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Environmental Assessment of heavy metals Concentration and Distribution in Surface Soils of Wasit Governorate/ Iraq

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Abstract
Wasit Governorate is characterized by industrials activities such as groups of asphalts and bricks factories, oil fields and thermal power plant, in addition to the agricultural activity that is widely separated, which leads to pollution of the surface soils with heavy metals. The main objective in this research is to assess heavy metals pollution and understand the distribution in the surface soils in the studied area**.** Twenty two surface soils samples were collected from 6 districts and 4 subdistricts within Wasit Governorate during April 2017. The results obtained showed that grain size analyzes are classified as sandy mud (sand 9.5%, silt 50.8 % and clays 39.8%). In the term of geochemical parameters, high level of soil salinity in Wasit Governorate was in Badrah station (8%). Organic matter records 3.7% as a relative maximum concentration in industrial soils at 7.2 pH. Heavy metals Mo, Cu, Pb, Zn, Ni, Co, Mn, As, Cd,V, Cr, Br, Ta, Zr, Ba and Sr were investigated in the soils samples in Wasit Governorate. Assessment of heavy metal pollution has calculated by using the index of geo-accumulation (I-geo), Contamination factor (CF), pollution load index (PLI) and I-geo has been commonly applied as a degree of pollution in soils samples. The pollution load index (PLI) characterizes the number of times in which the heavy metal concentrations of sediment exceeds the background concentration; it provides a cumulative indication of the overall level of heavy metal toxicity in a certain sample. By using these statistical indexes of soils, the results show that soils samples in the studied area are very polluted by the heavy metals of Titanium (72.7 ppm), Nickel (188.9) to considerable with Molybdenum (9.85 ppm), Chromium (226 ppm), Cadmium (2.2ppm), bromine (27.ppm) and Strontium (431.6 ppm), and with moderate pollution of the heavy metals of Copper (54.7) Cobalt (13.4 ppm), Manganese (781.8ppm), Vanadium (104.3ppm) and zinc (117.6ppm

Keywords: Environmental Assessment. Heavy metals. Contamination Factor. Pollution Load Index. I- Geo-accumulation Index. Wasit Governorate

تقييم بيئي لتركيز العناصر الثقيلة وتوزيعها في الترب السطحية لمحافظة واسط / العراق

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الخلاصة

تتميز محافظة واسط بنشاط صناعي كمصانع الاسفلت والطابوق و حقول انتاج النفط ووجود محطة حرارية لأنتاج الطاقه الكهربائيه في المحافظة بالأضافة الى الانشطة الزراعيه المتوزعه على مساحات شاسعه في المنطقة . هذا يؤدي الى تلوث الترب السطحيه بالعناصر الثقيلة. الهدف الرئيسي في هذا البحث هو تقييم التلوث بالعناصر النادره وفهم جيوكيمياء هذة العناصر وتوزيعها في منطقة الدراسة. جمعت 22 عينة تربه سطحيه من 6أقضية و5 نواحي ضمن محافظة واسط في نيسان 2017.النتائج المستحصلة أن حجم حبيبات الترب المدروسة ضمن صنف وحل رملي. فيما يخص المتغييرات الجيوكييمائية, المستوى العالي لملوحة الترب كان في محطة بدره (8%) . المواد العضوية سجلت تراكيز عالية نسبيا في الترب صناعية (3.7%) عند pH حامضي (7.2). تم دراسة تقييم تلوث العناصر الثقيلة باستخدام مؤشر جيو –التراكم (I-geo) ، عامل التلوث (CF) ومؤشر حمل التلوث (PLI) ، حيث تم تطبيق I-geo على نطاق واسع كمقياس للتلوث في منطقة عينات الرواسب. دليل لتراكم الجيولوجي قد طبق بشكل واسع كمقياس لدرجه التلوث في ترسبات ترب محافظة واسط في حين دليل حمل التلوث يمثل عدد المرات التي خرجت بها العناصر الثقيلة عن الحد المسموح بها وتشير الى التلوث الكلي في النموذج المعين في المنطقة الواحدة بالعناصر الثقيلة لهذة الدراسة. نتائج العوامل الاحصائيه للترب أظهرت ان هذة الترب هي ملوثه بالعناصر Taو Ni وبتراكيز معتبره لكل من العناصر Mo و Cr و Cd و Br و Sr ومتوسطة لكل من Cu و Co وMn و V و Zn.

1. Introduction

Soil continually undergoes development by the manner of numerous physical, chemical and biological processes, which include weathering with associated erosion [1]. Contamination by heavy metals has become a widespread serious problem in many parts of the world [2]. Heavy metals enter the environment as a result of both natural and anthropogenic activities. Naturally heavy metals occur in soils, usually at a relatively low concentration, as a result of the weathering and other pedogenic processes acting on the rock fragments on which the rock develops soil parent materials [3]. Anthropogenic sources of heavy metals for soils include commercial fertilizers, liming materials, agrochemicals and other materials used as soil amendment, irrigation waters and atmospheric decompositions[4] Soil pollution is defined as the build-up in soils of determined toxic compounds, chemicals, salts, radioactive materials, or disease producing agents, which have adverse effects on plant growth and animal health [5]. The assessment of soil sediment enrichment with elements can be completed in a number of ways. The most common ones are the index of geo-accumulation (I-geo) and pollution load index (PLI). This index is a quick tool in order to compare the pollution status of different places [6]. I-geo has been widely used as a measure of pollution although the pollution load index (PLI) symbolizes the number of times by which the heavy metal concentrations in the soils exceeds the background concentration [7]. Wasit Governorate has an area 17.153 km^2. The main source of water in Wasit province is the Tigris River with a length of 327 km within the borders of the province [8]. Iraqi soils show different degrees of development according to the sedimentation dominant local conditions mainly climatic and geological conditions. Each order shows some variations within the common properties reflecting the effect of the dominant local conditions mainly, climatic and type of parent materials [9]. Soils have evident horizontal and vertical spatial variability in their physo-chemical characteristics.

Wasit Governorate soil contains appreciable amounts of chemicals and organics [10]. It's characterized in a variation in soil texture in vertical and horizontal directions and the sandy loam texture was predominant in the soil of study area. The pH values were moderate alkaline to slightly acid. Also, the disparity in calcium carbonate minerals values, organic matter content with the decline in soluble cations and anions and rising toward the banks of Tigris River, due to the intensity of gradient and short distance. The difference was in totally free and amorphous iron oxides content. Mineralogical formation showed the predominance of carbonate rock segments within the light portion of the sand followed by quartz, then Evaporites, chert, flint, mud stone, igneous rocks, metamorphic rocks, and granules coated with mud and Feldspar. Soils were dominated by quartz, where the proportion of feldspar (plagioclase) excelled on quartz, with a few of Mica and Kaolinite minerals heavy metals take the following sequence superiority: consistent with the Pb > Cd > Zn in the soil of study area [11]. Soils of Wasit Governorate the periods (2007) and (2016) indication that the land in the study area go in the direction of desertification and soil degradation, consequently these factors back to several causes for example; the decreasing in the vegetation cover will effect on the soil and led to soil erosion, the pollution of soil in the study area from the waste of the Ahdeb Oil field such as (toxic gases, solid wastes) [12]. The study area is characterized by industrials activities like groups of asphalt and brick, factories, asphalt factors and thermal power plant in the governorate, in addition to the agricultural activity that is widely spread, which leads to pollution of the soils by heavy elements. The objectives of the present study are to assess heavy metals content and contamination of the environment by using contamination factors (CF), pollution load index (PLI). Geo-accumulation (I-geo).

2. Geological Setting

Wasit region Located within unstable Shelf. The north eastern part is characterized by High Mountain when Iranian- Iraqi borders which are within the low folded zone and other parts of Wasit Governorate in Mesopotamian zone. The Mesopotamian plain is covered mostly by Quaternary deposits and is considered as a part of it. The old geological outcrops in the area belong to the Pliocene age represents Bai Hassan and Mukdadiya Formations show in Figure-1 [13].

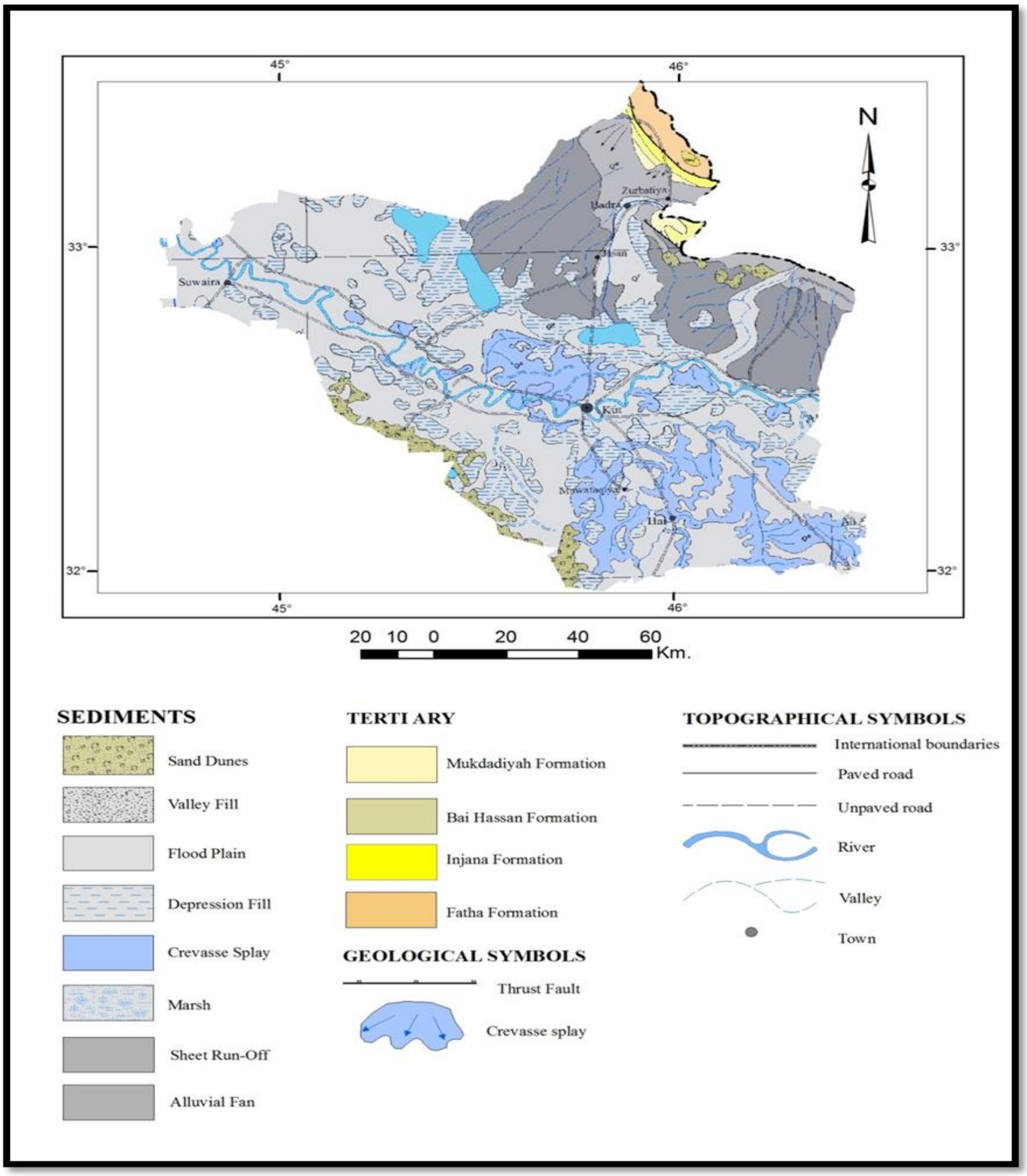

Figure1-Geological map of Wasit Governorate [14]

3. Materials and methods

Study area

Wasit province is located in the southern part of the central region of Iraq between 31.934210-33.486720 N and 44.533030-46.597930 E. Study area is Wasit governorate, Iraq. It is located in eastern Iraq, on the border with Iran. The barmaid border crossing in Wasit connects the two countries. Wasit shares internal boundaries with the governorates of Diyala, Baghdad, Babil, Qadissiya, Thi-Qar, and Missan**.** Wasit Governorate has a dry, desert climate, with temperatures easily more than 40°C in summer. Rainfall is rare and intense in the winter months [15].

Field and Sampling Works

Samples of soils were taken from 22 stations (cover the Wasit region) for the duration of April 2017. The samples were collected by using the clean plastic scoop and stored in polyethylene bags from Al Suwayra to Al Hayy city/ wasit/ Iraq (Table-1**).** The sample sites are carefully chosen on the base of large cities distribution, population community, industrials activities such as electrical thermal power plant), and agricultural areas on the study area (Figure-2). Geological formations, topography, are clearly detected thru field trip in order to support for data interpreting

Table1-Geographic coordination of soil sampling location

Number	Sample Name	Station	Land Use	N	E
1	1SU	Al Suwayra	Agricultural	482331.0772	3650970.695
2	2SU	Al Suwayra	Agricultural	465512.5012	3649540.283
3	3SU	Al Suwayra	Industrial	477462.8599	3644270.761
4	4SU	Al Suwayra	Industrial	478228.5265	3642470.477
5	1TJ	Taj Aldin	Agricultural	486677.3332	3648644.514
6	2TJ	Taj Aldin	Industrial	485049.9933	3650976.969
7	1AZ	Al Aziziya	Agricultural	489079.3161	3645900.366
8	2AZ	Al Aziziya	Industrial	505034.0249	3642026.404
9	1ZD	Al Zubaydiya	Industrial	508713.0117	3627224.245
10	1NM	Al Numaniya	Agricultural	534928.7243	3606153.881
11	2NM	Al Numaniya	Industrial	539233.694	3602014.27
12	1AH	Al Ahrarr	Industrial	562138.6019	3595586.238
13	2AH	Al Ahrarr	Agricultural	552051.3993	3576722.268
14	1K	Al Kut	Agricultural	572892.5665	3588333.929
15	2K	Al Kut	Industrial	556532.1422	3604819.522
16	3K	Al Kut	Agricultural	588270.703	3605421.091
17	4K	Al Kut	Industrial	578521.9863	3600660.305
18	1BR	Badrah	Urban	587023.8075	3664232.265
19	1JN	Jassan	Roadside	580883.5549	3648231.033
20	1HY	Al Hayy	Industrial	595443.482	3567631.073
21	2HY	Al Hayy	Agricultural	596302.2508	3552852.202
22	1MQ	Al Muwafaqiya	Industrial	589298.3222	3570497.849

Laboratory Works

This research involved the sampling and analysis of 22 surface soil samples in Wasit Governorate. That analysis included chemical analysis heavy metals are investigated in the Iraq German Lab, spectra Germany 2010 By XRF in Baghdad University- Science College – geology dept. pH, Salinity, Organic matter are also examined in Wasit University- College of Agriculture, Soil department, laboratory respectively according to [16] and [17]. Mineralogical analysis to determine clay and non - clay minerals studied by X-Ray diffraction (XRD) as well as soil texture of the surface is accomplished. The pipette analysis method is used in determining the grain size of studied samples in Minerals and rocks laboratory [18].

Calculations and Statistical Package

For Description of the evaluation of heavy elements pollution and the calculation of the index criteria for the researchers applied the following equations on the results of studied samples: Geo-accumulation index is defined by [19]:

$$I\text{-}geo = Ln\ (Cn / 1.5\ Bn) \quad (1)$$

Where: Ln= the notations "ln x" and "loge x" but h refer unambiguously to the natural logarithm of x. "log x" without an explicit base possibly will also refer to the natural logarithm.

$$CF = C\ metal / C\ background\ value \quad (2)$$

$$PLI = n\sqrt{(CF1 x CF2 x CF3 x \ldots x CFn} \quad (3)$$

Where:

CF = Contamination factor, n = Number of metals. C metal = Metal concentration in contaminated sediments, C Background value = Background value of that metal according to [20] based on clay fraction ratio.

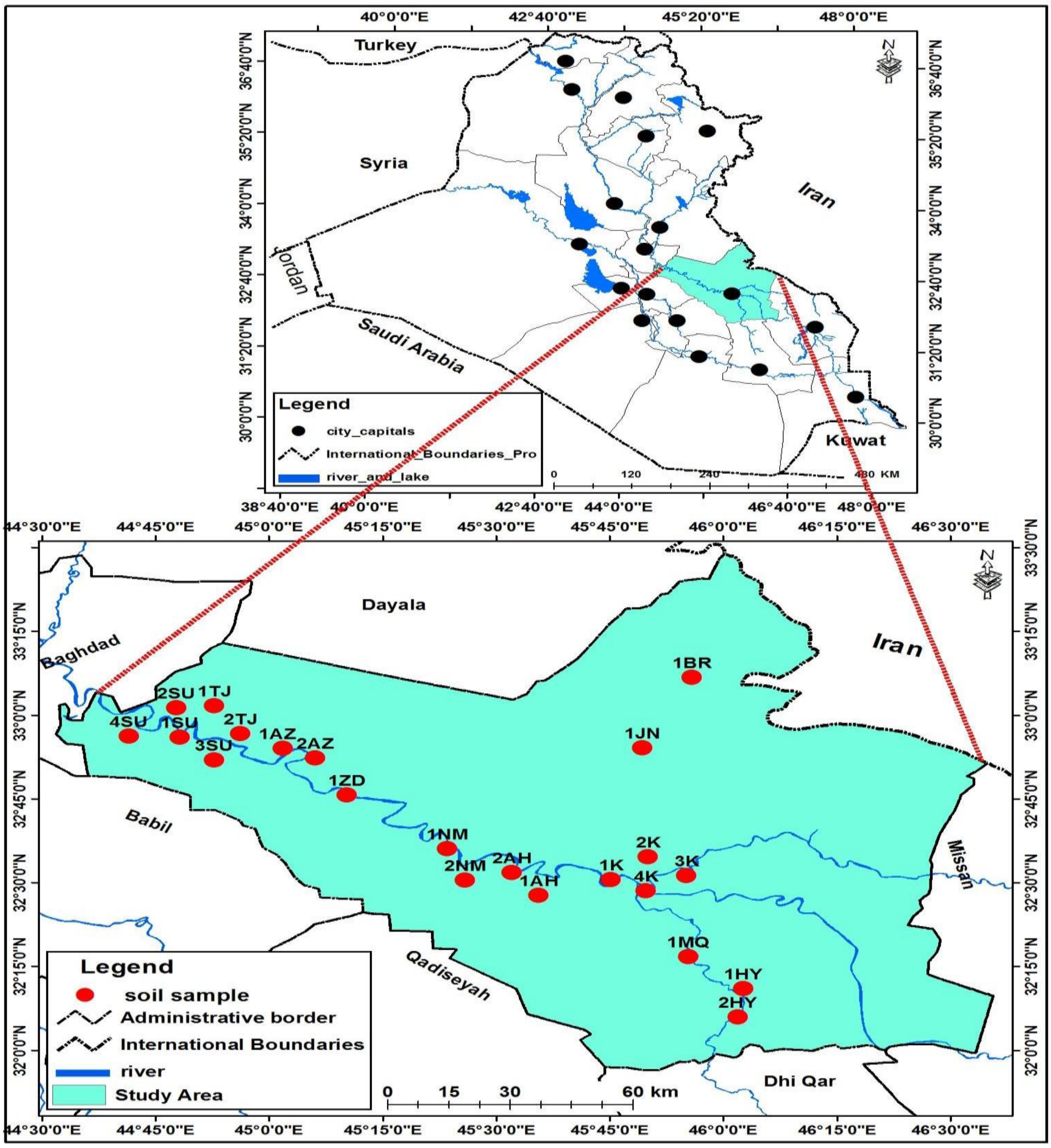

Figure 2-Sampling map of studied area based on Arc map program 10.5 (map scale 1:1000000 of Iraq)

Results and discussion

1.Grain size analysis

Soil texture productions significant roles in the capacity to exchange and hold elements that are transported in the soil solution [21]. Mostly, the texture class influences the contamination, and then the fine fraction is able to adsorb more cations than the coarse fractions [22]. The transportation of the sediment from its source or sources will further affect the grain size distribution of the final sample. The mechanism of transportation (wind, water, or leaching) will winnow the various sediments in accord with the capabilities of the energy conditions of transportation. The clastic sediments are usually fine-grained consisting of clay-silt and sand particles. These are mainly derived from surface runoff depression, either from flows of water or from standing water bodies [23]. Mesopotamia sediments: clay fraction: (41 – 57) %, silt fraction: (37 – 53) %, sand fraction: (1 – 13) %, gravel: none [24].

All soil samples are selected for grain size examines. Importance of grain size analyses in the study is proof of identity for clay fraction percentage for the reason that clay fraction in soils sediments has ability for accommodating heavy metals inside the crystalline structure, also within the exchangeable ions, also of adsorption of heavy metals on its surfaces [25]. Every enclosed large flat-bottomed depression area, without vegetation, covered by fine and very fine soils sediments accumulated for the duration of very long time due to physically and chemically weathering of rocks from high surrounding areas flooded in wet periods in the area [23]. The results of grain size analysis of soils show that the silt and clay are a major part of the studied samples where the silt average (50.8%), it ranges between (30.6% -66.2%) and clay(25.8-55.7) with mean value 39.8 % in addition to sand fraction (5.2- 14%) with main value 9.5% (Table-2). The fine clay fractions which are deposited provide a large specific surface area during long sedimentation time. Studied samples are signified in the sandy mud class according to [18].

Table 2-Grain size analysis of studied samples soil in Wasit Governorate

Nu	Station	Sam	Land use	Sand	Silt	Clay	Classification
1	Al Suwayra district	1SU	Agricultural	10.7	50.8	38. 5	Sandy Mud
2	Al Suwayra district	2SU	Agricultural	8.3	55.9	35.8	Mud
3	Al Suwayra district	3SU	Industrial	5.2	45.1	49.7	Mud
4	Al Suwayra district	4SU	Industrial	13.7	30.6	55.7	Sandy Mud
5	Taj Aldin district	1TJ	Agricultural	7.8	49.7	42.5	Mud
6	Taj Aldin district	2TJ	Industrial	9.9	43.7	46. 4	Mud
7	Al Aziziya district	1AZ	Agricultural	8.0	66.2	25.8	Mud
8	Al Aziziya district	2AZ	Industrial	12.2	58.7	29.1	Sandy Silt
9	Al Zubaydiya district	1ZD	Industrial	10.1	50.7	39.2	Sandy Mud
10	Al Numaniya district	1NM	Agricultural	8.3	46.6	45.1	Mud
11	Al Numaniya district	2NM	Industrial	6.6	56.8	36.6	Mud
12	Al Ahrarr subdistrict	1AH	Industrial	14.0	41.2	44.8	Sandy Mud
13	Al Ahrarr subdistrict	2AH	Agricultural	11.2	34.1	54.7	Sandy Mud
14	Al Kut district	1K	Agricultural	6.2	53.3	40. 5	Mud
15	Al Kut district	2K	Industrial	9.1	56.7	34.2	Mud
16	Al Kut district	3K	Agricultural	5.3	49.3	45. 4	Mud
17	Al Kut district	4K	Industrial	11.1	60.3	28.6	Sandy Mud
18	Badrah district	1BR	Urban	13.1	48.1	38.8	Sandy Mud
19	Jassan subdistrict	1JN	Roadside	9.0	63.7	27. 3	Silt
20	Al Hayy district	1HY	Industrial	8.3	46.6	45.1	Mud
21	Al Hayy district	2HY	Agricultural	12.1	59.2	28.7	Sandy Mud
22	Al Muwafaqiya	1MQ	Industrial	7.8	50.7	41. 5	Mud
23	Min	----	----	5.2	30.6	25.8	----
24	Max	----	-----	14	66.2	55.7	----
25	Mean	----	----	9.5	50.8	39.8	**Sandy Mud**

2.Mineralogy

To distinguish clay minerals and non-clay type minerals in surface soils, one soil samples are examined for XRD technique. Generality, Wasit Governorate, near kut city, XRD in soil illustration that the high percentage of calcite and quartz, as well as various non-clay minerals which are

(Dolomite, Gypsum, and Halite), whereas the clay minerals are (Phengite, Muscovite, Palygroskite, Illite, Chloride and Montmorillonite) [12]. Clay minerals own several qualities that make them relevant in the environmental studies, including that some of clay minerals swell easily and double thickness when hydration and then become with the ability to adsorb cations from aqueous solutions and release these ions later, Clay minerals are transported as clastic material from the surrounding area [26]. Bulk soils samples were investigated for recognizing minerals using the technique. The soils are formed of quartz, calcite, Albite, Dolomite, Feldspar, Mica, Clay minerals. Quartz appears dominant mineral; 32.7% contributes to the total soils (Figure-3). Calcite contributes to 29.2 %. Albite contributes 10.7%, Dolomite 6.8%, Mica contributes only 6.6%. Clay minerals are Kaolinite 9.3, Chlorite and 4.7%.

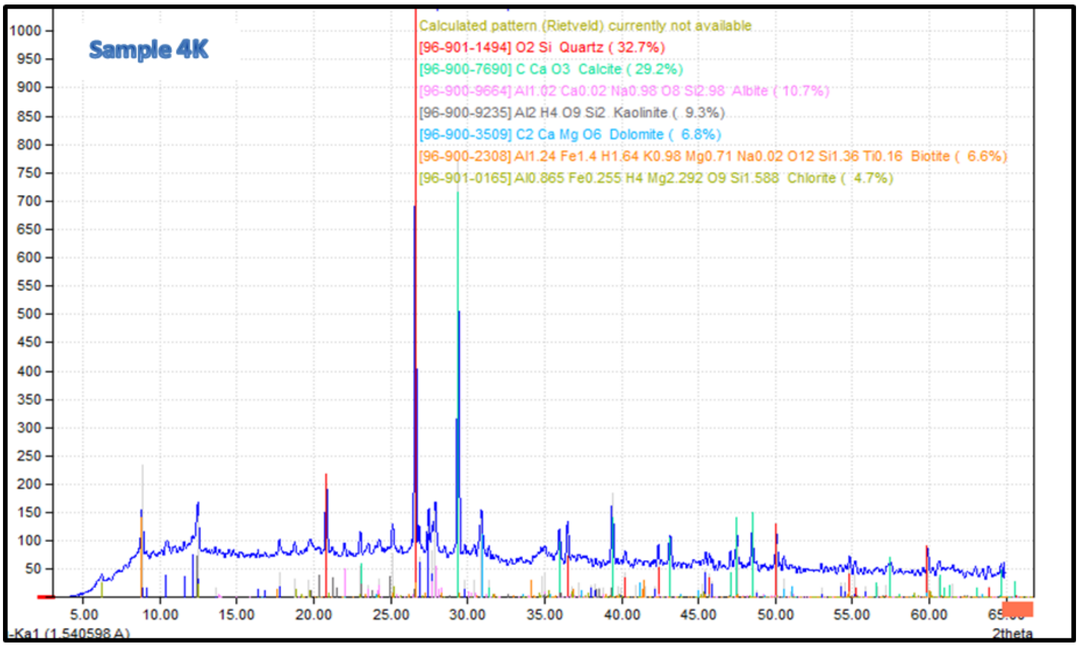

Figure 3-X-ray diffractograph of Wasit Governorate soil; samples Number 4K (Al Kut City)

3.Geochemical parameters

pH parameter, the solubility of ions (Ion Solubility) is the most significant influence of EC is ideal for the growth of most crops because it corresponds to the solubility of the most important nutrients for plants, more heavy elements are soluble at low pH, this makes the pH controlling agent [27]. In this study, pH values of the surface soil samples of the this study are ranged between 7 in agricultural surface soil to 8.16 in industrial soil (Table-3). This is indicating fluctuated in pH from neutral agricultural soil to slightly alkaline in industrial soils. Organic matter is the main sorbent for metals in the surface horizons of the soils [28]. In the soils of Wasit Governorate, OM concentration ranged from 1.2 in urban soil to 3.7 in industrial soil due to the combustion of fossil fuel by industrial activity in the studied area (oil refinery, power plants such as brick factories).

Salinity can effect on soil properties such as hydraulic conductivity and infiltration rate, Soils become saline when extreme soluble salts are added to soils and not removed by leaching or other means [29]. Approaches such as EC and TDS are not able to determine the species of ions that contribute to soil salinity. Soil salinity may result from a range of soluble salts, typically the cations Na^{+}, K^{+} Mg^{2+}, and Ca^{2+} and the anions Cl^{-}, SO_4^{2-}, CO_3^{2-}, and HCO_3^{-}. Soluble fertilizer also contributes other ions such as K^{+}, NH_4^{+} and NO_3^{-}. In order to determine the types and relative importance of the different ions that contribute to soil salinity [30]. Soil Salinity of the studied area ranged from 0.1% in agricultural soils to 8.5 % in urban soil at Badrah Station (Figure-4). High level Rate of salinity due to the Badrah area represents one of those deserted areas, in which the preliminary stage of aeolian activity is very evident. Nabkha dunes and sand sheets are the major wind formed deposits in the area. Nabkhas or more precisely micronabkhas represent the major dune type which imposes a clear indication of the desertification vitality in the area. Such an area may represent an ideal example of how desertification is acting; where a well-vegetated area is some three decades ago is turning now to a barren land. The dune sands indicate that the aeolian activity in Badra area is in its infantile dune stage (few years) as compared to the more developed Iraqi dune area [31].

Table 3-Chemical Parameters of studied Surface Soil samples in Wasit Governorate

Numbe	Station	Samples	Land use	OM %	pH	Salinity%
1	Al Suwayra	4SU	Agricultural	1.6	7.28	0.36
2	Al Suwayra	6SU	Agricultural	1.4	7.35	2.5
3	Al Suwayra	7SU	Industrial	3.5	7.22	2.58
4	Al Suwayra	10SU	Industrial	3.2	7.24	4.25
5	Taj Aldin	2TJ	Agricultural	1.5	7	0.42
6	Taj Aldin	5TJ	Industrial	2.9	7.2	2.89
7	Al Aziziya	1AZ	Agricultural	1.7	7.1	3.6
8	Al Aziziya	3AZ	Industrial	3.4	7.3	0.34
9	Al Zubaydiya	1ZD	Industrial	3.6	7.3	2.7
10	Al Numaniya	1NM	Agricultural	1.6	8	0.13
11	Al Numaniya	2NM	Industrial	3.7	8.16	0.83
12	Al Ahrarr	1AH	Industrial	3.3	7.86	1.6
13	Al Ahrarr	4AH	Agricultural	1.5	8.13	0.2
14	Al Kut	3K	Agricultural	1.8	7.74	1.5
15	Al Kut	4K	Industrial	3.5	7.5	4.1
16	Al Kut	14K	Agricultural	1.7	8.06	0.1
17	Al Kut	12K	Industrial	3.6	7.14	1.9
18	Badrah	1BR	Urban	1.2	7.07	8.5
19	Jassan	1JN	Roadside	1.5	7.16	4.4
20	Al Hayy	1HY	Industrial	3.7	7.25	3.9
21	Al Hayy	4HY	Agricultural	1.7	7.42	0.34
22	Al Muwafaqiya	2MQ	Industrial	3.4	7.02	0.9
23	Min	----	----	1.2	6.9	0.1
24	Max	----	----	3.7	8.16	8.5
25	Mean	----	----	2.5	7.44	2.4

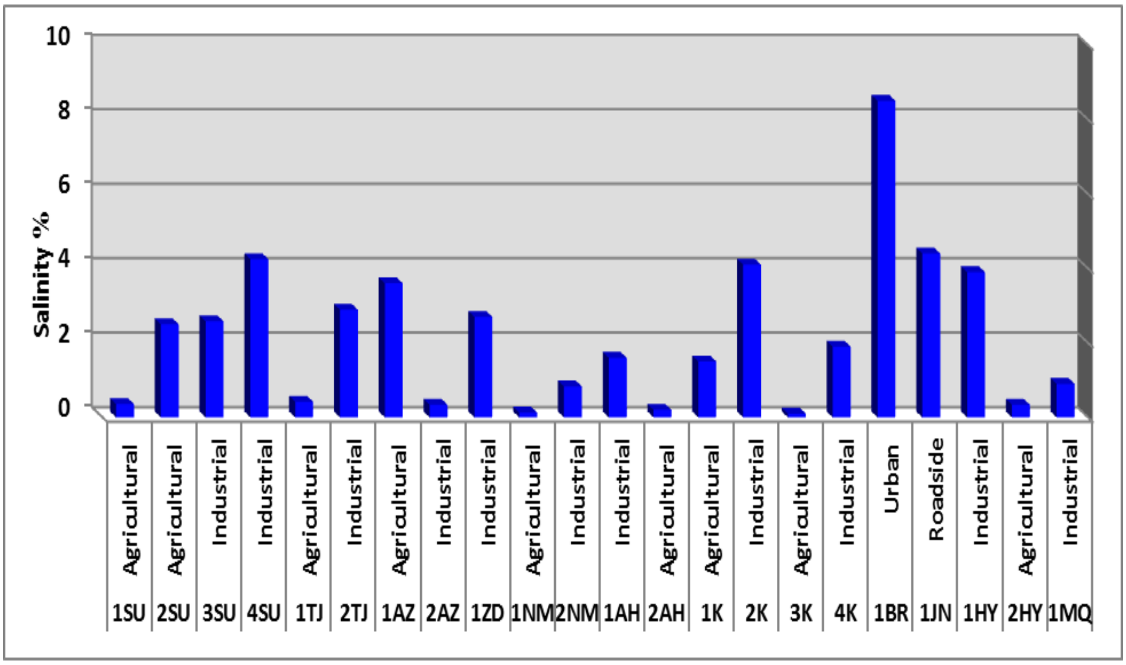

Figure 4-Bar shape for the salinity of studied soil samples in Wasit Governorate.

4.Heavy metals

Soil is critical environments where rock, air, and water interface, consequently they are subjected to a number of pollutants due to different anthropogenic activities (industrial, agricultural, transport, etc.). Evaluation of distribution of heavy metal pollution is the most concerned because the metal pollution in the soil causes a serious threat to human health and agricultural products [32]. Concentrations of some studied heavy metals in the types of land use soil in the study area (ppm) in assessment with local and global studies (Table-4).

Heavy metals concentrations in surface soil are different according to the degree of particle sedimentation, the rate of heavy metals deposition, the particle size and the occurrence or lack of organic matter in the soils, heavy metals Mo, Cu, Pb, Zn, Ni, Co, Mn, As, Cd, V, Cr, Br, Ta, Zr, Ba, and Sr in the soil of Wasit Governorate., possibly will be incorporated into carbonate and in that way transported from solution in the soil in the reducing conditions [23]. The mean value concentration of Mo, Cu, Pb, Zn, Ni, Co, Mn, As, Cd, V, Cr, Br, Ta, Ba, and Sr are a mainly higher concentration than global surface soil according to[20**] e**xcepting Br and Zr was lower than this global limit. The concentration of studied heavy metals in soil samples was higher than the results of [33] but Zn lower. The contamination resulted from the human activities especially the agriculture processes, decomposition of the garbage, sewage, and polluted air. Regarding agriculture operations, domestic sewage discharges, the human activities particularly agriculture, sewage, garbage, and desalination plants and wastewater represent the main sources of the pollution with a role from the natural sources [34]**.** Sr is the element which is incorporated with calcite mineral (29.2. 2%). Sr encountered in the clay fraction is common as a product of substitution for Ca in $CaCO_3$ derivative from the rocks the relatively higher values of Ni the soils are possibly due to the impact of carbonate and clay minerals. Some f heavy metals come from fertilizers such as Mo, Zn, Mn and Cu in reducing state, in elevation concentration of Zn which due to the extensive use of the fertilizers as the Iraq fertilizers are rich in zinc (35). Additional heavy metals determined in higher values indicating the industrial emissions source such as vanadium. High concentrations in some element take place due to the autogenic formation such as Ta, Ba, and Zr, The geochemical search submitted that source of heavy metals is natural in origin. Although receives significant for anthropogenic sources from land use activities, they still unimportant compared with natural source [35]. The height concentration of V recognized in the Al Zubaydia stations (Sample 1ZD). Cause of this relative rise is due to the fuel combustion and industrial emission from the Wasit Thermal Power Plant which is sited on the Tigris River bank in the Zubaidia district. The possible sources of contaminants in soils sediments: some solutes are of anthropogenic sources (mainly fertilizers and petroleum removal wastes), and others are from natural sources [36]**.** Cd provides the idea of slightly increase compared with global standards limits, this comes from combustion products increase the concentration of Cd in the atmosphere and then deposition on the soil, and followed by the bricks and asphalts factories that deal with Cd and its compounds as well as industries and other activities.

Table 4-Concentration of heavy metals of studied soil samples **(B.G**=Background Depends on [20]

Sample Name	ppm															
	Mo	Cu	Pb	Zn	Ni	Co	Mn	As	Cd	V	Cr	Br	Ta	Zr	Ba	Sr
1SU	**8.4**	**48.57**	**14.20326**	**95.61**	**182.4**	**14.7**	**1706**	**7.4**	**2**	**120**	**216**	**13.3**	**70.2**	**124**	**245.1**	**334**
2SU	**8.1**	**35.074**	**9.37**	**74.56**	**136.7**	**7.9**	**727**	**6.5**	**2**	**101**	**179**	**21.4**	**73.7**	**117**	**255**	**454**
3SU	**14.9**	**56.63**	**93.57**	**136.98**	**181.7**	**7.8**	**776**	**8**	**2**	**113**	**226**	**47.9**	**74.3**	**105**	**224.9**	**504**
4SU	**17.6**	**187.09**	**148.3**	**291.8**	**168.2**	**12.9**	**716**	**6.8**	**2**	**88**	**227**	**100.1**	**71.3**	**104**	**221.3**	**424**
1TJ	**8.3**	**55.44**	**14.85**	**96.09**	**200.3**	**7**	**868**	**7.2**	**2**	**83**	**359**	**15.2**	**70.6**	**149**	**24.12**	**373**
2TJ	**6**	**44.657**	**31.47**	**170**	**147.2**	**6.4**	**643**	**5.5**	**2**	**84**	**193**	**14.7**	**63.7**	**109**	**262.9**	**387**
1AZ	**14.4**	**39.30414**	**13.09**	**103**	**161**	**15.5**	**737**	**6.8**	**2**	**104**	**157**	**15**	**78.4**	**108**	**253**	**495**
2AZ	**6.9**	**49.44972**	**13**	**102**	**201.3**	**19.8**	**828**	**7.9**	**2**	**102**	**233**	**17.1**	**67.9**	**143**	**270.3**	**746**

1ZD	**16.6**	**41.94039**	**12.5**	**88.62**	**210.9**	**20.2**	**800**	**7.7**	**2**	**217**	**208**	**10.3**	**70.1**	**115**	**233**	**444**
1NM	**4.3**	**54.2429**	**13.92**	**106.5**	**469.3**	**38.6**	**844**	**7.8**	**2**	**118**	**256**	**9.6**	**62.8**	**137**	**253.5**	**335**
2NM	**18.3**	**70.06042**	**56.81**	**268.6**	**152.4**	**3.1**	**526**	**5.4**	**2**	**80**	**172**	**38.8**	**65**	**76**	**219.5**	**386**
1AH	**9.5**	**42.49959**	**11.88**	**89.9**	**194.9**	**17.1**	**827**	**7.6**	**2**	**101**	**198**	**31.9**	**71.7**	**114**	**264.4**	**390**
2AH	**4.8**	**26.28264**	**12.8**	**57.93**	**129.2**	**3**	**596**	**3.4**	**2**	**73**	**325**	**57.8**	**70.7**	**105**	**174.4**	**267**
1K	**3.4**	**44.17721**	**12.63**	**90.1**	**205.9**	**14.2**	**827**	**7.3**	**2**	**110**	**250**	**7.9**	**69.1**	**123**	**260.2**	**357**
2K	**15.6**	**34.99027**	**11.23**	**75**	**170.1**	**11.3**	**740**	**6.4**	**2**	**97**	**308**	**39.3**	**75**	**121**	**215.8**	**403**
3K	**7.3**	**37.54**	**10.9**	**81.15**	**181.8**	**15.4**	**777**	**6.4**	**2**	**110**	**315**	**9.4**	**70.9**	**151**	**262.6**	**322**
4K	**7.9**	**40.74**	**19.3**	**92.7**	**193.1**	**14.3**	**822**	**7.4**	**2**	**109**	**233**	**10.4**	**73.2**	**117**	**267**	**384**
1BR	**16.5**	**16.14**	**8.9**	**60.7**	**91.4**	**3.06**	**432**	**4.8**	**2**	**87**	**200**	**22**	**81.5**	**69**	**231.3**	**627**
1JN	**8.8**	**19.33**	**5.38**	**29.2**	**40.1**	**3.06**	**196**	**3.1**	**2**	**46**	**100**	**2**	**94.5**	**31**	**208.3**	**283.4**
1HY	**6.7**	**58.08**	**13.09**	**89.3**	**210.7**	**15.1**	**734**	**6.6**	**2**	**100**	**174**	**36**	**76**	**95**	**263**	**452**
2HY	**3.1**	**48.57**	**16.1**	**102.4**	**238.3**	**20.8**	**1073**	**11.4**	**2**	**123**	**254**	**6.4**	**71.2**	**127**	**288.4**	**413**
1MQ	**7.8**	**60.79**	**76.4**	**201.42**	**158.7**	**8.6**	**667**	**7.2**	**5.4**	**76**	**188**	**29.4**	**70.5**	**99**	**202.1**	**565**
Min	**3.1**	**16.14**	**5.38**	**29.2**	**40.1**	**3**	**196**	**3.1**	**2**	**46**	**100**	**2**	**62.8**	**31**	**24.12**	**267**
Max	**18.3**	**187.09**	**148.3**	**291.8**	**469.3**	**38.6**	**1706**	**11.4**	**5.4**	**217**	**359**	**100.1**	**94.5**	**151**	**288.4**	**746**
Mean	**9.85**	**54.7**	**32.2**	**117.6**	**188.9**	**13.4**	**781.8**	**6.7**	**2.2**	**104.3**	**226**	**27.4**	**72.7**	**109**	**225.5**	**431.6**
B.G1(8)	**1.8**	**14**	**25**	**62**	**18**	**6.9**	**418**	**4.7**	**1.1**	**60**	**42**	**-----**	**1.1**	**300**	**360**	**147**
B.G2(33)	**----**	**17.7**	**5.4**	**36.1**	**71.9**	**12**	**489.6**	**---**	**0.1**	**---**	**----**	**----**	**----**	**----**	**----**	**----**

5.Evaluation of heavy metal pollution

In the interpretation of geochemistry results, the heavy metals which have displayed considering concentrations which are derived from natural inputs and human activities [37].The Contamination Factor (CF), (I-geo) and pollution load index (PLI) and geo-accumulation index were employed to assess the pollution of heavy metals in soil sediment samples of Wasit Governorate.

Contamination Factor and Pollution Load Index

For the better assessment of anthropogenic input contamination factor (CF), and pollution load index (PLI) should be measured. Mostly pollution load index (PLI) as developed by, This CF is used to categorize the level of pollution of metals in the soil samples, the quotient achieved by dividing the concentration of every metal. The PLI for a single situate is the *n*th source of the product of *n* contamination factors (CF values), The PLI of the place is calculated by obtaining the n-root from the n- CFs that is obtained for all the metals (Table 4). The Contamination Factor is categorized consistent with [38]. The PLI value is methodical supportive to [39] and derived from Contamination Factor CF**.** the Contamination Factor results are listed in Table-5. The results give the impression that Ta and Ni are very high; while Cd, Cr, Br,Sr and Mo are considerable (Table-6). Based on the PLI results arranged in Table-7, all locations of soil samples are polluted. Pollution hazard and its variation along the sites were determined to **use** pollution load index. This index is a fast tool in order to compare the pollution station in different places [40]

Table 5-Contamination Factor values of studied soil sediments samples in Wasit Governorate

Sample Name	CF															
	Mo	Cu	Pb	Zn	Ni	Co	Mn	As	Cd	V	Cr	Br	Ta	Zr	Ba	Sr
1SU	3	2.11	0.5	1.59	7.01	1.47	3.24	0.89	4.4	1.59	4.24	1.66	35.13	0.22	0.47	1.59
2SU	2.89	1.52	0.33	1.24	5.25	0.78	1.38	0.78	4.4	1.33	3.53	2.68	36.89	0.21	0.49	2.16
3SU	5.32	2.46	3.34	2.28	6.98	0.77	1.47	0.96	4.4	1.49	4.43	5.99	37.14	0.19	0.43	2.4
4SU	6.28	8.13	5.29	4.86	6.47	1.29	1.36	0.81	4.4	1.16	4.45	12.51	35.63	0.18	0.42	2.01
1TJ	2.96	2.41	0.53	1.6	7.7	0.69	1.65	0.86	4.4	1.09	7.05	1.90	35.30	0.27	0.04	1.77
2TJ	2.14	1.94	1.12	2.83	5.66	0.63	1.22	0.66	4.4	1.11	3.79	1.84	31.86	0.19	0.5	1.84
1AZ	5.14	1.7	0.46	1.72	6.19	1.54	1.4	0.81	4.4	1.37	3.09	1.88	39.02	0.19	0.48	2.35
2AZ	2.46	2.14	0.46	1.7	7.74	1.98	1.57	0.94	4.4	1.34	4.59	2.14	33.95	0.26	0.51	3.55
1ZD	5.92	1.82	0.44	1.47	8.11	2.02	1.52	0.51	4.4	2.85	3.23	2.01	33.82	0.2	0.44	2.11
1NM	1.53	2.35	0.49	1.77	18.04	3.86	1.60	0.92	4.4	1.55	4.08	1.29	35.05	0.24	0.48	1.59
2NM	6.53	3.04	2.02	4.47	5.86	0.3	1	0.93	4.4	1.06	5.03	1.20	31.41	0.13	0.42	1.83
1AH	3.39	1.84	0.42	1.49	7.49	1.71	1.57	0.64	4.4	1.33	3.38	4.85	32.51	0.2	0.5	1.85
2AH	1.71	1.14	0.45	0.96	4.96	0.3	1.13	0.90	4.4	0.96	3.90	3.99	35.87	0.19	0.33	1.26
1K	1.21	1.92	0.45	1.5	7.91	1.42	1.57	0.41	4.4	1.45	6.39	7.23	35.34	0.23	0.5	1.7
2K	5.57	1.52	0.4	1.25	6.54	1.13	1.41	0.87	4.4	1.28	4.90	0.99	34.56	0.22	0.41	1.92
3K	3.21	6.17	7.85	2.77	6.94	0.85	1.5	0.46	4.4	1.35	5.63	0.54	34.60	0.2	0.51	1.77
4K	2.6	1.63	0.38	1.35	6.99	1.54	1.48	0.76	4.4	1.45	6.05	4.91	37.51	0.27	0.5	1.53
1BR	5.89	0.7	0.31	1.01	3.51	0.3	0.82	0.77	4.4	1.14	6.19	1.18	35.46	0.12	0.44	2.98
1JN	3.14	0.84	0.19	0.48	1.543	0.3	0.37	0.57	4.4	0.61	3.94	2.75	40.78	0.05	0.4	13.4
1HY	2.39	2.52	0.46	1.48	8.1	1.51	1.39	0.37	4.4	1.31	1.96	0.25	47.25	0.17	0.5	2.156
2HY	1.1	2.11	0.57	1.7	9.16	2.07	2.04	0.79	4.4	1.62	3.42	4.50	38.00	0.23	0.55	1.96
1MQ	2.78	2.64	2.72	3.35	6.1	0.86	1.27	1.36	12	1	4.99	0.80	35.58	0.17	0.38	2.69
Min	1.1	0.7	0.19	0.48	1.53	0.3	0.37	0.86	4.4	0.61	3.69	3.68	35.26	0.05	0.04	1.26
Max	6.53	8.13	7.85	4.86	18.05	3.86	3.24	1.36	12	2.85	7.05	12.51	47.25	0.27	0.55	13.4
Mean	3.53	2.56	1.55	2	7.24	1.31	1.48	0.80	5	1.37	4.54	3.47	36.47	0.19	0.43	3

Table 6-Mean Contamination Factor values of heavy metals in the study area of soils samples

Number	Present study								
	CF					I-Geo			
	Elements	**Min**	**Max**	**Mean**	**Grade**	**Min**	**Max**	**Mean value**	**Grade**
1	**M**	1.1	6.53	3.53	**Considerable**	-0.3	1.47	0.71	Unpolluted to Moderate
2	**Cu**	0.7	8.13	2.56	Moderate	-	1.69	0.32	Unpolluted to Moderate
3	**pb**	0.19	7.85	1.55	Moderate	-	1.65	-0.68	Unpolluted
4	**Zn**	0.48	4.86	2	Moderate	-	1.17	0.12	Unpolluted to Moderate
5	**Ni**	1.53	18.0	7.24	**Very high**	0.02	2.48	1.44	**Moderate Polluted**
6	**Co**	0.3	3.86	1.31	Moderate	-	0.94	-0.39	Unpolluted
7	**M**	0.37	3.24	1.48	Moderate	-	0.77	-0.1	Unpolluted
8	**As**	0.86	1.36	0.8	Low	-1.4	-	-0.69	Unpolluted
9	**Cd**	4.4	12	5	**Considerable**	1.1	2.1	1.2	**Moderate Polluted**
10	**V**	0.61	2.85	1.37	Moderate	-	0.64	-0.14	Unpolluted
11	**Cr**	3.69	7.05	4.54	**Considerable**	0.26	1.54	1.04	**Moderate Polluted**
12	**Br**	3.68	12.5	3.47	**Considerable**	-	2.12	0.35	Unpolluted to Moderate
13	**Ta**	35.5	47.2	36.4	**Very high**	3.04	3.45	3.18	**High Polluted**
14	**Zr**	0.05	0.27	0.19	Low	-	-	-2.08	Unpolluted
15	**Ba**	0.04	0.55	0.43	Low	-	-	-1.36	Unpolluted
16	**Sr**	1.26	13.4	3	**Considerable**	-0.16	2.19	0.42	Unpolluted to Moderate

Table 7-ollution Load Index (PLI) of heavy metals in the studied area of soil sediments samples

Sample Name	PLI	Decision	Sample Name	PLI	Decision
1SU	1.14	Polluted	1AH	1.13	Polluted
2SU	1.07	Polluted	2AH	1.02	Polluted
3SU	1.25	Polluted	1K	1.11	Polluted
4SU	1.48	Polluted	2K	1.02	Polluted
1TJ	1.68	Polluted	3K	1.09	Polluted
2TJ	1.17	Polluted	4K	1.28	Polluted
1AZ	1.15	Polluted	1BR	1	Polluted
2AZ	1.23	Polluted	1JN	1.03	Polluted
1ZD	1.16	Polluted	1HY	1.08	Polluted
1NM	1.17	Polluted	**2HY**	1.2	Polluted
2NM	1.06	Polluted	1MQ	1.28	Polluted

Geo-accumulation index (I-Geo)

The geo-accumulation guide is a quantitative measure of the degree of pollution in soil sediments involves seven grades fluctuating from uncontaminated to exceedingly polluted [41]**.** If the Results presented that the overall pollution indexes values (I- GEO , CF , and PLI) of trace elements were consistent, this indicates that the studied samples affected by the same type of sediments in their regions [11].

Pollution indices values exhibited polluted surface soils sediments by Ni due to anthropogenic activities (industrial and agricultural activities [42]. In the present study, results of Igeo- accumulation in studied area appearance that soil sediments samples are highly polluted with Ta and moderate with

Cd, Cr and Ni, unpolluted to moderately polluted with Cu , Zn, Br , Sr and Mo (Table-8). I- geo soils sediments are unpolluted with; Mn, Co, Pb, As,Zr ,V and Ba.

Table 8- I- Geo-accumulation index (I-Geo) values of studied soil sediments samples In Wasit Governorate

Sample Name	I-Geo															
	Mo	Cu	Pb	Zn	Ni	Co	Mn	As	Cd	V	Cr	Br	Ta	Zr	Ba	Sr
1SU	0.697	0.34	-1.08	0.06	1.54	-0.01	0.77	-0.51	1.1	0.05	1.03	0.1	3.15	-1.88	-1.15	0.06
2SU	0.65	0.016	-1.49	-0.18	1.25	-0.64	-0.07	-0.65	1.1	-0.11	0.85	0.57	3.2	-1.94	-1.11	0.36
3SU	1.26	0.49	0.8	0.42	1.53	-0.65	-0.01	-0.45	1.1	-0.002	1.08	1.38	3.2	-2.05	-1.24	0.47
4SU	1.43	1.69	1.26	1.17	1.46	-0.145	-0.09	-0.61	1.1	-0.25	1.08	2.12	3.16	-2.06	-1.25	0.29
1TJ	0.68	0.47	-1.03	0.06	1.63	-0.762	0.0971	-0.56	1.1	-0.31	1.54	0.23	3.15	-1.7	-3.47	0.16
2TJ	0.35	0.25	-0.28	0.63	1.32	-0.85	-0.2	-0.82	1.1	-0.29	0.92	0.2	3.05	-2.02	-1.08	0.2
1AZ	1.23	0.13	-1.16	0.13	1.41	0.03	-0.06	-0.61	1.1	-0.08	0.72	0.22	3.25	-2.02	-1.12	0.45
2AZ	0.49	0.35	-1.17	0.12	1.64	0.27	0.05	-0.46	1.1	-0.1	1.11	0.35	3.11	-1.74	-1.05	0.86
1ZD	1.37	0.19	-1.2	-0.01	1.68	0.29	0.01	-0.48	1.1	0.64	1	-0.15	3.15	-1.96	-1.2	0.34
1NM	0.02	0.45	-1.1	0.16	2.48	0.94	0.07	-0.47	1.1	0.03	1.2	-0.22	3.04	-1.79	-1.12	0.06
2NM	1.47	0.7	0.3	1.09	1.36	-1.58	-0.4	-0.85	1.1	-0.34	0.81	1.17	3.07	-2.37	-1.26	0.2
1AH	0.81	0.2	-1.26	-0.001	1.6	0.13	0.05	-0.5	1.1	-0.11	0.95	0.97	3.17	-1.97	-1.08	0.21
2AH	0.13	-0.27	-1.18	-0.44	1.19	-1.58	-0.27	-1.3	1.1	-0.44	1.44	1.57	3.15	-2.05	-1.49	-0.16
1K	-0.21	0.24	-1.2	0.001	1.66	-0.05	0.04	-0.54	1.1	-0.02	1.18	-0.41	3.13	-1.87	-1.09	0.12
2K	1.31	0.01	-1.31	-0.17	1.47	-0.28	-0.06	-0.68	1.1	-0.15	1.39	1.18	3.21	-1.91	-1.28	0.24
3K	0.76	1.41	1.65	0.61	1.53	-0.55	0.004	-1.18	1.1	-0.1	1.32	-1.02	3.13	-2	-1.07	0.17
4K	0.55	0.08	-1.35	-0.1	1.53	0.02	-0.01	-0.67	1.1	-0.02	1.41	-0.24	3.16	-1.6	-1.08	0.02
1BR	1.36	-0.75	-1.55	-0.39	0.854	-1.58	-0.59	-0.97	1.1	-0.26	0.96	0.6	3.3	-2.47	-1.21	0.68
1JN	0.73	-0.57	-2.05	-1.12	0.02	-1.58	-1.39	-1.4	1.1	-0.89	0.26	-1.79	3.45	-3.25	-1.32	2.19
1HY	0.463	0.52	-1.16	-0.007	1.68	0.006	-0.06	-0.63	1.1	-0.12	0.82	1.09	3.23	-2.15	-1.08	0.36
2HY	-0.3	0.347	-0.96	0.12	1.8	0.32	0.3	-0.09	1.1	0.07	1.2	-0.62	3.16	-1.86	-0.99	0.27
1MQ	0.619	0.56	0.59	0.8	1.4	-0.55	-0.16	-0.56	2.1	-0.39	0.89	0.89	3.15	-2.12	-1.35	0.58
Min	-0.3	-0.75	-2.05	-1.12	0.02	-1.58	-1.39	-1.4	1.1	-0.89	0.26	-1.79	3.04	-3.25	-3.47	-0.16
Max	1.47	1.69	1.65	1.17	2.48	0.94	0.77	-0.09	2.1	0.64	1.54	2.12	3.45	-1.69	-0.99	2.19
Mean	0.71	0.32	-0.68	0.12	1.44	-0.39	-0.1	-0.69	1.2	-0.14	1.04	0.35	3.18	-2.08	-1.36	0.42

Conclusions

Identification and quantification of heavy metal sources, as well as the fate of those trace elements, are important environmental scientific issues. The results of this study supply valuable information around some trace elements contents of soil land use from different sites along Wasit Governorate, So can be concluded that:

1- The grain size analysis of soils., the appearance that the silt and clay are a major part of these types of soils sediments where the silt comes in the main rank in terms of the relative distribution this refers to the sandy mud type as the classification of particle size

2- The XRD analysis showed the existence of non-clay minerals: quartz, calcite, dolomite, and albite with clay minerals: Kaolinite, Mica, and Chlorite, in the soil sediment samples of land use in the study area.
3- Concerning to the geochemical parameters, surface soils of Wasit Governorate tend to be alkaline, Iraqi soil has a high regulatory capacity as it resists the change in pH due to the presence of calcium carbonate in large quantities. The high level concentration of soil salinity was in urban soil at Badrah station because the evaporates mineral deposits, floods dryness, high evaporation, great distance from the main river and the area are exposed to desertification and sand dunes.
4- The mean concentration of heavy metals in the study area is in the order Mn> Sr> Cr> Ba> Ni> Zn> Zr> V> Ta> Cu>Pb> Br> Co> As and Cd. Contamination Factor (CF) with and I- Geo-accumulation indexes I_{geo}) showed soils sediments are ranging from very high polluted with Ta and Ni to considerable with Cd, Sr, Br, and Mo to moderate with Cu, Pb, Zn, Co, Mn and V. Based on PLI, all sampling locations are reflected to be polluted as results of high level concentration of these elements in anthropogenic activities urban wastes, agricultural and industrial activities, this indicator may be possible sources of pollution in the study area.
5- Some heavy metals are concentrated in the soils as a natural source in clay, heavy minerals and perhaps will be incorporated into carbonate minerals. The different contaminated kinds coming from many industrial emissions such as brick and asphalts factories and mud deposits exclusively the heavy elements of, Zn, Cr Ni, Cd and Cu.

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