applied sciences

MDPI

Supplementary Materials

Table S1. Meteorological parameters, seasonal and annual concentrations of PM_{10} (μg m^{-3}) and PAHs (ng m^{-3}).

	Summer (hot/humid)			Rainy season			Winter (cool/dry)			Annual		
	Roadside	Industrial	Urban bg	Roadside	Industrial	Urban bg	Roadside	Industrial	Urban bg	Roadside	Industrial	Urban bg
Sampling duration	2 May 2013 to 14 May 2013 21 February 2014 to 14 May 2014			20 May 2013 to 11 October 2013 21 May 2014 to 27 May 2014			17 October 2013 to 14 February 2014			May 2013 to May 2014		
Sample (n)	14	11	15	21	15	19	8	11	12	43	37	46
T (C)	33 ± 1.3	31.4 ± 1.3	30.8 ± 2.3	30.7 ± 1.4	29.5 ± 1.2	27.9 ± 3.1	29.3 ± 2.5	27.3 ± 2.7	26.9 ± 2.3	31.16 ± 2.13	29.46 ± 2.33	28.52 ± 3.02
%RH	64 ± 6	64 ± 6	61 ± 9	70 ± 7	72 ± 7	75 ± 6	60 ± 10	65 ± 13	67 ± 10	66 ± 8	67 ± 9	68 ± 11
PM_{10} (μg m^{-3})	44.98 ± 14.96	67.91 ± 15.31	37.56 ± 18.33	50.52 ± 18.66	39.96 ± 26.24	31.85 ± 15.07	92.03 ± 35.27	79.03 ± 32.45	55.18 ± 28.93	56.44 ± 27.29	50.96 ± 31.12	39.80 ± 22.17
PAHs (ng m^{-3})												
ACY	0.02 ± 0.04	0.02 ± 0.03	0.02 ± 0.02	0.07 ± 0.06	0.05 ± 0.05	0.02 ± 0.03	0.04 ± 0.02	0.08 ± 0.03	0.01 ± 0.01	0.04 ± 0.05	0.05 ± 0.04	0.02 ± 0.02
ACE	0.007 ± 0.010	<LOQ	<LOQ	0.04 ± 0.05	<LOQ	0.004 ± 0.009	<LOQ	0.002 ± 0.007	<LOQ	0.02 ± 0.04	0.001 ± 0.004	0.001 ± 0.01
FLU	0.004 ± 0.009	0.003 ± 0.006	0.01 ± 0.03	0.07 ± 0.08	0.03 ± 0.09	0.04 ± 0.08	0.07 ± 0.03	0.03 ± 0.02	0.03 ± 0.05	0.05 ± 0.08	0.02 ± 0.06	0.03 ± 0.06
PHE	0.09 ± 0.03	0.04 ± 0.02	0.07 ± 0.07	0.22 ± 0.15	0.10 ± 0.15	0.08 ± 0.08	0.35 ± 0.13	0.14 ± 0.05	0.13 ± 0.07	0.20 ± 0.14	0.09 ± 0.10	0.09 ± 0.08
ANT	0.03 ± 0.06	0.004 ± 0.008	<LOQ	0.09 ± 0.10	0.02 ± 0.06	0.01 ± 0.01	0.05 ± 0.02	0.03 ± 0.01	0.02 ± 0.01	0.06 ± 0.08	0.02 ± 0.04	0.01 ± 0.01
FLT	0.12 ± 0.16	0.05 ± 0.02	0.03 ± 0.03	0.28 ± 0.25	0.12 ± 0.15	0.08 ± 0.03	0.29 ± 0.12	0.19 ± 0.11	0.12 ± 0.11	0.21 ± 0.21	0.12 ± 0.12	0.07 ± 0.07
PYR	0.11 ± 0.04	0.07 ± 0.03	0.07 ± 0.03	0.21 ± 0.11	0.11 ± 0.08	0.10 ± 0.04	0.35 ± 0.14	0.22 ± 0.08	0.15 ± 0.07	0.19 ± 0.12	0.13 ± 0.09	0.10 ± 0.06
BaA	0.04 ± 0.04	0.04 ± 0.03	0.02 ± 0.03	0.18 ± 0.25	0.25 ± 0.36	0.23 ± 0.37	0.23 ± 0.13	0.12 ± 0.04	0.07 ± 0.03	0.12 ± 0.18	0.15 ± 0.24	0.12 ± 0.25
CHR	0.09 ± 0.06	0.06 ± 0.06	0.05 ± 0.10	0.28 ± 0.20	0.12 ± 0.07	0.15 ± 0.07	0.33 ± 0.20	0.12 ± 0.04	0.11 ± 0.06	0.23 ± 0.18	0.10 ± 0.06	0.11 ± 0.09
BbF	0.39 ± 0.26	0.31 ± 0.15	0.11 ± 0.16	0.95 ± 0.60	0.65 ± 0.41	0.45 ± 0.24	1.13 ± 0.47	0.70 ± 0.30	0.41 ± 0.16	0.76 ± 0.53	0.56 ± 0.36	0.33 ± 0.25
BkF	0.08 ± 0.06	0.07 ± 0.05	0.03 ± 0.05	0.11 ± 0.12	0.11 ± 0.15	0.06 ± 0.07	0.29 ± 0.11	0.22 ± 0.08	0.11 ± 0.05	0.12 ± 0.12	0.13 ± 0.12	0.06 ± 0.07
BaP	0.24 ± 0.26	0.19 ± 0.09	0.15 ± 0.09	0.55 ± 0.44	0.45 ± 0.36	0.34 ± 0.27	0.68 ± 0.28	0.38 ± 0.16	0.20 ± 0.08	0.47 ± 0.39	0.35 ± 0.27	0.24 ± 0.19
IP	0.61 ± 0.36	0.75 ± 0.08	0.77 ± 0.39	1.11 ± 0.75	1.21 ± 0.57	0.51 ± 0.32	1.38 ± 0.43	1.46 ± 0.60	0.61 ± 0.22	0.96 ± 0.62	1.15 ± 0.56	0.62 ± 0.34
DBA	0.03 ± 0.02	0.14 ± 0.20	0.03 ± 0.05	0.02 ± 0.03	0.11 ± 0.22	0.02 ± 0.02	<LOQ	0.55 ± 0.21	0.05 ± 0.02	0.02 ± 0.03	0.25 ± 0.28	0.03 ± 0.04
BP	0.76 ± 0.35	0.42 ± 0.21	0.27 ± 0.22	1.39 ± 0.90	0.77 ± 0.42	0.60 ± 0.32	1.65 ± 0.50	0.93 ± 0.45	0.43 ± 0.20	1.20 ± 0.70	0.71 ± 0.42	0.45 ± 0.30
7PAHs	1.49 ± 0.63	1.57 ± 0.34	1.17 ± 0.54	3.20 ± 1.53	2.89 ± 1.47	1.76 ± 0.98	4.04 ± 1.50	3.55 ± 1.36	1.55 ± 0.56	2.80 ± 1.60	2.69 ± 1.42	1.51 ± 0.79
15PAHs	2.63 ± 1.20	2.18 ± 0.53	1.64 ± 0.77	5.56 ± 2.69	4.09 ± 1.95	2.68 ± 1.34	6.84 ± 2.41	5.15 ± 1.97	2.44 ± 0.98	4.68 ± 2.51	3.84 ± 2.01	2.28 ± 1.16

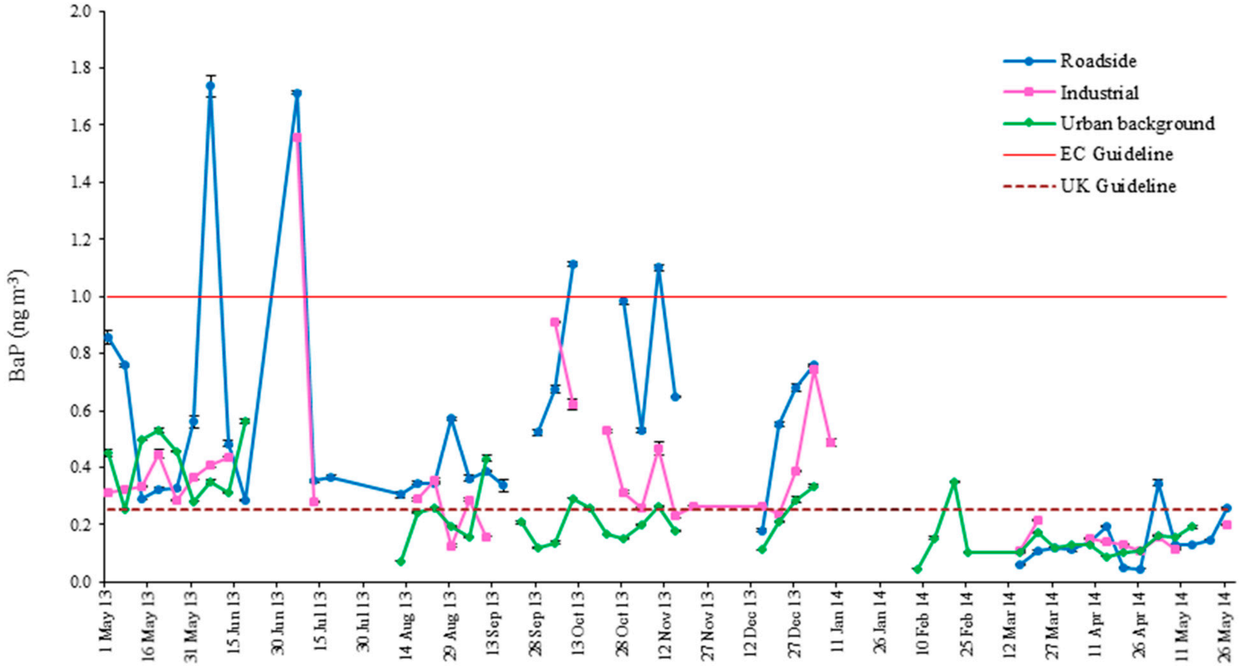

Figure S1. Daily mean concentrations of BaP (ng m-3) at the roadside, industrial and urban background sites compared with the EC (1 ng m-3) and UK (0.25 ng m-3) annual average guidelines.

Table S2 Concentrations of PM_{10} (μg m^{-3}) and BaP (ng m^{-3}) in different countries.

Country	Sampling area (type)	Sampling duration	PM_{10} (μg m^{-3})	BaP (ng m^{-3})	Reference
Argentina	Buanos Aires	13 August – 15 September 2008	61 ± 49	1.0 ± 0.1	Vasconcellos *et al.* (2011)
Brazil	Sãl Paolo	7 – 29 August 2008	64 ± 19	2.2 ± 2.1	Vasconcellos *et al.* (2011)
Chile	Santiago (urban)	7 – 9 July 2002	129.4 ± 28.1	5.28	Del Rosario Sienra *et al.* (2005)
		27 September – 7 October 2002	64.2 ± 17.1	0.93	
Colombia	Bogotá	24 November – 9 December 2008	47 ± 12	0.7 ± 0.2	Vasconcellos *et al.* (2011)
Finland	Virolahti (background)	January 2007 – September 2008	9.91	0.23	Vestenius *et al.* (2011)
India	Raipur region	January – December 2006	115 ± 36	0.04 - 29.7[a]	Giri *et al.* (2013)
India	Delhi	December 2009 – November 2010	222.23 ± 30	13.13 ± 5.91	Jyethi, Khillare and Sarkar (2014)
Italy	Milan	Winter 2007	92 ± 12	1.4 ± 0.33	Belis *et al.* (2011)
Italy	Milan	Winter 2009	85 ± 16	1.2 ± 0.35	Belis *et al.* (2011)
Mexico	Mèxico City	October 1998 – October 1999	-	0.69 ± 0.41	Amador-Muñoz *et al.* (2010)
Malaysia	Kuala Lumpur (urban)	June – September 2010	51.52 ± 19.9	0.11 ± 0.03	Jamhari *et al.* (2014)

Table S3. Annual mean pPAHs concentrations, BaP-TEQ concentrations and percentage of BaP-TEQ concentrations.

PAH	TEF	Roadside			Industrial			Urban Background		
		Ambient (ng m-3)	BaP-TEQ (ng m-3)	BaP-TEQ (%)	Ambient (ng m-3)	BaP-TEQ (ng m-3)	BaP-TEQ (%)	Ambient (ng m-3)	BaP-TEQ (ng m-3)	BaP-TEQ (%)
FLU	0.0005	0.05	0.000025	0.003	0.02	0.00001	0.001	0.03	0.000015	0.004
PHE	0.0005	0.20	0.0001	0.014	0.09	0.000045	0.005	0.09	0.000045	0.012
ANT	0.0005	0.06	0.00003	0.004	0.02	0.00001	0.001	0.01	0.000005	0.001
FLT	0.05	0.23	0.0115	1.590	0.12	0.006	0.726	0.07	0.0035	0.903
PYR	0.001	0.20	0.0002	0.028	0.13	0.00013	0.016	0.10	0.0001	0.026
BaA	0.005	0.15	0.00075	0.104	0.15	0.00075	0.091	0.12	0.0006	0.155
CHR	0.03	0.23	0.0069	0.954	0.10	0.003	0.363	0.11	0.0033	0.851
BbF	0.1	0.80	0.08	11.063	0.56	0.056	6.774	0.33	0.033	8.515
BkF	0.05	0.14	0.007	0.968	0.13	0.0065	0.786	0.06	0.003	0.774
BaP	1	0.47	0.47	64.997	0.35	0.35	42.340	0.24	0.24	61.925
IP	0.1	1.00	0.1	13.829	1.15	0.115	13.912	0.62	0.062	15.997
DBA	1.1	0.02	0.022	3.042	0.25	0.275	33.267	0.03	0.033	8.515
BP	0.02	1.23	0.0246	3.402	0.71	0.0142	1.718	0.45	0.009	2.322
Total		4.78	0.72		3.78	0.83		2.26	0.39	

The correlation between between PM10 and total PAHs show a positive correlation between PM10 and total PAHs at the industrial site (R2 = 0.61) but poor correlations at the roadside and urban background sites (supplementary information figure 3). Despite small sample numbers in each season, positive correlations between PM10 and total PAHs at the industrial site were observed in the winter (R2 = 0.62) and rainy season (R2 = 0.80) (supplementary information figure 4). No correlations between PM10 and PAHs were observed in the summer where R2 were 0.01, 0.09 and 0.27 respectively for roadside, industrial and urban background sites.

Seasonal high PM10 concentrations were observed in the winter particularly at the roadside and industrial sites where PM10 mean concentrations were double those in other seasons. Seasonal wind directions at each site (supplementary information figure 5) prevail from the south-southwest in the summer (hot and humid) and the rainy season, and for the cool and dry winter season, prevailing winds at the roadside and industrial sites were from the north-northeast. PAHs have little distinct variations with wind direction suggesting pPAHs were associated with fine particles emitted in the vicinity of each sampling site. Elevated PM10 concentrations during cool-dry weather conditions suggested long-range transportation of particles.

Fine particles are usually emitted from high temperature combustion sources. A previous study on size distribution of PM in Bangkok suggested that more than 97% of PAHs were found in the very-fine particle <0.95 μm which contributed to approximately 48% of total PM weight (Thongsanit et al., 2003). This implied that pPAHs found at the roadside and urban background sites in this study were likely distributed in the smaller particle size range that PM10. On the contrary, coarse particles were a major contributor of pPAHs at the industrial site. A good correlation of PM10 and pPAHs observed at the urban background site in the winter implied a better conservation of PAHs compositions after dispersal from sources. In addition to the winter (dry/cool) weather conditions that promote the suspension of particulate matter, the cool climate and less solar radiation may disfavour the photochemical degradation of pPAHs compared to other seasons.

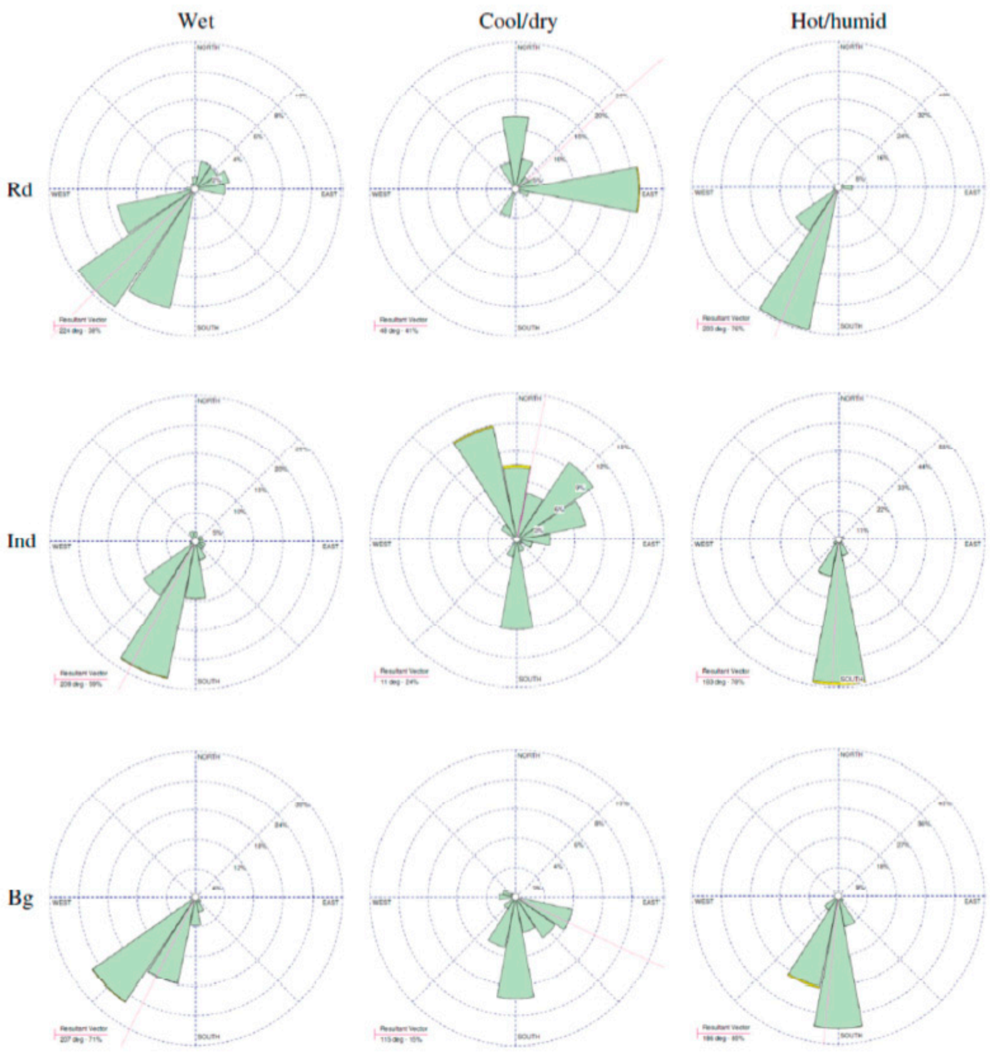

Figure S2. Dominant wind directions for each site in each of the 3 seasons. No statistical relationship between the wind patterns and the PAHs measured were found.

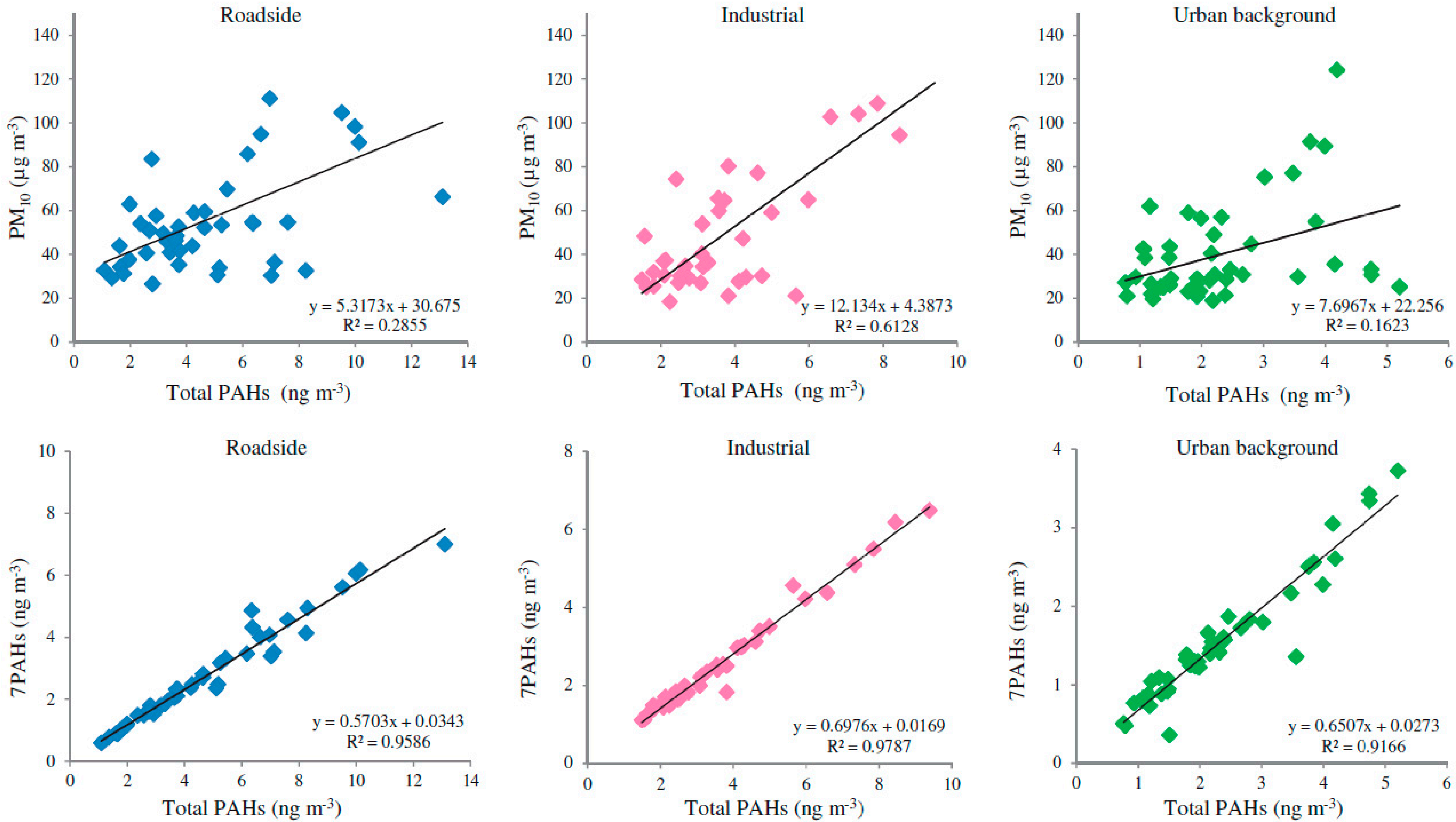

Figure S3. Linear correlation plots between PM10 vs. total PAHs from whole year data.

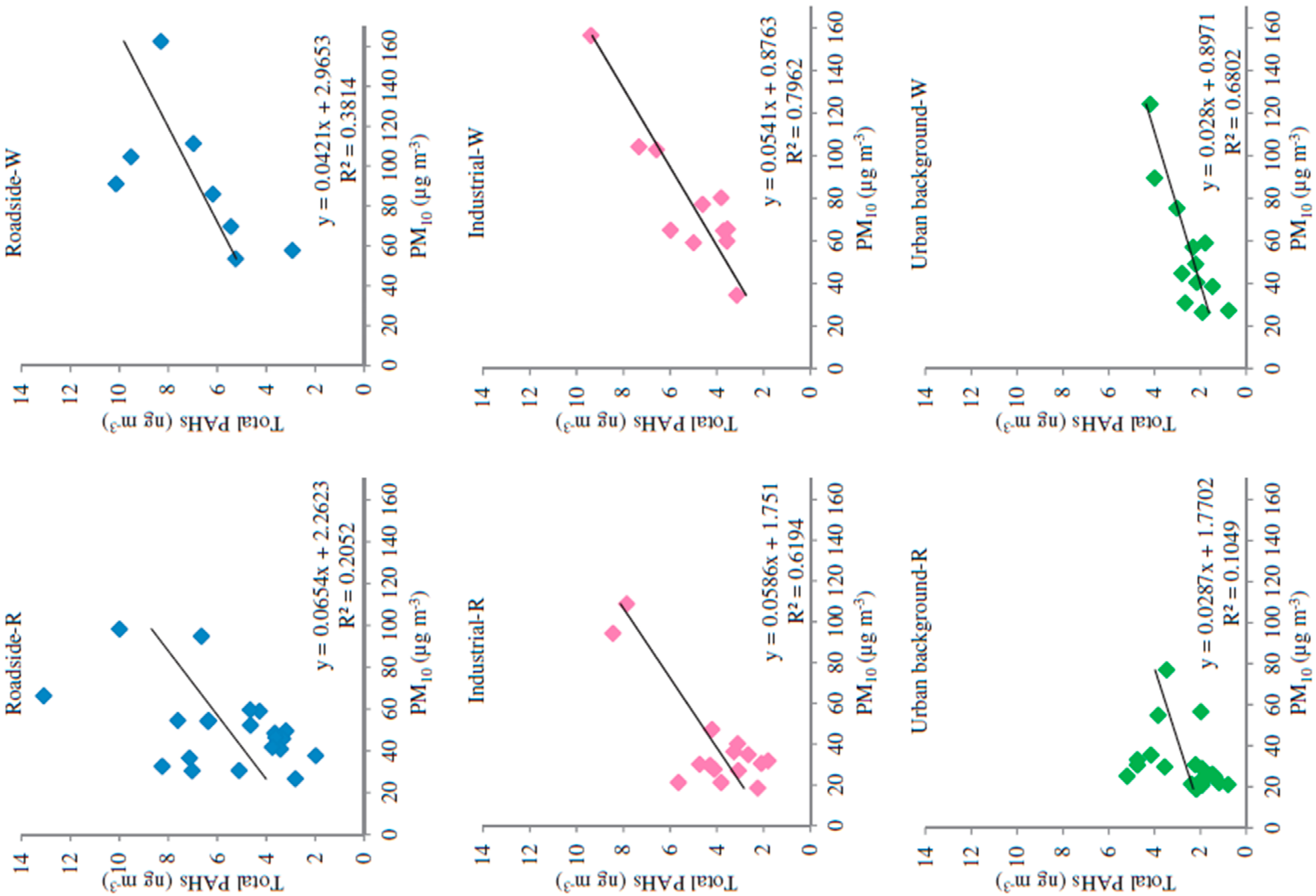

Figure S4. Seasonal correlation plots between PM10 and total PAHs concentrations in the wet season (R) and cool-dry season (W) at the three sampling sites.

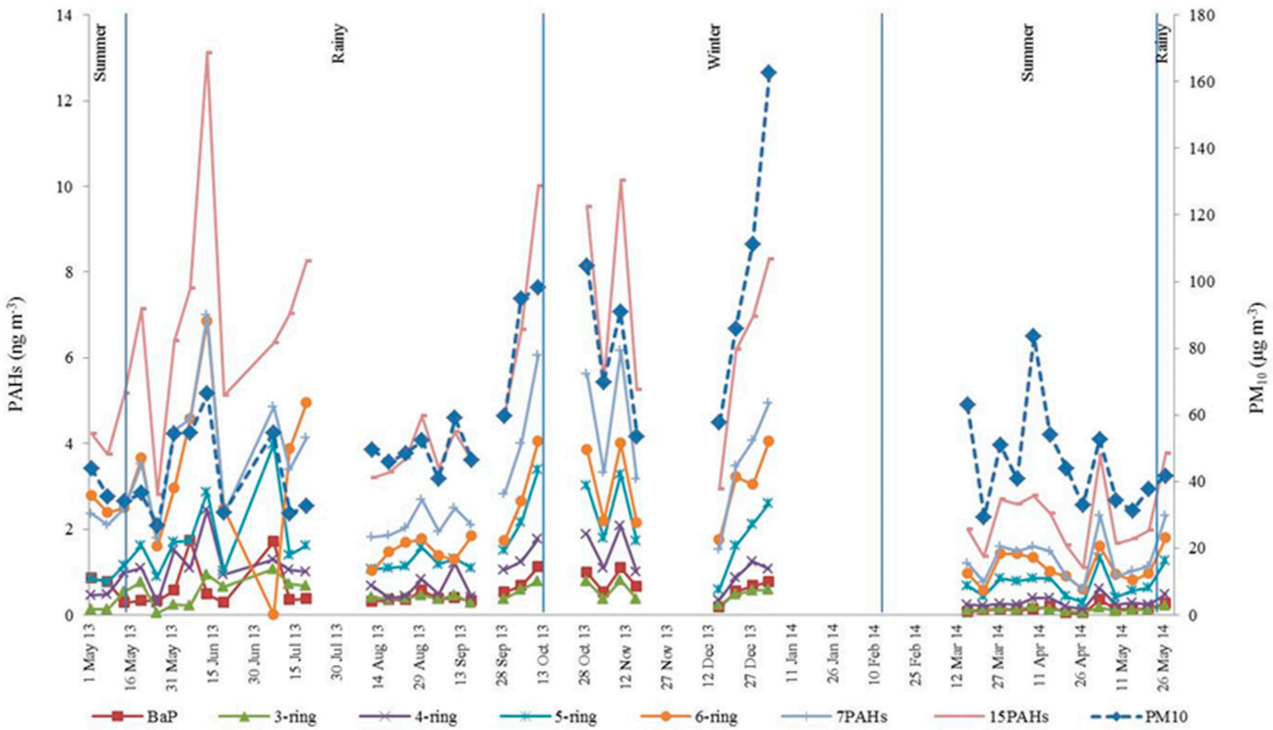

Figure S5a. Time series plot of daily mean PM_{10} (µg m^{-3}) and PAHs (ng m^{-3}) concentrations at the roadside site. (Missing data indicted sampling failures where PM_{10} filters were not collected.)

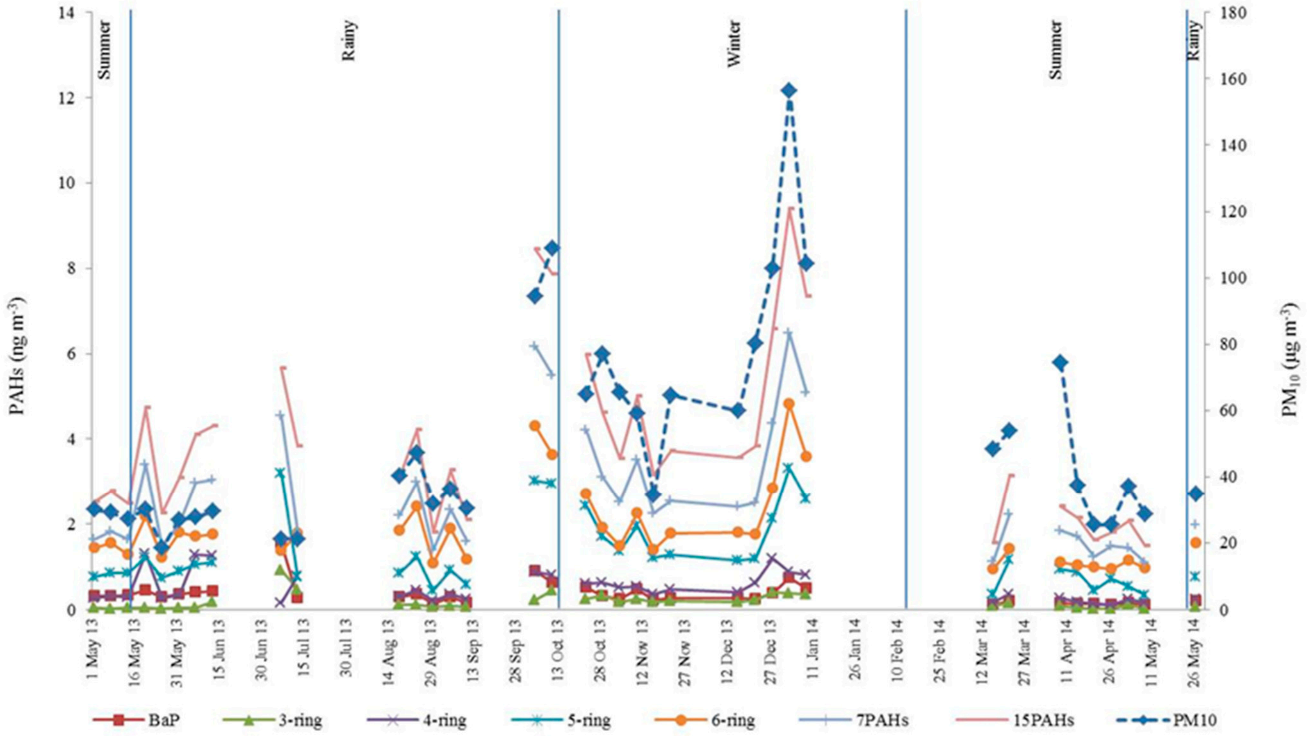

Figure S5b. Time series plot of daily mean PM10 (µg m-3) and PAHs (ng m-3) concentrations at the industrial site. (Missing data indicted sampling failures where PM10 filters were not collected.)

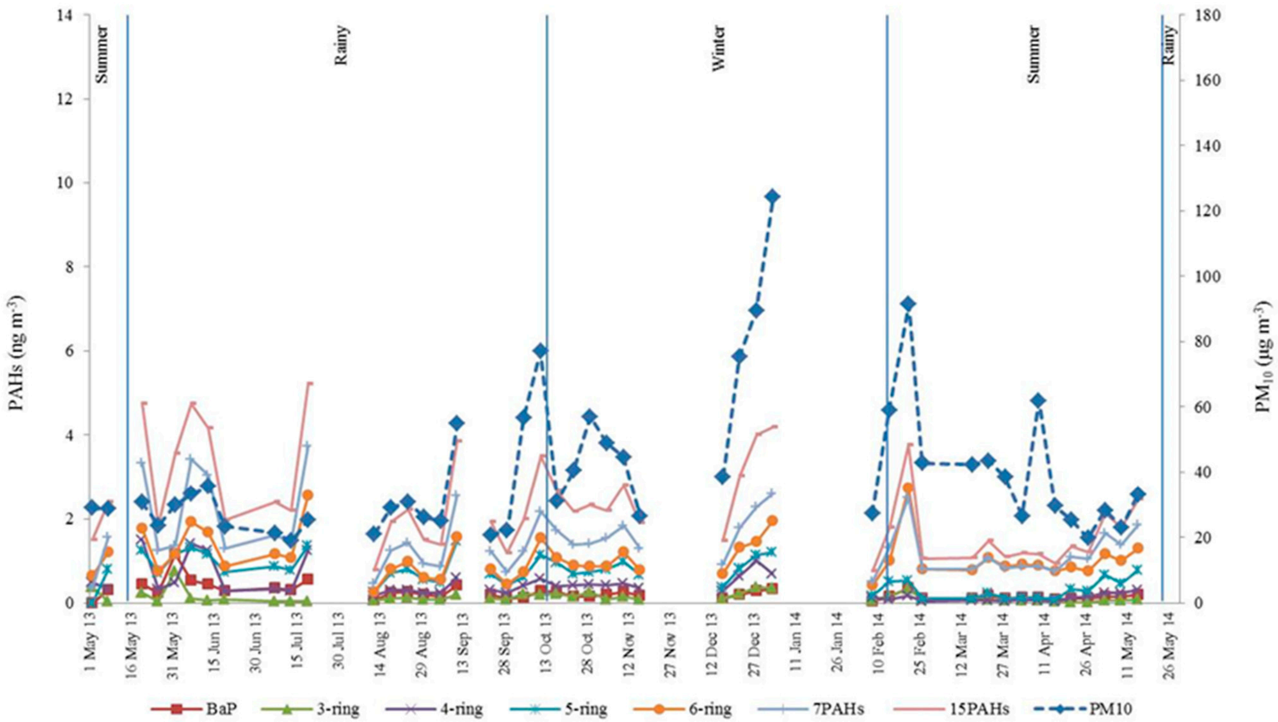

Figure S5c. Time series plot of daily mean PM_{10} (μg m^{-3}) and PAHs (ng m^{-3}) concentrations at the urban background site. (Missing data indicted sampling failures where PM_{10} filters were not collected.)