

## Captions

### **Fig. S1**

Meteorological data during the period of study (sand storm period in background of blue).

### **Fig. S2**

Concentrations of  $\text{SO}_2$ ,  $\text{SO}_4^{2-}$ ,  $\text{NO}_2$ , and  $\text{NO}_3^-$  during sampling period (sand storm period in background of blue).

### **Fig. S3**

Source profiles identified by PMF model.

### **Fig. S4.**

Clustering analysis of backward trajectories for whole sampling period.

### **Table S1**

Carcinogenic risk posed by  $\text{PM}_{2.5}$ -associated elements via inhalation, dermal contact, and ingestion exposure during sand storm and non-sand storm ( $\text{CR} > 1 \times 10^{-4}$  in bold).

### **Table S2**

Non-carcinogenic risk posed by  $\text{PM}_{2.5}$ -associated elements via inhalation, dermal contact, and ingestion exposure during sand storm ( $\text{HQ} > 1$  in bold).

### **Table S3**

Non-carcinogenic risk posed by  $\text{PM}_{2.5}$ -associated elements via inhalation, dermal contact, and ingestion exposure during non-sand storm ( $\text{HQ} > 1$  in bold).

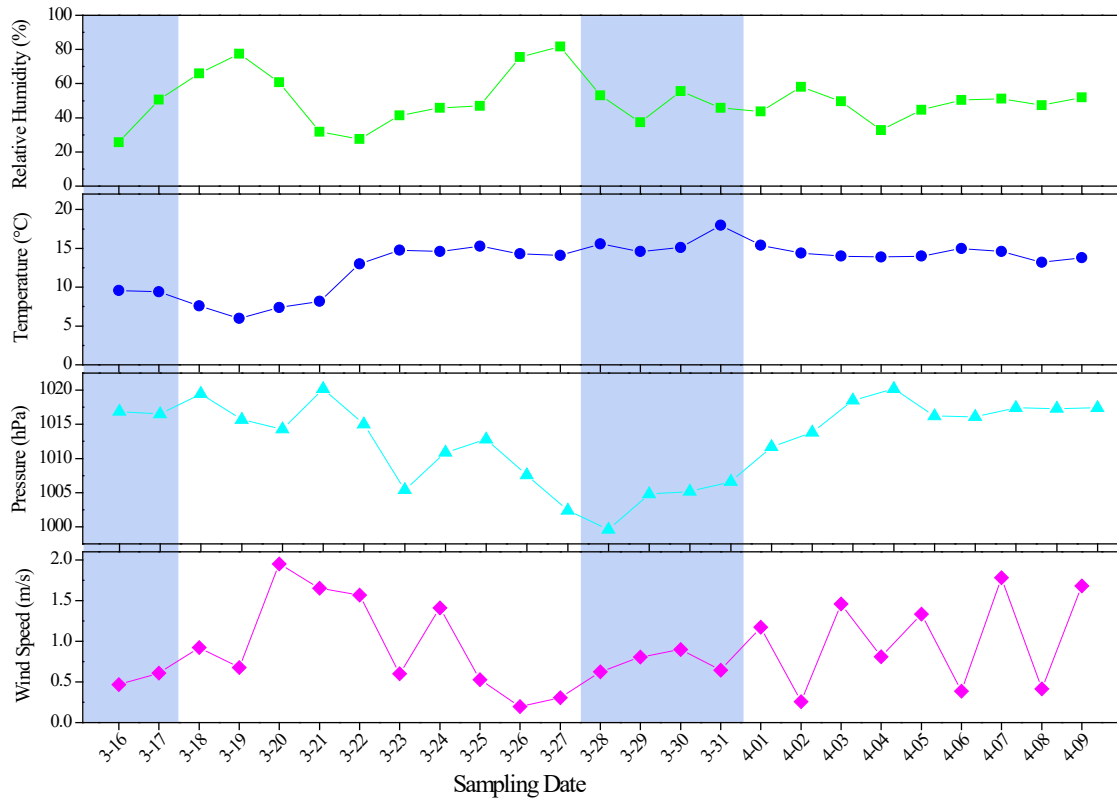


Fig. S1. Meteorological data during the period of study (sand storm period in background of blue).

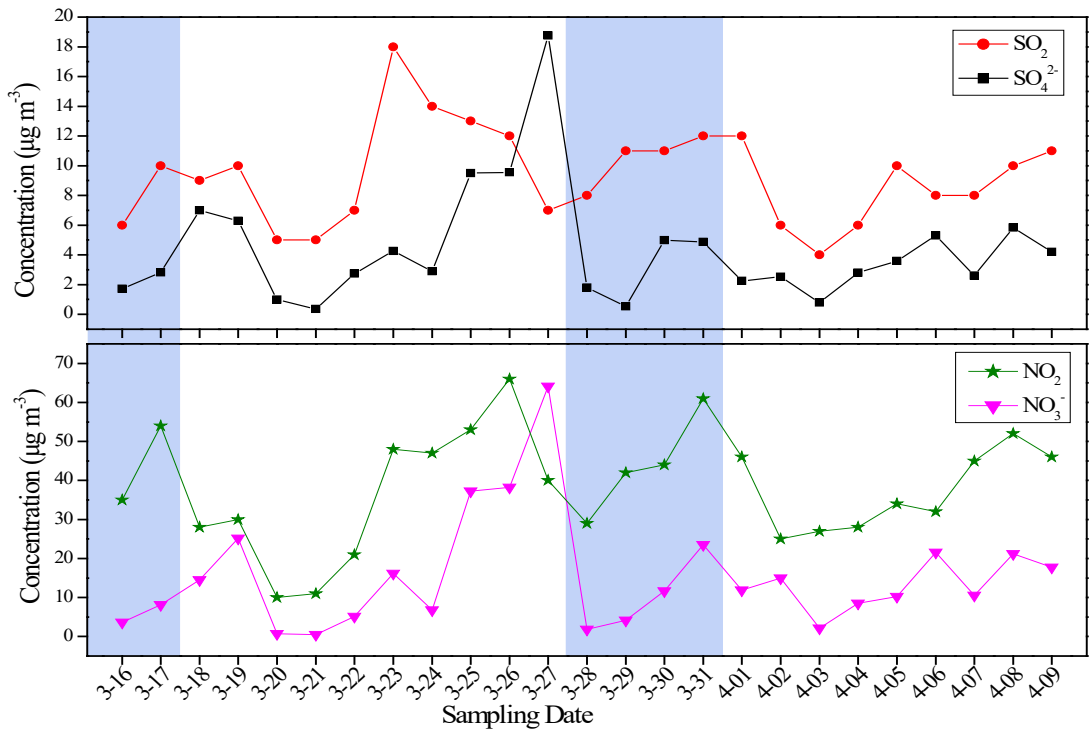


Fig. S2. Concentrations of  $\text{SO}_2$ ,  $\text{SO}_4^{2-}$ ,  $\text{NO}_2$ , and  $\text{NO}_3^-$  during sampling period (sand storm period in background of blue).



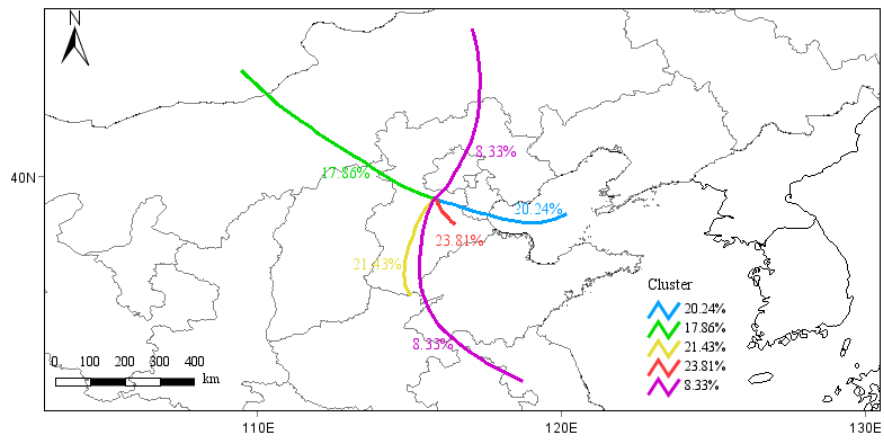


Fig. S4. Clustering analysis of backward trajectories for whole sampling period.

**Table 1S** Meanings and values of calculation parameters of the chemical daily intake, the dermal absorbed dose, and the exposure concentration.

Parameters/Unit	Parameter meaning	Child	Adult
C	concentration;		
BW/kg	Average body weight	15	70
EF/d·a <sup>-1</sup>	Exposure rate	350	350
ED/a	Exposure duration	6	24
AT,carcinogenic/d	Average time	70·365	70·365
AT,noncarcinogenic/d		ED·365	ED·365
IngR/mg·d <sup>-1</sup>	Ingestion rate	200	100
CF/kg·mg <sup>-1</sup>	Conversion factor	10 <sup>-6</sup>	10 <sup>-6</sup>
ET/h·d <sup>-1</sup>	Exposure time	24	24
SA/cm <sup>2</sup>	Exposed skin surface area	2800	5700
AF, mg·cm <sup>-2</sup> ·d <sup>-1</sup>	Skin adherence factor for airborne particulates	0.2	0.07
ABS	Dermal absorption factor	0.001 for other elements,0.03 for As and Cd	
ATn, carcinogenic/h	Average time	70·365·24	ED·365·24
ATn, noncarcinogenic/h		ED·365·24	ED·365·24

Table S2 Carcinogenic risk posed by PM<sub>2.5</sub>-associated metals via inhalation, dermal contact, and ingestion in the SSP and the NSSP (CR>1×10<sup>-4</sup> in bold).

Sampling period	Element	CR <sub>ing</sub>		CR <sub>derm</sub>		CR <sub>inh</sub>		Integrated Risk	
		Children	Adults	Children	Adults	Children	Adults	Children	Adults
SSP	As	6.01×10 <sup>-5</sup>	2.58×10 <sup>-5</sup>	5.05×10 <sup>-6</sup>	3.09×10 <sup>-6</sup>	9.23×10 <sup>-7</sup>	3.69×10 <sup>-6</sup>	6.61×10 <sup>-5</sup>	3.26×10 <sup>-5</sup>
	Cd					1.35×10 <sup>-7</sup>	5.40×10 <sup>-7</sup>	1.35×10 <sup>-7</sup>	5.40×10 <sup>-7</sup>
	Co					8.66×10 <sup>-7</sup>	3.46×10 <sup>-6</sup>	8.66×10 <sup>-7</sup>	3.46×10 <sup>-6</sup>
	Cr(VI)	8.13×10 <sup>-6</sup>	3.49×10 <sup>-6</sup>	9.11×10 <sup>-6</sup>	5.56×10 <sup>-6</sup>	7.66×10 <sup>-6</sup>	3.07×10 <sup>-5</sup>	2.49×10 <sup>-5</sup>	3.97×10 <sup>-5</sup>
	Ni	4.70×10 <sup>-5</sup>	2.01×10 <sup>-5</sup>	3.29×10 <sup>-5</sup>	2.01×10 <sup>-5</sup>	7.35×10 <sup>-8</sup>	2.94×10 <sup>-7</sup>	8.00×10 <sup>-5</sup>	4.05×10 <sup>-5</sup>
	Pb					2.65×10 <sup>-8</sup>	1.06×10 <sup>-7</sup>	2.65×10 <sup>-8</sup>	1.06×10 <sup>-7</sup>
	SUM	<b>1.15×10<sup>-4</sup></b>	4.94×10 <sup>-5</sup>	4.71×10 <sup>-5</sup>	2.87×10 <sup>-5</sup>	9.69×10 <sup>-6</sup>	3.87×10 <sup>-5</sup>	<b>1.72×10<sup>-4</sup></b>	<b>1.17×10<sup>-4</sup></b>
NSSP	As	5.02×10 <sup>-5</sup>	2.15×10 <sup>-5</sup>	4.21×10 <sup>-6</sup>	2.57×10 <sup>-6</sup>	7.09×10 <sup>-7</sup>	2.84×10 <sup>-6</sup>	5.51×10 <sup>-5</sup>	2.69×10 <sup>-5</sup>
	Cd					7.02×10 <sup>-8</sup>	2.81×10 <sup>-7</sup>	7.02×10 <sup>-8</sup>	2.81×10 <sup>-7</sup>
	Co					1.99×10 <sup>-7</sup>	7.96×10 <sup>-7</sup>	1.99×10 <sup>-7</sup>	7.96×10 <sup>-7</sup>
	Cr(VI)	4.39×10 <sup>-6</sup>	1.88×10 <sup>-6</sup>	4.92×10 <sup>-6</sup>	3.00×10 <sup>-6</sup>	3.32×10 <sup>-6</sup>	1.33×10 <sup>-5</sup>	1.26×10 <sup>-5</sup>	1.82×10 <sup>-5</sup>
	Ni	8.02×10 <sup>-5</sup>	3.44×10 <sup>-5</sup>	5.61×10 <sup>-5</sup>	3.43×10 <sup>-5</sup>	8.58×10 <sup>-8</sup>	3.43×10 <sup>-7</sup>	<b>1.36×10<sup>-4</sup></b>	6.90×10 <sup>-5</sup>
	Pb					2.20×10 <sup>-8</sup>	8.82×10 <sup>-8</sup>	2.20×10 <sup>-8</sup>	8.82×10 <sup>-8</sup>
	SUM	<b>1.35×10<sup>-4</sup></b>	5.77×10 <sup>-5</sup>	6.53×10 <sup>-5</sup>	3.99×10 <sup>-5</sup>	4.40×10 <sup>-6</sup>	1.76×10 <sup>-5</sup>	<b>2.04×10<sup>-4</sup></b>	<b>1.15×10<sup>-4</sup></b>

Table S3 Non-carcinogenic risk posed by PM<sub>2.5</sub>-associated elements via inhalation, dermal contact, and ingestion in the SSP (HQ>1 in bold).

Element	HQ <sub>ing</sub>		HQ <sub>derm</sub>		HQ <sub>inh</sub>		Integrated Risk	
	Children	Adults	Children	Adults	Children	Adults	Children	Adults
As	<b>1.56</b>	1.67×10 <sup>-1</sup>	1.31×10 <sup>-1</sup>	2.00×10 <sup>-2</sup>	1.67×10 <sup>-1</sup>	1.67×10 <sup>-1</sup>	<b>1.86</b>	3.54×10 <sup>-1</sup>
Ba	3.23×10 <sup>-2</sup>	3.46×10 <sup>-3</sup>	1.29×10 <sup>-2</sup>	1.97×10 <sup>-3</sup>	7.56×10 <sup>-2</sup>	7.56×10 <sup>-2</sup>	1.21×10 <sup>-1</sup>	8.11×10 <sup>-2</sup>
Cd	1.51×10 <sup>-1</sup>	1.62×10 <sup>-2</sup>	1.69×10 <sup>-2</sup>	2.58×10 <sup>-3</sup>	8.75×10 <sup>-2</sup>	8.75×10 <sup>-2</sup>	2.55×10 <sup>-1</sup>	1.06×10 <sup>-1</sup>
Co	6.43×10 <sup>-1</sup>	6.88×10 <sup>-2</sup>	1.80×10 <sup>-2</sup>	2.75×10 <sup>-3</sup>	1.87×10 <sup>-1</sup>	1.87×10 <sup>-1</sup>	8.48×10 <sup>-1</sup>	2.59×10 <sup>-1</sup>
Cr	7.59×10 <sup>-4</sup>	8.13×10 <sup>-5</sup>	1.64×10 <sup>-3</sup>	2.50×10 <sup>-4</sup>			2.39×10 <sup>-3</sup>	3.31×10 <sup>-4</sup>
Cu	1.90×10 <sup>-2</sup>	2.03×10 <sup>-3</sup>	5.31×10 <sup>-4</sup>	8.11×10 <sup>-5</sup>			1.95×10 <sup>-2</sup>	2.11×10 <sup>-3</sup>
Fe	6.48×10 <sup>-1</sup>	6.95×10 <sup>-2</sup>	1.82×10 <sup>-2</sup>	2.77×10 <sup>-3</sup>			6.66×10 <sup>-1</sup>	7.22×10 <sup>-2</sup>
Mn	1.11×10 <sup>-1</sup>	1.19×10 <sup>-2</sup>	3.11×10 <sup>-3</sup>	4.76×10 <sup>-4</sup>	<b>1.79</b>	<b>1.79</b>	<b>1.90</b>	<b>1.80</b>
Mo	1.49×10 <sup>-2</sup>	1.60×10 <sup>-3</sup>	4.18×10 <sup>-4</sup>	6.39×10 <sup>-5</sup>	1.31×10 <sup>-4</sup>	1.31×10 <sup>-4</sup>	1.55×10 <sup>-2</sup>	1.80×10 <sup>-3</sup>
Ni	5.48×10 <sup>-2</sup>	5.87×10 <sup>-3</sup>	3.83×10 <sup>-2</sup>	5.86×10 <sup>-3</sup>	1.65×10 <sup>-1</sup>	1.65×10 <sup>-1</sup>	2.58×10 <sup>-1</sup>	1.77×10 <sup>-1</sup>
Pb	<b>1.38</b>	1.48×10 <sup>-1</sup>	3.86×10 <sup>-2</sup>	5.89×10 <sup>-3</sup>			<b>1.42</b>	1.54×10 <sup>-1</sup>
Sb	<b>1.12</b>	1.21×10 <sup>-1</sup>	2.10×10 <sup>-1</sup>	3.21×10 <sup>-2</sup>	7.77×10 <sup>-3</sup>	7.77×10 <sup>-3</sup>	<b>1.34</b>	1.60×10 <sup>-1</sup>
Sn	3.84×10 <sup>-4</sup>	4.12×10 <sup>-5</sup>	1.08×10 <sup>-5</sup>	1.64×10 <sup>-6</sup>			3.95×10 <sup>-4</sup>	4.28×10 <sup>-5</sup>
Tl	<b>5.64</b>	6.04×10 <sup>-1</sup>	1.58×10 <sup>-1</sup>	2.41×10 <sup>-2</sup>			<b>5.79</b>	6.28×10 <sup>-1</sup>
V	1.91×10 <sup>-1</sup>	2.05×10 <sup>-2</sup>	2.06×10 <sup>-1</sup>	3.14×10 <sup>-2</sup>	1.41×10 <sup>-2</sup>	1.41×10 <sup>-2</sup>	4.11×10 <sup>-1</sup>	6.59×10 <sup>-2</sup>
Zn	3.55×10 <sup>-2</sup>	3.81×10 <sup>-3</sup>	9.95×10 <sup>-4</sup>	1.52×10 <sup>-4</sup>			3.65×10 <sup>-2</sup>	3.96×10 <sup>-3</sup>
Sum	<b>11.6</b>	<b>1.24</b>	0.854	0.130	<b>2.49</b>	<b>2.49</b>	<b>14.9</b>	<b>3.87</b>



Table S4 Non-carcinogenic risk posed by PM<sub>2.5</sub>-associated elements via inhalation, dermal contact, and ingestion in the NSSP (HQ>1 in bold).

Element	HQ <sub>ing</sub>		HQ <sub>derm</sub>		HQ <sub>inh</sub>		Integrated Risk	
	Children	Adults	Children	Adults	Children	Adults	Children	Adults
As	<b>1.30</b>	1.39×10 <sup>-1</sup>	1.09×10 <sup>-1</sup>	1.67×10 <sup>-2</sup>	1.28×10 <sup>-1</sup>	1.28×10 <sup>-1</sup>	<b>1.54</b>	2.84×10 <sup>-1</sup>
Ba	1.38×10 <sup>-2</sup>	1.48×10 <sup>-3</sup>	5.54×10 <sup>-3</sup>	8.45×10 <sup>-4</sup>	2.22×10 <sup>-2</sup>	2.22×10 <sup>-2</sup>	4.15×10 <sup>-2</sup>	2.45×10 <sup>-2</sup>
Cd	9.00×10 <sup>-2</sup>	9.65×10 <sup>-3</sup>	1.01×10 <sup>-2</sup>	1.54×10 <sup>-3</sup>	4.55×10 <sup>-2</sup>	4.55×10 <sup>-2</sup>	1.46×10 <sup>-1</sup>	5.67×10 <sup>-2</sup>
Co	2.00×10 <sup>-1</sup>	2.15×10 <sup>-2</sup>	5.61×10 <sup>-3</sup>	8.57×10 <sup>-4</sup>	4.30×10 <sup>-2</sup>	4.30×10 <sup>-2</sup>	2.49×10 <sup>-1</sup>	6.53×10 <sup>-2</sup>
Cr	4.10×10 <sup>-4</sup>	4.39×10 <sup>-5</sup>	8.83×10 <sup>-4</sup>	1.35×10 <sup>-4</sup>			1.29×10 <sup>-3</sup>	1.79×10 <sup>-4</sup>
Cu	4.07×10 <sup>-2</sup>	4.36×10 <sup>-3</sup>	1.14×10 <sup>-3</sup>	1.74×10 <sup>-4</sup>			4.18×10 <sup>-2</sup>	4.53×10 <sup>-3</sup>
Fe	1.89×10 <sup>-1</sup>	2.03×10 <sup>-2</sup>	5.30×10 <sup>-3</sup>	8.09×10 <sup>-4</sup>			1.95×10 <sup>-1</sup>	2.11×10 <sup>-2</sup>
Mn	3.22×10 <sup>-2</sup>	3.45×10 <sup>-3</sup>	9.00×10 <sup>-4</sup>	1.37×10 <sup>-4</sup>	4.35×10 <sup>-1</sup>	4.35×10 <sup>-1</sup>	4.68×10 <sup>-1</sup>	4.38×10 <sup>-1</sup>
Mo	1.22×10 <sup>-2</sup>	1.30×10 <sup>-3</sup>	3.41×10 <sup>-4</sup>	5.21×10 <sup>-5</sup>	1.01×10 <sup>-4</sup>	1.01×10 <sup>-4</sup>	1.26×10 <sup>-2</sup>	1.46×10 <sup>-3</sup>
Ni	9.35×10 <sup>-2</sup>	1.00×10 <sup>-2</sup>	6.54×10 <sup>-2</sup>	9.99×10 <sup>-3</sup>	1.92×10 <sup>-1</sup>	1.92×10 <sup>-1</sup>	3.51×10 <sup>-1</sup>	2.12×10 <sup>-1</sup>
Pb	<b>1.24</b>	1.33×10 <sup>-1</sup>	3.47×10 <sup>-2</sup>	5.30×10 <sup>-3</sup>			<b>1.27</b>	1.38×10 <sup>-1</sup>
Sb	8.66×10 <sup>-1</sup>	9.28×10 <sup>-2</sup>	1.62×10 <sup>-1</sup>	2.47×10 <sup>-2</sup>	5.80×10 <sup>-3</sup>	5.80×10 <sup>-3</sup>	<b>1.03</b>	1.23×10 <sup>-1</sup>
Sn	4.18×10 <sup>-4</sup>	4.47×10 <sup>-5</sup>	1.17×10 <sup>-5</sup>	1.79×10 <sup>-6</sup>			4.29×10 <sup>-4</sup>	4.65×10 <sup>-5</sup>
Tl	<b>4.65</b>	4.98×10 <sup>-1</sup>	1.30×10 <sup>-1</sup>	1.99×10 <sup>-2</sup>			<b>4.78</b>	5.18×10 <sup>-1</sup>
V	4.12×10 <sup>-2</sup>	4.42×10 <sup>-3</sup>	4.44×10 <sup>-2</sup>	6.78×10 <sup>-3</sup>	2.33×10 <sup>-3</sup>	2.33×10 <sup>-3</sup>	8.80×10 <sup>-2</sup>	1.35×10 <sup>-2</sup>
Zn	3.15×10 <sup>-2</sup>	3.37×10 <sup>-3</sup>	8.82×10 <sup>-4</sup>	1.35×10 <sup>-4</sup>			3.24×10 <sup>-2</sup>	3.51×10 <sup>-3</sup>
Sum	<b>8.79</b>	0.943	0.576	0.088	0.874	0.874	<b>10.3</b>	<b>1.91</b>