

**Appendix A. Supplementary data**

**Potassium: A Tracer for Biomass Burning in Beijing?**

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## Uncertainty analysis

The uncertainty analysis for this method is conducted by combining the uncertainties for the elements concentration measurements by the Xact (K, Ca, Pb) and elements ratios (K/Ca, K/Pb), and calculated using the error transfer formula in the following equations.

$$\left(\frac{U_{\text{dust}}}{K_{\text{dust}}}\right)^2 = \left(\frac{U_{\text{Ca}}}{C_{\text{Ca}}}\right)^2 + \left(\frac{U_{\text{K/Ca}}}{R_{\text{K/Ca}}}\right)^2 \quad (1)$$

$$\left(\frac{U_{\text{coal}}}{K_{\text{coal}}}\right)^2 = \left(\frac{U_{\text{Pb}}}{C_{\text{Pb}}}\right)^2 + \left(\frac{U_{\text{K/Pb}}}{R_{\text{K/Pb}}}\right)^2 \quad (2)$$

$$(U_{\text{biomass}})^2 = (U_{\text{K}})^2 + (U_{\text{dust}})^2 + (U_{\text{coal}})^2 \quad (3)$$

Where  $U_{\text{dust}}$ ,  $U_{\text{coal}}$  and  $U_{\text{biomass}}$  represented the uncertainties of dust, coal and biomass burning source contribution to K;

$K_{\text{dust}}$  and  $K_{\text{coal}}$  represented the concentration of dust and coal contribution to K for each samples;

$U_{\text{Ca}}$ ,  $U_{\text{Pb}}$  and  $U_{\text{K}}$  represented the uncertainties of Ca, Pb and K measured by the Xact, respectively, and use the 5/6 method detection limit of those elements to calculate, MDL: K: 2.36 ng m<sup>-3</sup>, Ca: 0.90 ng m<sup>-3</sup> and Pb: 0.22 ng m<sup>-3</sup>;

$C_{\text{Ca}}$  and  $C_{\text{Pb}}$  represented the concentration of Ca and Pb for each sample;

$U_{\text{K/Ca}}$  and  $U_{\text{K/Pb}}$  represented the uncertainties of the K/Ca and K/Pb ratios used to estimate the dust and coal contribution.  $U_{\text{K/Ca}}$  was 0.07 and  $U_{\text{K/Pb}}$  was 3.57.

$R_{\text{K/Ca}}$  and  $R_{\text{K/Pb}}$  represented the ratio value of K/Ca and K/Pb used to estimate the dust and coal contribution. For spring,  $R_{\text{K/Ca}}$  was 0.35 and for all other seasons was 0.15.

**Table S1.** The percent contribution of K and K<sup>+</sup> to PM<sub>2.5</sub> as well as the K/K<sup>+</sup> ratio from different source profiles.

	<b>Location_source type</b>	<b>K<sup>+</sup>(%)</b>	<b>K(%)</b>	<b>K/K<sup>+</sup></b>	<b>Reference</b>	
Cooking	Beijing_domestic kitchen	0.04	0.11	2.97	Zhang <i>et al.</i> , 2017	
	Shanxi_street food	0.83	1.76	2.12	Zhang <i>et al.</i> , 2016	
	Shanxi_hot pot	0.41	0.50	1.22		
	Shanxi_barbecue	1.69	2.32	1.37		
	Shanxi_restaurant	0.19	0.65	3.42		
Biomass Burning	Shannxi_Wheat straw	4.33	7.19	1.66	KLACP, 2017	
	Shandong_Wheat straw	3.79	4.44	1.17		
	Shannxi_Maize straw	2.72	5.47	2.01		
	Shannxi_Maize straw	2.34	3.99	1.71	Tian, 2016	
	Wheat straw	5.49	7.35	1.34		
	Rice straw	2.47	3.68	1.49		
Coal Combustion	Shanxi_coal power plant	0.25	1.73	7.03	Wang, 2016	
	Shanxi_coal power plant	0.18	1.90	10.68		
	Shanxi_coal power plant	0.16	1.75	10.92		
	Beijing_coal-fired boilers	Beijing_coal-fired boilers	2.69	2.87	1.06	Wang <i>et al.</i> , 2009
		Beijing_coal-fired boilers	2.20	3.48	1.59	
		Beijing_coal-fired boilers	1.00	1.04	1.04	
	Shannxi_coal-fired boilers	Shannxi_coal-fired boilers	0.61	0.86	1.41	KLACP, 2017
		Shannxi_residential coal	0.40	0.76	1.90	
		Shannxi_residential coal	0.83	1.95	2.35	
Dust	Beijing_road dust	0.17	0.94	5.53	KLACP, 2017	
	Beijing_road dust	0.11	0.91	8.27		
	Beijing_construction dust	0.19	1.18	6.21		
	Beijing_construction dust	0.15	0.59	3.93		
	Beijing_road dust	0.17	1.09	6.46	Shen <i>et al.</i> , 2016	
	Beijing_construction dust	0.23	1.20	5.17		
	Tianjin_road dust	0.18	1.03	5.75		
	Tianjin_construction dust	0.17	1.22	7.32		

**Table S2.** Pearson correlations between PM<sub>2.5</sub> and trace metals across the four seasons.

	PM <sub>2.5</sub> _Autumn		PM <sub>2.5</sub> _Winter		PM <sub>2.5</sub> _Spring		PM <sub>2.5</sub> _Summer	
	r	n	r	n	r	n	r	n
K	0.92**	592	0.83**	648	0.90**	622	0.77**	695
Pb	0.91**	592	0.85**	648	0.90**	622	0.68**	695
Zn	0.88**	592	0.89**	648	0.88**	622	0.68**	695
Fe	0.81**	592	0.85**	648	0.66**	622	0.68**	695
Mn	0.78**	592	0.83**	648	0.85**	622	0.67**	695
Cu	0.86**	592	0.79**	648	0.80**	622	0.62**	695
Ca	0.58**	592	0.68**	648	0.23**	622	0.23**	695
Ba	0.85**	592	0.82**	648	0.41**	622	0.51**	695
As	0.85**	391	0.78**	553	0.79**	512	0.67**	479
Cr	0.52**	464	0.78**	590	0.51**	524	0.36**	575
Se	0.92**	448	0.85**	633	0.92**	566	0.81**	600
Ni	0.65**	556	0.66**	634	0.78**	600	0.47**	639

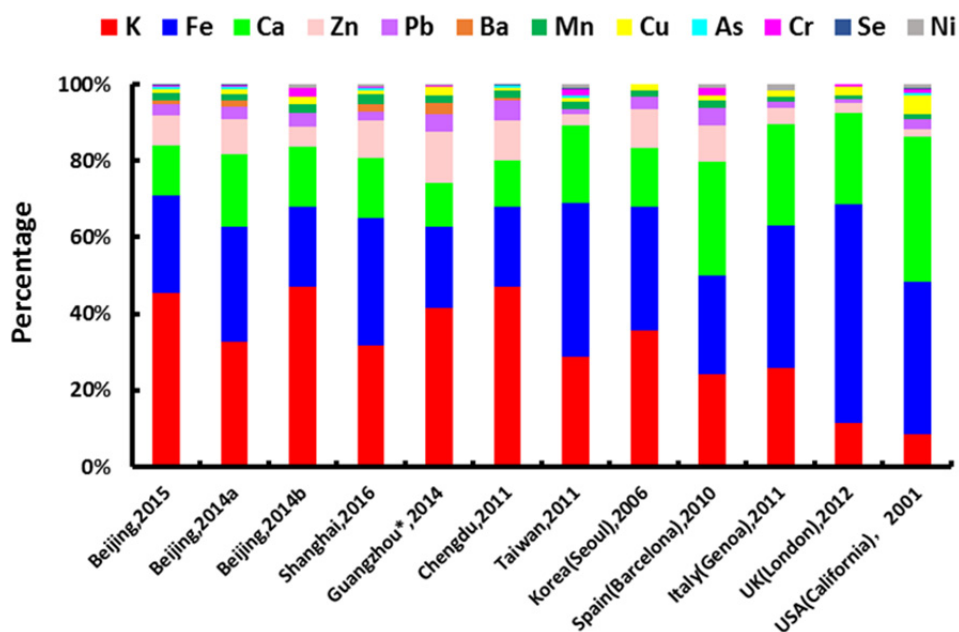
\*\*Correlation is significant at the 0.01 level.

“n” indicates the number of samples used in correlation analyses.

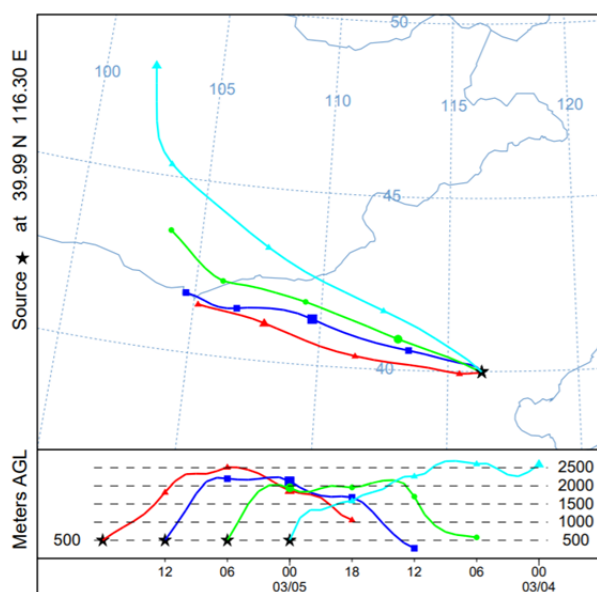
“r” indicates the correlation coefficient.

**Table S3.** Ratios (Mean ± S.D.) of K/Pb and K/As under different PM<sub>2.5</sub> concentration levels across the four seasons.

Ratio	Season	PM <sub>2.5</sub> <10 <sup>th</sup> percentiles	10 <sup>th</sup> <PM <sub>2.5</sub> <90 <sup>th</sup> percentiles	PM <sub>2.5</sub> >90 <sup>th</sup> percentiles
<b>K/Pb</b>	Spring	31.83±16.03	26.77±19.38	15.41±2.79
	Summer	37.10±29.88	24.98±18.24	14.27±3.88
	Autumn	39.06±24.18	29.71±15.60	17.71±2.48
	Winter	13.65±6.42	14.73±4.66	15.40±3.97
<b>K/As</b>	Spring	223.74±64.93	126.54±138.63	61.05±11.83
	Summer	127.47±43.37	162.13±96.16	77.07±29.12
	Autumn	162.87±85.46	143.21±94.43	53.17±17.11
	Winter	176.62±74.94	105.81±66.75	66.63±10.56



**Fig. S1.** Relative contributions of different metals to the select metals measured in this study ~~total metals measured~~ in different cities. Metals include K or  $K^+$ . The references for the different cities are as follows: Beijing, 2015 (this study), Beijing, 2014a (Gao *et al.*, 2016), Beijing, 2014b (Li *et al.*, 2017), Shanghai, 2016 (Chang *et al.*, 2017), Guangzhou, 2014 (Tao *et al.*, 2017), Chengdu, 2011 (Tao *et al.*, 2014), Taiwan, 2011 (Gugamsetty *et al.*, 2012), Korea (Seoul), 2006 (Heo *et al.*, 2009), Spain (Barcelona), 2010 (Dall'Osto *et al.*, 2013), Italy (Genoa), 2011 (Salameh *et al.*, 2015), UK (London), 2012 (Visser *et al.*, 2015), and USA (California), 2001 (Na *et al.*, 2009). All studies used K, except the study in Guangzhou, which used  $K^+$ .



**Fig. S2.** 24-h backward trajectories for dust episode on March 4<sup>th</sup> and March 5<sup>th</sup>, 2016 from the HYSPLIT model.

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