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Concentration of some Heavy Metals Emissions from Electrical Generators in Air and Green Plants in Basrah City, Iraq

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Abstract: The current study deals with determination of four heavy metal concentrations (Lead, Chromium, Cadmium and Nickel) in emissions released from electric generators in Basrah city, which used diesel or gasoline fuel, and their concentrations in leaves of six green plant species: *Phoenix dactylifera* (Date palm), *Lawsonia* sp. (Hinna), *Ficus carica* (Fig), *Cordia myxa* (Bamber), *Ziziphus* sp. (Seder) and *Cynodon* sp. (Thaiyil) that exposed to the emissions. The higher concentration of Lead (272.88 µg/g dry weight) was recorded in emissions of generators that using gasoline fuel as compared with those using diesel fuel, whereas the highest concentrations of Chromium, Nickel and Cadmium (11.72, 9.63 and 10.63 µg/g dry weight, respectively), were recorded in the emissions of generators that using diesel fuel. Cadmium, Chromium and Nickel recorded high concentrations in plants leaves exposed to emissions of the generators that using diesel fuel as compared with those using gasoline fuel. The higher averages concentrations were recorded in *P. dactylifera* (7.51, 1.50 and 6.36 µg/g dry weight, respectively), while the highest concentration of Lead (48.93 µg/g dry weight) was recorded in plants leaves exposed to emissions of generators using gasoline fuel.

Keywords: Air pollution, Heavy metals, Green plants, Electrical generators, Emission, Basrah city

Introduction

The term "heavy elements" refers to any metallic element that has a relatively high density (above 5 g/cm^3) and some of them are toxic or poisonous even at low concentrations (Lenntech Water Treatment and Air Purification, 2004).

Heavy metals exist in the environment as a result of natural processes or as pollutants produced by human activities. Factories, combustion of byproducts and traffics release large amount of dangerous and toxic gases to the atmosphere. These gases carry a lot of heavy element particles that ultimately precipitate on the soil surface and plants leaves (Fernandes & Henriques, 1991). Naturally, the main sources of heavy metals in plants is air, water and soil, where the absorption of these elements takes place either by roots or shoot system (Keane et al., 2001;

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Sharma et al., 2004). Plants are often sensitive both to the deficiency and to the excess availability of some heavy element ions (Fernandes & Henriques, 1991).

Lead is considered as one of the most toxic heavy elements in the environment (Tamura et al., 2005). It reaches air from internal combustion engines (Al-Saad & Salman, 2006), smoking, automobile exhausts, fuel combustion in electrical generator plants and from old Lead paints (Lenntech Water Treatment and Air Purification, 2004).

Plants respond to the toxic impacts of Lead using different methods (Gupta et al., 2009). The element interacts with the cellular compounds and increase the cell wall thickness. Usually the plant cell wall contains pectin and Lead can form a complex with the carboxyl group of pectin. This process is regarded as the corner stone of the plant cells resistance to lead toxicity (Eun et al., 2002). As the Lead uptake increases, it can damage the ultrastructure of the organ, tissue, chloroplast, nucleus, cell wall and cell membrane in the plants. This damage can cause a loss of organelle function and can affect the normal physiological functions that include photosynthesis, respiration, protein synthesis and cell division within the plant species (Salazar & Pignata, 2014).

Cadmium is a high toxic trace element even if it occurs in low concentration. Cadmium is produced by human activities like gas and coal combustion in electrical generation plants. It can be spread by air for long distances. It affects opening and closure of stomata, transpiration and photosynthesis processes in plants (AMAP, 1998; COWI, 2003). Plants grown in soil containing high levels of Cadmium show visible symptoms of injury reflected in terms of chlorosis, growth inhibition, browning of root tips and finally death (Küpper et al., 1996). Cd has been shown to interfere with the uptake, transport and use of several elements such as Ca, Mg, P and K by plants (Rout et al., 1997). So, Cd has been reported to interact with the water balance (Costa & Morel, 1994). Chloroplasts are highly sensitive to damage-exposed Cd toxicity (Sandalio et al., 2001).

Nickel is an essential element at low concentrations (0.05-10 mg/kg dry weight) for plants growth (Nieminen et al., 2007). It will be toxic to sensitive species if the concentration becomes more than 10 mg/kg dry weight (Kozlov, 2005). At the concentration of 50 mg/kg dry weight, it will be toxic to moderate sensitive species (Asher, 1991).

In plants that have the ability to accumulate Nickel in large quantities, the concentration of 1000 mg/kg dry weight is considered as toxic (Küpper et al., 2001; Courbot et al., 2004). The susceptibility of plants for Nickel toxicity differs due to plant species, stage of growth, the element concentration and the period of exposure (Krupa et al., 1993; Marschner, 1995; Assunção et al., 2003).

Entrance of Nickel into plants is influenced by the concentrations of other heavy metals. Nickel absorption takes place with nutrient elements by roots and transports to the leaves through the xylem tissue (Krupa et al., 1993). Increases of Nickel concentration in soil makes it unsuitable for plant growth (Duarte et al., 2007). It causes wilting and chlorophyll decay causing plant yellowing (Seregin & Kozhernikova, 2006).

Chromium is one of the toxic and unnecessary elements for plants (Cervantes et al., 2001). Its compounds are very toxic to plants that affect its growth and development. In spite of its disaffection by low concentration, but increasing of concentrations up to 100 mg/kg dry weight is considered to be toxic for higher plants (Davies et al., 2002). It has been found that Chromium decreases trees and some crops growth (Tang et al., 2001), and has a negative effects on stems of the plants (Rout et al., 1997), the growth of leaves and their surface area. Number of leaves are also affected by the increasing of Chromium concentration (Sharma & Sharma, 1993).

The aim of the present study is to determine the concentration of four elements (Lead, Chromium, Cadmium and Nickel) in the emissions that released from electric generators, which used two types of fuel (gasoline and diesel), and their accumulation in leaves of exposed green plants.

Materials and Methods

Air and plant leaves samples were collected from four sites in center of Basrah province, South of Iraq which include: Al-Jamiat, Al-Gazaaer, Al-Junaina and Al-Bradia, whereas the control samples were collected from Al-Taweel in Garmat Ali city (Figure 1).

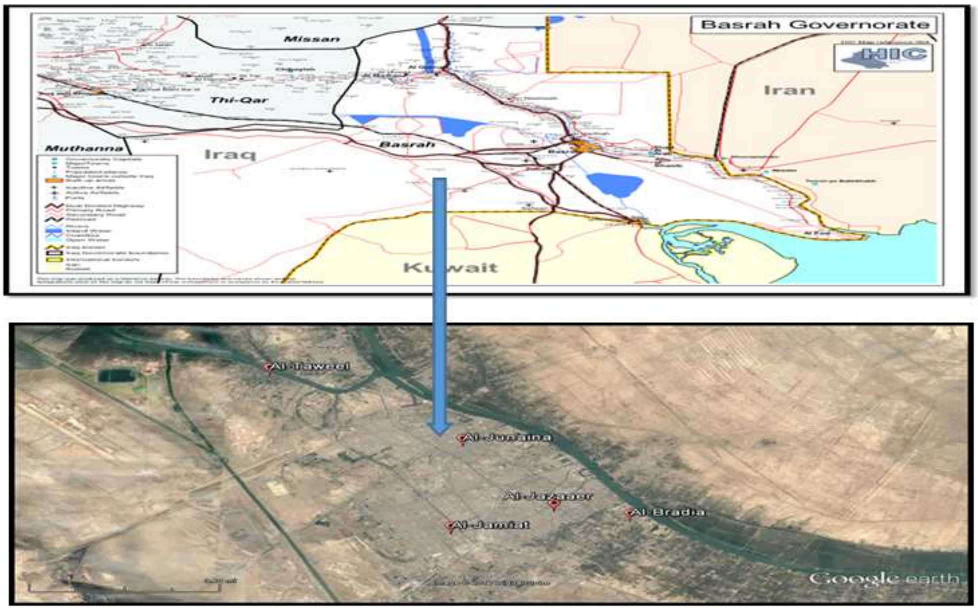

Figure 1: Study area

Air samples were collected from the exhaust of electrical generators by portable Air Sampler (type L5-10RB made by Rotheroe & Mitchell LTD, a division of Negrete Automation, UK) with filter paper type GF⁄C 0.8 µm (dried at60 C° for 24 hours and weighed before use). The samples were collected with a distance of

0.5-1 meter from the exhaust of the generator, exposure to the exhaust for two minutes with air flow rate of about 70 l/min.

Plant leaves samples (*Phoenix dactylifera* (Date palm), *Lawsonia* sp. (Hinna), *Ficus carica* (Fig), *Cordia myxa* (Bamber), *Ziziphus* sp. (Seder) and *Cynodon* sp. (Thaiyil) (Al-Mayah et al., 2016) were collected from six proper plant species at the house gardens. The leaves were put in clean plastic bags and labeled (date of collection, area of study, kind of fuel, plant species and the distance between the plants and the generator), and stored until reaching the laboratory.

Extraction of Heavy Metals

Filter paper type GF⁄ C 0.8 µm containing particulate matter (generator emission) and plant leaves were dried at 60 C° for 24 hours, then weighed carefully. The extraction process was achieved according to APHA (1999). One gram of each dried, milled plant leaves were taken to extract the heavy metals according to R.O.P.M.E. (1983).

The concentration of heavy metals were determined by using Flame Atomic Absorption Spectrophotometer type Phoenix–986 made by Bio Tech Engineering management Co., LTD, UK. The wave lengths of each metals as follows (Cd = 228.8, Cr = 357.9, Ni = 232 and Pb = 283.3).

Statistical Analysis

Analysis of Variance (One Way ANOVA) was applied by Minitab ver. 16.1 software to identify the existence of spatial and temporal significant differences. The relationship between the parameters and indices was tested by using the Parsons Correlation Coefficients.

Results

Concentration of Heavy Metals in Air Samples

Lead: Concentrations of Pb in emissions of gasoline generators were higher than those of diesel. Its highest concentration at emissions of gasoline generators was 272.88 µg/g dry weight of particulate, and the lowest concentration was 164.63 µg/g dry weight, whereas those of Pb in emissions of diesel generators ranged from 19.38 to 31.50 µg/g dry weight of particulate (Table 1).

Cadmium: Concentrations of Cd in emissions of diesel generators were higher than those of gasoline. Its highest concentration at emissions of diesel generators was 11.72 µg/g dry weight and the lowest concentration was 9.06 µg/g dry weight, whereas those of Cd in emissions of gasoline generators ranged from 2.81 to 4.59 µg/g dry weight (Table 1).

Nickel: Concentrations of Ni in emissions of diesel generators were higher than those of gasoline. Its highest concentration at emissions of diesel generators was 9.63 µg/g dry weight and the lowest was 7.50 µg/g dry weight, whereas those of Ni in emissions of gasoline generators ranged from3.75 to 4.88 µg/g dry weight.

Chromium: Concentrations of Cr in emissions of diesel generators were higher than those of gasoline. Its highest concentration at emissions of diesel generators was 10.63 µg/g dry weight and the lowest concentration was 6.63 µg/g dry weight, whereas the concentration of Cr in emissions of gasoline generators ranged from 3.00 to 4.98 µg/g dry weight (Table 1). Statistical analysis (ANOVA test) showed that there were significant differences (P<0.05) in the averages of studied elements concentrations in emissions of electric generators due to the kind of fuel used.

Concentration of Heavy Metals in Leaves of Green Plants

Lead: Pb concentrations accumulated in leaves of plants exposed to emissions of gasoline generators were highest (48.93 µg/g dry weight) in *Ziziphus* sp. and the lowest (9.79 µg/g) dry weight was in *F. carica*, whereas the those of Pb accumulated in leaves of plants exposed to emissions of diesel generators was 3.89 µg/g dry weight in *Ziziphus* sp. and the lowest (1.3 µg/g dry weight) in *Lawsonia* sp. (Figure 2). Statistical analysis showed significant differences (P<0.05) in the averages of Lead concentrations in the leaves of all studied plants due to the kind of fuel used.

Cadmium: The highest Cd concentration accumulated in leaves of plants exposed to emissions of gasoline generators was 0.59 µg/g dry weight in *Cynodon* sp. and the lowest (ND µg/g dry weight) in *F. carica*, whereas the highest concentration of Cd accumulated in leaves of plants exposed to emissions of diesel generators was 5.20 µg/g dry weight in *P. dactylifera* and the lowest (0.18 µg/g dry weight) in *F. carica* (Figure 2). Also, significant differences (P<0.05) were found in the averages of Cadmium concentrations in leaves of all studied plants except *F. carica* due to the kind of fuel used.

Nickel: The highest (0.38 µg/g dry weight) Ni concentration accumulated in leaves of plants exposed to emissions of gasoline generators was recorded in *P. dactylifera*, while the lowest (0.02 µg/g dry weight) was in *F. carica*, whereas the highest (1.09 µg/g dry weight) Ni concentration accumulated in leaves of plants exposed to emissions of diesel generators was recorded in *P. dactylifera* and the lowest (0.19 µg/g dry weight) was recorded in *Lawsonia* sp. (Figure 2). ANOVA test showed significant differences (P<0.05) in the averages of Nickel concentrations in leaves of *P. dactylifera* and *C. myxa* due to the kind of fuel used.

Chromium: The highest (1.19 µg/g dry weight) Cr concentration accumulated in leaves of plants exposed to emissions of gasoline generators was recorded in *P. dactylifera* and the lowest (0.07 µg/g dry weight) in *F. carica*, whereas the highest (7.23 µg/g dry weight) concentration of Cr accumulated in the leaves of plants exposed to emissions of diesel generators was recorded in *P. dactylifera* and the lowest (0.54 µg/g dry weight) in *F. carica* (Figure 2).

Table 1: Concentration of heavy metals (µg/g dry weight) in air samples on different stations in Basrah city.

Heavy metals	Stations	Type of fuel	Conc. (µg/g)	Age of generator (years)
Pb	Al-Gazaer	Diesel	31.50±3.89	6-8
		Gasoline	164.63±37.50	4
	Al-Ibradhia	Deisel	27.00±2.96	5-7
		Gasoline	188.87±49.30	3-5
	Al-Junaina	Deisel	19.38±3.02	4-6
		Gasoline	208.50±30.05	3-5
	Al-Jamiat	Deisel	20.13±1.94	4-6
		Gasoline	272.88±21.74	4-6
	Control	-	1.50±0.06	-
Cd	Al-Gazaer	Deisel	11.72±1.29	6-8
		Gasoline	3.82±1.22	4
	Al-Ibradhia	Deisel	10.45±0.88	5-7
		Gasoline	4.34±1.33	3-5
	Al-Junaina	Deisel	9.06±0.85	4-6
		Gasoline	2.81±0.04	2-5
	Al-Jamiat	Deisel	10.26±2.98	4-7
		Gasoline	4.59±0.18	4-7
	Control	-	0.61±0.13	-
Ni	Al-Gazaer	Deisel	9.63±0.53	6-8
		Gasoline	3.75±0.71	4
	Al-Ibradhia	Deisel	9.38±1.24	5-7
		Gasoline	4.58±1.24	3-5
	Al-Junaina	Deisel	7.50±1.06	4-6
		Gasoline	4.85±0.71	2-4
	Al-Jamiat	Deisel	8.38±0.88	4-6
		Gasoline	4.88±1.59	4-6
	Control	-	1.13±0.53	-
Cr	Al-Gazaer	Deisel	10.63±1.94	6-8
		Gasoline	3.88±0.88	4
	Al-Ibradhia	Deisel	8.63±2.65	5-7
		Gasoline	4.41±0.23	3-5
	Al-Junaina	Deisel	6.63±0.53	4-6
		Gasoline	3.00±0.35	2-4
	Al-Jamiat	Deisel	7.50±1.06	4-6
		Gasoline	4.98±1.24	4-6
	Control	-	1.00±0.21	-

ANOVA test showed significant differences ($P<0.05$) in the averages of Chromium concentrations in leaves of all studied plants due to the kind of fuel used.

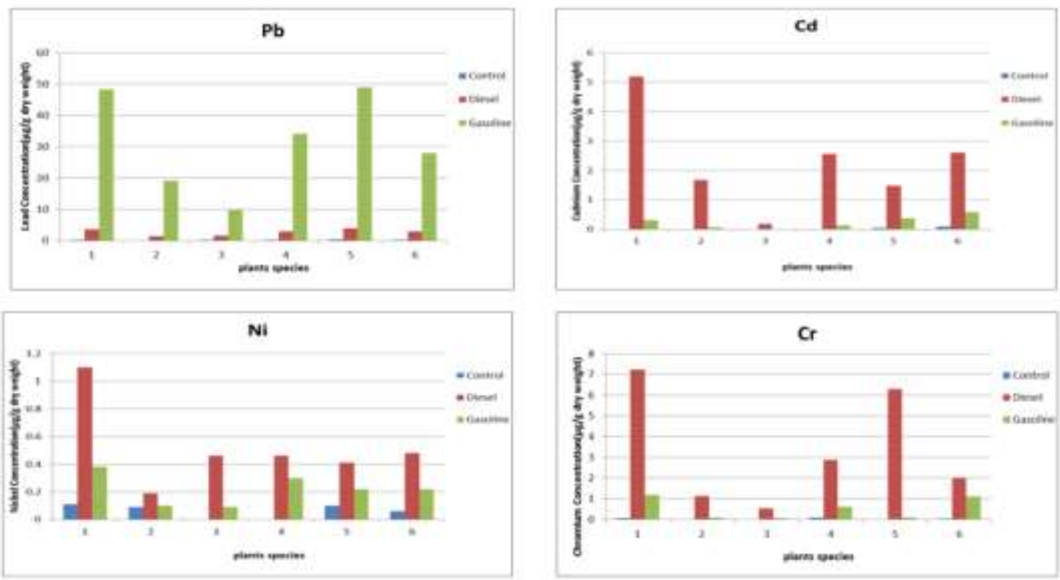

Figure 2: Concentration of Pb, Cd, Ni and Cr in plant leaves. 1- *Phoenix dactylifera*, 2- *Lawsonia* sp., 3- *Ficus carica*, 4- *Cordia myxa*, 5- *Ziziphus* sp., 6- *Cynodon* sp.

Discussion

Concentration of Heavy Metals in the Emissions of Electric Generators

This result is in agreement with Jassim (2006) who found that diesel powered engines offer low amounts of Lead to air as compared with gasoline engines. National Iraqi air quality determinants have been proposed by the Ministry of Health/ Department of Environment, that permissible value of Lead are 2 ppm within 24 hours. In comparison with the results of the current study, Lead concentration were found to exceed the permissible limit.

Jaradat & Momani (1998) estimated the concentrations of some heavy metals, including Lead in the air, in congested roads, and found that Pb concentrations ranged from 0.26 to 1.63 mg/m^3. Also, the concentrations of Pb and Ni were estimated by Srinivas et al. (2009) in the air and in some plant species collected from an industrial area, suburban area somewhat remote from the source of pollution and agricultural area which was considered as control area, and found that the concentration of Lead in the air of industrial zone was 1.467 mg/m^3, in suburban area was 1.376 mg/m^3 and in control area was 0.689, whereas the concentration of Ni reached 0.496, 0.977 and 0.087 mg/m^3 in the above-mentioned areas, respectively, which are lower than the concentrations of Lead and Nickel in the present study.

Concentration of Heavy Metals in Plant Leaves

Leaves represent the largest surface area that vulnerable to pollution. They represent suitable largest surface to absorb dust particles loaded with different air pollutants (Keane et al., 2001; Al-Khateeb & Leilah, 2005).

Results showed that *P. dactylifera* c.v. berhi can accumulate Ni, Cd and Cr higher than the other studied species. The concentration of elements in plant leaves have a negative relationship with distance between plant and generator, but have positive relationship with the age of the generator. On the other hand, the concentrations of elements varied depending on the type of fuel used. The concentration of Ni, Cr and Cd were higher in plant leaves that were exposed to emissions of generators by using diesel fuel, whereas Pb concentration was accumulated at highest level in plant leaves that exposed to emissions of generators by using gasoline fuel. This result indicated that diesel has a high concentration of these elements as compared with the gasoline that contains a high concentration of Lead.

Srinivas et al. (2009) found that the concentration of Pb in some plants (*Solanum lycopersicum*, *Capsicum* sp. and *Hibiscus cannabinus*) ranged from 1.72-4.63 µg/g dry weight in industrial and suburban areas. In the control area, the concentrations were ranged from 0.88-1.02 µg/g dry weight, whereas the concentrations of Ni were ranged from 1.29-2.62 µg/g dry weight in industrial and suburban areas and ranged from 1.1-1.53 µg/g dry weight in control area. These concentrations of Ni and Pb were approximate to their concentrations in some of the current studied plant species.

Shakour & Nasralla (1986) mentioned in their estimation of Cd and Pb in *Medicago sativa* growing nearby roads varied in terms of traffic density that the concentration of these two elements depends on plant distance from the road.

Jaradat & Momani (1998) found that plants growing on both sides of the road have less concentrations of elements, whenever plants stay away from the pollution source. Jassim (2006) mentioned that the amount of the pollutants produced by engines exhaust depends on lots of factors such as fuel types, age of engine and its maintenance.

The accumulation of the heavy elements in plant species depended on plants species and type of heavy element as noted by Pilegaard & Johnsen (1984) in their study to estimate Cd, Ni and Pb in air, soil and two plant species (*Achilla millefolium* and *Hordeum vulgare*). The concentration of Pb in plant is associated with the atmospheric deposition more than the concentration of the element in the soil, whereas other plant species contents of Ni and Cd elements is associated with their concentration in soil and with the atmospheric deposition.

Alloway & Ayres (1997) noted that dust particles containing heavy elements when falling on the leaves, can penetrate through the cuticle, which helps spread of these elements to other tissues of the plant. The spread of these elements varies in the plant parts according to the type of element, species and varieties of the plants (Rubio et al., 1994).

It is clear from the current study that the difference in the concentrations of elements depends on the type of trace element and the plant species. Also, the high concentration of Lead element in the studied plants is a result of high concentration in exhaust emissions of electric generators. An increasing in the concentration of Lead in the present plant leaves was found as compared to Aziz (1998), who pointed out that *P. dactylifera*, growing along the banks of Shatt Al-Arab river, has a lower concentration of Lead (5.52 mg/kg dry weight).

The studied plants were different in their ability to accumulate Nickel in their leaves. This is in agreement with Rabie et al. (1992) who studied the ability of some field plants to accumulate Ni element.

The results of the current study indicated that there was a difference in elements accumulated in the same type of plants according to different elements. This is in agreement with Aksoy & Özturk (1997), who used plant leaves of *Nerium oleander* as a bio-indicator of some heavy elements (Cd and Pb). The study indicated that the different concentrations of these elements in the leaves are depending on the type of element. The allowed concentration of Lead in the plant ranges from 2-2.5 µg/g dry weight (Samara et al., 1992), whereas permissible concentration of Nickel ranges from 0.02-2.7 µg/g dry weight (WHO, 1984).

Conclusions

1- Elevation of the concentration of Cr, Ni and Cd released from the emissions of electric generators used diesel fuel as compared with those used gasoline fuel.
2- The higher concentration of Pb emitted from the exhaust of gasoline electric generators as compared with that in the emissions of diesel electric generators.
3- *P. dactylifera* has a great ability to accumulate heavy elements as compared to other studied plant species.
4- There was a correlation between the concentration of heavy metals in the air and their concentrations in the leaves of the studied plants, and thus can be used as a bio indicator.
5- The concentration of elements in plant leaves was depending on the element type, plant species, type of fuel used, generator age and distance of plants.

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