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Environmental Assessment of Trace Elements Concentration and Distribution in Surface Soils at North Baiji City, Iraq

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Abstract

To assess the environmental pollution of the soil at north Baiji City, the concentration of As, Se, Cr, Co, Cu, Cd, Sb, Mn, Mo, Ni, Pb, V, U, Sr, Ba, Ag, Rb, Li, Sn, Bi, Tl and Zn were determined in 18 sites. Results showed that the range concentrations of metal in mg/kg were Mo (0.84-2.15), Cu (17.62-78.77), Pb (9.89-19.19), Zn (39.5-374.7), Ag (0.064-0.14), Ni (90.7-210), Co (12.8-26.6), Mn (407-863), As (4-7.1), Cd (0.18-0.37), Sb (0.38-0.77), Bi (0.06-0.17), V (74-281), Cr (128-287), Li (15.3-24.4), Tl (0.14-0.24), Sn (0.6-1.7), Rb (28-51.2), U (1.2-1.5), Se (0.3-0.6), Ba (173-310), Sr (218-1270). Based on enrichment factor (EF) of trace elements, Mo, Cu, Pb, Mn, Bi, U, V, Li, Sn, Rb, Ba and Tl were showed deficiency to minimal enrichment, while Zn, Ag, Co, Cd, Sb, Sr and Cr were showed moderate enrichment, whereas As, Ni, and Se were showed significant enrichment. According to contamination factor (CF), Mo, Cu, Mn, Bi, U, V, Sn, Rb, Ba and Tl were showed low contamination, while Pb, Zn, Ag, Co, Cd, Sb, Cr, Li and Sr were showed moderate contamination, whereas As was responsible for considerable contamination, whereas Ni and Se were showed very high contamination. Based on PLI, all sampling sites are considered to be polluted except sites 3 and 10.

Keywords: Contaminated soils, enrichment factor, contamination factor, pollution load index, trace elements.

تقييم بيئي لتراكيز العناصر النزرة وتوزيعها في ترب سطحية شمال مدينة بيجي، العراق

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الخلاصة

لتقييم التلوث البيئي للتربة شمال مدينة بيجي، تم تحديد تراكيز الزرنيخ، السيلنيوم، الكروم، الكوبالت، النحاس،الكادميوم، الانتيموني، المنغنيز، الموليبديوم، النيكل، الرصاص، الفناديوم، اليورانيوم،السنتروتيوم، الباريوم، الفضة، الربيديوم، الليثيوم، القصدير، الثاليوم، البزموث والزنك في 18 موقع تربة سطحية. ان مدى تراكيز العناصر الاثارية (mg/kg) كانت موليبديوم (0.84 – 2.15)، نحاس (17.62 – 78.77)، رصاص (9.89 – 19.19)، زنك (39.5 – 374.7)، فضة (0.064 – 0.14)، نيكل (90.7 – 210)، كوبلت (12.8 – 26.6)، منغنيز (407 – 863)، زرنيخ (4 – 7.1)، كادميوم (0.18 – 0.37)، انتيموني (0.38 – 0.77)، بزموث (0.06 – 0.17)، فناديوم (74 – 281)، كروم (128 – 287)، ليثيوم (15.3 – 24.4)، ثاليوم (0.14 – 0.24)، قصدير (0.6 – 1.7)، ربيديوم (28 – 51.2)، يورانيوم (1.2 – 1.5)، سيلينيوم (0.3 – 0.6)، باريوم (173 – 310)، سنترونتيوم (218 – 1270). اعتمادا على عامل الاغناء (EF) للعناصر الاثارية، اظهرت العناصر مولوبيديوم، نحاس، رصاص، منغنيز، بزموث، يورانيوم،

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فناديوم، ليثيوم، قصدير، ربيديوم، باريوم وثاليوم عدم وجود اغناء لها في التربة، بينما اظهرت العناصر زنك، فضة، كوبالت، كادميوم، انتيموني، سنترونتيوم والكروم وجود اغناء معتدل لهذه العناصر في التربة، في حين اظهرت العناصر زرنيخ، نيكل، وسيلينيوم وجود اغناء مهم. وفقا لعامل التلوث (CF) اظهرت العناصر موليبديوم، نحاس، منغنيز، بزموث، يورانيوم، فناديوم، قصدير، ربيديوم، باريوم وثاليوم وجود تلوث واطئ للتربة بهذه العناصر، بينما اظهرت العناصر رصاص، زنك، فضة، كوبالت، كادميوم، انتموني، كروم، ليثيوم وسنترونتيوم وجود تلوث معتدل، في حين كل من الزرنيخ، النيكل والسيلينيوم اظهرت تلوثا كبيرا. اعتمادا على دليل التلوث (PLI) ، اعتبرت جميع المواقع ملوثة باستثناء موقعي 3 و 10 .

Introduction

Rapid growth of the world population and the pursuit of material prosperity have generated a massive expansion in industrial and agricultural production in recent decades. The associated increase in energy consumption and the generation of waste have enormously increased the pressure on the natural environment and have led to changes in the composition of the atmosphere, soil, fresh water resources, seas, and oceans. This, in turn, has led to destabilization of natural ecosystems and a deterioration of environmental quality [1]. Soils are defined as dynamic natural bodies composed of mineral and organic solids ،gases, liquids and living organisms which have properties resulting from integrated effects of climate, organisms, parent material and topography over periods of time and which can serve as a medium for plant growth [2].The major anthropogenic sources of trace elements input to soils are: 1) atmospheric deposition, arising from coal and gasoline combustion, nonferrous and ferrous metal mining, smelting, and manufacturing, waste incineration, production of phosphate fertilizer and cement, and wood combustion; 2) land application of sewage sludge, animal manure and other organic wastes and co-products from agriculture and food industries; 3) land disposal of industrial co-products and waste, including paper industry sludge, coal fly ash, bottom fly ash and wood ash; and 4) fertilizers, lime and agrochemicals (pesticides) use in agriculture [3]**.** Soil pollution is defined as the build-up in soils of persistent toxic compounds, chemicals, salts, radioactive materials, or disease causing agents, which have adversely effects on plant growth and animal health. The most common chemicals involved in causing soil pollution are petroleum hydrocarbons, heavy metals, pesticides and solvents [4]. The study of heavy metal deposition and accumulation is of increasing interest because of the awareness that heavy metals present in soils may have negative consequences on human health due to elevated uptake of heavy metals by corps which affect food quality and safety. Besides they are non-biodegradable and persistent contaminants in the environment [5]. The aim of this study is to investigate the level of trace element concentrations and distribution in surface soils and to assess the contamination status using various metal assessment indices.

Study Area:

The study area is located around the industrial district (i.e. North Refineries Company, Detergents plant, Thermal Power Plant and Gaseous Power Plant) to the north Baiji City and lies in between northern 351160 to 371087 and eastern 3862912 to 3887201 in UTM units (Figure-1).

The rural area within the studied area including many villages are; Al-hinshi, Shwaish and Al-bojwari villages are located to the east to northeast of North Refineries Company and detergents plant and to the south to southeast of Thermal and Gaseous power plants. Breej village is located to the north of industrial district. Baiji city is located to the south of industrial district. Al-600 house and Baiji-Mousel highway are located to the west of industrial district. On the east bank of Tigris River there is Al-laqlaq village.

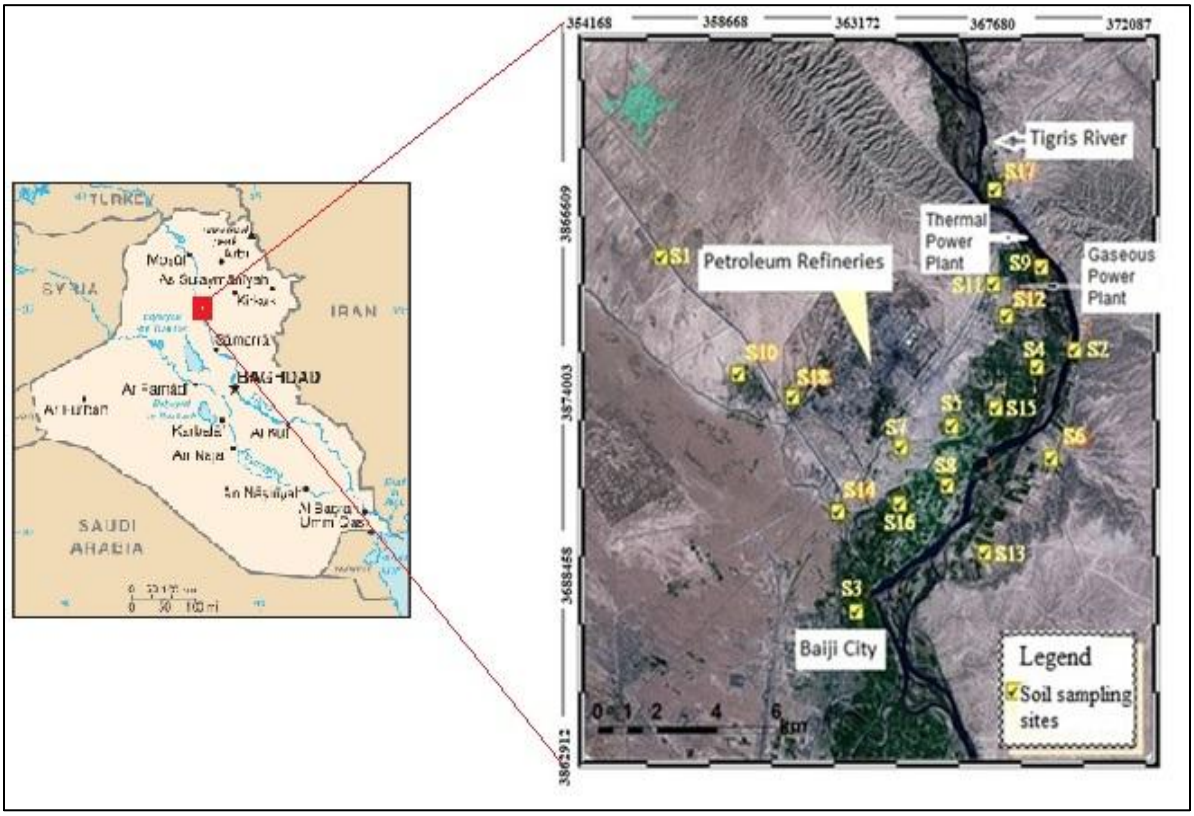

Figure 1- the study area.

Geology of the study area:

The study area is located within Hemrin-Makhul Subzone or foothill zone which characterized by a thick cover of sediments [6]. The old rock exposed is back to Fatha formation (Middle Miocene) characterized by the prevailing evaporates facies which consist of anhydrite, gypsum and halite refer to shallow marine environment [7].

Fatha formation is covered by Injana formation sediments (Upper Miocene) which consists of silty claystone, siltstone and sandstone with thin layers of gypsum nodules. Injana formation is covered by quaternary deposits (Pleistocene and Holocene) represented by river terraces deposits which consist of sandstone and sand, and flood plain deposits which consist of gravel, sand, silt and clay [8].

Material and Methods

Sampling Collection and Analysis:

Eighteen sampling sites were chosen for collection of soil from depth (0 – 25 cm), after removing leaves, grass and any large external objects (Table-1). The sampling was conducted on October 2013. The samples were placed in a polyethylene bags and transported to the laboratory for processing. The first step was drying the samples in the open air, crushed by hand in a porcelain mortar and sieved through a 2 mm screen. Air-dried <2 mm samples were stored in plastic bags and sent to Acmelabs/Canada for analysis. The digestion method of soils is called Ultratrace Geochemical Four-Acid Digestion which can be obtained by the following steps (Acmelabs 2014): the prepared sample is digested to complete dryness with an acid solution of (2:2:1:1) H_2O-HF-$HClO_4$-HNO_3. Then, 50% HCl is added to the residue and heated using a mixing hot block.

After cooling, the solutions are transferred to test-tubes and brought to volume using dilute HCl. Sample splits of 0.25g are analyzed by Enhanced ICP/ES and ICP/MS.

Table 1- Coordinates of the Soil Sampling Sites.

Site No.	Location name	Eastern	Northern
S1	Fuel Station	356546	3878539
S2	Al-laqlaq village	370370	3875698
S3	Jedaida village	363072	3867670
S4	Shwaish village	369122	3875162
S5	Al-bojwari village	366271	3873376
S6	Al-laqlaq village	369855	3872260
S7	Al-bojwari village	364576	3872706
S8	Al-bojwari village	366115	3871530
S9	Al-hinshi village	369273	3878246
S10	Al 600 house	359100	3874945
S11	Al-hinshi village	367647	3877717
S12	Old petroleum institute	368653	3876146
S13	Al-laqlaq village	367371	3869482
S14	Al-bojwari village	362448	3870724
S15	Campus of oils factory	367744	3873903
S16	Al-bojwari village	364532	3870971
S17	Breej village	368050	3881401
S18	New petroleum institute	360927	3874257

Assessment of Metal Contamination:

In order to assess the level of contamination and for a better estimation of anthropogenic input into soil, the Enrichment Factors (EF), Contamination Factor (CF) and Pollution Load Index (PLI) were estimated for some selected potentially hazardous elements evaluated in this study.

Enrichment factor (EF):

Geochemistry offers various methods for assessing anthropogenic influences. One of them is the use of geochemical calculations. When conducting studies on trace element concentrations in different environmental samples, several geochemical parameters may be established. One of the most commonly used is enrichment factor (EF) [9]. EF is a powerful tool to distinguish between anthropogenic and naturally occurring sources of heavy metals [10]. This factor was initially developed to speculate on the origin of elements in the atmosphere, precipitation, or seawater, but it was progressively extended to the study of soils, lake sediments, peat, tailings, and other environmental materials [11]. The following equation was used to calculate the EF [12].

$$EF = (C_m/C_{Al})_{sample} / (C_m/C_{Al})_{Earth's\ crust} \quad (1)$$

Where, $(C_m/C_{Al})_{sample}$ is the ratio of concentration of element (C_m) to that of Al (C_{Al}) in the soil or sediment sample and $(C_m/C_{Al})_{Earth's\ crust}$ is the same reference ratio in the earth's crust. Al was selected as the reference element, due to its crustal dominance and its high immobility [11, 13, and 14]. The reference value of Al is 7.8% [12].The world average elemental concentrations reported by [15] in the Earth's crust were used as reference in this study because regional geochemical background values for these elements are not available. Five contamination categories are recognized on the basis of the enrichment factor: EF< 2 states deficiency to minimal enrichment; 2≤EF<5, moderate enrichment; 5≤EF<20, significant enrichment; 20 ≤EF<40, very high enrichment; and EF > 40, extremely high enrichment [11, 16].

Contamination factor (CF):

The contamination factor is used to classify the level of contamination of metals in the soil samples by dividing the concentration of each metal in the soil or sediments by the baseline or background value [17-20]. Contamination factor is calculated as:

$$CF= (C_m)_{Sample} / (C_m)_{Background} \quad (2)$$

Where, $(C_m)_{Sample}$ is the concentration of a given metal in soil or river sediment, and $(C_m)_{Background}$ is meaning background contents of trace elements in continental crust. The following terminologies are used to describe the contamination factor: CF <1, low contamination factor; 1≤CF<3, moderate contamination factors; 3≤CF<6, considerable contamination factors; and CF≥6, very high contamination factor [5] and [21-23].

Pollution load index (PLI):

The PLI is able to give an estimate of the metal contamination status and the necessary action that should be taken. PLI is introduced by [24]. The PLI > 1 is polluted; whereas < 1 indicates no pollution [25], [26], [20]. This parameter is expressed as:

$$PLI= (CF1*CF2*CF3*\ldots..*CF_n)^{1/n} \quad (3)$$

Where, n is the number of metals.

Results and Discussion

Concentration of heavy metals in the soils of study area:

The trace elements contents in soils are presented in Table-2.

Soil Contamination Assessment:

In view of geochemistry results, the heavy metals in the soil of study area show anomalous concentrations which are derived from natural inputs and human activities. For a better estimation of anthropogenic input, enrichment factor (EF), contamination factor (CF), and pollution load index (PLI) should be considered.

Enrichment Factors (EF):

Mean EF values of elements in the surface soil were followed the order Ni> Se> As> Cd> Sb> Cr> Co> Ag> Sr> Zn> Li> Pb> Mo> V> Mn> Cu> U> Ba> Bi> Rb> Sn> Tl. Range and mean of EF value for elements in surface soil are listed in Table-3. Samples having EF value greater than 5 are considered to be contaminated with that certain element [12]. The highest EF values of Ni were at S11 and S16 respectively (Figure-2), indicating very high enrichment, while all other values suggesting significant enrichment, with a mean value of 14.07 (Table-3). This high EF values for Ni in surface soil may be related with oil combustion and agricultural activities (phosphate fertilizer) [15]. The EF values of arsenic, cadmium and cobalt were ranged from moderate to significant enrichment with a mean value of 5.69, 4.6, and 3.5 respectively (Table-3). The EF values of Cr and Sb were ranged from moderate to significant enrichment (Figure-2) with a mean value of 3.7 and 4.4 respectively (Table-3). The highest EF values of Ag was 6.41 at S11, suggesting significant enrichment, while all other EF values were within moderate enrichment category (Figure-3), with a mean value of 3.1 (Table-3).

Table 2- Concentration of trace elements in surface soil (mg/kg)

Site no.	Mo	Cu	Pb	Zn	Ag	Ni	Co	Mn	As	Cd	Sb	Bi	V	Cr	Li	Tl	Sn	Rb	U	Se	Ba	Sr
S1	1.10	22.89	11.84	64.1	0.078	147.6	18.9	497	4.0	0.20	0.40	0.06	104	197	19.0	0.19	1.0	42.4	1.5	0.3	215	278
S2	1.22	39.00	13.19	62.2	0.108	191.8	26.6	730	6.8	0.24	0.47	0.12	97	249	23.1	0.23	1.1	42.7	1.5	0.3	231	352
S3	0.97	18.48	9.89	39.5	0.082	90.7	12.8	407	4.0	0.18	0.38	0.06	74	128	15.3	0.14	0.6	28.0	1.3	0.3	173	218
S4	1.46	38.35	17.18	111.3	0.099	190.8	21.2	705	6.0	0.27	0.49	0.16	148	241	20.4	0.20	1.6	41.7	1.5	0.3	226	1270
S5	1.18	35.07	14.53	64.7	0.090	155.2	21.6	738	5.7	0.32	0.56	0.12	116	204	21.5	0.23	1.3	48.1	1.5	0.4	266	359
S6	2.15	27.26	13.25	88.3	0.140	199.9	19.4	833	6.1	0.28	0.47	0.13	99	217	21.3	0.16	1.2	40.9	1.4	0.4	254	691
S7	1.90	38.90	14.53	75.6	0.091	138.2	16.9	607	4.2	0.27	0.45	0.11	281	266	18.7	0.20	1.1	40.9	1.3	0.6	254	424
S8	1.50	78.77	18.95	75.4	0.085	118.4	19.8	608	6.5	0.24	0.58	0.09	133	203	19.8	0.19	2.0	43.4	1.4	0.3	282	316
S9	1.28	57.80	16.06	64.8	0.118	108.3	17.0	675	5.8	0.30	0.50	0.17	163	159	19.7	0.24	1.0	47.9	1.5	0.4	254	541
S10	1.02	27.29	10.46	61.4	0.064	96.3	13.6	498	4.4	0.21	0.43	0.06	69	185	24.4	0.22	1.0	35.7	1.2	0.3	187	484
S11	1.40	35.49	13.33	62.8	0.180	199.7	26.1	771	6.9	0.28	0.41	0.08	171	189	21.1	0.18	1.3	35.8	1.2	0.4	225	684
S12	1.63	69.43	19.19	93.9	0.111	187.2	15.8	863	7.1	0.37	0.77	0.11	215	201	21.2	0.22	1.1	47.7	1.5	0.3	270	933
S13	2.10	33.80	13.31	66.5	0.092	133.0	19.7	735	6.5	0.23	0.52	0.13	110	287	17.7	0.20	1.1	51.0	1.5	0.5	310	320
S14	1.33	17.62	17.51	67.1	0.087	146.7	23.2	481	4.5	0.31	0.43	0.09	201	223	20.5	0.21	1.0	33.3	1.2	0.6	220	751
S15	1.92	41.21	11.55	374.7	0.131	210.0	19.7	625	5.3	0.24	0.51	0.13	160	191	22.7	0.22	1.7	41.6	1.3	0.3	233	550
S16	1.74	29.70	15.23	61.1	0.095	193.0	20.3	595	5.6	0.27	0.50	0.09	88	212	19.7	0.19	1.0	44.0	1.2	0.4	257	399
S17	0.84	66.44	10.16	56.3	0.072	98.8	17.4	489	5.8	0.22	0.46	0.09	79	179	17.9	0.19	0.9	51.2	1.4	0.3	219	277
S18	1.86	27.26	11.46	72.2	0.096	167.2	20.5	620	5.2	0.19	0.44	0.08	91	190	18.8	0.20	1.0	40.9	1.2	0.4	231	368
Crustal average [15]	1.5	55	14	70	0.06	20	10	900	1.8	0.1	0.2	0.2	135	100	20	0.5	2.5	90	2	0.05	400	375

The EF value of Sr and Zn were fall within three categories which are deficiency to minimal, moderate and significant enrichment (Figure-3). The EF values of Mo, Pb Li and V were ranged from deficiency to minimal enrichment to moderate enrichment (Figure-3). The EF values of Cu were ranged from deficiency to minimal enrichment to moderate enrichment category. EF values of Mn, U, Ba, Bi, Rb, Sn and Tl were less than 2 (Figure-4) which is within deficiency to minimal enrichment, indicating that these elements in the surface soil are originated predominantly from lithogenous material [27].

Table 3- Range and mean of EF value of elements in the surface soil

Trace Element	EF value		EF category
	Range	Mean	
Mo	1.2 – 3	1.8	deficiency to minimal enrichment
Cu	0.5 – 2.3	1.2	deficiency to minimal enrichment
Pb	1.3 – 2.3	1.8	deficiency to minimal enrichment
Zn	1.4 – 9.3	2.2	moderate enrichment
Ag	2.1 – 6.4	3.1	moderate enrichment
Ni	9.1 – 21.3	14.0	significant enrichment
Co	2.7 – 5.6	3.5	moderate enrichment
Mn	0.9 – 1.8	1.3	deficiency to minimal enrichment
As	3.6 – 7.7	5.6	significant enrichment
Cd	3.2 – 6.3	4.6	moderate enrichment
Sb	3.3 – 6.6	4.4	moderate enrichment
Bi	0.4 – 1.4	0.9	deficiency to minimal enrichment
U	1.0 – 1.7	1.2	deficiency to minimal enrichment
V	1.1 – 3.6	1.8	deficiency to minimal enrichment
Cr	3.1 – 6.1	3.7	moderate enrichment
Li	1.5 – 2.5	1.8	deficiency to minimal enrichment
Se	9.6 – 22.2	13.9	significant enrichment
Sn	0.6 – 1.3	0.8	deficiency to minimal enrichment
Sr	1.2 – 5.66	2.4	moderate enrichment
Rb	0.6 – 1.2	0.8	deficiency to minimal enrichment
Ba	0.8 – 1.6	1.1	deficiency to minimal enrichment
Tl	0.5 – 0.9	0.7	deficiency to minimal enrichment

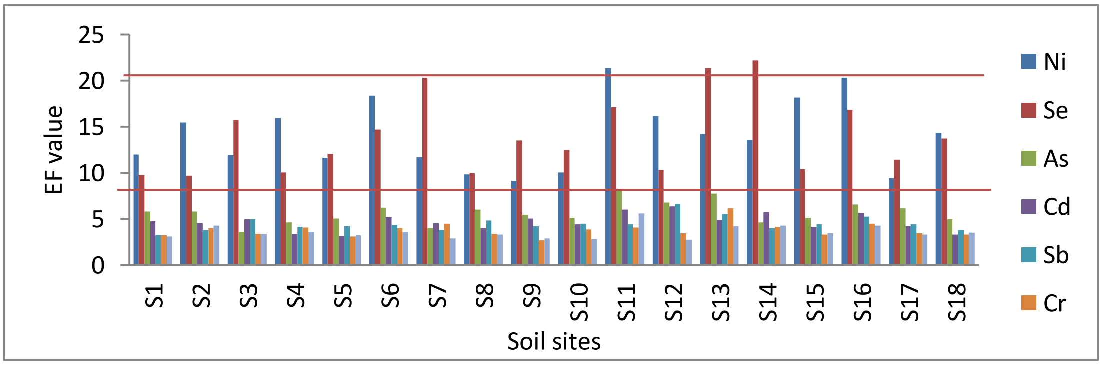

Figure 2- EF values of Ni, Se, As, Cd, Sb, Cr and Co in the Surface Soil.

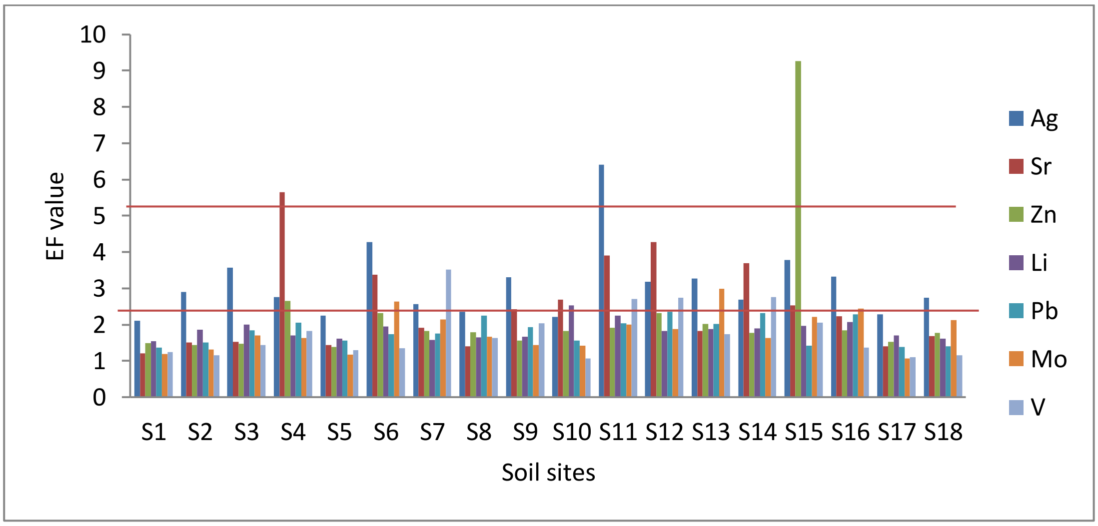

Figure 3- EF values of Ag, Sr, Zn, Li, Pb, Mo and V in the Surface Soil

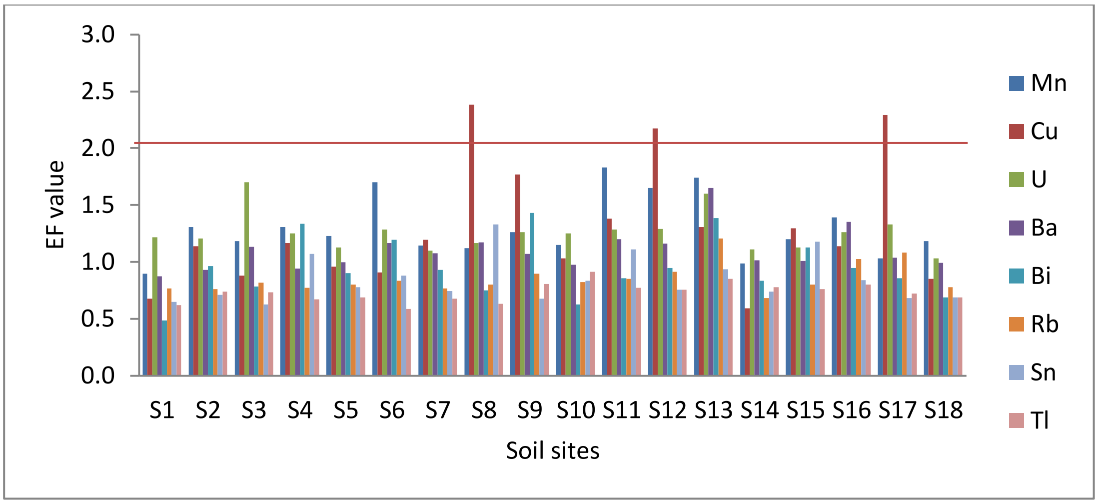

Figure 4- EF values of Mn, Cu, U, Ba, Bi, Rb, Sn and Tl in the surface soil

Contamination factor (CF):

Mean CF values of elements in the surface soil were followed the order Ni> Se> As> Cd> Sb> Cr> Co> Ag> Sr> Zn> Li> Pb> Mo> V> Mn> Cu> U> Ba> Bi> Rb> Sn> Tl. Range and mean of CF values for elements in surface soil are listed in Table -4. CF values of Se were ranged from 6.0 to 12.0 with a mean value of 7.56 (Table-4), indicating very high contamination due to industrial and agricultural activities [15]. Ni CF values ranged from considerable contamination at sites 3, 8, 9, 10 and 17 to very high contamination (Figure-5), suggesting that anthropogenic activities caused by fuel oil combustion (petroleum refiners) and agriculture are the main source [15], [28]. CF values of As and Cd were ranged from moderate to considerable contamination (Figure-5). CF values of Sb, Cr and Co were less than 3, implying moderate contamination, except S12 for Sb, indicating considerable contamination, may due to its location close to refineries and power generating plants, where fossil fuel combustion considered as anthropogenic source for Sb [29].

CF values Ag, Sr, Zn, Li, Pb, Mo and V were distributed between low moderate contamination, except sites 11, 4 and 15 for Ag, Sr and Zn respectively where showed considerable contamination (Figure-6), may due to closeness from industrial districts. CF values of Mn, Cu, U, Ba, Bi, Rb, Sn and Tl were < 1, indicating low contamination, except S12 for Mn and sites 8, 9, 12 and 17 for Cu where showed moderate contamination (Figure-5).

Table 4- Range and Mean of CF value of Elements in the Surface Soil

Trace Element	CF value of surface soil		CF category
	Range	Mean	
Mo	0.5 – 1.4	0.9	low contamination factor
Cu	0.3 – 1.4	0.7	low contamination factor
Pb	0.7 – 1.3	1.0	moderate contamination factor
Zn	0.6 – 5.4	1.2	moderate contamination factor
Ag	1.2 - 3.0	1.6	moderate contamination factor
Ni	4.5 – 10.5	7.7	very high contamination factor
Co	1.3 – 2.7	1.9	moderate contamination factor
Mn	0.5 – 1.0	0.7	low contamination factor
As	2.2 – 3.9	3.1	considerable contamination factor
Cd	1.8 – 3.7	2.5	moderate contamination factor
Sb	1.9 – 3.9	2.4	moderate contamination factor
Bi	0.3 – 0.8	0.5	low contamination factor
U	0.6 – 0.7	0.6	low contamination factor
V	0.5 – 2.1	0.9	low contamination factor
Cr	1.3 – 2.9	2.0	moderate contamination factor
Li	0.8 – 1.2	1.0	moderate contamination factor
Se	6.0 – 12.0	7.5	very high contamination factor
Sn	0.2 – 0.8	0.4	low contamination factor
Sr	0.5 – 3.3	1.3	moderate contamination factor
Rb	0.3 – 0.5	0.4	low contamination factor
Ba	0.4 – 0.7	0.6	low contamination factor
Tl	0.2 – 0.4	0.4	low contamination factor

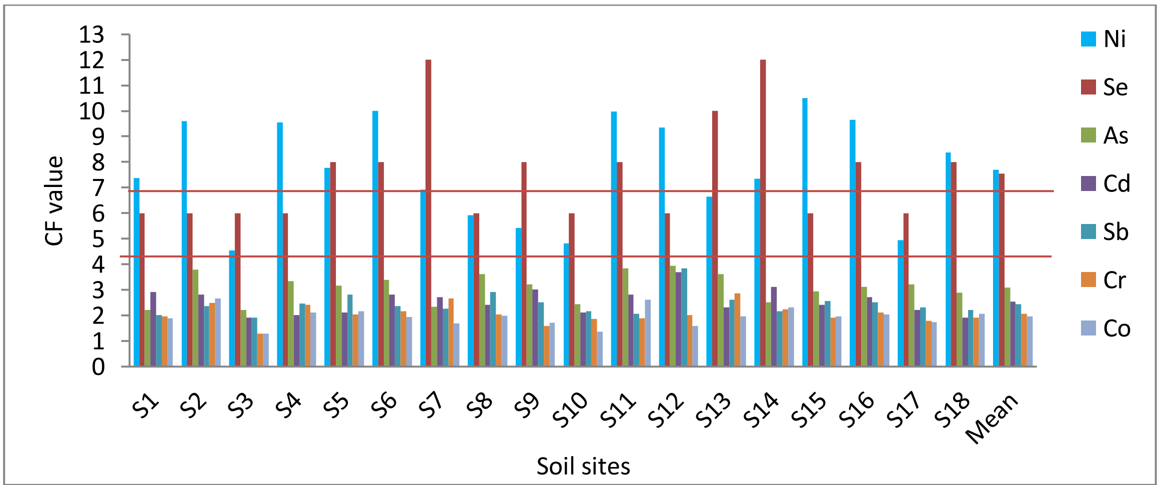

Figure 5- CF value of Ni, Se, As, Cd, Sb, Cr and Co in the Surface Soil

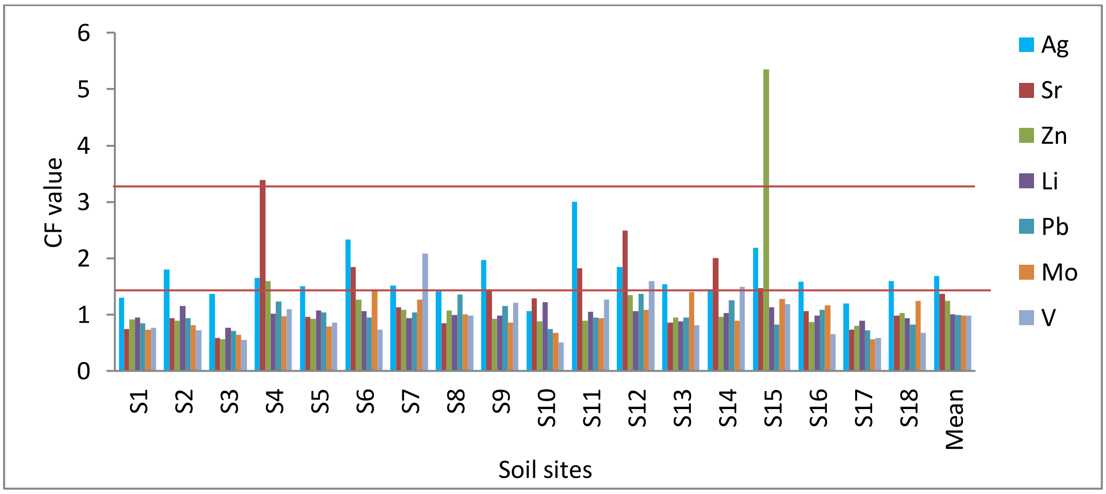

Figure 6- CF value of Ag, Sr, Zn, Li, Pb, Mo and V in the surface soil

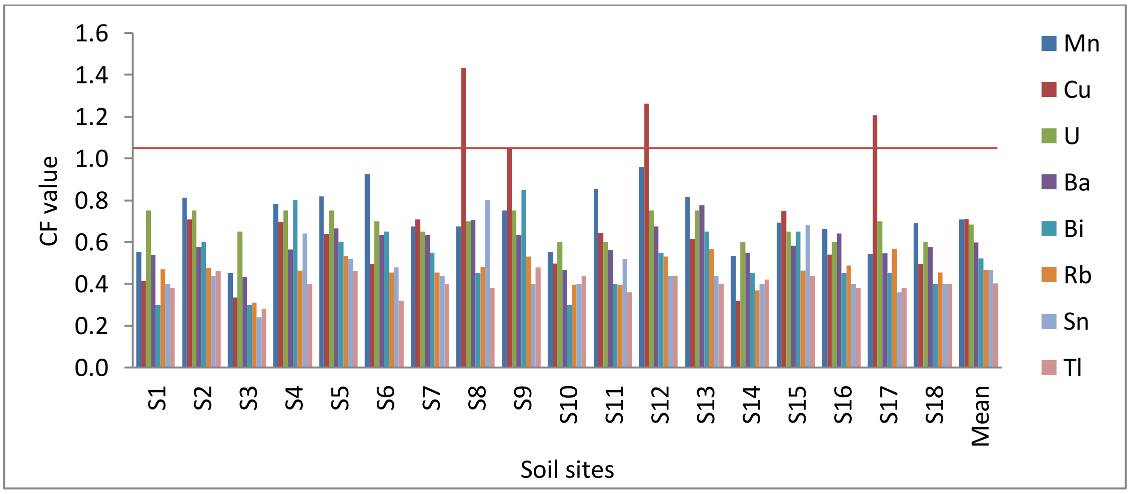

Figure 7- CF value of Mn, Cu, U, Ba, Bi, Rb, Sn and Tl in the Surface Soil

Pollution load index (PLI):

PLI values of 18 sites of surface soil were > 1 except S3 and S10 (Figure -8), indicating that the surface soil at north Baiji city is under load of pollution due to industrial and agricultural activities.

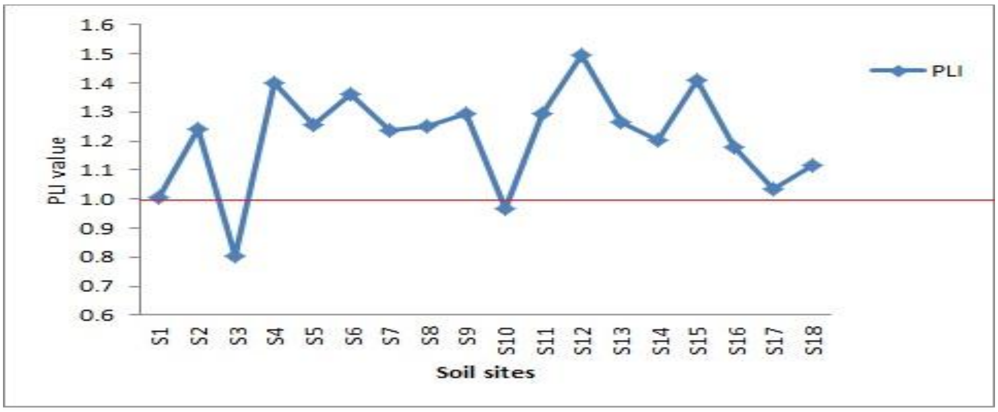

Figure 8- PLI value of the surface soil of Study Area

Conclusions

Results showed that the range concentrations of trace elements in mg/kg were Mo (0.84-2.15), Cu (17.62-78.77), Pb (9.89-19.19), Zn (39.5-374.7), Ag (0.064-0.14), Ni (90.7-210), Co (12.8-26.6), Mn (407-863), As (4-7.1), Cd (0.18-0.37), Sb (0.38-0.77), Bi (0.06-0.17), V (74-281), Cr (128-287), Li (15.3-24.4), Tl (0.14-0.24), Sn (0.6-1.7), Rb (28-51.2), U (1.2-1.5), Se (0.3-0.6), Ba (173-310), Sr (218-1270).

The calculated results of EF of trace elements revealed that Zn, Ag, Co, Cd, Sb, Sr, Cr, As, Se and Ni showed moderate to significant enrichment in the surface soil, while for CF the calculated results showed that Pb, Zn, Ag, Co, Cd, Sb, Cr, Li, Sr, As, Se and Ni were between moderate to very high contamination. EF and CF of Ni, Se and as recorded high values indicating that these elements are mainly originate from anthropogenic activities (industrial and agricultural). Based on PLI, all sampling sites are considered to be polluted except sites 3 and 10.

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