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The Geochemical Distribution and Assessment of Heavy metals Pollutions in Soil Sediment of Chamchamal City-Sulaimanya Governorate / NortherEastern Iraq.

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Abstract

The current study aims at the geochemical distribution of heavy elements in soil sediments.It assesses environmental pollution using pollution index and potential health hazards in the city of Chamchamal northeastern Iraq. Twenty-one samples of soil sediments were collected in the area of residential, commercial and industrial areas in mid-July 2017. Heavy metals (As, Cu, Cr, Cd, Co, Fe, Mn, Mo, Ni, Pb, Zn) were analyzed using ICP-MS. The results showed that arsenic, chromium, cadmium, cobalt, manganese and nickel were the highest concentration in residential areas.While molybdenum and lead were higher in commercial areas, wheras copper, iron and zinc recorded the highest concentration in industrial areas. The results of pollution indicators (Igeo) showed that the arsenic was the (Moderately contaminated), The values of the (EF) index of the arsenic are (Significant enrichment), the cadmium and nickel were (moderate enrichment), and the values of Cdeg showed that some of samples are (Contamination Moderate) wheras the rest of the sites are considered (Contaminated) by heavy metals studied. The PRI values indicated that some models were of (Riskable) and others (Very High Risk).

key words: chemchmal area, heavy metal, pollution , health risk

1. Introduction

Soil sediment is one of the most important surface environmental systems. It is also classified as one of the most important factors that have a major role in the exchange and distribution of chemical elements inside these sediments. The cycle of the elements in the earth ecosystem, as rapid urbanization led to pollution of the surface environment, resulting in serious environmental problems. (Hou et al. 2015 ; Zhao et al., 2010; Mahmoudabadi et al., Micó2006; et al., 2015). The pollution resulting from the high concentration of heavy elements in soil sediments is from the use of land, human processes for a long period of time, as well as the role of some mechanical factors in the distribution of heavy elements at the top of them (Xiaolu et al., 2018). The toxicity of the elements has a great effect on modern sediments compared with other surface systems because of their biological activity in this environment. The availability of residual crumbs materials, which contain elements and materials of different origins, have the potential to adsorb heavy metals as a result of adhesion on its surfaces (Salomons and Förstner, 1984).

Anthropogenic sources of the waste in urban environments is a major factor in the increase in concentrations of heavy metals, such as sewage, solid waste, burning of fossil fuels and agricultural activities (Alagarsamy,2006; ; Pang et al., 2015; Radenac et al. 2001 ;Naifar et al., 2018; Buccolieri et al., 2006); traffic jum , vehicle traffic and combustion products, (Navid et al., 2018; Liu et al., 2016). The presence of heavy metals in sediments is a hazard to the ecosystem because they are non-bioavailability with strong stability and highly toxic, and may cause serious health problems (Lai et al., 2013; Hwang et al., 2016). These metals accumulate slowly the soil zones over time and in the long-term the soil is a tank for heavy metals (Darko et al., 2015; Pakade et al., 2012),.They affect the environment and become toxic to living organisms when their concentration exceeds the permissible limits of the living organism (Darko et al., 2017).The current research aims at the geochemical distribution of heavy elements in soil sediments and assesses environmental pollution using pollution indexes and potential health hazards in the city of Chamchamal northeastern Iraq.**.**

2. Material and Methods

2.1 Location of study area

The area of the study is located in the city of Chamchamal -Sulaymaniy Governorate in the north-east of Iraq. It

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is located between latitudes (3921500 - 3941900 North) and latitudes (475300 - 492900 East) depending on the UTM units and at an altitude of about 690 m above sea level. The district of Chamchamal is about 195.7 Km2 and is located 47 km from Kirkuk Governorate to the northeast and 65 km from Sulaymaniyah to the southwest (Dartash, 2012).

2.2 Sample Collection

The fieldwork included on the collection 21 samples of the soil deposits of the city of Chamchamal.The samples taken in the middle of July 2017 and at a depth of 0-20 cm using the Auger device. The models were dried using the electric furnace and it was grinded and sieving by 150 mesh sieve. The models are divided into three sections depending on the quality of the land used in the area, namely residential areas, which include parks, public parks, open spaces, residential areas, Commercial areas represented by the external and internal roads, shops, and industrial areas of the industrial neighborhood.

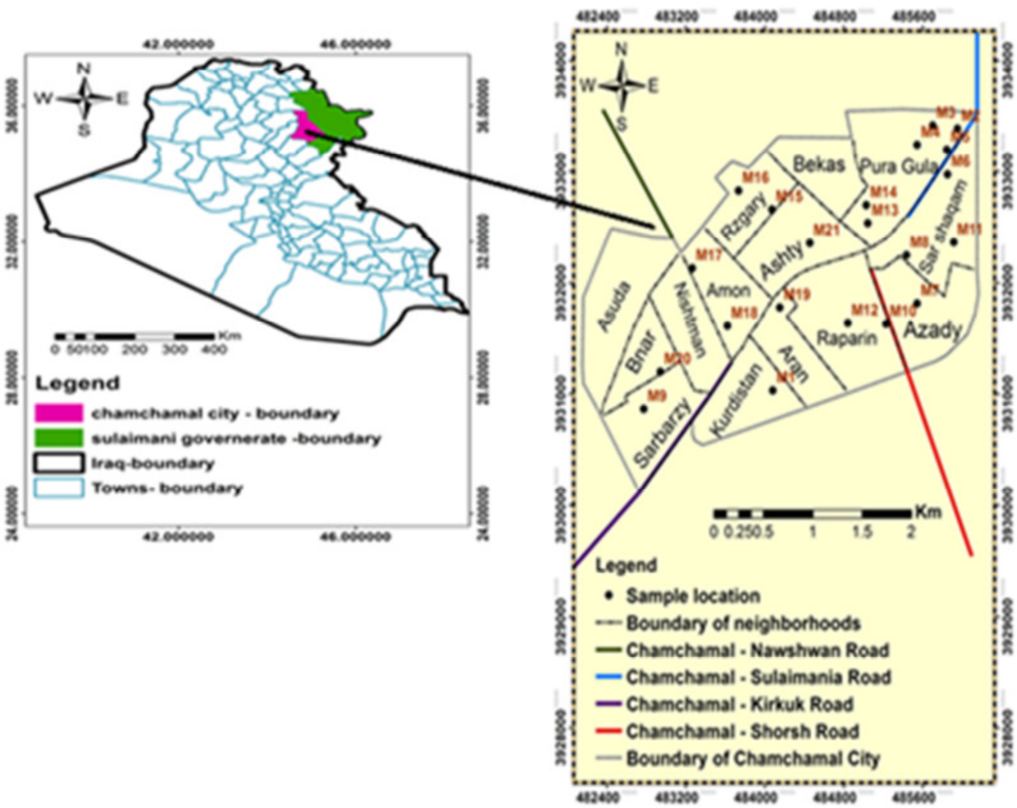

Figure1.Map of Iraq and showing the samples locations in Chamchamal City.

2.3 Chemical Analysis

The ICP-MS type (Elmer Elam, Perkin 6000) was used in the Acme Laboratories in Vancouver, Canada. Drying the models in a temperature 60 ° C and sifting it by a 150mesh sieve. 0.25 gm was taken from the solid sample and placed in special Teflon tubes. The models were digested by adding 10ml of the pre-prepared standard solution (HClO4 -HNO3 - Hf-H2O (2: 2: 1: 1) to the tubes containing the form and heated on the (Hot plate until the fumes are released and then left to dry. (4ml) of HCl acid 50% adds to the remnant solution heats in the oven and left to cool. The solution transferred to plastic test tubes and supplemented size to 10ml and then inserted into the machine in the input unit for analysis

2.4 Assessment pollution and Ecological risk of heavy metals

In order to assess the degree of pollution and the extent of the fortification of soil sediments by the heavy elements under study, many indicators and methods were used to determine the extent of contamination. These include the Geo accumulation index (Igeo), Enrichment Factor (EF), Contamination Factor (CF) & Degree of Contamination (Cdeg) Potential Ecological Risk Index (PRI), shown in Table 1.

Table 1: Categories of Sediment Pollution Cases Geo accumulation Index (Igeo) Values by (Muller 1969; Guan et al., 2014), Enrichment Factor (EF) values by (Jafaru et al., 2015; Mmolawa et al. 2011), Contamination Factor (CF) and Degree of Contamination (Cdeg) (Hakanson, 1980) and Potential Ecological Risk Index (PRI) (Guan et al., 2014).

Geo accumulation Index (Igeo)		**Enrichment Factor (EF)**		**Contamination Factor (CF) & Degree of Contamination (C_{deg})**			**Potential Ecological Risk index (PRI)**	
Rang	**Description**	**Rang**	**Description**	**Rang (CF)**	**Rang (C_{deg})**	**Description**	**Rang**	**Description**
Igeo < 0	**Uncontaminated**	**EF < 2**	**Deficiency to minimal enrichment**	**CF < 1**	**$C_{deg} < 8$**	**Low Contamination**	**RI ≤ 50**	**Low Risk**
0 < Igeo ≤ 1	**Uncontaminated to Moderately contaminated**	**2 ≤ EF < 5**	**Moderate enrichment**	**1< CF <3**	**$C_{deg} < 168 \le$**	**Moderate Contamination**	**50 ≤ RI < 100**	**Moderate Risk**
1 < Igeo ≤ 2	**Moderately contaminated**	**5 ≤ EF < 20**	**Significant enrichment**	**3 < CF < 6**	**$C_{deg}<3216 \le$**	**Considerable Contamination**	**100 ≤ RI < 150**	**Considerable Risk**
2 < Igeo ≤ 3	**Moderately to heavily contaminated**	**20 ≤ EF < 40**	**Very high enrichment**	**6 < CF**	**$C_{deg} > 32$**	**Very High Contamination**	**150 ≤ RI < 200**	**Very High Risk**
3 < Igeo ≤ 4	**heavily contaminated**	**EF ≥ 40**	**Extremely high enrichment**				**RI > 200**	**Extreme Risk**
4 < Igeo ≤ 5	**heavily to Extremely contaminated**							
Igeo > 5	**Extremely contaminated**							

Geo accumulation index

The geo accumulation index is one of the most commonly methods which used for determining the accumulation of heavy elements in sediments. This method proposed by Muller (1969) to calculate the extent of sediment and soil pollution by heavy metals (Golekar et al., 2013). It is calculated by equation (1)

$$Igeo = Log2\ (Cn / 1.5Bu) \qquad (1)$$

(Cn) represents the content of the metal (ppm) in the studied soil sediment while (Bu) represents the reference concentration of the element in earth crust content. 1.5 is the correction factor depending on the lithogenic.

Enrichment Factor (EF)

The enrichment factor reflects the relative content of the metals in soil sediments relative to the background rocks, indicating the degree of contamination of the heavy elements. It is used as an indicator for the determination of human (industrial) and natural sources of heavy elements in the sediments of the soil (Abed, 2015; Zhao et al., 2015; Kumar et al., 2017). It is calculated (EF) by equation (2) by (Ergin et al., 1991; Sinex & Helz, 1981).

$$EF = \frac{(Me/Fe)\ sample}{(Me/Fe)\ background} \qquad (2)$$

(Me / Fe) samples represent the concentration of the metals in the analyzed model for the study area / concentration of the iron metal in the study area samples, and the Me / Fe background is the concentration of the referential metal / concentration of the referential metal by Wedephol (1995) Iron Fe is one of the metals used as a referential value in the crust of earth among other metals such as Sc, Mn, Al, Ti, Fe, V (Simex & Helz, 1981)

Contamination Factor (CF) & Degree of Contamination (Cdeg)

The pollution index (CF) is one of the most important indexes used to assess soil contamination, which can through determine the extent of contamination. Furthermore, it is the only evidence of the pollutant components of each element (Hakanson, 1980) and is calculated by equation (3)

$$CF = C_{sample} / C_{background} \qquad (3)$$

C_{sample} represents the concentration of the element in the model. $C_{background}$ represents the concentration of the element in the crust. The current study is based on the rate of concentrations of elements in the crust, according to data published by (Wedepole 1995)

Cdeg is an important method in determining the degree of contamination, defined as the sum or the sum of the pollution index (CF) of the studied elements (Hakanson, 1980), shown in Table (1). It is calculated by equation (4)

$$C_{deg} = (CF_1 + CF_2 + CF_3 + CF_4 \ldots\ldots\ldots CF_n) \qquad (4)$$

CF = Contamination Factor, n = Number of studied elements.

Potential Ecological Risk Index (PRI)

This indicator was proposed by (Hakanson ,1980) to assess the potential environmental hazard of heavy metals. This method is a comprehensive approach to the expression of toxicity, heavy element pollution and ecosystem sensitivity towards these elements (Nabholz, 1991; Singh et al., 2010; Douay et al. , 2013). Therefore, the health risk index of the metals was calculated to assess their toxicity and was calculated based on (Pan et al., 2016; Mazurek et al., 2016; Hakanson, 1980) and equation (5)

$$\text{PRI} = \sum_{i=1}^{n} E_r^i \qquad (5)$$

$$E_r^i = T_r^i * \left(\frac{Ci}{Bi}\right) \qquad (6)$$

Ti is the coefficient of element toxicity (As = 10, Cu = 5, Cr = 2, Cd = 30, Ni = 5, Pb = 5, Zn = 1), according to (Hakanson, 1980). (C_i) represents the concentration of the metal, and (B_i) represents the concentration of the metal in the crust of earth. (CF) represents the Contamination Factor

3. Result and Discussion

3.1 Heavy Metals in The Soil sediment

Table 2 shows the concentrations of heavy metals (AS, Cu, Cr, Cd, Co, Fe, Mn, Mo, Ni, Zn and Pb) in the study area.

Table (2) Concentrations and Average of heavy metals in ppm for all metals except iron in% (%) for soil sediments

Residential											
Sample No	**As**	**Cu**	**Cr**	**Cd**	**Co**	**Fe**	**Mn**	**Mo**	**Ni**	**Pb**	**Zn**
M1	6.9	30.51	91.6	0.4	19.2	3	798	0.59	139.7	17.83	75.9
M7	7.7	34.14	82.2	0.45	17.9	2.72	733	0.82	119.6	31.07	161.5
M9	7.4	26.76	89.6	0.38	18.8	2.95	693	0.6	126.2	12.43	69.4
M10	7.9	27.21	87.4	0.32	18.4	2.84	684	0.66	130.4	10.31	55.3
M12	6.7	24.74	70.5	0.17	17.8	2.87	816	0.48	97.5	10.19	63.4
M15	8	30.17	92.2	0.29	19.5	3.16	831	0.74	138.3	11.86	70.5
M16	8.6	34.07	96.6	0.32	20.5	3.22	840	0.75	140.7	12.8	78
M18	7.8	29.12	90.8	0.27	19	2.9	750	0.64	136.2	10.36	65.2
M20	6.9	27.40	83.3	0.31	16.3	2.66	708	0.5	121	9.53	55.4
Avg	**7.54**	**29.34**	**87.13**	**0.32**	**18.6**	**2.92**	**761.44**	**0.64**	**127.73**	**14.04**	**77.17**
Commercial											
M6	7.6	26.48	80	0.35	17.3	2.66	654	0.61	115.8	19.6	69.5
M8	7.1	34.09	76.6	0.44	16.9	2.52	700	0.67	111.9	43.73	119.8
M11	8.2	29.37	83.3	0.31	18	2.75	728	0.9	124	23.11	62.6
M13	5.6	28.35	72.8	0.27	15.5	2.27	654	0.45	107.1	11.6	92.9
M14	5.8	29.2	70.9	0.21	14.9	2.21	607	0.4	105.4	8.59	65.2
M17	7.6	24.54	76.9	0.42	16.7	2.68	640	0.67	123.1	11.27	59.6
M19	6.9	26.33	75.7	0.27	16.4	2.57	772	0.71	101.3	13.3	56.4
M21	7	24.29	75	0.28	16.8	2.59	680	0.77	114.4	12.02	54.6
Avg	**6.97**	**27.83**	**76.4**	**0.31**	**16.56**	**2.53**	**679.37**	**0.65**	**112.87**	**17.90**	**72.57**
Industrial											
M2	7.6	27.7	68.9	0.23	17.8	3.11	761	0.54	96.5	14.53	81.4

M3	7.1	36.82	66.9	0.18	18.6	3.42	862	0.41	77.1	14.69	103.9
M4	6.8	25.93	77.5	0.25	16.8	2.54	674	0.75	119.6	11.85	83.8
M5	6.7	28.79	61.7	0.16	16.1	2.69	742	0.44	81	14.68	76.5
Avg	**7.05**	**29.81**	**68.75**	**0.20**	**17.32**	**2.94**	**759.75**	**0.53**	**93.55**	**13.93**	**86.4**

Arsenic (As). The highest average for (As) in the residential areas samples were in higher than in the industrial and commercial areas. They were in the following order: Residential > Industrial> Commercial. This may be due to industrial processes (anthropogenic source) as well as the use of pesticides in the garden soil and the existence of areas for throwing household waste which may have increased its concentration in soils (Al Hamdiany, 2017; Dehghani et al. 2017; Soltani et al. 2015; Hu et al., 2018)

Cuper (Cu) The highest average of (Cu) is found in Industrial areas higher than in residential and commercial areas as in the following order: Industrial > Residential > Commercial. This may be due to copper emissions from car repair workshops, fuel burning, tire get rid, oils leakage and battery eroded (Baker, 2007). As well as mechanical workshops and parking in industrial areas rather more than in residential and commercial areas (Garba and Abubakar, 2018; Al Hamndiany, 2017).

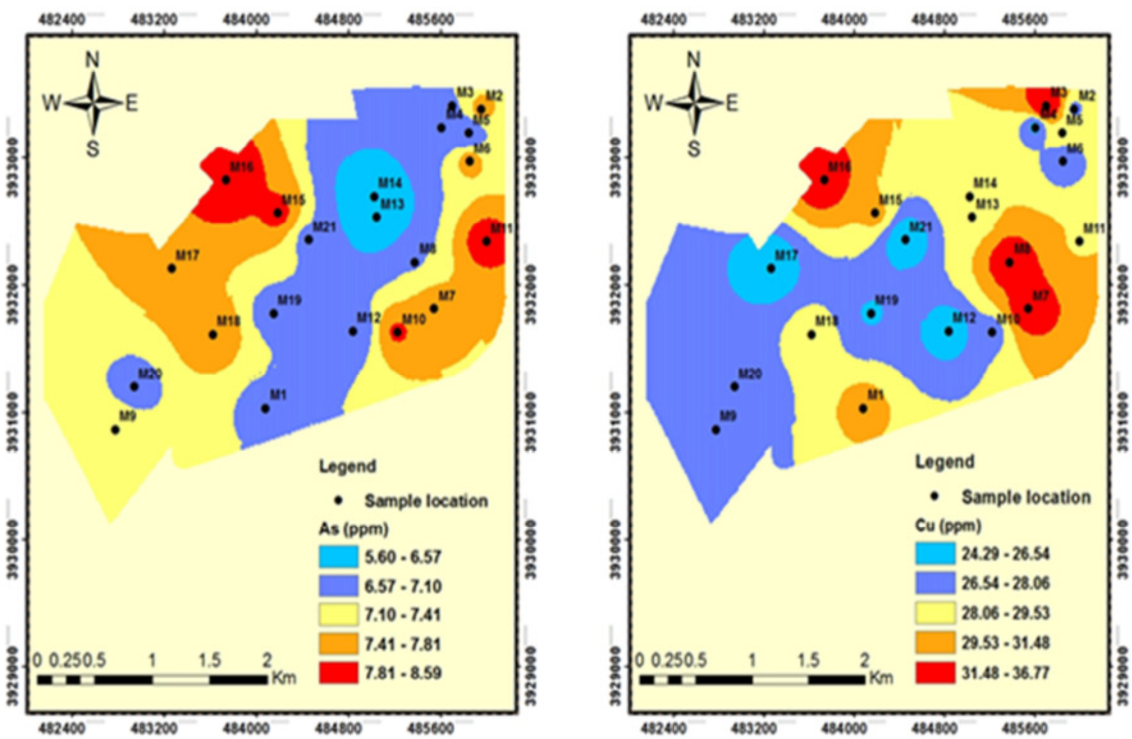

Figure (2) Distribution of (As) & (Cu) in soil sediments samples of the study area

Chromium (Cr). The highest concentration of (Cr) was in the residential areas. The arrangement of (Cr) in the soil deposits of the study area was as the following: Residential> Commercial> Industrial. This may be because of the industrial activities, traffic and the dumping of residues as well as the effects of the power plant located within residential areas. However, the weather, long dry periods and sediments density are other factor which may affect the accumulation of contaminants in the soil near the roads.This increases their concentration in the soil of roads and residential areas (Garba & Abubakar, 2018).

Cadmium (Cd). The results showed that the cadmium distribution was convergent to the study area as shown in Fig 3. The concentration of (Cd) in the land used has been shown that average concentration was in the residential areas higher than its concentration in the commercial and industrial areas as in the following order: Residential> Commercial> Industrial . Its high concentration in residential areas is due to the waste disposal sites, landfill, internal roads of vehicles, lubricant, old tires, eat tires wear, and disrupt on road vehicles in urban area (Alsbou & Al-Khashman, 2018), as well as thematerials used for construction (Eisa, 2016)**.**

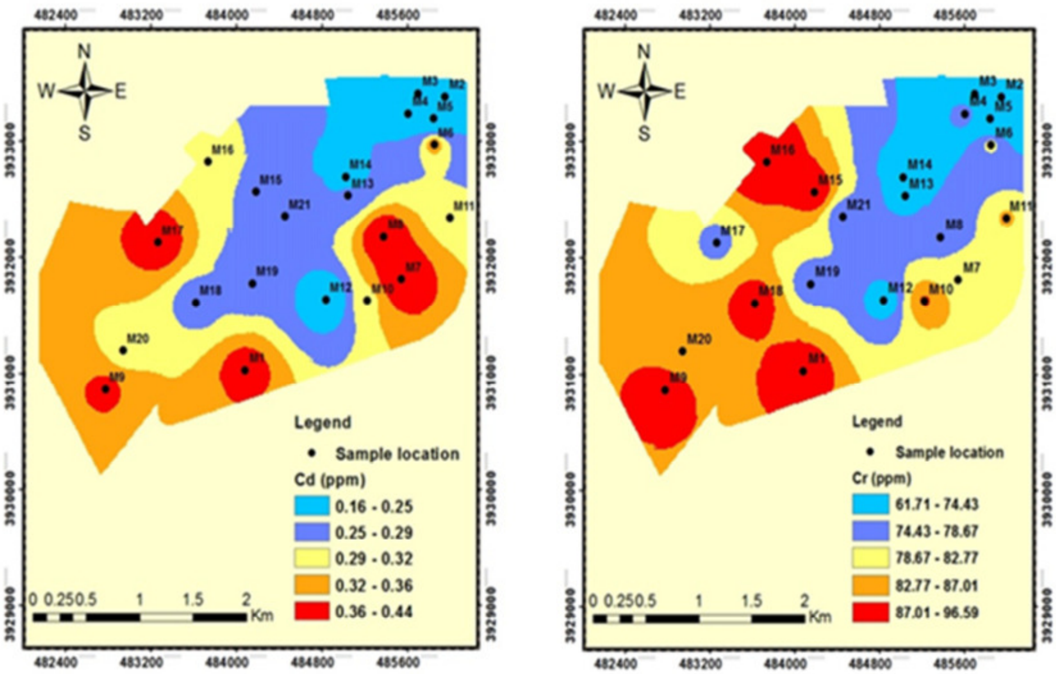

Figure (3) Distribution of (Cd) & (Cr) in soil sediments samples of the study area

Cobalt (Co). Its concentration were convergent and homogeneous in the land models used for the study area. In figure 4, although the cobalt distribution was similar, it recorded the highest rate in residential areas compared to the commercial and industrial areas, as in the following order: Residential> Industrial >Commercial. This may be because of the industrial source, which precipitates from the atmosphere due to the burning fuel and urban activities such as the movement of transport and waste water sewage, sewage and agricultural fertilizers (Smith and Carson, 1981)

Iron (Fe) The average concentration of (Fe) in the industrial zones samples was higher than it in the residential and commercial areas as in the following order: Industrial > Residential> Commercial. This belongs to the role of industrial activities resulting from the blacksmithing shops, welding workshops for reservoirs and car repair workshops, as well as stores of scrap and scraper for some devices and old cars.

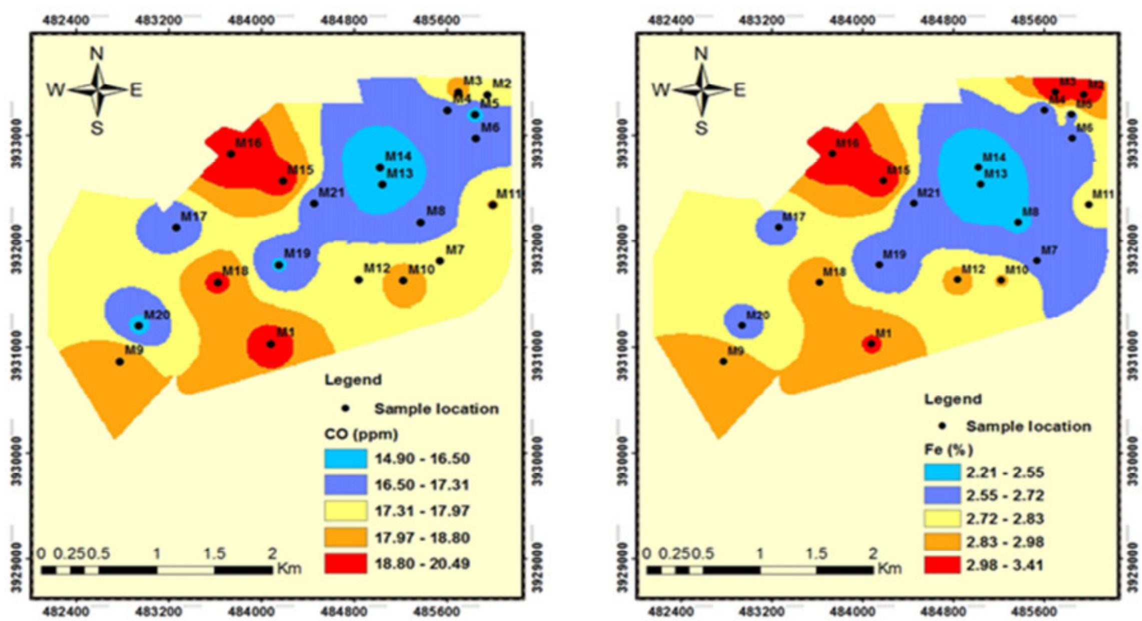

Figure (4) Distribution of (Co) & (Fe) in soil sediment samples of the study area

Manganese (Mn). The residential areas within the division of land used in the study area were characterized the accumulation (Mn) in soil sediment compared to other areas in the city of Chamchamal as in the following order: Residential> Industrial > Commercial. In general, the increasing of any metal concentration of heavy metals, including manganese, in soil sediments of urban areas may be because of human and industrial activities and vehicle fuel combustion residues (Wu et al ., Li et al. 2013; Szolnoki et al., 2013 ; Karim et al. 2014)

Molybdenum (Mo). The results of the present study showed that the concentration of (Mo) in the soil sediments of the study area recorded the highest rate in the commercial areas within the study area compared to the regions in the following order: Commercial> Residential> Industrial This may belong to the role of urban activities, including the movement of transport and erosion of road surface and the burning of tires and brakes in raising its focus.

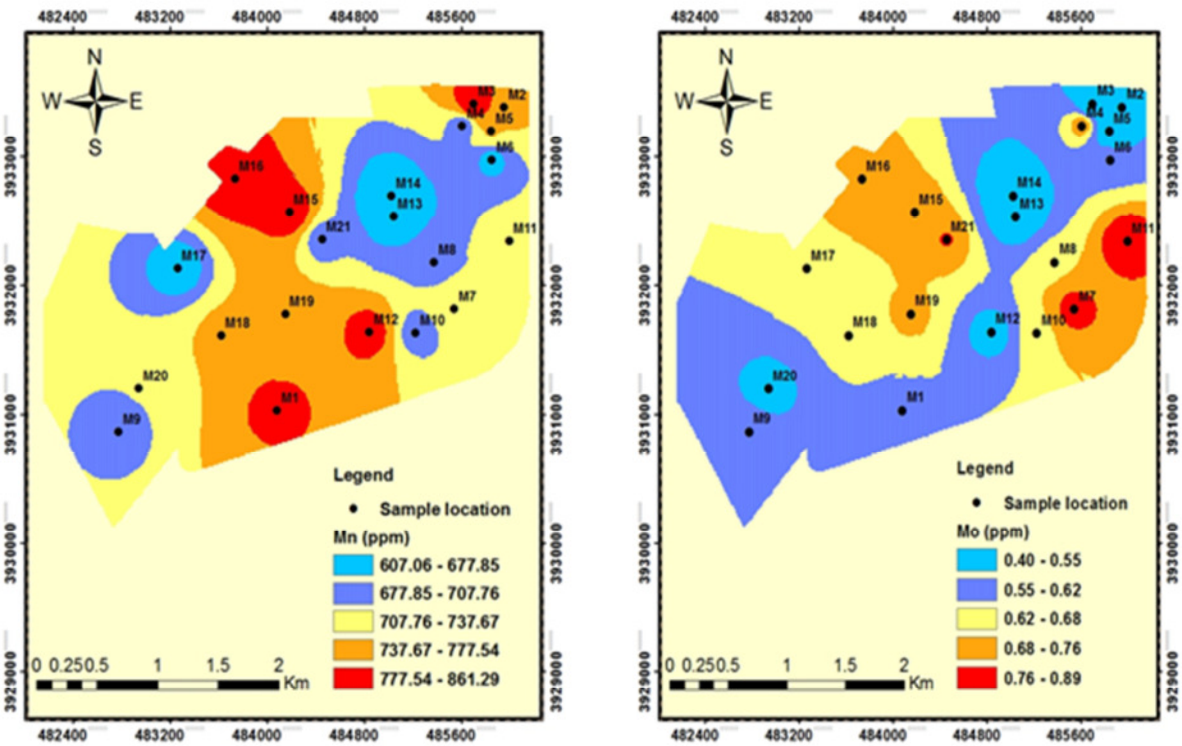

Figure (5) Distribution (Mn) & and (Mo) in soil sediment samples of the study area

Nickel (Ni). The average of (Ni) in residential area was higher than it in commercial and industrial areas as in the following order: Residential> Commercial> Industrial, which may be a result of municipal and domestic waste (Adriano, 1986; Papazotos et al., 2016; Celestin & Bemard, 2015).

Lead (Pb). The average concentration of lead in the commercial areas was found within the land used for the study area which has a highest concentration compared with the residential and industrial areas and Figure 4 and in the following order: Commercial> Residential> Industrial This may be due to the heavy traffic activities in the commercial areas. These areas emit particles of exhausts and car engines in the form of particles Carbonate monoxide resulting from the incomplete combustion of fuel. This fuel emits into the atmosphere and settles in the sides road, as well as industrial processes that led to differences in the distribution of lead in soil sediments (Lingyan et al., 2015)

Zinc (Zn). The average of (Zn) in Industrial area was higher than it in commercial and Residential areas as in the following order: Industrial> Residential> Commercial. This may be due to the presence of large spaces as garages for vehicles, and vehicles out of service as well as shops and workshops for car repair. Moreover, zinc is used in the lining of vehicle wheels. Therefore, throwing and burning the wheels may be released large quantities of it. (El-Gamal, 2000; Akbar et al., 2000; Manno et al., 2006; Matthews and Kakulu, 2013; Zakir et al., 2014).

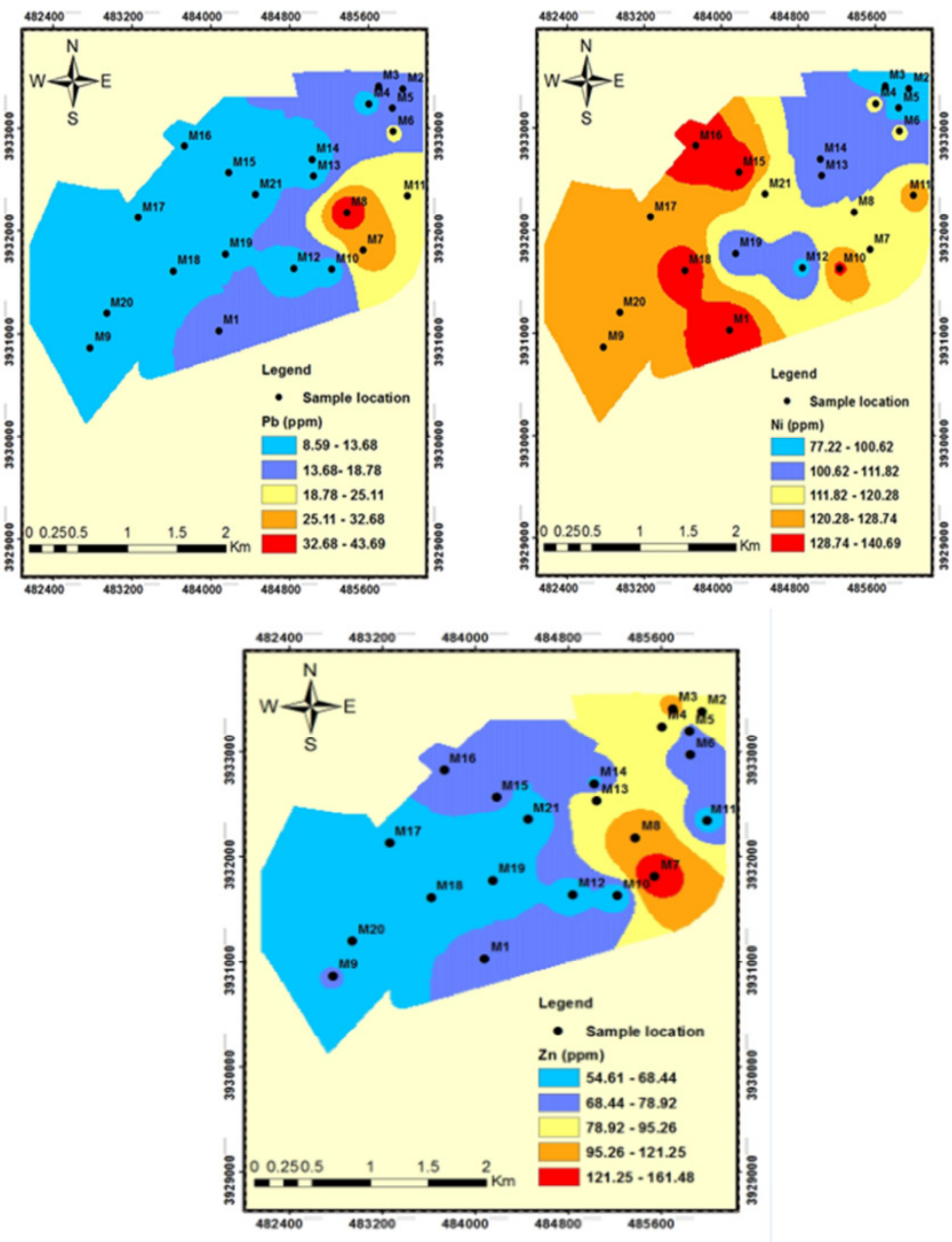

Figure (6) Distribution of (Pb), (Ni) and (Zn) in soil sediments samples of the study area

2.3 Correlation Matrix

Table (3) shows the correlation of the heavy metals in the study area. Arsenic is positively correlated with (Cr), (Co), (Fe), (Mo) and (Ni) interrelated values (0.61, ,0.77, 0.63, 0.66, 0.52), respectively. This may be due to that these metals may be derived from the same source, such as human sources, wastes water, household residues and agricultural impacts Urban areas (Xiaolu et al., 2018; Meng et al., 2014). Copper is associated with lead a positive relationship (r = 0.51). This relationship indicates the common origin of both metals. These are related to heavy traffic or emission from oil sources (Albanese & Breward, 2011), as well as the geochemical behavior of the two elements during transport and sedimentation processes. Copper may replace lead in lead metals

(Goldschmidtm, 1962; White, 2013; Rifaat, 2005). It has a positive correlation with manganese (r = 0.48) and with zinc in value (r = 0.69) which may refer to human sources, use of agricultural fertilizers and waste water and using both metals in the battery industry (Chen and Lu, 2018; Ali, 2007). Chromium has a positive relationship with cadmium, cobalt and nickel with a correlation in (0.56, ,0.70, 0.94,)respectively. This may be due to the impact of human, industrial and agricultural activities (Hind et al., 2017) as well as the accompanying metals in some phases of sulphide and in the fuel of various modes of transport, including cadmium and chrome (Alloway, 2012). Chromium is also associated with molybdenum a correlation in valu (0.53), indicating the role of urban factors in soil sediments, urban density, highways, traffic volume and land use ratio (Pouyat et al., 2008).

Cadmium is positively correlated with molybdenum in value (r = 0.53) due to similarity in their emission sources and has positive correlation with nickel and lead in values , r = 0.61, r = 0.56) respectively, Table 3. This may be attributed to the common sources in their emission such as combustion of fuel and oil derivatives as well as associated with sediments of alkaline metals (Kabata-Pendias & Mukherjee, 2007). It may also indicate the geochemical association of these two elements because they are associated with the phases of sulphide minerals.

Table 3 shows that cobalt has positive correlation with iron and manganese with value of (r =0.85, r =0.69), respectively. This may be due to its strong movement during transport and erosion. This relationship is reinforced by adsorption on secondary iron oxides (Krauskopfm, 1979;Qingzhen et al ., 2015). The strong relationship between cobalt and iron indicates the ability of cobalt to replaced to iron in some metal phases, particularly in geothite mineral (Schwerumann et al., 1989).It has a significant positive correlation with nickel with a correlation value (r = 0.52) due to geochemical affinity, as well as convergence in the ionic cathode with an ionic diameter of cobalt (0.73Ao) and nickel (0.69Ao. it may replace iron in the crystal structure of clay mineral (Goldschmidt, 1958; Al-Jubori, 1972;Rankama & Sahama, 1959).

Table(3) correlation coefficients of heavy metals in soil sediments.

Metals	As	Cu	Cr	Cd	Co	Fe	Mn	Mo	Ni	Pb	Zn
As	1										
Cu	0.21	1									
Cr	0.61**	0.13	1								
Cd	0.37	0.15	0.56**	1							
Co	0.77**	0.38	0.70**	0.22	1						
Fe	0.63**	0.40	0.32	-0.07	0.85**	1					
Mn	0.38	0.48*	0.18	-0.24	0.69**	0.81**	1				
Mo	0.661**	-0.006	0.53*	0.53*	0.37	0.06	0.02	1			
Ni	0.52*	-0.04	0.94**	0.61**	0.52*	0.11	-0.04	0.58**	1		
Pb	0.17	0.51*	-0.01	0.56**	0.02	-0.09	-0.004	0.34	-0.01	1	
Zn	-0.006	0.69**	-0.11	0.33	0.06	0.04	0.12	0.09	-0.16	0.70**	1
** Correlation is signification at the 0.01 level						* Correlation is signification at the 0.05 level					

Iron is positively correlated with manganese with a value of (r = 0.81). This correlation may indicate their natural origin (Ali, 2007) because they are a major soil component and their presence is related to the erosion of source rocks over time as well as their similar geochemical behavior (2018Xiaolu et al., 2018). Table (3) shows that molybdenum is positively correlated with nickel and has anemulation value (0.58), which may reflect the similarities in their sources of emission in urban areas. Lead is associated with strong and positive bonding with zinc (r = 0.70), due to the similarity of urban activities in the release of these two elements into the soil (Abdul Hameed, 2013).

3.3 Pollution Evaluation and Potential Ecological Risk indices

Table (4) shows the Geo accumulation Index (Igeo) factors in the study area. Copper, cobalt, iron, manganese, molybdenum, lead and zinc are in the Un contaminated category in soil sediment, while arsenic is in the category Moderately contaminated, while cadmium and nickel are in the Uncontaminated to Moderately Contaminated category. This indicates that there are many industrial and anthropogenic sources In human activities, in general, and industrial in particular in the study area, which in turn led to contamination of their deposits with these metals.

Table (4) Assessment Results of Soil Pollution in the Study Area by the (Igeo) Index

Igeo										
Sample No	As	Cu	Cr	Cd	Co	Fe	Mn	Mo	Ni	Pb	Zn
M1	1.43	-0.29	-1.15	1.41	-0.90	-1.11	-0.42	-1.48	0.73	-0.31	-0.36
M2	1.57	-0.43	-1.56	0.61	-1.01	-1.05	-0.49	-1.61	0.2	-0.61	-0.26
M3	1.47	-0.02	-1.60	0.26	-0.95	-0.92	-0.31	-2.00	-0.12	-0.59	0.09
M4	1.41	-0.53	-1.39	0.73	-1.09	-1.35	-0.67	-1.13	0.50	-0.90	-0.21
M5	1.39	-0.38	-1.72	0.09	-1.16	-1.26	-0.53	-1.90	-0.05	-0.59	-0.34
M6	1.57	-0.50	-1.3	1.22	-1.05	-1.28	-0.71	-1.43	0.46	-0.17	-0.48
M7	1.59	-0.13	-1.31	1.58	-1.00	-1.25	-0.55	-1.00	0.50	0.48	0.72
M8	1.47	-0.13	-1.41	1.55	-1.09	-1.36	-0.61	-1.3	0.41	0.97	0.29
M9	1.53	-0.48	-1.18	1.34	-0.93	-1.13	-0.63	-1.45	0.58	-0.83	-0.49
M10	1.63	-0.48	-1.22	1.09	-0.96	-1.19	-0.65	-1.32	0.63	-1.10	-0.81
M11	1.68	-0.35	-1.29	1.04	-1	-1.23	-0.56	-0.87	0.56	0.05	-0.63
M12	1.39	-0.6	-1.53	0.18	-1.01	-1.17	-0.39	-1.78	0.21	-1.12	-0.62
M13	1.13	-0.40	-1.48	0.84	-1.21	-1.51	-0.71	-1.87	0.35	-0.93	-0.66
M14	1.18	-0.36	-1.52	0.48	-1.27	-1.55	-0.82	-2.04	0.32	-1.36	-0.58
M15	1.64	-0.31	-1.14	0.95	-0.88	-1.03	-0.37	-1.15	0.71	-0.90	-0.46
M16	1.75	-0.13	-1.07	1.09	-0.81	-1.00	-0.35	-1.13	0.74	-0.79	-0.32
M17	1.57	-0.61	-1.40	1.48	-1.10	-1.27	-0.74	-1.3	0.55	-0.97	-0.71
M18	1.61	-0.36	-1.16	0.84	-0.92	-1.15	-0.51	-1.36	0.69	-1.09	-0.58
M19	1.43	-0.51	-1.43	0.84	-1.13	-1.33	-0.47	-1.21	0.27	-0.73	-0.78
M20	1.43	-0.45	-1.29	1.047	-1.14	-1.28	-0.60	-1.72	0.52	-1.22	-0.81
M21	1.45	-0.62	-1.43	0.9	-1.09	-1.32	-0.65	-1.09	0.44	-0.88	-0.83
Avg	1.50	-0.37	-1.35	0.95	-1.03	-1.22	-0.55	-1.41	0.46	-0.51	-0.33

Table 5 shows ,the Enrichment Factor (EF) of the metals under study that is copper, chromium, cobalt, manganese, molybdenum, lead and zinc are within (EF <2) (Deficiency to minimal enrichment) with these elements. Enrichment Factor (EF) of arsenic is within (5 > EF <20), indicating that the soil sediments are enriched with this metal. While the cadmium and nickel metals are in category (2 <EF E <5). That means the soil sediments of the city of Chamchamal are enriched (Moderate enrichment) by these two metals. The appearance has been attributed (Medium Enrichment-Significant enrichment) for the soil sediments of the study area with elements of arsenic, cadmium and nickel to the human activities represented with waste of municipal and municipal waste and sewage on the soil without any treatment, as well as the outputs of the power plant located in the east of the city of Chamchamal, causing an increase in the concentration of these elements in the soil deposits under study.

Table (5) Assessment Results of Soil Pollution in the Study Area by the (EF) Index

EF										
Sample No	As	Cu	Cr	Cd	Co	Fe	Mn	Mo	Ni	Pb	Zn
M1	5.84	1.73	0.96	5.77	1.15	-	1.60	0.76	3.88	1.74	1.33
M2	6.20	1.53	0.70	3.20	1.03	-	1.48	0.69	2.58	1.37	1.37
M3	5.27	1.86	0.62	2.27	0.97	-	1.52	0.47	1.87	1.26	1.59
M4	6.80	1.76	0.96	4.26	1.19	-	1.60	1.18	3.92	1.37	1.73
M5	6.32	1.84	0.78	2.57	1.07	-	1.67	0.65	2.50	1.60	1.49
M6	7.26	1.72	0.95	5.69	1.17	-	1.49	0.91	3.62	2.16	1.37
M7	7.19	2.16	0.95	7.16	1.18	-	1.63	1.20	3.66	3.35	3.12
M8	7.15	2.33	0.96	7.55	1.20	-	1.68	1.06	3.7	5.10	2.50
M9	7.40	1.56	0.96	5.57	1.14	-	1.42	0.81	3.56	1.23	1.23
M10	7.06	1.65	0.97	4.87	1.16	-	1.45	0.92	3.82	1.06	1.02
M11	7.57	1.84	0.96	4.87	1.17	-	1.60	1.30	3.75	2.47	1.19
M12	5.93	1.48	0.78	2.56	0.97	-	1.72	0.66	2.30	1.04	1.16
M13	6.26	2.15	1.01	5.14	1.18	-	1.74	0.79	3.93	1.50	2.15
M14	6.66	2.38	1.01	4.11	1.58	-	1.66	0.72	3.97	1.14	1.55
M15	6.43	1.64	0.92	3.97	1.16	-	1.59	0.96	3.64	1.10	1.17
M16	6.78	1.82	0.95	4.30	1.14	-	1.58	0.93	3.64	1.16	1.27

M17	7.20	1.58	0.91	6.78	1.12	-	1.44	1	3.82	1.23	1.17
M18	6.83	1.73	0.99	4.03	1.18	-	1.56	0.88	3.91	1.05	1.18
M19	6.82	1.77	0.93	4.54	1.14	-	1.82	1.10	3.28	1.52	1.15
M20	6.59	1.77	0.99	5.04	1.10	-	1.61	0.75	3.79	1.05	1.09
M21	6.86	1.62	0.91	4.68	1.16	-	1.59	1.18	3.68	1.36	1.10
Avg	6.63	1.79	0.91	4.52	1.14	-	1.58	0.87	3.21	1.63	1.85

After calculating the pollution index (CF) for soil sediments samples as shown in Table 6, it is found that arsenic was within the levels (Considerable Contamination). This may indicate the impact of continuous human activities and the urban development witnessed by the city of Chamchamal in the recent period and lead to add these metals to the Environmental system (Liu et al., 2014).

The level of (CF) of (Cd) that is (Moderate Contamination) except samples (M1, M6, M7, M8, M9, M10, M11, M16, M17, M20) which were of a level (Considerable Contamination). This indicates the landfill sites, the landfill sites and the disposal of waste disposal on the soil Containing cadmium through the use of household detergents and chemical powders, and the use of chemical fertilizers in public parks. (CF) for Copper is located in the level (Low Contamination) except the model (M3). This model is at the level (Moderate Contamination) in the industrial area. The increasing in copper may be due to car repair shops and the existence of large areas of parking, and workshops for the construction and restoration of reservoirs. CF of chromium, cobalt, iron, manganese and molybdenum refers to the Low Contamination level of all samples soil sediments. The CF pollution index for the Nickel metals, as in Table 6, indicates the level of "Moderate Contamination" for all models of the study area Due to the role of urban and industrial activity in the study area (Stirbescu et al., 2018).

The level (CF) of the lead metal of all soil sediments samples of the city of Chamchamal is located at the level of (Low Contamination) except the models (M7, M8, M11, M6 and M1). It refers to (Moderate Contamination). This may be due to the presence of these models in densely populated areas and human activities, and the nearness some sample to the main and secondary roads of the city. Therefore, their waste products, vehicle movements and combustion products may lead to increase the concentration of lead in soil sediments and thus cause contamination (Meie and Haizhen, 2018).

The CF of the Zinc component showed (Low Contamination) except samples (M3, M7, M8), which is (Moderate Contamination), indicating that the M3 sample in the industrial zone and the M7 and M8 models in the commercial and residential area respectively. All types of industrial and urban activities that occur in these areas may cause contamination of the surface environment with Zinc metals.

By calculating the degree of contamination (Cdeg) as in Table 6, it is noted that the models (M2, M3, M4, M5, M12, M13, M14, M19, M20, M21) were (Moderate Contamination), while rest samples are (Considerable Contamination). This is due to the different activities from one area to another and from one location to another. The areas polluted by heavy metals are the areas where traffic congestion prevails and the increasing population activity which caused the dumping of large amounts of liquid and solid waste and the use of Pesticides and agricultural fertilizers (Navid et al., 2018; Alloway, 1995; Yang et al., 2009).

Table (4) Assessment Results of Soil Pollution in the Study Area by the (CF), (C_{deg}) and (PRI) Index

	CF											C_{deg}	PRI
Sample No	As	Cu	Cr	Cd	Co	Fe	Mn	Mo	Ni	Pb	Zn		
M1	4.05	1.22	0.67	4	0.8	0.69	1.1	0.53	2.49	1.2	1.16	17.91	190.67
M2	4.47	1.1	0.5	2.3	0.74	0.71	1.06	0.49	1.72	0.98	1.25	15.32	137.95
M3	4.17	1.47	0.49	1.8	0.77	0.79	1.2	0.37	1.36	0.99	1.85	15.26	120.81
M4	4	1.03	0.56	2.5	0.7	0.58	0.94	0.68	2.13	0.8	1.28	15.2	140.1
M5	3.94	1.15	0.45	1.6	0.67	0.62	1.03	0.4	1.44	0.99	1.17	13.46	110.09
M6	4.47	1.05	0.58	3.5	0.72	0.61	0.91	0.55	2.06	1.32	1.06	16.83	178.6
M7	4.52	1.36	0.6	4.5	0.74	0.62	1.02	0.74	2.13	2.09	2.48	20.8	214.9
M8	4.17	1.36	0.56	4.4	0.7	0.58	0.97	0.6	1.99	2.95	1.84	20.12	211.01
M9	4.35	1.07	0.65	3.8	0.78	0.68	0.96	0.54	2.25	0.83	1.06	16.97	183.57
M10	4.64	1.08	0.64	3.2	0.76	0.65	0.95	0.6	2.32	0.69	0.85	16.38	167.94
M11	4.82	1.17	0.61	3.1	0.75	0.63	1.01	0.81	2.21	1.56	0.96	17.63	171.28
M12	3.94	0.98	0.51	1.7	0.74	0.66	1.13	0.43	1.74	0.68	0.97	13.48	112.35
M13	3.29	1.13	0.53	2.7	0.64	0.52	0.91	0.4	1.91	0.78	1.42	14.23	137.95
M14	3.41	1.16	0.52	2.1	0.62	0.51	0.84	0.36	1.88	0.58	1	12.98	119.57

M15	4.7	1.2	0.67	2.9	0.81	0.73	1.16	0.67	2.46	0.8	1.08	17.18	162.09
M16	5.05	1.36	0.71	3.2	0.85	0.74	1.17	0.68	2.51	0.86	1.2	18.33	176.21
M17	4.47	0.98	0.56	4.2	0.69	0.62	0.89	0.6	2.19	0.76	0.91	16.87	191.68
M18	4.58	1.16	0.66	2.7	0.79	0.67	1.04	0.58	2.43	0.7	1	16.31	153.65
M19	4.05	1.05	0.55	2.7	0.65	0.59	1.07	0.64	1.8	0.89	0.86	14.85	145.11
M20	4.05	1.09	0.61	3.1	0.67	0.61	0.98	0.45	2.16	0.64	0.85	15.21	157.73
M21	4.11	0.97	0.55	2.8	0.7	0.59	0.94	0.7	2.04	0.81	0.84	15.05	150.47
Avg	4.25	1.15	0.58	2.9	0.73	0.64	1.01	0.56	2.06	1.04	1.18	16.1	156.03

It has been shown through the account Potential Ecological Risk index (PRI), As shown in Table 6, the potential ecological risk index as a level (Considerable Risk) for samples (M2,M3,M4 ,M5, M12, M13 , M14, M19) , while at a level (Very High Risk) for samples (M1,M6,M9, M10,M11,M15,M16, M17, M18,M21) , and be (Extreme Risk) for (M7, M8). This may be due to the presence of severe pollution in these sites from industrial sources and human and urban activities (Stirbescu et al., 2018).

4. Conclusion

The concentrations average of studied heavy metals in the utilized land showed that Arsenic, Chromium, Cadmium, Cobalt, Manganese and Nickel were more concentrated in residential areas. This belongs to urban activities such as liquid and solid waste, sewage, waste combustion, heavy traffic and industrial waste. The concentrations of molybdenum and lead were higher in commercial areas due to the density of transport traffic and the increase in the number of vehicles whose burning fuel could cause to lead emission. Copper, Iron and Zinc showed the highest concentration in the industrial areas due to the presence of a large number of mechanical workshops, maintenance and welding shops as well as shops for the industries of domestic water tanks.

The results of the binary correlation showed that the sources of the heavy metals in the soil sediments of the study area are from urban and industrial activities.

The results of the Igeo of Cadmium and Nickel are shown to be in the uncontaminated to moderately contaminated category. This indicates that there are many industrial sources of anthropogenic activity in general and industrial in particular.

The values of the EF showed that soil sediments in study area of the Arsenic was "significant enrichment", while "moderate enrichment" of the elements of Cd and Ni. The classification of soil sediment in study area, modern enrichment-significant enrichment) according to (EF) index, may be attributed to the human activities such as movement of vehicles, household waste and municipal waste and waste water discharged to the soil without any treatment.

The results of the degree of pollution (Cdeg) showed some sites as being consistent contamination by studied heavy metals and this may be due to different industrial activities and the use of pesticides and fertilizers.

The results of the (PRI) values indicate that they are of a reasonable risk level for some sites, while they have a very high risk level for other sites, but for specific sites was extreme risk. This is due to the presence of severe pollution in these sites from industrial sources, urban and human activities.

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