Evaluation of Environmental Risk Index for Heavy Metals in Some Sedimentary Soils Pollution of Babylon Governorate

Abbas S.S. AL-Wotaify,
Department of Soil Sciences and Water resources
AL-Qasim Green University, Hilla, Iraq
dr.abbassabr@yahoo.com

Noor J. Al-Silmawy,
Department of Soil Sciences and Water resources
AL-Qasim Green University, Hilla, Iraq
Noorjawad42@yahoo.com, Iraq

Luay M. AL-Jubori
Soil Sciences and Water ,resources, Agriculture Coll.
AL-Qasim Green University, Hilla, Iraq
lwymnhl@gmail.com

***Abstract*—This research included study of some sedimentary soils pollution from the Babylon Governorate by As, Cu, Ni and Pb estimated with XRF spectra. The locations determined via GPS between longitude °32 08′ 757′′-°32 99′ 861′′N and Latitude °44 09′ 220′′- °44 99′ 928′′E. Soil total of As, Cu and Ni were high, as As recorded the highest values 24.5mg kg^{-1} in surface horizon of soil sample Ss5. While Cu and Ni: 70.2, 372.5mg kg^{-1} respectively in lower horizon of soil sample Ss2. Pb was below the limits allowed by the World Health Organization (WHO). The highest single pollution index (PI) for As: 3.31, Cu: 1.54, Ni: 1.55recorded the highest values in the surface horizon of the soil sample Ss5, and Pb: 1.87 in the lower horizon of the same sample. Newmerow integrated pollution index (NIPI), also follows the same pattern in mentioned samples: 2.78, 1.45, 1.45 and 1.65respectively. For the results of the potential ecological risk index (Er) the highest values of As: 33.1, Cu: 7.70 and Ni 7.75; Pb: 9.35 recorded in both mentioned two horizon. Thereby, the highest total comprehensive ecological risk index (RI) for the heavy metals group was 55.70 in the surface horizon of soil sample Ss5.**

Keyword—risk index; soils of Babylon, pollution, heavy metals.

I. INTRODUCTION

The work in [1] defined ecological risk assessment as a process that evaluated the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors. Among these indicators is the potential ecological index(Er) that indicates the extent to which a particular site is polluted by any heavy metal that is expected to be affected by the input of human activity in that ecosystem and is studied through the simple pollution indicator (PI). Comprehensively ecological risk index(RI) is the possible pollution of the site within an environmental system affected to the human inputs through a group of heavy metals [2]. The purpose of ecological risk assessment is to assess ecological effects of human activities through scientifically credible evaluation (chemical assessment and individual bioassay) to protect and manage the environment [3].

Soil is one of the main ecosystems which exposed to many environmental pollutants via the air and water, this leads to the spoilage physical, chemical and biological agricultural soil properties and their deviation from the natural situation. Therefore, following up the changes due to environmental pollutants produced by negative behaviors and degradation is an inevitable necessity related to the modern era because it is related to the health and existence of human beings [4]. Most important environmental pollutants resulting from the residues of human activity are heavy metals, which are increasingly exacerbated by the lack of a mechanism to reduce the sources of their spread and to work hard to find appropriate ways for re-rotate what is being released. Despite extensive studies and persistent warnings the sovereignty of its existence, thereby it cannot be called trace metals, and have become common in all environmental systems according to the concept knows as heavy metals that are set free through the geochemical cycles of the parent materials via a weathering processes of physical, chemical and biological which affect the crust components, to be among the elements of mineral soil. In addition, human activity came in the wake of the industrial progress contributing to the increase of heavy metals concerning with existences them in parent material of geological soil [5]. The study aims to achieve the following objectives:(1) Determination of the total content of some heavy metals in sedimentary soils from the Babylon Governorate. (2) Assessment of environmental risk index and specifying of its dimensions in the contamination of soils by heavy metals.

II. MATERIALS AND METHODS

Some sedimentary soils were selected from Babylon Governorate located between longitude °32 08′ 757′′-°32 99′ 861′′N and Latitude °44 09′ 220′′- °44 99′ 928′′E. Soil samples were taken from pedons described according to [6], which contain surface and lower horizons classified depending[7]. Where Ss_1 represents first pedon contains Ap(A: surface horizon, p:plowed) and Ck_3 (C: lower horizon, k: means carbonate accumulation in this horizon soil), Ss_2 refers to second pedons consists of Ap and C horizons, and so on for other samples, the samples were representing six different agricultural cities in the Governorate of Babylon. Soil samples kept in polyethylene containers, and then all samples were transferred to the laboratory in order to complete requirements of analysis. Its total content from heavy metals was estimated: As, Cu, Ni, and Pb via XRF spectra. The equations of indicators of pollution as following:

$$PI = Ci / Si \qquad (1)$$

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Where *PI* was the pollution index by mainly single method; *Ci* and *Si* represent the heavy metal concentrations in the wastewater irrigated soil and evaluation criteria values respectively[8].

$$NIPI=\sqrt{\frac{p^{2}_{ave.}+p}{2}} \qquad (2)$$

Where *NIPI* was the pollution index by composite index method(Newmerow integrated pollution index); *Pave* was the average pollution index; *Pmax* was the maximum value of the pollution index[8,9]. Table (I) shown the levels of PI and NIPI of heavy metals.

TABLE I. GRADES AND LEVELS OF POLLUTION SINGLE POLLUTION INDEX[8,10].

PI for each heavy metal		NIPI for heavy metals	
Range	Level of pollution	Range	Class
PI<1	Non Pollution	NIPI<0.7	Non pollution
1≤ PI <2	Low	0.7<NIPI≤1	Warning
2≤ PI <3	Moderate	1<NIPI≤2	Low
3≤ PI <5	Strong	2<NIPI≤3	Moderate
PI >5	Very strong	NIPI>3	High

III. RESULTS AND DISCUSSION

In Table (III) the amount of clay in the soil of surface horizons was 200-500, silt: 280-630 and sand: 40-428.5gm kg^{-1}. It was 108-550, 340-565 and 40-326gm kg^{-1} respectively in soil of the lower horizons. This is due to the nature of river sediments that are characterize by small particles size distribution (silt), since the study soils was adjacent to the Euphrates river, except for the soil sample Ss_3, where clay texture was predominant, because clay transfer easily from source of sedimentation to distances beyond sand and silt[12]. The results agreed with study[13] that distribution of the soil fractions was synchronize with the fluvial deposits characteristics, which would transfer the particles of sand, silt and clay to distances depending on their particles size and water flow rate. Table(IV) shows the total of soil surface horizons for heavy metals were ranged between, As:12.1-24.5, Cu: 51.6-69.2, Ni: 265.0-352.2 and Pb: 13.2-18.1mg kg^{-1}. In the lower horizons soil were 11.4-17.2, 52.2-70.2, 284.6-372.5 and 12.1-20.2mg kg^{-1} respectively.

TABLE III : THE SIZE DISRIBYTION OF SOIL FRACTION AND TEXTURE CLASS.

Sample	Horizon	Depth (Cm)	Size Distribution of Soil Fractions(g kg^{-1})			Texture Class
			Sand	Silt	Clay	
Ss_1	Ap	0-20	40	520	440	SiC
	Ck	66-110	80	370	550	CL
Ss_2	Ap	0-29	428	372	200	L
	C	82-130	326	565	108	SiL
Ss_3	Ap	0-46	210	280	510	C
	C	124-160	300	340	360	CL
Ss_4	Ap	0-25	265	425	310	CL
	C	78-110	80	550	370	SiL
Ss_5	Ap	0-32	140	500	360	SiC
	C	101-140	100	480	420	SiC
Ss_6	Ap	0-27	110	630	260	SiL
	C	87-120	40	500	460	SiC

$E_r^i = E_r^i T_r^i \times C_f^i$ (3) $C_f^i = C_{surface}^i / C_n^i$ (4)

Er: potential ecological risks of individual factors; *Tr*: represents for a certain kind of metal toxicity response coefficient such as As:10; Cu, Ni and Pb: 5[11]; C_f^i means concentration of metal in surface soil ($C_{surface}$) to its concentration in reference soil[11].

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

RI was comprehensive potential ecological risk index, sampling points of soil heavy metals[11]. The adjusted grading standard of these indicators classification were listed in TableII.

TABLE II : GRADES OF POTENTIAL AND COMPREHENSIVELY ECOLOGICAL RISKS[11].

Er		RI	
Ranges	Pollution	Ranges	Levels
<40	Slight	<90	Slight
40-80	Moderate	90-180	Moderate
80-160	Strong	180-360	Strong
160-320	Very strong	360-720	Very strong
> 320	Highly strong	>720	Highly strong

The results indicate that the Ni content in study soils was high, comparing with standard level of heavy metals in soil (Fig.1), although it does not exceed 50mg kg^{-1} in the soil[14], thus exceeded permissible limits in agricultural soils 10-40mg kg^{-1} [15], for its multiplicity of sources and use in many modern industries [16].

TABLE IV :THE TOTAL OF METALS IN SOIL HORIZONS.

Samples	Horizon	Depth (Cm)	Heavy metals(mg kg^{-1})			
			As	Cu	Ni	Pb
Ss_1	Ap	0-20	13.3	51.6	265.0	18.1
	Ck	66-110	17.2	54.1	286.9	15.5
Ss_2	Ap	0-29	12.1	59.0	304.2	13.2
	C	82-130	13.1	70.2	372.5	12.6
Ss_3	Ap	0-46	14.4	58.5	303.4	15.3
	C	124-160	11.4	52.2	284.6	12.1
Ss_4	Ap	0-25	14.5	64.7	308.2	16.6
	C	78-110	14.3	57.9	295.1	15.0
Ss_5	Ap	0-32	24.5	69.2	352.2	15.4
	C	101-140	16.1	63.8	309.1	20.2
Ss_6	Ap	0-27	7.4	44.9	227.6	10.8
	C	87-120	8.9	47.7	241.0	10.8

This reinforced the increased quantity in the soil sample Ss_2 because it is characterized by the accumulation the residues of military manufacturing, and soil sample Ss_5 because they are agricultural areas affected by biological combating which contains Ni, as well as manufacturing fertilizers from the remnants, chemical pesticides, the remnants of massacres and poultry contain high concentrations of this heavy metal [17].

For the same reasons, the amount of Cu in a soil of study was high (Fig.1). It exceeded that after limits mentioned before [18](20-50mg kg^{-1}). The movement of As is more in alkaline soil, it is considered of major components in agricultural pesticides, in chemical and fertilizers that are used without any side effects and safety for using in all world [5], and on this basis reached the highest values in the soil Ss_5 (Fig.1). Pb was less than the limits allowed by [19] (100mg kg^{-1}), because most of its sources are vehicles exhausts in highways [20].

Since most of the study's soils are adjacent to the Euphrates river, they are an exploited agricultural soils covered by vegetation from horticulture and palm, which is far from the movement of vehicles and rapid transport.

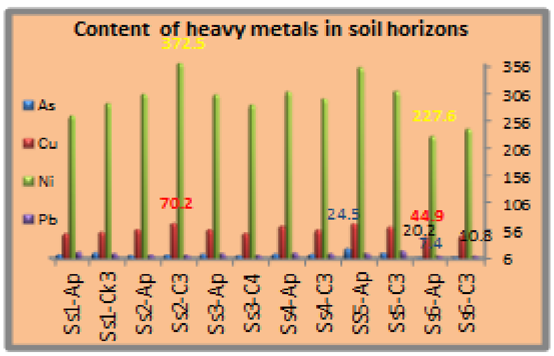

Fig.1 THE MAXIMUM AND MINIMUM LIMITS OF HEAVY METALS.

It is noted that most of these horizons in the soil of the study contain high amounts of Ni followed by Cu(Table IV and Fig.1), because of the enrichment of the parent material by the serpentine mineral, which belongs to kaolinite clays group(1:1), but the dioctahedral is called brucite [$Mg_3(OH)_6$] layer expected to be present due to the predominance of magnesium ions in arid and semi-arid soils, which crystallized during successive a wetting and dry cycles[21,22]. Serpentine mineral is the primary source in the soil components for Ni and Cu [23].

The soil content of the heavy metals played an important role in the fluctuation of the PI values(Table 5), especially, the soil of bottom horizons. PI attained highest values of As(3.31) in surface horizon of the soil sample Ss_5 (Fig.2), due to their high content of As in horizon Ap(Table IV).

TABLE V :THE SINGLE POLLUTION AND NEWMERO INTEGRATED POLLUTION IDEXS

Sample	Horizon	Depth (Cm)	PI As	PI Cu	PI Ni	PI Pb
Ss_1	Ap	0-20	1.80	1.15	1.16	1.68
	Ck	66-110	1.93	1.13	1.19	1.44
Ss_2	Ap	0-29	1.64	1.31	1.34	1.22
	C	82-130	1.47	1.47	1.55	1.17
Ss_3	Ap	0-46	1.95	1.30	1.33	1.42
	C	124-160	1.28	1.09	1.18	1.12
Ss_4	Ap	0-25	1.96	1.44	1.35	1.54
	C	78-110	1.61	1.21	1.22	1.39
Ss_5	Ap	0-32	3.31	1.54	1.55	1.43
	C	101-140	1.81	1.34	1.28	1.87
NIPI	Surface horizons		2.78	1.45	1.45	1.57
	Lower horizons		1.78	1.36	1.42	1.65

Thus for Cu and Ni were 1.54, 1.55 and 1.09, 1.12 for Cu and Pb in both the previous two horizon of Ss_5 and Ss_3 respectively. While Ni recorded the lowest values in the Ap of Ss_1, and Pb recorded the highest values(1.87) in lower horizon of soil sample Ss_5 (Fig.2). Therefore, the simple contamination index was low depending on Table1becuase all values in Table5 were less 2 except Ap-Ss_5 for As was moderate. Depending on results of PI, the NIPI in Table(5) showed the highest values of As(2.78) in the surface horizons soils and the lowest of Cu(1.36) in the soil of bottom horizons . This has made the NIPI in pollution levels ranged from low to moderate Table I.

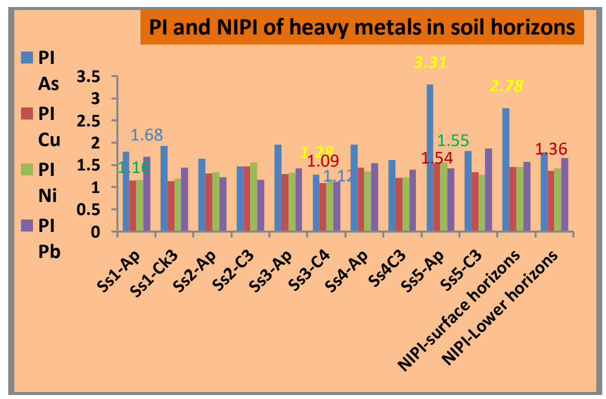

Fig.2 THE MAXIMUM AND MINIMUM LIMITS OF PI AND NIPI IN SOIL HORIZONS

The results that pollution indicators in the current study indicate that the soil of the study affected by the pollution of the most heavy metal under study, both in surface and bottom horizons of soil, comparative soil horizons were also affected by the pollution of heavy metals, which led to a decrease in the values of pollution indicators in the soils of study horizons. These results agree with study [24] for pollution standards by heavy metals of soil sample Ss_1 resulting in from the wastes of Al-Musayyib electric thermal power station which decreased because of high heavy metals content in comparison soil(Ss_2).

The Er for soil contamination in Table6 of As was between 12.8-33.1 and were the highest, compared with Cu: 5.45-7.70, Ni: 5.80-7.75 and Pb: 5.60-9.35, because toxicity of response coefficient for As was more than Cu, Ni and Pb. As well as PI values of As were generally higher than others (table 5). Fig.3 refers to highest recorded values of Er which were for As: 33.1, Cu: 7.70 and Ni: 7.75 in the surface horizon of soil sample Ss_5.While Pb recorded highest values in lower horizon of the sample itself(9.35). The lowest values recorded for As: 12.8, Cu: 5.45 and Pb: 5.60 in lower horizon of soil sample Ss_3, except Ni recorded 5.80 in surface horizon of soil sample Ss_1.

However, the Er did not reach the pollution levels mentioned in table2 because it is based on the values of PI, which its value declined due to the heavy metals content in comparison soil horizons, no significantly different from that found in the polluted soils according to Equation1.

The RI in Table(VI) for the heavy metals under study ranged from 35.75 to 55.70 in the surface horizon and in the bottom horizons it was 29.75-40.55. Fig.3 shows the highest values(55.70) recorded in the surface horizon of the Ss_5 sample and the lowest values(29.75)in lower horizon of soil Ss_3.

TABLE VI :THE POTENTIAL AND COMPREHENSIVLY ECOLOGICAL RISKS INDEXS

Sample	Horizon	Depth (Cm)	Er				RI
			As	Cu	Ni	Pb	
Ss_1	Ap	0-20	18.0	5.75	5.80	8.40	37.95
	Ck	66-110	19.3	5.65	5.95	7.20	38.10
Ss_2	Ap	0-29	16.4	6.55	6.70	6.10	35.75
	C	82-130	14.7	7.35	7.75	5.85	35.65
Ss_3	Ap	0-46	19.5	6.50	6.65	7.10	39.75
	C	124-160	12.8	5.45	5.90	5.60	29.75
Ss_4	Ap	0-25	19.6	7.20	6.75	7.70	41.25
	C	78-110	16.1	6.05	6.10	6.95	35.20
Ss_5	Ap	0-32	33.1	7.70	7.75	7.15	55.70
	C	101-140	18.1	6.70	6.40	9.35	40.55

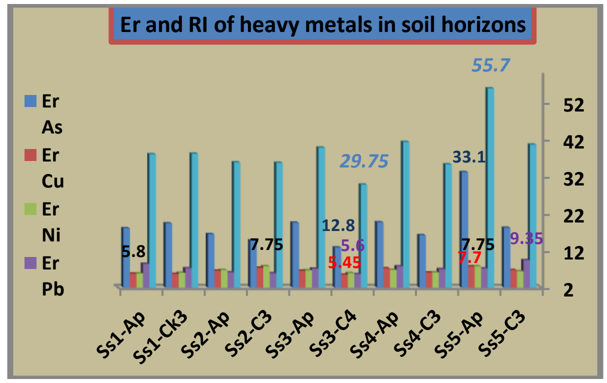

Fig.3 THE MAXIMUM AND MINIMUM LIMITS FOR Er AND RI OF HEAVY METALS

IV.CONCLUSIONS

The results indicated the soils total content of heavy metals was high, especially As, Cu and Ni. The highest soil contamination indicators for most heavy metals were in the surface horizon of soil sample Ss_5, and the lowest in lower horizon of soil sample Ss_3.

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