Tikrit Journal of Pure Science Vol. 25 (3) 2020

TJPS

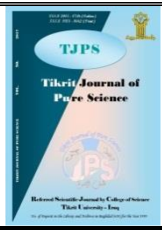
IASJ

المجلات الاكاديمية العراقية

Tikrit Journal of Pure Science

ISSN: 1813 – 1662 (Print) --- E-ISSN: 2415 – 1726 (Online)

Journal Homepage: http://tjps.tu.edu.iq/index.php/j



Investigating Impact of Industrial and Agricultural Activities on Surface Soil Contamination Using Pollution Indices, North Baiji City, Salah Alden Governorate, Iraq

Mahmood Fadhil Abed

Applied Geology Department, College of Sciences, Tikrit University, Tikrit, Iraq

https://doi.org/10.25130/tjps.v25i3.250

ARTICLE INFO.

Article history:

-Received: 27 / 1 / 2020

-Accepted: 5 / 4 / 2020

-Available online: / / 2020

Keywords: Trace elements, geoaccumulation index, ecological risk factor, surface soil

Corresponding Author:

Name: Mahmood Fadhil Abed

E-mail: dr.mahmood@tu.edu.iq

Tel:

ABSTRACT

A total of 18 surface soil samples were collected from surrounding of industrial district at north Baiji town, and the concentration of seven trace elements (i.e. Cu, Pb, Zn, Ni, As, Cd and Cr) were analyzed. The geo-accumulation index, pollution index, Nemerow pollution index, ecological risk factor and potential ecological risk index were utilized to assess soil contamination by trace elements. The mean values of geo-accumulation index showed that the study area soils are ranged from moderate to heavy contamination by Ni and slight contamination by As, Cd and Cr and uncontaminated by Zn, Pb and Cu. According to categories of pollution index, the surface soil of study area considers strongly polluted by Ni, moderately polluted by Cr and non-polluted by Cu, Zn, As, Pb and Cd. The Nemerow pollution index values of study area showed 11% of sites are slightly polluted, 17% of sites are moderately polluted and 72% of sites are seriously polluted. According to Eco- risk factor for an individual metal, the values showed moderate to considerable ecological risk by Cd, low to moderate ecological risk by Ni and low ecological risk for Cu, Zn, As, Pb and Cr. For Eco-risk index for metals, the results also showed that 27.8% of sites are low potential ecological risk and 72.2% of sites are moderate potential ecological risk.

Introduction

The increasing growth of world inhabitants and trying to achieve material prosperity have produced a tremendous expansion in industrial and agricultural production in recent decades. The conjugated increasing in energy consumption and the producing of waste have extremely increased the pressure on the natural environment and have resulted in destabilization of natural ecosystems and a deterioration of environmental quality [1]. Soil plays an important role in the terrestrial environment and acts as a reservoir or sinks for many kinds of pollutants [2].The major anthropogenic sources of trace elements input to soils are: the deposition from atmosphere, applying sewage sludge, dispose of (garbage, waste, or unwanted material), as well as fertilizers, lime and agrochemicals (pesticides) used in agriculture [3]. Contaminated soil is the presence of pollutants in soils at concentrations above background levels that pose a potential health or ecological risk. The study of trace element deposition and accumulation is of increasing interest because of the awareness that trace elements present in soils may have negative consequences on human health due to elevated uptake of trace elements by corps which affect food quality and safety. Besides they are non-biodegradable and persistent contaminants in the environment [4].

Many of inorganic potentially toxic metals are added to the environmental due to human activities. Petroleum refineries release metal pollutants (e.g. arsenic, cadmium, chromium, copper, lead, nickel, vanadium, zinc) into the surrounding environment [5]. Applying fertilizers and pesticides are likely sources of heavy metals in agricultural soils [6],7].

Industrial district (Baiji Refineries Company, Detergents plant, Thermal Power Plant and Gaseous Power Plant) which locate to the north of Baiji City contributes solid, liquid and gaseous wastes into the surrounding environment. Some of those wastes could contain harmful components such as trace elements which are indestructible and most of them have toxic effects on living organisms, when permissible concentration levels are exceeded. Furthermore, the study area is affected by agricultural activity which considers another source for trace elements due to fertilizers. The objective of this research is to investigate the soil contamination by some trace elements using some pollution indices such as geo-accumulation index, pollution index, nemerow pollution index, ecological risk factor and potential ecological risk index.

The study area:

The study area is situated close to the industrial district (i.e. Baiji Refineries Company, Detergents plant, Thermal Power Plant and Gaseous Power Plant) to the north Baiji City and within rural area and lies in between northern 351160 to 371087 and eastern 3862912 to 3887201 in UTM units (Figure.1). The rural area including several villages are; Al-hinshi village, Shwaish village and Albojwari village are located to the east to northeast of Baiji 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 town is located to the south of industrial district. Al-600 house and Baiji-Mosul highway are located to the west of industrial district. On the east bank of Tigris River there is Al-laqlaq village.

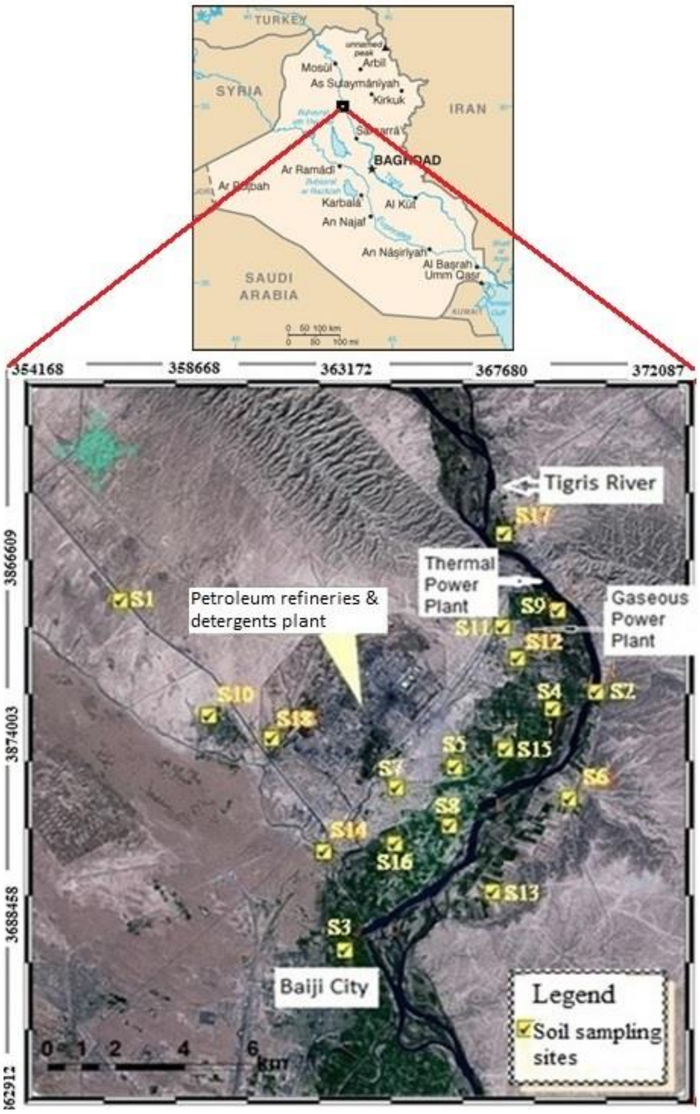


Figure 1. Location map

Geology of study area:

The study area is located within Hemrin-Makhul Subzone or foothill zone which characterized by a thick cover of sediments [8]. The old rocks exposed are back to Fatha Formation (Middle Miocene) characterized by the prevailing evaporates facies which consist of anhydrite, gypsum and halite refer to shallow marine environment [9]. The outcrops of Fatha Formation could see along Tigris River to the north of study area. Fatha Formation is overlying by Injana Formation (Upper Miocene) which consists of silty claystone, siltstone and sandstone with thin layers of gypsum nodules [8]. 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 [9]. Baiji soil is derived from erosion of exposed sedimentary rocks within the region, especially the rocks of the Makhoul mountain range, the most important of which are the rocks from Miocene epoch, represented by gypsum, limestone and mud rocks of Fatha Formation and sandstones and mud rocks of Injana Formation [10].

Material and Methods

Eighteen sample of surface soils were collected from depth (0 – 25 cm), after eliminating grass and leaves (Table.1). The sampling was done on October 2013. Those Samples were placed in plastic container then transmitted to the laboratory for processing. Bulk soil samples were air-dried at room temperature for 72 hours, smashed 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 by Enhanced ICP/ES and ICP/MS.

Table 1: Coordinates of the Soil Sampling Sites at Study Area

Site no.	Location	Eastern	Northern
S1	Jazerat Al-arab Fuel Station	356546	3878539
S2	Al-laqlaq village	370370	3875698
S3	Jedaida square	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	Campus of Oils Factory	367647	3877717
S12	Old petroleum institute	368653	3876146
S13	Al-laqlaq village	367371	3869482
S14	Al-bojwari village	362448	3870724
S15	Shwaish village	367744	3873903
S16	Al-bojwari village	364532	3870971
S17	Breaj village	368050	3881401
S18	New petroleum institute	360927	3874257

Contamination assessment methods

For assessing the degree of pollution and for a better estimation of anthropogenic input into soil, some pollution indices were used as follow:

Geoaccumulation Index (I_{geo})

The I_{geo} evaluates contamination degree of trace metals in soils through comparison the current concentration with the pre-industrial concentration. The index has developed by [11]. Geo-accumulation index can be computed by applying the below equation [12], [13], [14]:

$$\mathbf{I_{geo} = \log_2 [C_n / 1.5\, B_n]} \quad ......(1)$$

Where C_n is the measured value of a given metal "n" in the tested soil, and B_n is the background value of the same metal in the crustal average [2]. The factor 1.5 was applied as a correcting for background value [15], and minimizing lithogenic variables [16]. Both [11] and [17] referred to seven classes which are: (I_{geo} ≤0) no contamination; (0 < I_{geo} ≤ 1) slight contamination; (1< I_{geo} ≤ 2) moderate contamination; (2 < I_{geo} ≤ 3) moderate to heavy contamination; (3 < I_{geo} ≤ 4) heavy contamination; (4 < I_{geo} ≤ 5) heavy to extreme contamination; (I_{geo} > 5) extreme contamination.

Index of Pollution (Pi)

This index is applied for assessing the pollution caused by a metal and indicates to the proportion of the measured concentration of the involved metal and the maximum permissible concentration of that metal in soil [18]. As the index of pollution decreases, the degree of pollution decreases [19]. This index can be computed via the following mathematical expression [20]:

$$Pi = C_m / S_m \; ....(2)$$

Where C_m is the measured value of an element in a sample; S_m is the maximum allowable limit of that element in same sample. The maximum allowable limit of trace elements concentrations Cu, Pb, Zn, Ni, As, Cd and Cr in soil are 100, 100, 300, 50, 20, 3 and 100 respectively [21]. The Pi of each metal is classified into five contamination categories: no contamination (Pi < 1), low degree of contamination (1≤ Pi < 2), moderate degree of contamination (2 ≤ Pi < 3), strong degree of contamination (3 ≤ Pi < 5), very strong degree of contamination (Pi > 5) [22].

Nemerow Pollution Index (PI_n)

The index of Nemerow pollution is an approach for assessing contamination of trace elements in sediment, and therefore can be a best reflection for the level of soil contamination [18]. The Nemerow pollution index can be computed via the following mathematical expression [16],[23], [24]:

$$PI_n = \sqrt{\frac{(Pi)^2_{max} + \left(\frac{1}{n}\sum_{i=1}^{n} Pi\right)^2}{2}} \; ....(3)$$

Where, Pi is the individual pollution index of heavy element i; Pi_{max} is the maximum value of the individual pollution index of the investigated heavy metal(s) and n is the number of the trace element species. The quality of soil were classified into five categories from Nemerow pollution index: PI_n < 0.7, unpolluted; 0,7 ≤ PI_n < 1, little pollution; 1 ≤ PI_n < 2, slight pollution; 2 ≤ PI_n < 3, moderate pollution; PI_n ≥ 3, serious pollution [25], [26], [27].

Ecological risk factor (E_r) and Potential Ecological Risk Index (PERI)

The ecological risk factor and the potential ecological risk index are used to assess ecological risk of a trace element in a sediment. E_r can be calculated by the following formula [28]:

$$E_r = T_r \times C_f \; ....(4)$$

Where E_r is the individual index of ecological risk factor, T_r refers to toxic response factor of certain trace element. The value of toxic response factor for Zn, Cr, Ni, Cu, Pb, Cd, and As is 1.0, 2.0, 5.0, 5.0, 5.0, 30, and 10 respectively [28], [29], [30]. C_f represents the contamination factor, which can be computed via this formula:

$$C_f = C_{metal} / C_{background} \; ....(5)$$

Where C_{metal} refers to the concentration of a given metal, $C_{background}$ is a background concentration of trace elements. because of deficiency of pertinent background data of uncontaminated soil in the study area, the average values of trace elements in the earth crust were choose in this research [31].

The Potential ecological risk index of trace elements in surface soils were calculated using the following formula [32]:

$PERI = \sum_{i=1}^{n} E_r$………..(6)

PERI refers to the potential ecological risk index, that indicate to the total of E_r. It states the sensitiveness of the biological community to the toxic element and explains the potential ecological risk caused by the overall pollution. The following terms are applied to characterize the ecological risk factor (E_r) and the potential ecological risk index (PERI) and listed in Table (2).

Table 2: criteria for potential ecological risk index and ecological risk factor for metal pollution [33], [34].

E_r	Eco- risk factor for an single metal	PERI	Eco-risk index for metals
$E_r < 40$	Low ecological risk	PERI < 150	Low potential ecological risk
$40 \le E_r < 80$	Moderate ecological risk	150 ≤ PERI < 300	Moderate potential ecological risk
$80 \le E_r < 160$	Considerable ecological risk	300 ≤ PERI < 600	Considerable potential ecological risk
$160 \le E_r < 320$	High ecological risk	PERI ≥ 600	Very high potential ecological Risk
$E_r \ge 320$	Very high ecological risk		

Results and Discussion

The trace element values (Cu, Pb, Zn, Ni, As, Cd, Cr) in the involved samples are listed in Table (3)., which indicates that the mean values of Cu, Pb, Zn, As and Cd are less than the maximum permissible limits in soils, while Ni and Cr are higher.

Table 3: concentration of trace elements (mg/kg) in the study area with maximum permissible limits and crustal average of metals.

location no.	Cu	Pb	Zn	Ni	As	Cd	Cr
S1	22.89	11.84	64.1	147.6	4	0.2	197
S2	39	13.19	62.2	191.8	6.8	0.24	249
S3	18.48	9.89	39.5	90.7	4	0.18	128
S4	38.35	17.18	111.3	190.8	6	0.27	241
S5	35.07	14.53	64.7	155.2	5.7	0.32	204
S6	27.26	13.25	88.3	199.9	6.1	0.28	217
S7	38.9	14.53	75.6	138.2	4.2	0.27	266
S8	78.77	18.95	75.4	118.4	6.5	0.24	203
S9	57.8	16.06	64.8	108.3	5.8	0.3	159
S10	27.29	10.46	61.4	96.3	4.4	0.21	185
S11	35.49	13.33	62.8	199.7	6.9	0.28	189
S12	69.43	19.19	93.9	187.2	7.1	0.37	201
S13	33.8	13.31	66.5	133	6.5	0.23	287
S14	17.62	17.51	67.1	146.7	4.5	0.31	223
S15	41.21	11.55	374.7	210	5.3	0.24	191
S16	29.7	15.23	61.1	193	5.6	0.27	212
S17	66.44	10.16	56.3	98.8	5.8	0.22	179
S18	27.26	11.46	72.2	167.2	5.2	0.19	190
Average	39.15	13.98	86.77	154.04	5.58	0.26	206.72
Maximum Permissible limit [21]	100	100	300	50	20	3	100
Crustal average [2]	55	15	70	20	1.8	0.1	100

To investigate whether the industrial and agricultural activities have severe impacts on soil quality, the geo-accumulation index (I_{geo}), index of pollution (Pi), index of Nemerow pollution (PI_n), factor of ecological risk (E_r) and index of potential ecological risk (PERI) were applied. Values of the average I_{geo} showed decreasing with the order of Ni (2.4) > As (1.0) > Cd (0.8) > Cr (0.5) > Zn (- 0.5) > Pb (- 0.7) > Cu (- 1.1), indicating that the study area soils are within moderate to heavy contamination due to Ni and slight contamination due to As, Cd and Cr and uncontaminated by Zn, Pb and Cu (Table 4). The value of geoaccumulation index of Zn, Pb and Cu indicating that the targeted samples of study area are within background concentration with respect to these trace elements.

Table 4: the index of geoaccumulation for the surface soil samples.

location no.	Cu	Pb	Zn	Ni	As	Cd	Cr
S1	-1.8	-0.9	-0.7	2.3	0.6	0.4	0.4
S2	-1.1	-0.8	-0.8	2.7	1.3	0.7	0.7
S3	-2.2	-1.2	-1.4	1.6	0.6	0.3	-0.2
S4	-1.1	-0.4	0.1	2.7	1.2	0.8	0.7
S5	-1.2	-0.6	-0.7	2.4	1.1	1.1	0.4
S6	-1.6	-0.8	-0.2	2.7	1.2	0.9	0.5
S7	-1.1	-0.6	-0.5	2.2	0.6	0.8	0.8
S8	-0.1	-0.2	-0.5	2.0	1.3	0.7	0.4
S9	-0.5	-0.5	-0.7	1.9	1.1	1.0	0.1
S10	-1.6	-1.1	-0.8	1.7	0.7	0.5	0.3
S11	-1.2	-0.8	-0.7	2.7	1.4	0.9	0.3
S12	-0.2	-0.2	-0.2	2.6	1.4	1.3	0.4
S13	-1.3	-0.8	-0.7	2.1	1.3	0.6	0.9
S14	-2.2	-0.4	-0.6	2.3	0.7	1.0	0.6
S15	-1.0	-1.0	1.8	2.8	1.0	0.7	0.3
S16	-1.5	-0.6	-0.8	2.7	1.1	0.8	0.5
S17	-0.3	-1.1	-0.9	1.7	1.1	0.6	0.3
S18	-1.6	-1.0	-0.5	2.5	0.9	0.3	0.3
average	-1.1	-0.7	-0.5	2.4	1.0	0.8	0.5

Based on the average values, results of Pi for individual elements are within decreasing with the order of Ni (3.08) > Cr (2.07) > Cu (0.39) > Zn (0.29) > As (0.28) > Pb (0.14) > Cd (0.09) as shown in table 5. According to categories of pollution index, the surface soil of study area considers within strong pollution by Ni, moderately polluted by Cr and within no pollution by Cu, Zn, As, Pb, Cd. The Nemerow pollution index values of study area are listed in Table 5. The PI_n values showed that station S3 and S10 are slightly polluted, and this may due to their location which are located far from industrial and agricultural activities. The sites of S8, S9, and S17 were moderately polluted according to categories of Nemerow pollution index. The other sites had PI_n values were higher than 3, indicating that the surface soil are seriously polluted by metals (table 5).

Table 5: pollution index values and Nemerow pollution index for trace elements in surface soil samples

Site no.	Pi(Cu)	Pi(Pb)	Pi(Zn)	Pi(Ni)	Pi(As)	Pi(Cd)	Pi(Cr)	PI_n
S1	0.23	0.12	0.21	2.95	0.20	0.07	1.97	4.52
S2	0.39	0.13	0.21	3.84	0.34	0.08	2.49	7.66
S3	0.18	0.10	0.13	1.81	0.20	0.06	1.28	1.71
S4	0.38	0.17	0.37	3.82	0.30	0.09	2.41	7.59
S5	0.35	0.15	0.22	3.10	0.29	0.11	2.04	5.00
S6	0.27	0.13	0.29	4.00	0.31	0.09	2.17	8.27
S7	0.39	0.15	0.25	2.76	0.21	0.09	2.66	4.03
S8	0.79	0.19	0.25	2.37	0.33	0.08	2.03	2.99
S9	0.58	0.16	0.22	2.17	0.29	0.10	1.59	2.49
S10	0.27	0.10	0.20	1.93	0.22	0.07	1.85	1.97
S11	0.35	0.13	0.21	3.99	0.35	0.09	1.89	8.21
S12	0.69	0.19	0.31	3.74	0.36	0.12	2.01	7.27
S13	0.34	0.13	0.22	2.66	0.33	0.08	2.87	3.76
S14	0.18	0.18	0.22	2.93	0.23	0.10	2.23	4.48
S15	0.41	0.12	1.25	4.20	0.27	0.08	1.91	9.17
S16	0.30	0.15	0.20	3.86	0.28	0.09	2.12	7.70
S17	0.66	0.10	0.19	1.98	0.29	0.07	1.79	2.09
S18	0.27	0.11	0.24	3.34	0.26	0.06	1.90	5.77
average	0.39	0.14	0.29	3.08	0.28	0.09	2.07	5.26

To evaluate the ecological risks of the studied trace elements, in this research various ecological risk assessment methods are used. The ecological risk factor (E_r) estimated with individual elements along with potential ecological risk index (PERI) are given in Table 6. The order of mean E_r of trace elements was Cadmium > Nickel > Arsenic > Lead > Chromium > Copper > Zinc with values 77.0, 38.5, 31.0, 4.7, 4.1, 3.6 and 1.2 respectively. The Eco-risk grade of E_r for individual metals ranged from moderate to considerable for Cd, low to moderate for Ni, and low for all other metals. The PERI ranges from 107.0 at site S3 to 215.3 at site S12 with a mean value of 160.1 (table 6). Furthermore, the values show that 27.8% of PERI results are lower than 150 and 72.2% are in the range of 150 to 300, indicating low to moderate potential ecological risk, respectively.

Table 6: results of (E_r) and (PERI) of trace elements in study samples

Site no.	(E_r)							PERI	Eco-risk grade of PERI
	Cu	Pb	Zn	Ni	As	Cd	Cr		
S1	2.1	3.9	0.9	36.9	22.2	60.0	3.9	130.0	Low
S2	3.5	4.4	0.9	48.0	37.8	72.0	5.0	171.5	Moderate
S3	1.7	3.3	0.6	22.7	22.2	54.0	2.6	107.0	Low
S4	3.5	5.7	1.6	47.7	33.3	81.0	4.8	177.7	Moderate
S5	3.2	4.8	0.9	38.8	31.7	96.0	4.1	179.5	Moderate
S6	2.5	4.4	1.3	50.0	33.9	84.0	4.3	180.4	Moderate
S7	3.5	4.8	1.1	34.6	23.3	81.0	5.3	153.7	Moderate
S8	7.2	6.3	1.1	29.6	36.1	72.0	4.1	156.3	Moderate
S9	5.3	5.4	0.9	27.1	32.2	90.0	3.2	164.0	Moderate
S10	2.5	3.5	0.9	24.1	24.4	63.0	3.7	122.1	Low
S11	3.2	4.4	0.9	49.9	38.3	84.0	3.8	184.6	Moderate
S12	6.3	6.4	1.3	46.8	39.4	111.0	4.0	215.3	Moderate
S13	3.1	4.4	1.0	33.3	36.1	69.0	5.7	152.6	Moderate
S14	1.6	5.8	1.0	36.7	25.0	93.0	4.5	167.5	Moderate
S15	3.7	3.9	5.4	52.5	29.4	72.0	3.8	170.7	Moderate
S16	2.7	5.1	0.9	48.3	31.1	81.0	4.2	173.3	Moderate
S17	6.0	3.4	0.8	24.7	32.2	66.0	3.6	136.7	Low
S18	2.5	3.8	1.0	41.8	28.9	57.0	3.8	138.8	Low
Average	3.6	4.7	1.2	38.5	31.0	77.0	4.1	160.1	
Eco-Risk grade of E_r	Low	Low	Low	Low to moderate	Low	Moderate to considerable	Low		

Conclusions

Five pollution indices (i.e. index geoaccumulation, index of pollution, Nemerow pollution index, factor of ecological risk and index of potential ecological risk) were applied to assess the concentration of trace elements (Cu, Pb, Zn, Ni, As, Cd and Cr) in surface soils affected by industrial and agricultural activities. According to the average values of I_{geo}, the trace elements were grouped as follow: Ni > As > Cd > Cr > Zn > Pb > Cu, indicating that the study area are enriched by Ni, As, Cd and Cr due to anthropogenic activity, whereas Zn, Pb and Cu are of geogenic activity. The pollution index (Pi) values, which depends on the maximum permissible limit of metals in soil, revealed the surface soils are strongly polluted by Ni, moderately polluted by Cr and non-polluted by Cu, Zn, As, Pb and Cd. The values of Nemerow pollution index manifested that 44.44% of sites are seriously polluted by metals, while 27.77% are moderately polluted, 22.22% slightly polluted and 5.55% little polluted. According to ecological risk factor, the values showed moderate to considerable risk by Cd, low to moderate risk by Ni and low risk for Cu, Zn, As, Pb and Cr. The PERI values ranged from low to moderate potential ecological risk for all sites.

References

[1] Van der Perk, M. (2014). *Soil and Water Contamination*. 2nd edn., Taylor & Francis Group. London, UK: 419 pp.

[2] Kabata-Pendias A. (2011). Trace Elements in Soils and Plants. 4th edn., Taylor and Francis Group, LLC: 534 pp.

[3] Hooda P.S. (2010). Trace Elements in Soils. 1st edn., Blackwell Publishing Ltd. UK: 618 pp.

[4] Likuku A.S. Mmolawa K.B. and Gaboutloeloe G.K. (2013). Assessment of Heavy Metal Enrichment and Degree of Contamination around the Copper-Nickel Mine in the Selebi Phikwe Region, Eastern Botswana. *Environment and Ecology Research* **1(2)**: 32-40.

[5] Montgomery C.W. (2014). Environmental Geology. 10th edn. New York: McGraw-Hill. 564 pp.

[6] AlKhader A.M.F. (2015). The Impact of Phosphorus Fertilizers on Heavy Metals Content of Soils and Vegetables Grown on Selected Farms in Jordan. *Agrotechnology*. **4 (2):** 137

[7] AlSaadie N.A.J., falih A.S. and Mouhamad R. (2019). Effect of Mineral Fertilizers Application on Accumulation of Heavy Metals in Soils and Tomato Plant. *Syrian Journal of Agricultural Research.* **6(2):** 395-404

[8] Jassim S.Z. and Goff G.C. (2006). Geology of Iraq. 1st edn., Dolin, Prague and Moravian Museum, Brno. Czech Republic: 345 pp.

[9] Al-maiyahy D.S. (2004). Tectonic and structure of Anticline (Himreen – Makhul) North-East Iraq. M.Sc. thesis. University of Basra, Basra, Iraq (In Arabic).

[10] Kadhim L.S. Jasim R.M. and Saleh S.A. (2016). Sedimentological and Geochemical Study of Foundation Zone Sediment at Baiji City, North Iraq. *Tikrit Journal of Pure Science.* **5 (22):** 141-147

[11] Muller G. (1969). Index of geo-accumulation in sediments of the Rhine River. *GeoJournal* **2**: 108–118.

[12] Yang Q., Li Z., Lu X., Duan Q., Huang L. and Bi J. (2018). A review of soil heavy metal pollution from industrial and agricultural regions in China: Pollution and risk assessment. *Science of the Total Environment* **642 (1)**: 690–700

[13] Jayarathne A., Egodawatta P., Ayoko G.A. and Goonetilleke A. (2018). Assessment of ecological and human health risks of metals in urban road dust based

on geochemical fractionation and potential bioavailability, *Science of the Total Environment*. **635 (1)**: 1609-1619

[14] Okoro H.K., Orimolade B.O., Adebayo G.B., Akande B.I., Ximba B.J. and Ngila J.C. (2017). An Assessment of Heavy Metals Contents in the Soil around a Cement Factory in Ewekoro, Nigeria Using Pollution Indices. *Polish Journal of Environmental Studies.* **26 (1):** 221-228

[15] Ke X., Gui S., Huang H., Zhang H., Wang C. and Guo W. (2017). Ecological risk assessment and source identification for heavy metals in surface sediment from the Liaohe River protected area, China. *Chemosphere* **175**: 473–481.

[16] Siddiqui E. and Pandey J. (2019). Assessment of heavy metal pollution in water and surface sediment and evaluation of ecological risks associated with sediment contamination in the Ganga River: a basin-scale study. *Environmental Science and Pollution Research*. **26**: 10926–10940

[17] Sutherland R. A. (2000). Bed sediment-associated trace metals in an urban stream, Oahu, Hawaii. *Environmental Geology*. **39**:611–627.

[18] Wang X., Sun Y., Li S. and Wang H. (2019). Spatial distribution and ecological risk assessment of heavy metals in soil from the Raoyanghe Wetland, China. *PLOS ONE* **14(8)**: e0220409.

[19] Liu L., Zhang L., Sun Y., Si W., Men Z. and Zhang M. (2018). Relationship of heavy metal contents between the feathers of three ardeidae species and environment at the Nanhaizi Wetland in Baotou City. *Chin J Zoology*. **53(4):** 628–640.

[20] Yang M., Zhang D., Xu L., Khan S., Chen, F. and Jiang H. (2019). Heavy Metals Contents and Risk Assessment of Farmland on the Edge of Sichuan Basin. *Journal of Toxicology and Risk Assessment.* **5 (1):** 5:018.

[21] Kamunda C., Mathuthu M. and Madhuku M. (2016). Health Risk Assessment of Heavy Metals in Soils from Witwatersrand Gold Mining Basin, South Africa. *International Journal of Environmental Research and Public Health*, 13 (7): 663;

[22] Gevorgyan G.A., Ghazaryan K.A. and Movsesyan H.S. (2017). Assessment of Ecological and Agricultural Risks of Heavy Metal Pollution of Soils in The Vicinity of Kapan City, Armenia. *Chemistry and Biology*, **51(3):** 193–197.

[23] Ramdani S., Amar A., Belhsaien K., El Hajjaji S., Ghalem S., Zouahri A. and Douaik A. (2018). Assessment of Heavy Metal Pollution and Ecological Risk of Roadside Soils in Tlemcen (Algeria) Using Flame-Atomic Absorption Spectrometry. *Analytical Letters*. **51 (15)**: 2468-2487

[24] Ikpe N.C., Kenechukwu E.C. and Ikechukwu E.C. (2018). Use of integrated pollution indices in assessing heavy metals pollution in soils of three auto mechanic villages in Abuja. *African Journal of Environmental Science and Technology.* **12 (10):** 370-376.

[25] Qingjie G., Jun D., Yunchuan X., Qingfei W. and Liqiang Y. (2008). Calculating Pollution Indices by Heavy Metals in Ecological Geochemistry Assessment and a Case Study in Parks of Beijing. *Journal of China University of Geosciences*, **19 (3)**: 230–241

[26] Inengite A.K., Abasi C.Y and Walter C. (2015). Application of Pollution Indices for the Assessment of Heavy Metal Pollution in Flood Impacted Soil. *International Research Journal of Pure & Applied Chemistry* **8(3)**: 175-189.

[27] Jaffar S.T.A., Luo F., Ye R., Younas H., Hu X. and Chen L. (2017). The Extent of Heavy Metal Pollution and Their Potential Health Risk in Top soils of the Massively Urbanized District of Shanghai. *Archives of Environmental Contamination and Toxicology* **73**:362–376

[28] Sofianska E. and Michailidis K. (2016). Assessment of heavy metals contamination and potential ecological risk in soils affected by a former Mn mining activity, Drama district, northern Greece. *Soil and Sediment Contamination: An International Journal*. **25 (3)**: 296-312

[29] Yang, L. Y., & Wu, S. T. (2012). Ecological Risk Assessment of Heavy Metal Pollution in Soil of Beijing. *Advanced Materials Research,* **450–451**: 827–831.

[30] Tang J., Miaomiao H., Luo Q., Adeel M. and Jiao F. (2020). Heavy Metals in Agricultural Soils from a Typical Mining City in China: Spatial Distribution, Source Apportionment, and Health Risk Assessment. *Polish Journal of Environmental Studies*. **29 (2):** 1-12.

[31] Iwegbue C.M.A. and Martincigh B.S. (2017). Ecological and human health risks arising from exposure to metals in urban soils under different land use in Nigeria. *Environmental Science and Pollution Research.* **25:** 12373–12390

[32] Sezgin N., Nemlioğlu S. and Balkaya N. (2019). Ecological Risk Assessment of Heavy Metal Pollution in Urban Soils: A Case Study. In: Balkaya N. and Guneysu S. (eds), Recycling and Reuse Approaches for Better Sustainability. *Environmental Science and Engineering*. Springer, Cham. Switzerland: 215-230

[33] Zhang Y., Liu Y., Niu Z. and Jin S. (2017). Ecological risk assessment of toxic organic pollutant and heavy metals in water and sediment from a landscape lake in Tianjin City, China. *Environmental Science and Pollution Research* **24(13)**:12301-12311.

[34] Xu J., Wang H., Liu Y., Ma M., Zhang T., Zheng X. and Zong M. (2016). Ecological risk assessment of heavy metals in soils surrounding oil waste disposal areas. *Environmental Monitoring Assessment* **188**:125.

التحري عن تأثير الأنشطة الصناعية والزراعية على تلوث التربة السطحية باستخدام مؤشرات التلوث، شمال مدينة بيجي ، محافظة صلاح الدين ، العراق

محمود فاضل عبد

قسم علوم الأرض التطبيقية ، كلية العلوم ، جامعة تكريت ، تكريت ، العراق

الملخص

تم جمع 18 عينة التربة السطحية من مناطق محيطة بالمنطقة الصناعية شمال مدينة بيجي. تم تحليل تركيز سبعة عناصر ثقيلة هي (النحاس، الرصاص، الزنك، النيكل، الزرنيخ، الكادميوم والكروم). تم استخدام مؤشر التراكم الأرضي ومؤشر التلوث ومؤشر نيميرو للتلوث ومؤشر الخطر البيئي ومؤشر الخطر البيئي المحتمل لتقييم تلوث التربة بالفلزات الثقيلة. أظهر متوسط القيم لمؤشر التراكم الأرضي أن تربة منطقة الدراسة معتدلة إلى شديدة التلوث بالنيكل وقليلة التلوث بالزرنيخ والكادميوم والكروم وغير ملوثة بالزنك والرصاص والنحاس. وفقًا لفئات مؤشر التلوث، تعد التربة السطحية لمنطقة الدراسة ملوثة بشدة بالنيكل، ومعتدلة التلوث بالكروم وغير ملوثة بالنحاس والزنك والزرنيخ والرصاص والكادميوم. أظهرت قيم مؤشر نيميرو للتلوث في منطقة الدراسة أن 11٪ من المواقع ملوثة قليلاً ، و 17٪ من المواقع ملوثة بشكل معتدل و 72٪ من المواقع ملوثة بشكل خطي.. وفقًا لعامل الخطر البيئي لكل عنصر منفرد، فقد أظهرت القيم مخاطر بيئية معتدلة إلى كبيرة لعنصر الكادميوم، ومخاطر بيئية منخفضة إلى معتدلة للنيكل، ومخاطر بيئية منخفضة بالنسبة للنحاس والزنك والزرنيخ والرصاص والكروم. بالنسبة لمؤشر الخطر البيئي للعناصر، أظهرت النتائج أيضًا أن 27.8٪ من المواقع هي منخفضة الخطر البيئي المحتمل، وأن 72.2٪ من المواقع هي ذات خطر بيئي محتمل معتدل.