A decade comparison of heavy metal(loid)s in the river and children's health risk assessment of an e-waste recycling area

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Exposure parameters for health risk assessment

Exposure to non-carcinogenic substances was usually characterized by an average daily dose (ADI_w), and exposure to carcinogens was characterized by a lifetime average daily dose (ADI_{ds}).

The calculation model for the daily average exposure dose of heavy metal(loid)s ingested by mouth was:

$$ADI_w = \frac{c \times IR \times EF \times ED}{BW \times AT} \tag{1}$$

where ADI_w is the average daily exposure dose of non-carcinogenic and carcinogenic pollutants orally taken in, in $mg \bullet (kg \bullet d)^{-1}$; c is the concentration of pollutants, in $\mu g \bullet L^{-1}$; IR is average daily drinking water intake, in $L \bullet d^{-1}$; EF is exposure frequency, in $d \bullet a^{-1}$; ED is exposure duration, in a; BW is bodyweight, in kg; AT is average exposure time, in d.

The calculation model of the daily average exposure dose of heavy metal(loid)s ingested through the skin:

$$ADI_{ds} = \frac{c \times SA \times PC \times ET \times EF \times ED \times CF}{BW \times AT} \tag{2}$$

where ADI_{ds} is the average daily transdermal absorbed dose of non-carcinogenic and carcinogenic pollutants, in $mg \bullet (kg \bullet d)^{-1}$; SA is the skin surface area in contact with water during wading activities, in cm^2; PC is the skin penetration constant of pollutants, in $cm \bullet h^{-1}$; ET is the exposure time, in $h \bullet d^{-1}$; CF is the volume conversion factor ($1 L \bullet 1000 cm^{-3}$); c, EF, ED, BW, and AT are the same as above (1).

Health risk assessment model

Non-carcinogenic risk assessment model of pollutants:

$$HQ_i = ADI_i / RfD_i \tag{1}$$

where ADI is the average daily exposure dose of non-carcinogens, in $mg \bullet (kg \bullet d)^{-1}$; and RfD is the average daily reference exposure dose for different exposure routes, in $mg \bullet (kg \bullet d)^{-1}$. An HQ < 1 indicates that the non-carcinogenic risk of the pollutant warning exposure route is acceptable, and the possible health risk is small; when HQ ≥ 1, there may be a potential non-carcinogenic risk. If there are multiple exposure pathways for the same medium, it is assumed that the pollutants do not produce synergistic health risks, and the risks under different exposure pathways can be added to characterize the combined comprehensive exposure risk, which is represented by the hazard index (HI), and calculated according to (2):

$$HI = \sum_1^i HQ \tag{2}$$

HI is the comprehensive exposure risk of an individual under multiple exposure pathways of the same medium. An HI < 1 indicates that the non-carcinogenic risk of the pollutant through multiple comprehensive exposures is acceptable; an HI ≥ 1 indicates there may be a potential comprehensive non-carcinogenic risk, and the risk of each exposure route is subdivided and the potential harm evaluated individually.

$$ILCR_i = ADI_i \times CSF_i \tag{3}$$

where ILCR is the lifetime risk of equivalent death caused by a certain harmful health effect, dimensionless; ADI is the average daily exposure dose of carcinogenic pollutants, in $mg \cdot (kg \cdot d)^{-1}$; CSF is the slope factor of a carcinogen calculated from animals studies, in $kg \cdot d \cdot mg^{-1}$. If the comprehensive carcinogenic risk of a variety of non-threshold chemicals is evaluated, it can be assumed that there is no interaction between non-threshold compounds. The comprehensive carcinogenic risk is evaluated by adding the carcinogenic risk of each non-threshold compound. An ILCR ≤ 10^{-6} indicates that there is no carcinogenic risk or the risk of carcinogenesis is small, and ILCR of $1.0 \times 10^{-6} \sim 1.0 \times 10^{-4}$ indicates an acceptable risk level; an ILCR ≥ 10^{-4} indicates that there may be a potential carcinogenic risk.

According to the International Agency for Research on Cancer (IARC) definition and classification of compound toxicity, this study regarded Cu, Zn, Sn and other common water pollution metal(loid)s as key pollutants; Cr, As, Cd, Ni and Pb were regarded as carcinogens; the remaining elements were regarded as extended elements. The corresponding RfD and SF values of each compound are shown in **Table S2**.

Table S1

International research on heavy metal(loid)s exposure in e-waste recycling areas.

Heavy metal(loid)s	Environmental media	Intake	Health impact	Maximum Contaminant Levels (MCL) mg/L	Reference
Pb	air, dust, water and soil	inhalation, oral ingestion, dermal contact	Childhood neurobehavioral development, anemia, kidney damage, chronic neurotoxicity	0.01	[1-11]
Cr			Carcinogenicity, affects reproductive and endocrine functions	0.05	
Cd	air, dust, water, soil and food（especially rice and plants）		Kidney damage, nephrotoxicity, bone disease (osteochondrosis and osteoporosis), possible reproductive damage and emphysema	0.005	
Zn	air, dust, water and soil		Causes Cu deficiency	1	
Ni	air, dust, water, soil and food（especially rice and plants）		Carcinogenesis, pulmonary embolism, respiratory failure, adverse birth outcomes, asthma and chronic bronchitis	0.02	
Ba	air, dust and water		Increased blood pressure, changes in heart rate, stomach irritation, muscle weakness, changes in nerve reflexes, swelling of the brain liver and kidneys	2	
As	air, dust, water, soil and food		Weakened nerve conduction, increased risk of diabetes and cancer	0.01	
Cu	air, dust, water and soil		Chronic Cu exposure can cause headaches, stomach pain, dizziness, vomiting and diarrhea	1.3	

Se	Hair loss, brittle nails, cardiovascular, renal and neurological abnormalities	0.05
V	Severe eye, nose and throat irritation, cardiovascular disease, gastrointestinal inflammation, nerve damage, liver and kidney hemorrhage, skin rash	-
Mn	embolism, carcinogenicity	0.1
Sr	liver injury	-

Table S2

Quality analysis of heavy metal(loid)s

Heavy metal(loid)s	LOD [a] (μg/L)	LOQ [b] (μg/L)	Recovery (%)
As	0.30	1.20	79%-112%
Ba	0.50	1.70	57%-106%
Cr	0.10	0.60	65%-118%
Cu	0.20	0.80	66%-135%
Mn	0.20	1.00	61%-92%
Ni	0.20	1.00	91%-127%
Pb	0.40	1.50	61%-105%
Se	0.30	1.20	89%-102%
Sr	0.30	1.20	63%-112%
V	0.30	1.20	62%-108%
Zn	0.20	0.80	66%-119%
Cd	0.40	1.40	79%-120%

[a] The S/N ratio for LOD is typically set at 3:1. This means that the signal (response) from the analyze must be at least three times greater than the noise

(background signal) of the blank or control sample. The LOD can be calculated using the formula:LOD=(3×σ)/m.

[b] The S/N ratio for LOQ is typically set at 10:1. This means that the signal (response) from the analyze must be at least three times greater than the noise

(background signal) of the blank or control sample. The LOQ can be calculated using the formula:LOD=(10×σ)/m.

where σ is the standard deviation of the blank (noise) and m is the slope of the calibration curve.

Table S3

Exposure parameters used for health risk calculation in this study.

Exposure factors	Values	References
IR of the digestive tract	41.71 mL/day	This research [a]
Exposure frequency (EF)	365 days/year	[12]
Exposure duration (ED)	4 years	[12]
Body weight (BW)	17.19 kg (true value per child)	This research
Surface area (SA)	0.71 m^2	This research
Skin exposure time (ET)	0.209 h/d	This research
Average exposure time (AT)	22500 d	[12]

[a] Parameters obtained from the questionnaire **(Table S10)**.

Table S4

Summary of the penetration coefficients (PCs), reference doses (RfDs) and the cancer slope factors (CSFs) of 12 heavy

metal(loid)s (As, Ba, Cr, Cu, Mn, Ni, Pb, Se, Sr, V, Zn and Cd).

Heavy metal(loi d)s	PC cm/h	RfD$_{ing}$ mg•(kg•d)$^{-1}$	RfD$_{dermal}$ mg•(kg•d)$^{-1}$	CSF mg•(kg•d)$^{-1}$	Reference
As	0.0018	0.0003	0.000123	1.5	[13-16]
Ba	0.000004	0.2	0.014	/	[17]

Cr	0.002	0.003	0.003	0.5	[13-15,18]
Cu	0.0006	0.04	0.012	/	[17]
Mn	0.0001	0.046	0.0018	/	[17]
Ni	0.0001	0.02	0.0054	0.91	[13-15,18,19]
Pb	0.000004	0.0014	0.0014	0.0085	[17]
Se	0.0018	0.005	0.0022	/	[17]
Sr	0.0006	0.6	0.6	/	[17]
V	0.002	0.007	0.00007	/	[17]
Zn	0.0006	0.3	0.01	/	[17]
Cd	0.001	0.001	0.0003	6.1	[13-15,18]

Table S5

Comparisons of the mean values of HQ_i and HI of 12 heavy metal(loid) exposure (As, Ba, Cr, Mn, Ni, Pb, Se, Sr, V, Zn, Cd).

Risks	Mean±SD			
	2020-SY	2020-ZY	2020-XY	2009
HQ_{As}	2.87E-01±1.12E-01	3.48E-01±1.54E-01	3.22E-01±1.05E-01	4.72E-01±3.68E-01
HQ_{Ba}	7.34E-02±2.37E-02	6.13E-02±1.89E-02	8.37E-02±2.84E-02	9.90E-02±6.97E-02
HQ_{Cr}	9.61E-07±5.10E-07	9.66E-07±2.80E-07	1.16E-06±3.96E-07	9.82E-07±7.95E-07
HQ_{Cu}	2.75E-03±1.62E-03	3.60E-03±2.32E-03	3.50E-03±1.28E-03	3.61E-03±3.03E-03
HQ_{Mn}	2.93E-04±5.98E-04**	5.66E-04±6.13E-04**	9.72E-04±1.09E-03**	1.93E-02±2.75E-02
HQ_{Ni}	2.56E-02±1.04E-02**	2.94E-02±7.69E-03*	3.71E-02±1.02E-02	4.65E-02±2.04E-02
HQ_{Pb}	8.18E-04±2.45E-03	4.86E-03±9.81E-03	6.72E-04±2.02E-03	1.55E-02±3.37E-02
HQ_{Se}	1.07E-02±5.43E-03	1.15E-02±1.52E-03	1.36E-02±3.05E-03	1.32E-02±6.37E-03
HQ_{Sr}	1.47E-01±5.19E-02**	1.74E-01±5.55E-02	2.10E-01±4.75E-02	2.43E-01±9.86E-02
HQ_V	1.14E-01±4.60E-02	1.29E-01±3.51E-02	1.39E-01±3.88E-02	1.87E-01±1.65E-01
HQ_{Zn}	2.90E-03±3.67E-03	1.79E-03±2.03E-03	1.33E-03±9.52E-04	2.31E-03±1.79E-03
HQ_{Cd}	4.06E-03±4.53E-03**	7.04E-03±2.98E-03*	5.50E-03±1.81E-03**	9.35E-03±2.64E-03
HI	3.05E-01±2.62E-01	3.58E-01±2.90E-01	4.08E-01±2.40E-01	5.36E-01±7.97E-01

Mann-Whitney U test for pairwise comparison of heavy metal concentrations in 2020 with 2009.

*In the Mann-Whitney U test, mean values of the HQ_i and HI were considered statistically significant at $p < 0.05$ (two-sided).

**In the Mann-Whitney U test, mean values of the HQ_i and HI were considered statistically significant at $p < 0.01$ (two-sided).

Table S6

Comparisons of the mean values of $ILCR_i$ and $ILCR_{sum}$ of 5 heavy metal(loid) exposure (As, Cr, Ni, Pb, Cd).

Risks	Mean±SD

	2020-SY	2020-ZY	2020-XY	2009
$ILCR_{As}$	1.19E-04±4.65E-05	1.33E-04±4.33E-05	1.33E-04±4.33E-05	1.96E-04±1.52E-04
$ILCR_{Cr}$	1.60E-04±8.51E-05	1.61E-04±4.67E-05	1.93E-04±6.60E-05	1.64E-04±1.32E-04
$ILCR_{Ni}$	1.89E-02±7.67E-03**	2.17E-02±1.17E-04*	2.74E-02±7.52E-03	3.42E-02±1.50E-02
$ILCR_{Pb}$	6.54E-06±1.96E-05	3.88E-05±7.83E-05	5.37E-06±1.61E-05	1.24E-04±2.70E-04
$ILCR_{Cd}$	2.33E-02±2.60E-02**	4.04E-02±1.71E-02*	3.15E-02±1.04E-02**	5.36E-02±1.52E-02
$ILCR_{sum}$	4.25E-02±3.38E-02	6.24E-02±1.74E-02	5.92E-02±1.80E-02	8.83E-02±3.08E-02

Mann-Whitney U test for pairwise comparison of heavy metal concentrations in 2020 with 2009.

*In the Mann-Whitney U test, mean values of the $ILCR_i$ and $ILCR_{sum}$ were considered statistically significant at $p <$ 0.05 (two-sided).

**In the Mann-Whitney U test, mean values of the $ILCR_i$ and $ILCR_{sum}$ were considered statistically significant at $p <$ 0.01 (two-sided).

Table S7

Comparisons of the mean values of HQ_i and HI through ingestion of water and dermal absorption of water of 12 heavy metal(loid) exposure (As, Ba, Cr, Mn, Ni, Pb, Se, Sr, V, Zn, Cd).

	2020-SY		2020-ZY		2020-XY		2009	
Mean	HQw	HQds	HQw	HQds	HQw	HQds	HQw	HQds
As	2.48E-01	3.88E-02	3.01E-01	4.70E-02	2.78E-01	4.35E-02	4.09E-01	6.38E-02
Ba	3.83E-02	3.51E-02	3.20E-02	2.93E-02	4.37E-02	4.00E-02	5.17E-02	4.73E-02
Cr	9.03E-07	5.78E-08	9.08E-07	5.81E-08	1.09E-06	6.96E-08	9.23E-07	5.91E-08
Cu	2.26E-03	4.83E-04	2.97E-03	6.33E-04	2.89E-03	6.16E-04	2.97E-03	6.35E-04
Mn	1.11E-04	1.82E-04	2.15E-04	3.51E-04	3.69E-04	6.04E-04	7.32E-03	1.20E-02
Ni	2.07E-02	4.91E-03	2.38E-02	5.64E-03	3.00E-02	7.12E-03	3.76E-02	8.91E-03
Pb	7.69E-04	4.92E-05	4.57E-03	2.93E-04	6.32E-04	4.04E-05	1.46E-02	9.35E-04
Se	9.37E-03	1.36E-03	1.01E-02	1.47E-03	1.18E-02	1.72E-03	1.16E-02	1.68E-03
Sr	1.38E-01	8.86E-03	1.63E-01	1.04E-02	1.97E-01	1.26E-02	2.29E-01	1.46E-02
V	1.55E-02	9.90E-02	1.75E-02	1.12E-01	1.87E-02	1.20E-01	2.53E-02	1.62E-01
Zn	9.94E-04	1.91E-03	6.11E-04	1.17E-03	4.56E-04	8.77E-04	7.90E-04	1.52E-03
Cd	3.81E-03	2.44E-04	6.62E-03	4.24E-04	5.17E-03	3.31E-04	8.79E-03	5.63E-04

Table S8

Comparisons of the mean values of $ILCR_i$ and $ILCR_{sum}$ through ingestion of water and dermal absorption of water of 5 heavy metal(loid) exposure (As, Cr, Ni, Pb, Cd).

	2020-SY		2020-ZY		2020-XY		2009	
Mean	ILCRw	ILCRds	ILCRw	ILCRds	ILCRw	ILCRds	ILCRw	ILCRds
As	1.12E-04	7.15E-06	1.36E-04	8.68E-06	1.25E-04	8.02E-06	1.84E-04	1.18E-05
Cr	1.51E-04	9.64E-06	1.51E-04	9.69E-06	1.81E-04	1.16E-05	1.54E-04	9.85E-06
Ni	2.41E-05	1.88E-02	2.77E-05	2.16E-02	3.50E-05	2.73E-02	4.38E-05	3.42E-02
Pb	1.46E-09	6.54E-06	8.70E-09	3.88E-05	1.20E-09	5.37E-06	2.78E-08	1.24E-04
Cd	4.47E-07	2.33E-02	7.76E-07	4.04E-02	6.06E-07	3.15E-02	1.03E-06	5.36E-02

Table S9

Mean values of HQ_i and HI of 7 heavy metal(loid) exposure (Ba, Cu, Mn, Se, Sr, V, Zn).

Heavy metal(loid)s	Non-carcinogenic risks (HQi,HI)		
	HQw	HQds	HI

Ba	4.17E-02	3.82E-02	7.99E-02
Cu	2.78E-03	5.93E-04	3.37E-03
Mn	2.15E-03	3.52E-03	5.67E-03
Se	1.07E-02	1.56E-03	1.23E-02
Sr	1.83E-01	1.17E-02	1.95E-01
V	1.94E-02	1.37E-03	2.08E-02
Zn	7.15E-04	4.58E-05	7.61E-04
Total	6.12E-01	1.13E-01	7.25E-01

Table S10

Spearman correlation of 12 heavy metal(loid)s in water.

	As	Ba	Cr	Cu	Mn	Ni	Pb	Se	Sr	V	Zn	Cd
As	1											
Ba	0.823**	1										
Cr	0.765**	0.771**	1									
Cu	0.856**	0.729**	0.742**	1								
Mn	0.441**	0.391*	0.356*	0.358*	1							
Ni	0.31	0.337*	0.435**	0.347*	0.788**	1						
Pb	0.176	0.107	0.219	0.266	0.136	0.146	1					
Se	0.638**	0.723**	0.849**	0.666**	0.302	0.469**	0.358*	1				
Sr	0.293	0.348*	0.415*	0.356*	0.786**	0.945**	0.047	0.423**	1			
V	0.936**	0.791**	0.776**	0.888**	0.397*	0.305	0.226	0.704**	0.261	1		
Zn	0.305	0.219	0.188	0.410*	0.623**	0.480**	0.334*	0.024	0.486**	0.254	1	
Cd	0.429**	0.246	0.341*	0.451**	0.766**	0.670**	0.385	0.358*	0.609**	0.482**	0.599**	1

* $p < 0.05$ (two sides) were considered statistically significant

** $p < 0.01$ (two sides) were considered statistically significant.

Table S11

Principal component analysis of 12 heavy metal(loid)s in water

Heavy metal(loid)s	Water		
	KMO=0.55		
	PC1	PC2	PC3
As	**0.85**		
Ba	**0.92**		

Cr	**0.89**		
Cu	**0.92**		
Mn		**0.90**	
Ni	**0.52**	**0.83**	
Pb			**0.87**
Se	**0.93**		
Sr	**0.50**	**0.82**	
V	**0.87**	-0.30	
Zn		0.30	
Cd	0.39	0.43	**0.53**
Variance (%)	46.90	22.26	9.42
Cumulative variance (%)	46.90	69.16	78.58

The components with loadings < 0.3 were not listed in the table, and the components with loadings > 0.5 were bolded

Table S12

Child-related health parameters and behavioral patterns as measured by the questionnaire

		Analytic sample (N = 380)
Variables	n	Mean (SD) /percentage median
Child age (years)	372	4.80 (0.85)
<4	36	9.7
4~5	224	60.2
6~7	112	30.1
Gender [n%]	380	
Male	213	56.1
Female	167	43.9
Body mass index (BMI, kg/m^2)	380	14.98 (0.07)
Height (cm)	380	106.91 (0.39)
Weight (kg)	380	17.19 (0.15)
Sitting height (cm)	380	59.76 (0.20)
Birth weight (kg)	380	6.24 (0.04)
Birth height (cm)	380	50.50 (0.16)
Engage the e-waste		
Yes	307	80.8
No	73	19.2
E-waste recycling area 50 m from the residence		
Yes	320	87.4
No	46	12.6
Father's education level		
elementary school	14	3.7
middle school	253	67.5
technical school	29	7.7

high school	57	15.2
college	22	5.9
Mother's education level		
elementary school	27	7.3
middle school	216	58.2
technical school	43	11.6
high school	42	11.3
college	43	11.6
Father worked in the e-waste recycling area		
Yes	320	86.7
No	49	13.3
Mother worked in the e-waste recycling area		
Yes	365	98.4
No	6	1.6
Household income (¥)		
< 3000	39	11.8
3000-4500	53	16.1
4500-6000	94	28.5
6000-7500	49	14.8
>7500	95	28.8
Water contact habit by the river		
Yes	18	19.8
No	72	79.1
Water contact time		
one hours	84	92.3
two hours	7	7.7
three or more hours	0	0
Water contact frequency		
once per week	88	96.7
twice per week	0	
Three or more times per week	3	3.3
Swallowed volume		
One mouth (27 mL)	72	79.1
Two mouth	11	12.1
Three to four mouth	7	7.7
Five to eight mouth	1	1.1
Daily water consumption		
Once per day	5	5.5
Twice to five times per day	40	44
Over five times per day	21	23.1
Missing	25	27.5
Bathing cycle		
Once per day	91	100
Bathing time		
10 mins	71	78
20 mins	18	19.8
30 mins	2	2.2
Bath swallowing volume		
One mouth (27 mL)	79	86.8
Two mouth	6	6.6
Three to five mouth	6	6.6

Table S13

Sensitivity analysis of health risk factors were assessed by formula method

Sensitivity factors	As	Cr	Ni	Pb	Cd
Concentration in water (%)	97.77	98.38	99.64	0.08	53.41
Intake rate of water (%)	99.84	99.94	99.95	0.09	97.04

Table S14

Spearman correlation between BMI and 12 heavy metal(loid) ADI_w in water.

	BMI	As adi_w	V adi_w	Zn adi_w	Cd adi_w	Sr adi_w	Se adi_w	Ba adi_w	Pb adi_w	Ni adi_w	Mn adi_w	Cu adi_w	Cr adi_w
BMI	1												
As adi_w	0.013	1											
V adi_w	0.031	0.999**	1										
Zn adi_w	-0.174**	0.930**	0.917**	1									
Cd adi_w	0.068	0.992**	0.996**	0.883**	1								
Sr adi_w	-0.005	0.999**	0.997**	0.942**	0.986**	1							
Se adi_w	-0.220**	0.889**	0.873**	0.994**	0.834**	0.904**	1						
Ba adi_w	-0.414**	0.621**	0.597**	0.853**	0.545**	0.646**	0.899**	1					
Pb adi_w	0.076	0.987**	0.992**	0.874**	0.999**	0.981**	0.824**	0.532**	1				
Ni adi_w	0.043	0.998**	1**	0.907**	0.998**	0.995**	0.861**	0.581**	0.995**	1			
Mn adi_w	0.076	0.987**	0.992**	0.874**	0.999**	0.981**	0.824**	0.532**	1**	0.995**	1		
Cu adi_w	-0.231**	0.878**	0.862**	0.992**	0.823**	0.894**	0.999**	0.909**	0.812**	0.850**	0.812**	1	
Cr adi_w	-0.416**	0.618**	0.594**	0.851**	0.542**	0.643**	0.898**	1**	0.529**	0.578**	0.529**	0.907**	1

* $p < 0.05$ (two sides) were considered statistically significant

** $p < 0.01$ (two sides) were considered statistically significant.

Spearman correlation between BMI and 12 heavy metal(loid) ADI_{ds} in water

	BMI	As adids	V adids	Zn adids	Cd adids	Sr adids	Se adids	Ba adids	Pb adids	Ni adids	Mn adids	Cu adids	Cr adids
BMI	1												
As adi_ds	0.013	1											

V adi$_{ds}$	0.031	0.999**	1									
Zn adi$_{ds}$	-0.174**	.0.930**	0.917**	1								
Cd adi$_{ds}$	0.068	0.992**	0.996**	0.883**	1							
Sr adi$_{ds}$	-0.005	0.999**	0.997**	0.942**	0.986**	1						
Se adi$_{ds}$	-0.220**	0.889**	0.873**	0.994**	0.834**	0.904**	1					
Ba adi$_{ds}$	-0.414**	0.621**	0.597**	0.853**	0.545**	0.646**	0.899**	1				
Pb adi$_{ds}$	0.076	0.987**	0.992**	0.874**	0.999**	0.981**	0.824**	0.532**	1			
Ni adi$_{ds}$	0.043	0.998**	1**	0.907**	0.998**	0.995**	0.861**	0.581**	0.995**	1		
Mn adi$_{ds}$	0.076	0.987**	0.992**	0.874**	0.999**	0.981**	0.824**	0.532**	1**	0.995**	1	
Cu adi$_{ds}$	-0.231**	0.878**	0.862**	0.992**	0.823**	0.894**	0.999**	0.909**	0.812**	0.850**	0.812**	1
Cr adi$_{ds}$	-0.416**	0.618**	0.594**	0.851**	0.542**	0.643**	0.898**	1**	0.529**	0.578**	0.529**	0.907**	1

* $p < 0.05$ (two sides) were considered statistically significant

** $p < 0.01$ (two sides) were considered statistically significant.

Table S15

Association between heavy metal(loid)s and BMI in children

BMI	Model A		Model B		
	β (95% CI)	*P*-value		β (95% CI)	*P*-value
As	-0.206 (-0.900, 0.457)	0.521	As	0.334 (-0.226, 0.955)	0.225
Pb	-0.396 (-0.927, -0.092)	0.017*	Pb	-0.949 (-1.596, -0.863)	< 0.001**
Se	-0.417 (-1.572, 0.679)	0.436	Se	-0.911 (-1.888, -0.092)	0.031*
Zn	-0.224 (-2.736, 2.257)	0.850	Zn	0.209 (-1.745, 2.199)	0.821
Cd	0.787 (-1.468, 3.155)	0.473	Cd	0.247 (-1.581, 2.119)	0.775

Notes:

Model A: unadjusted

Model B: adjusted for gender, age, birth length, birth weight, sitting height, family education level, family income, hand washing problems, engaging with e-waste, e-waste within 50m of residence and parents working in e-waste. CI, confidence interval; β, standardized coefficient.

Table S16

Association between heavy metal(loid)s and WC in children

WC	Model A		Model B		
	β (95% CI)	*P*-value		β (95% CI)	*P*-value
As	0.027 (-0.917, 1.046)	0.897	As	-0.128 (-1.191, 0.581)	0.499
Pb	-0.573 (-2.221, -1.013)	< 0.001**	Pb	0.032 (-0.533, 0.712)	0.778
Se	-0.537 (-2.892, 0.365)	0.128	Se	-0.466 (-2.454, 0.243)	0.108
Zn	0.132 (-3.301, 3.921)	0.866	Zn	0.156 (-2.577, 3.318)	0.805
Cd	0.130 (-3.038, 3.649)	0.857	Cd	0.242 (-2.191, 3.340)	0.683

Notes:

Model A: unadjusted

Model B: adjusted for gender, age, birth length, birth weight, sitting height, family education level, family income, hand washing problems, engaging with e-waste, e-waste within 50m of residence and parents working in e-waste. CI, confidence interval; β, standardized coefficient.

Table S17

Association between heavy metal(loid)s and HC in children

HC	Model A			Model B	
	β (95% CI)	*P*-value		β (95% CI)	*P*-value
As	0.236 (-0.495, 1.112)	0.450	As	0.237 (-0.485, 1.112)	0.440
Pb	-0.284 (-0.940, 0.048)	0.077	Pb	0.001 (-0.559, 0.563)	0.994
Se	0.049 (-1.269, 1.396)	0.925	Se	-0.086 (-1.328, 1.102)	0.855
Zn	-0.933 (-4.172, 1.737)	0.418	Zn	-0.909 (-3.856, 1.455)	0.374
Cd	0.425 (-2.181, 3.290)	0.690	Cd	0.655 (-1.627, 3.357)	0.495

Notes:

Model A: unadjusted

Model B: adjusted for gender, age, birth length, birth weight, sitting height, family education level, family income, hand washing problems, engaging with e-waste, e-waste within 50m of residence and parents working in e-waste. CI, confidence interval; β, standardized coefficient. \

Figure S1. Percentage levels of heavy metal(loid) pollution in water from 2009 and 2020.
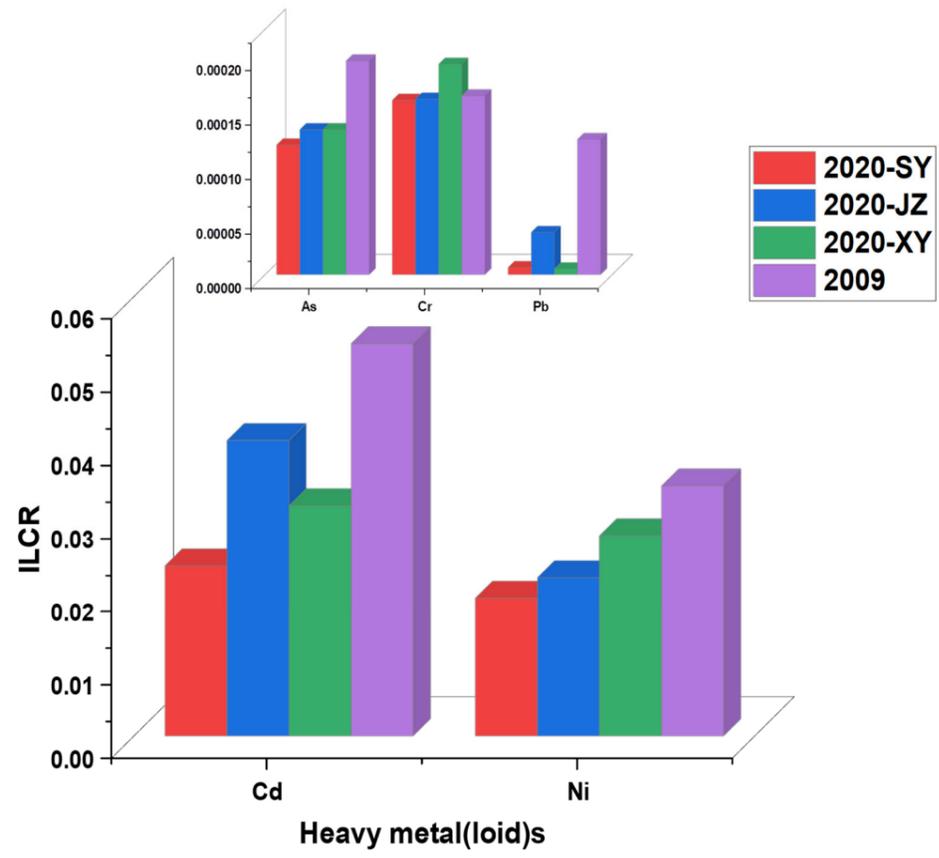
Figure S2. Comparison of ILCR$_i$ for 5 heavy metals (As, Cr, Ni, Pb, Cd).
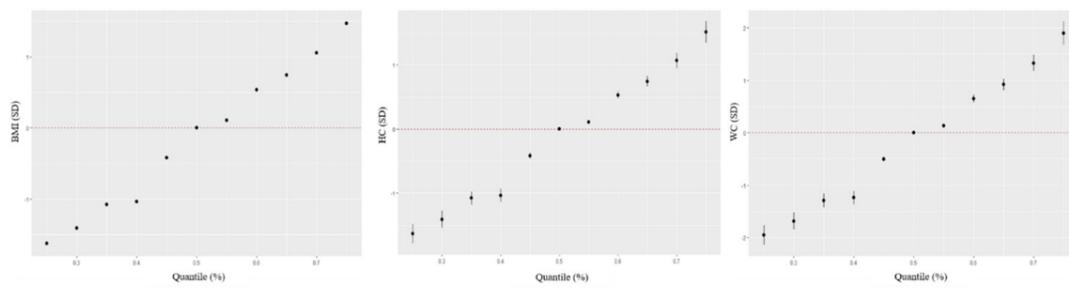
Figure S3. The correlation between the combined exposure of the 12 heavy metal(loid)s and health indicators for child development. Adjustments were made for gender, age, parents' education level and average monthly household income.
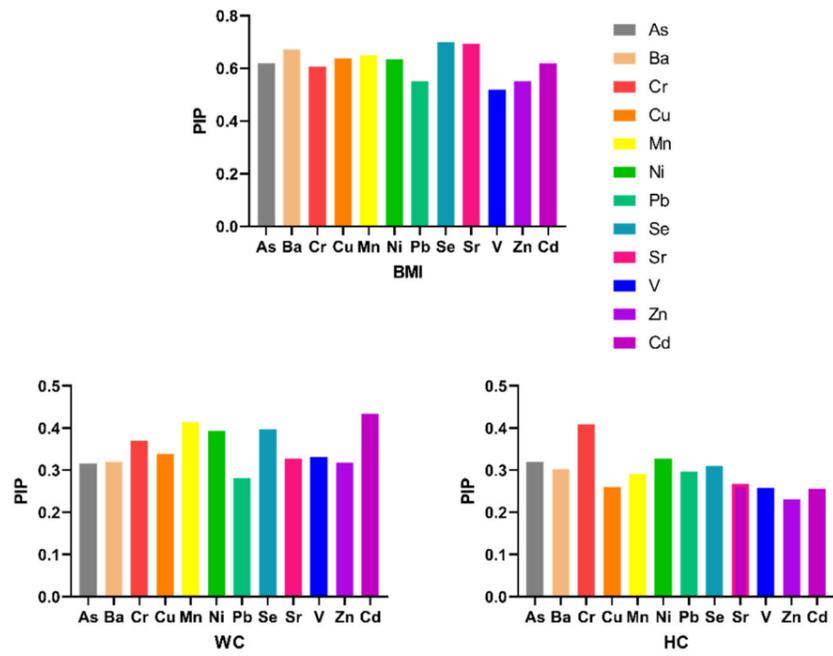
Figure S4. PIP histograms of exposures to the 12 heavy metal(loid)s and BMI, HC and WC.
Adjustments were made for gender, age, parents' education level, average monthly household income.
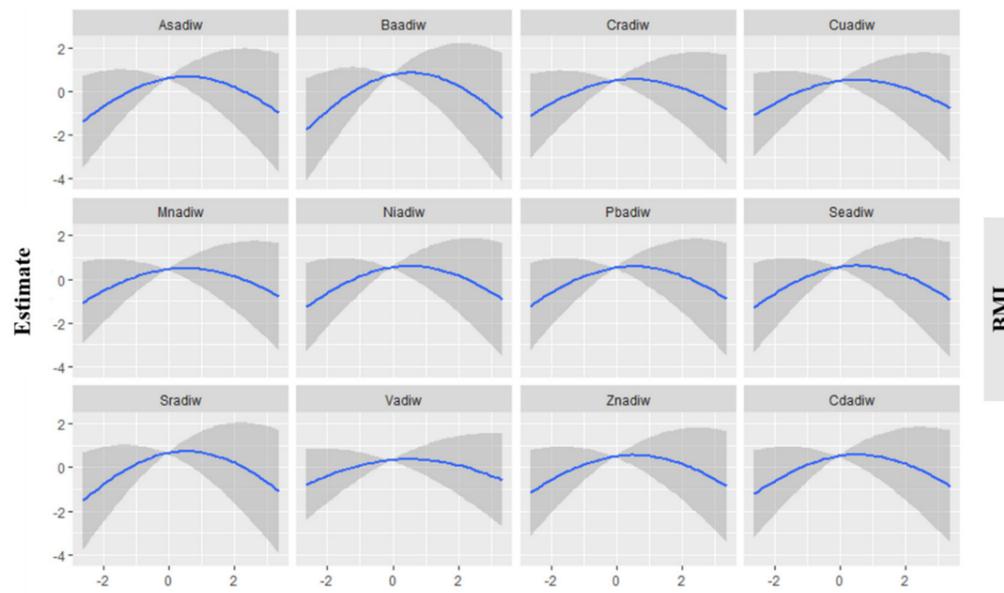
Figure S5. Association between individual heavy metal(loid) and BMI. Adjustments were made for
gender, age, parents' education level and average monthly household income.
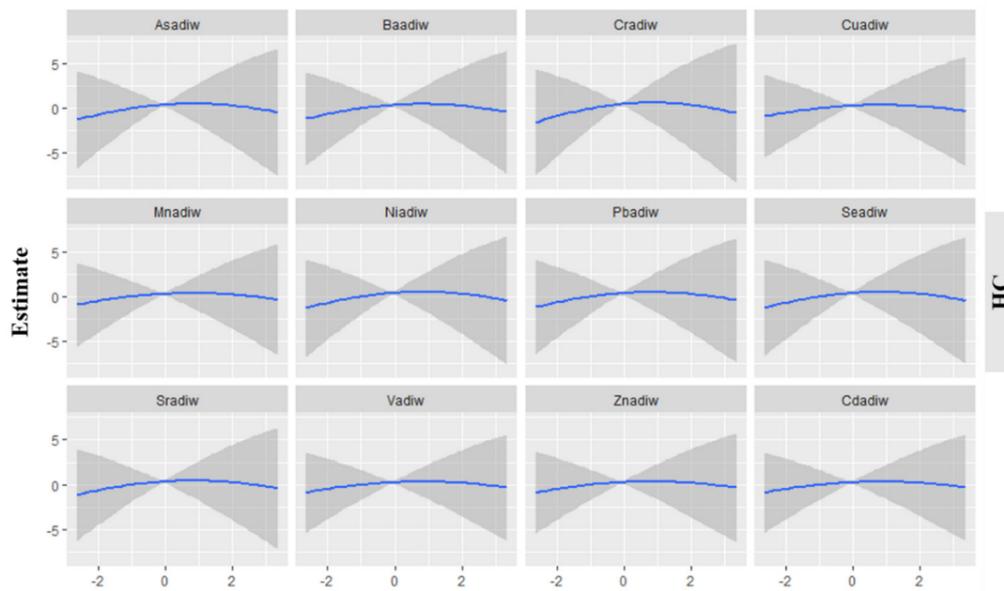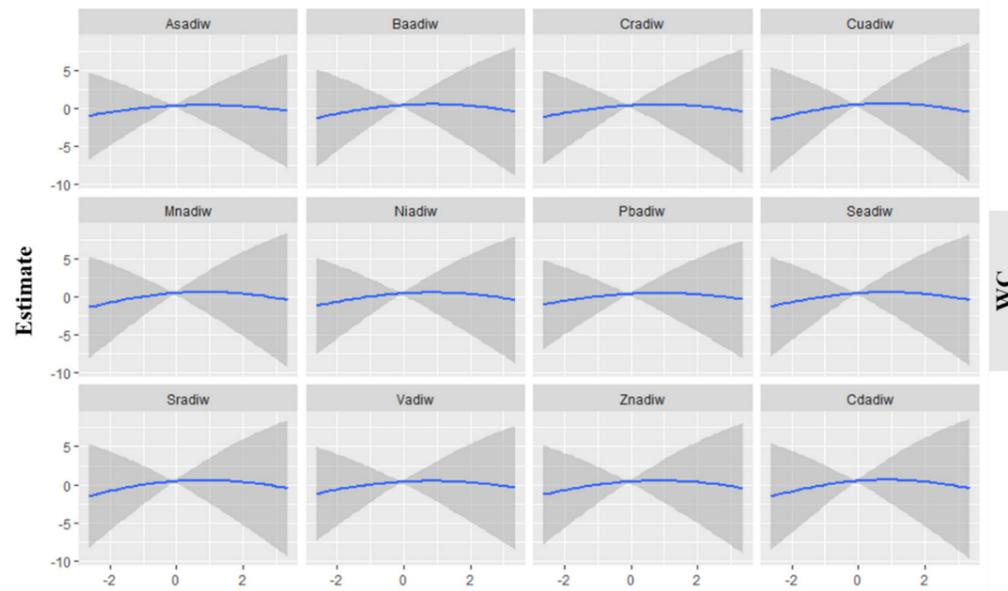
Figure S7. Association between individual heavy metal(loid) and WC. Adjustments were made for gender, age, parents' education level and average monthly household income.
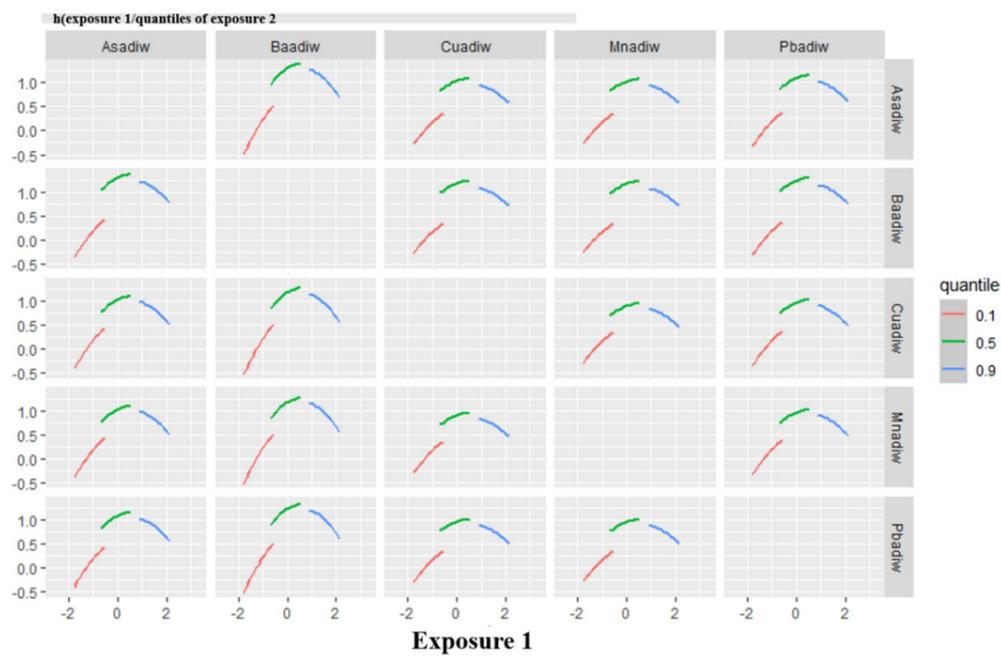
Figure S8. Bivariate plots of the interaction between exposures in their associations with BMI in the 12 heavy metal(loid)s model. Each plot shows the association between the vertical exposure ("Exposure 1") given fixed quantiles of the horizontal exposure ("Exposure 2") when all other exposures are fixed at the median adjusting for covariates.
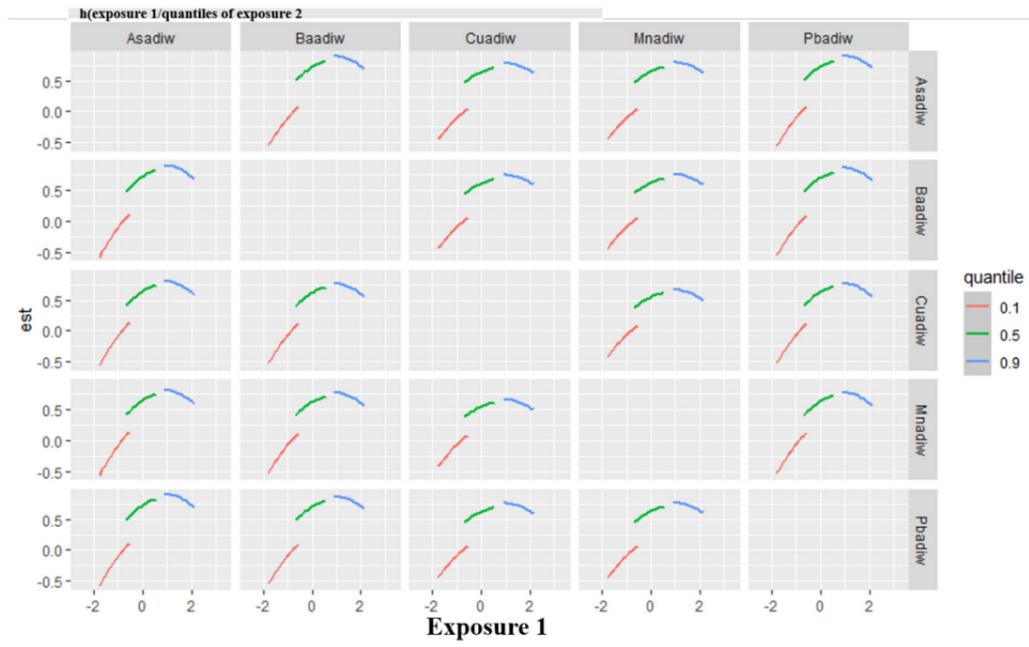
Figure S9. Bivariate plots of the interaction between exposures in their associations with HC in the 12 heavy metal(loid)s model. Each plot shows the association between the vertical exposure ("Exposure 1") given fixed quantiles of the horizontal exposure ("Exposure 2") when all other exposures are fixed at the median adjusting for covariates.
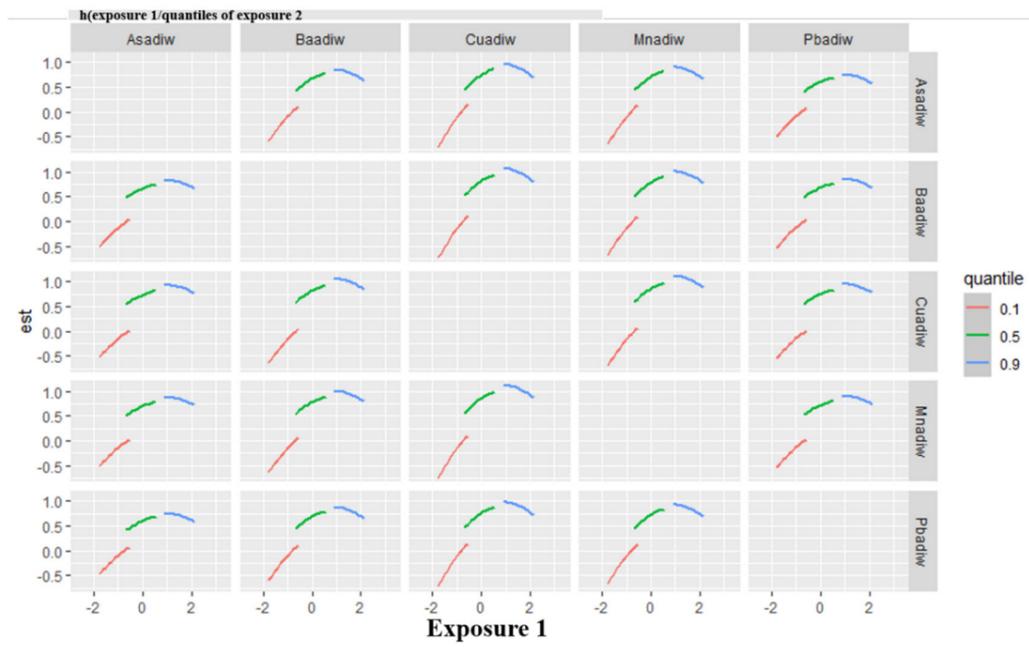
Figure S10. Bivariate plots of the interaction between exposures in their associations with WC in the 12 heavy metal(loid)s model. Each plot shows the association between the vertical exposure ("Exposure 1") given fixed quantiles of the horizontal exposure ("Exposure 2") when all other exposures are fixed at the median adjusting for covariates.
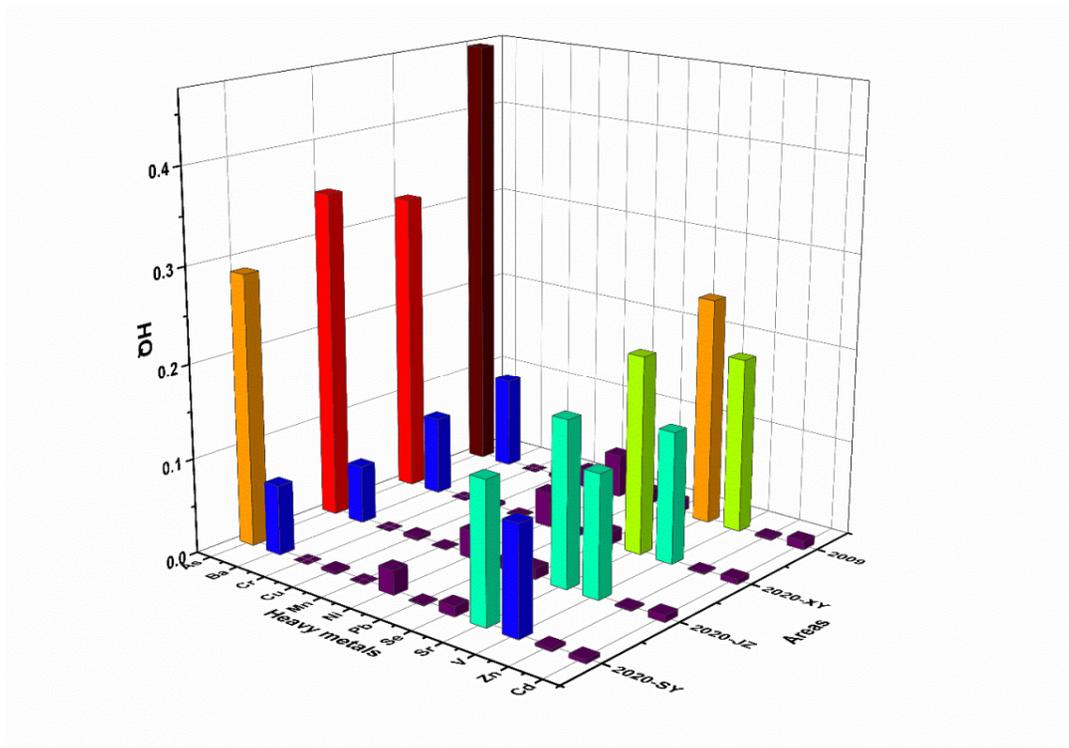
Figure S11. Non-carcinogenic risk assessment of 12 heavy metal(loid)s in water to children in Guiyu.
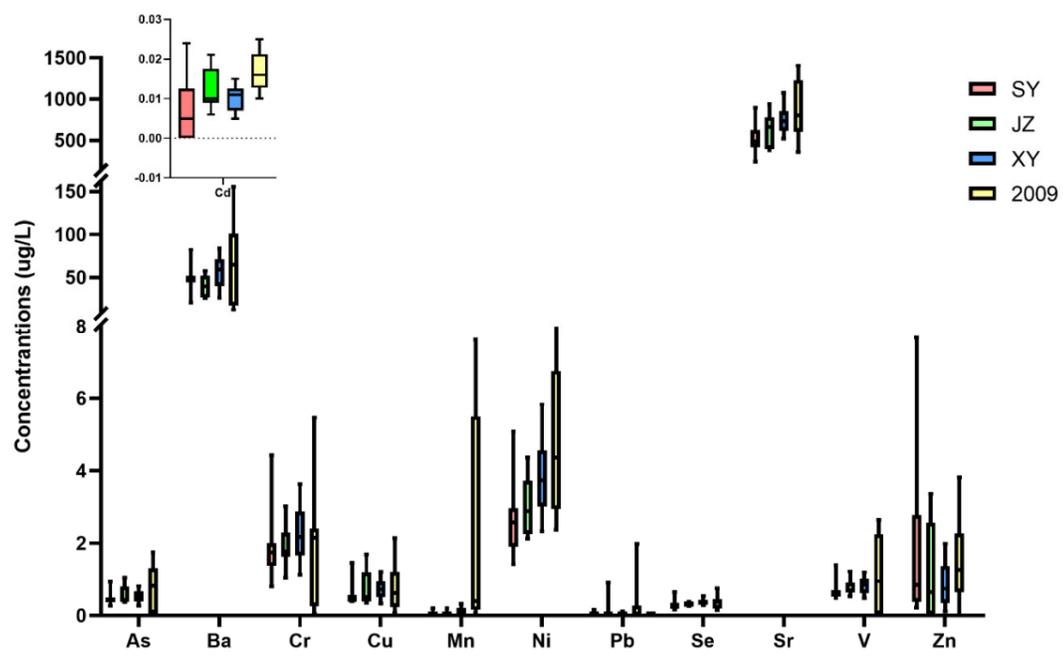
Figure S12. Box plot comparisons of the concentrations of 12 heavy metal(loid)s.
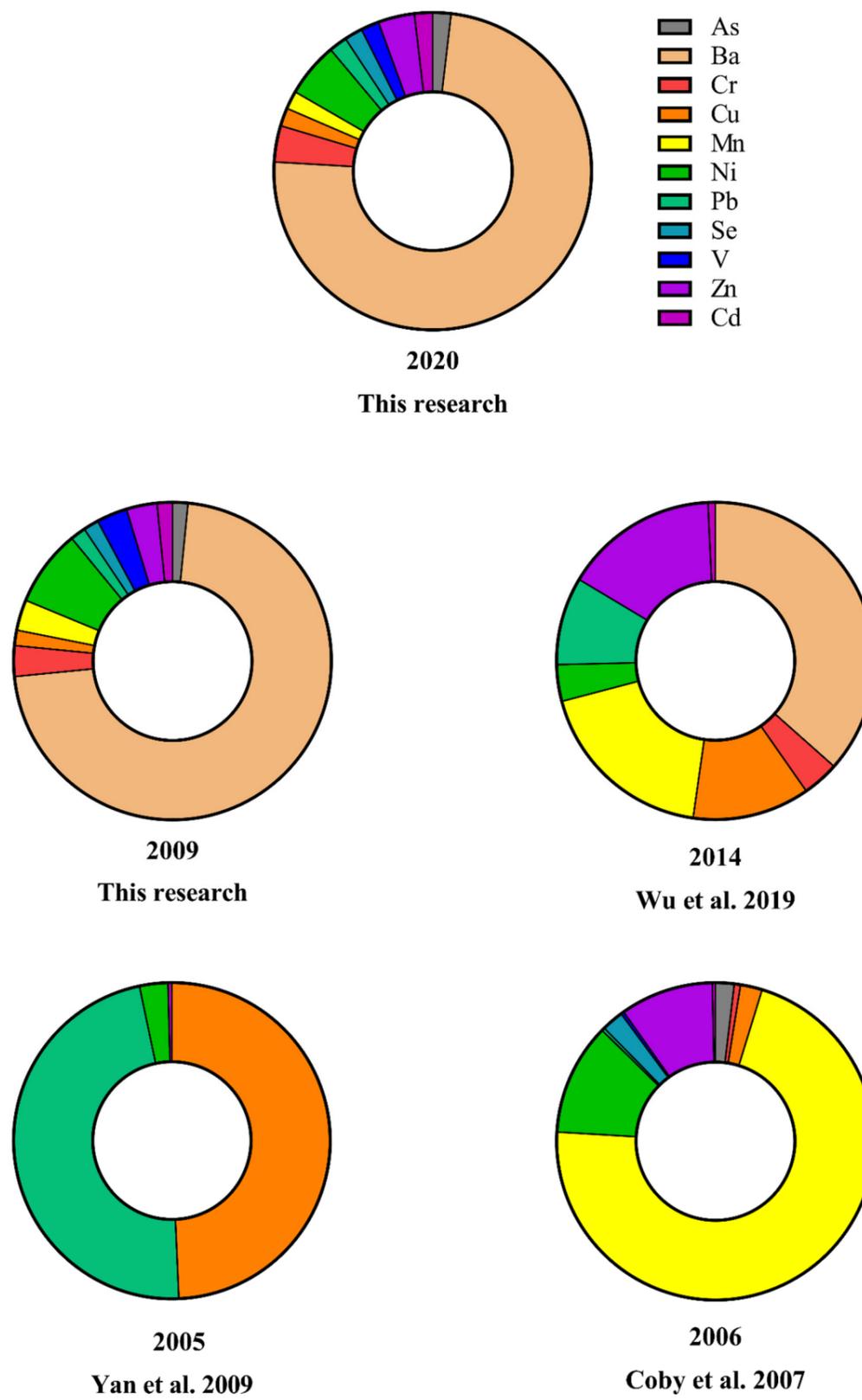
Figure S13. Percentage of heavy metal concentrations in Guiyu rivers, 2005-2020[20-22].
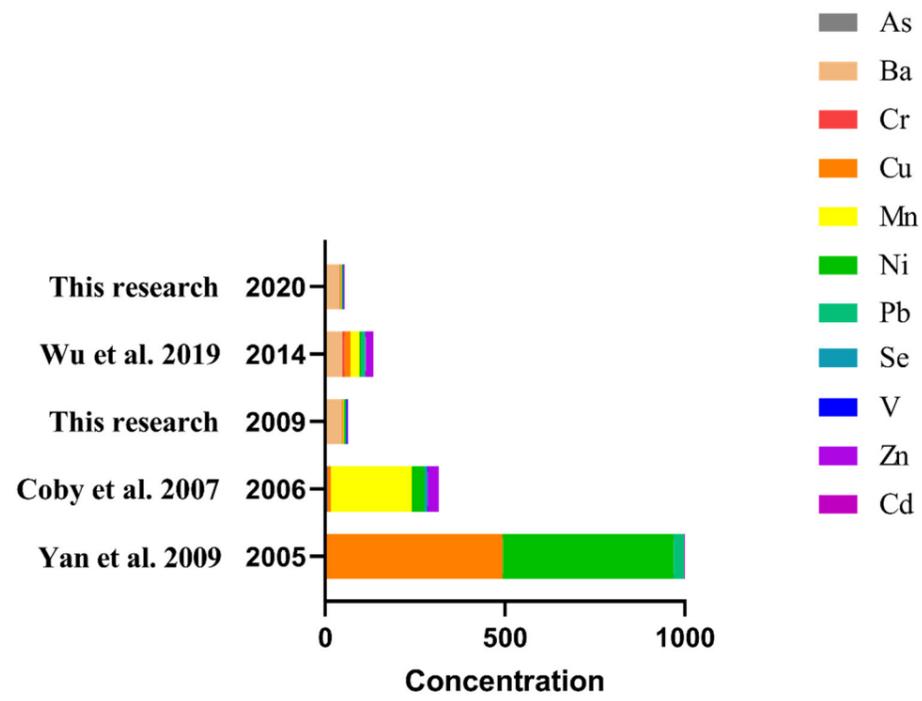
Figure S14. Comparison of heavy metal concentrations in rivers in Guiyu, 2005-2020[20-22]

**Figure S15.** Exposure of local people to river pollutants (Laundry)
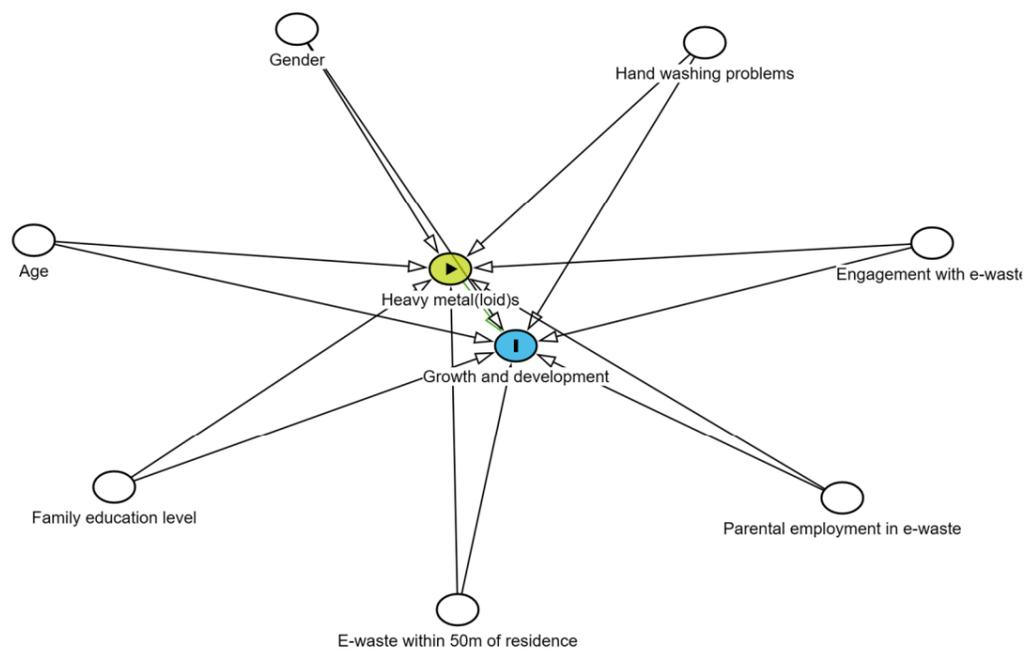
Figure S16. A directed acyclic graphs (DAGs) for judging and identifying Model B confounding factors

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