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# ASSESSMENT OF HEAVY METALS POLLUTION OF SOME ADJACENT SOILS TO INDUSTRIAL FACILITIES IN WASIT GOVERNORATE

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## Abstract

A case study of potential pollution has been studied in the soils adjacent to the four industrial establishments located within Wasit City in Iraq, which is the Zobaydiya power station, the licorice plant in Al-Aziziya, the textile factory in Al-Kut and the brick factories in the Alhay district, and the study of the effect of emissions resulting from the incomplete burning of fuel and wastewater from them For the river in soil pollution in the surrounding areas with some heavy metals (Pb, Cd, Cu, Cr, Fe, Mn, Co, Ni, V, and Zn) and to assess the state of pollution according to some international standards adopted for soil pollution. Soil samples were taken 0-500 m from the source of pollution and on the two depths (0-30 cm) and (30-60 cm). control samples were taken at a distance of up to 2-4 km from the same source and on two depths and by three replicates for each site during the month of September For the year 2018, the study showed that the total concentration of heavy metals in soils affected by industrial plant residues was higher than control soils, which generally indicates the impact of these establishments on environmental pollution. The results showed that most of the studied metals were within the permissible ranges in the soil except nickel at all sites studied and chromium at the first depth of the textile plant where it reached 208.7 mg Cr. $Kg^{-1}$ and when comparing the study soil content of heavy metals with the global average of these metals We find that Co, Mn, Cd, Ni, Cr concentrations were higher than the global average, whereas the concentrations of the metals Zn, Cu, V, Pb, Fe were close to their global average concentration. The Contamination factor CF values varied with the heavy metals in the study soils, but in general It was within the moderate range of pollution, except for Cd, as this level exceeded a considerable level of Contamination A wealth of waste from the power plant and brick factories, as for the degree of Contamination, their levels ranged between a moderate degree in most soils and exceeded them to a Considerable degree of Contamination in the soil of brick factories. As for the values of the ecological risk index $E_r$ for heavy metals in the study soils, all the elements fall within the range Low toxicity except for the element Cd whose values ranged between the second, third and fourth degree, which is the penultimate with high pollution according to the Er ranges. Cd contributed an average of 62% of the total ecological risk, and when calculating the values of the total ecological risk index ERI for the site, they differed according to the different study sites as they ranged Its levels are between a low indicator for most soils to a moderate degree of ecological risk at the first depth of the brick factory site, which reached 218.4, and it was followed by that first depth of the power plant, reaching 169.8.

***Keywords*:** Soil Pollution, Heavy Metals, Contamination Factor, Contamination Degree, Ecological Risk Index.

## Introduction

Soil represents the final sink of the materials that are thrown into the environment from various human activities, whether organic or mineral pollutants, which accumulate in the soil due to its physiochemical properties, which causes dangerous problems for the environment in general, as these substances affect the chemical and physical balance of the soil and enter the food chain and reach the human being from During the bioaccumulation process when pollutant concentrations reach values higher than the standard values for water, air, and soil that are described as pollutant Horta *et al*. (2015).

Electrical power stations contribute greatly to providing the population with heat and energy, but these stations work to liberate a wide range of pollutants carried in the air that affect poor air quality, as combustion of fossil fuels in power stations is a major source of emissions of heavy metals that are generally related With volatile dust, which adsorbed on the particulate surfaces and is transported by air, as well as these stations contribute effectively to adding quantities of heavy metals to the water environment through the process of wastewater disposal. The brick factories are also a source of pollution affecting human health in particular and the environment in general, as it is one of the phenomena that affect all environments due to its toxic emissions such as $PM_{2.5}$ and $PM_{10}$ particles and the heavy adsorbing on its surface that have a direct impact on Human health, as it is small in size, which facilitates inhalation and penetration into the respiratory system, as well as the length of time it remains in the atmosphere, unlike other large particles, in addition to the release of toxic gases such as $SO_x$, $NO_x$, $CO_x$ and various hydrocarbons that cause air pollution, and for textile factories is one of the Industries consuming large quantities of water and then producing large quantities of industrial wastewater, and this will be through the production steps of the printing, dyeing and palace units, which are often rich in color as they contain the remnants of used dyes that need to be treated before releasing them to the environment.

## Materials and Methods

### Study area

Four locations were chosen as pollution sources within Wasit Governorate in Iraq, which is the Zobaydiya Thermal Power Station in the Alsaouira district, the licorice plant in Al Aziziya, the textile factory in Al Kut, and the brick factories in the Alhay district.

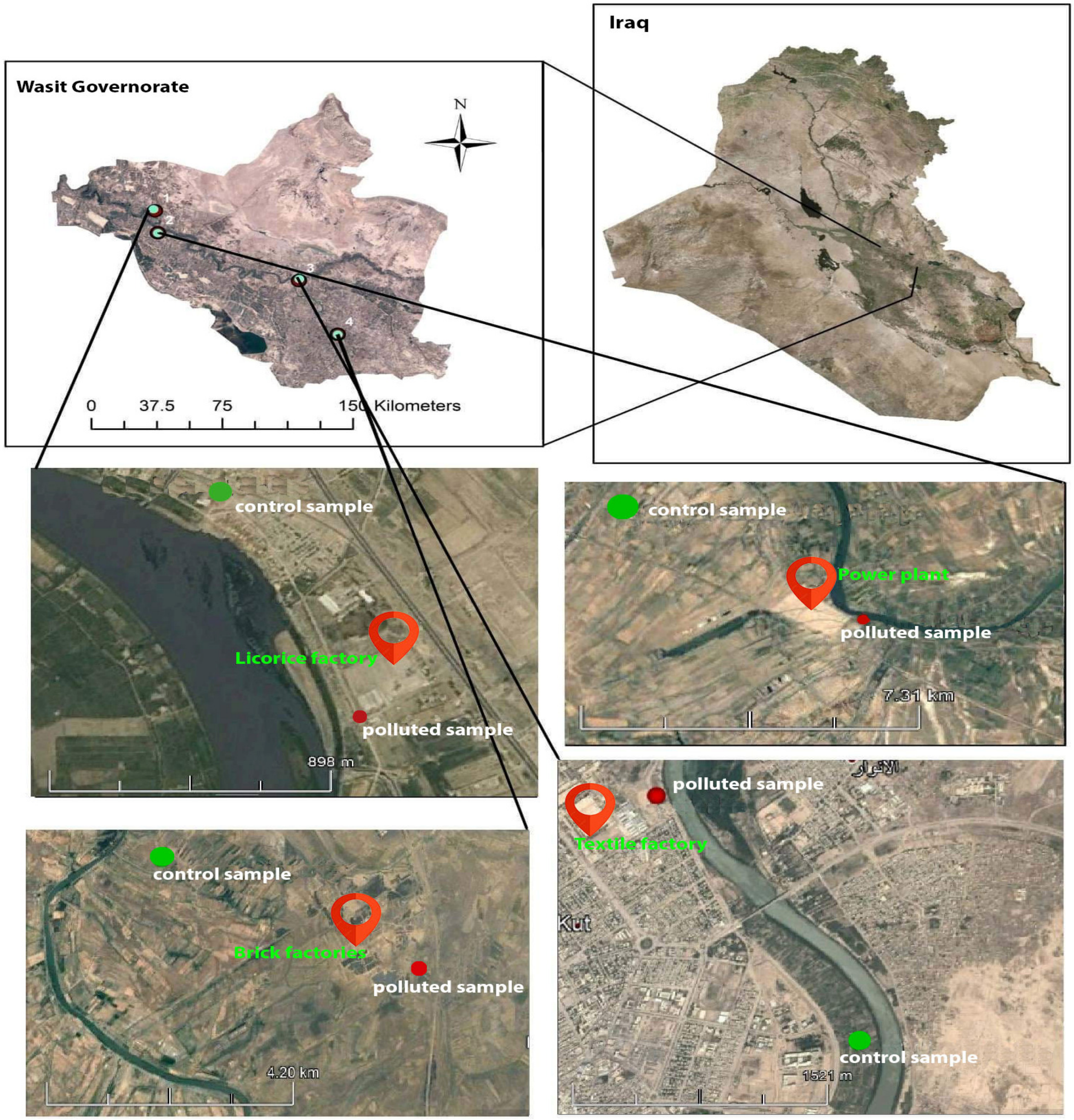


**Fig. 1 :** Study sites in Wasit governorate and soil sampling sites

**Table 1 :** The coordinates of the UTM system and Elevation for the samples of soil

| Site | | X | Y | Elevation(m) |
|---|---|---|---|---|
| Power Plant | Control | 45.037767 E | 32.797885 N | 21.9 |
| | Polluted | 45.100261 E | 32.770667 N | 22 |
| Licorice Factory | Control | 45.078002 E | 32.897514 N | 22.2 |
| | Polluted | 45.085211 E | 32.888348 N | 22.4 |
| Textile Factory | Control | 45.844966 E | 32.499344 N | 15.6 |
| | Polluted | 45.826774 E | 32.514278 N | 15.8 |
| brick factories | Control | 45.973854 E | 32.246079 N | 13.2 |
| | Polluted | 46.019035 E | 32.220494 N | 13.1 |

**Field work**

Soil samples were taken 0-500 m from the source of pollution and on the first two depths 0-30 and the second depth 30-60 cm. control samples were taken at a distance of up to 2-4 km from the same source and on two depths and by three replicates for each site during the month of September 2018.

**Laboratory work**

**Soil sampling analysis**

The soil samples were prepared after being collected from the specified sites, dried aerially, then crushed by a wooden hammer and passed through a sieve with a diameter of 2 mm openings. They were stored in plastic boxes to perform chemical and physical analyzes as in the soil analysis tables (2,3) according to the following methods:

The relative distribution of the soil particles was determined by the method of Hydrometer according to the Day (1965) method. The soil pH was measured in a soil suspension: 1: 1 water using a meter -pH device type (HACH\ HQ41-1d) according to the method mentioned in Jones (2001). EC soil was measured in a soil suspension: 1: 1 water using the EC - Meter type (HACH \ EC 71) according to the method described in Jones (2001), CEC was estimated by the Simplified Methylene Blue Method described in Savant (1994) for calcareous soils, the organic carbon in the study soils was measured by wet oxidation according to the Walkley and Black method described in Jackson (1958).

The total concentration of heavy elements (Pb, Cd, Cu, Cr, Fe, Mn, Co, Ni, V, Zn) was estimated in soil with X-ray Fluorescence (EDXRF) Energy Dispersive with a SPECTRO XEPOS-2010 device. Device in the Iraqi-German laboratory of the Department of Earth Sciences at the College of Science - University of Baghdad.

**Table 2 :** The chemical characteristics of the study soil

| Site | | Depth | pH | C.E.C C.mol.c.kg$^{-1}$ | O.M % | $CaCO_3$ % | EC ds.m$^{-1}$ |
|---|---|---|---|---|---|---|---|
| Power Plant | Control | 0 - 30 | 7.58 | 25.1 | 0.87 | 27.7 | 1.48 |
| | | 30 - 60 | 7.69 | 28.3 | 0.73 | 28.5 | 1.59 |
| | Polluted | 0 - 30 | 7.71 | 31.7 | 1.56 | 29.5 | 1.56 |
| | | 30 - 60 | 7.6 | 32.2 | 0.83 | 27.9 | 1.62 |
| Licorice Factory | Control | 0 - 30 | 7.67 | 34.6 | 0.98 | 31.6 | 3.87 |
| | | 30 - 60 | 7.47 | 32.8 | 0.59 | 26.3 | 3.92 |
| | Polluted | 0 - 30 | 8.1 | 36.1 | 1.1 | 29.9 | 4.98 |
| | | 30 - 60 | 7.96 | 35.3 | 0.79 | 28.3 | 5.38 |
| Textile Factory | Control | 0 - 30 | 8.13 | 31 | 1.23 | 30.5 | 1.41 |
| | | 30 - 60 | 7.81 | 29.6 | 0.91 | 28.3 | 1.52 |
| | Polluted | 0 - 30 | 7.77 | 34.3 | 1.37 | 29.2 | 1.65 |
| | | 30 - 60 | 7.82 | 36.8 | 0.65 | 31.3 | 1.46 |
| Brick factories | Control | 0 - 30 | 7.67 | 27.7 | 0.72 | 29.7 | 6.54 |
| | | 30 - 60 | 7.54 | 25.6 | 0.63 | 26.5 | 7.04 |
| | Polluted | 0 - 30 | 7.27 | 19.5 | 0.69 | 25.1 | 11.76 |
| | | 30 - 60 | 7.49 | 20.3 | 0.42 | 27.6 | 9.83 |

**Table 3 :** The Texture of the study soil

| Sites | | Depth | Clay | Silt | Sand | Texture |
|---|---|---|---|---|---|---|
| | | | gm.Kg$^{-1}$ | | | |
| Power Plant | Control | 0 - 30 | 367 | 217 | 416 | C.L. |
| | | 30 - 60 | 326 | 229 | 445 | C.L. |
| | Polluted | 0 - 30 | 373 | 266 | 361 | C.L. |
| | | 30 - 60 | 394 | 318 | 288 | C.L. |
| Licorice Factory | Control | 0 - 30 | 438 | 475 | 87 | Si.C. |
| | | 30 - 60 | 429 | 488 | 83 | Si.C. |
| | Polluted | 0 - 30 | 476 | 454 | 70 | Si.C. |
| | | 30 - 60 | 478 | 460 | 62 | Si.C. |
| Textile Factory | Control | 0 - 30 | 386 | 513 | 101 | Si.C.L. |
| | | 30 - 60 | 363 | 551 | 86 | Si.C.L. |
| | Polluted | 0 - 30 | 477 | 443 | 80 | Si.C. |
| | | 30 - 60 | 501 | 426 | 73 | Si.C. |
| brick factories | Control | 0 - 30 | 341 | 473 | 186 | Si.C.L. |
| | | 30 - 60 | 329 | 496 | 175 | Si.C.L. |
| | Polluted | 0 - 30 | 273 | 503 | 224 | C.L. |
| | | 30 - 60 | 281 | 516 | 203 | C.L. |

**Calculation of indicators of soil contamination**

- **Contamination factor (CF) : Hakanson (1980)**

$$C_f^i = \frac{C_S^i}{C_r^i}$$

$C_f^i$ = contamination factor, $C_s^i$ = concentration of the element in the polluted sample, $C_r^i$ = concentration of the element in the control sample.

- **Contamination Degree ($C_{deg}$) : Hakanson (1980)**

$$C_{deg} = \sum_{i=0}^{n} C_f^i$$

$C_{deg}$ = degree of contamination, $C_f^i$ = contamination factor.

- **Ecological Risk Index (RI) : Hakanson (1980)**

$$E_r^i = T_r^i \times C_f^i \,, \quad RI = \sum E_r^i$$

$E^i_r$: Ecological risk index of elements, RI: the total Ecological risk index.

$C^i_f$: contamination factor, $T^i_r$: toxic response factor for the single pollutant, and it differs according to the element according to (Cao *et al*., 2018) as follows:

Mn = Ti = Zn = 1 <Cr = V = 2 <Cu = Ni = Pb = Co = 5 <As = 10 <Cd = 30 <Hg = 40

## Results and Discussion

### Chromium

The results in table (4) indicate that there is a variation in the total chromium concentration in the soils adjacent to the various industrial establishments, where the highest total chromium concentration was at AL-Kut textile factory as it reached 187.1, 208.7 mgCr.$Kg^{-1}$ dry soil for the depths 0-30 and 30-60 cm respectively, When the total chromium values in other sites ranged between 89.1-142.4 and 91.6-166.6 mgCr.$kg^{-1}$ soil for the first and second depths respectively.

The results show an increase in the concentration of total chromium at AL-Kut textile factory, as heavy metals such as Cr, Cu, Co, Ni are used in the textile industry as a dye-fixing material or included in the composition of these dyes and this is what Malik and others (2014) indicated, as this study agrees with What Valh *et al*. (2011) found that the wastewater resulting from textile factories are loaded with high concentrations of Cr element that are dumped into the aquatic environment, which is strongly reflected on the concentrations of chromium in the water and the soil in which they are watered, and that the decrease in river levels during the summer months caused an increase in the concentration Pollutants in water and soil in general.

For the different concentrations of the element in the two depths, it indicates the presence of movement and transition of the element from the top to the bottom due to the proximity of these soils to rivers and the method of irrigation followed, which is irrigation by which heavy irrigation is given throughout the agricultural season, and when comparing the results with the global determinants, it was found that All values for all study sites were under the upper permissible limits for this element in agricultural soils (200 mg Cr.$Kg^{-1}$ soil) according to Kabata-Pendias (2011) except for the first depth soil for the textile factory, but these values were higher than the average concentration in the soil globally (60 mg Cr.$Kg^{-1}$soil) this is how To the fact that these agricultural lands and uses the various mineral fertilizers, including phosphate, which contribute to a marked increase chromium concentrations.

### Iron

The results indicate that the highest total iron concentration was found at the Kut Textile Factory, where it reached 43844, 42748 mgFe.$Kg^{-1}$soil for the first and second depths respectively.

It appears from the results obtained that the variance in the total concentration of iron between the different study sites was minimal compared to the rest of the studied elements and this is mainly due to the solubility of iron reaching the minimum in pH bases and also in calcareous soils and this is consistent with Kabata-Pendias (2011) Where he indicated that iron are toxic in non-ventilated acidic soils but in well-ventilated base soils contain very few concentrations of dissolved iron that may not meet the plant's need for this element as consistent with what Hooda (2010) stated that the high concentrations of carbonate Calcium in calcareous soils decrease Iron transmission and dissolution and absorbed by the plant.

It was found that the textile factory site has given the highest values to the total iron content in soils and this is due to several reasons, including the site silty clay soil texture, which is characterized by its high clay content, which is 47.7, 50.1% for the first and second depth respectively, and this is consistent With Kabata-Pendias (2011) where he indicated that the total concentration of iron increases in heavy mixture soils, and the high content of tissue soil of $CaCO_3$ compared to the rest of the sites reduced the solubility and iron release to the soil solution, as the soil analysis table shows that there is a slight increase in the degree of The pH soil of the textile plant site contributed to the reduction of iron's solubility Little readiness for the plant and thus there was an increase in the total concentration of iron, and when comparing the results with the average presence in the soil globally of 35,000 mgFe.$Kg^{-1}$soil The values of iron in the study areas were closely related to the average concentration of iron in the soil globally, which was indicated In Appendix (1).

### Nickel

The results in table (4) indicate that the highest concentration of total nickel at the first depth of the brick factor reached 196.3 mgNi.$Kg^{-1}$soil The second depth was the highest concentration of nickel at the power plant in Al Zobaydiya was 199.4 mg Ni.$Kg^{-1}$soil while the Total nickel values ranged in other locations between 98.2-192.4 and 103.3-184.8 mgNi.$Kg^{-1}$soil for depth 0-30 and 30-60 cm respectively.

It is clear from the results of the study that the location of the brick factories has given the highest value to the total nickel content in the soil due to incomplete combustion processes of the different types of fuel used in the factories, which varies according to what is available for the work of the factories, which leads to the emission of large quantities of pollutants as the combustion of this bad fuel and lack of emission control devices are responsible for emitting huge amounts of pollutants freely into the air and then depositing them in the areas adjacent to these polluted sources. This is indicated by WHO / IPCS (1991) that fossil fuel combustion and pollution resulting from nickel industries are the main sources increased in the concentration of Ni in the environment, and this is consistent with what the Alghaliby (2016) found, that the brick factories in Nahrawan were more enriched with nickel than the power station south of Baghdad and a refinery and Dora power station, while the second depth was the highest concentration of nickel at the power station in Al Zobaydiya This is due to the limited irrigation operations of the factories, as it is relatively far from the water source represented by the Al-Gharaf River, unlike the Al-Zobaydiya power station located on the right bank of the Tigris River, which depends on giving heavy irrigation during the agricultural season, which greatly contributed to washing the elements from the first depth to the second.

It is noted that all values for all study sites were higher than the permissible limits for this element in the soil (60 mg Ni. $Kg^{-1}$ soil) according to Kabata-Pendias (2011) Also, these values were higher than the average concentration of the element in the soil globally, which was indicated It has in the appendix (1), however, the appendix also indicated that calcareous soils reach higher ranges of (92 mg. $Kg^{-1}$). The reason can also be attributed to the fact that these lands are agricultural and use various mineral fertilizers, including phosphates, which contain high concentrations of Nickel.

**Table 4 :** Concentration of heavy metals in soil samples

| Element | Site | Power Plant | | Licorice Factory | | Textile Factory | | brick factories | |
|---|---|---|---|---|---|---|---|---|---|
| | | 0-30 | 30-60 | 0-30 | 30-60 | 0-30 | 30-60 | 0-30 | 30-60 |
| Cr | Polluted | 142.37 | 166.55 | 98.39 | 114.52 | 187.06 | 208.72 | 138.37 | 140.39 |
| | Control | 104.31 | 106.8 | 89.05 | 91.58 | 111.15 | 124.47 | 109.67 | 116.62 |
| Fe | Polluted | 39557 | 41034 | 38262 | 39152 | 43844 | 42748 | 39788 | 39704 |
| | Control | 38072 | 38024 | 35058 | 36470 | 40340 | 40494 | 38788 | 38662 |
| Ni | Polluted | 192.41 | 199.41 | 165.54 | 164.58 | 183.15 | 184.79 | 196.25 | 173.17 |
| | Control | 131.52 | 129.08 | 98.15 | 103.28 | 144.74 | 141.58 | 99.28 | 108.45 |
| Cd | Polluted | 3.51 | 2.17 | 1.83 | 1.92 | 2.93 | 3.57 | 4.73 | 2.89 |
| | Control | 0.81 | 0.65 | 1.58 | 1.82 | 1.78 | 2.17 | 0.85 | 1.28 |
| Pb | Polluted | 19.95 | 18.86 | 14.29 | 11.17 | 19.03 | 19.73 | 17.46 | 16.16 |
| | Control | 11.32 | 12.25 | 11.51 | 9.58 | 13.2 | 13.76 | 10.03 | 9.48 |
| V | Polluted | 137.12 | 125.4 | 107.28 | 85.26 | 131.66 | 120.4 | 155.28 | 117.52 |
| | Control | 105.28 | 95.76 | 77.84 | 67.44 | 99.68 | 100.8 | 65.52 | 61.58 |
| Mn | Polluted | 825.51 | 791.43 | 788.2 | 784.3 | 936.2 | 664.7 | 721.82 | 635.08 |
| | Control | 735.44 | 727.32 | 664.74 | 653.68 | 797.34 | 748.34 | 704.01 | 647.6 |
| Co | Polluted | 24.53 | 14.54 | 18.87 | 15.62 | 25.72 | 18.09 | 21.54 | 15.43 |
| | Control | 14.62 | 13.76 | 8.18 | 8.09 | 14.78 | 10.44 | 7.527 | 6.582 |
| Cu | Polluted | 46.01 | 38.34 | 33.15 | 36.66 | 48.25 | 42.52 | 47.26 | 35.85 |
| | Control | 29.78 | 27.3 | 39.26 | 34.85 | 44.09 | 40.02 | 26.28 | 22.23 |
| Zn | Polluted | 89.53 | 90.65 | 116.99 | 111.47 | 120.73 | 116.31 | 86.15 | 82.22 |
| | Control | 80.89 | 85.47 | 83.3 | 82.89 | 96.39 | 96.95 | 68.44 | 61.66 |

**Cadmium**

The results in table (4) indicate that the highest concentration of total cadmium was found at the first depth of the brick factor, as it reached 4.73 mg Cd. $Kg^{-1}$ soil. As for the second depth, the highest concentration of cadmium at the textile plant in Kut amounted to 3.57 mgCd.$Kg^{-1}$ soil while values ranged Total cadmium in other locations is between 0.81-3.51 and 0.65-2.89 mg Cd. $Kg^{-1}$ soil for depth 0-30 and 30-60 cm respectively.

The table shows that the brick factories site has given the highest value to the total cadmium content in the soil at the first depth due to incomplete combustion of coal or fuel in the brick factories that lead to the release of various gas emissions, particle matter PM and associated heavy metals that are thrown into the air without Treatment which causes an insecure environment represents a great danger not only to people who live near brick factories, but also affects those who depend on crops such as wheat and other major plants, and this is consistent with what Alghaliby (2016) found that the brick factories in Nahrawan were more enrichment in cadmium element compared to the power station south of Baghdad and a refinery and Dora power station. attributed this to the gas waste of these plants that are thrown into the air without treatment, which leads to the emergence of a black cloud covering the sky of the region as a result of the emission of black smoke resulting from the use of black oil as fuel, which consists mainly From the minutes of ash and soot (soot), as well as what it contains of heavy metals such as lead, cadmium and a number of other elements within these emissions.

It also agrees with the studies of Ravankhah *et al.* (2016), Achakzai *et al.* (2015), Ismail *et al.* (2012), Al-Asadi *et al.* (2011), Islam *et al.* (2017) and Al-Omar (2017) that indicated the effect of brick factories on increasing the concentration of cadmium in soil near to The source of pollution is at a higher level than the global determinants. As for the second depth, it show a marked superiority of the Kut textile factory compared to the rest of the sites, and this is mainly due to the fact that the Cd element is one of the main elements contained in the wastewater of the textile factories, and this is what Nessa *et al.* (2016) indicated that The main constituents of the textile wastewater disposal are Fe, Cu, Cd, Cr, Zn ,and with Kant (2012) where he explained that the textile industry uses some chemicals during the production process, so the wastewater of the textile includes some industrial dyes and toxic chemicals that contain acids, sulfates, nitrates, hydrogen peroxide and heavy toxic elements such as Cu, Ni, Pb, As, Zn, Cd, Cr, which are discharged directly to the river, leading to a change in the quality of drinking water and making it unfit for human consumption.

As for the variation of the element's concentration according to the depth, it is mainly due to the geographical location of the two sites, where the textile factory is located on the left side of the Tigris River, which represents a station for the discharge of wastewater for the factory. The elements are filtered to the bottom of the soil. As for the brick factories their geographical location is relatively far from a continuous water resource. Therefore, irrigation operations in the region are limited, in addition to that the waste of the brick factories is represented by the particles falling due to incomplete burning Fuel operations, leading to accumulation on the surface of the soil.

When comparing the current study values of the comparison soil, which ranged between (0.65-1.83) mg.$kg^{-1}$ and with an average of (1.37) mg.$kg^{-1}$ with the concentration of the element in the soil globally, we notice that the total concentrations of the element in the study soils were higher than the average The global cadmium content in soils is 0.41 mg. $Kg^{-1}$ Appendix (1). This increase in the soil compared to the global average can be attributed to the use of mineral fertilizers, especially phosphates that contain significant concentrations of Cd. in addition to the effect of soil characteristics Such as pH as total cadmium increases with increased degree of pH, $CaCO_3$ effect, soil texture, and higher soil CEC Find that the values of Cd for comparison soils were close to the content of calcareous soils that indicated the same source and ranged between 0.8-0.4 mg. $Kg^{-1}$ and we find that the values of the total concentration of the element for all study soils were below the critical upper limit of cadmium and ranges ranged between (1-5 mg Cd. $Kg^{-1}$ soil) according to Kabata-Pendias (2011) Appendix (1)

**Lead**

The results in the table (4) indicate that there is a variation in the total lead concentration in the soil of the various industrial establishments, where the highest total lead concentration was at the first depth of the power plant, as it reached 19.95 mg Pb. $Kg^{-1}$ soil. The second depth was the highest lead concentration at the textile plant in Kut It reached 19.73 mg Pb. $Kg^{-1}$ soil while total lead values at other sites ranged between 10.03-19.03 and 9.48-18.86 mgPb.$Kg^{-1}$soil for depth 0-30 and 30-60cm respectively.

It was found that the highest total lead concentration at the first depth of the Al-Zobaydiya power station, as emissions from power stations contain the result of incomplete combustion of fuel, as it is known as the main source of emissions containing heavy metals as it adsorbed on the particulate matter PM and is transported by air to The areas adjacent to the emission source. Therefore, Minnikova *et al*. (2016) indicated that estimating the effect of emissions containing heavy metals from power plants on the soil in the adjacent areas has great practical significance. As for the second depth, it was the highest total concentration of lead at the Kut textile factory due to use Cr, Cd, Pd, Cr to a large extent in the production of textile dyes, therefore, these elements are common in the wastewater of the textile factory, because some of the natural dyes of the tissue do not have a roll or low affinity for the textile materials, so salts of heavy metals are added as a color stabilizer to fix the colors , and this What Muthu (2017) indicated, and ILZSG (2012) indicated that 5% of the lead consumed globally, which is estimated at 10 million metric tons, is used in dyes, which in some dyes constitutes 40% of the dry weight, and this is consistent with what Noreen *et al*. (2017) found in a study to assess the environmental risk of textile industry waste, as the results indicated with Generally to high pollution with two elements, Pb, Cd. Majeed *et al*. (2006), when studying the wastewater of Diwaniya textile factory, found that the lead component is the most concentrated among the measured elements, and this is consistent with what Mekuyie (2014) found when measuring the concentrations of heavy metals in liquid waste for the textile industry. The concentration of Pb in contaminated water of the Tikur Wuha River in southern Ethiopia was higher than the other measured elements. In addition to the above, the reasons for the aging of the factory, as construction work was completed and machinery and equipment were installed in 1970.

It is noted that all values for all study sites and the two seasons were lower than the permissible ranges for this element in the soil, which amount (20-300 mg Pb.$Kg^{-1}$ soil) according to Kabata-Pendias (2011) Also, these values were close to the average concentration The element in the soil globally is located within the minimum content of the calcareous soil (17-65) mg. $Kg^{-1}$, which is indicated in Appendix (1).

**Vanadium**

The results in table (4) indicate that the highest concentration of total vanadium was at the first depth of the brick factory as it reached 155.3 mg V. $Kg^{-1}$ soil. The second depth was the highest concentration of vanadium at the power plant amounted to 125.4 mgV.$Kg^{-1}$soil while vanadium values ranged Total in other locations between 65.5-137.1 and 61.6-120.4 mgV. $Kg^{-1}$ soil for depth 0-30 and 30-60 cm, respectively.

The table shows that the location of the brick factor has given the highest value to the total vanadium content in the soil, as vanadium is found naturally in fossil fuels such as coal and crude oil, which when burned is the primary source of vanadium emissions to the air (Kabata-Pendias, 2011), and Nordberg *et al*. (2015) That some deposits of coal contain more than 1% of vanadium, and that the highest concentration of vanadium was found in the Middle East oil and Venezuela where it ranged between 100-1400 mg. $Kg^{-1}$, the highest concentration of total vanadium was found at the first depth of the brick factory due to the high amount of dust and the accompanying airborne particles On its surface adsorbed heavy metals resulting from brick factory emissions are adsorbed by fuel combustion, which is the main factor for vanadium accumulation and high concentration in the soil. As for the second depth, it was the highest concentration of total vanadium at the power plant, and this is due to the variation in irrigation operations in the two sites, which was preceded by the summer, where it greatly affected the variation in the depth of the brick factory site, while the impact was limited to the area of the power station, which is located on the Tigris River and is characterized by heavy irrigation, which in turn affects the washing of elements and salts to the bottom of the soil. It was noted that all values for all study sites were below the permissible limit for this element in the soil (150 mg V. $kg^{-1}$ soil) according to Kabata-Pendias (2011) except in the brick factor site at the first depth of the polluted soil as these values are generally It was an approximation of the global average element concentration in the soil, which amounts to (129 mg V. $kg^{-1}$ soil) and the values generally fall within the range of calcareous soil content of vanadium, which ranges between (50-400 mg. $Kg^{-1}$) as in Appendix (1)

**Manganese**

The results indicate that the highest concentration of total manganese at soil contaminated by the textile factory was 936.2 and 885.8 mg Mn. $Kg^{-1}$ for the first and second depths respectively, while the values of total manganese in other locations ranged between 664.7-825.5 and 647.6-791.4 mgMn.$Kg^{-1}$ soil for two depths 0-30 and 30-60 cm respectively. The results of the study show that the Kut textile factory site gave the highest value to the total manganese content in the soil due to the wastewater produced by the factory to the river water, which is then used to irrigate the near agricultural lands where HSDB (2012) indicated that manganese is involved in the textile industry. As one of its important uses is fabric bleaching and color palace, this is consistent with Gitet *et al*. (2016) when assessing the environmental impact of the Almeda textile plant in Ethiopia on the soil and vegetables of the sites adjacent to the plant where it was found that the highest concentration in soil was for the manganese compared to the rest of the elements as it reached 879.3 mg.$Kg^{-1}$, as you agree with what Deepali (2010) found that when he studied the concentrations of heavy metals in the liquid wastes of the textile laboratories in addition to the models of adjacent soils and groundwater, he found that the Mn concentration exceeded the standard determinants of the wastewater of the textile factory, and in general these concentrations were within the ranges of the Iraqi soil content of this element which Ali (2007) referred to it when studying the concentrations of heavy metals in the topsoil of the Hawija area southwest of Kirkuk and what Kazem and Zarak (2013) found when they studied soil pollution in Tikrit city with heavy metals.

It is noted that all values for all study sites higher than the global average element concentration in the soil, which is (488 mg Mn. $Kg^{-1}$ soil), and this is because of the enrichment processes that have a human source that includes disposal of industrial waste for these sites in addition to what the appendix (1) indicated The calcareous soils reach higher ranges reaching approximately (1000 mg. $Kg^{-1}$), which is characterized by high degree of pH soil and low available, thus increasing its total concentration in the soil.

## Cobalt

It was found that the highest concentration of the total cobalt was at the soil contaminated by the textile factory, as it reached 25.7 and 18.1 mg Co. $Kg^{-1}$ soils for the first and second depth respectively, while the values of the total cobalt in other locations ranged between 7.53-24.5 and 6.58-15.6 mg Co. $Kg^{-1}$ Soil for the depths 0-30 and 30-60 cm respectively.

The table (4) shows that the Kut textile factory has outperformed the rest of the study sites and this is mainly due to its geographical location, as it is located on the left side of the Tigris River, and therefore the wastewater that is loaded with heavy metals that are irrigated by the lands adjacent to the factory and which are more affected by it due to its proximity and receipt The water of the river before it was diluted whenever it moved away from the source taking into consideration what was indicated by Ali *et al*. (2016) that the heavy metals are non-biodegradable other than organic materials and therefore it continues to exist for a long time and tends to accumulate in the environment, as Co is used as a mordant substance According to Malik *et al*. (2014), there was a convergence in the concentration of Co in the soil with what Gitet *et al*. (2016) found when assessing the environmental impact of the textile plant on the sites adjacent to the Almeda textile factory in Ethiopia. He found that the concentration of Co was 22.0 mg. $Kg^{-1}$, as agreed by Wang *et al*. (2009). The liquid wastes of textile factories, leather and tanning factories, pigment factories and paints contained large amounts of toxic metal ions, one of which was Co. It was observed that all the values of the comparison soil were below the critical limits for the co element (20-50 mg Co.$kg^{-1}$ soil) according to Kabata-Pendias (2011) while the contaminated soils ranged from 12.6-25.7 mg.$Kg^{-1}$ was also below The minimum critical level except for the first depth of the textile factory and power plant due to the enrichment processes of human source at the textile plant and power station, while most of these values were higher than the global average concentration of the element in the soil (8 mg. $Kg^{-1}$ soil) and this is due Until the soil in the semi-arid and arid regions has the highest content of the cobalt element and this is shown in Appendix (1) that the calcareous soil reaches the content of Co in it about 70 mg Co. $kg^{-1}$ soil. Which is characterized by a high degree of pH soil and the lack of available of the element and thus increase the overall concentration in the soil compared with cold soils and icy areas (Kabata-Pendias, 2011).

## Copper

The results in table (4) indicate that there is a variation in the total copper concentration in the soil of the various industrial establishments. The highest total copper concentration was at the soil contaminated by the textile factory, as it reached 48.3 and 42.5 mg Cu. $Kg^{-1}$ soil for the first and second depth respectively. The values of total copper at other sites ranged from 26.3-47.2 to 22.2-40.02 mgCu.$Kg^{-1}$ for the first and second depths, respectively.

It was found that the highest total copper concentration of the tissue plant at the two depths due to the discharge of wastewater of the non-biodegradable and which Cu is used alongside Cr, Cd, Pb to a large extent in the production of fabric color dyes. Therefore, these elements are common to the textile wastewater, so soil contaminated with textile factory waste usually contains high concentrations of these elements Javed and Usmani (2013) and Malik *et al*. (2014), as copper enters the dyes used in textile factories and is also used as a preservative for dyes in general and this is consistent with what Deepali (2010) found when He studied the concentrations of heavy metals in wastewater no The textile factor in addition to the adjacent soil sample as their concentrations exceeded the standard determinants of wastewater for the textile factory, and the copper concentration in the soil reached 109.5 mg.$Kg^{-1}$. When comparing the values of the current study, which ranged between (22.2-53.4) mg.$kg^{-1}$ and an average of (37.84) mg. $kg^{-1}$ with the concentration of the element in the soil globally, we notice that the total concentrations of the element in the soil of the study were close to the global average of 39.9 mg $Kg^{-1}$ .and within the range of the total Cu concentration in calcareous soils (10-70) mg. $Kg^{-1}$ as shown in Appendix (1), and we find that the values of the total concentration of the element for all study soils were below the critical limits range that ranged Between (60-150 mgCu.$Kg^{-1}$ soil) according to Kabata-Pendias (2011) (Appendix 1).

## Zinc

The results in table (4) indicate that there is a variation in the total concentration of zinc in the soil of different industrial establishments where the highest concentration of total zinc was found at the soil contaminated by the textile factory as it reached 120.7 and 116.3 mg Zn. $Kg^{-1}$ soils for the first and second depth respectively, while the total zinc values ranged In other locations between 68.4-116.9 and 61.6-111.5 mg Zn.$Kg^{-1}$ soil for depth 0-30 and 30-60 cm respectively.

The table shows that the soil affected by the wastewater of the textile factory gave the highest value to the total zinc content and for the depths, as zinc is one of the main elements that the wastewater of the textile factories contain in addition to heavy toxic elements such as Cu, Ni, Pb, As, Cd, Cr, which are discharged directly to the river. Which changes the quality of drinking water and makes it unfit for human consumption and this is consistent with what Malik *et al*. (2014) indicated that among the toxic chemicals that are produced in the process of dyeing the fabric are heavy toxic elements such as Cr, Cu, Zn as they are consistent with Al-Kanani and Khafji (2015) Those who studied the effect of industrial theses resulting from the textile factory in the concentrations of six trace elements in the waters of the Euphrates at the center of the city of Nasiriya and found that the element Zn was higher than the rest of the other trace elements in the dissolved and stuck in the water as agreed with Al-Saadawi (2015) when evaluating the quality of industrial water coming out of a factory Cotton textile in Al-Kadhimiya and estimating concentrations of Cr, Pb, and Zn elements where zinc was the highest concentration compared to lead and chromium, and this is consistent with what Nessa *et al*. (2016) indicated that zinc is one of the main elements contained in the liquid wastes of the textile laboratories in addition to Fe, Cu , Cd, Cr which exceeded the allowed maximum limits of FAO / WHO in plants that have been watered from wastewater to the plant tissue. This clearly shows the effect of the continuous watering of water affected by the wastewater of the textile factory and for relatively long periods that started since the establishment of the plant in 1970, and the role of soil texture and the percentage of clay separation that has the most prominent role in adsorption of the elements and increasing the total content of the element other than Light soils that are characterized by low cationic exchange capacity with weak ability to hold the element, which leads to its dissolution into the soil solution and the speed of its washing or absorption by the growing plants. This is also noticed in soil polluted by licorice, which have the same type of texture and this is contrary to what it characterizes Contaminated soils for the sites of the power plant and the brick factories, which are characterized by a lighter texture, which leads to higher readiness of the element, making it susceptible to absorption by the plant and washing of the element to the bottom of the soil depth, which reduces its total concentration in the soil. Which have higher population density and traffic than the rest of the study areas of agricultural land.

When comparing the mean values of the study comparison, which amounted to 79.8 mg $Zn.Kg^{-1}$ soil with the average concentration of the element in the soil globally We note that the total concentrations of the element in the study soil were close to the global average of 70 mg Zn. $Kg^{-1}$ soil of Appendix (1), while the mean values of polluted soils were higher, reaching 100.6 mg Zn. $Kg^{-1}$ soil, as we find that the values of the total concentration of the element for all study soils were close to the minimum ranges of critical level, which ranged between (100-300 mg Zn. $Kg^{-1}$ soil), but they are below the upper limit according to Kabata-Pendias (2011), But when compared with the content of calcareous soils of the element Zn (50-100 mg. $Kg^{-1}$) we find that most of the values of Zn in the present study were within the range.

**Contamination factor**

To assess the soil pollution, the contamination factor $Cf_i$ is used, which is an indicator of the studied single element pollution that most other pollution indicators depend on, and the total contamination factor for all the studied elements represents to us the degree of contamination $CF_{deg}$, which is used to measure the total contamination level of the site (Asrari 2014), and both indicators are classified into Four levels as shown in Appendix (2).

**Table 5 :** Value of contamination factor for soil samples

| Element | Power Plant | | Licorice Factory | | Textile Factory | | brick factories | |
|---|---|---|---|---|---|---|---|---|
| | 0-30 | 30-60 | 0-30 | 30-60 | 0-30 | 30-60 | 0-30 | 30-60 |
| Cr | 1.365 | 1.559 | 1.105 | 1.25 | 1.683 | 1.677 | 1.262 | 1.204 |
| Fe | 1.039 | 1.079 | 1.091 | 1.074 | 1.087 | 1.056 | 1.13 | 1.106 |
| Ni | 1.463 | 1.545 | 1.687 | 1.594 | 1.265 | 1.305 | 1.977 | 1.597 |
| Cd | 4.333 | 3.338 | 1.158 | 1.055 | 1.646 | 1.645 | 5.565 | 2.258 |
| Pb | 1.762 | 1.54 | 1.242 | 1.166 | 1.442 | 1.434 | 1.741 | 1.705 |
| V | 1.302 | 1.31 | 1.378 | 1.264 | 1.321 | 1.194 | 2.37 | 1.908 |
| Mn | 1.122 | 1.088 | 1.186 | 1.2 | 1.174 | 0.888 | 1.025 | 0.981 |
| Co | 1.678 | 1.057 | 2.307 | 1.93 | 1.74 | 1.733 | 2.862 | 2.344 |
| Cu | 1.545 | 1.404 | 0.844 | 1.052 | 1.094 | 1.062 | 1.798 | 1.613 |
| Zn | 1.107 | 1.061 | 1.404 | 1.345 | 1.253 | 1.2 | 1.259 | 1.333 |
| CFdeg | 16.72 | 14.98 | 13.4 | 12.93 | 13.7 | 13.19 | 20.99 | 16.05 |

The results of table (5) indicate the values of the contamination factor with heavy metals of the study soil, where the highest value of the contamination factor for chromium element in the soil of the textile factory was 1.683, 1.677 for the first and second depths respectively, where the heavy metals such as Cr, Cu, Co and Ni are used in the textile industry as a fixing material for the dyes Or included in the composition of these dyes, as it was found that the highest value of the contamination factor of the iron element was in the soil of the brick factories as it reached 1.130, 1.106 for the first and second depths respectively and we find that the iron contamination factor is the lowest compared to the rest of the elements and this is consistent with Saha *et al*. (2017) and we can Generally, the soil was described according to this standard as being Moderate iron contamination.

As for the values of the contamination factor for nickel element of the soils, it was found that the highest value for the first depth was in the soil of the brick factories, as it reached 1.977, 1.597 for the first and second depths respectively, and this indicates a compatibility with the total concentration of the element in the contaminated soils comparative with the control soils, which was indicated above that Fossil fuel combustion and pollution from nickel industries are the main sources of increased Ni concentration in the environment and this is consistent with what the WHO / IPCS (1991) and well as what Islam et al. (2017) found, where the nickel pollution factor value was 1.6 When studying soil adjacent to brick factories, we can describe soil generally according to this standard as having a moderate element of nickel contamination.

The results of the table also showed the values of the contamination factor for cadmium of the study soils, where the highest value was for the first depth of the soil of the brick factories, as it reached 5.565, while the highest value for the second depth at the power plant soil was 3.338, and thus they are classified within the areas of considerable contamination, which was thus The most contaminated element as a result of human activities, and this is consistent with Islam *et al*. (2017), where it was found that the highest value of the contamination factor in soils adjacent to the brick factories was for the cadmium element compared to the rest of the elements.

As for the values of the contamination factor of the lead element of the study soil, the highest value in the first depth of the power plant soil was 1.762, and the second depth was the highest value at the brick factories of 1.705 and this corresponds to what Ravankhah *et al*. (2016) indicated when estimating Heavy metals in the surface soils around the brick factories located in Aran-o-Bidgol in Iran that the emissions of the brick factories have been affected by an increase in the concentration of elements Cd, Pb in particular, and the state of pollution in general according to this criterion is classified as soils with moderate contamination With the lead element.

The results also indicate the values of the vanadium element contamination, as the highest value of the brick factories reached 2.370, 1.908 for the first and second depths respectively. We find that the brick factories had an important impact on the rise of contamination factor for vanadium due to the incomplete burning of the black oil used In factories, this corresponds to what Kabata-Pendias (2011) stated that vanadium is found naturally in fossil fuels such as coal and crude oil, which when burned is the primary source of vanadium emissions to air (Kabata-Pendias, 2011). Soil can be described in general according to this criterion as Of moderate contamination with a For vanadium.

As for the values of the contamination factor in the manganese element of the study soils, the highest value in the soil of the textile factory was 1.186, 1.200 for the first and second depths respectively due to the dumping of the liquid wastes into the river and then used to irrigate the neighboring agricultural lands where manganese is used in the textile industry and this Consistent with HSDB (2012), Gitet *et al.* (2016) and Deepali (2010) these soils have been generally classified and according to this criterion as ranging from low contamination-moderate contamination to manganese.

The results also indicated the values of the contamination factor of the cobalt element of the study soils, where the highest value was in the soil of the brick factories, as it reached 2.862, 2.344 for the first and second depths respectively, as the increase of the pollution factor of the cobalt element is due to the type of fuel used in these factories, which produces It results in an increase in pollution by some heavy metals, including cobalt. We can describe the soil in general according to this criterion as having moderate pollution with the cobalt element.

The results of Tables indicate that the highest value of the contamination factor of the copper element was in the soil of the brick factories, as it reached 1.798, 1.613 for the first and second depths respectively. This is consistent with Islam *et al.* (2017) where it was found that the value of the contamination factor of copper was 1.8 when studying soil adjacent to Bricks factories, Soils can generally be described according to this criterion as having moderate pollution to copper. The results also indicate that the highest values of the contamination factor in the zinc element of the study soil were in the licorice factory soils as it reached 1.404, 1.345 for the first and second depths respectively and we note the convergence of the contamination factor values for this element may be due to its consumption by the vegetation found in the soil close to these Establishments being a nutrient and this corresponds to what Hacisalihoglu *et al.* (2001) indicated that increased zinc uptake by the plant in the soil being a micronutrient leads to a decrease in its available concentrations in the soil and we can describe the soil in general according to this criterion as having moderate pollution with an element Zinc.

As for the highest value of the degree of contamination $CF_{deg}$, it was found at the site of the brick factories, where it reached 20.99, 16.05 for the first and second depths respectively, and they are within the third level with a Considerable degree of contamination, followed by the site of Al-Zobaydiya power station with values of 16.72, 14.98, and then the textile factory, where the degree of contamination reached 13.70, 13.19 and finally The licorice plant has values of 13.40 and 12.93 for the first and second depths, respectively. All three sites were moderately polluted, except for the first depth of Al-Zobaydiya power station.

**Ecological risk ($E_r$)**

This indicator was proposed by the Swedish scientist Hakanson (1980) to assess the degree of contamination of heavy metals in soil and sediments depending on the arrangement of elements on the toxicity of the element and its ability to release and environmental response to it, where RI represents the sensitivity of different Bio communities to toxic substances represented by the Ecological risk caused by heavy metals (Chen *et al*., 2015).

The results the table (6) indicate the values of the Ecological risk index for the heavy metals $E_r$ in soils, as the highest $E_r$ value for the chromium element in the Kut textile factory was 3.37 and 3.35 while the Er values for the chromium element in other locations ranged between 2.21-2.73 and 2.41-3.12 for the first two depths. And the second in succession, and in general the results clearly indicated that the Ecological risk index for the chromium was low as it came with values well below the threshold 40 which is the minimum average level of risk for the element and this is mainly due to the low toxicity response factor for chromium which is 2 Which reduced the Ecological risk index.

**Table 6 :** Ecological risk index of heavy metals in soil samples

| Elements | Power Plant | | Licorice Factory | | Textile Factory | | brick factories | |
|---|---|---|---|---|---|---|---|---|
| | 0-30 | 30-60 | 0-30 | 30-60 | 0-30 | 30-60 | 0-30 | 30-60 |
| Cr | 2.73 | 3.12 | 2.21 | 2.5 | 3.37 | 3.35 | 2.52 | 2.41 |
| Ni | 7.32 | 7.72 | 8.43 | 7.97 | 6.33 | 6.53 | 9.88 | 7.98 |
| Cd | 130 | 100.15 | 34.75 | 31.65 | 49.38 | 49.36 | 166.94 | 67.73 |
| Pb | 8.81 | 7.7 | 6.21 | 5.83 | 7.21 | 7.17 | 8.7 | 8.52 |
| V | 2.61 | 2.62 | 2.76 | 2.53 | 2.64 | 2.39 | 4.74 | 3.82 |
| Mn | 1.12 | 1.09 | 1.19 | 1.2 | 1.17 | 0.89 | 1.03 | 0.98 |
| Co | 8.39 | 5.28 | 11.54 | 9.65 | 8.7 | 8.66 | 14.31 | 11.72 |
| Cu | 7.73 | 7.02 | 4.22 | 5.26 | 5.47 | 5.31 | 8.99 | 8.06 |
| Zn | 1.11 | 1.06 | 1.4 | 1.35 | 1.25 | 1.2 | 1.26 | 1.33 |
| ERI | 169.8 | 135.8 | 72.7 | 67.9 | 85.5 | 84.9 | 218.4 | 112.6 |

As for the highest $E_r$ value of the nickel in the soil of the brick factor was as it reached 9.88, 7.98 for the first and second depths respectively, whereas the $E_r$ values for the other sites ranged between 6.33-8.43 and 6.53-7.77 for the first and second depths respectively. We find that all sites were within the range that indicates that soil has a low toxicity index according to Hakanson (1980). The results of the table also showed the highest Er values for the cadmium element were for the first depth of the soil of bricks factories, as it reached 166.94, which is thus classified within the fourth degree ranges, which is the penultimate with High risk according to the $E_r$ ranges while the highest value for the second depth was Power plant soils reached 100.15 within the Considerable risk ranges, while the rest of the values for the cadmium element in other locations ranged between 34.75-130.0 and 31.65-67.73 for the first and second depths respectively, and the $E_r$ values for the lead in the study soils were the highest $E_r$ values for the lead element in depth The first of the soil of the power station reached 8.81 either The second depth was the highest $E_r$ value at the brick factories of 8.52, while the $E_r$ values for other locations ranged between 6.21-8.70 and 5.83-7.70 for the first and second depths respectively.

The results of the table also indicate the values of Er for vanadium element, where the highest in bricks factories soil was 4.74, 3.82 for the first and second depths respectively, while the index values for vanadium element in other locations ranged between 2.61-2.76 and 2.39-2.62 for the first and second depths respectively. The results of the table showed the values of Er for the manganese element in the study soils, as the highest $E_r$ value for the manganese element in the soil of the licorice plant was 1.19, 1.20 for the first and second depths respectively, while the $E_r$ values for other sites ranged between 1.03 - 1.17 and 0.89-1.09 for the first and second depths respectively, these values are the lowest among the studied factors, due to the low toxicity response factor of 1 in addition to the limited variation in its concentration between the polluted and the reference areas. The results also indicated the $E_r$ values for the cobalt element in the study soils where the highest $E_r$ value for the cobalt element was in The brick factories, reaching 14.31, 11.72 The first and second depth respectively, while ranged from Er element cobalt values in other locations between 8.39-11.54 and 5.28-9.65 for the first and second depths respectively.

The results of the table indicate the Er values of the copper element of the soil of the study sites, as the highest value of the brick factories was 8.99, 8.06 for the first and second depths respectively, while the index values for the copper element in other locations ranged between 4.22-7.73 and 5.26-7.02 For the first and second depths respectively, and generally the results clearly indicated that the Ecological risk index for the copper element was low and did not exceed the first level according to this standard.

The results of the table indicate the $E_r$ values of the zinc element in the study soils. It was found that the highest Er value of the zinc element was in the soil of the licorice factory as it reached 1.40, 1.35 for the first and second depths respectively, while the index values for the zinc element in other locations ranged between 1.11-1.26 and 1.06-1.33 for the first and second depths respectively and this indicates that all sites were located within the low range and this may be due to the fact that it is one of the nutrients of the plant, which led to its absorption by the cultivated plants in addition to its T value of 1, which caused a decrease in the value of the Ecological risk, as well as for the element manganese, these two elements are the least dangerous among the elements According (Hakanson,1980).

**Ecological Risk Index (ERI)**

The total Ecological risk index values for the site differed according to the different study sites, as their levels ranged between a Low risk to a moderate of Ecological risk, where the highest value of the Ecological risk index for the first depth at the brick factories was 218.4, and it was followed in that first depth of the power station, which amounted to 169.8 and they are within the level The second one has an Moderate risk, while the highest value for the second depth at the Zobaydiya power station was 135.8, followed by the second depth of the brick factories site with a value of 112.6, which is within the low risk of the ERI index, then the textile factory, where the values of the Ecological risk index reached 85.5, 84.9 and finally Licorice factory values 72.7 and 67.9 for the first and second depths, respectively.

It is noted through the table that the element of cadmium showed the highest value of Ecological risk and contributed an average of 62% of the total Ecological risk, which led to an increase in the value of the total Ecological risk and for all sites due to the high contamination factor for it as well as the toxicity response factor that is characterized by its high compared to the rest of the elements as it reaches 30 Whereas, the toxic response factor for heavy metals was as follows: (Mn = Zn = 1, Cr = V = 2, Cu = Ni = Pb = Co = 5) This is consistent with what Li *et al.* (2012) found that cadmium contributed nearly From 95% of the Ecological risk to the Jinzhou Bay Sediments in North China and What Islam *et al.* (2017) found when assessing the Ecological risk of heavy metals (Pb, Cd, As, Cu, Ni, Cr) in Patokala province in Bangladesh, where he found that the cadmium shares by 80%; 88% of the Ecological risk of brick factory and power plant respectively.

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**Appendix 1 :** Abundance of trace elements in Rocks and Soils (Kabata-Pendias , 2011)

| Rock / Soil | V mg.kg$^{-1}$ | Cr mg.kg$^{-1}$ | Mn mg.kg$^{-1}$ | Fe % | Co mg.kg$^{-1}$ | Ni mg.kg$^{-1}$ | Cu mg.kg$^{-1}$ | Zn mg.kg$^{-1}$ | Cd mg.kg$^{-1}$ | Pb mg.kg$^{-1}$ |
|---|---|---|---|---|---|---|---|---|---|---|
| Earth's crust | 35–60 | 126–185 | 716–1400 | 4.5–5 | 9–12 | 20 | 25–27 | 52–80 | 0.1–02 | 14–15 |
| Soils | 129 | 60 | 488 | 3.5 | 8 | 29 | 38.9 | 70 | 0.41 | 27 |
| Calcisols (calcareous) | 50 –400 | 22–500 | 50–7750 | 0.1–0.5 | 1–70 | 18–92 | 10–70 | 50–100 | 0.4–0.8 | 17–65 |
| Maximum Allowable Concentrations (MAC) | 150 | 50-200 | - | - | 20-50 | 20–60 | 60–150 | 100–300 | 1–5 | 20–300 |

**Appendix 2 :** Values of soil pollution indicators

| **Contamination factor value** | | | |
|---|---|---|---|
| CF < 1 | low contamination | | |
| 1≥CF>3 | moderate contamination | | |
| 3 ≥ CF > 6 | considerable contamination | | |
| CF ≥ 6 | very high contamination | | |
| **Contamination Degree** | | | |
| Cdeg<8 | Low degree of contamination | | |
| Cdeg<168< | Moderate degree of contamination | | |
| Cdeg<3216< | Considerable degree of contamination | | |
| 32 >Cdeg | Very high degree of contamination | | |
| **Ecological risk index** | | | |
| $E_r^i$ Value | Grade of ecological risk of single metal | Ecological risk index (RI) Total | |
| $E_r^i < 40$ | Low risk | RI value | Grade of potential ecological risk of environment |
| $40 < E_r^i < 80$ | Moderate risk | RI<150 | Low risk |
| $80 < E_r^i < 160$ | Considerable risk | 150<RI<300 | Moderate risk |
| $160 < E_r^i < 320$ | High risk | 300<RI<600 | Considerable risk |
| $> 320\ E_r^i$ | Very high risk | 600> RI | Very high risk |