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**Heavy Metal Pollution and Ecological Risk Assessment in Soils Adjacent to Electrical Generators in Erbil City, Iraq.**

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**Abstract:**

The purpose of this research was to assess the environmental effects of an electrical generator on some heavy metals in soil in Erbil, four different locations (Azadi, Kurdistan, Zhyan, and Control). Were specifically selected to identify the effects of leaching of oil from an electrical generator on soil properties. Different heavy metal distribution patterns (As, Cd, Cu, Cr, Hg, Pb, and Zn) were determined from the surface of leaching. Soil pollution was assessed using many indices, including: contamination factor (CF), Ecological Risk Factor and Potential Ecological Risk Index. The highest concentrations for (As, Cd, Cr, Cu, Zn, Pb, Ni, Mn) were (236.000, 19.800, 788.000, 84.460, 233.000, 566.000, and 603.910) mg/kg. According to contamination factor, there is a considerable contamination factor for (Azadi) while (Kurdistan) showed very high contamination factor. Lead concentrations in Azadi quarters ranged from 22 to 344 mg/kg, 66 to 250 mg/kg in Zhyan quarters, 44 to 178 mg/kg in Kurdistan quarters, and 19 to 25 mg/kg in Control. On the other hand, for RI recorded in study quarters as follows: (139.755, 510.39185, 1230.454, 1254.397) for Control, Kurdistan, Zhyan, and Azadi, respectively. This study provides environmental protection managers and decision-makers with important information about the risk of using electrical generators in residential neighborhoods. Furthermore, if we want to reduce heavy metals in the soil around the generators, we must plant trees to a large extent, and instead of the gas used for the generator, it is preferable to make electricity and locate the generators away from people and neighborhoods.

**Keywords:** Ecological Risk Index, Heavy metals, Soil and Electrical Generators.

1. **Introduction:**

Soil is the material basis for the sustainable economic and social development, and is one of the most valuable natural resources in each country, especially for our country. With continuous improvements of industrialization and urbanization level (Wang *et al*., 2017). Natural pollution occurs as a result of natural processes such as volcanic eruptions (gases, ashes, etc.), forest arsons, tempests, tornadoes, droughts, and other natural factors which cause defectiveness in natural equilibrium of environmental components that continues for long or short times. The concentration of elements in soils.

The main anthropogenic sources of pollution are industrial activities, vehicles, fallen dust, power plants, factories wastes, and treatment of mining products. Heavy metals exist in natural soils in low amounts and their concentrations have increased as a result of human activities to reach in some cases fatal limits. The anthropogenic activities are the other sources of pollution due to the advances of science and technological civilizations and decades of industrial evolutions; the tax of such activities is paid by the environment (Mohammed *et al*., 2013). Some metals that can be classified as soil pollutants such as arsenic (As), mercury (Hg), lead (Pb), antimony (Sb), zinc (Zn), nickel (Ni), cadmium (Cd), selenium (Se), beryllium (Be), thallium (Tl), chromium (Cr) and copper (Cu) (Shalttami, 2014).

Many researchers investigated emissions of heavy metals from thermal power plants and diesel engine generators and assessed their risks to human health and environment, along with their ecological risks on soil and water (Alonso-Hernández *et., al* 2011). The heavy metals are transported from the soil, accumulated in the plant tissues, and then consumed by humans. The heavy metals accumulate in fatty tissues and affect the activities of nerves, endocrine and immune systems, normal cellular metabolism, etc. (Wang, 2013). There is an increasing use of diesel engine generators to generate and supply electrical power for the citizens, due to the governmental inability in Iraq.

There is an increasing use of diesel engine generators to generate and supply electrical power for the citizens, due to the governmental inability in Iraq. Since 2003, the government has been unable to meet the citizen's needs for electrical power from the large power plants. This inability prompted private investment in the use of diesel engine generators to supply citizens with the electrical power. The motivation to carry out the current study is that most of these generators are located within residential neighborhoods, causing human health and environmental risks. The current study is the first attempt in Iraq to investigate the heavy metals emitted from diesel electrical generators and their effects on the surrounding soils (AL-Heety *et al.,* 2021).

Soil contamination caused by petroleum hydrocarbon is a matter of worry because these are harmful for various life forms, crude oil contamination is common due to its extensive use and its related dumping process and accidental spills, is a serious concern for the environment. (Srivastava *et al.,* 2019). Contamination with total petroleum hydrocarbons (TPH) subsequent to refining activities is currently one of the major environmental problems (Jabbarov *et al.,* 2019)

Plants grow on heavy metal polluted soils resultant in reduction in growth due to changes in their physiological and biochemical activities especially true when the heavy metal involved does not play any beneficial role towards the growth and development of plants, there are two aspects on the interaction of plants and heavy metals, one hand, heavy metals show negative effects on plants and other hand, plants have their own resistance mechanisms against toxic effects and for detoxifying heavy metal pollution (Asati *et al.,* 2016).

**Aims:**

* Indicate the amount of heavy metal in soil that caused by oil spill to the soil due to the electrical generators.
* Effect of these heavy metals to the soil and which metals in soil are more increase than others and all place around generators are the same to affected
* Measure the amount of heavy metals that increased.
* Assess the risks of contamination for eight heavy metals (zinc (Zn), cadmium (Cd), lead (Pb), manganese (Mn), nickel (Ni), copper (Cu), chromium (Cr) and mercury (Hg) of the soil by using ecological risk index.
1. **Material and method:**
	1. **Sample collection:**

First we collected sample in four different place to make a composite soil sample in Erbil city (Azadi, Zhyan, Kurdistan, collage of science its (control) figs.1. The soil samples that collected must be around the generators like (behind, front, in sides) of electrical generators and we stored in plastic bags. We placed in oven for 24hr in 105 C° temperature is used because it is high enough to evaporate all the water present in the pore spaces of the soil but is not so large that it drives water out of the structure of most minerals to drying soil.



 Figure 1: Map of Erbil city and studied sites around electrical generators.

After that they were sieved using a 2mm stainless steel sieve. The sieving process was carried out to remove large debris, gravel-sized materials, plant roots, and other waste materials. We replicate all these samples to ensure or to reduce the range of false results. The soil samples were dried and homogenized. XRF analyses were carried out at the Laboratory of environmental science and health department, College of Sciences, Salahaddin University. Sky ray Instrument (Genius 5000 XRF) analysers are used to determine the content of soil samples typically in seconds, without any requirement for instrument users to input empirical, sample specific calibrations. Again sieved the soil before put the soil in to the cell placed above of the instrument radiation comes out of it to the cell. And these instrument read these heavy metals that found in side of the soil or (these heavy metals that we worked on it like (zinc (Zn), cadmium (Cd), lead (Pb), manganese (Mn), nickel (Ni), copper (Cu), chromium (Cr) and mercury (Hg). And then we assessed the potential ecological assessment.

* 1. **Potential Ecological Risk Assessment:**

The potential ecological risk factor (Eir) to assess the ecological risk posed by heavy metals in sediments and soils. The Eir is calculated using the following equations:

 Cf = $\frac{Cs}{Cr}$……2.1

 Er = Tr \* Cf ……. 2.2

 RI=∑ Er …….2.3

Where (Er) is the potential ecological risk factor of metal and (Tf) is the toxic response factor of metal. The Tf values of heavy metals are 30, 5, 2, 5,1, 5, 5, and 1 for Cd, Co, Cr, Cu, Mn, Ni, Pb, and Zn, respectively. Cs is the metal i concentration in a sediment or soil sample and Cr is the reference value of metal. The potential ecological risk index (RI) is the sum of the risk factor values of all heavy metals at the sampling sites.

Er is categorized into five classes: light (Er< 40), moderate (40 ≤ Er < 80), heavy (80≤Ei r < 320), and very severe (Er ≥ 320). RI is classified into four grades: light (Ri < 150), moderate (150≤ Ri), heavy (300≤Ri), and severe (Ri≥600) (Al-Heety *et al.,* 2020).

* 1. **Statistical Analysis**:

Descriptive statistics, including mean, minimum, maximum, standard deviation and standard error were carried out using SPSS. Also, calculations of Eri and RI were conducted using Microsoft Excel.

1. **Results and Discussion:**
	1. **Concentrations of Heavy Metals:**

The descriptive statistics of the analyzed HMs, as well as those for the international guidelines, are given in Table-1. All mean values of HM concentrations exceeded the guidelines. The values of concentrations of heavy metals take a descending order, as follows: Cr > Ni > Zn > Pb> Cu > Co > Cd. This result suggests that Cu, Pb, Zn, and Cd had greater variations among the soil samples and, hence, may be influenced by external factors, such as anthropogenic activities. When comparing the mean concentrations of HMs in the soil of the study area with those reported for urban soils in a number of Erbil cities, we find them to be either higher or lower.

Weathering of Cd-rich rocks increases soil Cd content High concentrations of Cd were recorded in soils around power plants that use fossil fuel of various types as energy The source of Cd in diesel fuel is likely from fuel and engine wear. The magnitude of Cd emissions from diesel fuel depend on its Cd content, thus being either detectable or undetectable. The Cd sources in soil of the study area might be anthropogenic (fuel combustion emissions) or geogenic. the ranged of cd value in (control site) minimum to Maximum is 2.450 mg/kg to 5.150 mg/kg. and in Azadi quarters ranged from 16.500 mg/kg to 19.280 mg/kg. in Kurdistan quarters ranged from 18.570 mg/kg to19.800 mg/kg. in zhyan quarters ranged from 12.230 mg/kg to 15.330 mg/kg.

The Diesel exhaust emissions elevate Cr content in the soil. Diesel fuel contains different concentrations of Cr, depending on the type of fuel. In experimental studies, several authors investigated the Cr emissions from diesel fuel using different fuel types. The Cr content in the soil adjacent to the electricity generators might originate from weathering products of the ultramafic igneous rocks in Turkey and Syria that were brought by the Euphrates River, in addition to its emissions from diesel generators. the ranged of Cr value in (control site) minimum to Maximum is 34.000 mg/kg to 125.000mg/kg. and in Azadi quarters ranged from 245.000 mg/kg to 677.000 mg/kg. in Kurdistan quarters ranged from 344.000 mg/kg to 577.000 mg/kg. in Zhyan quarters ranged from 344.000 mg/kg to 788.000.

Significant Cu emissions as oil residue (waste) from fuel oil, Cu accumulates in the top horizon of the soil profile, which reflects its bioaccumulation and the recent anthropogenic sources of the metal The increase of Cu content in the soil samples of the study area is possibly due to its emissions from diesel fuel used to generate the electricity by generators. the ranged of Cu value in (control site) minimum to Maximum is 22.000 mg/kg to 54.000 mg/kg. and in Azadi quarters ranged from 72.490 mg/kg to 83.510 mg/kg. in Kurdistan quarters ranged from 67.640 mg/kg to 73.340 mg/kg. in Zhyan quarters ranged from 66.860 mg/kg to 84.460 mg/kg.

In Oil- and coal-fired power plants as well as trash-incinerators also release Ni into the environment, many authors reported Ni emissions from diesel fuel .Significant Ni emissions as oil residue (waste) from fuel oil were reported, and the enrichment factors were higher than those of the other heavy metals .The high concentration of Ni in soil of the study area can be explained in terms of its close proximity to the source ultramafic rocks, in addition to the Ni emissions as oil residues and bottom ash from the diesel engine generators. the ranged of Ni value in (control site) minimum to Maximum is 65.000 mg/kg to 122.000 mg/kg. and in Azadi quarters ranged from 265.000 mg/kg to 455.000 mg/kg. in Kurdistan quarters ranged from 233.000 mg/kg to 544.000 mg/kg. in Zhyan quarters ranged from 344.000 mg/kg to 566.000 mg/kg.

Lead enters the environment when it is released from mining fields of lead and other metals, factories producing or using lead and its alloys, lead compounds from coal combustion, and vehicle exhaustion in earlier investigations, high Pb emissions as oil residue of fuel oil used in the power plants. The high concentrations of Pb in the soils adjacent to the power generators in the study area are mainly caused by diesel generators emissions. the ranged of Pb value in (control site) minimum to Maximum is 19.000 mg/kg to 25.000 mg/kg. and in Azadi quarters ranged from 22.000 mg/kg to 344.000 mg/kg. in Kurdistan quarters ranged from 44.000 mg/kg to 178.000 mg/kg. in Zhyan quarters ranged from 66.000 mg/kg to 250.000 mg/kg.

The anthropogenic sources of Zn include traffic emissions, mechanical friction of vehicles, mining, steel processing from oil pools, coal and waste combustion, and fuel emitted from generators. Zn the higher enrichment factors for oil residue in fuel oil-based power plants. The lubricant oil combustion is a source of Zn emission. The high content of Zn in soils adjacent to the power generators in Erbil City can be attributed to the engine diesel oil and lubricant oil combustion by generators. the ranged of Zn value in (control site) minimum to Maximum is 23.000 mg/kg to 67.000 mg/kg. and in Azadi quarters ranged from 63.490 mg/kg to 250.000 mg/kg. in Kurdistan quarters ranged from 54.400 mg/kg to 176.000 mg/kg. in Zhyan quarters ranged from 81.410 mg/kg to 322.000 mg/kg.

Manganese is one of the most abundant trace elements in the lithosphere, its highest concentrations are usually associated with mafic rocks. Mn forms a number of minerals in which it commonly occurs as the ions Mn2+, Mn3+, or Mn4+, but its oxidation state +2 is most frequent in the rock-forming silicate minerals. During weathering, Mn compounds are oxidized under atmospheric conditions and the released Mn oxides are precipitated and readily concentrated in the form of secondary Mn minerals. The behavior of Mn in surficial deposits is very complex and is governed by different environmental factors, of which Eh-pH conditions are most important. Mn is easily removed, under cold climatic conditions. the ranged of Mn value in (control site) minimum to Maximum is 55.870 mg/kg to 97.690 mg/kg. and in Azadi quarters ranged from 462.290 mg/kg to 508.020 mg/kg. in Kurdistan quarters ranged from 515.420 mg/kg to 603.910 mg/kg. in Zhyan quarters ranged from 1938.530 mg/kg to 2135.510 mg/kg.

Iron is one of the major constituents of the lithosphere and comprises approximately 5%, being concentrated mainly in the mafic series of magmatic rocks. The geochemistry of Fe is very complex in the terrestrial environment and is largely determined by the easy change of its valence states in response to the physicochemical conditions. The behavior of Fe is closely linked to the cycling of O, S, and C. The reactions of Fe in processes of weathering are dependent largely on the Eh-pH system of the environment and on the stage of oxidation of the Fe compounds involved. The general rule governing the mobilization and fixation of Fe are that oxidizing and alkaline conditions promote the precipitation of Fe, whereas acid and reducing conditions promote the solution of Fe compounds. The released Fe readily precipitates as oxides and hydroxides. the ranged of Mn value in (control site) minimum to Maximum is 1836.920 mg/kg to 1940.100 mg/kg. and in Azadi quarters ranged from 2453.460 mg/kg to 2581.880 mg/kg. in Kurdistan quarters ranged from 2318.710 mg/kg to 2391.910 mg/kg. in Zhyan quarters ranged from 1938.530 mg/kg to 2135.510 mg/kg.

**Table 1-** Results of descriptive statistics analysis of HMs in Control soil.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **HMs** | **Mean (mg/kg)** | **Minimum** | **Maximum** | **Std. Dev** | **Std. Error** |
| **Pb** | **22.000** | **19.000** | **25.000** | **2.051** | **1.450** |
| **Cd** | **0.500** | **2.450** | **5.150** | **1.904** | **1.347** |
| **As** | **43.500** | **33.000** | **54.000** | **0.648** | **0.458** |
| **Zn** | **45.000** | **23.000** | **67.000** | **11.161** | **7.892** |
| **Cu** | **38.000** | **22.000** | **54.000** | **4.025** | **2.846** |
| **Ni** | **93.500** | **65.000** | **122.000** | **5.159** | **3.648** |
| **Mn** | **76.780** | **55.870** | **97.690** | **29.571** | **20.910** |
| **Cr** | **79.500** | **34.000** | **125.000** | **0.000** | **0.000** |
| **Fe** | **1888.510** | **1836.920** | **1940.100** | **72.955** | **51.587** |

**Table 2-** Results of descriptive statistics analysis of HMs in soils adjacent to electrical generators in Azadi Quarters.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **HMs** | **Mean (mg/kg)** | **Minimum** | **Maximum** | **Std. Dev** | **Std. Error** |
| **Pb** | **183.000** | **22.000** | **344.000** | **2.056** | **1.454** |
| **Cd** | **17.890** | **16.500** | **19.280** | **1.964** | **1.389** |
| **As** | **127.500** | **22.000** | **233.000** | **3.236** | **2.287** |
| **Zn** | **156.745** | **63.490** | **250.000** | **2.070** | **1.464** |
| **Cu** | **78.000** | **72.490** | **83.510** | **7.791** | **5.509** |
| **Ni** | **360.000** | **265.000** | **455.000** | **15.083** | **10.665** |
| **Mn** | **485.155** | **462.290** | **508.020** | **32.332** | **22.862** |
| **Cr** | **461.000** | **245.000** | **677.000** | **23.366** | **16.522** |
| **Fe** | **2517.670** | **2453.460** | **2581.880** | **90.809** | **64.212** |

**Table 3-** Results of descriptive statistics analysis of HMs in soils adjacent to electrical generators in Kurdistan Quarters.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **HMs** | **Mean (mg/kg)** | **Minimum** | **Maximum** | **Std. Dev** | **Std. Error** |
| **Pb** | **111.000** | **44.000** | **178.000** | **3.468** | **2.452** |
| **Cd** | **19.185** | **18.570** | **19.800** | **0.870** | **0.615** |
| **As** | **67.850** | **12.700** | **123.000** | **8.166** | **5.774** |
| **Zn** | **115.200** | **54.400** | **176.000** | **5.185** | **3.666** |
| **Cu** | **70.490** | **67.640** | **73.340** | **4.028** | **2.848** |
| **Ni** | **388.500** | **233.000** | **544.000** | **6.846** | **4.841** |
| **Mn** | **559.665** | **515.420** | **603.910** | **62.571** | **44.244** |
| **Cr** | **460.500** | **344.000** | **577.000** | **13.896** | **9.826** |
| **Fe** | **2355.310** | **2318.710** | **2391.910** | **51.761** | **36.601** |

**Table 4-** Results of descriptive statistics analysis of HMs in soils adjacent to electrical generators in Zhyan.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **HMs** | **Mean (mg/kg)** | **Minimum** | **Maximum** | **Std. Dev** | **Std. Error** |
| **Pb** | **158.000** | **66.000** | **250.000** | **1.995** | **1.410** |
| **Cd** | **2.400** | **12.230** | **15.330** | **2.190** | **1.548** |
| **As** | **126.500** | **17.000** | **236.000** | **1.446** | **1.022** |
| **Zn** | **201.705** | **81.410** | **322.000** | **7.424** | **5.250** |
| **Cu** | **75.660** | **66.860** | **84.460** | **12.447** | **8.801** |
| **Ni** | **455.000** | **344.000** | **566.000** | **28.245** | **19.927** |
| **Mn** | **360.220** | **337.100** | **383.340** | **32.693** | **23.117** |
| **Cr** | **566.000** | **344.000** | **788.000** | **10.034** | **7.095** |
| **Fe** | **2037.020** | **1938.530** | **2135.510** | **139.285** | **98.489** |

* 1. **Correlation Matrix Analysis:**

Correlation matrix analysis is an effective tool to show the relations between multiple variables and to understand the influencing factors as well as the chemical parameter sources (Li *et al.,* 2013). The correlation relations between heavy metals provide important information about sources and pathways of heavy metals (Manta *et al.,* 2002). In general, a correlation coefficient > 0.967308 is interpreted as a strong correlation, while the value between 0.15 and 0.967308 reflects moderate correlation, and the value less than 0.15 is interpreted as low correlation (pam *et al.,* 2011)**.** The results of correlation matrix analysis at a significant level (p ≤ 0.05) are listed in Table-5. The strong and moderate correlations are interpreted in terms of the common origin or source, while the low correlation reflects the different origin or source. The results showed a positive strong correlation of Cu and Pb with the other metals (except for Cr), with the highest correlation coefficient being between Cu and Pb, implying that these latter two metals originated from the same source. The deposition of these metals in the soil is associated with the emissions of fuel engines (Hui *et al.,* 2017).

* 1. **Ecological Risk Assessment:**

The descriptive statistics results of Eri and RI of HMs in urban soils of Erbil City are listed in Table 4 The descending mean values of Eri are ranked as follows: Ni > Cd > Zn > Cu > Cr > Pb. The mean values of Eri for Ni, Cd, and Zn indicate very severe, severe, and heavy potential ecological risks, respectively. The mean values of Eri for Cu, Cr, and Pb are classified as light potential ecological risk. Al-Heety and Saod (Al-Heety., soad.,2019) calculated Eri of different HMs in the urban soils for several Iraqi cities. The mean value of Eri for Ni and Zn in the soil samples of the current study is more than that reported earlier (Al-Heety., soad.,2019)*.* The light potential ecological risk for Cu, Cr, and Pb in the soils of the study area is consistent with that inferred previously (Al-Heety., soad.,2019). The high values of Eri for Ni, Co, and Zn depend on their concentrations, while the Eri for Cd depends on its toxic response factor and concentration. The RI value ranges from 510.39185 to 1254.397. According to the categories of RI (Hakanson L.,1980). the RI values are classified as severe ecological risk. The contributions of the single ecological risk Eri in RI take the following descending order: Ni > Cd > Zn > Cu > Cr > Pb. There is a relation between the RI value and the type, concentration, and toxicity of the HM, while the lower RI reflects a lower content of the HM and slight toxicity (Gupta *et al.,* 2014). The obtained RI value for the urban soils in Erbil City was higher than that reported previously (Al-Heety., soad.,2019) for soils in Baghdad. The high RI value in the urban soils of Erbil City can be attributed to the anthropogenic activities, such as emissions from the power generators, traffic emissions, atmospheric deposition, and other human activities.

**Table 5-** Correlation matrix analysis for HMs in soils adjacent to the electrical generators in Erbil City.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **HMs** | **Pb** | **Cd** | **As** | **Zn** | **Cu** | **Ni** | **Mn** | **Cr** | **Fe** |
| **Pb** | **1** |  |  |  |  |  |  |  |  |
| **Cd** | **0.501** | **1** |  |  |  |  |  |  |  |
| **As** | **0.944** | **0.203** | **1** |  |  |  |  |  |  |
| **Zn** | **0.908** | **0.170** | **0.933** | **1** |  |  |  |  |  |
| **Cu** | **0.965** | **0.593** | **0.848** | **0.894** | **1** |  |  |  |  |
| **Ni** | **0.865** | **0.438** | **0.763** | **0.913** | **0.950** | **1** |  |  |  |
| **Mn** | **0.750** | **0.872** | **0.496** | **0.577** | **0.872** | **0.816** | **1** |  |  |
| **Cr** | **0.899** | **0.443** | **0.807** | **0.932** | **0.967** | **0.997** | **0.813** | **1** |  |
| **Fe** | **0.701** | **0.950** | **0.464** | **0.364** | **0.724** | **0.524** | **0.867** | **0.549** | **1** |

**Table 6-** Results of Contamination Factor (CF) of HMs in soils adjacent to electrical generators in Erbil City.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **HMs** | **Azadi** | **Kurdistan** | **Zhyan** | **Control** |
| **Pb** | **4.575** | **2.775** | **3.95** | **0.55** |
| **Cd** | **29.816** | **31.975** | **4** | **0.833** |
| **As** | **18.667** | **9.934** | **18.521** | **6.368** |
| **Zn** | **1.274** | **0.936** | **1.639** | **0.365** |
| **Cu** | **2.184** | **1.974** | **2.119** | **1.064** |
| **Ni** | **22.5** | **24.281** | **28.437** | **5.843** |
| **Mn** | **0.994** | **1.146** | **0.738** | **0.157** |
| **Cr** | **12.326** | **12.312** | **15.133** | **2.125** |

**Table 7-** Results of potential ecological risk index (Eri) and risk index (RI) values of HMs in soils adjacent to electrical generators in Erbil City.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **HMs** | **Azadi** | **Kurdistan** | **Zhyan** | **Control** |
| **Pb** | **22.875** | **19.75** | **13.875** | **2.75** |
| **Cd** | **894.5** | **120** | **959.25** | **25** |
| **As** | **186.676** | **185.212** | **99.341** | **63.689** |
| **Zn** | **1.274** | **1.639** | **0.936** | **0.365** |
| **Cu** | **10.924** | **10.596** | **9.872** | **5.322** |
| **Ni** | **112.5** | **142.187** | **121.406** | **29.218** |
| **Mn** | **0.994** | **0.738** | **1.146** | **0.157** |
| **Cr** | **24.652** | **30.267** | **24.625** | **4.251** |
| **RI** | **1254.397** | **510.391** | **1230.454** | **130.755** |

**Conclusions:**

According to this study, the amount of pollutant (heavy metals) in soil that was released by the fuels or diesel of electrical generators was measured (Pb, Cd, As, Zn, Cu, Ni, Mn, and Cr). Increase the range of HMs adjacent to electrical generators in Erbil city. The CF of heavy metals is higher in Azadi and Zhyan quarters, and the range of HMs is higher than in other quarters. The ranges of (Eri) and (RI) are increased, as shown in table-7. Should keep electrical generators away from residential areas. Or the wastes (fuel or diesel) of generators before they are released to the soil must be treated by putting a tank adjacent to the places of generators that release the diesel instead of releasing the (fuel or diesel) and other wastes to the soil, and then re-using these waste for other purposes instead of contacting these waste with the soil, which destroys the soil.

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