DOI: 10.24996/ijs.2019.60.5.15

ISSN: 0067-2904

Environmental Geochemical Assessment of Heavy Metals in Soil and Sediment of (Shatt-Al-Hilla) Babil Governorate, Central Iraq

Mansour Hussain Manea[1], Balsam Salim. Al-Tawash[1], Younus I. Al-Saady*[2]
[1]Department of Geology/ College of Science/ University of Baghdad, Baghdad, Iraq
[2]Iraq Geological Survey (GEOSURV), Baghdad, Iraq

Abstract

Heavy metals concentration in the soils and sediments has increased worldwide during the last century as a result of the rapid increase in population which combined by an increase in human activity as agriculture, industrial and many other activities. Ten soil and three river sediment samples were collected from 10 main sampling stations at Shatt Al-Hilla River from Sada area to Dora Bridge in Babylon province. The chemical analysis of the sedimentation sample in the laboratory included pH calculation, electrical conductivity (EC) (Cation Exchange Capacity (CEC), organic matter (OM), and heavy metals as (Mn, Ni, Cr, Zn, Cu, Co, Pb, Cd, As and Fe). Indirect geochemical background (IGB) of heavy metal was calculated by the iterative 2 standard deviations (SD) method.

The results of enrichment factor for heavy metals of the soil and sediment show that the all heavy metals in the studied samples were within Ef<2 indicate to depletion to minimal enrichment (i.e. no or minimal pollution). While Cd in the sample (5), Co in the sample (7), Cr in the sample (8) and Mn in the sample (1S) are within $2 \leq EF < 5$ indicate to Moderate enrichment. Contamination factor (Cf) for heavy metals of soil and sediment show that the all heavy metals in the studied samples were within $Cf < 1$ -Low contamination. While Sample "2" (Cd, Fe), sample "3" (Ni, Cr, Pb, and Cd), sample "4" (Mn, Fe) and sample "8" (Cr) are within $1 \leq Cf < 3$ moderate contamination.

Pollution load index result of all the soil and sediment samples are less than one indicate that "no pollution" are present, except sample 3 where the PLI value higher than 1 indicates the samples have been "polluted ". The modified degree of contamination (mCd) data indicate nil to a low degree of contamination for all of the soil and sediments samples.

Keywords: Geochemical assessment, Heavy metals, Enrichment factor

التقييم الجيوكيميائي البيئي للعناصر الثقيلة في التربة والترسبات النهرية لشط الحلة، محافظة بابل، وسط العراق

منصور حسين مانع[1]، بلسم سالم الطواش[1]، يونس ابراهيم الساعدي*[2]
[1]قسم علم الارض ،كلية العلوم/جامعة بغداد ، بغداد، العراق
[2]هيئة المسح الجيولوجي العراقية ، بغداد، العراق

الخلاصة

جمعت (10) نماذج تربة وثلاث نماذج من الرواسب النهرية من 10 محطات رئيسية لأخذ العينات في شط الحلة من ناحية السدة إلى جسر دورا في محافظة بابل. تضمن التحليل الكيميائي لنماذج التربة

*Email: younusalsaady@gmail.com

والرسوبيات النهرية في المختبر حساب pH ، والتوصيل الكهربائي (EC) قدرة تبادل الأيونات الموجبة (CEC)، والمواد العضوية (OM)، والمعادن الثقيلة وتشمل (Mn، Ni، Cr، Zn، Cu، Co، pb، Cd، Fe،As). تم حساب الخلفية الجيوكيميائية غير المباشرة (IGB) للمعادن الثقيلة بواسطة طريقة الانحرافات المعيارية (2SD) التكرارية.

تظهر نتائج معاملات الاثراء للمعادن الثقيلة في التربة والرواسب أن جميع المعادن الثقيلة في جميع العينات المدروسة ضمن Ef <2 والتي تشير إلى انخفاض او الحد الأدنى للإثراء (أي عدم وجود التلوث أو التلوث عند الحد الأدنى). بينما Cd في العينة (5) ، Co في العينة (7) ، Cr في العينة (8) و Mn في العينة (S1) ضمن معامل تاثير 2≥ EF >5 والتي تشير إلى أثراء معتدل. يوضح عامل التلوث (Cf) للعناصر الثقيلة في نماذج التربة والرسوبيات أن جميع العناصر الثقيلة في جميع العينات المدروسة ضمن التلوث المنخفض –1> Cf التلوث المنخفض. في حين أن النماذج "2" (Fe ،Cd)، العينة "3" (Cd ،Pb ،Cr ،Ni) "4" (Fe ،Mn)، النموذج"8" (Cr) تقع ضمن حد تلوث معتدل 3>Cf≥1.

تشير نتائج مؤشر حمّل التلوث (PLI) لكل عينات التربة والرواسب الى أقل من 1 "عدم وجود تلوث"، باستثناء النموذج 3 حيث تشير قيمة PLI أعلى من 1 إلى أن النموذج "ملوث". وتشير بيانات درجة التلوث المعدلة إلى (عدم وجود تلوث – درجة منخفضة من التلوث) لجميع عينات التربة والرواسب. (mCd)

1. INTRODUCTION

The soil is an important environmental media receiving a significant amount of pollutants from different sources with time [1]. Heavy Metals associated with soils and sediments in an urban area are of environmental significance because of their direct and indirect effects on human health. Heavy metals in soils are found naturally or generated from anthropogenic activities. Anthropogenic sources of heavy metals in the environment involve many sources as the burning of fossil fuels, municipal wastes, sewage, pesticides and fertilizers [2]. River sediment of Shatt Al-Hillah and soil from surrounding areas suffer from increased effluent especially in recent years, due to increasing population, urban expansion, dense and vast agriculture lands on both sides of the river which result in increased uses of fertilizers and pesticide. Theses aforementioned factor necessity led to increased contaminants, where the emission and deposition of wastes rich in heavy could be increased in our ecosystems, particularly soil in urban and agricultural lands which act as sinks for these metals.

Consequently, this study is designed to test the effects of anthropogenic activity on heavy metals status of the soil and river sediment in Shatt Al-Hilla area by comparing the result with the geochemical background. Assessment of Metal contamination risk index, which can be used as a tool to identify the degree of pollution in the soil, was also assessed using the enrichment factor (EF), Contamination factor (Cf), Pollution Load Index (PLI), and Modified degree of contamination (mCd). It is hoped that the current study could provide baseline data regarding the distribution and accumulation of the selected metals in the river sediment of Shatt Al-Hilla and soil of the surrounding area and would help reduce the contamination by identifying the major pollution sources.

2. Study Area

The study area is located in Babil Governorate, Central Iraq, between longitudes (44º 2´E) (45º 13´E), and latitudes (32 º 5´N) (33 º 8´N) as shown in Figure-1. The total area of Babil Governorate is 5119 Km^2, representing 1.3% of the total area of Iraq. Babil Governorate consists of four districts and 12 administrative units and 674 villages. These administrative units are located directly on the Shatt Al-Hilla or on one or more of its distributors. The study area is a part of Mesopotamian Plain, one of the oldest agricultural lands in the world. The main components of sediments are old river deposits and irrigation sediment [3].

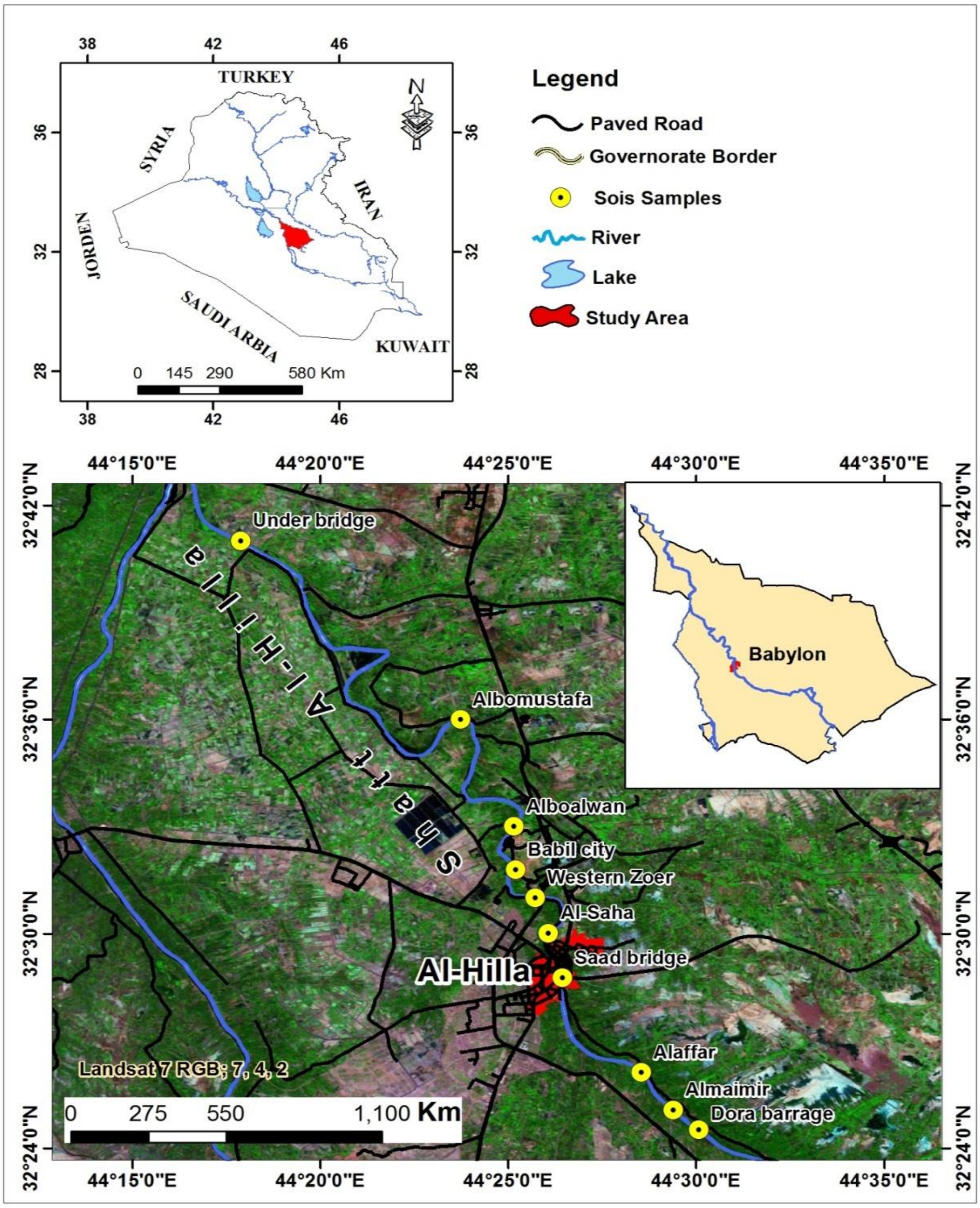

Figure 1- Location map of soil and Shatt Al-Hilla Sediments samples

3. Materials and Methods

3.1 Sampling Collection and Analysis

During dry seasons (30/7/2018), ten soil and three river sediments samples were collected from 10 main sampling stations at Shatt Al-Hilla from Sada Area to Dora Bridge in Babylon Province (Figure-1, Table-1). The soil sample was collected at 15 cm depth around the sample area; it was first air dried, mixed and transferred into clean and labeled polythene bags and carefully preserved for required chemical analysis. .The soil and sediments samples were mix, and sieved through 2-mm-mesh sieve. The resulting fine fraction was prepared for digestion. The chemical analysis of the soil and sediment samples included pH calculation, electrical conductivity (EC), Cation Exchange Capacity (CEC), organic matter (OM), and heavy metals as Mn, Ni, Cr, Zn, Cu, Co, pb, Cd, As and Fe. The previously digested soil samples were used in determining the content of heavy metals using an atomic absorption spectrophotometer.

Table 1-Location and detailed description of Soil and river sediments samples

No	Longitude	Latitude	Type	Sample name	Description
1	44°17’52.99”E	32°40’60.0”N	Soil	Under bridge	Under Al-Hidia Barrage and high population density, beginning Sada City .Pont to river policy.
2	44°23’43.99”E	32°35’60.0”N	Soil –Sediment	Albomustafa	farmland and Fish pond - Rural areas and animal activity
3	44°25’9.42”E	32°32’59.96”N	Soil	Alboalwan	Intensive agricultural and animal activity and the presence of a drainage water drain - Many fish ponds- Rural areas and irrigation activity by machines to clean the river from clay sediment and plant
4	44°25’11.57”E	32°31’47.31”N	Soil	Babil city	Tourist and agricultural area – boat moving –and some new Building in two banks
5	44°25’42.88”E	32°31’0.69”N	Soil	Western Zoer	Farmland - fish ponds- moderate population density
6	44°26’4.31”E	32°30’1.05”N	Soil	Al-Saha	Population density -many restaurants and Car – wash and Margan Hospital
7	44°26’26.43”E	32°28’45.84”N	Soil –Sediment	Saad bridge	High population density Residues of commercial activities and clinics –sewage pipe
8	44°28’32.47”E	32°26’6.64”N	Soil	Alaffar	High population density - sewage pipes and the large
9	44°29’23.14”E	32°25’4.06”N	Soil	Almaimir	Riverside waste.
10	44°30’4.48”E	32°24’30.68”N	Soil –Sediment	Dora barrage	Farmland and presence of sewage pipes **and** the large

The chemical analysis of the sedimentation sample in the laboratory included PH calculation, electrical conductivity (EC) Cation Exchange Capacity (CEC), organic matter (OM)., and heavy metals include Mn, Ni, Cr, Zn, Cu, Co, pb, Cd, As and Fe.

Table 2-Analytical methods are used for analyses of soil and Shatt Al- Hilla Sediments samples .

Parameters	Methods of analysis
Zn, Cd, Cu , Co , Fe ,Cr ,	Atomic-absorption spectrometer
Ni, Pb, Mn, As,	Atomic-absorption spectrometer
pH	pH meter
TDS (mg/l)	TDS-EC-pH meter
EC µs/c	Electrical ConductivityTDS-EC-pH meter
Organic compounds	FTIR Prestige-21,Shimadzu 1601 pc, Japan

3.2. Geochemical background of the Soil and river sediments

The background is defined as a relative measure to distinguish between the natural element or compound concentrations and anthropologically influenced concentrations in real sample collectives which may be determined with direct, indirect, and integrated methods [4] and [5].

The statistical method is iterative 2 standard deviations (SD) method. The iterative 2 SD technique [average ± 2SD] is mainly used to define background values because it approximates the original data set to a normal distribution [6].

3.3. Assessment of Metal Contamination

To evaluate the degree of contamination in the sediments, we used four parameters: Enrichment Factor (EF), Contamination Factor (CF), Pollution Load Index (PLI) and Modified degree of contamination (mCd).

The enrichment factor (EF)

The enrichment factor of metals is a useful indicator reflecting the status and degree of environmental contamination [7].

The EF calculations compare each value with a given background level, either from the local site, using older deposits formed under similar conditions, without anthropogenic impact, or from a regional or global average composition [8]. The EF was calculated using the method proposed by [9] as follows

$$Ef = \frac{(C_M/C_{Fe})\ sample}{(C_M/C_{Fe})\ \text{background}} \quad (1)$$

Where (Me/Fe) sample is the metal to Fe ratio in the sample of interest; (Me/Fe) background is the natural background value of metal to Fe ratio.

Indirect geochemical background obtained from the computation of statistical background methods is used as a reference background. In the current study. Iron was chosen as the element of normalization because natural sources (1.5%) vastly dominate its input [10][11]. Increasing in EF value indicate increasing metals supply from anthropogenic activity [12]. Enrichment factor categories are listed in the Table-3.

Table 3- Enrichment factor (EF) categories [13]

Enrichment factor (EF)	Enrichment factor (EF) Categories
EF < 2	Deficiency to minimal enrichment
2 ≤ EF < 5	Moderate enrichment
5 ≤ EF < 20	Significant enrichment
20 ≤ EF < 40	Very high enrichment
EF ≥ 40	Extremely high enrichment

Contamination factor (Cf)

The level of contamination of sediment by metal is expressed in terms of a contamination factor. The Cf is the ratio obtained by dividing the concentration of each metal in the river sediments and soil (C_M) by the background (C_B) value [14].

$$Cf = \frac{C_M}{C_B} \quad (2)$$

Where Cm is the concentration of a given metal in the river sediments and soil river sediment, and C_B is the background concentration of the metal. CF values for describing the contamination level are shown in the Table-4 [15].

Table 4-CF and level of contamination [15]

Contamination Factor (CF)	Contamination Level
Cf < 1	Low contamination
1 ≤ Cf < 3	Moderate contamination
3 ≤ Cf < 6	Considerable contamination
Cf > 6	Very high contamination

Pollution Load Index (PLI)

Pollution load index for each site is calculated according to the procedure of Tomlinson[15] as follow;

$$PLI = \sqrt[n]{CF1x\ CF2\ x\ CF3\ x.......CFn} \quad (3)$$

Where: n = number of metals and CF = contamination factor. According to [16] the PLI value higher than 1 indicates the samples have been polluted while the PLI value less than 1 indicates no pollution occurred

Modified degree of contamination (mCd)

The degree of contamination by metals is calculated based on the method presented by Hakanson [15] using the following formula:

$$C_{D=\sum Cf} \quad (4)$$

Where $\sum C_f$ is the sum of contamination factor for all metals

Furthermore, all n species must be analyzed in order to calculate the correct Cd for the range of classes defined by Hakanson [15]. Abrahim & Parker [17] presented a modified and generalized form of the Hakanson [15] equation for the calculation of the overall degree of contamination at a given sample. The modified equation for a generalized approach to calculating the degree of contamination is given as follow:

$$mCd = \frac{\sum Cf}{n} \quad (5)$$

Where n is the number of metals analyzed and CF is the contamination factor. According to mCd classification Table-5

Table 5-Classification of *mCd* [17]

mCd values	Sediment quality
mCd<1.5	Nil to low degree of contamination
1.5≤mCd<2	Low degree of contamination
2≤mCd<4	Moderate degree of contamination
4≤mCd<8	High degree of contamination
8≤mCd<16	Very high degree of contamination
16≤mCd<32	Extremely high degree of contamination
mCd>32	Ultra-high degree of contamination

4. Results and Discussion

Analysis results of pH, EC, CEC, and organic matter (OM) for soil and sediment samples along the Shatt Al-Hilla course are presented in Table-6. pH value of soil and Shatt Al-Hilla sediment ranges from 7.18 to 8.09 with a mean of 7.67 and7.84 to 8.1 with a mean of 7.94 respectively (Table-6 and Figure-2). The values within the alkaline range may be due to the sediment content of carbonate, which affects the pH values. Carbonate increases pH moderately [18] whereas the alkaline soils are primarily caused by a calcium carbonate-rich parent materials.

Electrical conductivity values of soil and Shatt Al-Hilla sediment ranged from 3.4 to 85 ds/ m with a mean 32.19 ds/m and 13.2 to 34 with mean 22.86 respectively. The values of the electrical conductivity of soil and sediment samples of the Shatt Al-Hilla were shown in (Table- 6 and Figure-2). According [19] the sample 8 considered as a very slightly saline, sample 1 as a slightly saline, sample 2-3-2S as a moderately saline while samples 4-5-6-7-9-10-1S-and 3S as a strongly saline (Table 7) Cation exchange capacity (CEC) is a measure of the soil's ability to hold positively charged ions [20]. CEC of the different types of material (modified from [18] are presented in Table-8. CEC values of soil and sediment samples ranged from 9.6 to 17.5 cmol (+)/kg with a mean of 13.2 cmol (+)/kg and 10.8 to 13.9 with mean 12.4 cmol (+)/kg respectively. The values of the (CEC) of soil and sediment samples of the Shatt Al-Hilla were shown in (Table-6 and Figure-2). CEC result of the studied soil is within the normal range and has the ability to retain and supply nutrients, specifically cations, Organic matter (OM) content of soil and sediment samples ranges from 0.88 to 1.63 with a mean of 1.044 % and0.78 to 0.91 with mean 0.84% respectively. The results of the organic matter analysis showed that the levels of the organic matter presented in sediment samples varied throughout the river and all sampling sites have relatively low organic matter content (Table-6 and Figure-2).

Table 6-pH, EC, CEC, and organic matter (OM) results of soil and sediment samples along the Shatt Al-Hilla course

S. No.	Parameter (Soil Sample)			
	PH	EC (ds/m)	MO %	CEC cmol (+)/kg
1	7.7	6.6	1.13	15.4
2	7.55	8.9	1.1	13.9
3	7.62	12.6	1.36	17.5
4	8.09	32.0.	1.21	16
5	7.82	85	0.88	9.6
6	7.93	54	0.98	12.4
7	7.61	64	0.92	11.5
8	7.48	3.4.0	1.04	13.5
9	7.18	18	0.93	10.2
10	7.8	46.5	0.89	12.4
Min	7.18	34	0.88	9.6
Max	8.09	85	1.36	17.5
Mean	7.67	32.19	1.044	13.2
SD	0.25	28.7	0.15	2.5
Sediments Samples				
1S	7.82	34.1	0.78	10.8
2S	7.9	13.2	0.85	12.7
3S	8.1	21.4	0.91	13.9
Min	7.84	13.2	0.78	10.8
Max	8.10	34	0.91	13.9
Mean	7.94	22.86	0.84	12.4
SD	0.13	10.4	0.06	1.56

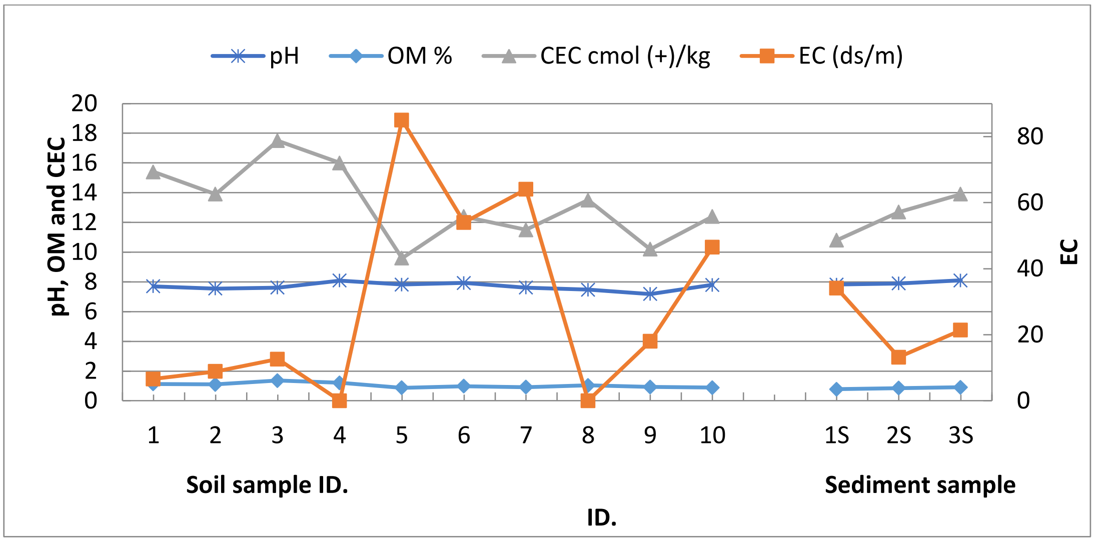

Figure 2-Variation pattern of pH , OM, CEC and EC in soil and sediment samples .

Table 7-Classification the soil and sediment according EC and described general relationship of EC and plant growth [19].

Class	ECe (dS m−1)	Plant Growth
Non saline	0-2	Salinity effects mostly negligible
Very slightly saline	2-4	Yields of very sensitive crops may be restricted
Slightly saline	4-8	Yields of many crops restricted
Moderately saline	8-16	Only tolerant crops yield satisfactory
Strongly saline	>16	Only a few very salt-tolerant crops yield satisfactory

Table 8-CEC of the different types of material (modified after [21])

Type of material	CEC (meq/100g)
Kaolinite	3-15
Chlorite	10-40
Illite	10-40
Smectite	80-150
Organic matter	150-400
Goethite & Hematite	up to 100

Heavy metals concentration in ppm of soil and sediments with geochemical background index and sediment quality guidelines, are presented in Table-9. Sediment contamination in (trace element) is a measure of environmental pollution. The increase in soil content from rare elements leads to disease [22].

Table 9-Heavy metals concentration in ppm of soil and sediments with geochemical background index and sediment quality guidelines

Type	Metal	Mn	Ni	Cr	Zn	Cu	Co	Pb	Cd	As	Fe
Soil Samples	Min	21	8.9	9	31	15	11.3	9.6	2.4	5.1	314
	Max	74	68	31.6	131	102	43	76.5	11.5	8.20	3120
	Mean	43.7	28.9	18.2	77.3	59	30.3	32	4.8	6.29	1021
	SD	17.1	18.5	7.6	32.3	26.5	11.8	21.2	2.8	0.9	859
Sediment samples	Min	34	12.4	9	31.6	15	21	13	2.7	5.2	321
	Max	43	21.6	15	48	46	34.1	31	3.1	6.8	745
	Mean	38	15.9	11.5	37.5	28	28.1	20.9	2.9	6.13	599.6
	SD	4.58	4.9	3.1	9.09	16.09	6.6	9.17	0.2	0.83	219.2
IGB*		64	46.4	23	135	106	49	53.3	5.34	12	1098
WHO,2004		-	20	25	123	25	-	-	6	-	-
USEPA,1999		30	16	25	110	16	-	40	0.6	-	30

IGB*: Indirect Geochemical Background that calculate according to aforementioned statistical methods

Manganese: Mn concentration in soil samples ranges from 21 to 74 ppm with a mean of 43.7 ppm and ranges from 34 to 43 ppm with a mean 38 ppm in sediment samples (Table-9 and Figure-3A). The fourth sample contains a concentration of manganese (74 ppm) higher than IGB of Mn (64 ppm) this may result from the variations in the source materials from which soils are derived or anthropogenic activities. In comparison with sediment quality guideline, the mean value of Mn exceeds the limits [23].

Copper: Cu concentrations in the soil range from 9.6 to 76.5 ppm with a mean of 32 ppm and in Shatt Al-Hilla sediment samples range from 13 to 31.0 ppm with a mean of 20.9 ppm (Table-9 and Figure 3A). All samples contain a concentration of Cu less than IGB (106), this means that copper exists at levels lower than its natural occurrences in soil or rocks in the study area**.** In comparison with sediment quality guideline [the mean value of Cu exceed the limits of [23] and [24].

Zinc: Zn concentrations in the soil range from 31 to 131 ppm with a mean of 77.3 ppm and in Shatt Al-Hilla sediment samples ranges from 31.6 to 48 ppm with a mean of 37.5 ppm (Table-9 and Figure-3A). All samples contain a concentration of Zn less than IGB (135), this means that Zn exists at levels lower than its natural occurrences in soil or rocks in the study area. In comparison with sediment quality guideline, the mean value didn't not exceed [12]. and [24] limits.

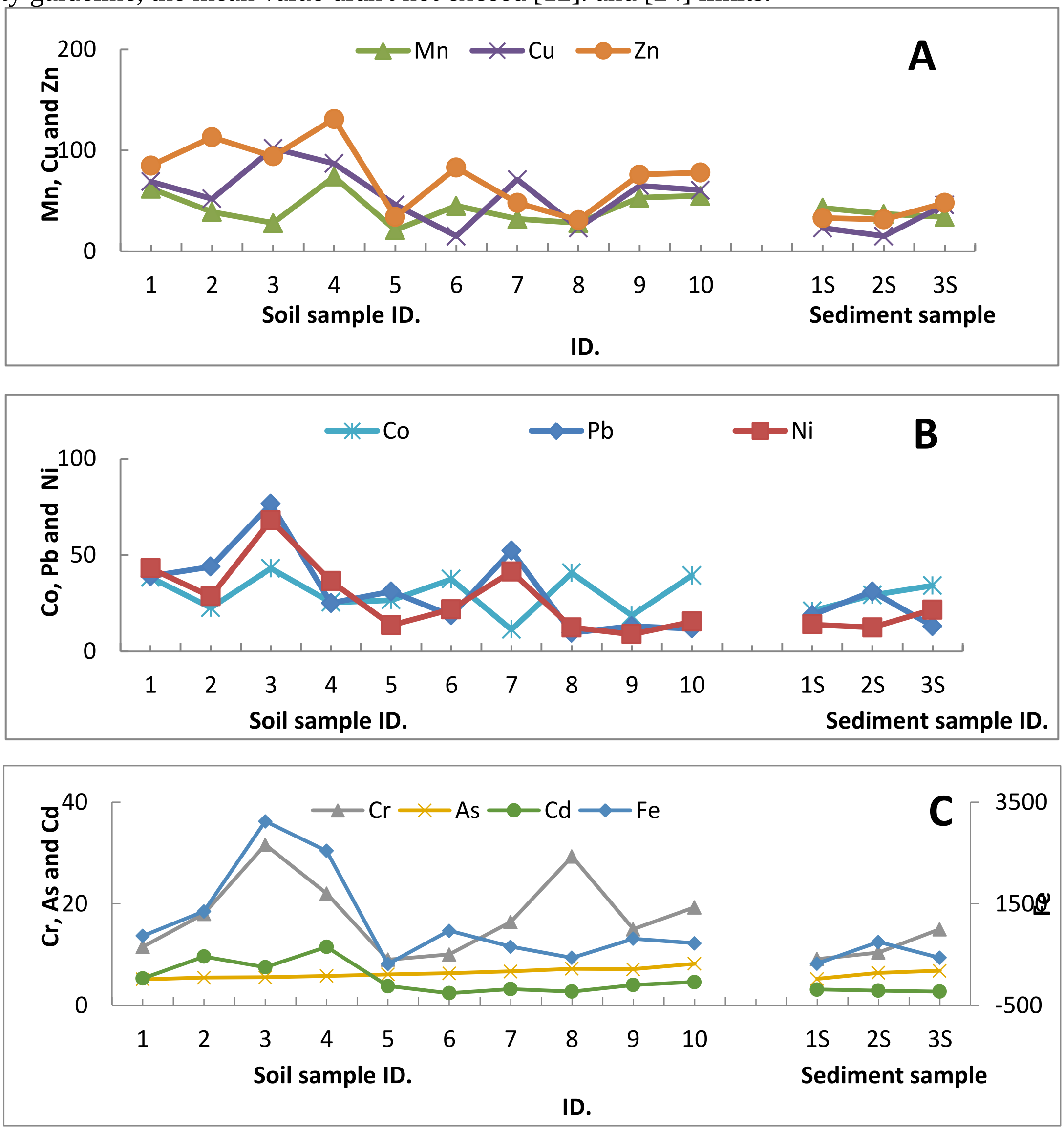

Figure 3-Heavy metals in the soil and Shatt Al-Hilla sediment samples.

Nickle: Ni concentrations in the soil range from 8.9 to 68 ppm with a mean of 28.9 ppm and in Shatt Al-Hilla sediment samples range from 12.4 to 21.6 ppm with a mean of 15.9 ppm (Table- 9 and Figure- 3B). The third sample contains a concentration of Ni (68 ppm) higher than IGB (46.4) this may result from the variations in the sources rocks or anthropogenic activities. In general, Ni means concentration of soil are exceeding the [23] and [24] limits but for river sediments Ni mean (15.9) was very closer to [23] limits and lower than [24] limit.

Cobalt: Co concentrations in the soil range from 11.3 to 43 ppm with a mean of 30.3 ppm and in Shatt Al-Hilla sediment samples ranges from 21 to 34.1 ppm with a mean of 28.1 ppm. All samples contain a concentration of Co less than IGB (49) suggest that Co exists at levels lower than its natural occurrences in the soil of the study area (Table-9 and Figure-3B).

Lead: Pb concentrations in the soil range from 9.6 to 76.5 ppm with a mean of 32 ppm and in Shatt Al-Hilla sediment samples ranges from 31 to 31 ppm with a mean of 20.9 ppm (Table-9 and Figure-3B). The third sample contains a concentration of pb (76.5 ppm) higher than IGB (53.3). In comparison with sediment quality guideline, the mean value did not exceed the limits, and this result shows that the Shatt Al-Hilla sediments are not polluted by Pb.

Chromium: Cr concentrations in the soil range from 9 to 31.6 ppm with a mean of 18.2 ppm and in Shatt Al-Hilla sediment samples ranges from 9 to 15 ppm with a mean of 11.5 ppm (Table-9 and Figure-3C), the third and eighth samples contains a concentration of Cr 31.6 and 29.3 ppm respectively, higher than IGB (23), this may result from anthropogenic activities. In comparison with sediment quality guideline, the mean value did not exceed the limits. But the soil is contaminated with Cr at site 3 and 8, due to many anthropogenic activities at these two sites, as shown in Table-1.

Arsenic: As concentrations in the soil range from 5.1 to 8.2 ppm with a mean of 6.29 ppm and in Shatt Al-Hilla sediment samples ranges from 5.2 to 6.8 ppm with a mean of 6.13 ppm (Table-9 and Figure-3C). When comparing the As concentrations in soil and sediment samples with the IGB of As (12), all samples contain a concentration of As less than IGB, this means that As exists at levels lower than its natural occurrences in the soil in the study area.

Cadmium: Cd concentrations in the soil range from 2.4 to 11.5 ppm with a mean of 4.8 ppm and in Shatt Al-Hilla sediment samples range from 2.7 to 3.1 ppm with a mean of 2.9 ppm (Table-9 and Figure-3C). The second, third and fourth samples contain a concentration of Cd 9.6, 7.5 and 11.5 ppm respectively, higher than IGB, this may result from anthropogenic activities that are represented in Table-1. Such activates may lead to increase in Cd concentration at these three sites above the IGB, WHO [12] and [13].

Iron: concentrations in the soil range from 314 to 3120 ppm with a mean of 1021 ppm and in Shatt Al-Hilla sediment samples range from 321 to 745 ppm with a mean of 599 ppm (Table-9 and Figure-3C). The second, third and fourth samples contain a concentration of Fe 1350, 3120 and 2450 ppm respectively, higher than IGB (1098). In comparison with sediment quality guideline, the mean value were exceeded USEPA [12] limit that means the soil and river sediments are polluted with iron.

Detail description result of enrichment factor (Ef), Contamination factors (Cf), modified degree of contamination (mCd) and pollution load index (PLI) of the heavy metals for the soil and sediment samples of Shatt Al-Hilla are listed in the Tables-(10 and 11).

Table 10-Detail description result of (Ef), PLI of the heavy metals for the soil and sediment samples of Shatt Al-Hilla.

Enrichment factor (Ef)											
S.ID.	Mn	Ni	Cr	Zn	Cu	Co	Pb	Cd	As	Fe	PLI
Soil and sediment samples											
1	1.2	0.32	0.66	0.81	0.82	0.09	0.93	1.27	0.85	1	0.68
2	0.94	0.5	0.66	0.68	0.4	0.37	0.96	1.48	0.4	1	0.76
3	0.15	0.51	0.5	0.24	0.34	0.31	0.51	0.5	0.17	1	1.02
4	0.5	0.34	0.43	0.42	0.35	0.22	0.2	0.94	0.22	1	0.88
5	1.15	0.1	1.43	0.88	1.52	1.92	2.05	2.52	1.94	1	0.69
6	0.8	0.05	0.51	0.7	0.16	0.87	0.4	0.51	0.65	1	0.47
7	0.84	1.5	1.25	0.6	1.12	4.61	1.6	1.01	1.01	1	0.56
8	1.1	0.67	3.36	0.58	0.05	0.12	0.45	1.29	1.65	1	0.40
9	1.10	0.26	0.92	0.76	0.83	0.52	0.33	1.02	0.87	1	0.50
10	1.31	0.5	1.33	0.88	0.87	1.23	0.34	1.32	1.34	1	0.59
1S	2.3	1.03	1.41	0.84	0.74	1.48	1.22	2.01	1.61	1	0.36
2S	0.85	0.39	0.67	0.34	0.2	0.89	0.86	0.81	0.85	1	0.42
3S	1.34	1.17	1.72	0.9	1.09	1.77	0.63	1.29	1.55	1	0.46
Min.	0.15	0.05	0.43	0.24	0.05	0.09	0.20	0.50	0.17	1.0	0.36
Max.	2.30	1.50	3.36	0.90	1.52	4.61	1.94	2.52	1.94	1.0	1.02
Mean	1.04	0.56	1.14	0.66	0.65	1.10	0.8	1.22	1.00	1.0	0.59
SD	0.55	0.42	0.79	0.21	0.44	1.22	0.54	0.55	0.57	0.0	0.19

Table 9-Detail description result of Cf and mCd of the heavy metals for the soil and sediment samples of Shatt Al-Hilla.

B - Contamination factors (Cf)											
S.ID.	Mn	Ni	Cr	Zn	Cu	Co	Pb	Cd	As	Fe	mCd
1	0.96	0.92	0.5	0.62	0.65	0.78	0.73	0.97	0.42	0.62	0.717
2	0.6	0.61	0.78	0.83	0.49	0.46	0.82	1.76	0.45	1.22	0.80
3	0.43	1.46	1.37	0.69	0.96	0.87	1.43	1.4	0.45	2.84	1.12
4	1.15	0.77	0.95	0.97	0.82	0.51	0.46	2.15	0.48	2.31	1.05
5	0.32	0.29	0.39	0.25	0.43	0.54	0.58	0.71	0.5	0.28	0.42
6	0.7	0.46	0.43	0.61	0.14	0.76	0.34	0.44	0.52	0.88	0.52
7	0.5	0.89	0.71	0.35	0.66	0.23	0.97	0.59	0.55	0.59	0.6
8	0.43	0.26	1.27	0.22	0.21	0.83	0.18	0.5	0.6	0.39	0.43
9	0.82	0.19	0.65	0.56	0.61	0.37	0.24	0.74	0.59	0.73	0.55
10	0.85	0.33	0.83	0.57	0.57	0.82	0.22	0.86	0.68	0.65	0.63
1S	0.67	0.29	0.39	0.24	0.21	0.42	0.35	0.58	0.43	0.29	0.38
2S	0.57	0.36	0.45	0.23	0.14	0.59	0.58	0.54	0.53	0.67	0.46
3S	0.53	0.46	0.65	0.35	0.43	0.69	0.24	0.5	0.56	0.39	0.48
Min.	0.32	0.19	0.39	0.22	0.14	0.23	0.18	0.44	0.42	0.38	0.38
Max.	1.15	1.46	1.37	0.97	0.96	0.87	1.43	2.15	0.68	2.84	1.12
Mean	0.65	0.56	0.72	0.49	0.48	0.60	0.54	0.9	0.52	0.91	0.62
SD	0.23	0.46	0.36	0.31	0.26	0.20	0.36	0.53	0.07	0.78	0.23

The results of enrichment factor for heavy metals of the soil and Shatt Al-Hilla Sediment according classification in Table-3 shows that the all heavy metals in samples (1, 2, 3, 4, 6, 9, 10, 2S, and 3S) were within Ef<2 indicate to depletion to minimal enrichment (i.e. no or minimal pollution). While Cd in Sample (5), Co in the sample (7), Cr in the sample (8) and Mn in the sample (1S) are within 2 ≤ EF < 5 indicate to moderate enrichment (Table-10.A and Figure-4(A, B, and C).

According to the results of contamination factor (Cf) and classification in Table-4 for heavy metals of the soil and Shatt Al-Hilla Sediment show that the all heavy metal in samples (1, 5, 6, 7, 9, 10, 1S, 2S and 3S) lay within Cf < 1 Low contamination. While sample "2" (Cd and Fe), sample "3" (Ni, Cr, Pb, and Cd) sample "4"(Mn and Fe) and sample "8' (Cr) are within $1 \leq Cf < 3$ moderate contamination as shown in Table-10.B and Figure 5-(A, B, and C).

The pollution load index result of all the soil and Shatt Al-Hilla sediment samples are less than one indicate that "no pollution" are present, except sample 3 where the PLI value higher than 1 indicates the samples have been "polluted " as shown in Table-10 A and Figure-6.

The modified degree of contamination (mCd) data according to classification in the Table-5 indicates nil to a low degree of contamination for all of the soil and sediments samples (Table-10B and Figure- 7).

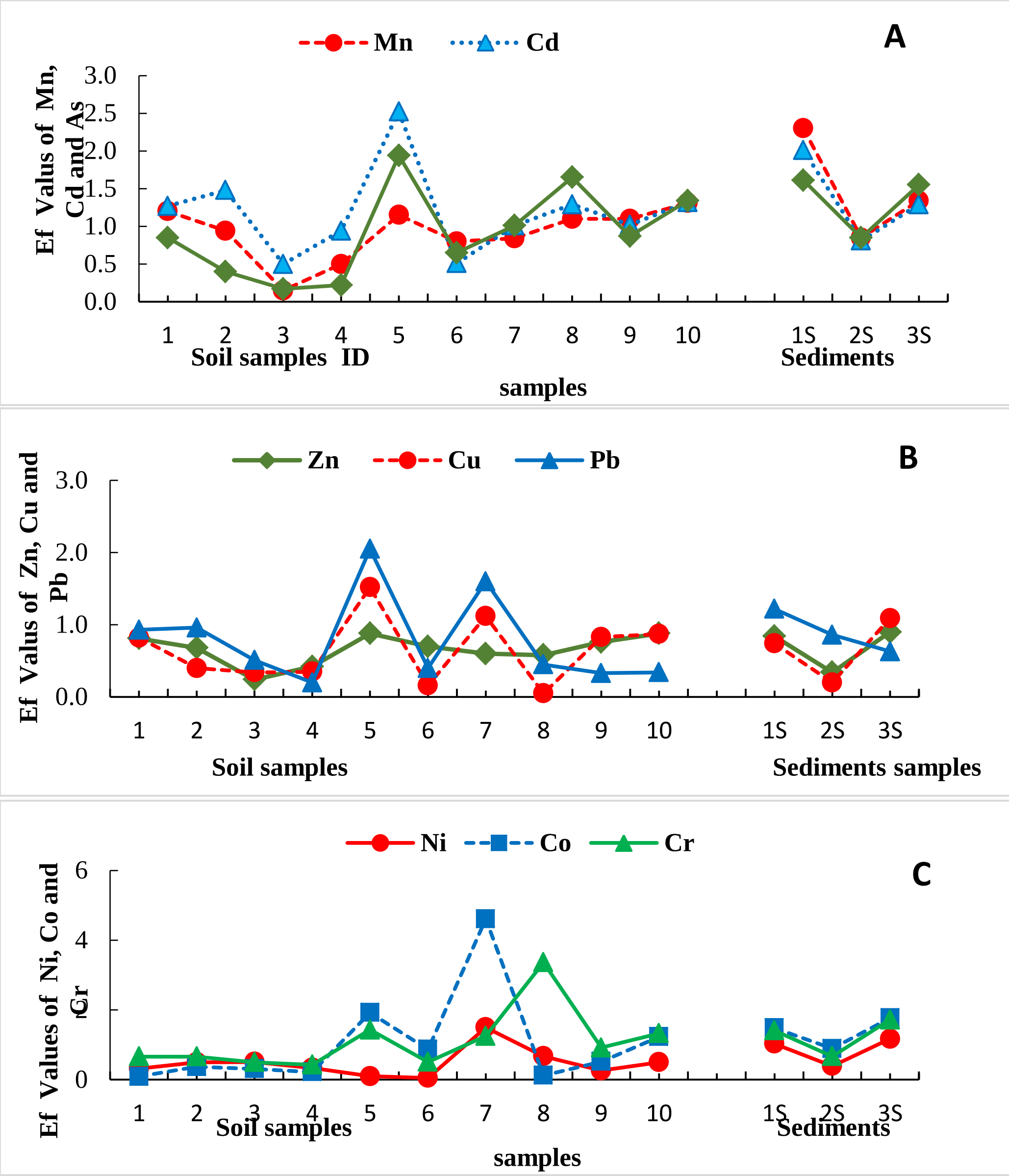

Figure 4 A , B, C-Variation pattern of Enrichment factor values in Soil and Shatt Al-Hilla sediment samples.

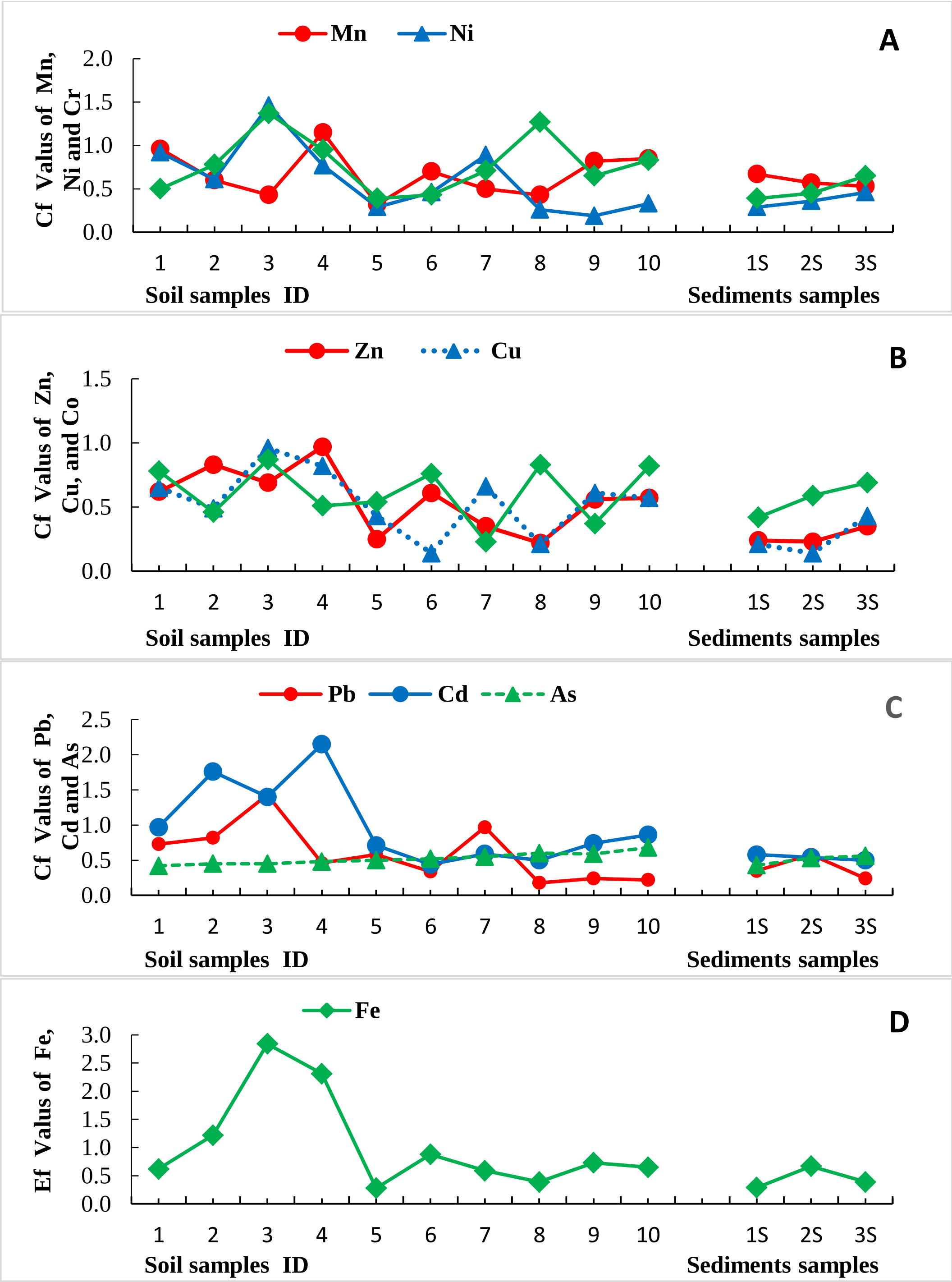

Figure 5-A,B and C:Variation pattern of contamination factor (Cf) values in Soil and Shatt Al-Hilla sediment samples.

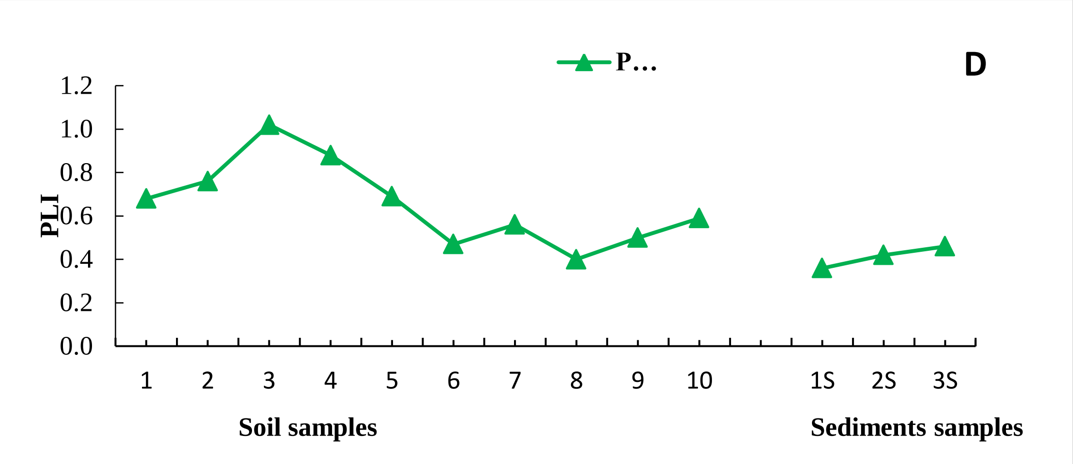

Figure 6- Variation pattern of the pollution load index values in Soil and Shatt Al-Hilla sediment samples.

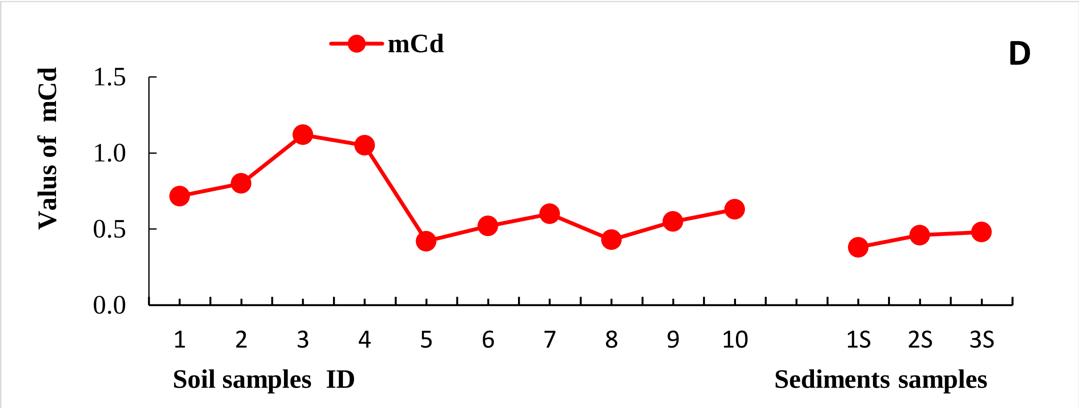

Figure 7-Variation pattern of the modified degree of contamination (mCd) in Soil and Shatt Al-Hilla sediment samples.

5. Conclusions

In Study area, pH value of Soil and Shatt Al-Hilla sediment within the alkaline range, and the results of the organic matter analysis have relatively low organic matter content.

The results of enrichment factor for heavy metals of the soil and Shatt Al-Hilla sediment show that the all heavy metal in soil samples (1, 2, 3, 4, 6, 9 and 10), and sediment samples (2S, and 3S) within Ef<2 indicate to depletion to minimal enrichment (i.e. no or minimal pollution). While Cd in the sample (5), Co in the sample (7), Cr in the sample (8) and Mn in the sample (1S) are within $2 \leq EF < 5$ indicate to Moderate enrichment. The results of contamination factor (Cf) for heavy metals of the soil and Shatt Al-Hilla sediment show that the all heavy metals in soil samples (1, 5, 6, 7, 9, and 10) and sediment samples 1S, 2S, and 3S) within Cf < 1 -Low contamination. While sample "2" (Cd, and Fe) sample "3" (Ni, Cr, Pb, and Cd) sample "4" (Mn, and Fe) and sample "8'(Cr) are within $1 \leq Cf < 3$ moderate contamination. The pollution load index result of all the soil and Shatt Al-Hilla sediment samples are less than one indicate that "no pollution" are present, except sample 3 where the PLI value higher than 1 indicates the samples have been "polluted ". The modified degree of contamination (mCd) data indicates nil to a low degree.

References

1. Hashmi, M. Z., Yu, C., Shen, H., Duan, D., Shen, C., Lou, L. and Chen, Y. **2013.** Risk assessment of heavy metals pollution in agricultural soils of siling reservoir watershed in Zhejiang province, China. Biomed Research International, 2013.
2. Kabata-Pendias, A. **2010.** *Trace elements in soils and plants*. CRC press.
3. AL-Zubaidy, A.H. and Pagel, H. **1974.** *Chemical characteristics of some Iraqi soil*, Beitrage trop. land writsch veferhamed, 12 p.

4. Matschullat, J., Ottenstein, R. and Reimann, C. **2000.** Geochemical background–can we calculate it? Environmental Geology, **39**(9): 990–1000.
5. Gałuszka, A. **2006**. Methods of determining geochemical background in environmental studies. Problems of Landscape Ecology. *Polish Association of Landscape Ecology*. Warsaw (in Polish with English Summary), **16**(1): 507–519.
6. Rodrigues, de L., Sueli, A., Malafaia, Guilherme, Costa, Terezinha, A. and Nalini-Jr, H. A. **2014.** Background values for chemical elements in sediments of the Gualaxo Do Norte River basin, MG, Brazil. Revista de Ciências Ambientais, **7**(2): 15-32.
7. Feng, H., Han, X., Zhang, W.G. and Yu, L. Z. **2004.** "A Preliminary Study of Heavy Metal Contamination in Yangtze River Intertidal Zone Due to Urbanization," *Marine Pollution Bulletin*, . **49**(11-12): 910-915.
8. Choi, K., Kim, S., Hong, G. and Chon, H. **2012.** "Distribution of Heavy Metals in the Sediments of South Korean Harbors," *Environmental Geochemical Health*, **34**(1): 71-82.
9. Sinex and G. Helz, "Regional Geochemistry of Trace Elements in Chesapeak Bay Sediments," *Environmental Geology*, **3**(6): 315-323.
10. Emad A. M. S. Tahseen A. Z, Ahmed S. A. **2012.** Assessment of Heavy Metals Pollution in the Sediments of Euphrates River, Iraq, *Journal of Water Resource and Protection*, Published Online, (http://www.SciRP.org/journal/jwarp).
11. Tippie, V. **1984.** "An Environmental Characterization of Chesapeake Bay and a Framework for Action," In: V. Kennedy, Ed., The Estuary as a Filter, Academic Press, New York, pp. 467-487.
12. Sutherland, R. A**. 2000.** Bed sediment-associated trace metals in an urban stream, Oahu, Hawaii. Environmental Geology, **39**(6): 611–627
13. Mmolawa, K., Likuku, A. and Gaboutloeloe, G. **2011**. "Assessment of Heavy Metal Pollution in Soils along Roadside Areas in Botswana," *African Journal of Environmental Science and Technology*, **5**(3): 186- 196.
14. Varol, M. **2011.** Assessment of heavy metal contamination in sediments of the Tigris River (Turkey) using pollution indices and multivariate statistical techniques. *Journal of Hazardous Materials*, **195**: 355–364.
15. Hakanson, L. **1980.** An ecological risk index for aquatic pollution control. A sedimentological approach. *Water Research*, **14**(8): 975–1001.
16. Chakravarty, M. and Patgiri, A. D. **2009.** Metal pollution assessment in sediments of the Dikrong River, NE India. *Journal of Human Ecology*, **27**(1): 63–67.
17. Abrahim GMS, Parker R. J**. 2008.** Assessment of heavy metal enrichment factors and the degree of contamination in marine sediments from Tamaki Estuary, Auckland, New Zealand. *Environ Monit Assess*, **136**: 227–238.
18. Black, C.A. **1965.** *Methods of soil analysis*. Part I, American Society of Agronomy. Madison, Wisconsin, USA. 1572 P.
19. Richards, L. A. **1954.** *Diagnosis and Improvement of Saline and Alkali Soils*. U.S. Department Agriculture Handbook 60. U.S. Gov. Printing Office, Washington, DC.
20. Hazelton PA, Murphy B. W. **2007.** '*Interpreting Soil Test Results What Do All The Numbers Mean*?' CSIRO Publishing Melbourne.
21. Appelo, C. A. J. and Postma, D**. 2005.** *Geochemistry, groundwater, and pollution*. A.A. Balkeme publishers, Great British, 668 P.
22. Hodges, L. **1973.** *Environmental pollution*, Holt Rinehart and Winstone ,Inc, 370 P.
23. USEPA, "US Environmental Protection Agency, **1999.** *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion facilities*," Appendix E: Toxicity Reference Values, Vol. 3.
24. WHO, **2004.** *Guidelines for Drinking-Water Quality*, 2nd Edn., Vol. 1, Recom-mendations, Geneva.