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Heavy Metal Pollution in Surface Dust from Urban Squares in Suzhou, China: Total Concentrations, Speciation Analysis and Health Risk

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Abstract: An investigation of thirty dust samples collected form five squares in Suzhou was performed to analyze the concentrations and speciation distribution of heavy metals by ICP-OES and Tessier sequential extraction procedure, and to assess the associated human health risks, using the health risk assessment model (USEPA). Compared with the environmental background and existing standard, higher pollution level of Cd, followed by Pb, Cu and Cr, were recorded. Speciation analysis showed that Cu was abundant in the oxidizable (F4) and residual (F5) fractions, Pb was associated with the reducible (F3) and residual (F5) fractions, more than 90% of Cr existed in the residual fraction (F5), while Cd was mainly dominated by the reducible (F3) and acid-soluble (F2) fractions. Mobility factors (MF) of the four metals were followed the order of Cd>Pb>Cu>Cr. The results of exposure risk assessment indicated incidental ingestion of dusts was the dominant exposure route to local residents, Cr and Pb were the major source of health risk caused by exposing to square dusts. Both the calculated non-cancer risk (HI) and the carcinogenic risk values were all below the risk limits recommend by USEPA, suggesting little probability of posing health risk. However, children were found to be more vulnerable than adults, and their exposure risk value had reached 5.75×10^{-1}, which should be paid more attention.

Keywords: *Heavy metal, Dust, Urban square, Speciation analysis, Health risk*

1. Introduction

As an important part of urban environment, surface dust is the most pervasive and important factor affecting human health [1]. It often contains high concentrations of many pollutants, such as toxic heavy metals [2]. Heavy metals accumulated in urban dust have serious damage to the environment and public health because of their toxicity and non-degradability [3, 4], and are mainly derived from anthropogenic activities, such as industrial production, fossil fuel combustion, traffic and transportation, etc [5-7]. Toxicity characterizations of heavy metals are complex and strongly depend on their mobility and chemical speciation rather than the total concentrations [8, 9]. To acquire comprehensive cognition to the speciation feature of heavy metal, many different sequential extraction procedures, such as five-step [10] and three-step [11] (Community Bureau of Reference, BCR), have been created and used extensively in soils, dusts, sediments and plants [12-15].

Exposure to the metal-contaminated dust may cause human health issue through three pathways of ingestion, inhalation and skin contact [16]. Adverse health effects of urban dust were reported by many scholars [17-20]. These studies indicate that metal concentrations in dust from most cities reached significant levels of pollution and posed a significant threat towards the human health, especially for young children. Urban squares are used for leisure, sporting, or recreational activities and they are the commonest places of the outdoor activities for urban residents. Heavy metals in square dust can easily enter into human body during the leisure activities, and thus has an important impact on human health [1]. So it is necessarily to investigate the pollution situation and health risk of heavy metals in dust from urban squares.

In this article, thrity surface dust samples from five biggest squares in Suzhou City were collected and analyzed. Our specific objectives were to (1) investigate the concentrations and pollution status of Cu, Pb, Cr and Cd in square dusts; (2) analyze the speciation distribution and mobility of the above four metals; (3) assess the health risk posed by heavy metals in the square dusts.

2. Materials and Methods

2.1. Study Area

Suzhou, located in the northern part of Anhui Province of China, between latitude 33°18'N~34°38'N and longitude 116°09'E~118°10'E, with an area of 9,785 sq km. Suzhou is under the influence of a warm and semi--humid monsoons climate with a wide variation in temperature ranging from 32°C in summer to -2°C in

winter. The mean annual precipitation is of 800 mm. The central urban district of Suzhou covers an area of 110 sq km and has over 0.5 million urban residents.

2.2. Sample Collection and Pretreatment

On 25 March 2015, a total of 30 surface dust samples were collected from five biggest squares in Suzhou city (Fig 1): Municipal Square (MS), Science and technology square (SS), Train station square (TS), Delta park square (DS), Xuefeng park square (XS). At each square, 6 dust samples were gathered by sweeping using a rabbit hair brush and polyethylene tray from ground. All collected dusts were stored in clean sample bags and immediately transported to the laboratory of State Engineering & Technological Research Center for Coal Mine Water Disaster Prevention. Samples were air-dried, ground, sieved through a 100-mesh nylon sieve to remove coarse debris, and then stored in the sealable plastic bags before analysis.

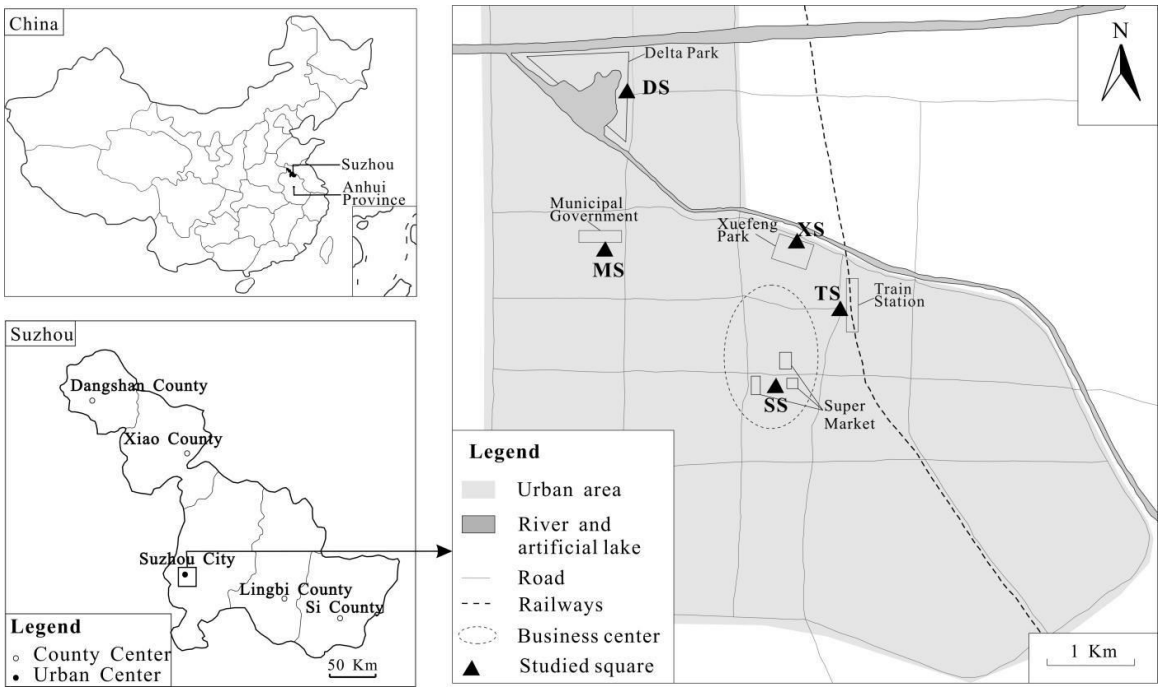

***Figure 1** Map of dust sampling sites*

2.3. Sample Analysis and Quality Control

2.3.1. Sample analysis

To analyze the total concentrations of heavy metals in the investigated samples, a portion (0.15g) of each dust sample was weighed and poured into a 50mL digestion tank, adding 8.0 mL of concentrated HNO_3-$HClO_4$ (4:1, v/v) and 6.0 mL of concentrated HCl. After initial reaction, the mixture was allowed to stand overnight. Then the tanks were placed in a graphite digester (SH230N, Hanon Instruments Co., LTD, China) and digested at the temperature of 170±5°C until the solution become transparent. The digested sample was transferred quantitatively to a 50 mL volumetric flask and diluted with 2% HCl solution for later determination. Total concentrations of Cu, Pb, Cr and Cd in the digested solution were determined by inductively coupled plasma optical emission spectrometry (ICP-OES).

2.3.2. Sequential extraction

Various chemical fractions of Cu, Pb, Cr and Cd in dusts were extracted using the Tessier sequential extraction procedure [10]. Each fractions, defined by the Tessier method, of heavy metals were as follows:

Exchangeable fraction (F1): 1.0 g dust sample was prepared in polyethylene centrifuge tube and mixed with 8 mL of 1.0 mol·L^{-1} $MgCl_2$ (pH of 7.0), the mixture was incubated at 25°C for 1 h with continuous shaking of 150 rpm;

Acid-soluble fraction (F2, bound to carbonates): 8.0 mL of 1.0 mol·L^{-1} CH_3COONa (pH of 5.0) was mixed with the residue from the F1 extracting process, the mixture was incubated at 25°C for 5 h with continuous shaking of 150 rpm;

Reducible fraction (F3, bound to Fe-Mn oxides): 20 mL of 0.04 mol·L^{-1} NH_2OH·HCl in 25% acetic acid (v/v) was mixed with the residue from the F2 extracting process, the mixture was incubated at 96°C for 6 h with continuous shaking of 150 rpm;

Oxidizable fraction (F4, bound to organic matter): 3.0 mL of 0.02 mol·L^{-1} HNO_3 and 5.0 mL of 30% H_2O_2 were mixed with the residue from the F3 extracting process (adjusting pH to 2.0 with nitric acid), the mixture was heated to 85°C for 2 h with intermittent shaking, and then an addition 3.0 mL of 30% H_2O_2 was added into the tube, heating was performed again at 85°C for 3 h. After cooling to room temperature, 5.0 mL of 3.2 mol·L^{-1} CH_3COONH_4 in 20% HNO_3

(v/v) was added into the tube, and the extracted liquid was diluted to 20 mL and continuously shaken for 30 min;

Residual fraction (F5): the residual fraction of Cu, Pb, Cr and Cd in dust was calculated by the difference between total concentration and the sum of the above four fractions.

After each extraction process, the supernatant liquid was separated from solid phases by centrifugation at 4000 rpm for 10 min, and decanted into volumetric flask carefully to avoid loss of the solid residues. Then we diluted it to 50 mL with MilliQ water and stored it in a refrigerator at 4°C prior to analysis. The concentrations of Cu, Pb, Cr, Cd and Ni in different fractions were determined by ICP-OES.

2.3.3. Quality control

To avoid contamination during the process of sample preparation, all glassware and containers were previously soaked in HNO_3 (5%, v/v) for at least 24 hours, and then rinsed with MiliQ water for three times. The acids used in this experiment were of guaranteed grade, and the other reagents were of analytical grade. During the process of sample determination, reagent blanks were used for background subtraction and eliminate analytical bias. Each sample was determined with three replicates and the consistency of the repeated measured values was calculated to be 92.58%.

Table 1 *Pollution categories based on the I_{geo} value*

Classification	I_{geo}	Pollution categories
0	≤ 0	Clean
1	0-2	Slight
2	2-3	Moderate
3	3-4	Partially serious
4	4-5	Serious
5	>5	Severe

Table 2 *The implications and selected values of the parameters in health risk model*

Parameter	Implications	Units	Children	Adult
C_{UCL}	Upper limit of the 95% confidence interval for the mean concentration of heavy metals	mg/kg	95%UCL	95%UCL
IngR	Ingestion rate of dust particles	mg/day	100	200
InhR	Inhalation rate of dust particles	m^3/day	7.6	20
EF	Exposure frequency	day/year	180	
CF	Conversion factor	kg/mg	1×10^{-6}	
ED	Exposure duration	year	6	24
BW	Average body weight	kg	15	55.9
AT	Average exposure time	day	ED×365 (no-cancer) 70×365 (carcinogenesis)	
PEF	Emission factor of dust particles	m^3/kg	1.36×10^{9}	
SA	Average superficial area of exposed skin	cm^2	899	1701
SL	Skin adhesive capacity	mg/cm^2·d	0.2	0.07
ABS	skin absorption factor	unitless	0.001	

2.4. Data Analysis

2.4.1. Geo-accumulation Index

The geo-accumulation index (I_{geo}) [21] was used to assess the pollution level of heavy metals in surface dust. It is calculated by the following equation (1):

$$I_{geo} = \log_2 \frac{C_i}{1.5 \times B_i} \qquad (1)$$

Where C_i (mg/kg) is the measured concentration of element i in dust sample, B_i (mg/kg) is the background values of the element i, and 1.5 is modified coefficient used to offset the influence of sedimentary characteristics and litho logical variations. Based on the value of I_{geo}, six pollution categories can be classified and listed in Table 1.

2.4.2. Mobility factor

The mobility of Cu, Pb, Cr and Cd in surface dust was evaluated according to an index which is called mobility factor (MF). The MF value is calculated as the radio of the potential bioavailable forms (F1+F2: exchangeable and acid-soluble fraction) to the sum of all fractions. The equation is given as follows:

$$MF = \frac{F1 + F2}{F1 + F2 + F3 + F4 + F5} \qquad (2)$$

A high MF value indicates that metals can be easily released into the surface ecological environment and posing a great potential toxicity to the local inhabitants.

2.4.3. Health Risk Assessment

The Soil Health Risk Model in United States Environmental Protection Agency (USEPA) Exposure Factors Handbook is internationally adopted in the currently studies that focused on the health risk of heavy metals in dust [22].

According to the USEPA, three main potential exposure pathways to heavy metals in soil or dust are identified as follows: (1) incidental ingestion of dust particles, (2) inhalation of resuspended dusts, and (3)

absorption of dust particles adhered on skin surface. Chemical daily intake (CDI, mg/kg·day) of heavy metals through the above mentioned pathways can be individually calculated based on the following equations (3)-(5). Additionally, Cr and Cd can also cause a risk of cancer induction, and only the carcinogen risk for inhalation exposure modes is considered in the assessment model. Referring to the relevant literature, the life time average daily dose (LADD, mg/kg·day) for the inhalation exposure pathway of carcinogens was used in this study for the assessment of cancer risk and calculated by equation (6).

$$CDI_{ing} = C_{UCL} \times \frac{IngR \times EF \times ED}{BW \times AT} \times 10^{-6} \quad (3)$$

$$CDI_{inh} = C_{UCL} \times \frac{InhR \times EF \times ED}{PEF \times BW \times AT} \quad (4)$$

$$CDI_{derm} = C_{UCL} \times \frac{SA \times SL \times ABS \times EF \times ED}{BW \times AT} \times 10^{-6} \quad (5)$$

$$LADD_{inh} = C_{UCL} \times \frac{EF}{PEF \times AT} \times \left(\frac{R_{inhchild}}{BW_{child}} \times ED_{child} + \frac{R_{inhadult}}{BW_{adult}} \times ED_{adult} \right) \quad (6)$$

Where, CDI_{ing}, CDI_{inh} and CDI_{derm} represent the daily average intakes of heavy metals exposed to from square dust through ingestion, inhalation and skin absorption, respectively (mg/kg·day). $LADD_{inh}$ is the lifetime average daily exposure levels for a risk of cancer from heavy metals in dust through inhalation (mg/kg·day). The implications and selected values of the other parameters in the above formulas were presented in Table 2.

Based on the above-mentioned intakes that calculated for each element through each exposure pathway, both the no-cancer and cancer risk of heavy metals were quantitatively assessed with equations (7)-(10).

$$HQ_{ij} = \frac{CDI_{ij}}{RfD_{ij}} \quad (7)$$

$$HI = \sum HQ_{ij} \quad (8)$$

$$Risk_i = LADD_i \times SF_i \quad (9)$$

$$Risk_T = \sum Risk_i \quad (10)$$

Where, HQ_{ij} and RfD_{ij} represent the no-cancer risk value and maximum allowable dose level of a particular heavy metal through specific exposure pathway, respectively. HI is the sum of all the HQ for each element through each exposure pathway. If HQ or HI≤1.0, it can be considered that no obvious potential risk for exposure to dust, whereas a HQ or HI>1.0 indicates that the no-cancer risk exists and should be concerned. $Risk_i$ is the cancer risk value of certain polluting element through inhalation, and SF_i is the slope coefficient. $Risk_T$ is the total cancer risk of all heavy metals, and when $Risk_i$ or $Risk_T$ ranges from 10^{-6} to 10^{-4}, it suggests a greater probability of posing carcinogenic risk.

3. Results and Discussion

3.1. Total Concentrations of Heavy Metals in Dusts

Total concentration of heavy metals in dust samples collected from the investigated squares were listed in Table 3. As shown in Table 3, the average Cu, Pb, Cr and Cd concentrations were 67.38, 45.70, 58.11 and 0.77 mg/kg, respectively. Considering that there are no unified guidelines or regulations for heavy metals in dust currently, the soil background values of Anhui (BVA) and the National Secondary Environmental Quality Standards for Soil (EQS, GB15618-1995) were used for comparing, and results indicated that the average concentrations of all tested metals, except for Cr, were obviously higher than BVA, while only Cu and Cd were higher than EQS.

Among the five squares investigated, the highest mean metal concentrations appeared in TS (Cu, 79.89±6.27 mg/kg; Pb, 52.01±6.06 mg/kg) and SS (Cr, 94.99±40.69 mg/kg; Cd, 0.93±0.32 mg/kg). Both of the two squares are located in the city center, close to the main roads with heavy traffic and dense population, indicating that enrichment of heavy metals in surface dusts are mainly influenced by human activities and traffic pollution, which is coincident with the result reported by Zhang et al in small towns of Shanghai suburban area [23]. Additionally, MS had the lowest concentrations of Pb (42.650±2.163 mg/kg), and DS had the lowest concentrations of Cr (32.357±10.957 mg/kg) and Cd (0.656±0.034 mg/kg), while XS owned the lowest concentrations of Cu (55.250±6.460 mg/kg).

The geo-accumulation indexes (I_{geo}) of Cu, Pb, Cr and Cd in dust samples were calculated by Eq (1) and shown in Fig 2. From Fig 2, I_{geo} values of the four elements can be ordered as Cd>Cu>Pb>Cr and divided into three categories. Cd had the highest I_{geo} value of 2.39, and thus fell into the first category, showing that Cd in the square dust was moderate polluted and mainly relate to the human activities. The second category consists of Cu and Pb with the I_{geo} values ranges from 0 to 2. They were slightly enriched, and mainly originated from both the nature environment and human activities. Cr belonged to the third category with average I_{geo} value of -0.80 and no significant enrichment, indicating it was mainly originated from the natural environment, such as soil particles and soil parental materials.

3.2. Chemical Fractions and Mobility of Heavy Metals

The fractionation of Cu, Pb, Cr and Cd in the dust samples were shown in Fig 3. It was obviously that chemical fractions varied largely between different elements. For Cu, the dominant fraction revealed that 43.73% of Cu were retained in the oxidizable fraction (F4), indicating that the Cu was strongly influenced

by the organic contents in dusts. The second and third dominant fractions were that of residual fraction (F5, 31.67%) and reducible fraction (F3, 17.09%), only 4.09% and 3.42% of Cu existed in acid-soluble (F2) and exchangeable (F1) fraction, respectively. The Pb content in each fraction followed the order F3(44.48%)>F5(31.42%)>F2(12.73%)>F4(6.16%)>F 1(5.22%), and the largest percentage (44.48%) associated with the reducible fraction implied that Pb sorption on Fe-Mn oxides is probably the most important mechanism that controls the behavior of this element, because Pb can precipitate with metal oxides or can be adsorbed at the surface of metal oxide [9]. More than 90% of Cr existed in the residual fraction (F5), and for other fractions, percentages of Cr were 2.06% (F1), 2.31% (F2), 3.76% (F3) and 1.64% (F4), respectively. The strong association of Cr to the residual fraction indicated low activity and was probably due to the natural geochemical origin of Cr. Cd in the dust was mainly dominated by the reducible (F3, 36.46%) and acid-soluble (F2, 33.05%) fractions. The exchangeable (F1), oxidizable (F4), and residual (F5) fractions accounted for 14.87%, 9.17% and 6.45% of total Cd concentration. Like Pb, Cd also had a close affinity with the Fe-Mn oxides. Nevertheless, it was noted that the Cd in dust can be easier released in acidic conditions as the result of higher concentration in the acid-soluble fraction (F2).

Table 3 *Total concentrations of heavy metals in dusts from the investigated squares (mg/kg)*

Element	Index	MS (n=6)	SS (n=6)	TS (n=6)	DS (n=6)	XS (n=6)	Average	BVA	EQS
Cu	Max	90.91	100.15	86.58	113.30	61.73	67.38	20.4	50
	Min	14.18	25.78	74.15	14.70	48.81			
	Mean	67.53	67.65	79.89	66.54	55.25			
	SD	35.84	38.06	6.27	49.49	6.46			
Pb	Max	45.17	55.29	56.69	41.50	73.09	45.70	26.6	250
	Min	40.41	46.38	45.17	31.69	12.86			
	Mean	42.65	51.24	52.01	38.02	44.59			
	SD	2.16	4.51	6.06	5.49	30.24			
Cr	Max	65.77	134.48	76.44	44.80	62.71	58.12	67.5	150
	Min	44.07	53.20	46.90	24.17	39.93			
	Mean	54.97	94.99	56.95	32.36	55.25			
	SD	9.64	40.69	16.88	10.96	11.52			
Cd	Max	0.89	1.22	0.77	0.70	0.80	0.77	0.097	0.3
	Min	0.72	0.59	0.61	0.63	0.73			
	Mean	0.80	0.93	0.69	0.66	0.76			
	SD	0.07	0.32	0.08	0.03	0.03			

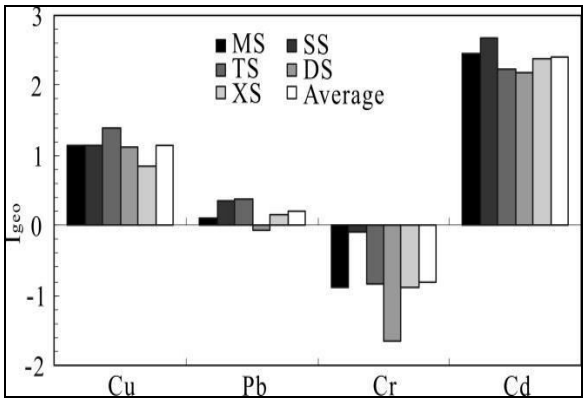

Figure 2 *Heavy metal enrichment with respect to* I_{geo}

Mobility and potential toxicity of heavy metals are mainly dependent on their existing chemical fractions [24]. In general, the exchangeable (F1) and acid-soluble (F2) fractions are the most potential active forms and usually regarded as the "mobilizable component". The mobility factors (MF) of Cu, Pb, Cr and Cd in urban dust were calculated by Eq (2) and the results were summarized in Fig 3. Compared with the other three metals, Cd displayed the largest MF value of 47.92%, providing a clear indication of high lability and biological availability of Cd in square dust. Pb had the second largest MF value of 17.95%, followed by Cu (7.51%) and Cr (4.37%). The mobility of the four metals in dusts was in order of Cd>Pb>Cu>Cr.

Table 4. *Chemical fractions of heavy metals in dusts from the investigated squares (mg/kg)*

Element	Square	F1		F2		F3		F4		F5	
		Content (mg/kg)	%	Content (mg/kg)	%	Content (mg/kg)	%	Content (mg/kg)	%	Content (mg/kg)	%
Cu	MS	1.42	2.10	2.892	4.28	13.840	20.50	31.235	46.26	18.141	26.86
	SS	3.11	4.60	2.675	3.95	9.571	14.15	28.003	41.40	24.286	35.90
	TS	1.90	2.38	2.788	3.49	12.039	15.07	38.503	48.20	24.654	30.86
	DS	3.99	6.00	3.340	5.02	12.624	18.97	26.935	40.48	19.648	29.53
	XS	1.13	2.04	2.041	3.69	9.251	16.74	23.382	42.32	19.450	35.20

	Average	2.31	3.42	2.747	4.09	11.465	17.09	29.612	43.73	21.236	31.67
Pb	MS	1.62	3.80	4.150	9.73	15.493	36.33	2.334	5.47	19.054	44.68
	SS	3.09	6.03	7.786	15.19	26.168	51.07	2.883	5.63	11.318	22.09
	TS	2.31	4.44	6.909	13.28	26.215	50.40	2.575	4.95	14.002	26.92
	DS	2.03	5.34	4.464	11.74	15.066	39.63	2.034	5.35	14.424	37.94
	XS	2.88	6.47	6.107	13.70	20.040	44.95	4.197	9.41	11.357	25.47
	Average	2.39	5.22	5.883	12.73	20.596	44.48	2.805	6.16	14.031	31.42
Cr	MS	0.58	1.05	0.623	1.12	1.687	3.04	0.743	1.34	51.953	93.46
	SS	0.59	0.61	0.721	0.75	2.181	2.28	0.827	0.86	91.443	95.49
	TS	3.02	5.25	3.311	5.77	1.224	2.13	0.919	1.60	48.926	85.24
	DS	0.47	1.44	0.549	1.67	1.353	4.12	0.737	2.24	29.730	90.53
	XS	1.04	1.93	1.210	2.25	3.895	7.25	1.168	2.17	46.402	86.39
	Average	1.14	2.06	1.283	2.31	2.068	3.76	0.879	1.64	53.691	90.22
Cd	MS	0.11	13.90	0.243	30.63	0.292	36.83	0.070	8.82	0.078	9.82
	SS	0.14	15.39	0.329	35.51	0.358	38.62	0.087	9.40	0.010	1.08
	TS	0.11	16.12	0.230	33.52	0.219	31.88	0.091	13.25	0.036	5.24
	DS	0.09	13.56	0.202	30.77	0.234	35.58	0.040	6.09	0.092	14.00
	XS	0.12	15.41	0.265	34.84	0.300	39.37	0.063	8.28	0.016	2.10
	Average	0.11	14.87	0.254	33.05	0.281	36.46	0.070	9.17	0.046	6.45

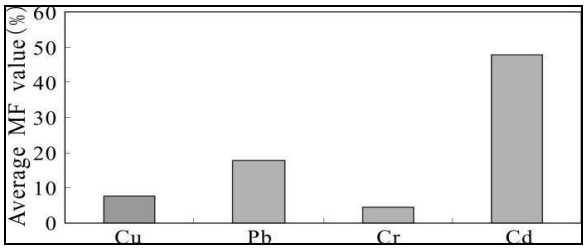

Figure 3*Mobility factors (MF) of heavy metals in dust*

3.3. Health Risk Assessment

The exposed dose of Cu, Pb, Cr and Cd through three different pathways of exposure were calculated using Eq (3)-(6) and given in Table 5. As shown in Table 5, the chronic daily intakes for both children and adults can be ordered as Cu>Cr>Pb>Cd, and the dominant exposure route was incidental ingestion of dusts, followed by skin absorption, and inhalation was the tertiary route of exposure. In addition, children had higher exposure level than adults, which means children were more vulnerable through each exposure pathway. Based on the exposed dose of heavy metals and Eq (7)-(8), the non-cancer risk posed by heavy metals in dust were calculated and shown in Table 6. The results indicated that the total non-cancer risk (HI) for both children and adults can be ordered as Cr>Pb>Cu>Cd. T.K.Rout et al [22] found that Cr and Pb in outdoor dust have larger HQ value and regarded them as the most potential harmful elements to human health. Similarly, the HQ values of Cr and Pb in our present study showed much higher level than other elements, accounting for 58.15% (Cr), 34.87% (Pb) of total non-cancer risk for children, and 58.61% (Cr), 34.47% (Pb) for adults. It suggested that Cr and Pb accumulated in dust were the major source of health risk caused by exposing to square dusts. As the result of that children are more prone to contact with dusts in sufficiently large doses, it can be also found that the non-cancer risk of exposure was higher in children than in adults, revealing children are more vulnerable and should be concerned because that is going to have a long-term adverse impact on their growth. Additionally, comparison between different exposure pathways showed the exposure pathway with highest HQ value was incidental ingestion, which accounted for 97.07% of total risks for children and 95.84% of total risks for adults. Overall, the total non-cancer risk values (total HI) of the four heavy metals in square dusts of Suzhou through the three exposure pathways were 5.75×10^{-1} for children and 7.82×10^{-2} for adults, not exceeding 1.0, just indicating that the health risk posed by heavy metals is relatively insignificant. However, there are also many other exposure sources (vegetable, meat, water and etc) of heavy metal intake, which may increase more health risk to urban inhabitants, so it is necessary to carry out comprehensive investigations involving other pathways in urban area as quickly as possible.

Table 5 *Chronic daily intake (CDI) of each heavy metal in the investigated squares*

Elements	C(95%UCL, mg/kg)	ADD_{ing} (mg/kg·day)		ADD_{inh} (mg/kg·day)		ADD_{derm} (mg/kg·day)		LADD (mg/kg·day)
		Children	Adults	Children	Adults	Children	Adults	
Cu	82.899	1.11×10^{-3}	1.48×10^{-4}	3.19×10^{-8}	1.44×10^{-8}	9.94×10^{-7}	1.77×10^{-7}	
Pb	52.316	6.98×10^{-4}	9.36×10^{-5}	2.02×10^{-8}	9.08×10^{-9}	6.27×10^{-7}	1.11×10^{-7}	
Cr	72.456	9.66×10^{-4}	1.30×10^{-4}	2.79×10^{-8}	1.26×10^{-8}	8.69×10^{-7}	1.54×10^{-7}	$1/19\times10^{-9}$
Cd	0.851	1.13×10^{-5}	1.52×10^{-6}	3.28×10^{-10}	1.48×10^{-10}	1.02×10^{-8}	1.81×10^{-9}	1.40×10^{-11}

Table 6 *Hazard quotient (HQ) for each heavy metal in the investigated squares*

	RfD_{ing}	RfD_{inh}	RfD_{derm}	Children				Adults			
				HQ_{ing}	HQ_{inh}	HQ_{derm}	HI	HQ_{ing}	HQ_{inh}	HQ_{derm}	HI
Cu	4.00×10^{-2}	4.00×10^{-2}	1.20×10^{-2}	2.78×10^{-2}	7.98×10^{-7}	8.28×10^{-5}	2.78×10^{-2}	3.70×10^{-3}	3.60×10^{-7}	1.48×10^{-5}	3.72×10^{-3}
Pb	3.50×10^{-3}	3.50×10^{-3}	5.25×10^{-4}	1.99×10^{-1}	5.77×10^{-6}	1.19×10^{-3}	2.01×10^{-1}	2.67×10^{-2}	2.59×10^{-6}	2.11×10^{-4}	2.70×10^{-2}
Cr	3.00×10^{-3}	2.80×10^{-5}	7.50×10^{-5}	3.22×10^{-1}	9.96×10^{-4}	1.16×10^{-2}	3.35×10^{-1}	4.33×10^{-2}	4.50×10^{-4}	2.05×10^{-3}	4.58×10^{-2}
Cd	1.00×10^{-3}	1.00×10^{-3}	1.00×10^{-5}	1.13×10^{-2}	3.28×10^{-7}	1.02×10^{-3}	1.23×10^{-2}	1.52×10^{-3}	1.48×10^{-7}	1.81×10^{-4}	1.70×10^{-3}
Total				5.60×10^{-1}	1.00×10^{-3}	1.39×10^{-2}	5.75×10^{-1}	7.53×10^{-2}	4.53×10^{-4}	2.46×10^{-3}	7.82×10^{-2}

By calculating the cancer risk of Cr and Cd (Table 7), we can get the SFs of Cr and Cd were 42.0 and 6.4, and the carcinogenic risk of Cr and Cd were 5.01×10^{-8} and 8.96×10^{-11}. These values were all lower than the limit ranges from 10^{-6} to 10^{-4}, suggesting little probability of posing carcinogenic risk.

Table 7 *Slope factors and the carcinogenic risks*

Elements	SF	Carcinogenic risk
Cr	42.0	5.01×10^{-8}
Cd	6.4	8.96×10^{-11}

4. Conclusions

Square dust samples in Suzhou were analyzed for the concentrations, speciation and health risks of trace metals (Cu, Pb, Cr and Cd). The average concentrations of Cu, Pb and Cd were higher than the soil background values of Anhui province, and Cu and Cd were also higher than the National Secondary Environmental Quality Standards for Soil. From the result of geo-accumulation indexes, Cd is the dominant contaminant followed by Pb, Cu and Cr in dusts mainly influenced by human activities and traffic pollution. Speciation analysis showed that Cd was the most mobile metal, displaying an abundance of the acid-soluble (F2, 33.05%) and exchangeable (F1, 14.87%) fractions, Pb was less mobile with the second largest MF value of 17.95%, Cu and Cr were the stable elements, because they were associated with the stable fraction (F3, F4 and F5). Based on the health risk assessment model (USEPA), the calculated results indicated that incidental ingestion of dusts, accounting for more than 90% of total non-cancer risks, was the dominant exposure route to both children and adults. Health risk posed by heavy metals was mainly originated from Cr and Pb accumulated in square dusts, and displayed higher level for children than adults. Although both the non-cancer and cancer risk of heavy metals in urban square dusts of Suzhou were relatively insignificant, in consideration of that the other exposure sources, such as vegetable, meat, water and etc, may cause more intakes of heavy metals, comprehensive investigation are suggested to be conducted.

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