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Effects of Heavy Metals Emission from Al_Dura Power Station on the Soil Surrounding

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Effects of Heavy Metals Emission from Al_Dura Power Station on the Soil Surrounding

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Abstract- Three selected sites with gradual distances from Al-Daura thermal power station (0.5 km (St. 1), 1Km (St. 2) and 2Km (St.3), were chosen for sampling according to the direction of downwind of site. In addition, one of unpolluted site was chosen for comparison as a control site in Baghdad around 4 Km upwind from Al-Daura thermal power station. The samples were taken for two seasons; the first season was in December 2014 and the second season was in March 2015. The concentrations of some pollutants that originated from Al-Daura thermal power station as air pollutants and heavy metals in the soil were measured. Whereas the results of heavy metals in soil refer to significant differences in the concentrations of Nickel (Ni), Cadmium (Cd), and Copper (Cu) in all three sites comparing with control site, they were higher in site 2 than other sites, while the Lead (Pb) concentration was higher in site 3. There was a significant increase in concentrations of Ni and Pb in the first season than in the second season, whereas no significant differences appeared in the concentrations of Cd and Cu between the two seasons.

I. Introduction

Power generating stations are one of the mega projects, which require not only huge capital investment, but also various natural resources like, fossil fuels and water, thus create an everlasting and immeasurable impacts on the environment and generate tremendous stress in the local ecosystem (Pokale, 2012).

Thermal power stations are one of the main sources of the generation of electricity for any developing country and are the most popular power station present because of its high production and its dependence on fossil fuel or their derivatives as a major fuel. So, it is classified as a high pollution project (Kumar *et al.,*2013).

Various physico-chemical and biological factors control the mobility of metals in soils, one of them is a change in pH, results in a converting the element from one phase to another and thus, permit the estimation of mobility of heavy metals in the soil (Naim *et al*., 2004; Lu and Bai, 2010).

The link between the pH of the soil and heavy metal threshold values reflects the complex interaction between the heavy metals and the various soil properties. Increasing and decreasing pH of the soil influences the chemical reactions in the soil. At low pH, metals generally exist as free cations, at alkaline pH, however, tend to precipitate as insoluble hydroxides, oxides, carbonates, or phosphates (Karathanasis *et al.,* 2005; Gawlik and Bidoglio, 2006; Mamboya, 2007).

The aim of the present study was to determine the effect of the heavy metals exit from Al-Dura thermal power station on the soil surrounding.

II. Materials and Methods

a) Sampling sites

Three sites with gradual distances from Al-Daura thermal power station (0.5, 1 and 2 Km, respectively) were chosen for sampling. In addition, one of unpolluted site was chosen for comparison as a control around 4 Km upwind from Al-Daura thermal power station. All samples were collected for two seasons; the first season was in December 2014 and the second season was in March 2015 (fig. 1).

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Figure 1 : The study area of Al-Daura thermal power station with 4 sampling stations

b) Soils Sampling

Three replicates of soil samples were collected from 0 to 20 cm depth from the top surface of the soil for each site for each season for heavy metals analysis and pH value measurement. The samples were collected in labeled sacks and transported to the laboratory.

c) Soil Samples

The chemical analysis of soil samples has been done in the laboratory with air dried at room temperature for one week, then crushed, sieved using a stainless steel sieve (2 mm) to remove stones and to homogenized elements. Finally, put in oven at 105°C for 3 hours. The resulted powder was stored in plastic sucks until digestion (Lazar *et at*., 2008).

d) Measurement of soil pH

The pH value was measured for each soil sample according to Rayment and Lyons (2011)

e) Analysis of Heavy Metals in Soil

The concentrations of heavy metals (Ni, Pb, Cd and Cu) were determined using Atomic Absorption Spectrometer (AAS). For heavy metals analysis, the chemical digestion of soil samples was done according to Page *et al.*, (1982).

III. Results and Discussion

a) Soil Heavy Metals Measurements

The concentrations of heavy metals were measured in soil samples at 0-20 cm depth from the soil surface to estimation of soil pollution caused by Al-Daura thermal power station.

Nouri *et al.* (2009) reported that the contamination of heavy metals was mainly concentrated in the top 20 cm of soil. El-Ghawi *et al.* (2007) proved that the metals distribution on the top layer of soil is important in relation to the bioavailability for plants and the hazard of entrance of these metals into the food chain. This accumulation of heavy metals on top of soil is within the reason of the organic matter accumulation at this layer which acts as an absorbent factor for these metals.

The data obtained from this study; shown in tables 1-4 included the measurements of the concentrations of Ni, Cd, Cu and Pb.

b) Ni concentration in soil

The present study found that there was a significant increase in the concentrations of Ni in season 1 than season 2, also there were significant differences in the concentrations of Ni among all sites, where site 2 (was 177.79 ± 3.11µg/g) recorded the highest value among all sites. The higher interaction value with a significant difference was found in season 1 at site 2, whereas the lowest value was found in season 2 at the control site.

The concentrations of Ni in all three sites were higher than the worldwide mean abundance of Ni in the soil that was estimated at 20 µg/g (Kabata-Pendias, 2011).

Table 1 : Concentrations of Ni (g/g) in the soil for two seasons

Site	Season		Mean ± SE
	1 December 2014	2 March 2015	
Control	21.81 ± 1.16	20.47 ± 1.23	21.14 ± 0.81 D
1 (0.5 Km distance)	171.20 ± 2.40	165.56 ± 3.25	168.38 ± 2.21 B
2 (1 Km distance)	181.82 ± 4.37	173.76 ± 3.63	177.79 ± 3.11 A
3 (2 Km distance)	50.23 ± 3.15	44.71 ± 3.31	47.47 ± 2.39 C
Mean ± SE	106.26 ± 21.4 A	101.13 ± 20.8 B	---

*LSD value: Site: 6.386 *, Season: 4.516 * , Interaction of Site × Season: 9.666 **
(P>0.05), N.S: Not significant

c) Cd concentration in soil

The results in the table 2 show no significant difference has been recorded in the concentrations of Cd in the soil for the two seasons. While there were highly significant differences in the concentrations of Cd among all sites. The mean concentration of Cd in site 2 was 10.02 ± 0.37 µg/g which gave the higher value among all sites. The interaction value was higher with a significant difference in season 1 at site 2, while being the lowest in season 2 at the control site.

The Cd concentrations in all sites for two seasons were higher from the worldwide mean abundance of Cd that is 0.53 µg/g (Kabata-Pendias, 2011).

Table 2 : Concentrations of Cd (µg/g) in the Soil for Two Seasons

Site	Season		Mean ± SE
	1 December 2014	2 March 2015	
Control	0.850 ± 0.06	0.730 ± 0.04	0.79 ± 0.04 D
1 (0.5 Km distance)	6.97 ± 0.68	6.81 ± 0.56	6.89 ± 0.39 B
2 (1 Km distance)	10.15 ± 0.49	9.90 ± 0.65	10.02 ± 0.37 A
3 (2 Km distance)	3.84 ± 0.42	3.75 ± 0.43	3.79 ± 0.27 C
Mean ± SE	5.452 ± 1.06 A	5.297 ± 1.05 A	---

*LSD value: Site: 1.017 * , Season: N.S, Interaction of Site × Season: 1.555 **
(P>0.05) N.S: Not significant

d) Cu concentration in soil

The results of this study show that there was no significant difference in the concentration of Cu in the soil between the two seasons (Table 3), and found that there were significant differences in the concentrations of Cu among all sites, where it was higher in site 2 (was 75.665 ± 2.56 µg/g) than the other sites. While the concentration of Cu in site 3 not differ significantly from the control site. The higher interaction value with a significant difference was found in season 1 at site 2, while the interaction value in season 2 of the control site recorded the lowest value.

The concentrations of Cu in site 3 and control site were within the worldwide mean abundance of Cu (38.9 µg/g), while the mean of the concentrations in sites 1 and 2 were higher from the worldwide mean (Kabata-Pendias, 2011).

Table 3 : Concentrations of Cu (µg/g) in the soil for two seasons

Site	Season		Mean ± SE
	1 December 2014	2 March 2015	
Control	22.10 ± 1.23	20.93 ± 1.06	21.515 ± 1.19 D
1 (0.5 Km distance)	70.28 ± 1.34	68.10 ± 2.40	69.19 ± 1.60 B
2 (1 Km distance)	77.96 ± 2.41	73.37 ± 2.16	75.665 ± 2.56 A
3 (2 Km distance)	31.31 ± 3.15	28.47 ± 1.15	29.89 ± 1.89 C
Mean ± SE	50.417 ± 2.32 A	47.717 ± 0.69 A	---

*LSD value: Site: 4.24 * , Season: N.S , Interaction of Site × Season: 6.37 **
(P>0.05) N.S: Not significant

The results in tables 1,2 and 3 showed that the concentrations of Ni, Cd, and Cu in the soil were higher in site 1 and 2, while they were lower in the control site and site 3. The high accumulation of these heavy metals in the soil on site 1 and 2 compared with that in the control site and the global values refers to the pollution of soil near Al-Daura thermal power station that resulted from the combustion of fossil fuel.

Akoteyon, (2012) stated that the release of heavy metals into the environment is not limited to areas adjacent to the point sources, such as the industrial facilities.

e) Pb concentration in soil

There was a significant difference between the two seasons in the mean concentrations of Pb in the soil (Table 4). The concentration of Pb in season 1 was higher than season 2. Also, the results in the same table show that there were significant differences in the concentrations of Pb in all the three sites when compared with the control site. The concentration mean of Pb insite 3 appeared on a higher level compared with all other sites.

The mean concentration in Season 1 showed the higher interaction value in site 3 that was 44.84 ± 2.45 µg/g, while season 2 showed the lowest interaction value in the control site that was 27.78 ± 1.06 µg/g. The overall mean value of Pb for different soils is estimated at 27 µg/g (Kabata-Pendias, 2011).

Table 4 : Concentrations of Pb (µg/g) in the soil for two seasons

Site	Season		Mean ± SE
	1 December 2014	2 March 2015	
Control	29.47 ± 0.55	<u>27.78</u> ± 1.06	28.625 ± 0.65 C
1 (0.5 Km distance)	36.35 ± 1.18	32.54 ± 1.39	34.445 ± 1.18 B
2 (1 Km distance)	37.68 ± 1.47	33.71 ± 1.49	35.695 ± 1.29 B
3 (2 Km distance)	<u>44.84</u> ± 2.45	41.95 ± 1.77	43.395 ± 1.49 A
Mean ± SE	37.085 ± 1.65 A	33.995 ± 1.69 B	---
*LSD value: Site: 3.21 *, Season: 2.27 *, Interaction of Site × Season: 4.76 ** *(P>0.05), N.S: Not significant*			

The first suspected cause for this elevated value of Pb concentrations in site 3 returned to the emissions from Al-Daura thermal power station, the vehicle exhausts in heavy traffic of Al-Daura main street that was nearest to site 3 add another source of Pb concentrations.

Al-Ameri (2011) stated that when Pb is an air pollutant, the larger size particles will be down to the ground and polluted soils or surface waters and the smaller particles will go long distances through air and remain in the atmosphere. Part of these Pb particles will fall back on earth when it is raining.

The distributions of Ni, Cd, Cu and Pb in soil for all three sites and control site are shown in figure 2.

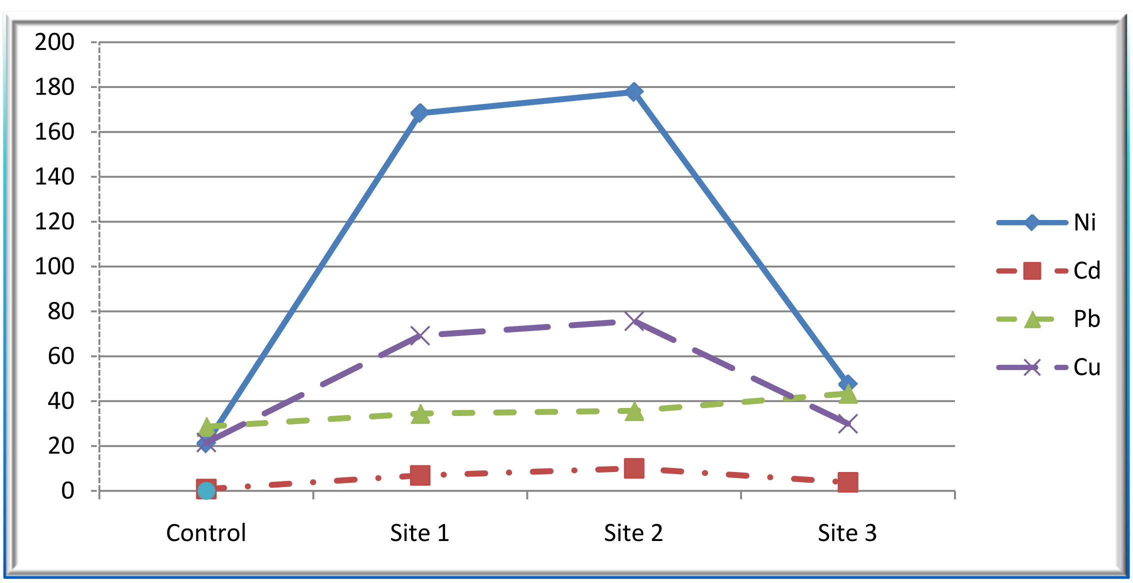

Figure 2 : Distributions of Ni, Cd, Cu and Pb in soil for all three sites and control site

The results of report of the Iraqi Ministry of Environment about heavy metals` pollution in soil, around Al-Daura thermal power station in 2013, showed a high concentration of heavy metals, especially Ni that reached to 110 µg/g (Sahieb *et al.*, 2013).

Habib *et al.,* (2012) measured the concentrations of some heavy metals in soil for many regions of Baghdad and found that the average concentrations of Ni and Pb in the soil of Al-Daura suburbs were 105,and 37 (µg/g), respectively; which agreed with the results in this study.

Also, there was a significant difference in the concentrations of Ni and Pb in season 1 than season 2, whereas no significant differences in the concentrations of Cd and Cu between the two seasons and less in season 2.

Metals from the upper layer of soil were flushed out to some range and hence all the index values were lower in the season 2 compared to season 1 (Rahman, 2012).

Results of Yahaya *et al.* (2009) and Najib (2012) support the results of this study. They found that the average concentration of metals during the dry season (in this study, closer to season 1) in the surface layer of the soil is higher than that in the wet season (in this study, closer to season 2). They explained that the seasonal rainfall may facilitate the reduction of soil solution during the wet season and seasonal variations in patterns of metal deposition. Thus, the precipitation may limit the concentration in soil during the wet season.

The result in the present study differs somewhat from the findings of Onweremadu *et al*. (2007) and Jian *et al.* (2014) who showed that the content of heavy metals in soil in the dry season was comparatively low compared to the wet season.

f) The pH soil measurement

There are many factors affecting the disruption of heavy metals in soil such as pH. The results of pH values for the soil of the study sites are listed in tables 5.

Table 5 : The pH Value (Mean ± SE) of soil in the study sites for the two seasons

Site	Season		Mean ± SE
	1 December 2014	2 March 2015	
Control	7.55 ± 0.014	7.60 ± 0.17	7.575 ± 0.11 A
1 (0.5 Km distance)	6.75 ± 0.12	6.50 ± 0.08	6.625 ± 0.13 B
2 (1 Km distance)	7.22 ± 0.16	7.33 ± 0.16	7.275 ± 0.11 A
3 (2 Km distance)	7.50 ± 0.16	7.42 ± 0.11	7.46 ± 0.25 A
Mean ± SE	7.255 ± 0.10 A	7.212 ± 0.15 A	---
*LSD value: Site: 0.503 *, Season: N.S , Interaction of Site × Season: 0.741 * (P>0.05) N.S: Not significant*			

The results presented in table 5 show that there was no significant difference in the values of soil pH between the two seasons. Also, no significant difference for interaction (seasons * sites) in the soil pH.

In general, all the pH values of soil in the all three sites were near to neutral, Results indicated that Soil pH for sites 2 and 3 not differ significantly from control site which gives 7.275, 7.46 and 7.575, respectively. Whilst site 1 was more acidic 6.625 and differ significantly from all other sites. The cause of the lower pH values of soil, particularly in site 1 due to the acidic rain resulted from the reaction between air sulfur dioxide and oxides of nitrogen with water vapor component originated from thermal power station as mentioned by USEPA (2001).

The results of the neutral pH values of soil in this study agreed with the illustration of Kabata-Pendias (2011), who reported that the neutral values of pH play an important role to keep the accumulation of heavy metals at the top layers of soil, because at the neutral values of pH some heavy metals such as Ni and Pb have a strong relation with the soil solids, and hence its movement towards the deeper layers will be limited.

Sulaiman *et al*. (2014) studied the effect of some characteristics of soil around Kashe power station in Duhok-Iraq and found that the acid rain precipitation that was originated from Kashe power station has an effect on decreasing the pH value of soil samples. They explained that the decrease of pH value was due to the high concentration of SO_2 that dissolved in raindrops to form sulfuric acid (H_2SO_4).

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