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Preliminary Assessment of Heavy Metal in Selected Sites within Duhok City, Iraq

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Abstract

Environmental pollution is an emerging issues in the developed and developing countries. Rapid urbanization and industrialization is directly involved with the pollution of heavy metal in roadside dust. Heavy metals present in roadside dust are of interest due to their deleterious impacts on both human and ecosystem health. This study attempts to investigate the pollution by heavy metal in roadside dust at Duhok city, Iraq. Five locations were selected based on the traffic density on the roads and different anthropogenic activity. To assess the pollution of heavy metal in roadside dust samples were collected under stable weather conditions during dry season, and analyzed for Zinc (Zn), lead (Pb), Zinc (Zn), Nicle (Ni), Cobalt (Co) and Cadmium (Cd) concentrations. The range of Zn and Pb was concentration varied from 90.6 to 559.2 mg/kg and from 25.1 to 169.1 mg/kg in the roadside dust respectively, with a higher mean value observed in the industrial area. The results indicate that roadside dust is moderately contaminated with respect to Pb, Zn, Ni, Cd, and Co. High contents of these elements could be attributed to anthropogenic effects related to traffic sources. Also, the results of this study were compared with several cities around the world.

Keywords: Heavy metals; roadside dust; Highways in Duhok City; vehicle traffic.

1. Introduction

Study of Heavy metals (HM) present in roadside dust is an important subject because it is often associated with environmental pollution. The components of road dust in cities are significantly affected severely by human activities, or by anthropogenic pollutants. Potential toxic metals or metal ions at trace levels (such as Pb, Zn, Ni, Cd, etc.) from anthropogenic sources in road dust may significantly affect the human health and well-being [1].

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Roadside dust with its high HM contents has a high possibility of causing cough or breathing problems in both children and adults during inhalation [2]. Fine particles in Road dust can be absorbed by human through inhalation, ingestion, and dermal absorption. These toxic metals will continue to accumulate in urban environment due to their non-biodegradability and long residence time. Urban surfaces receive deposits from sources such as vehicular emissions, industrial discharges, domestic heating, waste incineration, and others anthropogenic activities through atmospheric transport and local activities [3-5]. Investigation of dust is of particular importance for the following reasons. 1-dust is freely being inhaled by those traversing the roads and those residing within the vicinity of the roads. The more the dusts on such roads become contaminated with HM, the more health hazards associated with such metals [6]. 2-when rains are received, dust usually gets discharged in the adjoining marine environment, and could seriously pollute water. This might prove toxic to marine life [7]. 3- dust highly influence the energy collection, e.g. solar radiation, PV systems performance and efficiency are affected by dust and dust storms [8]. The vehicle traffic, industry and weathered materials are the main factors that influence the levels of trace elements in roadside dust. It is known that HM are often associated with high traffic densities [9, 10]. HM are emitted into the atmosphere as aerosols. They are transported up to several kilometers away from their sources and transferred to the soil by wet or dry deposition. This precipitated metals pollute natural waters and terrestrial and aquatic living organisms. Transfer of HM in the soil from the atmosphere is an important part of their biogeochemical cycle [11]. Also, pollutants can enter the soil and alter its pH, causing root injury. However, there is no Iraqi limits concerning acceptable and maximum permissible values of HM hold in soils [12].

In the recent years, there have been numerous studies on the extent of HM contamination in roadway and airborne dust and source identification in different countries of the world [3, 4, 6, 12-17]. However a few have been studied in Iraq. And, to our knowledge, There is no record of research or work carried out, or any published studies to date reported about roadside dust in Duhok city (DC). It is therefore necessary to determine the levels of heavy metals in dust from highways, and roads, in DC, as well as assess the health implications of the metals on the pupils.

This work was carried out on roadside dust in the Duhok city –DC. Five locations were selected (e.g. the international highway linking Iraq by Turkey (Zakho highway). The objective of this study is also to elucidate the distribution of heavy metals (such as Zn, Cd, Ni and Pb) and their levels on roadside dust, and to assess the roadside dust contamination. Then compare the HM results from study areas at DC with those available in various areas throughout the world.

2. Materials and methods

2.1 Description of the Area

The study was performed at Duhok City (DC), in Iraq. DC is situated at the northwest of Iraq and western part of Kurdistan region, (latitude 36°5′N, longitude 43°0). The climate at DC is semi arid climate, and characterized by hot summers and moderately rainy, cold winters. Usually, precipitation occurs during the months from October until April. More details are given in previous paper [18]. Naturally, DC receipts a significant particulate matter from the atmosphere, and it typically influences by gases emitted from the automobile exhausts. There is no record of research on the levels of metals in dust from the DC. Hence, it is necessary to determine the levels and assess the health implications of the metals on the pupils.

2.2. Site sampling

A total of 120 samples were collected along the both sides of roads in DC, under rather stable weather conditions during the hot, and dry season. Samples were collected at positions near the pavement edges of 5 zones (highways, Roads, streets, sub-streets) in DC, during the period August and September, 2014, (to avoid rain washing out the HM), from different depth with an interval of 5 -10 cm. 3-5g of dust/ soil sample were collected. A small clean plastic brush was used to whisk road dust together with a stainless steel spade, and a plastic scoop. The studied locations were covered the major area as possible based on the traffic activity (see Table-1). Locations where samples were collected are shown on map in figure 1.

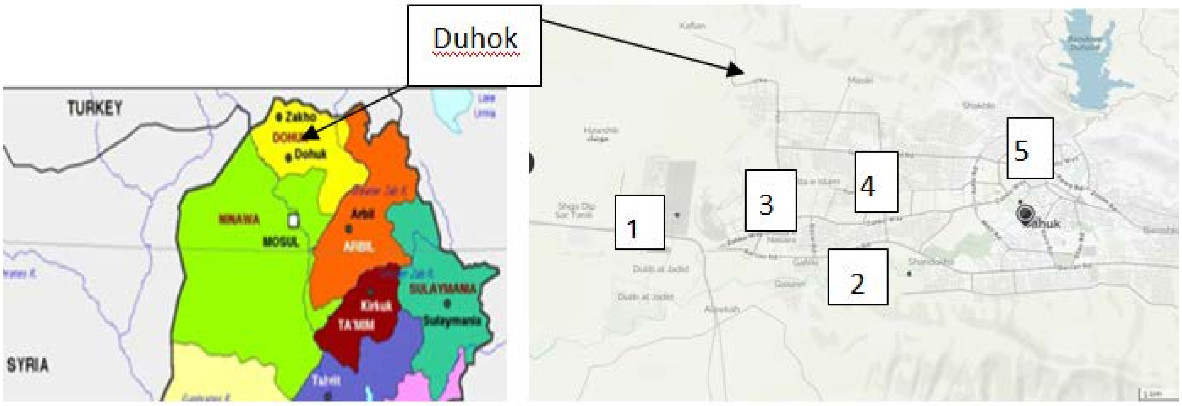

Figure 1: Map of north of Iraq, and sampling area (in Duhok). (From Google Maps).

1-ZH. 2-BH. 3-ZWM. 4-ZWU 5- VLT. (See Table-2).

Each sample represents dust from a multiple of 6 spots on the road (distance between two spots ~ 90-100m), and between 25 to 50 cm from the road curb at the selected location. All dust samples (DS) collected were stored in sealed polythene bags and carefully labeled and taken to the laboratories for analysis. Powder free gloves were worn during sample collections. DS were sieved through a 2.0 mm to remove any visible extraneous material (hair, soil, and grit). DS were then oven-dried at 65˚C for 48 hours. DS were homogenized and sieved again through 63μm sieve size. DS were moisture equilibrated for at least 12 h in desiccators and weighted. After weighting, the road DS were digested for the metal analysis. DS were stored at temperature of 10-15 0C for pre-treatment and analyses [19]. Type of environment in the selected sampling stations, traffic volume, and the major sources of gaseous emissions in the study area are given in Table 1.

2.3. Chemical Analysis

pH was measured for DS to determine acidity. For this purpose an ultra-pure water 1:5 (w/v) suspension was prepared. pH measurements were taken on this suspension by immersed pH probe. DS were digested using aqua regia (HCl/HNO3, 3:1 solution)- [20]. Metals concentrations (CON) in the final solutions were determined using (Shimadzu model 6401F, Japan). All solvents and chemicals used were analytical reagent grade. The instrument was calibrated using metal standards for each element being analyzed.

Table 1: Description of the studied location/ zones

Sample No.	**Sampling zones**	**Site Description / Source of air pollution**	**No. of vehicles/hr**	**traffic volume**
ZH (ZH1-ZH4)	Zakho highway	Agricultural, urban, agricultural fields, with some educational institutes. / Urban contaminates	1440- 1650	very high traffic volume (100 m street)
BH (BH1-BH4)	Barzan highway	Agricultural, urban, some recreational areas, some Health Centers and residential areas. / Urban contaminates	1124 - 1276	high traffic volume.
ZWM (ZWM1-ZWM4)	Zakho Way Road/Near Malta	Industrial, Agricultural, urban/ Industrial and Urban contaminates/ Power station (Elect. generators)	1002- 1093	medium traffic (60 m street)
ZWU (ZWU1-ZWU4)	Zakho Way Road/Near UOZ	Residential, Commercial/ Urban contaminates/ Power station (Elect. generators)	485-598	low traffic volume (40 m street)
VLT(VLT1-VLT 4)	Near Galy Way	Residential/ Urban contaminates	5-8	very low traffic volume (sub-street)

3. Results and Discussion

The measured pH values of DS are shown in Table 2. The pH value is an important parameter to measures alkalinity or acidic nature of dust/soil. During the present investigation, the pH of soil fluctuated from 6.8±0.4 to 8.8 ±0.3. It is known that road dust is a complex mixture of particles from a number of natural (e.g. mold spores and pollen fragments, etc.) and anthropogenic sources (which may be contain carcinogenic components and heavy metals from exhaust and non-exhaust processes), so many gases, and metals released as a combustion product in the accumulators of motor vehicles or in carburetors [15]. Therefore, road dust can subsequently become re-suspended by wind or by passing vehicle-induced turbulence or shearing stress of the tires [21].

Table 2: The measured pH values of road dust samples.

Sampling zones	ZH	BH	ZWM	ZWU	VLT
pH	8.2±0.7	7.5±0.5	6.8±0.4	8.8±0.3	8.5±0.2

Figure (2) shows variation of Pb, Zn, Ni, Cd and Co concentrations (CON) in road dust at several location in DC. The Pb CON varied from 25.1 to 169.1 mg/kg with a higher mean value (MV) observed in the industrial zone (i.e. workshops for vehicles, welding of metals, etc.). The motor vehicles burning leaded gasoline (that contains tetraethyl lead as an anti-knock agent) can be considered as the main source of the Pb pollution in the soils of the study zone [14]. Previous studies indicated that road traffic can be contribute to airborne metals through different pathways, e.g. combustion products from fuel, wear products from tires, brake linings and road construction materials, and re-suspension of road dust [22, 23]. As the number of vehicles in DC city is on the increase in the past decade (e.g. No. of vehicles in Duhok on 2002 was ~20000, and it was ~ 130277 vehicles, on 2010. So there were tremendous traffic growth in Duhok. It was ~ 25 % between 2002 and 2010) [24]. Traffic has become a very important source of HM and other environmental pollutants. Emissions from heavy traffic contain potentially toxic metals such as Pb, Zn, Ni, Cd, and Cu [25-27]. Higher CON of Zn in road dust at heavy traffic zones have been found. The Zn CON varied from 90.6 to 559.2 mg/kg with a higher MV observed in the industrial area. Zn may have originated from wear and tear of vulcanized vehicle tires, and corrosion of galvanized automobile parts [28].

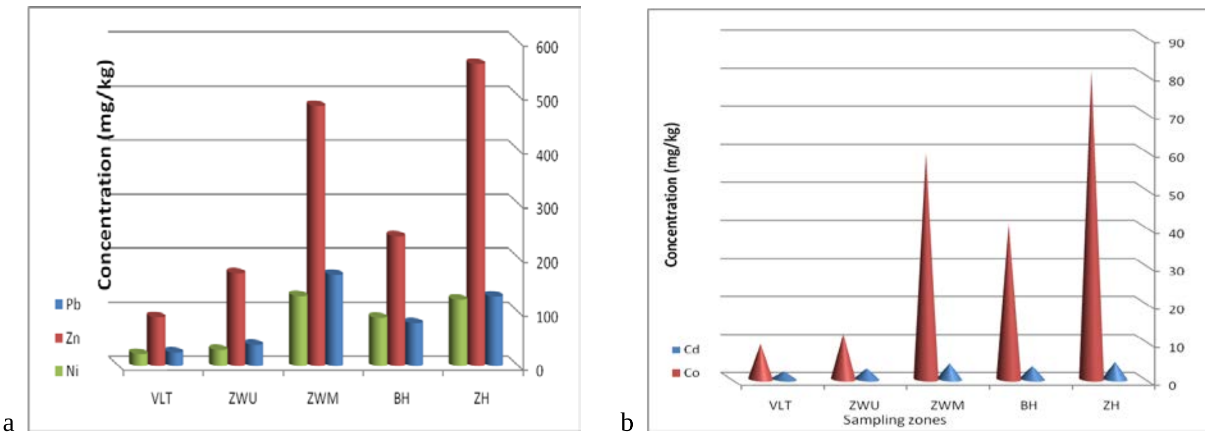

Figure 2: Variation of Pb, Zn, Ni, Cd and Co concentrations in several cities.

The Ni CON varied from 22.4 to 129.5 mg/kg with a higher MV observed in the industrial cite. Ni pollution on a local scale may be caused by emissions from vehicle engines that use Ni gasoline and by the abrasion and corrosion of Ni from vehicle parts [29]. Ni pollution on a local scale is caused by emissions from vehicle engines that use. Cd is released as a combustion product in the accumulators of motor vehicles or in carburetors (Divrikli et al., 2003 In this research, Cd CON were found to be within acceptable value. Naturally in soils, acceptable values of Cd is around (3 mg/kg) [30]. The results showed that all heavy metal CON except Cd and Co, are higher than acceptable values in natural soils. High CON of these elements could be attributed to anthropogenic effects related to traffic sources. The Percentage increase in the heavy metal concentration (PIMC) in roadside dust in several location of DC can be given in Table -3. The relative increase in CON of the individual metals in the SD of both urban and industrial areas were, respectively, 35.96%, and 85.15% for Pb, 21.84% and 84.36% for Co. The distribution of PIMC of individual measured metals were found to follow the pattern of Co > Zn > Ni > Pb > Cd at crowded roads of high traffic volume (ZH, and BH). While there was higher PIMC of Pb at ZWM (Industrial cities, workshops for vehicles, electrical power generators). Pb and Zn were the abundant metals in this industrial area. Summary statistics of CON of HM in dust collected from DC is given in Table -4. The arithmetic mean CON of Pb and Zn was ~ 88.3., and 308.9 respectively. Table-4 shows that the CON of Zn is the highest CON in DC as compared to other heavy metal CON. These values indicate that road dust is moderately contaminated with respect to Pb and Zn. The results indicated that metal pollutants in dust of DC did not originated from common anthropogenic sources, e.g. probably, automobile and the welding of metals as well as construction works are the major sources for metal pollutants, for DS at ZWM.

Table 3: Percentage increase in the metals concentrations (PIMC) in several cities in DC

Metals	Sampling zones			
	ZH	**BH**	**ZWM**	**ZWU**
Pb	80.48	68.42	85.15	35.96
Zn	83.79	62.31	81.18	47.23
Ni	81.72	74.93	82.7	24.83
Co	56.52	42.85	52.38	28.57
Cd	56.52	42.85	52.38	28.57
% increase in of the metal	Co >Zn>Ni>Pb>Cd	Co>Ni>Pb>Zn>Cd	Pb >Co>Ni>Zn>Cd	Zn>Pb>Cd>Ni>Co

Table 4: Descriptive statistics of heavy metal CON (mg/kg) in the study areas in DC

Metal	Minimum	Maximum	Median	Mean	S.D
Pb	25.1	169.1	79.5	88.28	54.12
Zn	90.6	559.2	240.4	308.68	180.89
Ni	22.4	129.5	89.35	78.73	45.13
Co	9.3	81.2	40.8	40.54	27.6
Cd	2	4.6	3.5	3.42	0.94

Large standard deviations (S.D) were found in all HM levels. This indicates the wide variation of CON in Local dust. It is evident that the automobile exhaust emission and vehicle tire wear contributed significantly to the HM accumulation in the road dust. The obtained results in this work were compared to the literature values in some cities around the world (Table 5). The results showed that the CON of the elements in the DC was lower than in India [31]. The values of Pb, Zn, and Cd in this study were lower than the studies carried out in London, UK [32]. Also, the values of Pb, Ni, and Cd in this study were lower than the studies carried out in Tokat, Turkey [33]. Results of the study carried out in Amman, Jordan [34], were rather close to the values in this study, except for Cd and Pb. As shown in Table-5, it could be seen in general that CON of Pb, Zn, Ni, Co, and Cd, MV in other locations of the world. The variation in the CON levels was presumably due to the difference in the traffic density, land use patterns, human activities, industrial activities, and may be due to weather patterns. The difference in road design and driving conditions can also influence the amount of metal CON among these sites.

Table 5: Heavy metal concentrations in street dust in some cities worldwide (mg/kg)

Site	Cd	Co	Cu	Ni	Pb	Zn	Reference
Duhok city, Iraq	3.42	40.54	ND	78.73	88.28	308.68	This study
London, UK	3.5	ND	155	ND	1030	680	[32]
Jeddah, KSA	2.24	ND	125.52	39.71	70.36	340.85	[22]
Beijing., China	0.73	ND	107.7	36.1	71.7	238.6	[35]
Amman, Jordan	1.7	ND	177	88	236	358	[34]
Tokat, Turkey	5.4	22	38	128	266	98	[33]
Delhi, India.	15.8	ND	230	130	205	330	[31]
Yazgat Turkey	10.9	26.1	66.7	57	165.5	ND	[15]
Erbil, Iraq	1.432*	ND	27.717 *	ND	0.4725 *	243.327*	[36]

4. Conclusions

The relative Percentage increase in CON of the individual metals in the street dust of both urban and industrial areas in DCwere, respectively, 35.96%, and 85.15% for Pb, 21.84% and 84.36% for Co. In this research, the mean metal CON values in DC are arranged in the following order Co > Zn > Ni > Pb > Cd at crowded roads of high traffic volume (ZH, and BH). While there was higher PIMC of Pb at ZWM (Industrial cities, i.e. workshops for vehicle, elect. power generators). The results in the present study confirmed that the main reason of high CON of heavy metals localized in industrial and in urban roadsides are either related to industrial activity or the density of the traffic. The elevated CON of Zn and Ni can be attributed to the impact of motor vehicle emissions on the surrounding atmosphere as mentioned before. Zn particles may be derived from industrial sources, with the abrasion of tires of motor vehicles a possible second source. The obtained results in this study were compared to the literature values in major cities around the world (Table 5).

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