the substances.

Depending on Håkanson, 1980, we can determine the CF in the soil of the study area because there are four types of contamination factors, as shown in (Table 9):

TABLE 9. Soil pollution classifications depending on the level of (CF)

CF Value	Contamination Level
CF<1	Low contamination
1<CF<3	Moderate contamination
3<CF<6	Considerable contamination
CF>6	Very high contamination

When comparing the CF results of the Cu element in the soil samples, found the CF mean value of Cu was recorded (0.818) which is CF <1, this indicates low contamination in soil samples, (Table 9), but some CF values for the Cu in the soil samples, observed that it recorded more than 1<CF<3 such as AL-JADRIA, BASTNA-2, and NHR-DYALA, Table (10), which indicate moderate contamination in soil of these areas.

TABLE 10. CF values of Cu concentrations in the soil sample

Site name	CF value	Contamination Level
AL-JADRIA	1.485	Moderate contamination
AL-JAZERA	0.457	Low contamination
AL-LATIFIA	0.740	Low contamination
BASTNA- 1	0.138	Low contamination
BASTNA - 2	1.440	Moderate contamination
NHR-DYALA	1.264	Moderate contamination
CONTROL	0.201	Low contamination
Mean value	0.818	Low contamination

As for the process of calculating the Contamination Degree (C_{deg}), it can be done according to the formula:

$$C_{deg} = \sum_{i=1}^{n} CF \quad …………….(4)$$

Where CF is the single index of contamination factor, and n is the count of the heavy metal species. This index refers to the total amount of contamination factors. It is a modified and designed variant of the degree of contamination (C_{deg}), (Aikpokpodion et al., 2010). Table (11) shows the terms that have been used to describe the degree of contamination:

TABLE 11. Soil contamination classifications of (C_{deg})

Cdeg value	Contamination level
Cdeg< 6	low degree of contamination
6 = Cdeg < 12	moderate degree of contamination
12= Cdeg < 24	considerable degree of contamination
C_{deg} = 24	very high degree of contamination

The results of the process of calculating the C_{deg} of the soil samples of the study area by Cu element indicated that all study area soil was a low degree of contamination because the C_{deg} values were < 6, Table (12).

TABLE 12. CF values of Cu concentrations in the soil sample

Site name	CF value	Contamination Level
AL-JADRIA	5.725	low degree of contamination
AL-JAZERA	4.240	low degree of contamination
AL-LATIFIA	4.601	low degree of contamination

BASTNA- 1	3.861	low degree of contamination
BASTNA - 2	3.723	low degree of contamination
NHR-DYALA	2.283	low degree of contamination
CONTROL	1.020	low degree of contamination
Mean value	3.636	low degree of contamination

Pollution Load Index (PLI)

To estimate the contamination status of metals in soil, the pollution load index indicates whether the quality of soil is suitable for vegetable growth and agricultural use (Liu et al., 2005). Due to anthropogenic inputs, agricultural runoff, and industrial activities, the pollution load is due to heavy metals. For the total assessment of the degree of contamination in soil, the PLI is also used. This index provides an easy way to prove the deterioration of the soil conditions as a result of the accumulation of heavy metals (Varol 2011). PLI is calculated as a geometric average of PI based on the following formula:

PLI = n$\sqrt{CF1 * CF2 * CF3 * \ldots\ldots CFn}$…………(5)

Where n: is the number of analyzed heavy metals, CF represents the contamination factor of each metal and n is the number of metals tested, and PI: is the calculated value for the Single Pollution Index. The following terminology has been utilized:

The PLI value > 1 is polluted, whereas < 1 indicates no pollution. The PLI value of all soil samples by Cu element is (0.159), which is less than 1, that indicating the absence of soil pollution by this element in the study area.

Potential ecological risk (RI)

Potential ecological risk (RI) is an index applicable for the assessment of the degree of ecological risk caused by heavy metal concentrations in the water, air, as well as soil. Also, it assesses the toxicity of certain trace elements in sediments (Zheng, 2013) and is now used in soil analysis to determine the ecological risk of copper in the soil of the study area. This index was introduced by Håkanson (1980), and it is calculated using the following formula:

RI = $\sum Er$ …………….(6)

Where RI is the Potential ecological risk index (PERI), Er: is the single index of the ecological risk factor calculated based on the equation:

Er = Tr * CF…………..(7)

Where Tr: is the toxic reaction factor, with a standard value of 5 for Cu, and CF is the contamination factor. The possible ecological risk index is classified into five classes of soil quality follow (Table 13):

According to the results of the ecological risk index (PERI) assessment (Table 14), the single index of the ecological risk factor from the mean Cu concentrations in soil samples varied from (0.689 to 7.427). The observed results indicate a minimum potential ecological risk in all sites. When comparing the results obtained from the process of calculating the environmental risk factor with the scale of classification of heavy metals according to the potential environmental hazards of the soil, it was noted that all the values of the environmental risk factor are very low, which indicates that there is no environmental risk for the element copper in all the soils of the study area.

TABLE 13. Grading scale of heavy metals in soil's potential ecological risk

Er value	The ecological risk level of single-factor pollution	RI value	The general level of potential ecological risk
Er <40	Low	< 150	low
40≤ Er <80	Moderate	150 _ 300	moderate
80≤ Er <160	Moderate to high	300 - 600	High
160≤ Er <320	High	≥ 600	Very high
Er ≥320	Very high		

TABLE 14. Ecological Risk Index (PERI) values and ecological risk level for study soil samples

Site name	Cu			
	Er value	Potential risk degree	RI value	Risk degree
AL-JADRIA	7.427	Low	32.714	Low
AL-JAZERA	2.283	Low		
AL-LATIFIA	3.699	Low		
BASTNA- 1	0.689	Low		
BASTNA - 2	7.199	Low		
NHR-DYALA	6.322	Low		
CONTROL	1.006	Low		
Mean value	4.089	Low		

CONCLUSIONS

1- The results for Fe concentrations in the soil of the study area were higher than WHO limits because is one of the dominant metals among the essential elements in agricultural soils. While the Cu concentrations were below WHO permissible, but some soil samples in sites such as Al-Bestna-2 and AL-JADRIA were higher or close to the permissible limit. This is due to there being high concentrations of these elements in the agricultural soils taken from the study area. It is believed that this is due to an increase in its concentrations in irrigation water (with sewage water or agricultural drainage water), which Agricultural lands are irrigated for a long time, in addition to the continuous use of inorganic fertilizers.

2- To arrange Fe and Cu values in study soil samples from highest to lowest, the following is observed: NH. DYL. > BAST.2 > JAZ. > LAT. > JAD. > BAST.1 > CONT., and JAD. > BAST.2 > NH. DYL. > LAT. > JAZ. > CONT. > BAST.1 respectively. The increase in Fe and Cu concentrations in the soils of the study area is attributed to the fact that the soil of Baghdad city is rich in iron, and to the long-term use of chemical fertilizers, and the irrigation of agricultural soil by not suitable water for cultivation, in addition to the, adding of pollutants from the ambient environment which leads to increase these metals, especially Cu element and accumulative it in the soil. These results agreed with previous studies such as (Habib et al., 2012; Abdul Hameed et al., 2013; Mahdii et al., 2021).

3- The results of calculating the pollution indices for the element copper only indicated that the soil of the study area is unpolluted or low pollution, except for some sites such as AL-JADRIA, BASTNA-2, and NHR-DYALA in some periods in which the pollution was moderate, and this is due to the irrigation by wastewater, or Agricultural drainage water or river water containing high concentrations of Cu, in addition to the long-term use of the fertilizers containing copper.

4- In general, according to the results of the ecological risk index (PERI) assessment, the single index of the ecological risk factor from the Cu concentrations in soil samples, the results indicate a low potential ecological risk in all sites. When comparing the results with the scale of classification of heavy metals according to the potential environmental hazards of the soil, it was noted that all the values of the environmental risk factor are very low, which indicates that there is no environmental risk for the element copper in all the soils of the study area.

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