

Supplementary Materials

Table S1 Definition and reference value of some parameters for health risk assessment of heavy metal

Symbol	Parameter	Units	Value		Reference
			adults	children	
Csoil	mean	mg/kg	-	-	this study
IngR	ingestion rate	mg/day		100	200 [1]
EF	exposure frequency	days/year		365	365 [1]
ED	exposure duration	year		24	6 [1]
SA	exposed skin area	cm ²		5.70E+03	2.80E+03 [1]
SAF	skin adherence factor	mg/cm ² /day		0.07	0.2 [2]
ABS	dermal absorption factor			0.001	0.001 [1]
BW	Body weight	kg		56.8	15.9 [2]
ATnon-carcinogens	averaging time	day		8.76E+03	2.19E+03 [1]
ATcarcinogens	averaging time	day		2.56E+04	2.56E+04 [1]
InhR	Inhalation rate of soil	m ³ /day		15	7.5 [2]
PEF	particle emission factor	m ³ /kg		1.36E+09	1.36E+09 [1]

Table S2 Summary of reference doses (RfD) and slope factors (SF) of heavy metals

Heavy metals mg/kg	Reference dose (RfD) mg/kg/day			Heavy metals mg/kg	Slope factor (SF) mg/kg/day		
	Ingestion	Dermal	Inhalation		Ingestion	Dermal	Inhalation
Cr ^a	3.00E-03	6.00E-05	2.86E-05	Cr ^a			4.20E+01
Ni ^c	2.00E-02	5.40E-03	2.06E-02	Ni ^a			8.40E-01
Cd ^b	3.00E-03	3.00E-03	5.71E-05	Cd ^{ab}	5.01E-01	2.00E+01	6.30E+00
Pb ^c	1.40E-03	5.24E-04	3.52E-03	Pb			
Cu ^c	4.00E-02	1.20E-02	4.00E-02	Cu			
Zn ^c	3.00E-01	6.00E-02	3.00E-01	Zn			
As ^c	3.00E-04	1.23E-04	1.23E-04	As ^a	1.50E+00	3.66E+00	1.51E+01
Hg ^a	3.00E-04	2.10E-05	8.57E-05	Hg			

[3]^a; [4]^b; [5]^c

Table S3 Correlation matrix for the heavy metals of urban soil in Shijiazhuang city

	Cr	Ni	Cd	Pb	Cu	Zn	Al ₂ O ₃	As	Hg
Cr	1								
Ni	0.870**	1							
Cd	0.869**	0.752**	1						
Pb	0.301**	0.232**	0.382**	1					
Cu	0.182**	0.255**	0.214**	0.596**	1				
Zn	0.163*	0.094	0.254**	0.483**	0.284**	1			
Al ₂ O ₃	-0.077	0.123	-0.182**	-0.167*	0.039	-0.104	1		
As	0.011	0.055	0.023	0.035	0.179**	-0.003	0.254**	1	
Hg	-0.022	-0.043	0.011	0.084	0.123	0.064	0.033	0.124	1

**Correlation is significant at the 0.01 level (two-tailed).

*Correlation is significant at the 0.05 level (two-tailed).

Table S4 Rotated component matrix for heavy metals data of urban soils from Shijiazhuang city.

Element	Component			
	1	2	3	4
Cr	0.96	0.12	-0.04	0.00
Ni	0.93	0.08	0.16	-0.07
Cd	0.90	0.23	-0.13	0.05
Pb	0.21	0.86	-0.08	0.04
Cu	0.12	0.77	0.28	0.06
Zn	0.06	0.72	-0.16	0.01
Al ₂ O ₃	-0.03	-0.15	0.82	-0.11
As	0.02	0.12	0.72	0.19
Hg	-0.02	0.06	0.07	0.98
Eigenvalue	2.66	1.96	1.35	1.02
% Of variance	29.6	21.77	14.95	11.4
% Of cumulative	29.6	51.37	66.32	77.72

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

Method for human health risk assessment

Human health risk assessment is the process of estimating the probability of adverse health effects of hazard chemicals to human's health according to human exposure characters. In general, direct oral ingestion, inhalation and dermal contact are three common exposure pathways to the individuals. The average daily intake (ADI) of metals through these three primary pathways was calculated according to the methodology advocated by USEPA for health risk assessment as follows:

$$ADI_{\text{ing}} = C_{\text{soil}} \times \frac{\text{IngR} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}} \times 10^{-6}$$

$$ADI_{\text{dermal}} = C_{\text{soil}} \times \frac{\text{SA} \times \text{SAF} \times \text{ABS} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}} \times 10^{-6}$$

$$ADI_{\text{inh}} = C_{\text{soil}} \times \frac{\text{InhR} \times \text{EF} \times \text{ED}}{\text{PEF} \times \text{BW} \times \text{AT}} \times 10^{-6}$$

The definition, reference values and data source of the abbreviation for the parameters were shown in Table S1.

Hazard quotient (HQ) is typically used to characterize non-carcinogenic risk and evaluate the risk level of human exposure. It is derived by the specific value between the doses calculated for each element and exposure pathway and the toxicity threshold value which is referred to as the reference dose (RfD, mg/kg/day) of a specific chemical. In addition, for multiple chemicals, the sum of the HQ values of all chemicals is expressed as a hazard index (HI) to assess the overall non-carcinogenic risk effects. Whereas for carcinogens the dose is multiplied by the corresponding slope factor (SF, mg/kg/day) to calculate CR to indicate the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the potential carcinogen [6]. Generally, the values of $HI > 1$ and $CR > 10^{-4}$, respectively, represent adverse effects to human health and lifetime carcinogenic risks [4]. On the contrary,

if $HI < 1$ and $CR < 10^{-6}$ indicate no adverse health effects and negligible carcinogenic risk to health from soil, respectively [7]. The reference doses (RfD) and slope factors (SF) of heavy metals were shown in Table S2.

$$HI = \Sigma HQ = \Sigma \frac{ADI_i}{RfD_i}$$

$$CR = ADI \times SF$$

References

1. United States Environmental Protection Agency (USEPA). **2002**. Supplemental guidance for developing soil screening levels for superfund sites, OSWER 9355. Office of Solid Waste and Emergency Response, Washington, DC
2. Ministry of Environmental Protection (MEP). **2014**. Technical guidelines for risk assessment of contaminated sites, HJ 25.3-2014. China Environ Sci Press, Beijing
3. Chen, H., Teng, Y., Lu, S., et al. Contamination features and health risk of soil heavy metals in China. *Sci. Total Environ.* **2015**, *512*, 143-153.
4. Pan, L., Wang, Y., Ma, J., et al. A review of heavy metal pollution levels and health risk assessment of urban soils in Chinese cities. *Environ. Sci. Pollut. Res.* **2018**, *25(2)*, 1055-1069.
5. Adimalla, N. Heavy metals pollution assessment and its associated human health risk evaluation of urban soils from Indian cities, a review. *Environ. Geochem. Hlth.* **2019**, *42(4)*, 173-190.
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7. Wu, S., Peng, S., Zhang, X., et al. Levels and health risk assessments of heavy metals in urban soils in Dongguan, China. *J. Geochem. Explor.* **2015**, *148*, 71-78.