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Concentrations of Heavy Metals in Soil of West Qurna-1Oilfield Northern Basrah

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Abstract

The current experiment set out to determine the level of heavy metal pollution in the studied soil. Sixteen sites were chosen to collect soil samples. ICP-MS was utilized to assess heavy metals in soil samples. The detected heavy metal concentrations were compared with the values of the Geochemical Background WHO recommendations. Based on the pH values, all soil samples in the research region are determined to be alkaline. The average pH of the research area is 7.30. The heavy metal pollution was evaluated using descriptive statistical analysis and a correlation matrix. The soil exhibits a range of heavy metal pollution, varying from very low to severe. The mean concentration of elements B, Cu, Hg, Cr, Ni, and Sr was higher than the global soil concentration. The Co level of pollution was moderate. The pollution levels of Ce, Zn, V, Ba, and As in the world soil were lower. Unlike the global average percentage of contaminated soil, the remaining elements exhibited lower pollution levels.

Keywords: West Qurna1 Oilfield, Heavy metals(HMs), Hydrogen Number (pH) Statistical analysis, Icp-Ms, correlation matrix analysis

تراكيز العناصر الثقيلة في تربة حقل غرب القرنه-1 النفطي في شمال محافظة البصرة

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الخلاصة

تحديد مستوى التلوث بالمعادن الثقيلة في تربة منطقة البحث كان هدف التجربة الحالية. تم اختيار 16 موقعاً لجمع عينات التربة. تم استخدام ICP-MS لتحليل المعادن الثقيلة في عينات التربة باستخدام طريقة GPS. تمت مقارنة تركيزات المعادن الثقيلة مع قيم الخلفية الجيوكيميائية. إرشادات منظمة الصحة العالمية. جميع عينات التربة في منطقة الدراسة قلوية بناءً على قيم الرقم الهيدروجيني هذه. متوسط الرقم الهيدروجيني لمنطقة الدراسة هو 7.30. تم استخدام التحليل الإحصائي الوصفي ومصفوفة الارتباط لتقييم تلوث التربة بالمعادن الثقيلة. هناك طيف خفيف إلى شديد من التلوث بالمعادن الثقيلة في التربة. وجد أن متوسط تركيز (B, Cu, Hg, Cr ,Ni, Sr) أكبر من تركيزالتربة العالمية. وكان التلوث معتدل (Co).بينما كانت تراكيز

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اقل من الحد المسموح في التربة العالمية. وعلى النقيض من متوسط النسبة المئوية (Ce, Zn, V, Ba, As)
للتربة الملوثة في جميع أنحاء العالم، كانت العناصر المتبقية أقل شدة تلوثاً.

1. Introduction:

Urbanization and industrial expansion worldwide are contributing to the build-up of potentially heavy metals in soil, causing significant concerns in some developing nations. [1, 2, 3]. Urban soil is an important source and sink of heavy metal pollutants due to their long residence time and non-degradability in urban ecosystems. [4,5]. Urban pollution, primarily caused by power plants, oil emissions, hydrocarbon burning, and municipal garbage, poses a significant threat to human health and ecosystem health. [6, 7]. Despite numerous studies on monitoring and assessing HM's increasing content in urban soils, it is still important [9]. Environmental scientists have developed methods to assess the ecological risk of HMs, pH, salinity, statistical analysis, and matrix correlation. [10,11,12,13]. Assessing the environmental risk of heavy metals (HMs) in soil is crucial to managing pollution and developing effective mitigation strategies [14]. Heavy metals pose a significant threat to ecosystems due to their toxicity and importance as essential nutrients. Understanding the background concentration of these elements in soils is crucial for preventing contamination. Polluted soil deviates from typical chemical makeup but does not pose a threat. [44]. Soils are exposed to pollutants such as heavy metals from industrial, agricultural and transport activities, causing significant risks to agriculture and human health [41]. Human health risk assessment has gained attention for measuring the health risk of heavy metals in soil alongside environmental risk assessment [15]. Research primarily relies on the US EPA model, a disadvantage as many countries lack their national health risk assessment methods, as seen in numerous studies, including those in Poland [17], China[18], Chad, Africa[19], India[20], Turkey[21], and Brazil[22], The USEPA technique has been used to assess the health risks of HMs in contaminated soils. Combined with GIS, it allows for a comprehensive evaluation of pollution distribution. [23,24]. Numerous studies utilize deterministic and geostatistical interpolation techniques to determine the geographical distributions of soil HM.. [25, 26, 27, 28, 29]. The study investigates the distribution of heavy metals in soil samples, their concentrations, and pollution levels using pollution indicators involving statistical analysis and correlation of matrices.

2.1 Study area.

West Qurna-1 are in the southeast of the Republic of Iraq. Approximately 70 km northwest of Basra City is where you'll find the WQI [30]. The field is 500 km² in size. The Zagros Fold Belt is located in southern Iraq, on the eastern edge of the Arabian Platform, south of the Mesopotamian Basin, and shares a northern border with the West Qurna-1 Oilfield [31]. The study area bounded by longitudes (47 º 19 ′ 12″ E,47 º19 ′53″) and latitudes (30º 45 ′ 35″ N, 30º 52 ′ 54″ N). GPS located the sample sites with accuracy shown in Figure 1. The wind direction is NW, SE.

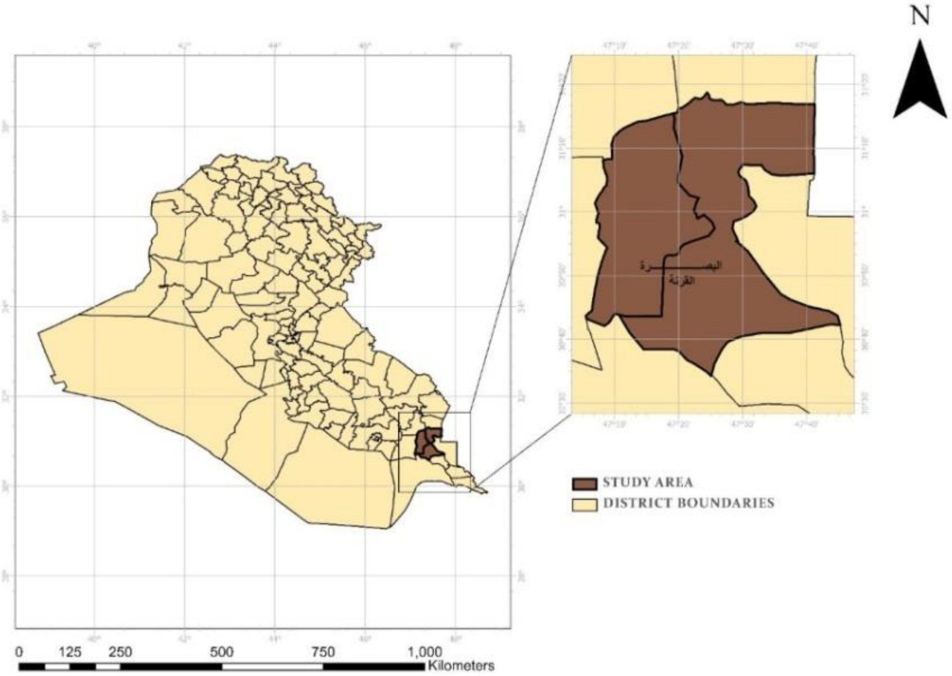

Figure 1: Modified map of the study area.

2. Material and methods

2.1 Sample collection

Sixteen soil samples were collected from the research region in the field at a distance of one kilometer, different depths (0, 30, and 50 cm) (Figure 2). The samples were then transfered to the laboratory, where they were allowed to dry at ambient temperature before passing through two-millimetre sieving. These were placed in polyethylene bags and digested using a solution of nitric and hydrochloric acids. The purpose of this study is to ascertain the levels of heavy metals in the soil samples using Inductively coupled plasma mass (ICP-MS). The analysis was done in the Geology Department, Faculty of Sciences, Tarbiat Modarres University in Tehran, Iran Islamic.

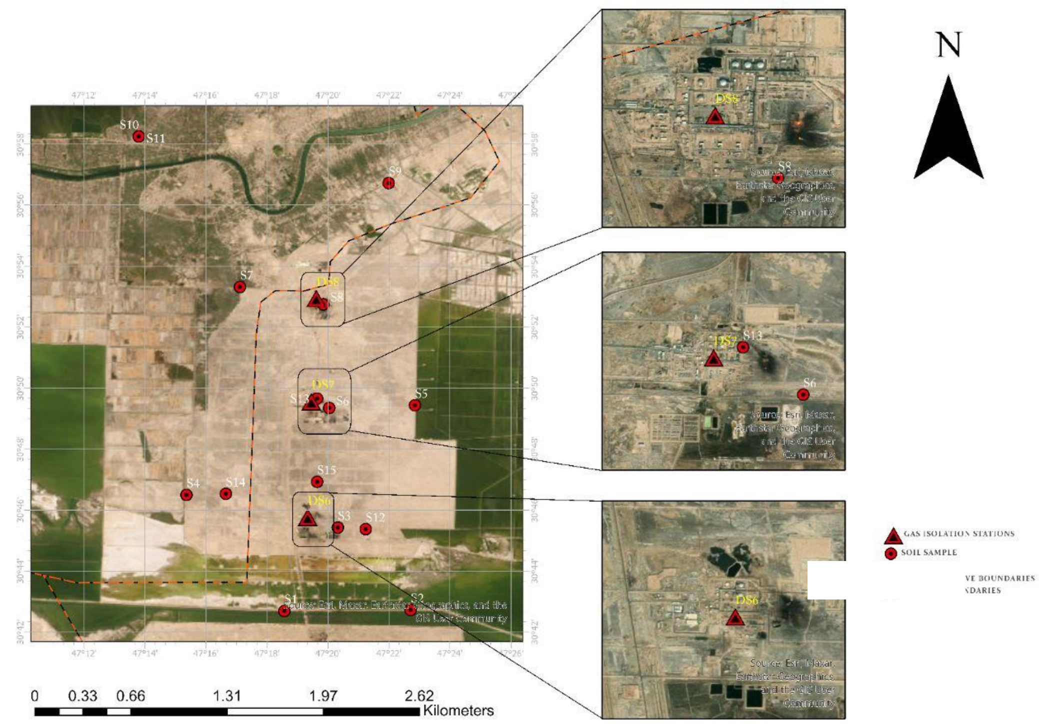

Figure 1: Locations map of soil sample in the study area.

2.2 Statistical analysis method

Environmental research on measurements and monitoring has increasingly used multivariate statistical analysis, especially when evaluating vast and complicated geochemical datasets. Examples of these analyses include cluster analysis and correlation analysis [45]. These methods are useful tools for obtaining and analyzing important data. Descriptive statistics, such as maximum, minimum, mean, standard deviation (SD), and coefficient of variation (CV), were used to analyze the content of heavy metals in the soil. Correlation coefficients were calculated to determine the relationships between the concentrations of heavy metals. A study determined the differences in metal concentrations across different geographic directions and distance intervals.

2.3 Result and Discussion

2.3.1 Oxides major

The major oxide average abundance is distributed as CaO% > K_2O% > MnO % > Fe_2O_3 % > TiO_2% > SO_3 % > P_2O_5 % > Na_2O%. Figure 2 displays the main oxides' spatial distribution patterns. CaO has an average value of 8.55%, ranging from 4.16 to 15.98%. Sample S16, which has the greatest MnO%, has the lowest value. Table 1.S9 of the primary research area is where the high CaO values above 15.98% are limited. The relatively high values of these samples are interpreted partly due to the presence of gypsum (Figure 2). K_2O has an average value of 0.79% and ranges from 0.53 to 1.04 % (Table 1). P_2O_5 content in all samples is below the global average. In every soil sample, the Na_2O concentration is relatively high. The soils' average Fe_2O_3 content is 1.25%, ranging from 0.74% to 2.52%. This could be interpreted as the Fe in primary silicate minerals and crystalline Fe oxides. Every sample was lower than the global soil average, except for S2, which has a higher Fe_2O_3 level (Table 1) (Figure 2). The TiO_2 ranges from 0.11 to 0.23 %, averaging 0.17%. All samples are lower than average world soil. The wide range of CaO is probably due to the predominance of carbonate formations in the area. The was SO_3 in all the samples highest from the world soil.

Table 1: Concentrations of Oxides of soil sample. *[46]

Sample No.	CaO	K_2O	MnO	Fe_2O_3	TiO_2	SO_3	P_2O_5	Na_2O
S1	8.51	0.8	0.008	1.12	0.15	1.09	0.04	1,94
S2	15.98	1	0.02	2.52	0.19	0.59	0.04	2.34
S3	7.73	0.61	0.005	1.06	0.13	1.56	0.04	1.44
S4	6.02	0.99	0.003	0.88	0.11	1.11	0.03	2.36
S5	9.66	0.74	0.017	1.53	0.2	0.76	0.04	2.14
S6	7.92	0.53	0.008	0.74	0.12	1.33	0.04	2.80
S7	8.97	1.04	0.009	1	0.14	0.94	0.03	1.31
S8	5.62	0.72	0.013	0.96	0.16	1.06	0.04	1.57
S9	14.77	0.77	0.012	1.42	0.15	1.49	0.11	1.70
S10,30cm	9.77	0.64	0.014	1.70	0.23	0.27	0.05	0.50
S11,50cm	7.40	0.8	0.01	1.50	0.22	0.57	0.07	0.76
S12,30cm	5.26	0.72	0.007	0.76	0.18	0.48	0.03	1.55
S13,50cm	11.70	0.86	0.012	1.15	0.19	0.41	0.03	1.42
S14	5.00	0.79	0.012	1.22	0.17	1.54	0.06	2.61
S15	9.93	0.84	0.009	1.38	0.17	1.55	0.05	2.81
S16	4.16	0.76	0.008	1.03	0.18	1.45	0.06	1.89
Max	15.98	1.04	0.02	2.52	0.23	1.56	0.11	2.81
Min	4.16	0.53	0.002	0.74	0.11	0.27	0.03	0.5
Mean	8.65	0.79	0.01	1.25	0.17	1.01	0.05	1.81
Soil world*	**2**	**1.6**	**0.07**	**2.16**	**0.67**	**0.03**	**0.19**	**0.09**

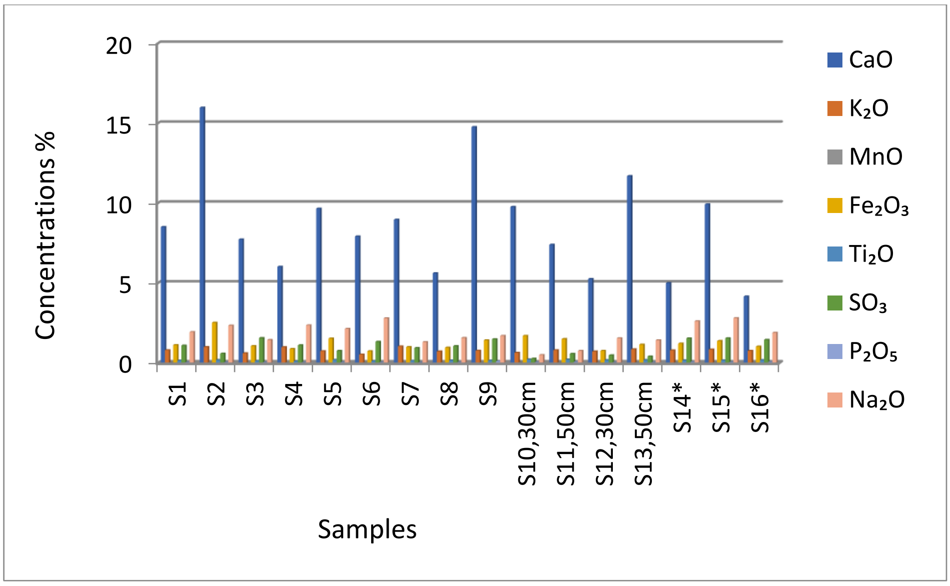

Figure 2: Concentrations of the major oxides in soil sample.

2.3.2 Heavy metals of soil in the study area

Measure the concentrations of a few heavy metals in the soil of the study area utilizing data from local and international research (Table 3). The degree of particle sedimentation, the velocity of heavy metal deposition, the size of the particles, and the presence or absence of organic matter in the soil all affect the concentration of heavy metals in surface soil. Under reducing conditions, heavy metals such as As, B, Ba, Ce, Co, Cu, Cr, Hg, Li, Ni, Pb, Sr, Ti, V, and Zn will possibly be incorporated into carbonate and in that way transported from solution in the soil of the West Qurna1 oilfield and then transported from solution [43]. The mean value concentrations of B, Cr, Hg, Ni, Sr, and Cu are generally higher than those of global surface soil, except for As, Co, Ba, Ce, Li, Ti, V and Zn, which were lower than this worldwide limit, according to [40] (Table 4, Figure 4). The pollution was caused by human activities, including the processes involved in burning hydrocarbon, the emissions of crude oil, the contaminated air, etc. Sr is the element that is incorporated with calcite (29.2. 2%) (Figure 3). Due to the widespread use of fertilizers—many of which are rich in zinc—some heavy metals, including Zn and Cu, are found in reducing states and elevated concentrations of Zn (35). Vanadium and Ba are primarily sourced from industrial emissions, with autogenic synthesis contributing to their high concentrations. [42].

Table 3: Concentrations of essential and heavy metals in soil samples of the study area. [40]*

Sample No.	Co	Cu	Ce	Zn	Sr	V	B	Ba	As	Hg	Cr	Ni
S1	9.63	331.42	4.73	59.59	221.4	54.49	149.88	119.60	0.74	1.08	74.48	159.13
S2	13.18	169.2	21.44	68.68	265.5	70.38	27.78	162.70	3	1.08	127.53	331.51
S3	9.36	195.13	0.5	47.32	258.1	54.26	159.96	43.28	3.88	1.41	56.56	99.28
S4	8.40	198.5	2.08	40.14	197.1	45.69	180.96	155.10	0.4	1.32	54.26	88.28
S5	14.29	118.03	4.13	62.55	214.7	75.62	177.48	94.68	2.71	1.37	99.31	151.96
S6	8.05	70.34	0.4	40	261.3	41.16	82.55	66.33	2.97	0.66	43.7	80.44
S7	8.96	100.41	2.35	44	200	48.27	182.64	133.30	0.3	1.55	72.2	86.3
S8	9.44	54.60	0.44	44.91	156.7	54.91	192.24	38.33	0.74	0.99	56.65	95.51
S9	9.74	37.12	10.72	49.50	312.4	52.47	112.61	159.40	0.4	1.34	86.38	133.97
S10,30 cm	15	50.33	2.56	60.93	185.8	79.96	179.64	79.57	2.81	0.85	100.28	234.95
S11,50 cm	12.88	129.2	2.47	53.58	164.3	77.96	158.76	68.31	1.09	1.26	101.86	211.55
S12,30 cm	8.15	69.85	0.5	30.87	115.2	48.77	180.84	57.15	0.5	1.43	61.95	88.99
S13,50 cm	11.60	48.09	4.39	47.34	172.5	58.92	143.40	124.70	1.38	1.91	78.87	285.38
S14	11.05	49.79	0.45	62.67	182.5	69.76	281.4	32.37	3.19	1.17	62.44	114.11
S15	12.42	44.57	2.05	56.98	349.9	76.32	206.88	81.73	3.58	1.06	77.71	146.11
S16	9.32	61.68	0.4	41.34	151.4	65.68	282.36	68.54	5.37	0.67	66.5	140.26
Max	15	331.42	21.44	68.68	349.9	79.96	282.36	162.7	5.37	1.91	127.53	331.51
Min	8.05	37.12	0.4	30.87	115.2	41.16	27.78	32.37	0.3	0.66	43.7	80.44
Mean	10.72	108.02	3.73	50.65	213.05	60.91	168.71	92.82	2.07	1.20	76.29	152.98
Soil world*	**11.3**	**38.9**	**56.7**	**70**	**175**	**129**	**42**	**460**	**6.83**	**0.07**	**59.5**	**29**

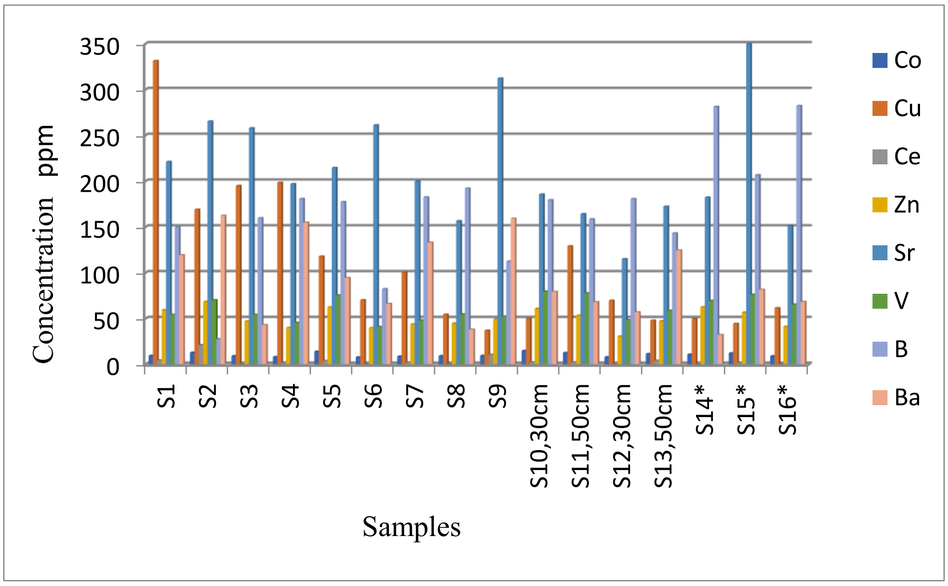

Figure 3: Concentration essential elements in soil samples.

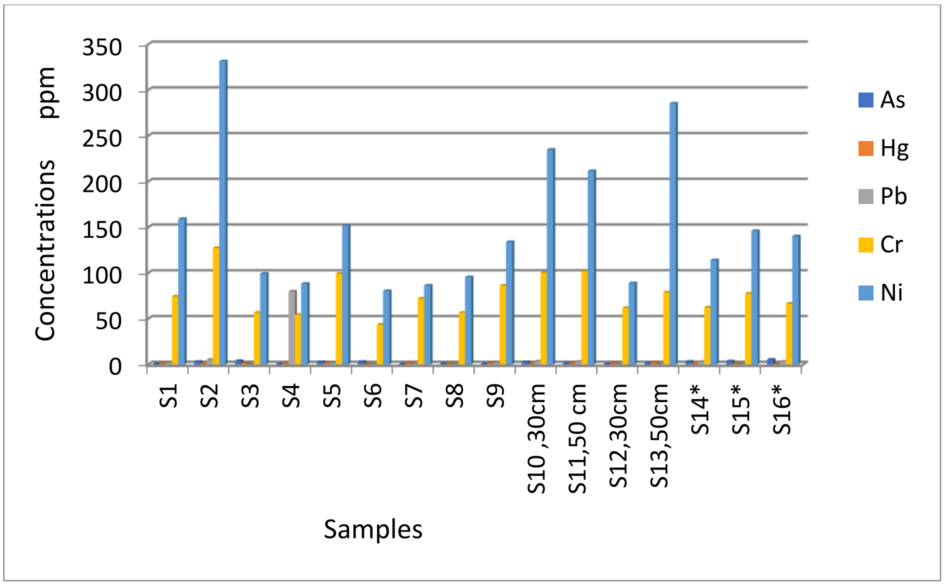

Figure 4: Concentration of heavy metals in soil samples.

2.3.3 Descriptive statistical

Each parameter's descriptive statistics (mean, standard deviation, minimum, and maximum) were examined to determine the overall pattern of heavy metal pollution on the study area's topsoil and subsurface soil. In order to determine the associations between heavy metals in the topsoil and subsurface layer of the research region, a correlation coefficient of 0.05% significance was employed (Plate 2). The statistical analysis was carried out entirely with SPSS 20.

Table 4: The descriptive statistics of heavy metal concentrations(ppm) of the soil samples in the west qurna1 oilfield.

Variable	Mean	Minimum	Maximum	Std.Dev.	Coef.Var.	Standard (Error)
As	2.7419	0.7430	5.3700	1.38632	50.5607	0.38450
B	164.2998	27.7800	282.3600	56.16806	34.1863	13.62275
Ba	92.9153	32.3700	162.7000	44.05108	47.4099	10.68396
CaO	8.5339	4.1639	15.9781	3.38375	39.6507	0.82068
Ce	6.2291	2.0500	21.4400	6.03782	96.9294	1.82047
Co	10.9266	8.0456	15.6827	2.36363	21.6320	0.57326
Cr	79.7666	43.6962	129.6618	25.34561	31.7747	6.14721
Cu	103.3446	34.0143	331.4211	80.24773	77.6507	19.46293
Fe_2O_3	1.2653	0.7389	2.5182	0.43817	34.6295	0.10627
Hg	1.2335	0.6600	1.9100	0.31557	25.5830	0.07654
K_2O	0.7924	0.5291	1.0440	0.13092	16.5217	0.03175
MnO	112.7471	32.6000	229.7000	46.78689	41.4972	11.34749
Na_2O	1.8515	0.7631	2.8120	0.57999	31.3248	0.14067
Ni	147.5279	80.4378	331.5067	74.95872	50.8099	19.35426
Pb	10.3273	0.7569	79.8671	23.15546	224.2162	6.98163
16-Sr	210.1706	115.2000	349.9000	66.42964	31.6075	16.11155
17-TiO_2	0.1708	0.1147	0.2335	0.03509	20.5436	0.00851
18-V	62.1324	41.1600	83.9200	13.33642	21.4645	3.23456
19-Zn	50.4770	30.8703	68.6759	10.17703	20.1617	2.46829

The coefficient of variation (CV) might occasionally represent the variance in the distribution of the heavy metal concentration in each sample. The value of the coefficient of variation is influenced by human activity. Low variability is defined as CV ≤ 10%, moderate variability as 10% < CV <100%, and high variability as CV > 100% [32]. The computed CV is shown in Table 2. Compared to other heavy metals, the analysis of CV values shows this. Based on the Ce and As CV values, there was significant variability in 96.92% and 50.56% of the sample locations, respectively, whereas the remaining regions showed minor variability. Nevertheless, according to the Pb CV value analysis, the linked heavy metals exhibited CV values greater than 100%. The elevated lead levels demonstrated the considerable variations in these metals between sample sites in the study soil and the major influence of human activity (burning fossil fuels such as oil and natural gas).

A- Hydrogen number (pH)

The pH of 16 samples of saline soils in the study area was measured using a calibrated pH meter. To calibrate the device sensor, immerse it in the solution that has been heated to a temperature of 25°C and press the CAL button. All soil samples from the soils under study are alkaline based on these pH values. This may be due to the high calcium and magnesium carbonate concentrations; the study area's mean pH is 7.30.

2.3.3 Correlation Matrics

correlation matrix is a statistical tool that illustrates the strength and direction of a relationship between two or more variables. It is widely applied in finance, economics, psychology, and biology since it facilitates understanding the relationships between various entities [39]. Table 5 lists the findings of the correlation matrix analysis for the metals in the study region soil samples. There are substantial positive and negative correlation linkages between the measured HMs in the soil samples of the research area, with a significant value of 0.54. Significant negative correlation coefficients show that those metals have distinct origins or sources, whereas significant positive correlation values show that those metals have a single origin or source [33]. Table 8 revealed substantial and moderate positive correlations between pairs of heavy metals. The study area's alkaline soil (Table 6) [37] is responsible for the strong positive relationships among heavy metals, which point to a common anthropogenic source of pollution. On the other hand, the weak relationships indicate differences in the geochemical behavior and source of heavy metals [34, 35]. Finally, [36] describes the study area's brown, alkaline soil, which contains approximately (1-2)% organic matter. Chemical weathering is a significant factor in this layer and may impact the bioavailability of heavy metals in the studied area.

Table 5: Interpretation of Pearson's Correlation Coefficient [37]

Strength and Direction of Correlation	*Strongly negative	*Moderately negative	*Weakly negative	*No association	*Weakly positive	*Moderately positive	*Strongly positive
Correlation value	(-0.8) -(-1.0)	(-0.5) -(-0.8)	(-0.2) -(-0.5)	(+0.2)-(-0.2)	(+0.2)-(+0.5)	(+0.5)-(+0.8)	(+0.8)-(+1.0)

Table 6: Correlation matrix analysis of heavy metals in soil samples of study area.

variable	As (ppm)	B (ppm)	Ba (ppm)	Ca (%)	Ce (ppm)	Co (ppm)	Cr (ppm)	Cu (ppm)	Fe (%)	Hg (ppm)	K(%)	Mn (ppm)	Ni (ppm)	Pb (ppm)	Sr (ppm)	Ti (%)	V (ppm)	Zn (ppm)
As	1.0																	
B	-0.255	1.0																
Ba	0.041	-0.956	1.0															
Ca	0.575	-0.938	0.809	1.0														
Ce	0.362	-0.992	0.929	0.969	1.0													
Co	0.916	0.146	-0.401	0.205	-0.040	1.0												
Cr	0.858	-0.717	0.508	0.913	0.788	0.584	1.0											
Cu	-0.880	-0.196	0.459	-0.150	0.099	-0.992	-0.531	1. 0										
Fe	0.755	-0.819	0.625	0.964	0.869	0.445	0.980	-0.402	1.0									
Hg	0.002	0.046	0.099	-0.042	0.020	-0.058	-0.021	0.165	-0.134	1.0								
K	0.069	-0.952	0.992	0.830	0.940	-0.336	0.556	0.407	0.653	0.200	1.0							
Mn	0.859	-0.658	0.484	0.865	0.748	0.5897	0.971	-0.514	0.918	0.216	0.557	1.0						
Ni	-0.131	-0.554	0.716	0.419	0.568	-0.421	0.201	0.528	0.212	0.753	0.771	0.348	1.0					
Pb	0.595	-0.808	0.608	0.899	0.819	0.312	0.858	-0.309	0.934	-0.461	0.591	0.718	0.999	1.0				
Sr	0.097	-0.929	0.975	0.820	0.927	-0.306	0.564	0.387	0.643	0.295	0.995	0.588	0.586	0.546	1.0			
Ti	0.860	0.178	-0.452	0.158	-0.091	0.974	0.526	-0.993	0.414	-0.279	-0.413	0.488	0.323	0.362	-0.405	1.0		
V	0.902	0.172	-0.427	0.178	-0.068	0.999	0.560	-0.997	0.423	-0.094	-0.368	0.558	0.270	0.304	-0.342	0.982	1.0	
Zn	0.634	-0.891	0.771	0.981	0.942	0.271	0.932	-0.198	0.949004	0.136	0.815	0.928	0.834	0.815	0.825	0.184	0.239	1.0

Conclusions

the average of all oxides was lower than the permitted limit in the world soil except Na_2O, SO_3, and CaO, which was higher than the permitted soil world. The contents of available heavy metals are more significant than those of total metals. Available Hg (at S13), Ni (at S2), Cr (at S2), Sr (at S15), B (at S16), and Cu (at S1) levels were discovered to be above recommended and permitted limits in the study area. Every other metal's concentration in the soil was either below or within the range allowed for bioavailable concentrations. At both soil depth ranges, the average accessible amounts of heavy metals displayed the following order: Sr>B >Ni >Cu >Ba >Cr >Co >V >Zn >Co >As >Hg. All soil samples from the soils under study are alkaline based on these pH values. This may be due to the high calcium and magnesium carbonate concentrations. Statistical studies indicate that oil emissions, which can be traced back to human activities, are the primary cause of pollution caused by heavy metals. The combustion of crude oil results in the dispersion of heavy metals, such as nickel, through wind deposition into the soil. The nickel concentration in the soil is significantly higher than the global limit.

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