Carpathian Journal of Earth and Environmental Sciences, April 2010, Vol. 5, No. 1, p. 5 - 12

ASSESSMENT OF TRACE METALS IN STREET DUST OF MUTAH CITY, KARAK, JORDAN

Waleed A. MANASREH
Faculty of science, Department of Chemistry, Mutah University, Mutah, Karak, Jordan. P.o.Box-7
E-mail afwkmd@yahoo.com

Abstract: Street dust samples were collected from two main streets in Mutah City, Karak, Jordan. The samples analyzed for Fe, Zn, Mn, Cu, Pb, Cd, and Ni, and showed remarkably high levels of Fe, Zn, Mn, Pb and Cu. in the Mutah dusts. The samples from Mazar-Karak Street had higher heavy metal concentrations than those from University Street especially for Fe, Pb, Cu and Ni. Contents of Zn, Cu, Ni, and Fe in the industrial areas were greater than those from the commercial and residential areas. Discernible variations in Pb contents were recognized between two streets. Increases in these anthropogenic trace metals in the surface environment can most likely be attributed to rapid urbanization cars repairing centers and increased vehicle emissions to the atmosphere occur mainly in industrial areas. However, Pb contamination in the Mutah dusts is probably caused by Pb particles from vehicle emissions. The accuracy of the results has been cheeked using the standard reference material, SRM (soil-7). In addition some heavy metals have been analyzed in different laboratories. The results showed good precision and accuracy with a relative error of less than 3%.

Keywords: heavy metals; dust; AAS; Jordan; pollution.

1. INTRODUCTION

Trace metals are useful indicators for contamination in surface soil, sediment and dust environments. Accumulations of metals including Pb, Zn, and Cu on urban surfaces can be attributed to vehicle exhausts, industrial discharges, oil lubricants, automobile parts, corrosion of building materials, atmospheric deposition (Adriano, 2001; Li et al., 2001) and particulate emission (Sutherland & Tolosa, 2000). Exposure to lead (specifically) is among the most significant yet preventable threats to human health in the world, especially to young children (Purves, 1985). It was suggested that street dust would act as a good marker for generalized urban lead pollution.

Numerous studies of heavy metal contamination, of street dust have been carried out in developed countries (Li et al. 2001; Sezgin, et al., 2003 and Charlesworth, et al. 2003), but only limited information is available on heavy metals in the street dust of developing countries, including Jordan. Many studies of concentrations of heavy metals in street dusts from different environments in Jordan have been reported, (Al-Khashman, 2004 and El-Hassan et al. 2006). The Investigation of heavy metal distribution in street dust and soil from the working areas of the Karak Industrial Estate was used to indicate that there is a pollution of trace metals within the above area. (El-Hassan et al. 2006) found elevated level of Cd and Cr in Down Town of Al-Karak city. (Jiries et al., 2003) found elevated levels of lead and cadmium in the center of Amman with concentrations of 1042 and 2.85 ppm, respectively. These levels were attributed to fossil fuel emissions at the studied sites. The impact of vehicles on road soils along the sides of a major highway in Maan and Amman was studied by Al-Rawashdeh, (2007) and Jaradat et al., (1999). They reported that the concentrations of all analyzed heavy metals decreased with distance from the road. The main objective of this initial study was to determine the concentration of some heavy metals in street dust samples collected from two main streets: Mazar-Karak and University Streets in down town of Mutah city, Jordan, and to assess their contamination level. As an indicator of environmental pollution, the following metals were chosen for the evaluation: Fe, Zn, Mn, Pb, Cu, Cd and Ni.

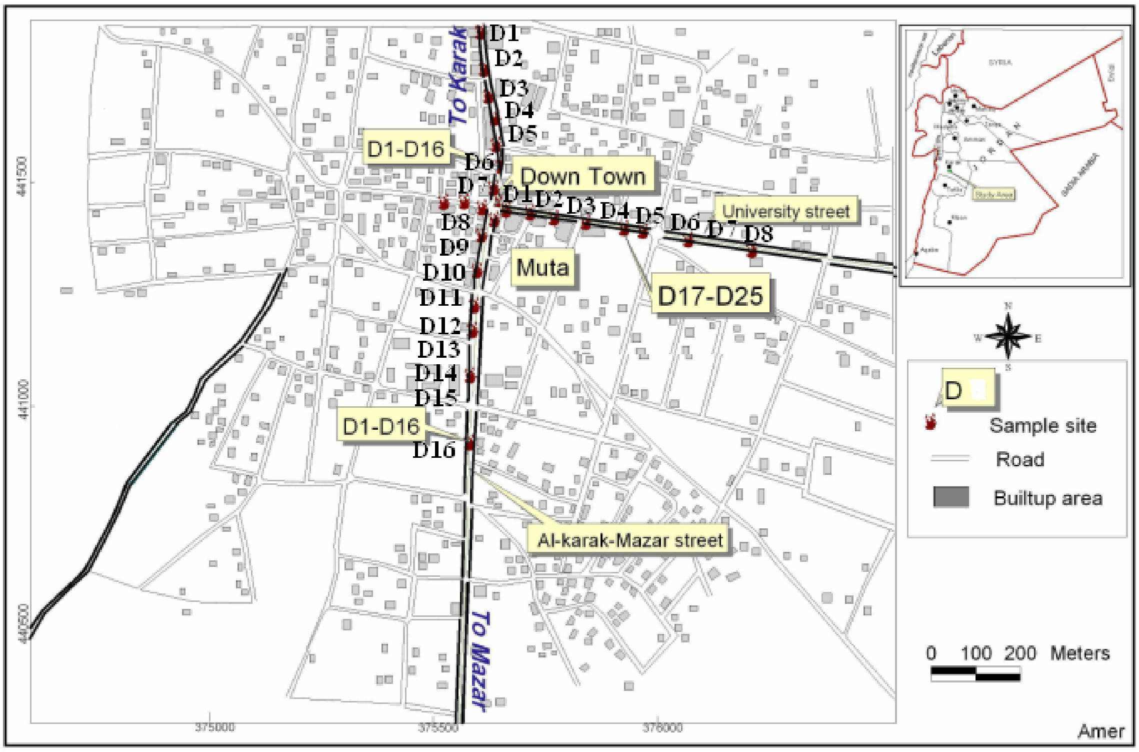

Figure1. Map of the studied area showing sampling locations

2. MATERIALS AND METHODS

2.1. The study area

Mutah is located in the central part of Jordan in Al- Karak governorate and it is about 15 km from Al- Karak city, and is surrounded by many villages and towns. In Al-Karak is located one of the major universities in Jordan; Mutah campus which contains about 27 000 students and workers. The main campus is located literally on the borders of the town center. Total area of the town is about 20 km^2 with an urban population of approximately 50 000. The Al-Karak governorate represents a semi-arid area with a Mediterranean climate, where rainfall occurs only in the winter season during a very limited period (from November-to April). The prevailing winds are of western to southwestern direction. They are often hot, dry and dusty most the time. Mutah is a main trade center for surrounding villages and towns, so it has a high vehicular traffic density that causes serious pollution problems. There is no previous research focused on pollution of the street dust in this area except for Al Karak city (El-Hassan et al., 2006). The sampling sites were subdivided into two main streets: Mazar-Karak and the University streets (Fig. 1).

Mazar-Karak street commercial area is strongly affected by many small workshops, a vehicle garages, a scrap yard and has a heavy traffic density (400-600 vehicles h^{-1}). In contrast, the University Street contains a mix of commercial and residential areas with medium traffic density (200–400 vehicles h^{-1}). This was done by the author himself, by counting the average number of passing vehicles through each street per hour.

2.2. Sampling and analytical procedures

All of the 24 representative samples of street dust were collected from the localities situated at the two main streets and their intersections under stable weather conditions during the summer, on August 2008 (Fig. 1). The dust sampling was carried out from pavement edges using a plastic dustpan and brushes. Dusts were not collected adjacent to site-specific pollution sources, e.g. industries or gasoline stations. About 200 g of dust particles that had accumulated within a 4m radius circle around each selected sampling point and were stored in small self-sealing plastic bags. All the samples were dried for 24 hours in an oven at temperature105 $^{\circ}C$ to constant weight, and were subsequently sieved in all-sieving sets, through size 2 mm, 500, 250 and 63μm. The dust samples were mostly very fine grained sands and fine silts. Metal concentrations in the <63 μm fraction were determined after decomposition using concentrated nitric acid reflux according to Momani et al., (2000). Because particles of this size are easily resuspended (unlike to bigger particles which move mainly by "saltation" and "screep"; Nicholson, 1988 and Sehmel, 1980), the particles of this fraction can be inhaled and cause a serious risks to human health (Zhou et al., 2003). Each sample (0.5–1.0g) of the size <63 µm was digested in 10 ml of concentrated trace-element-grade nitric acid, and left overnight at room temperature. Samples were then heated in a water bath heater at 95^{o}C for 1hour. The extract was then sonicated for 30 min in an ultrasonic bath (Quantrex -210H) at 50 ^{o}C, and filtered through a 0.45-mm prewashed filter with 1%HNO_3 into a 25ml polyethylene volumetric flask. The filtrate was diluted to the mark (25 ml) with1%HNO_3. The extract solutions were then kept in a refrigerator at 5 ^{o}C until the time of analysis. Blank solutions were prepared in the same way employed for the street dust samples. The content of heavy metals (Fe, Cu, Pb, Zn, Mn, Cd, and Co) was determined by Flame Atomic Absorption Spectrophotometer, model (AA-6200, Shimadzu). All reagents and chemicals used were analytical grade (Fluka Chemica). All laboratory ware used for the extraction process was washed with soap, tap water, rinsed with distilled water, and soaked in 1% HNO_3 in order to remove any adhered impurities.

2.2.1 XRD Characterization of dust

Mineral abundances in the fine dust were determined by Powder X-ray diffraction (XRD). The analyses were performed with a TIT XRD-3003 diffractometer (Germany), using Ni-filtered, Cu-$K\alpha$ radiation. The scan was performed from 20.000^o to 80.000^o through 0.020^o stepscan.

2.3 Quality control

Series of standard solutions were used to calibrate the analytical procedure. These standard stock solutions were further diluted to multilevel standards for all the metals, to minimize the error effects. To minimize the error, blank samples were run simultaneously for all the metal determinations. Beside blanks, standard reference material soil-7 was used to asses the accuracy of the method. The results were cheeked using atomic absorption spectrophotometer, Model Smith-Hieftje 11 (USA), with SH background correction of another laboratory in Mutah University. The error was less than 3% and the analytical precision measured as the relative standard deviation which gave RSD < 5%.

2.4 Enrichment factor (EF)

Enrichment factors of heavy metals were calculated for each street dust sample, based on the standardization of a measured element to a reference element. Iron the commonly used element, as reference (Yongming, et al. 2006, Tasdemir et al. 2005 and Turner & Simmonds 2006)**.** The EF calculation is expressed bellow as:

$$\text{EF} = \frac{[Cx/Cref]Sample}{[Cx/Cref]Background}$$

where C_x is the concentration of the element of interest and C_{ref} is the concentration of reference element (iron) for normalization. Enrichment factor values less than 5.0 are not considered as significant, because such small enrichments may arise from differences in the composition of local soil material and reference soil (Kartal, et al., 2006). Five contamination categories are recognized on the basis of the enrichment factor: EF< 2 states deficiency to minimal enrichment, EF = 2-5 moderate enrichment, EF = 5-20 significant enrichment, EF = 20-40 very high enrichment and EF > 40 extremely high enrichment (Yongming, et al., 2006). The mean enrichment factors of Zn, Mn, Pb, Cu, Cd and Ni are 12.2; 1.4; 63.6; 13.6; 38.7; and 0.3 respectively.

3. RESULTS AND DISCUSSION

3.1 Heavy metal concentrations in street dust

The descriptive statistic results of heavy metal concentrations investigated in the studied samples, as well as background values (Tab.1) of Mutah soils (El-Hassan, 2006). Table 1 shows the average concentrations of Fe, Zn, Mn, Pb, Cu, Ni and Cd in street dusts of studied samples are higher than the background values of Mutah soils.

In all samples, the abundances of Fe (3126-15163 mg.kg^{-1}), Zn (65- 351 mg.kg^{-1}), Mn (85-184 mg.kg^{-1}), Pb (49-368 mg.kg^{-1}), Cu (22-474 mg.kg^{-1}), Cd (0.3-3.60 mg.kg^{-1}) and Ni (0.8-11.30 mg.kg^{-1}) in Al-Mazar-Karak Street dust, while in the University Street Fe (2630-8328 mg.kg^{-1}), Zn (70-250 mg.kg^{-1}), Mn (56-246 mg.kg^{-1}), Pb (26-136 mg.kg^{-1}), Cu (15-77 mg.kg^{-1}), Cd (1.2-2.8 mg.kg^{-1}) and Ni (0.8-1.8 mg.kg^{-1}) dust. These results show significant differences between the two groups of samples. This is due to the presence of high traffic (vehicle intensity), shopping centers, work shops and residential areas.

The detected concentrations of elements including Mn, Fe, Pb, Cu ,Ni, Cd and Zn at the studied site (Mazar-Karak Street, samples 1-16 Fig 2.), are higher than from the University Street especially in the central part, site number 8, due to different activities and high traffic density.

In contrast, the University Street sites also show a high concentrations of analyzed heavy metals except Ni and Cd in some sites number 4, 5 and 6; (Fig. 3). The maximums of Fe, Mn, Pb, Cu and Zn have been found in the samples Mazar Karak Street taken from mechanical-electrical work shops and heavy traffic sites, while their minimums were detected in dust sample taken from residential site with less traffic density and work shop activities sites number 10, 11, 12, 13 and 14, see figure 2.

The highest concentration of analyzed heavy metals were detected in the sample of the sites number 5, 6, 7 and 8 which located at the main two gates of Mutah University (southern and military gates), which are characterized by a heavy traffic density.

Table1. Heavy metal concentrations (mg.kg^{-1}) in all street dust collected from Mutah city

Element	Minimum	Maximum	Mean	Standard deviation	Median	Skewness	Reference value*
Fe	2630	15163	5362	2515	5229	2.69	2859
Zn	65	351	132	88	75	1.10	43
Mn	56	246	136	39	131	0.70	86
Pb	26	368	143	109	99	1.11	16
Cu	15	474	69	39	46	4.29	8
Cd	1.3	3.6	1.33	0.99	1.3	0.5	0.8
Ni	1.0	11.3	1.70	3.0	0.7	2.6	14
*El-Hassan et al., (2006).							

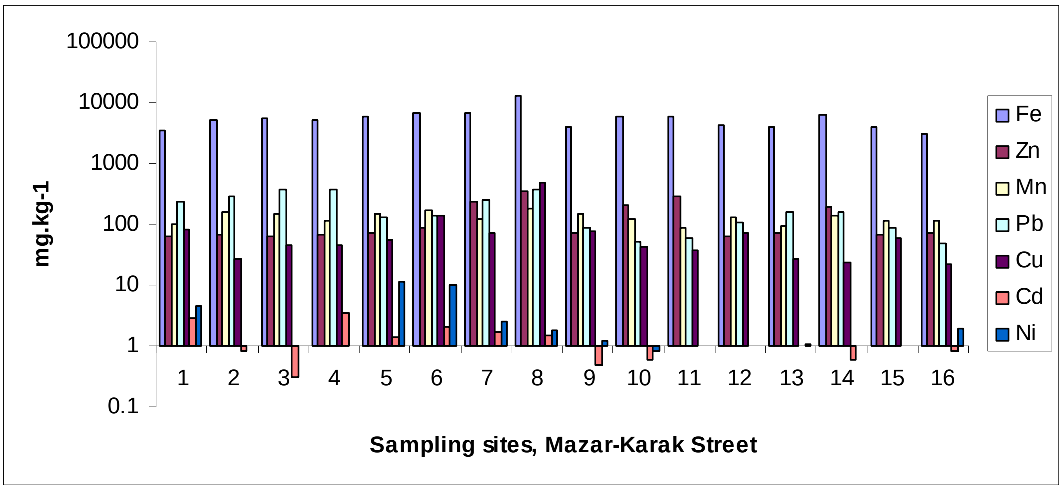

Figure 2. Distribution of heavy metals in Mazar-Karak Street.

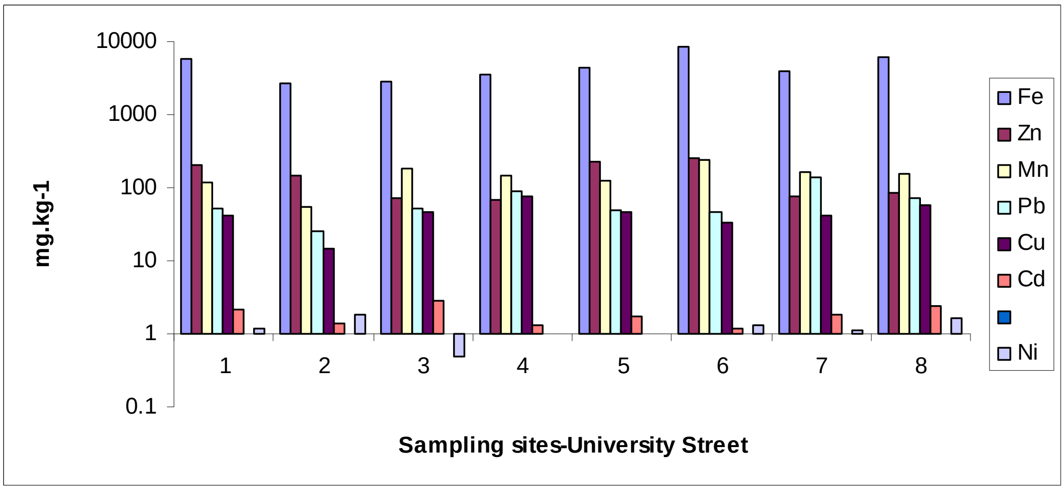

Figure 3. Distribution of heavy metals in the University Street

4. DISCUSSION

4.1 Heavy metals concentration in street dusts

In this study, the elemental compositions show a slight variation among the two sample streets for Fe, Zn, and Mn, while the other elements illustrate considerable variation as shown in figure 4.

Concentrations of Cd in most dust samples were found to be in the range of 0.3–3.6 mg/kg, which are slightly higher than background levels (EL-Hasan, et al., 2006). This shows that Cd in street dusts mainly originated from natural sources (Sezgin et al., 2003). Nickel concentrations measured at all points of both streets were found within the range of 0.1-11.3 mg/kg and this range is lower than the background value (14 mg/kg). The concentration of nickel in Mazar-Karak Street were ranged from 0.8-11.3 $mg.kg^{-1}$ and ranged from 0.3-1.8 $mg.kg^{-1}$ in University Street. The concentration of Ni (11.3 and 10.1 $mg.kg^{-1}$) was found in sites having industrial activities, smelters, foundries and high traffic density. The concentration of nickel was attributed to the pollution originated from traffic and anthropogenic sources (Ferguson & Kim, 1991 and Akhter et al., 1993). Maximum Zn and Cu content are higher than that of the back ground in all the studied sites which suggest an anthropogenic source for these metals.

The source of Cu and Zn in street dust with high traffic density areas may originate from traffic sources, such as wear, tear of vulcanized vehicle, tires, the corrosion of metallic parts in scrap yards, lubricants and exhaust emissions from both gasoline and diesel fuelled road vehicles (Pacyna, 1986; Arslan, 2001 and Jiries, et al., 2001). High concentrations of Pb and Mn were found almost in all dust sample collected from both streets area with high traffic density, iron and cement distribution centers, and near Al-Karak industrial city (sample sites from (1-8) Mazar-Karak Street, but the lowest concentrations were detected in samples from residential sites with low traffic density. It may be concluded the sources of Pb and Mn in street dusts of Mutah mainly originated from automotive emissions and industrial activities. The results showed elevated level of iron, which is a major natural constituent of the soil, and they do not reflect any specific anthropogenic source in the street dust, (Moreno-Grau et al., 2002). Therefore, a significant difference between iron concentrations of some sites in both streets does not occur, except for some sites close to industrial activities. On the other hand, it is a useful to compare mean concentrations of heavy metals in street dusts in different urban environments (De Miguel; et al, 1997; and Charlesworth; et al., 2003). Table 2, shows the contents of heavy metals found in street dusts of different world wide cities and the concentrations of heavy metals measured in street dusts of Mutah are compared with data reported for other cities. The total concentration of Cd in street dusts samples of this work is similar to those found in Birmingham and Oslo, higher than those found in Coventry and Ottawa. The total concentration of Zn determined in this work is higher than those founds in Karak and Bursa. According to the element Pb, the concentration found in Mutah street dust samples is higher than those founds in Karak, Coventry, Birmingham, Ottawa and Hong Kong (Rasmussen; et al., 2001 and Yeung; et al., 2003). This fact probably indicates that traffic is a relevant source of Pb in Mutah street dusts. In general each city has its own characteristics combination of elemental compositions of its street dusts due to different urban settings.

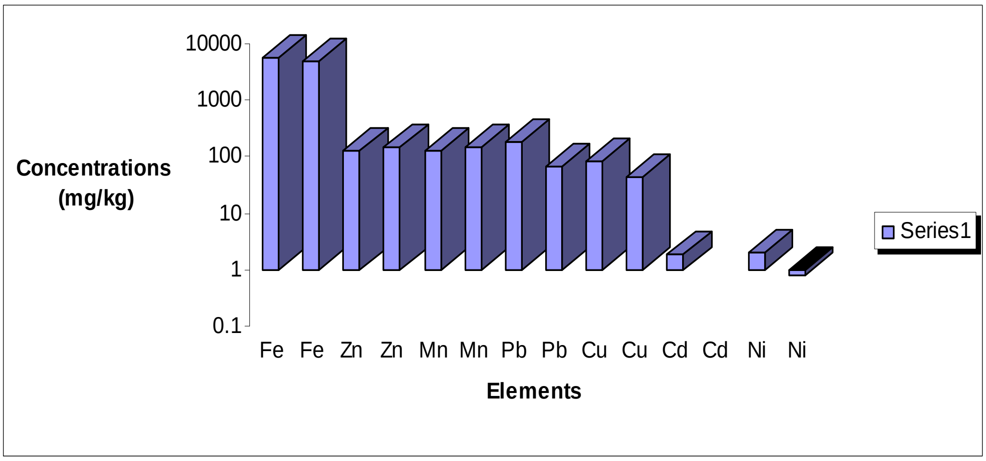

Figure 4. Comparison between mean concentrations of heavy metals in Mazar-Karak and University streets respectively.

Table 2. Mean concentration of trace elements (mg.kg^{-1}) in street dust from several cities (last two columns show particle size in µm — retained for analysis and the protocol used to digest the samples, respectively)

City	Ag	B	Ba	Fe	Cd	Cu	Cr	Pb	Zn	∅(µm)	Digestion
Aviles[a]	1.31	9.57	361	42.2	22.3	183	41.6	514	4829	<2000*	$HCl+HNO_3$
Karak[b]				4349	2.60	24	16	51	85	<595	HNO_3+HClO_4
Birmingham[C]					1.6	466.9		48	534	<63	$HNO_3+H_2SO_4+HClO_4$
Bursa[d]					3.1			210	57	<200	$HCl+HNO_3$
Coventry)c(					0.9	226.4		47.1	385	<63	$H_2SO_4+HNO_3+HClO_4$
Delhi)e(					18.94	512.28	4816.94	597.63	365.92	<500	$HClO_4+HNO_3+HF$
Kuala Lumpur[f]				1790	2.96	35.5		2466	344	<63	Σsequential
London[g]				26	3.5	155		1030	680	<500*	$HCl+HNO_3$
Mutah				5362	1.33	69		143	132	<63	HNO_3
Madrid[h]				19.3		188	61	1927	476	<100	$HClO_4+HNO_3+HF$
Manchester[i]				8767		113		265	653	<1000	HNO_3
Oslo[h]			526	51.452	1.4	123		180	412	<100	$HClO_4+HNO_3+HF$
Ottawa[j]	0.2			25.66	0.6	188	59	68	184	100-250	$HF+HClO_4$
Seoul[k]					3	101		245	296	<2000	HCL+HNO_3
Amman [l]						177		236	356	<200	HNO_3

a)Ordońez et al. (2003), (b)El-Hassan et al. (2006) (c)Charlesworth et al .(2003) (d)Arslan (2001) (e)Banerjee(2003) (f)Ramlan and Badri (1989) (g)Schwar et al. (1988) (h)De Miguel et al. (1997) (i)Robertson et al. (2003) (j)Rasmussen et al. (2000) (k)Chon et al. (1995) (1)Al-Khashman (2007).

The mean concentrations of Zn in street dusts of Mutah are high compared with several cities like Bursa and Karak, while Pb in Mutah dust is higher than in Coventry, Birmingham and Ottawa. Also concentration of copper is higher than in Kulalumpure and Karak. The Fe concentration in street dusts is similar to Karak city, while lower than other cities like Manchester and higher than for example: Madrid, Ottawa and Kuala Lumpur. In general, each city has its own characteristics combination of elemental pollution, which can be due to different anthropogenic activities of each city.

4.2 Enrichment of measured elements

The mean EF can be used as an effective tool to differentiate between a natural origin from anthropogenic sources. The mean EF of Zn, Pb, Cu and Cd, is higher than 10, while the mean EF of Mn and Ni is less than or close to unity. Maximum EF of Pb, Cd, Cu and Zn is close to or higher than 10, which may suggest that Cu, Pb and Zn in street dusts mainly originate from anthropogenic sources in such a study (Liu, et al., 2003). The order of mean EF values in this study are Pb > Cd > Cu >Zn>Mn>Ni. The mean EF (63.6) of Pb in EF>40 indicates Pb of street dusts is extremely high enriched (Yongming, et al., 2006; and Kartal, et al., 2006). Cadmium has EF 20-40, reflecting that Cd has significant contamination. Cu and Zn have EF in 5-20, with mean EF below 20, indicating also a significant contamination. Mn and Ni have EF less than 2, revealing the lack of contamination with Mn and Ni as a whole. Table 1 shows the skewness values of measured metals (Fe, Zn, Mn, Pb, Cu, Cd and Ni).Values are higher than unity for almost all of them, which mean that, the elements positively skew towards the lower concentrations, as can also be confirmed by the fact that the median concentrations of these metals are lower than their mean concentrations. So, the geometric means of all investigated heavy metals present more probable content data than the arithmetic means.

4.3 XRD diagram

As shown from the figure 5, we can see some main peaks at different angels: 26.49°, 29.33°, 39.35°, 47.44° and 59.85° which represents different phases such: Calcite, Copper Iron Lead Telluride, Neodymium Silicate and Neodymium Oxide. These phases highlight the existence of heavy metal pollutants in the studied street dust samples **5.**

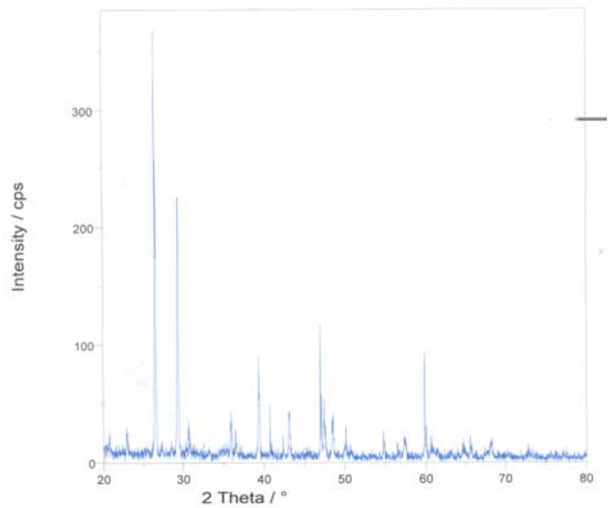

Figure 5. XRD of analyzed dust

5. CONCLUSIONS

This is the first pollution study in Mutah city and in the whole adjacent region. The present results suggest that the increase in the anthropogenic concentration of, Fe, Zn, Mn, Pb, Cu, Cd and Ni in street dusts in Mutah city can be most likely attributed to the rapid development, increase in vehicle emissions and to the lack of sophisticated management of wastes and effluents from workshops and other activities. Heavy metal contents in the dusts of both selected streets showed differences in concentrations that may be due to mainly differences in vehicular intensity. Lead pollution in the street dusts is likely caused by Pb vehicle emissions. The street dusts are also contaminated with Zn, Cu, Mn, Cd, and Ni originating mainly from vehicles and industrial activities. Although the contamination in Mutah is not severe as in cities with longer histories of urbanization such as London, Oslo, and Madrid, the found levels in Mutah dust still exceed permissible values in soils. Therefore, management programs such as planned reduction of Pb and other metal contents from fuel, improved treatment techniques for the wastes and effluents of different activities should be implemented by government to minimize the environment pollution in Mutah City. Such action would also improve air quality in the city.

6. Acknowledgments

The author thanks the Prince Faisal Center for Dead Sea Studies for access to the AAS facilities, to Mr. Mazen Adanat , for his help in AAS analysis and Mr. Ammer Al-Kateep for his help with the figure 1.

REFERENCES

Adriano, D., C., 2001, *Trace Elements in Terrestrial Environments: Biogeochemistry, Bioavailability and Risks of Metals,* second ed. Springer, New York, p. 867.

Akhter, M.,S. & Madany, I.,M. 1993. *Heavy metals in street dust and house dust in Bahrain.* Water, Air and Soil pollution, 66, 111-119.

Al-Khashman, O., A. 2004. *Heavy metal distribution in dust street and soils from the work place in Karak industrial Estate, Jordan.* Atmospheric environmental, 38, 6803-6812.

Al-Khashman, O., A. 2007. *Determination of metal accumulation in deposited street dusts in Amman, Jordan,* Environ. Geochem. Health, 29, 1-10.

Al-Rawashdeh, A. 2007. *The contamination of roadside soils and plants with heavy metals in Maan city Jordan.* Master thesis, Mutah University-Jordan. p. 21-75.

Arslan, H. *2001Heavy metals in street dust in Bursa, Turkey,* J. Trace Microprobe Tech, 19, 439–445.

Arslan, H., 2001. *Heavy metals in street dust in Bursa, Turkey.* Journal of Trace Microprobe Technology, 19, 439-445.

Banerjee, A., K. 2003.Heavy metal levels and solid *phase speciation in street dust of Delhi, India.* Environmental Pollution, 123, 95–105.

Charlesworth, S., Everett, M., McCarthy, R., Ordóñez, A., & de Miguel, E. 2003. *A comparative study of heavy metal concentration and distribution in deposited street dust in a large and a small urban area: Birmingham and Coventry, West Midlands, UK,* Environ. Int., 29, 563–573.

Chon, H.,T., Kim, K.,W.,& Kim, J.,Y. 1995. *Metal contamination of soils and dust in Seoul metropolitan city, Korea.* Environmental Geochemistry and Health, 17, 139–146.

De Miguel, E., Llamas, J., F., Chacón,, E., Berg, T., Larssen, S., Rẙset, O. & Vadset, M. *1997 Origin and patterns of distribution of trace elements in street dust: unleaded petrol and urban lead,* Atmos. Environ., 31, 2733–2740.

El-Hassan, T., Batarseh, M., Al-Omari, H., Ziadat, A., El-Alali, A., Al-Naser, F., Bruce, W. & Jiries, A. 2006. *The distribution of heavy metals in urban street dust of Karak city, Jordan,* Soil & sedimentcontamination, 15, 357-365.

Ferguston, J.E., & Kim, N. 1991. *Trace elements in street dust and house dusts source and separation.* Science o f Total Environment, 100, 125-150.

Jaradat, Q., Momani, K., Jiries, A., El-Alali, A. Batarseh, M., Sabri, T.G., & Al-Momani, I. 1999. *Chemical composition of urban wet deposition in Amman, Jordan.* Water, Air and Soil Pollution, 112, 55-65.

Jiries, A., Hussein, H., & Halaseh, Z. 2001.*The quality of water and sediments of street runoff in Amman, Jordan,* Hydrol. Process, 15, 815–824.

Kartal, S., Aydın, Z., & Tokalıo˘glu, S. 2006. *Fractionation of metals in street sediment samples by using the BCR sequential extraction procedure and multivariate statistical elucidation of the data,* J. Hazard. Mater.,132, 80–89.

Li, X. Poon, C. & Liu, P., S. 2001. *Heavy metal contamination of urban soils and street dusts in Hong Kong,* Appl. Geochem., 16, 1361–1368.

Liu, Q.T. Diamond, M.E Gingrich, S.E. Ondov, J.M. Maciejczyk, P.. Sterm, G.A 2003. *Accumulation of metals, trace elements and semivolatile organic compounds on exterior windows surfaces in Baltimore,* Environ. Pollut., 122, 51–61.

Momani, K., Jiries, A. & Jaradate, Q. 2000. *Atmospheric deposition of Pb. Zn, Cu, and Cd in Amman, Jordan.* Turk. J. Chem., 24, 231-237.

Moreno-Grau, S., Cascales-Pujalte, A., Mrtinez-Garcia, J., Moreno, J., Bayo, J., Garcia-Sanchez, A., & Moreno-Clavel, J. 2002. *Relationshipe between levels of lead, cadmium, zinc, and copper in* *soil and settleable particulate matter in Cartagena (Spain).* Water, Air, and Soil., 137, 365-383.

Nicholson, K., W. 1988. *A review of particle resuspension. Atmospheric Environment, 22, 2639–2651.*

Ordóñez, A., Loredo, J., De Miguel, E. & Charlesworth, S. 2003. *Distribution of heavy metals in street dust and soils of an industrial city in Northern Spain.* Archives of Environmental Contamination and Toxicology , 44, 160–170.

Pacyna, J.,M. 1986. *In: Nriagu, J.O., Davidson, C. I. (Eds.), Toxic Metals in the Atmosphere*. Wiley, New Yourk. p.,1-32

Purves, D.1985. *Trace Element Contamination of the Environment.* Elsevier, Amesterdam. p. 92.

Ramlan, M. N. & Badri, M. A. 1989. *Heavy metals in tropical city street dust and road side soils: a case of Kuala Lumpur, Malaysia.* Environmental Technology Letters, 10, 435–444.

Ramussen, P.E.,Subramanian, K.S.& Jessiman, B. J. 2001. *A multi-element profile of house dust in relation to exterior dust and soils in the city of Ottawa.Canada,* Sci. Total Environ. 267, 125-140.

Rasmussen, E., Subramanian, K.S., Jessiman, B., Robertson, D.J., Taylor, K.G. Hoon, S. R. 2003. *Geochemical and mineral magnetic characterization of urba sediment particulates, Manchester, UK.* Applied Geochemistry, 18, 269–282.

Rasmussen, P.E.,Subramanian, K.S.& Jessiman, B. J. 2000. *A multi-element profile of house dust in relation to exterior dust and soils in the city of Ottawa.Canada,* Sci. Total Environ. 267, 125-140.

Robertson, D.J., Taylor, K.G., Hoon, S.R., 2003. *Geochemical and mineral magnetic characterization of urban sediment particulates, Manchester, UK.* Applied Geochemistry 18, 269–282.

Royal Jordanian Geographic Center. 2001. *Map of the governorate of Karak. Amman, Jordan.*

Schwar, M.J.R., Moorcroft, J.S., Laxen, D.P.H., Thomson , M., Armorgie, C., 1988. *Baseline metal-in-dust concentrations in Greater London.* The Science of the Total Environment 68, 25-43.

Sehmel, G. A. 1980. *Particle resuspension: a review.* Environment International, 4, 107–127.

Sezgin, N., Ozcan, H.,K., Demir, G., Nemlioglu, S. & Bayat, C. 2003. *Determination of heavy metal concentrations in street dusts in Istanbul E-5 highway,* Environ. Int., 29, 979–985.

Sutherland, R. A. &Tolosa, C. A. 2000. *Multi-element analysis of road deposited sediment in an urban drainag basin, Honolulu, Hawaii.* Environmental Pollution, 110, 483–495.

Tasdemir, Y. & Kural, C. 2005. *Atmospheric dry deposition fluxes of trace elements measured in Bursa, Turkey,* Environ. Pollut., 138, 462–472.

Turner, A., & Simmonds, L. 2006. *Elemental concentrations and metal bioaccessibility in UK household dust,* Sci. Total Environ., 371, 74–81.

Yeung, Z.L., Kwok, R.C., & Yu, K.N. 2003. *Determination of multi-element profiles of street dust using energy dispersive X-ray fluorescence (EDXRF),* Appl. Radiat. Isot.58, 339-346.

Yongming, H., Peixuan, D., Junji, C. & Posmentier, E., S. 2006. *Multivariate analysis of heavy metal contamination in urban dusts of Xi'an, Central China,* Sci. Total Environ., 355, 176–186.

Zhou, Y., Levy, J.I., Hammitt, J.K. & Evans, J.S., 2003. *Estimating population exposure to power plant emissions using CALPUFF: a case studying Beijing, China.* Atmospheric Environment, 37, 815-826.

Received at: 23. 07. 2009
Revised at: 18. 11. 2009
Accepted for publication at: 07. 12. 2009
Published online at: 12. 01. 2010