

Spatial Assessment of Heavy Metal Pollution in Roadside Soils of Erbil City Using Integrated Pollution Indices

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Abstract

Soil, also commonly referred to as earth, is a mixture of organic matter, minerals, gases, water, and organisms that together support the life of plants and soil organisms. The recent study targets to evaluate roadside soil pollution in Erbil city by using a single index and integrating indices by analyzing the heavy metal concentration in the soil in different seasons were sampled and collected on different roads. The five locations from different roadsides in the Erbil District such as (120 m, 100 m, 60 m, 30 m, Sami Abdurrahman park (Control)) with seeds collected from *Nerium* spp., *Callistemon* spp., and *Dodonaea* spp., were specially selected to identify the effect of traffic activity on soil properties during two season spring and autumn. At each sampling place, three samples of soil were taken around the small trees at a distance of 50-150 cm from the stem. Additionally, in each location, 10-30 plants will be selected randomly. Different heavy metal in the soil and leaves distribution patterns (Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Pb, Cd) were determined. Soil pollution was assessed by using many indices such as contamination factor (CF), degree of contamination (Cdeg), Ecological Risk Factor (RI), and Potential Ecological Risk Index. As the results show all of the seasons Iron (Fe) has the highest contamination factors and the other metals shown have moderate to lower contamination factors. In addition, (Ni, Co, Cd, and Cr) donate the most Ecological risk factor (ER) of trace metals in *Callistemon Viminalis*, *Dodonaea viscosa*, and *Nerium oleander* in the rhizospheres in all seasons. In summary, the combined analysis of RI, Cdeg, and CF demonstrated that the study area experiences low ecological risk factors and moderate contamination, and no significant levels of metals.

Keywords: Roadside Soil, Contamination Factor (CF), Degree of Contamination (Cdeg), Ecological Risk Factor (RI), and Pollution Load Index (PLI)

Introduction

Soil is a highly heterogeneous body in the terrestrial ecosystem that has evolved through thousands of years of natural processes and has remained a habitat for enormous biodiversity, at the same time plays a major role in maintaining environmental balance, and acts as a medium for the growth of plants, and an accumulator for nutrients and water [1]. However, the intensification of urban, industrial, and agricultural activities degrades soil quality

through soil contamination as measured by the concentration of heavy metals (2). In addition, Heavy metal contamination in roadside soil due to traffic emissions has been recognized for a long time. However, little has been reported regarding the identification of critical factors influencing the accumulation of heavy metals in urban roadside soils due to the frequent disturbances, such as the repair of damaged roads and green belt maintenance [3]. Rapid economic development has led to rapid expansion of the highway transportation industry

which has resulted in increases in the emissions of such contaminants as heavy metals, roadside soils tend to accumulate pollutants directly emitted from vehicle exhaust, and soils can easily come into contact with pedestrians and inhabitants near the roads, either via inhalation of suspended particles or by direct contact exposure to inhalable emissions from roadways has been implicated as a threat to human health[4] According to this results show that the addition of oil residues significantly stimulated the activity of urease and catalase enzymes but inhibited the activity of dehydrogenase [5].

soil pollution, ecosystem services can be lost, as well as serious economic losses and social injustices jeopardizing the attainment of the 2030 Agenda at risk. Among the top contaminant sources resulting in soil contamination (order of significance) are mining, industrial operations, agriculture, waste treatment, extraction as well as processing of fossil fuels, as well as transportation emissions. However, there is not anything solid as well as comparable statistics on each sector's real emissions[6].The presence of potentially hazardous elements (PHEs) in playground soils is generally associated with anthropogenic sources such as vehicle traffic, industries, construction sites, and biomass burning [7]. However, metal ions at higher concentration are toxic to plants, but they are necessary as trace elements. Many heavy metals (As, Cd, Cr, Cu, Hg, Ni, Pb, and Zn) are now hazardous to the environment globally and lead to a negative impact on human health. Due to their persistence in the environment for very long periods, such as for many hundreds to thousands of years, they negatively impact human and animal health [8]

Erbil City Iraq's Kurdistan Region's capital, is becoming more and more polluted by particulate matter (PM), heavy metals, and chemical contaminants, due to traffic emissions, industrial activities, and urban development [9]. Erbil metropolis as one of the most important cities in Iraq due of its location, has a heavy load of traffic, including various types of heavy and

light vehicles and machineries including petroleum product transportation, leads to the need of extensive air and soil quality monitoring program and implementing more restrictions to this extensive anthropogenic input[10]. Depending to this study shows a significant relationship between environmental situations and road traffic accidents in Erbil [11]. A limited study has been conducted about the evaluation soil contamination in roads. The present study aims to evaluate roadside soil pollution in Erbil city by using single index and integrating indexes by analyzing the heavy metal concentration in the soil in different seasons were sampled collected in different roads.

1. Materials and Methods

1.1.Area Study

The experiment was carried out in late summer or early autumn from different roadsides in the Erbil District, with seeds collected from Nerium spp., Callistemon spp., and Dodonaea spp., as shown in the table below. In each location, 10-30 plants were selected randomly, as shown in table 2.



Figure 1. Google map show location of samples.

Table 1. Shows different location where collected the samples

Longitude m N	Latitude m E	Traffic congestion
36°12'16"N	44°03'59"E	120 m
36°12'55"N	43°58'52"E	100 m
36°11'52"N	43°59'48"E	60 m
36°10'51"N	44°00'29"E	30 m
36°11'13"N	43°59'33"E	Sami Abdurrahman park (Control)



Figure 2. Google map shows the specific location of samples.

1.2.Sampling

Table 2: In each location, 10-30 plants will be selected randomly

Name of Plants	Number of Samples
<i>Nerium Oleander</i>	10-30
<i>Calistimon Viminalis</i>	10-30
<i>Dodonea Viscosa</i>	10-30

1.3.Soil sample

Two season spring and autumn, at each sampling place, three samples of soil were around the small trees with a distance 50-150 cm from the stem.

1.4.Soil Characteristics

Heavy metal in the soil and leaves (Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Pb, Cd).

1.5.laboratory measurements or analyses.

1 g of air-dried soil was placed in a 50 ml beaker with 5 ml of concentrated nitric acid and heated at 95–100 C for 30 min, followed by adding a 5 ml mixture of concentrated nitric and perchloric acid (3:1 v/v) and heating again. After proper digestion, the digest was made up to 50 ml with deionized water.

Eleven heavy metals were selected for the analysis including: Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Pb, Cd. The standard used for the atomic absorption analysis of these metals was multi- elements system, which was prepared from the stock standard (BD spectrosol, UK) by appropriate dilution with 0.5 N nitric acid.

The tests are comprehensive and excellent.

Single indices

Single indices are indicators used to calculate or assess only one contamination metal, which include contamination factor, ecological risk factor, enrichment factor, and index of geoaccumulation [4], thus only five methods illustrated as follows:

1.4.1. Contamination Factor

Acontaminationfactor(C_f^i)used to describe

thecontaminationofagiventoxic substancein a lake or a sub-basin is

$$C_f^i = \frac{C_{0-1}^i}{C_n^1}$$

Where C_{0-1} is the mean content of the substance i in at least 5 sample sites, and is the pre-industrial reference level for the substance. The following terminologies are used to describe the contamination factor: $C_f^i < 1$; low contamination factor, $1 \leq C_f^i < 3$; moderate contamination factors, $3 \leq C_f^i < 6$; considerable contamination factors and

$C_f^i \geq 6$; very high contamination factor. Here, contamination factor (C_f^i) was expanded to be defined as $C_f^i = C_i / C_{ri}$ Where C_i is the metal content (i) instead of mean content from at least 5 sample sites; C_{ri} is the reference value of (baseline level), or national criteria of metal (i). When the sediment quality guideline was selected for the C_{ri} , the concentration factor (CF) is equal to the sediment quality guidelines such as effect range low (ERL) per effect range median (ERM), and threshold effect level (TEL) per probable effect level (PEL).

1.4.2. Ecological Risk Factor

An ecological risk factor (Er^i) quantitatively express the potential ecological risk of a given contaminant, which is suggested by Hakanson [13] is: $Er^i = Tr^i \cdot C_f^i$ Where Tr^i is the toxic-response factor for a given substance, and C_f^i is the contamination factor. The Tr^i values of heavy metals concluded by [13]. The following terminologies used to describe the risk factor: $Er^i < 40$; low potential ecological risk, $40 \leq Er^i < 80$; moderate potential ecological risk, $80 \leq Er^i < 160$; considerable potential ecological risk, $160 \leq Er^i < 320$; high potential ecological risk and $Er^i \geq 320$; very high ecological risk. It was use to assessing the quality of sediments and soils in environment by heavy metals.

1.4.3. Pollution Index

A sum of pollution index (PI_{sum}) might be defined as

$$PI_{sum} = \sum_{i=1}^m pi$$

Where Pi is the single pollution index of heavy metal i , and m is the counted heavy metal species. The sum of pollution index was widely used in soil and sediment quality assessment by heavy metals, such as the degree of contamination and the potential ecological risk index [4].

1.4.4. Degree of Contamination

The degree of contamination (C_d) was originally defined as

$$C_d = \sum_{i=1}^m C_f^i$$

the sum of all contamination factors where C_f^i is the single index of contamination factor, and m is the counted heavy metal species. For the description of contamination degree, the following terminologies have used $C_d < m$; low degree of contamination, $m \leq C_d < 2m$; moderate degree of contamination, $2m \leq C_d < 4m$; considerable degree of contamination and $C_d > 4m$; very high degree of contamination [4].

1.4.5. Potential Ecological Risk Index

The potential ecological risk index (RI) was in the same manner as degree of contamination defined as the sum of the risk factors

$$RI = \sum_{i=1}^m Er^i$$

Where Er^i is the single index of ecological risk factor, and m is the counted heavy metal species. The following terminology or ranges were used for the potential ecological risk index: $RI < 150$; low ecological risk, $150 \leq RI < 300$; moderate ecological risk, $300 \leq RI < 600$; considerable ecological risk and $RI > 600$; very high ecological risk when the toxic-response factors were used for the eight elements [5].

1.4.6. Index of Geoaccumulation

The index of geoaccumulation (I_{geo}) is a quantitative measure of the extent of metal

pollution in the studied soil. It is calculated using the geo-accumulation index proposed by Muller (1969) and given by [14]. This index (I_{geo}) of heavy metal is calculated using the following mathematical relation:

$$I_{geo} = \log_2 [C_n / 1.5B_n] \dots\dots\dots [1]$$

where C_n is the measured total concentration in the soil with the metal n , B_n is the background value for the metal n ; the factor 1.5 (correction

factor) is used because of possible variations of the background data due to lithological variations.

2.5.2. Enrichment Factor the Enrichment Factor (EF) is a normalization method to assess the concentration of the metals [15].

Results and Discussion

1.5. Autumn Seasonal

1.5.1. Contamination factor of trace metals in autumn

The characteristics of heavy metals content in soils are related to both the physical and chemical properties of soils. As shows in Table [3] the Contamination factor of trace metals in rhizosphere of selected plants during autumn, which showed that iron had the highest contamination factor values (5.26-5.54). as well as other metals recorded low contamination values (lower than 1) like (Cr, Mn, Cu, Zn, As, Pb, Se, Cd). In addition, (Co, Ni) recorded moderate contamination factors between (2.35-2.89). At the same time as showed in the table below that among these three plants *Nerium oleander*, slightly higher contamination factor values and able to tolerate and accumulate more metals in its rhizosphere than other plants *Callistemon Viminalis*, *Dodonaea viscosa*, *Nerium oleander* known as tolerance for metals able to accumulate more metals, has been reported by Always, W.S.A. and Nafawa, S.M., 2022 [16] heavy metals such as (Ni, Fe, and Co) has been absorbed and accumulated in the rhizosphere of *Nerium oleander*, so this results showed that more contamination factor accumulated in this species. Additionally, according to this study (17) *Callistemon Viminalis*, *Dodonaea viscosa* showed moderate accumulation level of contamination factors values.

1.5.2. Ecological risk factor of trace metals in autumn

As demonstrated in Table 4 that (Ni, Co, Cd, and Cr) donate the most ERF of trace metals in *Callistemon Viminalis*, *Dodonaea viscosa*, and *Nerium oleander* in the rhizospheres, which Ecological risk factor help to evaluate that how contamination effect on soil. As shown the high level of Ni present, approximately (14.46, 14.38,

14.25) *Nerium oleander*, *Dodonaea viscosa*, and *Callistemon Viminalis*, respectively. According to this study Ni value have been observed in metal rich soil [18]. As well as the level of Co shows slightly in a high level (11.78, 12.08, 12.46mg/Kg) from lowest to highest, which according to this study evidently demonstrates the metal (cadmium) accumulation potential of *Nerium oleander* [19]. In addition, high level of Cr was accumulated in the *Nerium oleander* (9.961 mg/Kg) than other species and similar to the study of kabata-pendias (2011) which Cr accumulated in the polluted soil [20]. While if we see the (pb, Se, and Zn) showed the lowest value in all species which recorded the same value as comparable to the study [21].

1.5.3. Contamination factor of trace metals in selected locations in autumn

As shown in table 5 **Decrease in some locations and increase in others (L2–L5):** Spatial differences in pollution levels can result from:

Distance-decay effect: Metal concentration generally decreases as distance from the pollution source increases.

Wind direction and atmospheric transport: Prevailing winds can transport and deposit pollutants unevenly across locations.

Traffic patterns: Intersections and congested roads usually show higher contamination than open roads.

Surface runoff and drainage: Metals may accumulate in areas where runoff collects.

Seasonal variations: Rainfall can either dilute contamination (via leaching) or redistribute metals to lower areas.

Soil properties: pH, organic matter content, and texture influence metal mobility and retention.

the contamination factors were moderate, especially (Ni, Co, Cr, Mn, and Fe), which is similar to the study of [22], which records the assessment of heavy metals. Additionally, the contamination factors such as (Cu, As, Se, Pb, Cd, Zn) were very low[23].

1.5.4. Ecological risk factor of trace metals in selected locations in autumn

As demonstrated in the table 6 ,the moderate ecological factors in metals like (Cr, Co, and Ni) have been recorded; it is the same with this study(24), which records the moderate level of metals. Possibly as a result of human activities like industrial influence and transportation pollutants. As well as the most metals such as (Fe, Mn, Cu, Zn, As, Se, and Pb) indicate the low ecological risk factors[20]. Additionally, location 5 shows reasonably high Co, Ni, and Cd, signifying localization improvement.

Table 3. Heavy metals Contamination factor mg Kg-1 in the rhizosphere of selected plants in autumn

Contamination factor of trace metals in rhizosphere of selected plants in autumn											Plants
Trace metals mg Kg-1 (Iron %)											
Cd	Pb	Se	As	Zn	Cu	Ni	Co	Fe	Mn	Cr	
0.293	0.014	0.105	0.123	0.234	0.276	2.851	2.416	5.260	1.640	1.671	<i>Callistemon Viminalis</i>
0.415	0.013	0.150	0.119	0.266	0.248	2.878	2.356	5.340	1.623	1.736	<i>Dodonaea Viscosa</i>
0.268	0.015	0.085	0.123	0.235	0.232	2.893	2.492	5.540	1.562	1.992	<i>Nerium oleander</i>

Table 4. Ecological risk factor of trace metals in rhizosphere of selected plants in autumn

Ecological risk factor of trace metals in rhizosphere of selected plants in autumn											plants
Trace metals mg Kg-1 (Iron %)											
Cd	Pb	Se	As	Zn	Cu	Ni	Co	Fe	Mn	Cr	
8.780	0.140	0.210	1.225	0.234	1.378	14.256	12.080	5.260	1.640	8.355	<i>Callistemon viminalis</i>
12.439	0.133	0.300	1.185	0.266	1.238	14.389	11.780	5.340	1.623	8.680	<i>Dodonaea viscosa</i>
8.049	0.145	0.170	1.230	0.235	1.160	14.464	12.460	5.540	1.562	9.961	<i>Nerium oleander</i>

Table 5. Heavy metals Contaminations mg Kg-1 in soil of selected locations in autumn

Contamination factor of trace metals in in soil of selected locations in autumn											Locations
Trace metals mg Kg-1 (Iron %)											
Cd	Pb	Se	As	Zn	Cu	Ni	Co	Fe	Mn	Cr	
0.195	0.012	0.040	0.099	0.191	0.181	2.349	2.018	4.360	1.090	1.136	L1
0.317	0.017	0.075	0.121	0.235	0.309	2.860	2.436	5.560	1.593	1.426	L2
0.293	0.014	0.090	0.130	0.239	0.215	3.200	2.634	5.960	1.754	1.935	L3
0.512	0.015	0.245	0.127	0.264	0.255	2.769	2.370	4.900	1.781	2.219	L4
0.317	0.013	0.120	0.130	0.296	0.298	3.193	2.652	6.140	1.824	2.283	L5

Table 6. Ecological risk factor of trace metals in soil of selected locations in autumn

Ecological risk factor of trace metals in soil of selected locations in autumn											Locations
Trace metals mg Kg-1 (Iron %)											
Cd	Pb	Se	As	Zn	Cu	Ni	Co	Fe	Mn	Cr	
5.854	0.120	0.080	0.990	0.191	0.907	11.744	10.090	4.360	1.090	5.680	L1
9.512	0.165	0.150	1.205	0.235	1.546	14.299	12.180	5.560	1.593	7.129	L2
8.780	0.135	0.180	1.300	0.239	1.075	15.998	13.170	5.960	1.754	9.676	L3
15.366	0.146	0.490	1.273	0.264	1.277	13.845	11.850	4.900	1.781	11.095	L4
9.512	0.130	0.240	1.295	0.296	1.488	15.964	13.260	6.140	1.824	11.413	L5

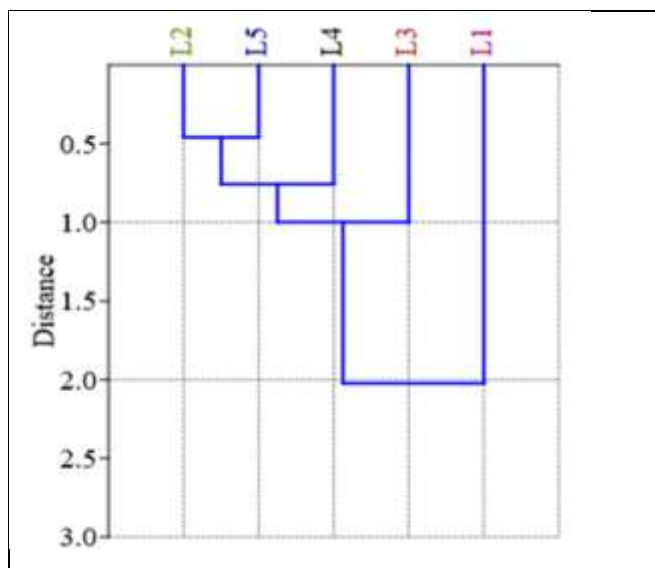


Figure 3. Hierarchical clustering similarity index of heavy metals contamination factor among locations during Autumn.

1.5.5. Hierarchical clustering similarity index of heavy metals Contamination Factors

As illustrated in the figure 3 the clustering relationships among five locations rendering to the contamination factors of the trace metals in soil, which location 4 join location 2 and 5 which are cluster at a slightly moderate distance (1.0) showing moderate similarity, in addition Location 3 showing highest distance about (2.0). however, when compare to other site, location 1 appear the most to be remote, connecting the other cluster at distance about (2.0), which indicating the biggest variation in metal content and contamination factors. As well as, there is a supporting reference which support that the soil of roadside in Iraq grouped based on the intensity of pollution and the source of metals [25].

1.5.6. Some Single and Intergrade Indexes for plants during Autumn

As shown in the table below, each of the ecological risk index (RI), Degree of contamination (Cdeg), and pollution load index. As indicated in Plants 1 low ecological risk and moderate Cdeg, At the same time PLI shows below 1 it means there is no heavy pollution in

the soil. While, in Plants 2 shows moderate ecological risk and moderate Cdeg, At the same time PLI shows below 1 it means there is no heavy pollution in the soil. However, plant 3 (*Nerium Oleander*) indicates the highest value in each of RI, Cdeg, and PLI which means shows low to moderate risk. As generally shown in the table below plant 3 contain more contamination due to its rhizomes which accumulate more metals. This study [26] described the similar ecological risk index (RI) value for roadside were lower than 100 which indicates for low RI.

Table 7. Shows Some Single and Intergrade Indexes

PLI	Cdeg	RI	Plants
0.503	13.697	53.702	P1
0.528	15.220	60.858	P2
0.569	16.740	70.034	P3

1.5.7. Some Single and Intergrade Indexes for locations

As confirmations the 5 locations indicate low ecological risk and moderate metal contaminations, with no heavy pollutants. At the same time, locations 3 and 5 indicate higher ecological risk and higher environmental influence, whereas location 1 represents the least polluted site. Depending on the study of Hussain et. al 2022 [27], which reported similar RI ranges between 40-80, it means low ecological risk, but contamination is measurable in the urban roadside soils.

Table 8. Shows Some Single and Intergrade Indexes for different locations

PLI	Cdeg	RI	Plants
0.389	13.703	50.654	L1
0.572	17.594	64.553	L2
0.572	19.248	67.851	L3
0.555	17.021	59.160	L4
0.567	18.034	65.957	L5

1.6.Spring Seasonal

1.6.1. Contamination factor of trace metals in Spring

As shows in Table [9] the Contamination factor of trace metals in rhizosphere of selected plants during spring, which showed that iron (Fe) had the highest contamination factor values (5.26-5.54). Depending on this study (28) Fe has the highest contamination factor. In addition, (Co, Ni) recorded moderate contamination factors between (2.35-2.89), similar to the recent study which Co and Ni records moderate contamination [29]. As well as other metals recorded low contamination values (lower than 1) like (Cr, Mn, Cu, Zn, As, Pb, Se, Cd). At the same time as showed in the table below that among these three plants *Nerium oleander*, slightly higher contamination factor values and able to tolerate and accumulate more metals in its rhizosphere than other plants, *Callistemon Viminalis*, *Dodonaea viscosa*. Depending to this study [30] also record which *Nerium oleander* accumulate more heavy metals than other species.

1.6.2. Ecological risk factor of trace metals in Spring

As demonstrated in Table 10 that (Ni) shows the highest ecological risk factors in all plants. Khalid et al, [31] reported that *Nerium oleander*, which accumulates more heavy metals and could be used for sustainable management of traffic-borne elemental-enriched roadside soils. Additionally, (Co, and Cr) donate the most Ecological risk factor (ERF) of trace metals in *Callistemon Viminalis*, *Dodonaea viscosa*, and *Nerium oleander* in the rhizospheres. At the same time, Cd shows a lower concentration and high risk index specially in *Dodonaea viscosa*. However, (Cu, Zn, As, Se, Pb) indicate lower ecological factors, which is lower than (2.0). Depending to this study [32] which showed Cu, Zn, and Fe are more associated with industrial areas. while Cu, Pb, and Mn were the most contaminating metals at park sites.

1.6.3. Contamination factor of trace metals in selected locations in Spring

As represent in the table 11 there are many location shows moderate pollution many of them dominated by (Cr, Co, Ni) which are indicators of industrial and vehicular emission. Especially, Cr, Ni show the highest contamination factors among most metals in all locations.

As well as Location 1 shows the lowest contamination metal factors, indicating cleaner location while location 5 shows the highest contamination factors during spring among locations. According to this study [10], which regional study from Kurdistan report the same finding which investigate the roadside and soil of urban recorded the highest level of Cr and Ni.

1.6.4. Ecological risk factor of trace metals in selected locations in Spring

As demonstrated in the table 12 the ecological risk factors of trace metals in the soil of five different locations during the spring season, which pose the greatest ecological risk in metals like (Cd, Co, and Ni) in locations 4 and 5, which are the most contaminated factors. As well as the most metals such as (Fe, Mn, Cu, Zn, As, Se, and Pb) indicate the low ecological risk factors. This study supports the recent study[33], which roadside soils are linked to traffic-related sources, especially metals like Ni and Cr, which both metals contributed significantly to ecological risk. On the other hand, metals such as (Fe, Mn, Cu, Zn, As, Se, and Pb) indicate a low ecological risk, which this study [33] suggests that the soil has a significant impact in the presence of these metals in the soil rather than strong industrial enrichment.

Table 9. Heavy metals Contaminations mg Kg⁻¹ in plant rhizosphere in spring

Trace metals mg Kg ⁻¹ (Iron %)											plants
Cd	Pb	Se	As	Zn	Cu	Ni	Co	Fe	Mn	Cr	
0.293	0.014	0.105	0.123	0.234	0.276	2.851	2.416	5.260	1.640	1.671	<i>Callistemon viminalis</i>
0.415	0.013	0.150	0.119	0.266	0.248	2.878	2.356	5.340	1.623	1.736	<i>Dodonaea viscosa</i>
0.268	0.015	0.085	0.123	0.235	0.232	2.893	2.492	5.540	1.562	1.992	<i>Nerium oleander</i>

Table 10. Ecological risk factor of trace metals in rhizosphere of selected plants in spring

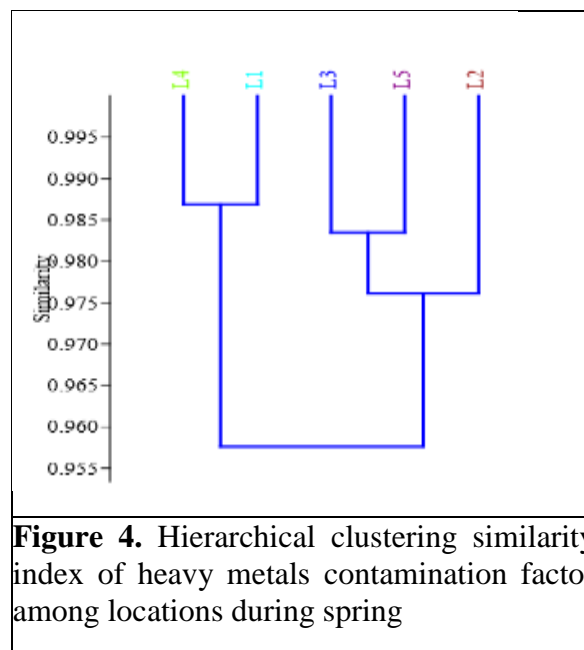
Trace metals mg Kg ⁻¹ (Iron %)											plants
Cd	Pb	Se	As	Zn	Cu	Ni	Co	Fe	Mn	Cr	
8.780	0.140	0.210	1.225	0.234	1.378	14.256	12.080	5.260	1.640	8.355	<i>Callistemon viminalis</i>
12.439	0.133	0.300	1.185	0.266	1.238	14.389	11.780	5.340	1.623	8.680	<i>Dodonaea viscosa</i>
8.049	0.145	0.170	1.230	0.235	1.160	14.464	12.460	5.540	1.562	9.961	<i>Nerium oleander</i>

Table 11. Heavy metals Contaminations mg Kg⁻¹ in soil of selected locations in autumn

Trace metals mg Kg ⁻¹ (Iron %)											Locations
Cd	Pb	Se	As	Zn	Cu	Ni	Co	Fe	Mn	Cr	
0.195	0.012	0.040	0.099	0.191	0.181	2.349	2.018	4.360	1.090	1.136	L1
0.317	0.017	0.075	0.121	0.235	0.309	2.860	2.436	5.560	1.593	1.426	L2
0.293	0.014	0.090	0.130	0.239	0.215	3.200	2.634	5.960	1.754	1.935	L3
0.512	0.015	0.245	0.127	0.264	0.255	2.769	2.370	4.900	1.781	2.219	L4
0.317	0.013	0.120	0.130	0.296	0.298	3.193	2.652	6.140	1.824	2.283	L5

Table 12. Ecological risk factor of trace metals in soil of selected locations in autumn

Trace metals mg Kg ⁻¹ (Iron %)											Locations
Cd	Pb	Se	As	Zn	Cu	Ni	Co	Fe	Mn	Cr	
5.854	0.120	0.080	0.990	0.191	0.907	11.744	10.090	4.360	1.090	5.680	L1
9.512	0.165	0.150	1.205	0.235	1.546	14.299	12.180	5.560	1.593	7.129	L2
8.780	0.135	0.180	1.300	0.239	1.075	15.998	13.170	5.960	1.754	9.676	L3
15.366	0.146	0.490	1.273	0.264	1.277	13.845	11.850	4.900	1.781	11.095	L4
9.512	0.130	0.240	1.295	0.296	1.488	15.964	13.260	6.140	1.824	11.413	L5



1.6.5. Hierarchical clustering similarity index of heavy metals Contamination Factors

As illustrate in the figure 4 Hierarchical clustering similarity index of heavy metals contamination factor among locations during spring, which the clustering relationships among five locations rendering to the contamination factors of the trace metals in soil, which location 4 and 1 form tight cluster

at a slightly highest distance (0.995), in addition Location 3 ,2, and 5 form second major cluster, joined at lower similarity (0.97-0.98). this study [35] support the recent study which that similarity in the pollution source create strong statistical clustering.

1.6.6. Some Single and Intergrade Indexes for plants during Spring

As shows in the table 13, each of the ecological risk index (RI), Degree of

contamination (Cdeg), and the pollution load index. As indicated in all plants, low ecological risk from (64-77), second plant (*Dodonaea viscosa*) records the highest RI (77.84) and the lowest is Nerium Oleander, at the same time Cdeg Value was from [13-14]which record contamination from low to moderate. As well as about the PLI the value

Table 13. Shows Some Single and Intergrade Indexes

PLI	Cdeg	RI	Plants
0.540	14.131	72.460	P1
0.566	14.349	77.843	P2
0.507	13.542	64.553	P3

1.6.7. Some Single and Intergrade Indexes for locations during Spring

As confirmations RI in all of the locations was below 150 so it means indicate the low ecological risk factors, which Location 1 has highest level (93.7) and location 2 record the lowest ecological risk factors (60.8). as well as Cdeg in location 4 (13.35) record the lowest value while in location 3 record highest value

was lower than 1 so it means the soils are not polluted by metals. Depending to this study[36] who reported the plants covered the soil they showed the low ecological risk factors due to enhance the stabilization of metals and due to the immobilization process in the soil.

(18.43). Additionally, there are no pollution in any of the locations because the PLI was lower than one. This study is similar to our finding, which recorded that RI below 100 in the soil of the roadside it means low ecological risk [37]

Table 14. Shows Some Single and Intergrade Indexes for different locations

PLI	Cdeg	RI	Location
0.555	14.794	93.713	L1
0.501	16.619	60.835	L2
0.543	18.437	69.665	L3
0.448	13.358	69.388	L4
0.563	16.529	69.461	L5

(Scientific Interpretation)

The finding of the current study suggests that the soil samples in all locations were below 150, which suggest the low Ecological risk factors. Specifically, Location exhibited the highest ecological risk index at 62.28, while Location1 recorded the lowest ecological risk index at 41.10. Furthermore, the contamination degree was lowest at location 1,

and it was highest in location 5; at the same time, it was moderate in the other locations. As well as the pollution Load Index being below one in all locations and seasons, it means there was no pollution.

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