

Considering the Size Distribution of Elements in Particle Matter and Oxidation Potential: Association before and after Respiratory Exposure

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Methods Introduction

Sample Digestion Steps.

Step 1: The digestion vessel was placed in the fume hood for 40 minutes for predigestion. Step 2: Digestion vessel was exposed to a three-stage microwave system and was digested at 195 °C for 50 minutes. Step 3: The dissolved solutions were warmed at 180 °C to remove the excess acid because HF can corrode glassware and cause torch damage in ICP-MS. Step 4: After the vessels were cooled to room temperature, the residue was transferred to PET bottles with deionized water (conductivity: 18.2 MΩ cm) by repeatedly washing the digestion vessel.

OP_m^{DTT} and OP_v^{DTT} Calculation Method.

$$\sigma DTT = -\sigma Abs \times \frac{N_0}{Abs_0} \quad (S1)$$

$$OP_m^{DTT} = \frac{\sigma DTT_s - \sigma DTT_b}{\frac{V_a \times M_p}{V_e}} \quad (S2)$$

$$OP_v^{DTT} = \frac{\sigma DTT_s - \sigma DTT_b}{\frac{V_a \times V_p}{V_e}} \quad (S3)$$

where σAbs is the slope of absorbance (412 nm) versus time; Abs_0 is the initial absorbance calculated from the intercept of linear regression of absorbance versus time; N_0 is the initial moles of DTT added in the reaction (5ml); σDTT_s (σDTT_b) is the rate of DTT consumption for the sample (blank); and V_e and V_a are the extraction volume (6.5mL) and actual sample volume added to the reaction vial (1mL), respectively. M_p and V_p are the mass of sampling PM and sampling air volume (m^3) in the extraction volume.

Enrichment Factor (EF) Calculation Method.

$$EF_x = \frac{\left(\frac{X}{Al}\right)_{sample}}{\left(\frac{X}{Al}\right)_{crust}} \quad (S4)$$

where EF_x represents the enrichment factor value of element X in air PM; $\left(\frac{X}{Al}\right)_{samples}$ represents the ratio of X/Al in the samples; and $\left(\frac{X}{Al}\right)_{crust}$ represents the ratio of X/Al in the local continental crust elements. The reference concentrations of Al, K, Ca, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Ag, Cd, Sn, Sb, Ba, Hg, Tl, and Pb in the crust of Guangdong province were 62.9 g kg⁻¹, 7.40 g kg⁻¹, 40 g kg⁻¹, 39.0 mg kg⁻¹, 35.6 mg kg⁻¹, 163 mg kg⁻¹, 20.6 g kg⁻¹, 5.30 mg kg⁻¹, 9.60 mg kg⁻¹, 10.5 mg kg⁻¹, 36.3 mg kg⁻¹, 6.80 mg kg⁻¹, 0.65 mg kg⁻¹, 0.10 mg kg⁻¹, 0.04 mg kg⁻¹, 3.70 mg kg⁻¹, 0.41 mg kg⁻¹, 126 mg kg⁻¹, 0.06 mg kg⁻¹, 0.61 mg kg⁻¹, and 29.8 mg kg⁻¹, respectively. [1]

Table S1. Field blanks and limit of detection of the procedure for microwave digestion.

Elements	Field blanks	Limit of detection
	Air (ng m ⁻³)	Air (ng m ⁻³)
Al	228	0.07
K	128	0.02
Ca	228	0.02
V	0.15	0.01
Cr	4.93	0.02
Mn	0.70	0.03
Fe	31.5	0.03
Co	0.04	0.01
Ni	0.61	0.04
Cu	0.54	0.04
Zn	7.13	0.02
As	0.01	0.01
Se	0.55	0.02
Ag	0.00	0.03
Cd	0.14	0.02
Sn	3.10	0.02
Sb	0.00	0.01
Ba	2.68	0.01
Hg	0.00	0.02
Tl	0.00	0.01
Pb	0.52	0.03

Field blanks in the solution were calculated to be equal to the mean values of element concentrations in 12 filter blanks. Limit of detection (LOD) corresponds to three times the standard deviation of the blank signals obtained by using the results of 6 replicate measurements of the solvent blank. Field blanks and LOD in air (ng m⁻³) = concentrations in solution (ng ml⁻¹) × solution volume (ml) / air volume (m³)

Table S2. Definitions and recommended values of the parameters for health risk assessment of elements via inhalation pathway.

Parameter	Definition	Unit	Value	Reference
DF	Deposition flux	ng h ⁻¹	-	This study
ET	Exposure time	H day ⁻¹	12.5	This study
EF	Exposure frequency	Days year ⁻¹	335	This study
ED	Exposure duration	years	30	[2]
CF	Conversion factor	kg mg ⁻¹	10 ⁻⁶	
AT	Average time	days	Non-carcinogens, AT=ED×365 days	[3]
			Carcinogens, AT=70×365 days	[4]
BW	Body weight	kg	70	[5]

Table S3. Oral reference dose (RfD) (mg kg⁻¹ day⁻¹) and cancer slope factor (CSF) (kg·day mg⁻¹) of elements.

Elements	RfD ⁶ (mg kg ⁻¹ day ⁻¹)	SF ⁶ (kg·day mg ⁻¹)
Cu	4.02×10 ⁻²	
Zn	3.00×10 ⁻¹	
Pb	3.52×10 ⁻³	2.80×10 ⁻¹
Fe	7.00×10 ⁻¹	
Mn	1.43×10 ⁻⁵	
Cd	1.00×10 ⁻³	6.30
V	7.00×10 ⁻³	
Cr	2.86×10 ⁻⁵	4.20×10 ¹
Tl	1.00×10 ⁻⁵	
As	3.01×10 ⁻⁴	1.51×10 ¹
Co	5.71×10 ⁻⁶	9.80

Table S4. Values (mean ± standard deviation) of element concentrations (ng m⁻³), and OP_m^{DTT} (pmol min⁻¹ ug⁻¹) and OP_v^{DTT} (nmol min⁻¹m⁻³) of PM with different sizes in the waste recycle plant, South China.

Species	Unit	Particle size range								
		0–0.4	0.4–0.7	0.7–1.1	1.1–2.1	2.1–3.3	3.3–4.7	4.7–5.8	5.8–9.0	9.0–10
Al	µg m ⁻³	0.82±0.60	0.77±0.56	0.68±0.27	0.87±0.52	0.97±0.54	1.14±1.13	1.10±0.49	2.53±2.43	3.25±2.20
K	µg m ⁻³	0.18±0.17	0.24±0.11	0.33±0.15	0.31±0.15	0.30±0.15	0.33±0.09	0.31±0.09	0.62±0.71	0.89±0.70
Ca	µg m ⁻³	0.41±0.28	0.48±0.20	0.41±0.20	0.52±0.22	0.50±0.24	0.68±0.26	0.61±0.27	1.52±1.26	2.02±1.24
V	ng m ⁻³	0.30±0.47	0.19±0.12	0.28±0.11	0.40±0.15	0.51±0.18	0.73±0.18	0.74±0.18	1.39±0.39	3.08±1.17
Cr	ng m ⁻³	24.1±15.0	13.5±11.6	11.3±10.0	9.11±10.8	14.7±14.0	12.9±12.2	22.3±19.6	16.6±13.1	24.1±10.3
Mn	ng m ⁻³	4.28±3.05	7.72±3.31	14.2±6.00	12.5±5.17	8.26±2.71	10.9±2.42	11.5±1.87	24.5±7.04	62.7±21.5
Fe	ng m ⁻³	191±180	141±47.0	186±57.9	298±90.0	442±154	713±168	831±146	1672±410	4713±1573
Co	ng m ⁻³	0.07±0.07	0.34±0.24	0.19±0.15	0.24±0.23	0.42±0.40	0.31±0.23	0.30±0.20	0.51±0.19	1.17±0.47
Ni	ng m ⁻³	2.86±2.70	1.33±1.15	0.81±0.49	1.22±0.61	2.01±1.82	1.57±0.84	1.86±1.45	3.02±3.01	6.02±4.32
Cu	ng m ⁻³	10.0±9.05	3.54±2.65	4.14±2.63	5.68±4.11	4.45±2.77	5.64±3.24	5.61±3.36	11.7±6.57	37.3±27.4
Zn	ng m ⁻³	85.6±52.9	79.0±39.9	86.3±50.8	82.2±49.5	79.3±49.9	77.6±40.0	92.1±38.3	102±32.9	147±24.8
As	ng m ⁻³	19.9±14.1	19.8±10.2	19.0±11.3	29.1±23.4	24.5±24.2	26.9±17.4	23.3±16.8	31.7±14.7	33.0±20.3
Se	ng m ⁻³	0.63±0.45	0.84±0.48	1.05±0.39	0.89±0.58	0.85±0.56	0.49±0.36	0.43±0.29	0.41±0.28	0.67±0.58
Ag	ng m ⁻³	0.64±0.60	0.56±0.30	0.89±0.80	1.30±1.00	0.51±0.38	0.27±0.15	0.65±0.60	0.48±0.20	0.47±0.20
Cd	ng m ⁻³	0.06±0.05	0.17±0.07	0.28±0.14	0.36±0.18	0.16±0.06	0.08±0.04	0.06±0.02	0.10±0.05	0.13±0.04
Sn	ng m ⁻³	17.4±13.6	21.3±13.0	19.1±14.1	34.5±27.9	31.7±23.4	33.3±14.0	29.7±17.6	28.2±12.0	52.7±53.3
Sb	ng m ⁻³	12.8±19.9	20.7±14.3	21.8±33.2	44.2±26.5	28.4±33.2	19.1±14.3	23.6±19.1	25.6±14.4	33.6±19.9
Ba	ng m ⁻³	31.4±22.8	43.1±33.2	60.2±60.4	39.4±28.5	39.5±21.9	42.6±26.6	38.9±23.1	41.5±27.3	76.6±34.1
Hg	ng m ⁻³	0.03±0.03	0.05±0.03	0.06±0.04	0.07±0.05	0.06±0.06	0.04±0.02	0.06±0.02	0.03±0.02	0.06±0.01
Tl	ng m ⁻³	0.02±0.02	0.04±0.02	0.07±0.03	0.05±0.03	0.01±0.01	0.01±0.01	0.01±0.01	0.02±0.01	0.03±0.01
Pb	ng m ⁻³	2.28±2.20	4.13±1.56	6.63±2.52	7.28±3.33	4.41±2.02	5.05±2.73	4.61±1.57	8.68±3.94	19.9±9.01
DTT _m ^{DTT}	pmol min ⁻¹ ug ⁻¹	22.2±22.0	83.9±80.9	27.6±21.9	20.7±9.86	21.8±13.2	24.2±20.0	18.9±14.3	10.8±7.16	9.28±4.81
DTT _v ^{DTT}	nmol min ⁻¹ m ⁻³	0.33±0.26	0.28±0.18	0.38±0.13	0.41±0.17	0.34±0.12	0.32±0.19	0.29±0.10	0.23±0.07	0.28±0.112
PM	µg m ⁻³	8.57±7.27	18.9±10.1	23.2±12.8	20.5±12.1	16.3±7.77	20.4±9.16	43.5±41.2	31.9±7.54	74.9±16.5

Table S5. Relationships between enrichment factor (EF) and enrichment degree of the studied elements.

Enrichment Factor (EF)			
EF	Degree of enrichment	Level	Source
EF < 1	Almost no enrichment	1	Natural sources
1 ≤ EF < 10	Slight enrichment	2	Natural sources and anthropic sources
10 ≤ EF < 100	Moderate enrichment	3	Anthropic sources
100 ≤ EF < 1000	High enrichment	4	Anthropic sources
1000 ≤ EF	Super enrichment	5	Anthropic sources

Table S6. Enrichment factor of elements in PM with different sizes in the waste recycle plant, South China.

species	Enrichment Factor (EF)		
	PM _{0.4}	PM _{0.4–2.1}	PM _{2.1–10}
Al	1	1	1
K	3.42 ± 3.13	3.38 ± 2.53	2.76 ± 1.46
Ca	1.09 ± 0.81	0.97 ± 0.58	0.96 ± 0.10
V	0.32 ± 0.36	0.62 ± 0.43	1.71 ± 1.44
Cr	47.6 ± 46.4	17.3 ± 13.6	42.6 ± 78.8
Mn	1.44 ± 1.06	5.49 ± 3.35	7.97 ± 7.59
Fe	0.44 ± 0.42	0.88 ± 0.51	5.05 ± 6.09
Co	1.62 ± 2.28	2.25 ± 2.80	5.21 ± 4.33
Ni	5.29 ± 5.65	7.70 ± 5.16	17.8 ± 26.8
Cu	1.82 ± 0.36	32.4 ± 22.6	85.7 ± 52.8
Zn	179 ± 213	235 ± 194	125 ± 95.8
As	186 ± 244	146 ± 207	146 ± 236
Se	75.3 ± 84.9	111 ± 63	40.4 ± 54.0
Ag	248 ± 214	538 ± 267	204 ± 123
Cd	92.5 ± 92.3	502 ± 279	127 ± 81.3
Sn	171 ± 102	255 ± 243	311 ± 265
Sb	387 ± 233	352 ± 205	120 ± 948
Ba	25.3 ± 27.5	31.0 ± 34.2	15.8 ± 5.45
Hg	20.5 ± 3.86	77.0 ± 105	33.8 ± 25.2
Tl	0.06 ± 0.05	6.30 ± 4.06	1.90 ± 1.08
Pb	2.39 ± 1.65	15.3 ± 9.06	16.6 ± 16.9

Table S7. Comparison of OP_m^{DTT} ($\text{pmol min}^{-1} \mu\text{g}^{-1}$) and OP_v^{DTT} ($\text{nmol min}^{-1} \text{m}^{-3}$) in PM with different sizes around the world.

Country	Environment or source	PM	OP_m^{DTT} ($\text{pmol min}^{-1} \mu\text{g}^{-1}$)	DTT_v^{DTT} ($\text{nmol min}^{-1} \text{m}^{-3}$)	Ref.
USA	Urban outdoor	$PM_{0.17}$	11.0–60.0	-	[6]
	Urban outdoor	$PM_{0.17-1}$	24.0–92.0	-	[6]
	Urban outdoor	PM_1	71.0±9.00	-	[6]
	Urban outdoor	$PM_{2.5}$	5.00–100	0.10–1.50	[7]
	Urban outdoor	$PM_{3.2}$	-	0.06±0.06	[8]
	Urban outdoor	$PM_{3.2-18}$	-	0.05±0.03	[8]
	Roadside	$PM_{3.2}$	-	0.03±0.01	[8]
	Roadside	$PM_{3.2-18}$	-	0.17±0.14	[8]
	Biomass burning	$PM_{2.5}$	69.0±20.0	-	[9]
	Biomass burning organic aerosol	$PM_{2.5}$	151±20.0	-	[10]
	More-oxidized organic aerosol	$PM_{2.5}$	36.0±22.0	-	[10]
	Light-duty gasoline vehicles	$PM_{2.5}$	110±22.0	-	[9]
	Heavy-duty diesel vehicles	$PM_{2.5}$	52.0±10.0	-	[9]
India	Trash combustion	$PM_{2.5}$	-	100–3500	[11]
Italy	Urban outdoor	PM_{10}	8.00±2.00	0.17±0.05	[12]
	A traffic site	TSP	330±180	40.0±30.0	[13]
Singapore	Tunnel	$PM_{2.5}$	9.30 ± 5.40	0.80 ± 0.40	[14]
	Depot	$PM_{2.5}$	11.0± 10.0	0.80 ± 0.70	[14]
Netherlands	Urban background	PM_{10}	-	1.70	[15]
	Farm	PM_{10}	-	2.30	[15]
	Stop&Go traffic	PM_{10}	-	2.60	[15]
	Continuous traffic	PM_{10}	-	3.70	[15]
	Underground	PM_{10}	-	51.5	[15]
	Farm	$PM_{2.5}$	-	2.70	[15]
	Stop&Go traffic	$PM_{2.5}$	-	1.70	[15]
	Continuous traffic	$PM_{2.5}$	-	3.30	[15]
	Underground	$PM_{2.5}$	-	18.0	[15]
	Rural indoor	$PM_{2.5}$	88.9	9.70	[16]
China	Urban outdoor	$PM_{2.5}$	10.3	0.53	[17]
	Urban outdoor	$PM_{2.5}$	49.0±16.0	6.80 ± 3.40	[18]
	Urban outdoor	$PM_{2.5}$	35.0±18.0	4.4 0± 2.60	[18]
	Urban outdoor	$PM_{2.5}$	30.0±16.0	4.20 ± 2.70	[18]
	Urban outdoor	$PM_{2.5}$	130±100	12.3 ± 6.82	[19]
	Urban outdoor	$PM_{0.056-18}$	-	0.19	[20]
	Residential indoor	dust	7.14 ± 6.68		[21]
	Office	PM_{18}	-	0.15	[22]
	Laboratory	PM_{18}	-	0.15	[22]
	Home	PM_{18}	-	0.14	[22]
	Cigarette	PM_{10}	60.0±4.00	-	[23]
	Coal burning	PM_{10}	40.0±3.00	-	[23]
	Diesel	PM_{10}	130±4.00	-	[23]
	Biomass burning	$PM_{2.5}$	12.5–20.6	-	[23]
This study	Indoor	PM_{10}	12.6±4.54	2.83±0.50	

Mean ± standard deviation.

Table S8. Deposition fluxes of OP^{DTT} (nmol min^{−1} h^{−1}) and elements (ng h^{−1}) in PM with different sizes in the whole respiratory tract and health risks of elements in different positions of respiratory tract.

		Deposition flux	Non-carcinogenic risks (HQ)				Carcinogenic risks (CR)			
			PM _{0.4}	PM _{0.4-2.1}	PM _{2.1-10}	SUM	PM _{0.4}	PM _{0.4-2.1}	PM _{2.1-10}	SUM
HA	V	3.69±0.92	9.30 × 10 ^{−8}	4.39 × 10 ^{−6}	8.20 × 10 ^{−5}	8.65 × 10 ^{−5}	-	-	-	-
	Cr ^a	63.9±36.5	2.17 × 10 ^{−4}	5.13 × 10 ^{−3}	4.22 × 10 ^{−2}	4.76 × 10 ^{−2}	1.83 × 10 ^{−5}	4.33 × 10 ^{−4}	3.57 × 10 ^{−3}	4.02 × 10^{−3}
	Mn	71.5±16.4	2.51 × 10 ^{−4}	7.70 × 10 ^{−2}	7.43 × 10 ^{−1}	8.20 × 10 ^{−1}	-	-	-	-
	Fe	4890±1220	3.76 × 10 ^{−7}	3.43 × 10 ^{−5}	1.11 × 10 ^{−3}	1.15 × 10 ^{−3}	-	-	-	-
	Co	1.60±0.51	4.15 × 10 ^{−5}	3.73 × 10 ^{−3}	4.22 × 10 ^{−2}	4.60 × 10 ^{−2}	1.63 × 10 ^{−7}	1.47 × 10 ^{−5}	1.66 × 10 ^{−4}	1.81 × 10^{−4}
	Cu	40.6±23.2	4.83 × 10 ^{−8}	1.27 × 10 ^{−5}	1.53 × 10 ^{−4}	1.66 × 10 ^{−4}	-	-	-	-
	Zn	305±115	5.78 × 10 ^{−7}	2.41 × 10 ^{−5}	1.42 × 10 ^{−4}	1.67 × 10 ^{−4}	-	-	-	-
	As	29.2±9.01	4.40 × 10 ^{−6}	2.19 × 10 ^{−3}	1.37 × 10 ^{−2}	1.59 × 10 ^{−2}	1.41 × 10 ^{−6}	6.98 × 10 ^{−4}	4.38 × 10 ^{−3}	5.08 × 10^{−3}
	Cd	0.44±0.13	1.05 × 10 ^{−7}	2.66 × 10 ^{−5}	4.59 × 10 ^{−5}	7.26 × 10 ^{−5}	4.64 × 10 ^{−8}	1.18 × 10 ^{−5}	2.03 × 10 ^{−5}	3.21 × 10 ^{−5}
	Pb	27.1±9.22	8.31 × 10 ^{−7}	1.67 × 10 ^{−4}	1.10 × 10 ^{−3}	1.26 × 10 ^{−3}	5.76 × 10 ^{−8}	1.16 × 10 ^{−5}	7.59 × 10 ^{−5}	8.75 × 10 ^{−5}
	Tl	0.07±0.02	2.15 × 10 ^{−7}	4.66 × 10 ^{−4}	6.96 × 10 ^{−4}	1.16 × 10 ^{−3}	-	-	-	-
	OP ^{DTT}	0.98±0.29	0.00±0.00 ^b	0.21±0.06 ^b	0.77±0.14 ^b	-	-	-	-	-
TB	V	0.15±0.03	3.07 × 10 ^{−8}	4.18 × 10 ^{−7}	2.96 × 10 ^{−6}	3.41 × 10 ^{−6}	-	-	-	-
	Cr ^a	3.33±2.30	7.17 × 10 ^{−5}	4.74 × 10 ^{−4}	1.94 × 10 ^{−3}	2.48 × 10 ^{−3}	6.06 × 10 ^{−6}	4.00 × 10 ^{−5}	1.64 × 10 ^{−4}	2.10 × 10^{−4}
	Mn	2.84±0.57	8.28 × 10 ^{−5}	7.28 × 10 ^{−3}	2.52 × 10 ^{−2}	3.26 × 10 ^{−2}	-	-	-	-
	Fe	171±41.7	1.24 × 10 ^{−7}	3.28 × 10 ^{−6}	3.66 × 10 ^{−5}	4.00 × 10 ^{−5}	-	-	-	-
	Co	0.07±0.03	1.37 × 10 ^{−5}	3.50 × 10 ^{−4}	1.68 × 10 ^{−3}	2.05 × 10 ^{−3}	5.39 × 10 ^{−8}	1.38 × 10 ^{−6}	6.62 × 10 ^{−6}	8.05 × 10 ^{−6}
	Cu	1.55±0.84	1.59 × 10 ^{−8}	1.20 × 10 ^{−6}	5.12 × 10 ^{−6}	6.34 × 10 ^{−6}	-	-	-	-
	Zn	15.9±7.61	1.91 × 10 ^{−7}	2.26 × 10 ^{−6}	6.22 × 10 ^{−6}	8.68 × 10 ^{−6}	-	-	-	-
	As	1.41±0.05	1.45 × 10 ^{−6}	2.11 × 10 ^{−4}	5.55 × 10 ^{−4}	7.67 × 10 ^{−4}	4.64 × 10 ^{−7}	6.75 × 10 ^{−5}	1.77 × 10 ^{−4}	2.45 × 10^{−4}
	Cd	0.03±0.01	3.46 × 10 ^{−8}	2.54 × 10 ^{−6}	2.28 × 10 ^{−6}	4.85 × 10 ^{−6}	1.53 × 10 ^{−8}	1.12 × 10 ^{−6}	1.01 × 10 ^{−6}	2.15 × 10 ^{−6}
	Pb	1.21±0.40	2.74 × 10 ^{−7}	1.58 × 10 ^{−5}	4.02 × 10 ^{−5}	5.63 × 10 ^{−5}	1.90 × 10 ^{−8}	1.10 × 10 ^{−6}	2.78 × 10 ^{−6}	3.90 × 10 ^{−6}
	Tl	0.00±0.00	7.10 × 10 ^{−8}	4.38 × 10 ^{−5}	2.95 × 10 ^{−5}	7.33 × 10 ^{−5}	-	-	-	-
	OP ^{DTT}	0.06±0.01	0.00±0.00 ^b	0.02±0.01 ^b	0.04±0.01 ^b	-	-	-	-	-
PA	V	0.25±0.05	2.24 × 10 ^{−7}	1.53 × 10 ^{−6}	4.00 × 10 ^{−6}	5.76 × 10 ^{−6}	-	-	-	-
	Cr ^a	7.19±5.61	5.23 × 10 ^{−4}	2.11 × 10 ^{−3}	2.72 × 10 ^{−3}	5.36 × 10 ^{−3}	4.42 × 10 ^{−5}	1.78 × 10 ^{−4}	2.30 × 10 ^{−4}	4.52 × 10^{−4}
	Mn	5.52±1.26	6.04 × 10 ^{−4}	2.88 × 10 ^{−2}	3.38 × 10 ^{−2}	6.32 × 10 ^{−2}	-	-	-	-
	Fe	262±64.8	9.06 × 10 ^{−7}	1.18 × 10 ^{−5}	4.87 × 10 ^{−5}	6.13 × 10 ^{−5}	-	-	-	-
	Co	0.13±0.06	9.99 × 10 ^{−5}	1.40 × 10 ^{−3}	2.35 × 10 ^{−3}	3.86 × 10 ^{−3}	3.93 × 10 ^{−7}	5.52 × 10 ^{−6}	9.25 × 10 ^{−6}	1.52 × 10 ^{−5}
	Cu	2.86±1.57	1.16 × 10 ^{−7}	4.66 × 10 ^{−6}	6.89 × 10 ^{−6}	1.17 × 10 ^{−5}	-	-	-	-
	Zn	35.4±18.1	1.39 × 10 ^{−6}	9.33 × 10 ^{−6}	8.64 × 10 ^{−6}	1.94 × 10 ^{−5}	-	-	-	-
	As	2.69±0.98	1.06 × 10 ^{−5}	6.88 × 10 ^{−4}	7.68 × 10 ^{−4}	1.47 × 10 ^{−3}	3.38 × 10 ^{−6}	2.20 × 10 ^{−4}	2.45 × 10 ^{−4}	4.69 × 10^{−4}
	Cd	0.08±0.03	2.52 × 10 ^{−7}	9.43 × 10 ^{−6}	3.33 × 10 ^{−6}	1.30 × 10 ^{−5}	1.12 × 10 ^{−7}	4.18 × 10 ^{−6}	1.47 × 10 ^{−6}	5.76 × 10 ^{−6}
	Pb	2.53±0.78	2.00 × 10 ^{−6}	6.09 × 10 ^{−5}	5.47 × 10 ^{−5}	1.18 × 10 ^{−4}	1.39 × 10 ^{−7}	4.22 × 10 ^{−6}	3.79 × 10 ^{−6}	8.15 × 10 ^{−6}
	Tl	0.01±0.01	5.18 × 10 ^{−7}	1.82 × 10 ^{−4}	4.16 × 10 ^{−5}	2.24 × 10 ^{−4}	-	-	-	-
	OP ^{DTT}	0.15±0.05	0.01±0.01 ^b	0.08±0.02 ^b	0.06±0.01 ^b	-	-	-	-	-

^a: The health risk of Cr is mainly for Cr (VI); the concentrations of Cr (VI) were estimated based on a concentration ratio of Cr (VI) to total Cr of 0.13. ^b: The deposition fluxes of OP^{DTT} of PM with different sizes.

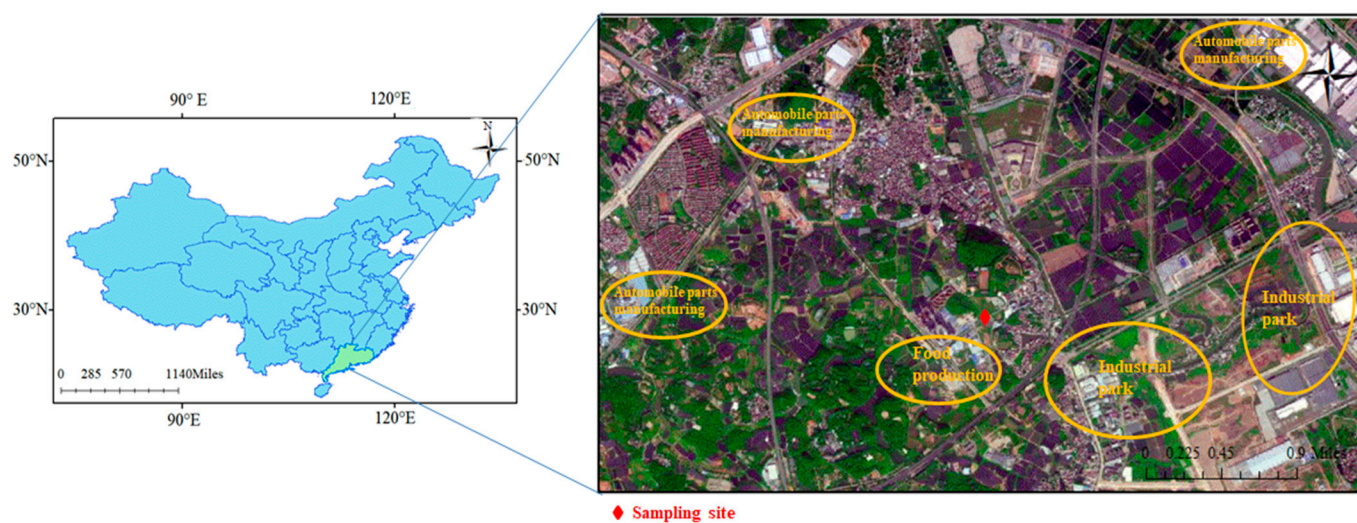


Figure S1. Sampling site and surrounding environment of the plant.

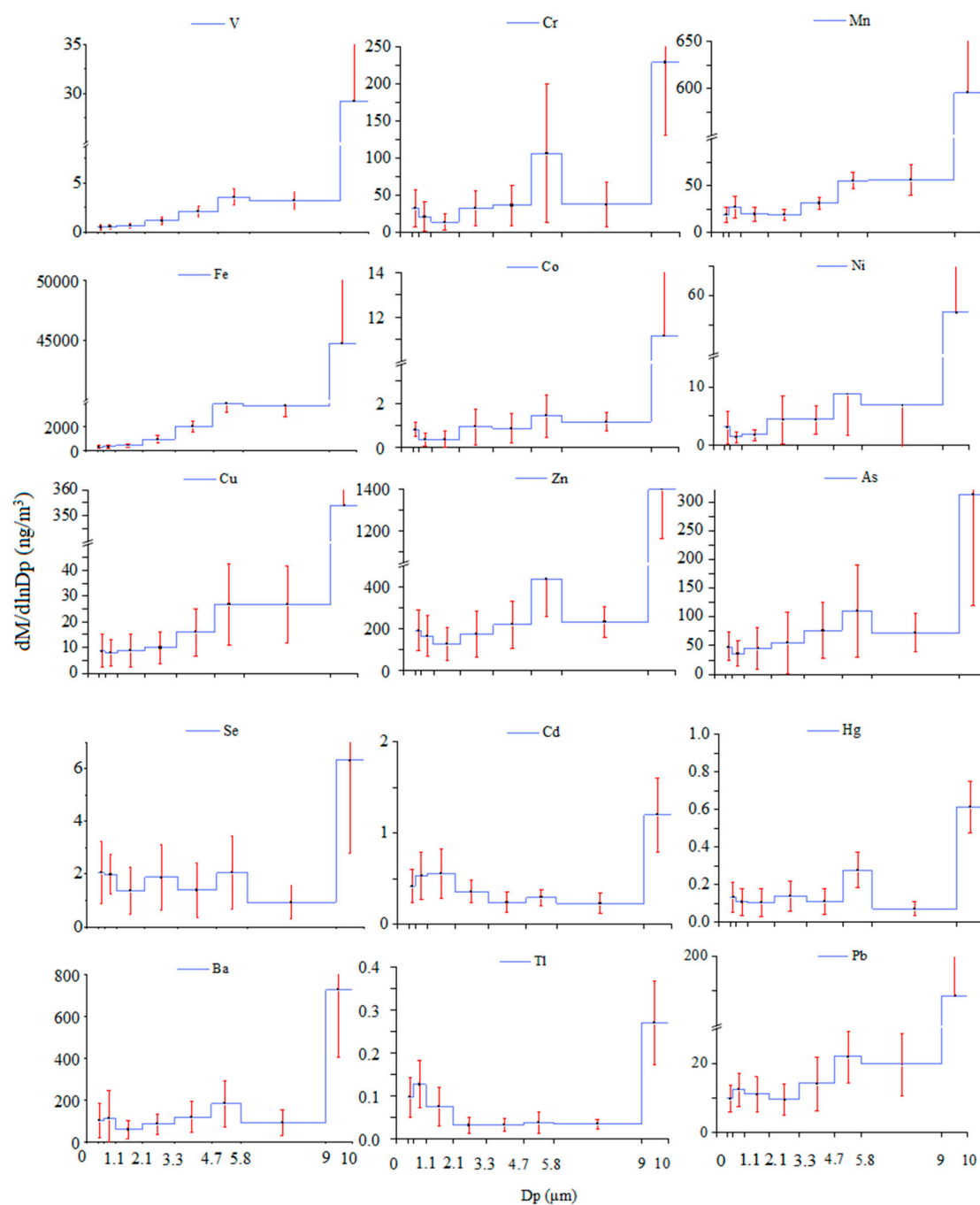


Figure S2. Size distribution of mean concentration of PM-bound elements (ng m⁻³) in the waste recycling plant, South China. (Error bars in red refer to the standard deviations (n = 12); Dp is the particle diameter (μm).)

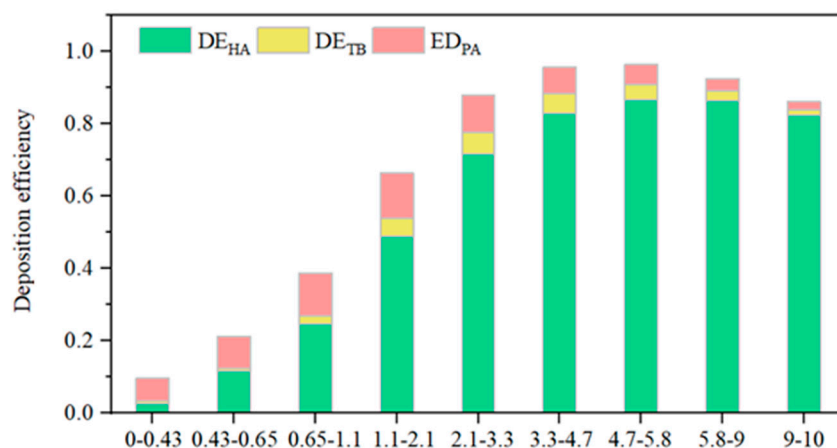


Figure S3. Deposition efficiency of size-resolved PM in head (HA), tracheobronchial (TB), and pulmonary (PA) regions using ICRP model.

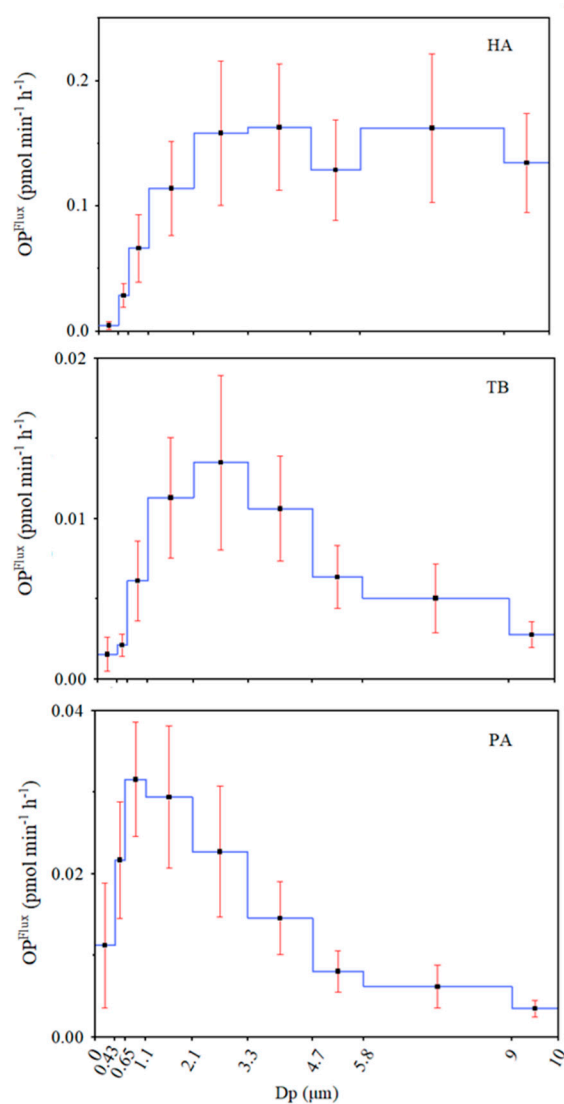


Figure S4. Mean deposition flux of OP^{DTT} (OP^{Flux}) in different size-fractionated stages in head (HA), tracheobronchial (TB), and pulmonary (PA) regions using ICRP model. (Error bars in red refer to the standard deviations (n = 12); Dp is the particle diameter (μm).)

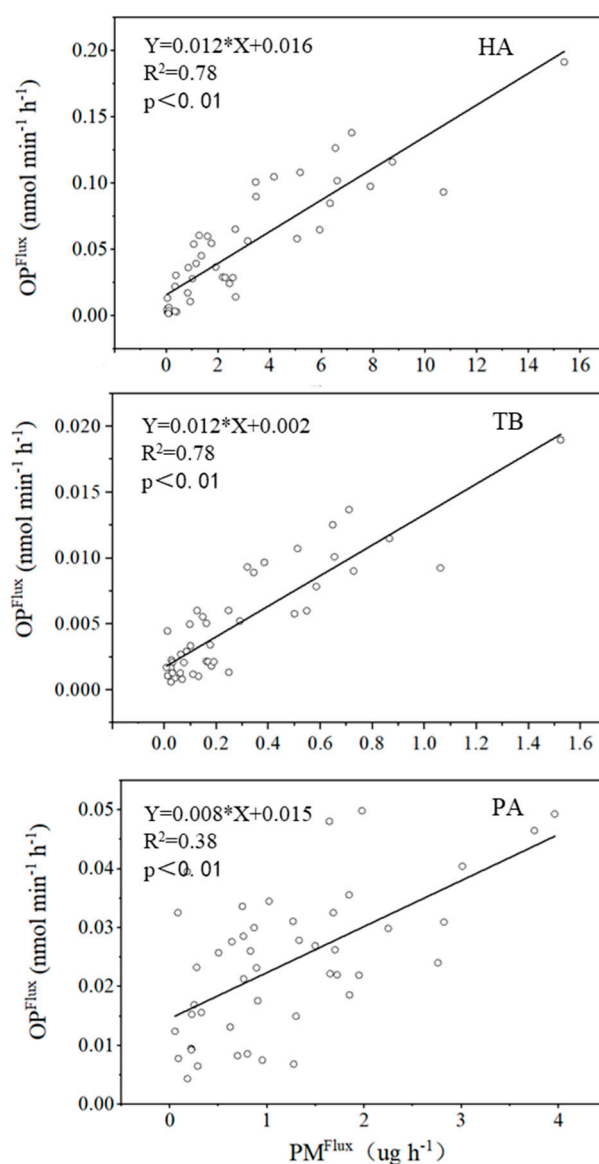


Figure S5. Univariate linear regression analysis between deposition flux of OP^{DTT} (OP^{Flux}: dependent variable) and mass concentration of PM_{2.1} (PM_{2.1}^{Flux}: independent variable) in head (HA), tracheobronchial (TB), and pulmonary (PA) regions using ICRP model.

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