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RESEARCH PAPER

Effects of the Brand of Electrical Generator on the Concentration of Heavy Metals in Soil and Plants

Shakar Jamal Aweez [1], Zhian Rashid Salih[2], Lubna ahmad abdulkarim[3], Aveen Muhsin Asaad[4]

[1] Department of Environmental Sciences and Health, College of Science, Salahaddin University-Erbil, Iraq.
[2] Department of biology, College of Education, Salahaddin University- Erbil, Iraq.
[3] Department of Environmental Sciences and Health, College of Science, Salahaddin University-Erbil, Iraq.
[4] Koya Technical Institute, Erbil Polytechnique University-Erbil, Iraq.

A B S T R A C T:

There are serious health and environmental problems caused by the use of diesel generators for backup power at many locations. For this purpose, ten different locations (Baharykon S1, Azadi 1 S2, Azadi 2 S3, Nasejan S4, Kuran S5, Nawroz S6, Kurdistan S7,92 Zanko S8, Nargz S9, and Nishtiman S10) were selected. Three different brands of electrical generators were used (B1 Cater piller, B2 Cummins, and B3 Locally manufactured aggregates). The heavy metals (As, Cd, Cr, Cu, Zn, Pb, and Hg) were determined from both soil and plants. For soil pollution assessment indices were applied contamination factor (CF), degree of contamination (Cdeg), Ecological Risk Factor, Potential Ecological Risk Indices, and biological accumulation factor. Results showed that the highest values of (5.368, 232.873, 3.023, 4.205, 1.697, 4.101,0.178) were recorded in (B2S2, B3S5, B2S9, B3S5, B3S1, B2S9) while for the degree of contamination was (249.199) were recorded in (B3S5). According to contamination factor their indications of low contamination (B2S9) moderate contamination factor for (B2S9) considerable contamination factor for (B2S2, B2S9, B3S5, B3S1), with high degree of contamination in (B3S5). The ecological risk factor and RI with the highest values were (53.682, 6986.193, 6.046, 21.027, 1.697, 20.507,13.936) and RI was (7081.261), which were recorded in (B1S2, B3S5, B2S9, B3S5, B3S1, B2S7) and (B3S5), respectively. The ecological risk factor and potential ecological risk indices showed that (B2S9, B3S5, B3S1, B2S7) low potential ecological risk, (B1S2) moderate potential ecological risk, (B3S5) very high ecological risk. The biological accumulation coefficient factor of two different plants (*Eucalyptus amygdalina Labill*, (Plant1), and *Dodonaea viscosa Jacq* (Plant2) are (8.433, 15.358, 23.311, 42.236, 52.626, 48.094, 0.190) which were recorded in (B3S8P1, B2S7P1,S3S5P2, B2S9P2, B2S7P2, B3S8P1,B3S4P1.The aim of this study is to assess the effect of the brand electrical generator on concentration heavy metal in soil and dust soil and plant heavy metal levels in Erbil city

KEY WORDS: Heavy metals, Electrical generator, Contamination factor, Potential ecological risk index, Biological Accumulation Coefficient.
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1.INTRODUCTION :

The usage of diesel generators for backup power at numerous venues, including malls, retail centers, wedding gardens, office buildings, and other locations, causes major health and environmental issues. Exploitation of mineral resources damages the local ecological environment in addition to promoting rapid economic growth. (Chen *et al*.,2022) .Heavy metal pollutants are deposited on the surface of plant leaves and the topsoil by atmospheric aerosol particles(Molnár *et al.*, 2020).

The core of all agroecosystems is soil, which is also an important component of the earth. The majority of soils are threatened by various forms of erosion and pollution, heavy metals and hazardous elements are among the major contaminants(Aweez *et al*.,2021). There are two broad categories of soil pollution: anthropogenic (produced by human activity) and naturally occurring. In some incredibly uncommon processes, some toxins are naturally collected in soils; this can occurs because the soil is deposited differently by the atmosphere(Tao *et al.*, 2020).

The main anthropogenic sources of soil pollution are chemicals used in or produced as

* **Corresponding Author:**
Shakar Jamal Aweez
E-mail: shakar.aweez@su.edu.krd
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byproducts of industrial activities, household and municipal wastes, including wastewater, agrochemicals, and products derived from petroleum, although a variety of human activities can contaminate soil the following are some of the causes of soil pollution(Rodríguez-Eugenio *et al*., 2018). The pollution of soil with metals due to electrical generators as an important issue in Iraq. Three types of energy sources are in Iraq about 50%of electricity is generated by petroleum gas,28% is steam generators and fueled by heavy oil and 15% is diesel generators(Khatteeb and Istepanian, 2016).

The presence of heavy metals in soils can caue them to become highly toxic to human beings. 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), chromium (Cr) and copper (Cu) (Shaltami, 2014). The main anthropogenic sources of soil pollution are chemicals used in or produced as byproducts of industrial activities, and household and municipal wastes, including wastewater, agrochemicals, and products derived from petroleum. Although a variety of human activities can contaminate soil, the following are some of the causes of soil pollution (Srivastava *et al*., 2019). More recently, the connection between plants and pollutants has been understood (AL-Heety *et al*., 2021). Living things including plants, planktons, animals, and microorganisms are called bioindicators, and they are used to assess the health of the environment's natural ecosystem as well as environmental changes in biogeography(Parmar *et al.*, 2016). Heavy metal (HM) toxicity, a group of 52 metals that directly affect performance in a concentration-dependent manner, has emerged as one of the most significant threats to crop production. (Riyazuddin *et al.*, 2021).

There are two aspects to how heavy metals interact with plants: on the one hand, heavy metals have negative effects on plants, and on the other hand, plants have defense mechanisms against toxic effects and for decomposition. When plants grow in heavy metal-polluted soils, their growth is reduced due to changes in their physiological and biochemical activities. This is especially true when the heavy metal involved has no beneficial role in the growth and development of plants(Asati *et al*., 2016).

Due to a lack of electricity, the utilization of alternative energy sources has quickly gained importance in recent years. Our study sought to assess the environmental impacts of electrical generators on the concentration of heavy metals in soil and dust plants in Erbil city. The usage of petrol engine generators at homes, offices, and stores is one of the growing demands of everyone to address the electricity deficit.

2. MATERIALS AND METHODS:

2.1 Site description

Erbil governorate is situated 414 meters above sea level, at longitude 43º 15’ E and latitude 35º 11’ N to 37º 24 N’(Aweez et al., 2021). Due to its origins in limestone and dolomite from various formations, the soil in Erbil is calcareous. The topsoil is calcareous and may contain 1-2% organic matter and this type of soil occurs in areas with hot dry summers and cold-rainy winters(Khudhur and Khudhur, 2015). The weather in Erbil resembles that of the semi-arid zones in Iran and Turania in certain ways, with chilly winters, mild spring growing seasons, and hot summers (Aweez *et al*., 2021). Kurdistan's environmental and climatic conditions vary due to its latitude and altitude, ranging from Mandali at 150 m to Halgurd (Hasarost) at 3607 m. (Aziz,*et al*,.2022)

2.2 Sample analysis

The quarters (Baharykon S1, Azadi 1 S2, Azadi 2 S3, Nasejan S4, Kuran S5, Nawroz S6, Kurdistan S7,92 Zanko S8, Nargz S9, and Nishtiman S10) were the ten sites where soil samples were taken from the locations of the generators at a depth of 0–20 cm surface leaching (B1 Caterpiller, B2 Cummins, B3 Locally manufactured aggregates). The locations were recorded by GPS as shown in Figure 1. In every sampling site, an aggregated sample was made by mixing the 3subsamples together. Plastic bags were used to keep the soil samples. After drying for 24 hours at 105 degrees Celsius in the lab oven, these samples sieved through a 106-mesh stainless steel sieve. The sieving procedure was used to have huge particles, gravel-sized materials, plant roots, and other waste products. With a porcelain pestle and mortar, the samples were then blended. They were kept in polyethylene containers, being ready for analysis of heavy metals: As, Cd, Cr, Cu, Zn, Pb, Hg Select the metal distinctly by using XRF (X-ray fluorescence spectrophotometer) Sky Instrument Genius. Plant samples were taken a meter away from the leaching area. leaves were placed in sterile plastic bags, labeled with the date of collection, the study area, the type of fuel, the species of plant, and distance between plants and generator, and stored until we got to the lab. There, we dried the leaves at 65 °C for 24 hours before preparing them for heavy metal analysis.

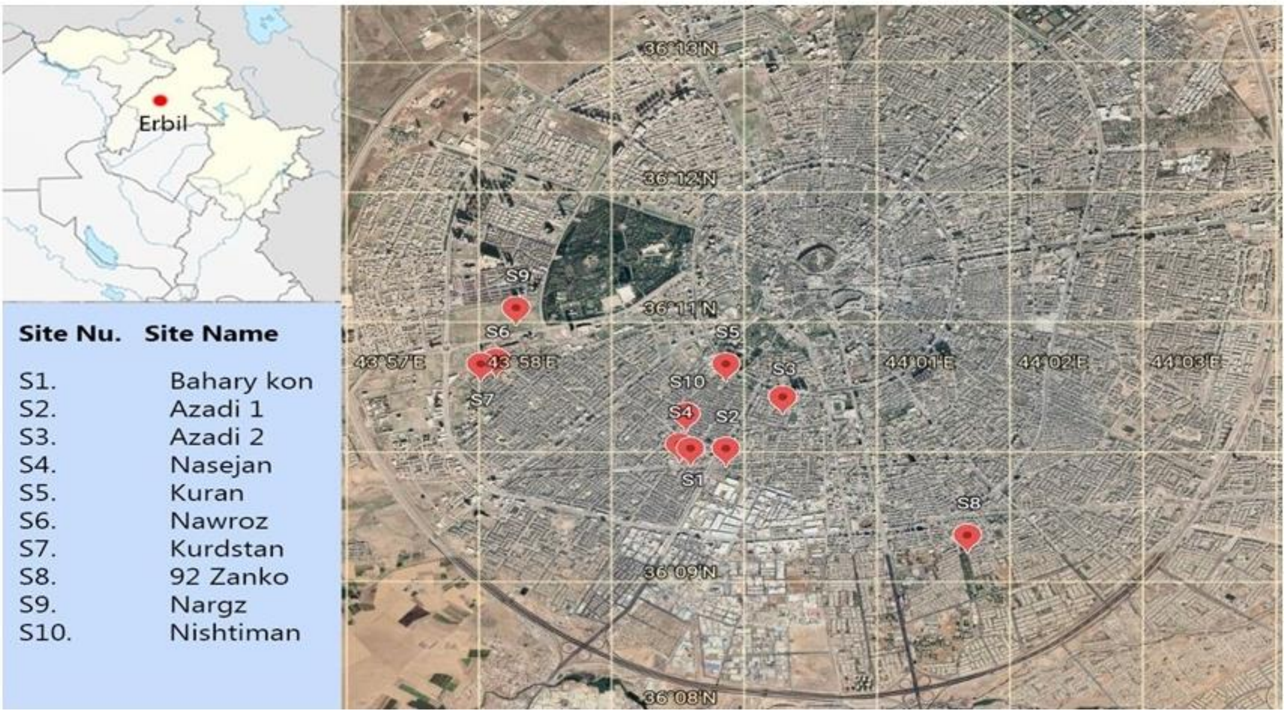

Figure 1 Sampling locations in Erbil City.

2.3 Soil pollution indices

From the perspective of algorithms, there are two types of pollution indices: single index and integrated index. Heavy metal contamination is assessed using pollution indices(Qingjie et al., 2008).

Table 1. Pre- industrial reference value (pg.g^{-1}) and toxic–response factor.

Elements	Hg	Cd	As	Cu	Pb	Cr	Zn
Pre-industrial reference value	0.25	1	15	50	70	90	175
Toxic response factor	40	30	10	5	5	2	1

2.3.1. Single indices

Single indices, such as the contamination factor, ecological risk factor, enrichment factor, and index of deaccumulation, are indicators that are used to compute or evaluate only one contaminated metal.

2.3.2. integrated indices

Indicators that calculate several metal contaminations based on single indices are known as integrated indices. The aforementioned single indices can be used separately to create several types of integrated indices.

2.3.4. Contamination factor:

A contamination factor (*Cif*) used to describe the contamination of a given toxic substance, is:

$$C_f^i = \frac{\overline{C}_{0-1}^i}{C_n^i}$$

Where *C* 0-1 is the pre-industrial reference level for the substance and is the mean content of the substance in at least five sampling sites. The contamination factor is referred by the following terms: Ci f<1 Low contamination factor, 1≤Ci f<3 moderate contamination factor, (3≤Ci f<6) considerable contamination factor, Ci f≥6 very high contamination factor, here ($C_i\ f$) was defined as follows:

$$C^i_f = C_i / C_{ri}$$

Where Cri is the reference value of (baseline level), or national criteria of metal, and Ci is the metal content I rather than the mean content from sampling sites (i). The effect range low (*ERL*) per effect range median (*ERM)* and the threshold effect level (*TEL*) per likely effect level are examples of soil quality guidelines that were chosen for the Cr (*PEL*).

2.3.5. Ecological risk factor:

An ecological risk factor (*ErI*) quantitatively expresses the potential ecological risk of a given contaminant .(Qingjie *et al.,* 2008)

$$Er^i = Tr^i \cdot C^i_f$$

Where Tri the toxic-response factor for a given substance, and Ci f is the contamination factor. The Tri values of heavy metals. The following terminologies are used to describe the risk factor: Eri. (Qingjie *et al.,* 2008)

2.3.6. Degree of contamination (C_d):

The degree of contamination (C_d) was originally defined as the sum of all contamination factors

$$C_d = \sum C_f$$

Where m is the counted heavy metal species and *C*i f is the single index of contamination factor. The terms C_dm (low degree of contamination), m C_d 2m (moderate degrees of contamination), 2m C_d 4m (significant degree of contamination), and C_d >4m (extremely high degree of contamination) have been used to describe the degree of contamination(Qingjie *et al.,* 2008).

2.3.7. Potential ecological risk index (RI):

The degree of contamination was determined as the total of the risk variables, just like the possible ecological risk index (RI).

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

The *Er*i is the total index of ecological risk factors, and m is the counted species of heavy metal. The prospective ecological risk index was described or measured using the following terms or ranges: When the toxic response factor was applied to seven elements, the ecological risk factors were *RI*150 (low ecological risk factor), *RI*300 (moderate ecological risk), *RI*600 (significant ecological risk), and *RI*600 (extremely high ecological danger) (Qingjie *et al.,* 2008)

2.3.8. Biological Accumulation Coefficient (accumulation factors):

Biological Accumulation Coefficient (BAC) calculation was used to determine the ability of the plants to uptake and accumulate some heavy metal from the media. The determination for BAC was based on the following equation. (Titah,. *et al.*2020)

BAC = (Metal) plant / (Metal) soil

2.4. Statistical analysis:

With the help of SPSS version 24, data from an experimental design in a completely randomized design (CRD) were statistically evaluated. The mean value is used to express all data. Duncan multiple comparison tests were used to compare the variance in the soil means at a level of significance of 5% (Steel and Torrie, 1980).

3. RESULTS AND DISCUSSION:

3.1 Soil heavy metals content:

The potential toxicity of heavy metals in soil depends on their mobility and bioavailability, which is a major concern for human and environmental health globally (Maas et al., 2010). The findings in Table 2 demonstrated that there was a significant change in soil heavy metal concentrations ($p \leq 0.05$). The highest values for As, Cd, Cr, Cu, Zn, Pb, and Hg (33.043, 37.208, 272.111, 210.27, 287.12,287.11 and 0.087) mg.kg^{-1} were reported in (B3S8, B3S4, B2S9, B3S5, B3S8, B2S9, and B2S7) respectively.This result suggests that the electrical generator's leaching has become a significant factor in the contamination of soil with heavy metals. It has been determined that the electrical generator's leaching releases some toxic metals into the environment, the majority of which are released adjacent to soil, and that their concentration in the soil is a major concern due to their toxicity and threat to both human life and the environment. Combustion of fuel, oil leaks, etc. are some of the other sources of soil contamination with heavy metals (Aloysius *et al.,* 2013). which discovered that heavy metals might enter human bodies through food or the food chain, ingestion, inhalation, dermal contact, or contact with the skin (Khudhur *et al.,* 2018). In particular, the metals arsenic, antimony, lead, mercury, copper, chromium, and chromium VI can have negative harmful effects on human health and the environment as the soluble compound of chromium. Out of the forty heavy metals on the earth, As, Cd, Cr, Cu, Pb, Hg, and Ni were the most common heavy metals that are considered a pollutant.

3.2 Plant's heavy metals content:

The data shown in Table 3 indicated that the concentration of heavy metals in the plant changed significantly at ($p \leq 0.05$). The highest values were (8.182, 23.187, 48.131, 49.980, 58.132, 0.031) $mg.kg^{-1}$, for As, Cr, Cu, Zn, Pb, and Hg, respectively were recorded in (B2S8P2, B3S5P1, B2S8P1, B2S2P2 B2S8P2, B2S2P2). According to this finding, heavy metal pollution from electrical generators is dispersed over a wide area, where it then spreads to nearby soils and plants. Heavy metals are absorbed by plants and vegetables through their roots, stems, and leaves, which can lead to necrotic lesions, color changes like mottling, bronzing, reddening, and chlorosis, and stunted plant growth. Hamdy *et al.,*(2015) observed that deposits of heavy metals from polluted environments and contaminated soils are taken up by plants by absorbing them from deposits on the sections of the plants exposed to the air.

3.3 Soil pollution indices:

3.3.1 Contamination factor and degree of contamination:

The recorded results in Table 4 indicate that the leaching of oil from electrical generators significantly at ($p \leq 0.05$) which affected on contamination factor and degree of contamination. The highest contamination factor and degree of contamination values were (5.368, 232.873, 3.023, 4.205, 1.697, 4.101,0.178) were recorded in (B2S2, B3S5, B2S9, B3S5, B3S1, B2S9) while for the degree of contamination was (249.199) were recorded in (B3S5). According to contamination factor their indications of low contamination (B2S9) moderate contamination factor for (B2S9) considerable contamination factor for (B2S2,B2S9,B3S5,B3S1), with high degree of contamination in (B3S5). This conclusion can be linked to the effects of electrical generators since regarded as a source of heavy metal content in the soil. This outcome were comparable to those of Martin *et al*., (2017) Who indicated *Cf* of the trace elements (Al, As, Co, Cr, Mn, Ni, Ti, and V) of soil samples in the studied areas were low to moderate contamination. Mlitan (2013) showed *Cf* values between 0.5 and 1.5 indicate that the metal was entirely from crust materials or natural processes; whereas *Cf* values greater than 1.5 suggest that the sources were more likely to be anthropogenic, the *Cf* revealed that soils show the highest contamination factors for Pb and Cu ranging from considerable contamination to very high contamination, while Zn, Cd had minimal to moderate contamination, on the other hand, they demonstrated that Ni might be moderate to considerable contamination, in case degree of contamination, the windward soils fall under considerable contamination. All sites have a very high degree of contamination ($C_d eg \geq 32$).

3.3.2 Ecological risk factor and potential ecological risk indices:

Table 5 shows that the ecological risk factor and RI are impacted by the leaching of electrical generator pollution significantly at ($p \leq 0.05$). The ecological risk factor and RI with the highest values were (53.682, 6986.193, 6.046, 21.027, 1.697, 20.507,13.936) and RI was (7081.261), which were recorded in (B1S2, B3S5, B2S9, B3S5,B3S1,B2S7) and (B3S5), respectively. The ecological risk factor and potential ecological risk indices showed that (B2S9, B3S5,B3S1,B2S7) low potential ecological risk, (B1S2) moderate potential ecological risk, (B3S5) very high ecological risk . This result shows that metals in soil their discharge of heavy metals into the environment, especially in the soil, varies over time, space, the level of human activity, and the amount of leaching, mobility, and bioavailability of the metals and can result in the production and release of inflammatory mediators by the respiratory tract epithelium. The results of the study and its interpretation were only partially consistent with those stated by (Jiang *et al*., 2014).

3.3.3 Biological Accumulation Coefficient:

The findings in Table 6 show that the biological accumulation coefficient is considerably impacted by the leaching of electrical generator pollution at ($p \leq 0.05$). The maximum biological accumulation coefficient w (8.433, 15.358, 23.311, 42.236, 52.626, 48.094, 0.190,) was measured in (B3S8P1, B2S7P1,S3S5P2, B2S9P2, B2S7P2, B3S8P1,B3S4P1), respectively. This finding suggests that because environmental elements like soil, air, and water play a significant influence in a plant's growth and development and can cause abnormal symptoms to manifest in a plant, it is impossible for a plant to travel or survive outside of its ecosystem. This result is similar to the result Vaca *et al*., (2011) stated that the level of heavy metal buildup varies within and across portions of plants and depends on factors such as waste concentration, amount of metals present in the soil, and its amendments. Sudmoon *et al*., (2015) reported that the concentrations of the examined heavy metals were higher in the roots of *Dodonaea viscosa* and *Eucalyptus amygdalina* than in the shoots. All plant species have a BCF, and if the BCF is more than 1, a plant species has the potential to be utilized in phytoextraction or phytostabilization.

Table 2. The concentration of heavy metals in the soil of the studied sites and brands of the electric generators in Erbil city

	Heavy metals mg.kg^{-1}						
Sites	**As**	**Cd**	**Cr**	**Cu**	**Zn**	**Pb**	**Hg**
B3S1	13.837 [e]	25.231 [e]	68.231 [h]	125.252 [e]	297.132 [a]	243.132 [c]	0.023 [d]
B2S2	20.523 [d]	28.873 [d]	20.321[j]	25.187 [i]	83.278 [g]	232.212 [d]	0.073 [b]
B1S3	23.581 [c]	35.873[b]	60.252 [i]	177.22 [b]	63.32 [h]	158.872 [i]	0.015 [d]
B3S4	25.758 [b]	37.208 [a]	101.271 [f]	95.673 [f]	222.878 [d]	262.52 [b]	0.009 [e]
B3S5	25.555 [b]	32.871 [c]	232.111 [b]	210.27 [a]	182.132 [e]	242.12 [c]	0.001 [e]
B1S6	32.333 [a]	20.308 [f]	88.281 [g]	66.703 [h]	182.13 [e]	182.212 [h]	0.011 [d]
B2S7	25.337 [b]	25.732 [e]	125.231 [e]	132.31 [d]	292.264[b]	217.87 [f]	0.087 [a]
B3S8	33.043 [a]	35.218 [b]	192.111 [d]	161.23 [c]	287.12 [c]	201.31 [g]	0.004 [e]
B2S9	25.876 [b]	32.027 [c]	272.111 [a]	178.23 [b]	92.128 [f]	287.11 [a]	0.002 [e]
B1S10	20.973 [d]	31.382 [c]	197.201 [c]	87.254 [g]	221.11 [d]	221.21 [e]	0.044 [c]

Post -Hoc Duncan - test: no difference between groups with the same letter p value .
Significant differences between groups with different letters p value . B= The brands of the electrical generators. S= The number of the sampling sites.

Table 3. The concentration of heavy metals in the dust plants in the studied sites and brands of the electric generators in Erbil city

	Heavy metals mg.kg $^{-1}$						
Sites	**As**	**Cd**	**Cr**	**Cu**	**Zn**	**Pb**	**Hg**
B3S1P1	5.232 c	0.001	10.036 g	10.176 k	20.111 h	40.675 f	0.001 d
B3S1P2	5.033 c	0.001	10.287 g	20.218 i	20.201 h	23.198 h	0.010 c
B2S2P1	4.268 d	0.001	18.154 c	45.952 b	27.074 e	23.112 h	0.002 d
B2S2P2	4.127 d	0.001	10.232 g	31.837 f	49.980 a	20.907 i	0.031 a
B1S3P1	3.165 e	0.001	8.625 i	32.123 ef	15.226 i	20.009 i	0.001 d
B1S3P2	6.334 b	0.001	10.070 g	15.278 j	12.111 j	41.110 f	0.004 d
B3S4P1	2.216 f	0.001	12.339 e	23.113 h	10.765 k	23.987 h	0.023 b
B3S4P2	2.568 f	0.001	12.110 e	20.284 i	10.267 k	12.542 j	0.011 c
B3S5P1	5.278 c	0.001	23.187 a	33.336 e	31.121 d	46.876 d	0.003 d
B3S5P2	3.661 e	0.001	20.935 b	30.118 f	25.657 f	43.323 e	0.002 d
B1S6P1	1.102 g	0.001	8.899 i	22.292 h	38.285 c	25.167 g	0.001 d
B1S6P2	4.908 d	0.001	8.231 i	20.897 i	27.165 e	42.290 e	0.001 d
B2S7P1	2.210 f	0.001	12.205 e	43.181 c	12.276 j	52.573 b	0.001 d
B2S7P2	2.837 f	0.001	10.11 g	31.979 f	15.187 i	50.126 c	0.002 d
B2S8P1	5.212 c	0.001	12.361 e	48.131 a	23.132 g	42.217 e	0.001 d
B2S8P2	8.182 a	0.001	11.117 f	38.004 d	32.124 d	58.132 a	0.001 d
B2S9P1	1.694 g	0.001	8.186 i	25.378 g	42.133 b	25.333 g	0.002 d
B2S9P2	2.234 f	0.001	9.235 h	25.009 g	25.234 f	19.508 i	0.001 d
B1S10P1	6.676 b	0.001	10.877 g	10.877 k	15.110 i	20.116 i	0.003 d
B1S10P2	6.073 b	0.001	15.333 d	33.119 e	15.012 i	25.432 g	0.002 d

Post – Hoc Duncan – test: no differences between groups with the same letter p value
Significant differences between groups with different letters p value. B= The brands of the electrical generators. S= The number of the sampling sites. P1= *Eucalyptus amygdalina.*
P2= *Dodonaea viscosa*

Table 4. Contamination Factor and Degree of Contamination

	Contamination Factor							
Sites	**As**	**Cd**	**Cr**	**Cu**	**Zn**	**Pb**	**Hg**	***C*deg**
B3S1	4.255	125.230	0.758	2.105	1.697	3.473	0.092	137.612
B2S2	5.368	28.837	0.459	0.503	0.475	3.317	0.293	39.255
B1S3	4.905	55.874	0.669	3.544	0.361	2.269	0.061	67.687
B3S4	1.716	67.290	1.125	1.913	1.273	3.750	0.039	77.109
B3S5	5.036	232.873	2.579	4.205	1.040	3.459	0.044	249.199
B1S6	2.155	210.302	0.980	1.334	1.041	2.603	0.044	218.461
B2S7	3.022	75.732	1.391	2.647	1.670	3.111	0.348	87.922
B3S8	2.202	55.212	2.134	3.224	1.640	2.876	0.017	67.308
B2S9	2.391	32.023	3.023	3.565	1.669	4.101	0.008	46.783
B1S10	4.861	61.383	2.191	1.745	1.263	3.160	0.178	74.783

Table 5. Ecological Risk Factor and Potential Ecological Risk Index.

	Ecological risk factor							
Sites	**As**	**Cd**	**Cr**	**Cu**	**Zn**	**Pb**	**Hg**	**RI**
B3S1	42.555	3756.903	1.516	10.525	1.697	17.366	3.696	3834.260
B1S2	53.683	865.119	0.918	2.518	0.475	16.586	11.744	951.045
B3S3	49.054	1676.229	1.338	17.724	0.361	11.347	2.464	1758.520
B3S4	17.167	2018.724	2.250	9.567	1.273	18.752	1.568	2069.304
B3S5	50.370	6986.193	5.158	21.027	1.040	17.295	0.176	7081.261
B1S6	21.557	6309.084	1.960	6.670	1.041	13.019	1.760	6355.093
B2S7	30.222	2271.960	2.782	13.235	1.670	15.558	13.936	2349.364
B3S8	22.029	1656.384	4.269	16.123	1.640	14.380	0.688	1715.514
B2S9	23.917	960.711	6.046	17.826	1.669	20.507	0.352	1031.030
B1S10	48.618	1841.496	4.382	8.725	1.263	15.802	7.136	1927.424

Table 6. Biological accumulation coefficient of *Eucalyptus amygdalina* and *Dodonaea viscosa*.

	Biological Accumulation coefficient						
Sites	**As**	**Cd**	**Cr**	**Zn**	**Pb**	**Cu**	**Hg**
B3S1P1	5.283	2.978	10.748	20.854	23.26	35.307	0.0903
B3S1P2	5.388	2.321	10.161	20.214	40.728	38.271	0.0486
B2S2P1	4.378	5.001	10.692	50.633	20.967	31.927	0.0442
B2S2P2	5.231	0.997	18.278	37.178	23.165	36.047	0.0499
B1S3P1	6.585	10.876	10.531	12.763	41.171	15.368	0.027
B1S3P2	4.131	8.743	8.749	15.331	20.061	32.217	0.0488
B3S4P1	2.818	4.231	12.571	10.921	12.602	20.374	0.1908
B3S4P2	4.217	4.878	12.463	10.869	24.041	23.207	0.0981
B3S5P1	2.943	2.225	21.396	10.921	12.621	30.208	0.0855
B3S5P2	6.437	6.878	23.311	31.221	46.929	33.431	0.048
B1S6P1	5.159	8.373	8.691	27.817	42.349	20.987	0.084
B1S6P2	1.795	10.112	9.023	10.869	25.221	22.386	0.048
B2S7P1	3.087	15.358	10.578	15.839	52.186	32.069	0.085
B2S7P2	6.664	12.221	12.329	12.379	52.626	43.275	0.049
B3S8P1	8.433	8.792	11.578	32.777	48.191	48.094	0.084
B3S8P2	6.995	5.241	12.485	23.235	42.271	52.225	0.048
B2S9P1	2.485	2.801	9.695	25.887	19.568	25.099	0.084
B2S9P2	3.264	2.998	8.311	42.236	25.385	25.473	0.049
B1S10P1	6.324	6.790	15.794	15.665	25.491	33.209	0.023
B1S10P2	7.995	4.221	11.001	15.214	20.169	10.972	0.031

4. CONCLUSIONS

The study's findings demonstrated that soil and plant properties in all different location of Erbil city(Baharykon, Azadi 1, Azadi 2, Nasejan, Kuran, Nawroz, Kurdistan,92 Zanko, Nargz, and Nishtiman) are severely impacted by the leaching of three different brands of electricity generators . Based on all available concentration heavy metals data and application indices, Brand 1 Caterpillar is more environmentally benign than Brand 2 Cummins and Brand 3 locally manufactured aggregates.

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