

# Bioaccumulation and health risk assessment of severe metal pollution of street dust from various urban regions in Baghdad, Iraq

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**Abstract.** This study sought to define the metals bioaccumulation from street dust in Baghdad, Iraq for the first time. The samples were collected that research the levels, sources, and health hazard model Cd, Cr, Zn and Cu. The geo accumulation Index (Igeo) found that the contamination level for Cd was moderately to strongly polluted in Karada, Jihad and Kinidi streets. Hence, it is important to measure the level of cadmium in the local environment. The relative bioaccumulation of chromium was high in Jadriyah Street (87.2%). The PCA showed two major sources of these minerals in Baghdad road dust that Cd, Zn are likely to originate from tire wear, brake wear and vehicular emissions as well as the fact that Cr and Cu originate from metal-processing industries. Assessing hazard to human health utilized measure population show suggested both non-carcinogenic and carcinogenic hazards minerals Baghdad road dust harmless to human environment.

## 1 Introduction

Industrialization and urbanization in Baghdad are major sources of air contamination constituting heavy metal content in urban dust due to human activity, such as traffic exhaust fumes, garbage, city construction, power generation plants and industrial production that are giving way to the reduction of the quality of urban environments [1]. Many developed countries suffer from various grades of weighty metal pollution in road dust, caused through anthropogenic, natural factors [2]. Furthermore, weighty metals could collect in urban street dust through point and non-point pollution sources through absorption and atmospheric deposition [3]. As a consequence, necessarily to check heavy metal pollution/contamination heavy populated cities.

Several researches in road dust concentrate on weighty Minerals contents, researchers found metals in road dust higher than those in soil, trace elements in street dust perhaps facily absorbed by people over assimilation, inspiration and touching the skin [4].

Therefore, the dust in urban cities can be harmful for human health especially in densely populated urban settings. Although many studies have proven heavy metals pollution in streets [5], metals bioaccumulation investigations are important to the assessment of environmental and health risks. Using bioaccumulation is accurate and more feasible to measure the health risks as heavy metals dissolve in gastrointestinal fluid and simulate Biochemistry situations in people digestive [6].

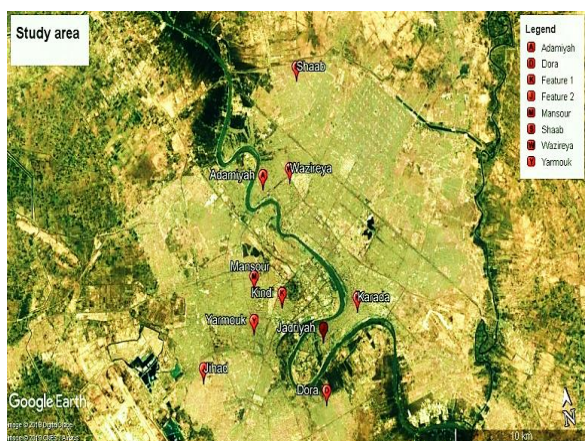
This research, we present the results of a quantitative measurement of metal bioaccumulation from Baghdad. Therefore, this study objective is (i) to define the sources and concentration of total and bioaccumulation of minerals in road dust in various civilian environments Baghdad - and (ii) to estimate health hazards to people in Baghdad.

## 2 Materials and methods

### 2.1 Search space

Baghdad capital and great city in Iraq, with a population of about 8.7 million. The urbanization and industrialization in the city has led to increasing numbers of vehicles on the roads. Moreover, rebuilding efforts in Iraq devoted to the reconstruction/rehabilitation and repair of sorely damaged urban infrastructure can contribute to higher levels of dust in the atmosphere/environment/air. Baghdad has three power plants and around 16 industrial what? That includes oil refinery, chemical, steel mill, cement plant, textile, plastic manufacturing. The climate in Baghdad is arid to semiarid and dry and hot in summer (50°C) cool in winter (4°C); Annual rainfall nearly 151.8mm (Al-Adili, 2005). Samples were collected from different Baghdad suburbs including: Yarmouk (S1), Adamiyah (S2), Shaab (S3), Wazireya (S4), Mansour (S5), Kindi (S6), Jihad (S7), Jadriyah (S8), Dora (S9), Karada (S10) (Figure 1).

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**Fig.1.** Sampling location at Baghdad city, Iraq

## 2.2 Street dust sampling

The street dust was collected according to Trujillo-González [7]. The street dust samples (n=30) were collected in April and May 2018. The sites, designation, description, and coordinates of samples collected are shown in Table.1. A frame of 0.25 m<sup>2</sup>, clump and a plastic scoop were utilized gather the dust elements from Baghdad streets. Polyethylene bags were used to store dust samples collected. The bags were labeled and carefully transported to the laboratory. In order to get a uniform mass of samples, the dust was desiccated at room heat and identical 2 mm colander based on former test [8].

**Table 1.** The coordinates and characterization for all specimen centers

Centers	Specimen centers	Coordinates	Characterization
1	Yarmouk	33°17'44.22"N 44°20'29.27"E	Hospital area
2	Adamiyah	33°22'6.16" N 44°21'44.19"E	Residential area
3	Shaab	33°25'14.30"N 44°23'58.48"E	Residential area
4	Wazireya	33°22'8.51" N 44°23'4.71" E	Industrial area
5	Mansour	33°19'3.09" N 44°20'44.76"E	Commercial area
6	Kindi	33°18'21.92"N 44°22'0.32" E	Hospital area
7	Jihad	33°16'32.96"N 44°17'47.51"E	Commercial area
8	Jadriyah	33°17'2.79" N 44°23'48.76"E	Residential area
9	Dora	33°15'7.12" N 44°23'36.95"E	Power generation plant
10	Karada	33°17'46.19"N 44°25'37.64"E	Commercial area

## 2.3 Sample digestion and analysis

The samples of dry dust (0.5 g) were screened from a 75 µm network sieve and a 10 mL solution of 3: 1 mixture (HCl / HNO<sub>3</sub>) was used to digest the samples combine to all experiment pipe. The pipe mixtures were neglect to room heat throughout the night to avoid lost minerals. The tube test of the samples was wrapped in air capacitor,

heated at 80 ° C two hours. Samples were then filtered into 50 mL sterile flasks [9]. The samples were then cooled and specimens w mingled 50 mL double distilled water (DDW). SBET performed using dust-dried air (0.5 g) with a sieve (75 microns) in dismiss pipe. Specimens mingled 50 mL of the gastric sol 0.4 glycin pH = 1.5. intensified hydrochloric acid. two tubes were finally rotated 30 rpm one hour at 37 ° C centrifuged 3500 g 15 min. extract samples were then purified over 0.45 µm drum candidate of acetate. After pH determination, contagious sol samples preserved in the fridge 4 ° C. Dust specimens measured concentrations of trace minerals using acetylene atomic absorption flame.

The data obtained are displayed on dry weight basis (mg/kg dry weight). All glass wares were soaked in acid wash (10 % HNO<sub>3</sub>) for at least 24 h to avoid contamination and later rinsed with double distilled water and air dried before use. Quality and quantity insurance of heavy metals analysis were conducted to ensure setting and regulation of the analytical method, through generated calibration curves by analyzing multiple-level calibration standards Blank was used to zero the instrument and a quality control samples were analyzed after every four samples during metal analysis.

## 2.4 Health risk assessment

Due to residents livening close the main streets of Baghdad the health hazard estimation was conducted present research in order to enumerate detection metals hazard to human from dust via ingesting contaminated. The chemical every day assimilation (CDI) (mg kg<sup>-1</sup> day<sup>-1</sup>) of metals from assimilation of street dusts was calculated based on following equation:

$$CDI = C_{dust} \times \frac{EF \times ED \times IR}{BW \times AT} \times 10^{-6}$$

Where IR assimilation average 200 mg/day dust daily per kids and 100 mg daily per adolescents, detector hesitancy (EF) at 350 days year<sup>-1</sup> [10], the exposition period (ED) was 6 years for children and 30 years for adults, body weight (BW) per kids was 15kg and 70Kg per adolescents calculated of rate time (AT) was ED × 365 no carcinogens and 70 × 365=25,550 days for carcinogens.

Possibility carcinogenic and non-carcinogenic hazards per single minerals evaluated US EPA (2007) protocol and followed by [11] utilizing next one formulas:

$$\text{Carcinogenic hazard (CR)} = CDI \times RBA \times CSF$$

$$\text{Risk division (HQ)} = (CDI \times RBA) / RfD$$

$$RBA\% = \frac{SBET_{Metal}}{\text{Contant metal}} \times 100$$

$$HI = \sum HQ_i$$

Signal dosage (RfD) (mg kg<sup>-1</sup> day<sup>-1</sup>) and cancer decline factor (CSF) (mg kg<sup>-1</sup> day<sup>-1</sup>) were calculated according to U.S. Environmental Protection Agency United States Department of Energy. Accordingly, the values of RfD were 0.0010 for Cd, 0.0030 for Cr, 0.3 for Zn and 0.037 for Cu [12], while values of CSF were 6.3 for Cd, and 5.00E-01 for Cr. The calculated of prorated bioaccumulation adjustment (RBA) based on the rate of clearly bioaccumulation essence test (SBET) heavy metals extracted to their total concentrations in dust.

Risk division (HQ) rate indicate to beginning reference rate proposed by US EPA as the admissibility for non-carcinogenic health impacts. If HQ ≤ 1, indicates

innocuous health influences and if  $HQ > 1$  suggested hurtful health influences. HI rate overall HQs and reveals the overall hazard of non-carcinogenic for solo poisonous mineral and again If HI less than one, refers to no hazard of non-carcinogenic influences, If HI more than one, points to non-carcinogenic effects [13].

### 2.5 Statistical analysis

Multivariate approaches were utilized to distinguish pollutant sources of minerals in road dusts through principal component analysis [14]. Pearson correlation ( $r_2$ ) between weighty minerals in the road dusts was accomplished in research. All mathematical and statistical computations on the dataset resulted utilizing SPSS 19.0 software (Chicago, Illinois, USA).

## 3 Results and discussion

Whole bioaccumulation metals levels in street dusts of Baghdad Mean concentrations of total and bioaccumulation of Cd, Cr, Zn and Cu from all the collection sites are presented in Table. 2. Zn Most prolific metals in streets dust succeed Cu, Cr and Cd, It has been noted that streets dust was significantly contributed to weighty mineral condensation grades in streets of civilian regions [15]. In general, Zn and Cr concentrations were found to be higher in streets of Adamiyah city (26.65 mg/kg) and the lowest level was in streets of Karada city (2.57 mg/kg). However, the results were lower than those reported in Tehran streets (Iran), Delhi streets (India) and Baoji streets (China) [16]. Weighted bioaccessible Zn condensations all specimens are much decrease than general Zn condensations ranging from highest in Jadriyah Street (16.58 mg/kg) to less Karada Street (0.12 mg/kg), increasing of Bio-Zn in study area is because high anthropogenic actions like battery factories ,oil refinery which are concentrated in these locations. Cd was higher in Kinidi and Jihad streets than in other locations. In contrast, the minimum concentration of Cd (0.09 mg/kg) was in Shaab Street. Moreover, Bio-Cd was also high in the same streets (0.24, 0.30 mg/kg) due to these sites being closer to commercial activity or chemical industries which are more affected by extensive human activities. The concentrations of total and bioaccumulation of Cu were high in Dora streets (24.22; 18.75 mg/kg) that because metal-processing and power plant generation in the Dora city as well as brake abrasion from frequent brake use can be associated with increasing Cu level in the street [17].

In order to know level of metals contaminations in street dusts, we used Geo accumulation list (Igeo) suggested by Müller (1979) and which also utilized to evaluate grade of minerals pollution from civil street dusts [4,10,13]. The Igeo illustrated utilizing next one form (Müller, 1979):

$$I_{geo} = \log_2 \left( \frac{C_n}{1.5B_n} \right)$$

**Table 2.** Total and bioaccumulation of metals condensations in Dusts Roads in various cities in Baghdad (mg/kg)

Sites	Cd	Bio -Cd	Cr	Bio -Cr	Zn	Bio -Zn	Cu	Bio -Cu
Yarmo uk	0.04	0.04	5.68	4.72	14.87	3.58	8.42	3.30
Adamiyah	0.39	0.06	22.40	15.58	26.65	13.88	1.43	0.49
Shaab	0.09	0.04	1.56	0.59	18.52	2.49	17.31	11.33
Wazir eya	0.13	0.06	2.87	1.07	10.12	5.79	1.66	0.59
Mansour	0.03	0.01	2.38	1.31	15.97	3.29	5.55	2.07
Kindi	1.36	0.24	3.67	2.10	7.14	4.30	14.35	8.72
Jihad	1.60	0.32	2.22	1.51	6.62	2.75	11.78	6.96
Jadriyah	0.08	0.04	11.53	10.06	19.58	16.58	8.81	3.63
Dora	0.05	0.01	4.28	3.37	9.18	5.70	24.22	18.75
Karada	1.81	0.88	8.12	3.77	2.57	0.12	4.56	0.29
Total mean	0.55	0.15	6.47	4.40	13.12	5.48	9.80	5.61

Cn calculated condensation of studied element n in dust and Bn Geochemistry setting rate of items n of rate shale. Seven various grades of geo-accumulation list with connected dusts street dirtiness are given in the Table. 3.

It has been showed that the concentrations of cadmium in the streets of Kennedy, Jihad and Dora were significantly higher than average rock rates, and based on Igyo found moderately contaminated to strong pollution on the same streets suggesting that human resources have a severe impact on the quality of these functional areas [18]. In addition, some weather conditions such as high temperature as well as reconstruction of the infrastructure of the city of Baghdad, lead to the wear of pots, dikes, bulbs and wall, often includes weighty minerals like Zn, Cu, Cd and Cr, in the end, can lead These include emission of minerals into civilian climate and summation of dust in urban streets [19]. Hence, the region should pay attention to pollution in the future. On the other hand, Igeo of Cr, Zn, and Cu were at all sites of class 0 and <0 and therefore indicated that street dust could be considered unsaturated for these metals.

The relative availability of weighty minerals defined as rate of metals that can be obtained with respect to their total minerals, showed the contamination of absorbed minerals through the ingestion of dust as shown in Figure. 2. R-Bio-Cd in the streets of dust, 1.70 and 51.8%, while R-Bio-Cd showed high among these sampling sites in Al-Shaab Street. The value of R-Bio-Cr ranged from 37.4% to 87.2% and R-Bio-Cr was recorded high on Al-Jadriya Street. This may be related to social and economic procedures occurring in the trade section, there is great amount of length. constructing and height inhabitance intensity in the city of Baghdad [19]. Access to minerals in street dust from Iraq has not been reported for comparison with previous studies. Therefore, outcomes of research were contrast with different global studies. Relative ratios of zinc and

copper that showed less than zinc and copper access (more than 90%) of road dust and soil were recorded on the side of the road along a semi-urban area, Italy [18]. However, our results from Vital Bio Cr were higher than CR (5.83%) of urban street dust in the mega city, Nanjing, China [19].

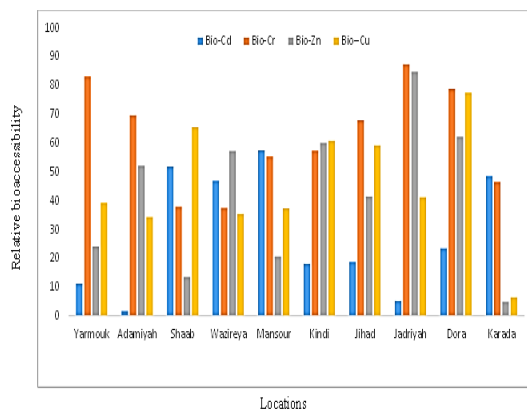
**Table 3.** The Igeo and classes of metals in Baghdad streets dust

Sites	Cd	Cl as s	Cr	Cl as s	Zn	Cl as s	Cu	Cl as s
Yarmouk	- 3.3 7	0	- 4. 57	0	- 3. 26	0	- 3.0 0	0
Adamiyah	- 0.1 9	0	- 2. 59	0	- 2. 41	0	- 5.5 6	0
Shaab	- 2.3 2	0	- 6. 43	0	- 2. 94	0	- 1.9 6	0
Wazireya	- 1.7 9	0	- 5. 55	0	- 3. 81	0	- 5.3 4	0
Mansour	- 7.0 7	0	- 5. 82	0	- 3. 15	0	- 3.6 0	0
Kindi	1.5 9	2	- 5. 19	0	- 4. 31	0	- 2.2 3	0
Jihad	1.8 3	2	- 5. 92	0	- 4. 41	0	- 2.5 1	0
Jadriyah	- 2.4 9	0	- 3. 54	0	- 2. 86	0	- 2.9 3	0
Dora	- 6.3 1	0	- 4. 97	0	- 3. 95	0	- 1.4 7	0
Karada	2.0 1	3	- 4. 05	0	- 5. 78	0	- 3.8 8	0
Average shale	0.3 0	0	90	0	95	0	45	0

### 3.1 Multivariate statistical analysis

Correlations and PCA analysis between heavy metals The Pearsons correlation coefficients (r2) and principal component analysis (PCA) weighty minerals in the street dust of Baghdad showed in Shape. 5. Significant positively correlation between Zn, Cd and Cr (-0.631, 0.600; p<0.01) respectively, indicated that major common source of metals are artificial performances like manufacturing, trade vehicular, traffic performances. Cu was negative correlated with Cr (-0.449; p< 0.05) and other correlated between metals was not showed relationship with each other indicated different sources of origin. PCA has been implemented to determine the proportion of contributions from various heavy metals sources to a particular sample of dust. The value of KMO experiment 0.43, and the Bartlett ball experiment statistically important (p <.000), mentioning information probably to be changeable. PCA Metal detected two components with a value greater than one eigenvalues. Two components were extracted,

accounting for 82.37% all difference, mentioning weighty mineral references can be split into two categories (Table 4). The first component of Cd and Zn consists of the fact that Cd and Zn originate from the same sources, and Zn can arise again from top tyres corrosion and erosion of wheel car accessories. Cadmium may also produce benzene compounds in the streets [20]. The second component consists of Cr and Cu, and this component formed the constituent components of man. Cr and Cu sources can be affected by metal processing industries and congested traffic.



**Fig. 2.** Extractable relative bioaccumulation of heavy metals from Street dust at Baghdad city

**Table 4.** Pearsons correlation coefficients and main ingredient test between weighty minerals (PCA cargos > 0.7 illustrated in bold)

	Cd	Cr	Zn	Cu
Cd	1			
Cr	-0.060	1		
Zn	<b>-0.631**</b>	<b>0.600*</b>	1	
Cu	-0.081	<b>-0.449*</b>	-0.233	1
Elements	Component			
	1	2	Communalities	
Cd	-0.927	0.144	0.880	
Cr	0.284	<b>0.836</b>	0.780	
Zn	0.842	0.447	0.909	
Cu	0.114	<b>-0.845</b>	0.727	
Eigenvalue	2.032	1.263		
% of variance explained	41.540	40.837		
% of cumulative	41.540	82.377		

\* p< 0.05

\*\* p< 0.01

### 3.3 Health hazard assessment of heavy minerals

In order to be determined the risk assessment, both carcinogenic and non-carcinogenic hazards was estimated to kids and adolescents from absorbing road dusts, health

hazard utilized to illustrated the population of the city was shown in Table. 5 and (Supplementary data Table S1).

Risk division (HQ) rate Cr and Cu for both adolescents and kids were high, between 0.0004 to 0.026 and  $25 \times 10^{-5}$  to 0.031 respectively but are lowest safe rate (HQ = 1) so far. Metals in street dusts for adolescents and kids are not likely non-carcinogenic health hazard (HI > 1), for adults, the HI values of the human exposure to dust for metals studied are represented by Cu > Zn > Cr > Cd and for children by Cr > Cu > Cd > Zn decreasing series [21].

The HI for non-carcinogenic effects in kids lowered because Cr > Cu > Cd > Zn, same order decreased for adults Cr > Cu > Cd > Zn, the HI of metals were less than the safe level, suggested that metals in street dusts of Baghdad city posed a little health risks. The high values for Cr in Baghdad street dusts may impose adverse health in the future for human population especially for children (0.47). The results of non-carcinogenic and carcinogenic hazards of minerals from Baghdad road dusts serious health assessment, due to used metals bioaccumulation concentrations is accurately and absolutely necessary to estimate health risks [22].

**Table 5.** Non-carcinogenic and carcinogenic health risk of weighty minerals in street dusts

Element	Concentration	HQ		HI ( $\Sigma$ HQ)		CR	
		Adolescent	Kid	Adolescent	Kid	Adolescent	Kid
Cd	0.55	3.33 E-04	0.006	3.33 E-03	0.006	3.18 E-07	5.93 E-07
Cr	6.47	0.0253	0.0473	2.54 E-01	0.473	8.38 E-06	1.56 E-05
Zn	13.1	0.0004	0.0008	0.004	0.008		
Cu	9.81	0.0034	0.0064	0.034	0.064		

## 4 Conclusion

The street dust in Baghdad has elevated levels of four -metals (Cd, Cr, Zn and Cu). The findings of this study indicated that Karada, Jihad and Kindi are highly contaminated by Cd -from street dust. An in vitro digestion model utilized to measure bioaccessible fraction of minerals in the road dust. R-Bio-Cd was quite low in the Karada Street and higher for R-Bio-Cr in Jadriyah Street. The different bioaccumulation values in Baghdad streets are associated with the differences in anthropogenic activities sources. The correlation coefficient and main ingredient test - employed to know possible references of weighty minerals studied in road dust. Cd, Zn are from the

same sources originated from tyre wear, brake wear-weighty transit, while Cr Cu originated from metal processing industries. Whole bioaccumulation of weighty minerals results were used in the calculation of human health risks, and HI (children and adults) was within safe levels. These results can help us to get a better insight into potential health risks to Baghdad residents [23].

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