Atmospheric deposition of polycyclic aromatic hydrocarbons (PAHs) in Shanghai: the spatio-temporal variation and source identification

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The information of sampling sites

This study set 24 sampling sites in 18 districts of Shanghai in total, they are: Baoshan (BS), Changning (CN), Chongming (CM), Fengxian (FX1, FX2), Hongkou (HK), Huangpu (HP), Jingan (JA),Jiading (JD), Jinshan (JS),Luwan (LW), Minghang (MH1, MH2), Pudong (PD1, PD2, PD3, PD4), Putuo (PT), Qingpu (QP1, QP2), Songjiang (SJ), Xuhui (XH), Yangpu (YP), Zhabei (ZB).

Table S1 The information of sampling sites and sampling dates

Sites	Sampling date	Latitude (N)	Longitude (E)
BS	2010.11–2011.10	31.40°	121.49°
CM	2010.11–2011.10	31.62°	121.40°
CN	2010.11–2011.4	31.20°	121.43°
FX1	2010.11–2011.4	30.91°	121.45°
FX2	2011.5–2011.10	30.82°	121.49°
HK	2010.11–2011.10	31.26	121.48°
HP	2010.11–2011.10	31.24°	121.47°
JA	2010.11–2011.10	31.23°	121.43°
JD	2010.11–2011.10	31.40°	121.25°
JS	2010.11–2011.10	30.89°	121.16°
LW	2010.11–2011.4	31.22°	121.47°
MH1	2010.11–2011.10	31.11°	121.37°
MH2	2010.11–2011.10	31.01°	121.41°
PD1	2010.11–2011.10	31.19°	121.70°
PD2	2010.11–2011.10	31.05°	121.76°
PD3	2011.5–2011.10	31.25°	121.74°
PD4	2011.5–2011.10	30.99°	121.87°
PT	2010.11–2011.10	31.24°	121.40°
QP1	2010.11–2011.10	31.19°	121.07°
QP2	2011.5–2011.10	31.09°	120.98°
SJ	2010.11–2011.10	31.01°	121.23°
XH	2010.11–2011.10	31.19°	121.45°
YP	2010.11–2011.10	31.28°	121.54°
ZB	2010.11–2011.4	31.28°	121.45°

Precipitation sampling device

The precipitation sampling device was made of stainless steel. The receiver was a cone with a diameter of 100 cm, which was made by seamless stretch forming process. The receiver was supported with a stainless steel tripod with a height of 100 cm. A stainless steel lid was overlyed on the top of the receiver. The collection mouth was at the bottom of the cone with a diameter of 2 cm (Figure S1). The number of effective samples of each month is shown in Table S2.

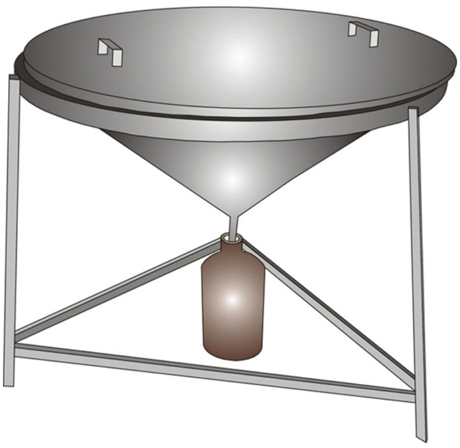

Fig. S1 Precipitaion sample device.

Table S2 The amount of precipitation and dust fall samples collected during Nov. 2010 to Oct. 2011

Sample quantity	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.
Precipitation	18	20	20	20	20	20	18	20	15	19	17	20
Dust	19	18	18	20	20	20	20	19	15	19	17	19

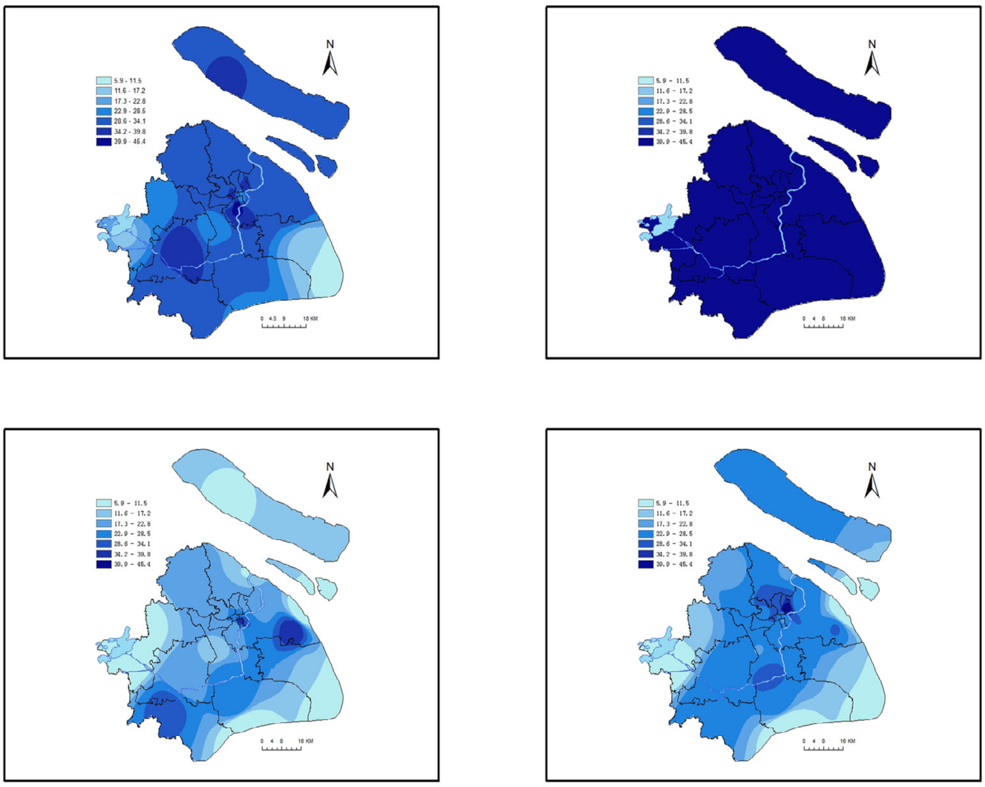

Fig. S2 The spatial distribution characteristic of cumulative precipitation from Nov. 2010 to Oct. 2011 in Shanghai (mm). (a) spring(from Mar. 2011 to May. 2011), (b) summer(from Jun. 2011 to Aug. 2011), (c) autumn (Nov. 2010, Sep. 2011,Oct.2011), (d) winter(from Dec. 2010 to Feb. 2011).

Table S3 Wet deposition in Shanghai from Nov. 2010 to Oct. 2011 (mm)

Sites	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.
CM	–	39.2	9.9	24.7	53.2	20.0	29.7	295.4	37.9	394.5	8.2	12.7
BS	6.7	42.0	11.6	13.9	34.4	26.1	25.3	612.4	102.1	281.9	17.9	9.9
JD	0.7	38.9	14.4	14.1	39.7	21.2	32.3	294.7	65.8	282.3	13.4	49.5
MH2	17.9	51.9	17.1	20.0	31.2	38.0	21.0	339.9	50.8	200.1	42.1	14.9
FX	16.8	49.3	19.2	12.4	28.0	47.3	26.9	377.6	15.1	131.1	41.0	27.5

PD2	10.7	37.8	6.3	6.0	22.1	16.8	5.9	262.0	9.8	192.4	23.0	16.8
QP	6.8	30.1	5.8	10.5	25.7	33.5	16.9	240.5	54.7	98.5	19.2	6.0
SJ	15.8	46.2	18.5	18.2	39.5	44.5	31.9	396.3	59.5	212.2	25.0	16.5
JS	23.7	52.1	20.0	12.8	38.1	42.0	17.4	292.9	34.1	127.1	26.1	41.4
BLG	–	–	–	–	–	–	31.8	301.8	39.0	–	–	–
SYZ	–	–	–	–	–	–	5.9	262.0	9.8	–	–	–
FXS	–	–	–	–	–	–	26.9	377.6	15.1	–	–	–
BGS	–	–	–	–	–	–	16.9	240.5	54.7	–	–	–
CN	10.9	44.4	21.2	18.4	34.5	31.6	28.1	319.1	47.7	254.9	27.0	17.0
PT	8.9	43.7	20.0	20.8	30.6	28.9	30.9	318.5	72.0	300.0	35.6	18.6
ZB	8.3	46.5	20.6	20.3	30.2	31.4	32.7	342.3	85.4	297.4	36.3	18.7
YP	7.7	45.7	16.2	14.9	30.3	29.3	36.3	306.2	58.0	342.6	33.1	13.7
HK	10.4	94.8	20.0	22.3	21.2	40.1	50.0	464.8	124.0	416.3	39.3	17.9
HP	10.2	43.0	20.1	19.0	30.4	28.1	25.1	303.7	68.1	358.5	50.9	14.7
LW	6.7	41.8	5.1	21.1	37.7	25.3	19.0	284.5	77.0	247.5	46.9	55.3
JA	10.8	51.8	18.2	18.8	39.8	33.6	40.0	333.1	84.6	432.0	51.6	21.5
PD1	12.6	48.6	18.3	19.0	33.2	30.7	31.8	301.8	39.0	402.8	59.7	42.7
XH	6.5	40.1	20.7	16.5	51.8	43.4	41.0	435.1	24.0	316.4	32.9	17.9
MH1	10.7	38.1	15.3	15.0	23.9	27.2	20.3	285.0	61.6	211.9	19.2	13.6

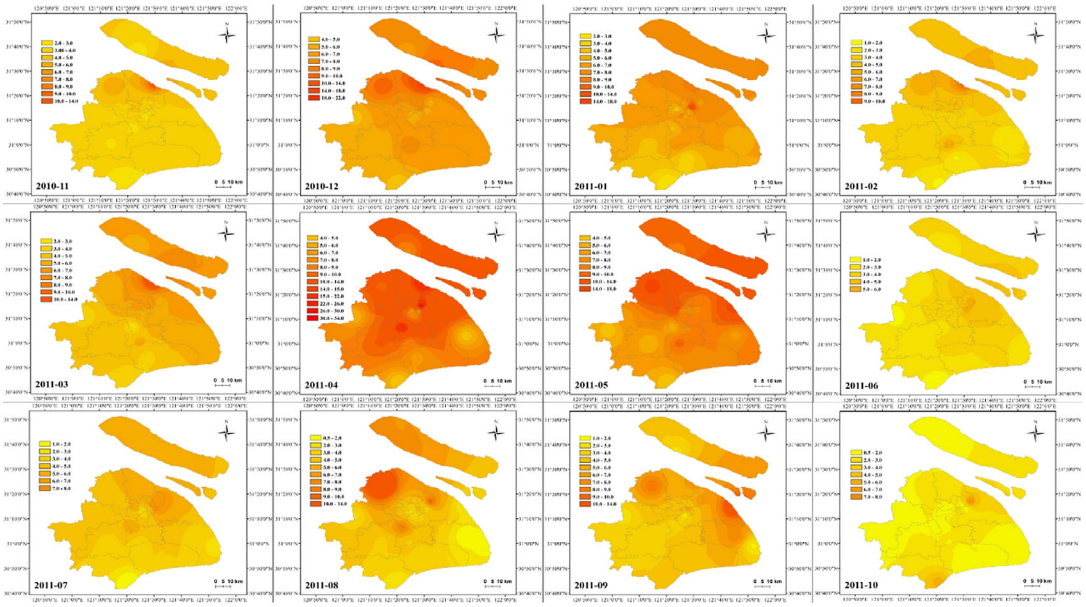

Fig. S3 The spatio-temperal variation characteristic of dust fall fluxes (g·m^{-2}·month^{-1}) from Nov. 2010 to Oct. 2011 in Shanghai.

Table S4 Proportion of PAHs in wet disposition in Shanghai from Nov. 2010 to Oct. 2011(μg·m^{-2}·month^{-1})

Sites	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.
CM	–	8.85	1.14	3.80	13.72	5.44	6.46	92.77	7.20	65.98	0.68	3.42
BS	0.90	7.23	1.33	3.57	8.41	6.71	9.37	200.58	29.65	–	1.83	2.04
JD	0.36	12.58	4.11	3.55	7.55	3.38	15.31	83.02	22.05	63.19	1.82	13.55
MH2	2.40	13.84	2.95	4.75	6.50	10.18	3.84	115.09	14.23	33.50	3.75	2.74
FX	4.94	6.22	2.70	2.37	5.59	19.00	–	–	–	–	–	–
PD2	1.23	6.34	1.22	0.78	4.88	3.50	0.83	36.93	–	28.07	–	1.48
QP	1.66	7.93	1.15	4.28	5.69	7.28	9.35	139.76	13.85	14.97	3.61	1.84
SJ	4.25	18.26	3.04	4.24	11.13	12.63	7.03	200.44	–	39.57	5.90	3.54
JS	2.15	13.11	3.11	3.21	8.56	5.87	5.21	48.51	9.69	14.36	–	5.48
BLG	–	–	–	–	–	–	7.67	66.64	–	–	–	–
SYZ	–	–	–	–	–	–	1.48	75.67	–	–	–	–
FXS	–	–	–	–	–	–	7.78	72.76	–	–	–	–
BGS	–	–	–	–	–	–	–	53.61	12.76	–	–	–
CN	1.09	12.10	2.06	2.75	8.99	8.98	–	–	–	–	–	–
PT	1.17	4.75	2.73	4.54	13.98	6.82	8.81	120.48	26.06	33.06	6.35	4.18
ZB	0.59	17.57	2.20	2.36	7.08	8.15	–	–	–	–	–	–
YP	–	9.87	2.57	3.27	6.83	6.31	9.07	70.72	17.14	60.66	9.20	1.23
HK	2.32	42.13	2.77	3.21	6.75	10.84	10.83	203.61	29.33	71.98	4.31	2.35

HP	1.62	7.39	2.29	4.25	9.18	8.92	9.12	71.68	16.55	58.00	13.76	2.05
LW	0.88	8.76	0.91	3.41	11.32	8.78	–	–	–	–	–	–
JA	1.23	20.67	2.97	4.46	8.98	10.88	–	82.66	20.09	47.81	17.97	4.94
PD1	1.54	7.64	2.32	4.50	9.09	7.59	5.25	144.96	9.83	69.50	9.09	7.91
XH	1.28	7.19	4.46	3.47	13.43	11.37	17.79	290.06	5.86	70.83	6.98	1.49
MH1	2.13	5.13	2.22	4.90	6.56	5.89	5.02	45.60	20.42	48.32	5.07	3.12

Table S5 The total deposition fluxes of PAHs (dry and wet) from Nov. 2010 to Oct. 2011 in Shanghai ($g \cdot m^{-2} \cdot month^{-1}$)

Sites	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.
CM	0.10	0.31	0.13	0.13	0.22	0.26	0.29	0.25	0.22	0.07	0.07	0.03
BS	0.10	0.47	0.22	0.26	0.19	0.33	0.37	0.30	0.03	0.13	0.18	0.00
JD	0.13	0.18	0.00	0.13	0.09	0.17	0.37	0.17	0.02	0.27	0.18	0.08
MH2	0.11	0.19	0.18	0.13	0.18	0.16	0.19	0.21	0.06	0.11	0.11	0.06
FX	0.00	0.01	0.03	0.04	0.08	0.17	–	–	–	–	–	–
PD2	0.07	0.34	0.14	0.12	0.18	0.06	0.24	0.04	0.03	0.05	0.11	0.02
QP	0.07	0.12	0.10	0.08	0.07	0.13	0.12	0.18	0.06	0.05	0.03	0.02
SJ	0.07	0.13	0.10	0.08	0.10	0.21	0.09	0.25	0.11	0.10	0.10	0.06
JS	0.12	0.16	0.06	0.06	0.10	0.10	0.13	0.07	0.04	0.06	–	0.10
BLG	–	–	–	–	–	–	0.69	0.23	–	0.04	0.12	0.03
SYZ	–	–	–	–	–	–	0.24	0.19	0.05	0.02	0.03	0.02
FXS	–	–	–	–	–	–	0.11	0.15	–	0.07	0.05	0.01
BGS	–	–	–	–	–	–	0.10	0.10	0.01	–	–	0.01
CN	0.05	0.10	0.38	0.06	0.12	0.16	–	–	–	–	–	–
PT	0.04	0.08	0.06	0.06	0.10	0.18	0.25	0.18	0.11	0.10	0.11	0.06
ZB	0.08	0.21	0.23	0.13	0.12	0.22	–	–	–	–	–	–
YP	0.12	0.12	0.21	0.14	0.10	0.23	0.28	0.25	0.20	0.10	0.12	0.03
HK	0.11	0.25	1.15	0.10	0.15	1.30	0.15	0.38	0.12	0.43	0.06	0.03
HP	0.09	0.13	0.18	0.14	0.15	0.15	0.11	0.17	0.09	0.15	0.06	0.05
LW	0.10	0.10	0.14	0.08	0.09	0.12	–	–	–	–	–	–
JA	0.06	0.11	0.18	0.08	0.15	0.17	0.15	0.14	0.08	0.10	0.09	0.04
PD1	0.08	0.10	0.00	0.08	0.08	0.15	0.12	0.35	0.09	0.14	0.06	0.03
XH	0.06	0.12	0.14	0.10	0.14	0.21	0.18	0.45	0.11	0.28	0.04	0.06
MH1	0.08	0.01	0.06	0.04	0.22	0.15	0.16	0.12	0.07	0.09	0.04	0.03

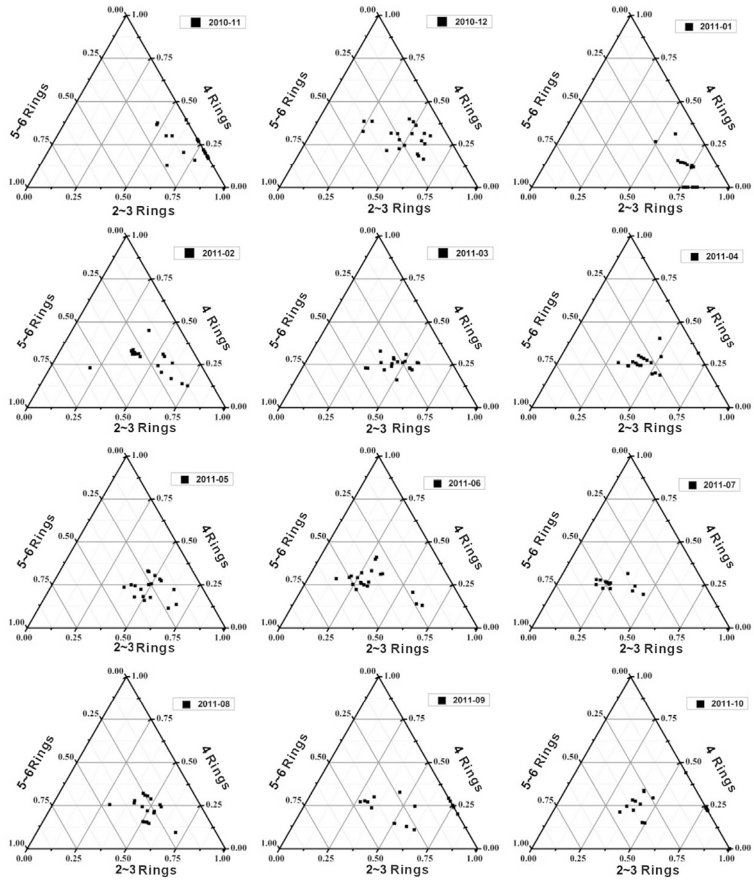

Fig. S4 The variation of PAHs composition in precipitation from Nov. 2010 to Oct. 2011.

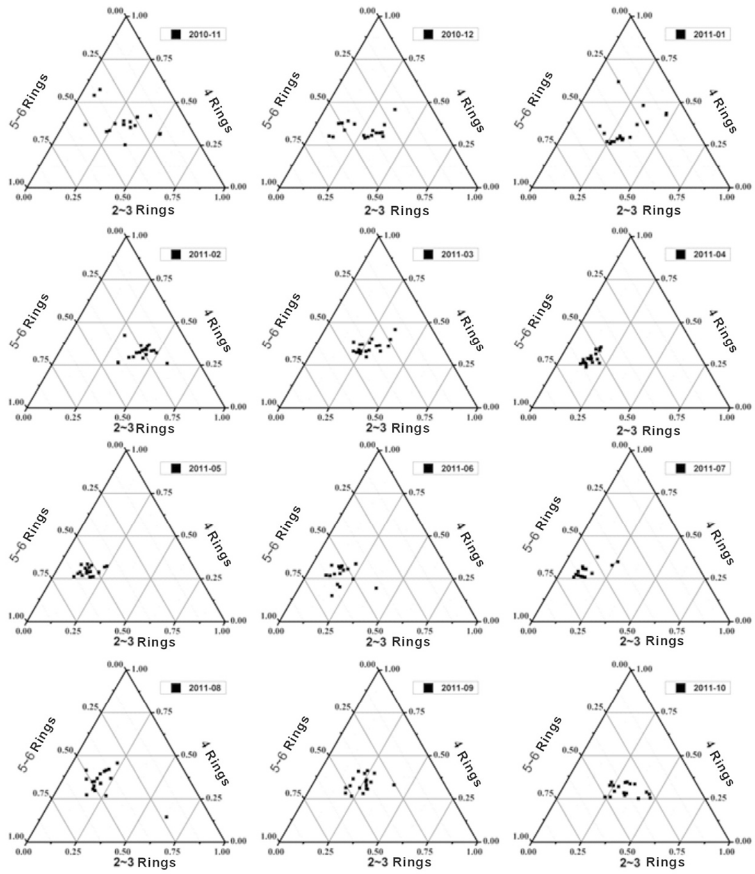

Fig. S5 The variation of PAHs composition in dust fall from Nov. 2010 to Oct. 2011.

Table S6 The characteristic ratio of PAHs in precipitation and dust fall in winter during the study period (from November to April)

Sites	BaA/(Chr+BaA)		BghiP/ BaP		Fla/(Fla+Pyr)		Phe/Ant		Pyr/BghiP	
	Precipi-tation	Dust fall	Precipi-tation	Dust fall	Precipi-tation	Dust fall	Precipi-tation	Dust fall	Precipi-tation	Dust fall
BS	0.58	0.50	0.20	0.56	0.50	0.59	1.11	1.29	2.67	2.23
CM	0.59	0.42	0.39	0.94	0.50	0.57	1.14	1.69	1.10	1.75
CN	0.58	0.53	0.24	0.78	0.50	0.59	1.26	1.48	2.71	1.62
FX	0.61	0.51	0.21	1.08	0.49	0.60	1.28	2.28	3.07	1.01
HK	0.52	0.51	0.54	0.92	0.51	0.45	1.10	1.37	1.34	1.47
HP	0.51	0.50	0.39	0.62	0.50	0.59	1.27	1.29	1.33	2.52
JA	0.51	0.49	0.55	0.59	0.51	0.58	1.12	1.46	1.10	2.31
JD	0.51	0.48	0.26	0.67	0.51	0.58	1.17	1.89	5.62	2.43
JS	0.58	0.49	/	0.66	0.51	0.59	1.08	1.44	/	2.42
MH1	0.57	0.45	/	1.02	0.49	0.58	1.28	2.95	/	1.29
MH2	0.50	0.50	0.21	1.00	0.53	0.52	1.12	1.80	3.06	1.18
LW	0.50	0.50	0.39	0.73	0.51	0.58	1.36	1.39	1.36	2.13
PD1	0.51	0.50	/	1.01	0.50	0.59	1.20	1.35	/	1.46
PD2	0.61	0.46	/	0.88	0.49	0.58	1.08	1.89	/	1.61
PT	0.51	0.50	0.21	0.93	0.50	0.55	1.09	1.37	2.47	1.41
QP	0.52	0.49	0.24	1.11	0.50	0.59	1.07	1.41	2.62	1.24
SJ	0.51	0.49	0.55	0.87	0.51	0.57	1.08	1.39	1.27	1.69
XH	0.52	0.49	0.19	0.47	0.50	0.56	1.37	1.48	3.39	2.93
YP	0.52	0.49	0.17	1.27	0.50	0.61	1.26	1.29	3.54	1.29
ZB	0.51	0.48	0.35	0.86	0.51	0.59	1.16	1.29	1.37	1.65

Table S7 The characteristic ratio of PAHs in precipitation and dust fall in summer during the study period (from May to October)

Sites	BaA/(Chr+BaA)		BghiP/ BaP		Fla/(Fla+Pyr)		Phe/Ant		Pyr/BghiP	
	Precipi-tation	Dust fall	Precipi-tation	Dust fall	Precipi-tation	Dust fall	Precipi-tation	Dust fall	Precipi-tation	Dust fall
BGS	0.54	0.46	0.70	1.15	0.51	0.56	1.34	2.98	1.07	0.68
BLG	0.55	0.47	0.15	0.73	0.50	0.58	1.41	2.35	5.73	1.09
BS	0.51	0.51	0.71	0.29	0.50	0.59	1.27	8.87	1.24	3.52
CM	0.51	0.46	1.50	0.55	0.50	0.60	1.16	2.60	0.84	1.66
FXS	0.50	0.44	0.00	0.51	0.49	0.56	1.29	2.13	/	1.78
HK	0.51	0.35	0.78	0.95	0.51	0.58	1.30	4.76	1.44	1.59
HP	0.55	0.44	1.05	0.32	0.51	0.57	1.33	4.28	0.72	2.63
JA	0.52	0.49	1.05	0.70	0.52	0.58	0.74	3.85	0.67	1.11
JD	0.54	0.44	0.88	1.01	0.50	0.57	2.19	4.70	0.69	1.06
JS	0.49	0.44	1.08	0.73	0.50	0.57	1.70	1.67	1.14	1.03
MH1	0.55	0.41	0.65	0.96	0.50	0.50	1.48	6.39	0.88	1.21
MH2	0.54	0.43	1.14	0.43	0.51	0.58	1.48	4.18	1.23	2.25
PD1	0.65	0.44	1.08	1.09	0.51	0.57	1.28	2.88	1.34	0.79
PD2	0.61	0.44	1.09	0.91	0.50	0.57	1.51	2.14	3.44	0.94
PT	0.51	0.46	0.73	0.62	0.52	0.57	1.45	3.96	1.27	1.54

QP	0.54	0.46	1.08	1.09	0.51	0.56	1.68	3.18	0.70	0.85
SJ	0.54	0.43	0.64	1.02	0.51	0.56	1.13	8.10	0.86	0.97
SYZ	0.49	0.47	1.08	0.78	0.50	0.57	1.50	1.56	0.93	0.91
XH	0.52	0.41	0.82	0.96	0.54	0.50	1.26	6.39	1.02	1.21
YP	0.54	0.43	0.80	0.72	0.51	0.62	1.66	1.71	1.05	1.33

Table S8 Characteristic ratio of PAHs from various typical sources in domestic and foreign related studies (Azevedo et al., 1999; Bi et al., 2003; Chen et al, 2005; Kalaitzoglou et al., 2004; Kavouras et al., 1999; Kendall et al., 2001; Masclet et al., 1987; Manoli et al., 2004; Papageorgoulou et al., 1999; Rogge et al., 1993; Sicre et al., 1987; Simcik et al., 1999; Yang et al., 1998)

	BaA/(Chr+BaA)	BghiP/BaP	Fla/(Fla+Pyr)	Phe/Ant
Vehicle	0.39	1.28–3.33	/	2.7
Road dust	/	/	0.42	8
Gasoline combustion	0.22–0.55	2.50–3.33	0.38–0.4	3.4–8
Wood combustion	0.48	/	0.74	3
Coal combustion	0.50–0.55	0.15–1.11	0.68–0.74	3
Disel combustion	0.16–0.26	1.23–2.17	0.6–0.7	7.6–8.8
Coke oven	0.41	0.20	0.21–0.25	0.79
Incinerator	/	1.67–7.14	0.21–0.25	/
Oil fired power station	/	>0.50	/	/
Refinery	/	0.59–1.54	/	/

Table S9 Monitoring characteristic ratio of PAHs from industrial source in Shanghai (Cheng et al., 2007; Ma, 2009; Zhang, 2008)

	BaA/(Chr+BaA)	BghiP/BaP	Fla/(Fla+Pyr)	Phe/Ant	Pyr/BghiP
Thermal power plant	0.39–0.52	0.2–2.16	0.45–0.71	0.53–6.27	0.93–1.15
Chlor–alkali plant	0.56–0.61	0.27–0.33	0.37–0.47	4.41–5.49	0.89–1.54
Coke-oven plant	0.66–0.72	0.26–1.4	0.51–0.79	0.98–2.66	0.36–1.03

Refference:

Azevedo D A, Moreira L S, Siqueira D S (1999). Composition of extractable organic matter in aerosols from urban areas of Rio de Janeiro city, Brazil. Atmos Environ, 33(30): 4987–5001 (J) doi:10.1016/S1352-2310(99)00270-8

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