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Indoor and Outdoor Heavy Metals Evaluation in Kindergartens in Amman, Jordan

R. Z. Al Bakain[a], **Q. M. Jaradat**[b] and **K. A. Momani**[a]

[a] *Department of Chemistry, Mu'tah University, Al-Karak, Jordan.*
[b] *Department of Chemistry, Yarmouk University, Irbid, Jordan.*

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Abstract: Selected heavy metals and water-soluble cations and anions in street, playground and indoor dust samples in the kindergartens (KGs) of Amman area-Jordan were determined by using flame atomic absorption spectrometer and ion chromatography. To achieve this aim, dust samples were collected from 38 different KGs at 4 different sites during summer season. It was found that the average total levels of Cu, Zn, Pb, Fe and Mn in street dust were 23.45, 188.47, 148.05, 8829.68 and 67.73 mg/kg, respectively. While for outdoor dust samples, the levels were 4.63, 127.38, 18.48, 8361.10 and 57.83 mg/kg, and finally, for indoor dusts were 23.51, 262.78, 71.33, 5566.14 and 51.28 mg/kg, respectively. The anions; F^-, Cl^-, NO_3^- and SO_4^{2-} and the cations; Na^+, K^+, Ca^{2+} and Mg^{2+} were analyzed by ion chromatography (IC). The results showed that there were high levels of these ions in all dust samples. The physiochemical properties; pH, moisture and organic matter content were also determined. The accuracy of results for heavy metals was examined by analysis of a standard reference material (SRM). Pearson coefficient was used to measure the correlation between the ions and the heavy metals in all the sites. ANOVA was also used to study the relation between the type of site and the heavy metals content.

Keywords: Heavy metals; Indoor, outdoor and street dust; Kindergartens; Major ions; Amman-Jordan.

Introduction

Heavy metals are natural constituents of the earth-crust and emitted to the environment by different ways; combustion of fossil fuel and road traffics, tears of tires, corrosion of building materials, automobile bodies, brake lining, industry and human activities, then settled in soil, water, air, dust and sediments. [1, 2-6]. Increasing industrialization has been accompanied throughout the world by the extraction and distribution of mineral substances from their natural deposits. Many of these substances have undergone chemical changes through technical processes, and finally dispersed in solutions, by way of effluent, sewage, dumps, dust, into the water, the earth and the air and thus into the food chain [1]. Thus, the threat posed by heavy metals to human health and the environment has risen sharply over the past decades, so there is arising public health interest in possible effects of heavy metals on the human health. Many investigations were carried out to determine the levels of heavy metals in different sites and materials worldwide, including: road side sediment [7], soil and vegetation [8], street dust and soils [9], human blood [10], indoor air [11], children hair [12], sewage sludge [13], sediment core [14], air [15], human teeth [16] and food [17].

Heavy metals can inter human bodies through many ways; the common modes of intake of external materials are inhalation of air into the lungs, ingestion of food, water and at times non–food items into the gastrointestinal system and transfer through the skin, also intravenous,

Corresponding Author: R. Z. Al Bakain **Email**: ramia.bakain@yahoo.com

intramuscular and vaginal routes. Food is digested in the stomach by enzyme hydrolysis to produce small molecules which are absorbable. The pH values of the stomach fluids are around 1 to 3 due to the presence of HCl. The digested materials move into the duodenum and the small intestine, where the pH is around 6 to 7. The materials on the surface of the gastrointestinal tract may be absorbed into the walls and into the blood stream.

Identification the toxicity and the percentage of heavy metals in the location we live in is important, especially on children who are more likely to ingest quantities of dust than adults with their habit of placing dirty fingers and objects of all kinds into their mouths (mouth- to -hand) activity [1], so they are more susceptible to intake of toxin than adults [18]. Preschool children under the age of five are particularly vulnerable to heavy metal poisoning because of development and behavioral consideration. The maximal brain growth and differentiation are found in the first few years of life.

In this study, Amman had been chosen, the capital of the Hashemite Kingdom of Jordan, located in the center of Jordan. It is the densest city with a population of about 2.2 millions and consists of two main parts: (the new Amman = the west) and (the old Amman = the east). The environment of Amman is influenced by natural emissions due to the geological location as well as man-made sources, such as vehicle emissions, industrial waste and emissions. Therefore, in this study we intend to:

- Evaluate the levels of heavy metals (Zn, Cu, Pb, Fe and Mn) in the dust of 38 different kindergartens.
- Measure the levels of the cations: Ca^{2+}, Mg^{2+}, NH_4^+, Na^+ and K^+, and the anions: NO_3^-, F^-, Cl^-, PO_4^{3-}, Br^- and SO_4^{2-} in street dust and compare them with those in outdoor and indoor dusts.

Experimental conditions

Sampling sites

Thirty eight KGs from sixteen sites were chosen as sampling sites in Amman. These sites represent different possible sources of pollution with different: geological type of area, cleaning mode, heating system, age of building, presence of gas stations around and road type. The sampling sites are illustrated in Fig. 1. The first set of sampling sites An; A1-A10 were: Wadi Al-Seer, Sweifieh, Abdoun, 7th and 8th circles with medium and steady traffic are free from industries with new house structure compared to the others. The second set Bn; B1-B10 were: Al-Ashrafiye, Hai-Nazal (east and west) and Jabal Al-Taj, with almost old structure buildings placed close to each others, nearby roads and dense inhabitants in the same neighborhood. The third set Cn; C1-C10 were: Marka region, Tabarbour and North Al-Hashimi, an area with high traffic density. Sampling sites number four Dn; D1-D8 were the downtown regions: Al-Hussein, Al-Abdalli, Al-Shmeisani and Al-Weibdeh, that are located in the center of the city, near high traffic routes, with high density vehicular traffic and large traffic stations with diesel-powered buses.

Sample collection procedure

Samples of indoor, outdoor and street dusts were collected during summer season prior to rain season to avoid washing of the heavy metals. Indoor dust samples were collected from the classrooms by using electrical vacuum, with clean and pre-washed paper bags, and then kept in polyethylene bags until the time of analysis. Outdoor dust samples were collected from the playgrounds and the entrance by gently sweeping the surface with a clean broom. The collected dust was transferred to a plastic scoop with the aid of a nylon brush and placed into pre-washed bags until the time of analysis. Finally, street dust samples were collected from the nearest street to each KG in the same way used for outdoor dust sample collection.

Sample pretreatment

Moisture and organic matter content

Moisture content was determined by weighing around 1.0 g of the dust samples, and then heated in an oven at 105ºC for 12 hours. The weight loss was calculated based on the difference between the final and the initial weights. The same samples were transferred into a furnace at 550º C for 4 hours, in order to determine the organic matter content, which was then calculated gravimetrically based on the weight difference.

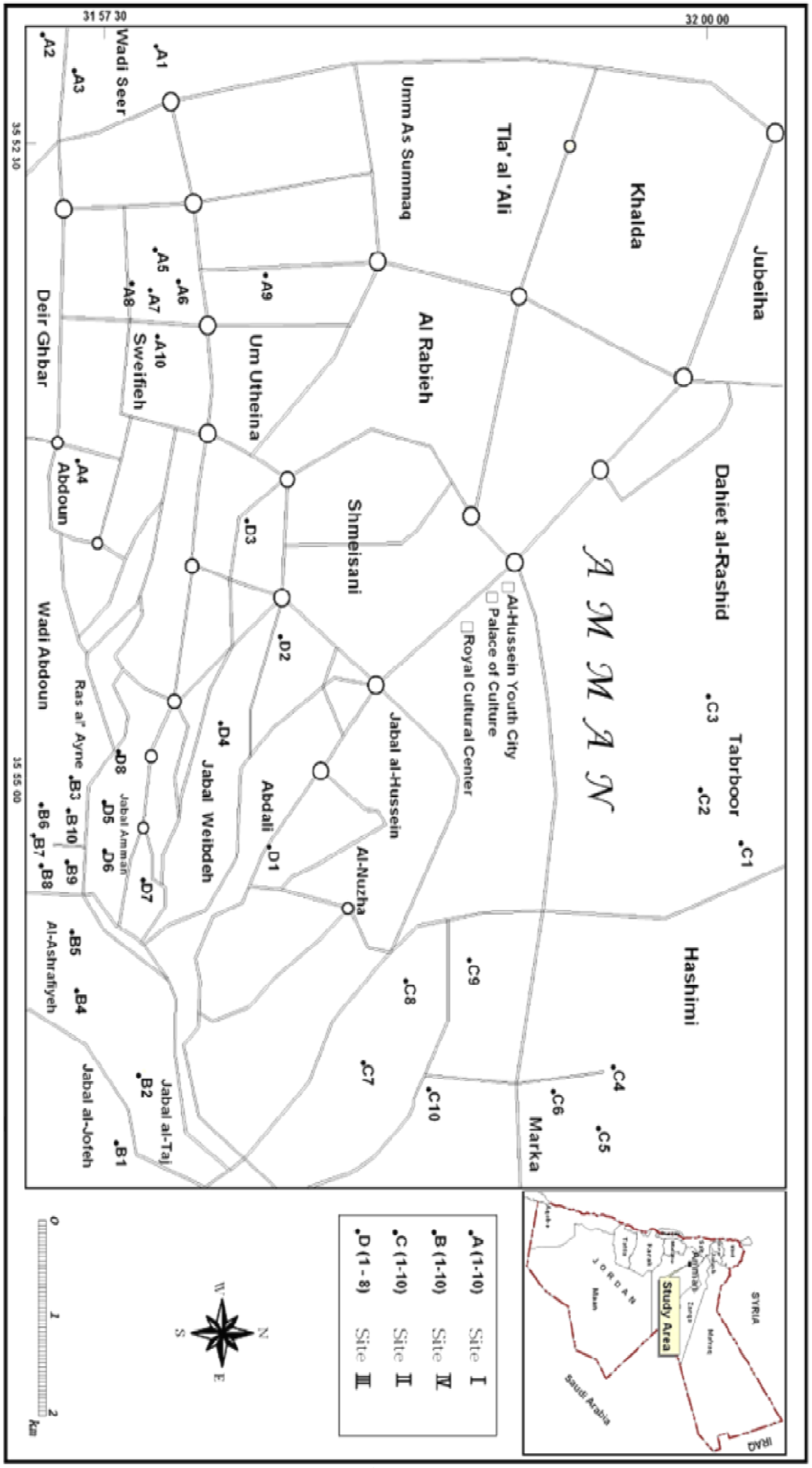

FIG. 1: The map of sampling sites in Amman.

pH measurement

The pH values of the water extract of dust samples were determined in milli-Q water (1: 2.5 wt/v) using polypropylene test tubes, with pH-meter (WTW, PH 523, Weilheim, Germany) after being calibrated at pH 4 and 7 buffer solutions at room temperature.

Water soluble anions and cations

Extraction of anions and cations was carried out by adding 15 ml of water to 0.7 g of dust sample. Then the mixture was heated at 95º C for 2 h by using test tube heater, sonicated for 30 minutes in ultrasonic bath at 50º C, filtered, diluted with water, then transferred into polyethylene sample bottles and stored at 4°C until the time of analysis. Blank solutions were then prepared in the same way as employed for the real samples.

Acid-extractable fraction of heavy metal

Extraction of heavy metals in dust samples was carried out by weighing around 0.7 g of dry sample. 15 ml of concentrated HNO_3 (high purity) was added in 50 ml polypropylene test tubes, heated for 2 h at 95º C in a water bath, sonicated for 30 minutes in ultrasonic bath at 50º C, then centrifuged for 15 min at 1000 rpm. The sample was diluted with 1% HNO_3. Blank solutions were prepared in the same way as employed for the real samples.

Chemicals and instrumentation

All glassware and test-tubes used were initially cleaned with soap, washed thoroughly with tap water, rinsed with distilled water and socked in 10% HNO_3 (v/v) overnight, respectively. Centrifuge (MSF, Mior35, England), Furnace (Nebertherm, N5/RL, Germany), oven (Mipo/5/SS/EC, England), water bath shaker (D-3162, Kottermann laboratechchnike, 3047, West Germany) and Ultrasonic bath (Quantrex 210H) were used.

All the reagents were of analytical grade purity, HNO_3 assay 65% (Scharleau). Determination of anions and cations was carried out on DIONEX (DX-100), USA, Ion chromatographic system (IC). 250 × 4.0 mm ID, DIONEX AS4A-SC and 250 × 4 mm ID, DIONEX CS12 columns, with mobile phases of (1.8 mM Na_2CO_3 + 1.7 mM $NaHCO_3$) and (20 mM Methanosulfonic acid), respectively, were used for anion and cation measurements.

Determination of heavy metals was carried out using flame atomic absorption spectrometer (FAAS) (Varian 55B). The manufacturer's recommended procedures were followed throughout this work.

Running conditions for the analysis of ions

A standard mixture of six anions: F^-, Cl^-, Br^-, NO_3^-, PO_4^{3-} and SO_4^{2} with the following concentrations: 200, 300, 1000, 1000, 1500 and 1500 ppm, respectively of standard stock solution (Dionex, California) was used to prepare our standard solutions, based on the following concentrations of fluoride: 1, 2, 4, 8 and 16 ppm. A standard mixture of five cations: Na^+, NH_4^+, K^+, Mg^{2+} and Ca^{2+} of 2000, 4000, 2000, 2000 and 10000 ppm, respectively, of standard stock solution (Dionex, California) was used to prepare standard solutions based on the following concentrations of sodium: 1, 2, 4, 8, 16, 20, 30 and 40 ppm.

Validity and quality control

To estimate the analytical precision and accuracy of analytical results, reagent blanks, replicate samples and standard reference materials (SRM) were used. Blanks were prepared in a similar manner to that of the real samples and were analyzed before each measurement. All extractions and analyses were made with duplicates (n = 2) for quality assessment, and the average results were reported. Analysis of SRM was conducted by tested analytical method and comparison of the results obtained with the certified values. In this study, SRM (soil 7) was subjected to the extraction (duplicate trials) and then the results were reported as the percent of recovery for Fe, Cu, Pb, Zn and Mn.

Results and discussion

Physico-chemical properties of street, outdoor and indoor dust samples

Moisture (Mois), organic matter content (OM) and pH are some of the common physical and chemical soil properties that can influence the presence of metals in the environment. They were determined for the street, outdoor and indoor dust samples.

pH is a test for measuring binding strength and potential mobility of heavy metals in soil [19-21]. It has an influence on the form and other parameters affecting the concentration, mobility, transformation and the presence of organic matter [21]. Changes in pH results in a transfer of elements from one phase to another may thus influence the mobility of heavy metals in the soil [9]. Metal solubility increases at low pH values [10]. For example, Pb precipitates when pH $>$ 7 [22-24]. The results in this study showed that pH values in the KG soil samples were neutral to sub-alkaline values for all the sampling sites (pH > 7). There was no significant difference in pH values in all the studied sites (An, Bn, Cn and Dn). For street, outdoor and indoor dust samples, the average values of pH at all the sites were 7.64, 7.54 and 7.19, with ranges of 7.00 – 9.26, 6.62 – 10.04 and 5.65 – 10.88, respectively. The reason behind this is that the nature of soil in Jordan is almost calcareous (high carbonate content,) which enhances the pH values [25]. $CaCO_3$ provided a buffer against the mobilization of heavy metals such as Pb [22]. The highest value of pH in street dust samples was in A4 due to the new constructions that were built during sample collection. For outdoor samples, the highest value of all sites was for B1, and for indoor samples it was for A10 due to the intensive daily cleaning in these kindergartens with detergents that are almost alkaline. On the other hand, the lowest pH value for street, outdoor and indoor dust pH samples was for B9, B7 and D4, respectively. This was referred to traffic emissions that emit acidic oxides as (SO_2) leading to lower the pH values [26].

The moisture content of the different types of samples is presented in Table 1. No wide variations in moisture content values were shown between inside, outside KGs and street dust samples. The highest overall average was found for the inside samples (1.88%), and the lowest was for outside samples (0.76%). This could be related to the lack of sunlight and lower temperature inside the kindergartens which decrease the evaporation rates.

TABLE 1. Physiochemical properties: organic content and moisture for street, outdoor and indoor samples with their standard deviations.

	OM%		Mois%		OM%		Mois%		OM%		Mois%	
KG	In	S.D.	In	S.D.	Out	S.D.	Out	S.D.	Street	S.D.	Street	S.D.
An	14.98	7.28	0.83	0.20	2.72	2.79	1.01	1.38	5.12	2.53	0.86	0.75
Bn	46.39	6.06	4.25	4.00	3.97	3.14	0.46	0.34	12.22	4.49	1.08	0.71
Cn	N.A	N.A	N.A	N.A	4.76	5.24	0.95	1.11	8.72	2.64	0.86	1.27
Dn	5.34	1.84	0.56	0.30	4.77	5.40	0.63	0.69	13.81	11.54	0.90	0.94
Mean	22.24	5.06	1.88	1.50	4.06	4.14	0.76	0.88	9.97	5.30	0.92	0.92
Min.	3.77		0.22		0.65		0.03		1.63		0.11	
Max.	56.16		11.40		15.29		3.87		32.92		4.47	

The average organic matter content in all the sites in street, outdoor and indoor dust samples was 9.97%, 4.06% and 22.24%, respectively, as illustrated in Table 1. The order was similar to that for the moisture content, indoor > street > outdoor. This might be due to the high organic contamination inside the KGs because of the paints and food residues, while for street samples; it might be due to the high traffic volume and car emission. The order of values in all the sites for street dust samples was Dn > Bn > Cn > An, for outdoor samples the order was Dn > Cn > Bn > An and for indoor samples it was Bn > An > Dn, while Cn was not analyzed due to low sample amount. Site Dn has the highest values in the street and outdoor samples due to the high traffic density in these sites. For indoor samples, Bn showed the highest values due to the usage of oil for heating in most of the KGs in these sites and also as a result of the high food residues that fall down from children with low cleaning rate.

Water soluble anions and cations

For anions, PO_4^{3-} and Br^- were not detected in all dust samples, while for cations, $NH_4^+$was not detected as shown in Table 2. The table indicated that SO_4^{2-} was the dominant anion in street and outdoor dust samples which might be due to the type of motor vehicles, mainly diesel powered buses and trucks. For indoor dust samples, Cl^- was the highest due to table salt (NaCl) and the food residues that fall down. The highest value for cationic species in all the sites of street and outdoor dust samples was for Ca^{2+}. This outcome could be due to the type of soil which exists in the studied sites with calcareous nature. For indoor dust samples, Na^+ was the highest, due to the children food components such as chips, biscuits and table salt of high levels of sodium that falls down. Site Bn showed the highest concentration of SO_4^{2-} due to the type of motor vehicles used, mainly diesel powered bus and trucks [27]. However, F^- in street dust is attributed to dust from phosphate raw materials carried by automobiles and from natural soil [27] since the crude oil used in Jordan is of relatively high sulfur content ranging from 2-8% [27].

TABLE 2. The average concentrations for cations and anions (mg/kg) in all sites.

		K^+	Na^+	NH_4^+	Mg^{2+}	Ca^{2+}	NO_3^-	F^-	Br^-	Cl^-	PO_4^{3-}	SO_4^{2-}
An	**Indoor**	830	5291	274	246	1980	469	326	50	3258	114	2305
	S.D	**590**	**3215**	**185**	**340**	**2141**	**303**	**373**	**18**	**2762**	**65**	**2273**
	Outdoor	86	409	35	133	705	360	17	12	523	102	700
	S.D	**91**	**408**	**11**	**135**	**406**	**334**	**9**	7	**734**	**53**	**555**
	Street	373	616	73	101	1741	173	29	17	800	97	1357
	S.D	**379**	**251**	**24**	**59**	**984**	**55**	**9**	**10**	**200**	**51**	**632**
Bn	**Indoor**	2293	5611	1303	511	1539	623	810	N.D	5479	168	3170
	S.D	**631**	**1739**	**748**	**103**	**485**	**409**	**394**	**N.D**	**1605**	**113**	**1965**
	Outdoor	271	449	165	123	1128	417	34	N.D	382	612	761
	S.D	**91**	**408**	**11**	**135**	**406**	**334**	**9**	**N.D**	**734**	**53**	**555**
	Street	817	1227	381	390	1842	80	42	N.D	1427	N.D	1519
	S.D	**733**	**718**	**252**	**174**	**895**	**27**	**19**	**N.D**	**629**	**N.D**	**735**
Cn	**Indoor**	1713	5555	1356	348	1036	91	1113	154	5921	274	2104
	S.D	**1003**	**1525**	**783**	**129**	**451**	**53**	**847**	**89**	**2138**	**158**	**774**
	Outdoor	230	611	183	159	770	320	25	N.D	679	135	643
	S.D	**200**	**400**	**99**	**109**	**360**	**369**	**11**	**N.D**	**517**	**63**	**468**
	Street	291	981	272	154	1171	240	29	0	1325	N.D	1046
	S.D	**125**	**338**	**86**	**124**	**481**	**154**	**15**	**0**	**695**	**N.D**	**430**
Dn	**Indoor**	868	3216	185	214	1896	575	373	N.D	1933	287	2670
	S.D	**735**	**2608**	**76**	**162**	**1656**	**414**	**470**	**N.D**	**1618**	**117**	**2939**
	Outdoor	272	447	247	86	826	496	30	7	589	145	653
	S.D	**551**	**493**	**121**	**42**	**749**	**543**	**17**	**3**	**852**	**90**	**805**
	Street	471	922	273	215	1546	242	91	58	1355	71	1427
	S.D	**372**	**907**	**143**	**146**	**805**	**191**	**179**	**20**	**1183**	**118**	**1004**

NO_3^- might come from the type of fuel used, mainly diesel powered buses and trucks [27], so results showed high values of NO_3^- for street and outdoor dust samples in the site Dn due to the high traffic density when it is compared with the other studied sites. The normal range of NO_3^- in the atmosphere is 0.1-10 µg/m^3 [27]. To conclude, the high levels of water soluble anions and cations were mostly due to their associations in soluble natural compounds [28-29]. Furthermore, the use of local water for washing floors might be a source of cations and anions since it is full with ions.

Total heavy metals evaluation

In order to assess the accuracy of the results obtained by the analytical method used in this study, two methods were used; blank solution and standard reference materials (SRM). SRM soil 7 was subjected to the same extraction (triplicate trials) of the real samples. The recovery of heavy metals in soil 7 for Zn, Pb, Cu, Mn and Fe was 97.4%, 117 %, 115 %, 90% and 103.2%, respectively as shown in Table 3.

The results in Fig. 2 showed the average concentration of heavy metals in different street, outdoor and indoor dusts samples. Street dusts in sites An have the highest concentration levels for Pb, Fe and Mn, while Dn showed the highest levels of Cu and Zn. KGs in An sites are located on the major streets or nearby crowded major streets at about 20-50 m, so Pb sources come from automobile emissions [9, 21, 30], while Fe and Mn in street dusts come from metal corrosion, such as of the bodies of automobiles [31-32]. The highest content of Cu and Zn was found in Dn sites. This may be due to the presence of a bus station near these KGs with high traffic density, since Zn exists in the automobile door panels, carburettors and pumps, where Cu can be found in buses (bars, windings in motor and generator). This may increase the levels of Cu and Zn [33].

TABLE 3. Analysis of heavy metals (mg/kg) for SRM- soil -7.

Element	DL*	Certified value	Measured value	Recovery%
Fe	0.30	25700	26521	103.2
Cu	0.002	11	12.7	115
Pb	0.006	60	70.2	117
Zn	0.002	104	101.3	97.4
Mn	0.03	630	566	90

DL*: is the minimum detection limit of 6 samples (mg/L).

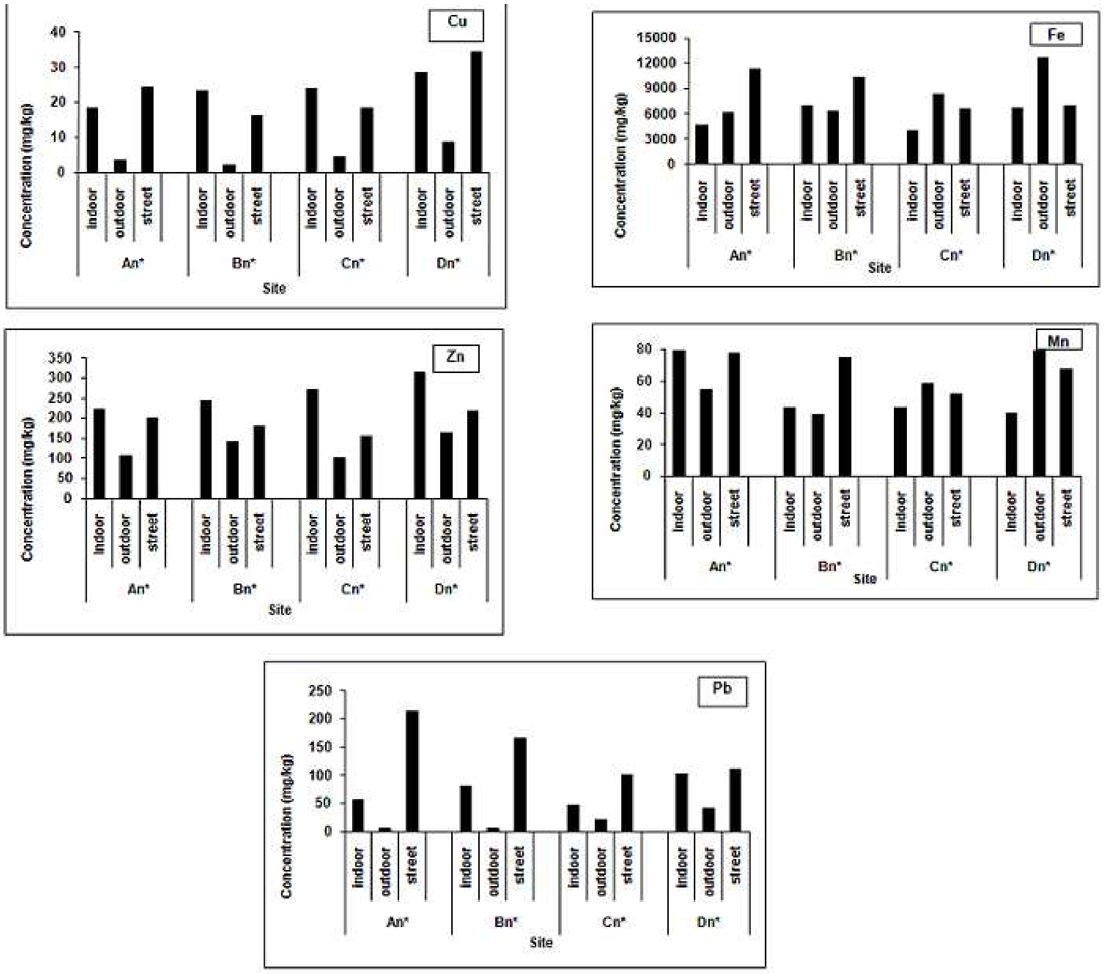

FIG. 2: The average total concentrations (mg/kg) of heavy metals in all sites, An: (A1 to A10), Bn: (B1 to B10), Cn: (C1 to C10) and Dn: (D1 to D8), for street, outdoor and indoor dust samples.

For outdoor dust samples, Dn showed the highest levels for all heavy metals due to the high traffic density with a bus station [33].

For indoor dusts, Dn has high contents for Cu, Zn and Pb due to high traffic density and bus stations. While for Mn; An showed the highest levels due to high corrosion of automobile bodies since the majority of KGs in An sites are located along the major streets.

Enrichment factor for street dust

The enrichment factor (EF) for heavy metals gives an indication of the degree of pollution of the dust by these metals in Amman city. Iron was used as a reference element because it is a crust – dominated element [21]. The enrichment factor was computed in accordance with the formula reported by Mason [34].

$$\mathrm{EF} = \frac{[\,C_x / C_{Fe}\,]_{dust}}{[\,C_x / C_{Fe}\,]_{crust}}$$

where:

$[\,C_x / C_{Fe}\,]_{dust}$: the ratio of the concentration of the metal being determined (C_x) to that of Fe (C_{Fe}) in the dust samples.

$[\,C_x / C_{Fe}\,]_{crust}$: the ratio of the concentration of metal X to that of Fe in the earth crust.

Enrichment factors less than 2.0 are not considered significant, because such small enrichment may arise from differences in the composition of local soil material and reference soil used in EF calculations. The three contaminated categories recognized were based on the enrichment factor values as: (EF $<$ 10) less enriched, (10 $<$ EF $<$ 100) intermediately enriched and (EF $>$ 100) highly enriched. Enrichment factor values for heavy metals in all sites for street, outdoor and indoor dust samples are summarized in Table 4.

TABLE 4. Enrichment factor values for heavy metals in street dust samples.

	Cu	Zn	Pb	Mn
Indoor	0.48	11.52	7.30	0.53
Outdoor	3.99	35.35	48.55	0.37
Street	2.60	16.01	63.44	0.42

The results indicated that the highest enrichment factors observed in dust samples were for Pb and Zn due to the presence of the anthropogenic sources of these metals, such as traffic in street and outdoor sites. For indoor samples, the transfer of these metals from outside, in addition to some sources present inside, might be the reasons of the high EF. Mn was less enriched in all samples which is an indication of crustal contributions [35].

Statistical analysis

Pearson correlation coefficient between anions and cations was computed in all sites (indoor, outdoor and street) to measure the degree of correlation between the ion concentrations. High correlation coefficients were found between (Cl^- vs. Na^+), (K^+ vs. Mg^{2+}), (NH_4^+ vs. K^+), (F^- vs. K^+), (Cl^- vs. K^+), (NO_3^- vs.Ca^{2+}), (Cl^- vs. F^-) and (Br^- vs. F^-) with correlations of (0.69, 0.65, 0.60, 0.64, 0.51, 0.74, 0.66 and 0.53), respectively. This may suggest that each pair of ions has the same source/s, e.g. in this study high levels of Cl^- and Na^+ were found in indoor dusts, which may be due to their same source which is: table salt. While for street dusts, the high levels of ions may be due to high dissolved salt deposited on the surface from the vaporization of water.

Pearson correlation between heavy metals in each site (indoor, outdoor and street) dusts was calculated, which showed that there are no correlation between heavy metals in indoor dusts, where for outdoor dusts there are high correlations between (Zn vs. Pb) and (Fe vs. Pb) as follows: (0.62) and (0.51), respectively. This may suggest that these pairs have the same source which is: automobiles [36]. The street dusts have also high correlations between (Fe vs. Pb) and (Pb vs. Cu) as follows: (0.45) and (0.47), which indicates that automobiles are the common source of these heavy metals [36].

Also, Pearson correlation coefficients were calculated between heavy metal contents of sites (indoor vs. outdoor), (indoor vs. street) and (outdoor vs. street), which showed that there were correlations between Mn and Mn in indoor and each of street (0.38) and outdoor dusts (0.38), also between Pb indoor and outdoor dusts (0.41). These results may be due to the common source of these heavy metals in streets, which is automobiles [32] that may influence the environment of indoor and outdoor KGs.

(One-way ANOVA) followed by (Post Hoc Test, Tukey HSD) were used to study the relation between the types of sites (indoor, outdoor and street dusts) of KGs and heavy metal contents. It was shown that there were differences between heavy metal contents with changing the type of site, except for Mn.

The relation between the student's number inside KGs and heavy metal contents was determined by T-Test. No relation was found between Cu, Pb, Zn and Mn concentrations with number of students inside KGs: 0.416, 0.063, 0.611 and 0.729. Where for Fe concentrations, there is a significant relation between Fe levels and number of students inside KGs (0.001).

Conclusions

Based on the results of the current study, the following conclusions were obtained:

1- Average pH values for street, outdoor and indoor dust samples were neutral to sub-alkaline due to the type of soil in Jordan which is calcareous.

2- Moisture contents for street, outdoor and indoor dust samples were lower due to the evaporation rate that decreases the moisture content.

3- Organic matter was found in a high value for indoor dust samples due to high organic contamination.

4- For cation analysis, high levels of Ca^{2+} were found for outdoor and street dust samples due to the calcareous nature of soil in Jordan. For indoor dust, Na^+ had the highest levels due to table salt and food stuff which contain high contents of Na^+.

5- For anion analysis, SO_4^{2-} had the highest levels in outdoor and street dust samples due to traffic emissions. Where for indoor dust samples, Cl^- had the highest level due to table salt.

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