



Autumn and Wintertime Polycyclic Aromatic Hydrocarbons in PM_{2.5} and PM_{2.5-10} from Urumqi, China

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ABSTRACT

Concurrent sampling of PM_{2.5} and PM_{2.5-10} aerosols on a rooftop (15 m above ground) was conducted at a location in urban Urumqi (Xinjiang University 43°77'N, 87°61'E) during September 2010 to March 2011. These filters were analyzed for fifteen polycyclic aromatic hydrocarbons (PAHs). The ΣPAHs (sum of 15 PAHs) ranged from 0.11 to 1058.08 ng/m³ in PM_{2.5} and 0.01 to 90.89 ng/m³ in PM_{2.5-10}, respectively. 90% of the ΣPAHs existed in PM_{2.5}. In the autumn the ΣPAHs ranged from an undetectable level to 10.93 ng/m³ in PM_{2.5} and 2.10 ng/m³ in PM_{2.5-10}, and in the winter from an undetectable level to 54.11 ng/m³ in PM_{2.5} and 5.12 ng/m³ in PM_{2.5-10}.

Benzo(a)pyrene-equivalent carcinogenic potency (BaP_{eq}) was calculated to evaluate the cancer risk of carcinogenic PAHs to the public. The level of BaP_{eq} in PM_{2.5} was an average of 5.97 ng/m³, significantly higher than the value recommended by the WHO (1 ng/m³). This suggests that it is important to control regional combustion sources to reduce air pollution-related health risks in urban Urumqi.

Keywords: Fine particulate (PM_{2.5}); Coarse particulate (PM_{2.5-10}); PAHs Source apportionment; Urumqi.

INTRODUCTION

Polycyclic aromatic hydrocarbons (PAHs) are formed by incomplete combustion or pyrolysis of materials containing carbon and hydrogen. They have both anthropogenic and natural sources. The former includes combustion processes of fossil fuels and biomass, and the release of uncombusted petroleum products (Simcik *et al.*, 1999). PAHs, such as benzo(a)pyrene, have been shown to be causative agents of lung, esophageal, gastric, colorectal, bladder, skin, prostate and cervical cancers in humans and animal models; and lung cancer is one of the leading causes of cancer-related death in many countries (Lodovici *et al.*, 1998).

Many epidemiological studies have shown a strong relationship between the exposure to PM₁₀ (particulate matter with aerodynamic diameter smaller than 10 μm) and morbidity and mortality rates. Since partition between PM_{2.5} (particles with aerodynamic diameter less than 2.5 μm, Fine fraction) and PM_{2.5-10} (2.5 μm < aerodynamic diameter < 10 μm, Coarse fraction) is still unknown, it is important to obtain PAHs size distribution for the purpose of effective

air pollution control and establishing air quality standards by assessing public exposure to PAHs and their associated health risks (Slezakova *et al.*, 2009; Kong *et al.*, 2010).

Urumqi, the capital of the Xinjiang Uygur Autonomous Region of China, is in central Xinjiang, at the north foot of Tianshan Mountain and on the south edge of Jungger Basin. Urumqi is located almost in the center of Asia, north of the Taklamakan Desert, and south of the Guerbantonggute Desert. Urban Urumqi is bordered by the Tianshan Mountains in three directions, with summit up to 5000 m, and into the northern face of the city, the wind can carry soil dust into the urban area. Urumqi city is divided into six administrative areas. Tianshan District, Saybag district, Xinshi district, Shuimogou district, Midong district, and Toutunhe district (Chetwittayachan *et al.*, 2002). During the past two decades, the air has been heavily polluted and Urumqi is always found to be one of the most polluted cities in the world (Mamtimin and Meixner, 2007).

In this study we present the spatial and temporal variations of PAHs in PM_{2.5} and PM_{2.5-10} in urban Urumqi. The possible sources are also discussed based on the diagnostic ratios and the principal component analysis (PCA).

DATA AND METHODS

Sampling Sites

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A total of 84 particle samples, half in PM_{10-2.5} and PM_{2.5}, were collected the rooftop of a 5-storey building (~15 m above ground) in the campus of Xinjiang University (XUT, 43°77'N, 87°61'E, Fig. 1) between 25 September 2010 and 5 March 2011. The XUT campus is situated between the Urumqi Friendship hospital and water park; and the building is approximately 500 m away from the main road (Sheng Li Road).

Sampling Method

A middle-volume sampler (NL20; Tokyo Dylec Corp JP) was used to collect PM_{10-2.5} and PM_{2.5} particles simultaneously on quartz fiber filters (Whatman, Mainstone, UK) at a flow rate of 20 m³/min for 24-h. PM_{10-2.5} samples were collected on filters with 47 mm outside diameter and 20 mm inside diameter and PM_{2.5} samples on 47 mm diameter filters. Before field use, filters were baked in an oven for 4 h at 450°C, then wrapped in aluminum foil and zipped in Teflon bags. After sample collection, filters were again wrapped in aluminum foil, zipped in polytetrafluoroethylene bags, and stored in a refrigerator at 5°C until analysis.

Sample Extraction

Prior to 72 h Soxhlet extraction with redistilled (dichloride methane) DCM, a mixture of deuterated PAH standards (acenaphthene-d10, phenanthrene-d10, chrysene-d12, and erylene-d12) was added to each sample as surrogate compounds. The extracts were concentrated and solvent-exchanged to redistilled hexane, and then purified using a 1:2 alumina/silica column chromatography. The first fraction, containing aliphatic hydrocarbons, was eluted with 30 mL of hexane. The second fraction, containing PAHs, was collected by eluting 70 mL of DCM/hexane (3:7 v/v). The latter was then concentrated to a final volume of 200 mL under a gentle stream of nitrogen. Eight microliters of 50 mg/L hexamethylbenzene (Aldrich Chemicals, Gillingham, Dorset, USA), was added to the samples as an internal standard before instrumental analysis.

Instrumental Analysis and Parameters

PAHs were analyzed by an Agilent 6890N gas chromatograph (GC) coupled with an Agilent 5973N mass selective detector in the selective ion monitoring mode. The GC column used was a 30 m HP-5 capillary column (0.25 mm id., 0.25 μm film thickness). The column temperature was initiated at 80°C (held for 2 min) and increased to 290°C at 4 °C/min (held for 30 min). Target compounds were identified based on their mass spectra and retention times.

PAHs were quantified by authentic standards with internal approach (Cao *et al.*, 2005), including Naphthalene (Nap), acenaphthylene (Acey), fluorene (Flu), phenanthrene (Phe), anthracene (Ant), fluoranthene (Flu), pyrene (Pyr), benz[a]anthracene (BaA), chrysene (Chr), benzo[b]fluoranthene (BbF), benzo[k]fluoranthene (BkF), benzo[a]pyrene (BaP), indeno [1,2,3-cd] pyrene (IcdP), benzo[g,h,i]perylene (BghiP), dibenz [a,h]anthracene (DahA).

Quality Control/Quality Assurance

Six laboratory blanks were extracted and analyzed in the same way as field samples. Target PAHs were very low and in most cases not detectable in the blanks. Recovery efficiencies were determined by evaluating surrogate standards in the samples. The mean recoveries were 30% for naphthalene-d8, 40% for acenaphthalene-d8, 37% for phenanthrene-d10, 89% for chrysene-d12, 65% for perylene-d12 and 87% for evoglucosan-¹³C₆.

RESULTS AND DISCUSSION

Concentrations of PM_{2.5} and PM_{2.5-10}

The concentrations of PM_{2.5-10} and PM_{2.5} mass were measured approximately twice a week during the period of September 2010 to March 2011. The daily concentrations of PM_{2.5-10} and PM_{2.5} reached 139.05 μg/m³ and 263.77 μg/m³ with the latter 7.5 times higher than the daily standard of 35 μg/m³ for PM_{2.5} proposed by the U.S EPA (showing

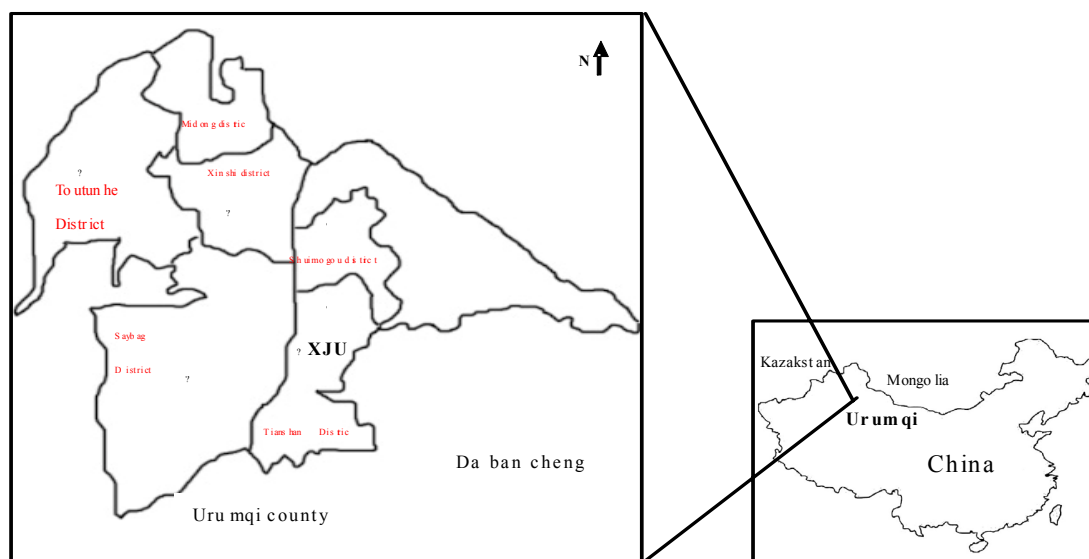


Fig. 1. Aerosol sampling sites.

in Fig. 2). As expected, the high concentrations of PM_{2.5} (averagely 297.21 µg/m³) and PM_{2.5-10} (averagely 143.2 µg/m³) were found in winter (November, December, January), which was most likely associated with high activities of fossil fuels burning for heating. Whereas the relatively low PM_{2.5} and PM_{2.5-10} level were observed in autumn (September and October) (196.89 µg/m³ and 130.76 µg/m³, respectively), due to the absence of combustion sources. In Urumqi there is a half-year for house heating domestically and industrially from 15 October to 15 April of next year.

Table 1 presents the maximum, minimum, and mean concentrations of ΣPAHs in PM_{2.5} and PM_{2.5-10}. A sharp increase in PAHs concentration was found in early morning with the peak concentration observed between 7:00 and 8:00 a.m., and followed by a rapid reduction during the daytime and gradually increase again in the evening (Chetwittayachan et al., 2002). Enhanced biomass burning and less photo-degradation of PAHs further contributed to the higher level of PAHs in January (Gao et al., 2011).

Seasonal Variations of PAHs in PM_{2.5} and PM_{2.5-10}

Table 2 presents the mean concentrations of individual PAH in PM_{2.5} and PM_{2.5-10} in autumn and winter. The total concentrations of PM_{2.5} PAHs and PM_{2.5-10} PAHs were in the range of 0.11–1058 ng/m³ and 0.01–90.89 ng/m³. The mean concentrations of PAHs were the higher in autumn (10.93 ng/m³ in PM_{2.5} and 2.1 ng/m³ in PM_{2.5-10}) and the highest in winter (54.11 ng/m³ and 5.12 ng/m³ in PM_{2.5} and PM_{2.5-10}, respectively). Fig. 3 shows the mean PAH profiles (contribution of each PAH compound to ΣPAH). During no-heating period Nap, BaA and Chr were abundant in PM_{2.5}, and Nap, Ant were dominant in PM_{2.5-10}, while during

heating period Flu, Pyr, BaA, BbF, BkF, BeP, BaP, IcdP, BghiP, DahA exhibited high levels in PM_{2.5} and Acey, FL exhibited high concentrations in PM_{2.5-10}. This phenomenon revealed the importance of vehicle emissions as PAH sources in no-heating period and coal combustion and vehicular emissions as PAH sources in heating period, because BkF, BbF, Chr and BaA were identified as markers of vehicle emissions and Pyr, FL, Ant and Chr were abundant in coal combustion emission (Khalili et al., 1995).

Distributions of PAHs with Different Ring Numbers

These 15 PAHs can be classified into 3 groups: 2 + 3-ring (Nap, Acey, Fl, Phe and Ant), 4-ring (Flu, Pry, BaA, Chr) and 5 + 6-ring (BbF, BkF, BaP, IcdP, DahA and BghiP) PAHs. Atmospheric PAHs exist in both gaseous and particle phases. PAHs with 2–3 aromatic rings were predominant in gaseous phase, while compounds with 4 or more rings are primarily associated with particulate phase (Katsoyiannis et al., 2007). It can be observed that the PAHs with 2 + 3-, 4- and 5 + 6-rings are dominant in both fine and coarse particles (Fig. 4). High molecular weight (HMW) PAHs prefer partitioning in PM_{2.5} as compared to low molecular weight (LMW) PAHs (Yunker et al., 2002). The 2 + 3-ring PAHs exhibited low concentrations in particle phase owing to their high volatility. The 4-rings PAHs were lower in autumn than winter Not only in PM_{2.5} and PM_{2.5-10}. Due to semi-volatility the 4-ring PAHs in the atmosphere exhibited a strong seasonal variation in Urumqi. The 5 + 6-rings PAHs were much richer in PM_{2.5} than PM_{2.5-10} in both seasons. The carcinogenic 5 + 6-rings species are predominantly associated with particles especially in the accumulation mode (0.5 µm < d < 1.0 µm) (Fang et al., 2006).

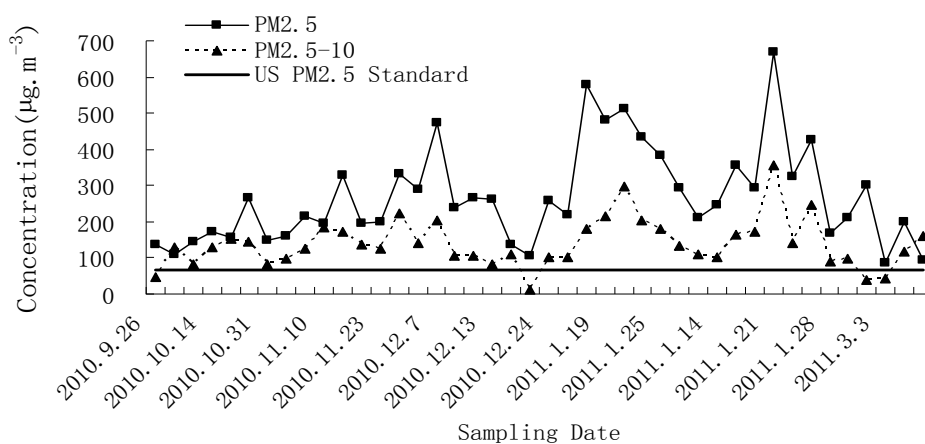


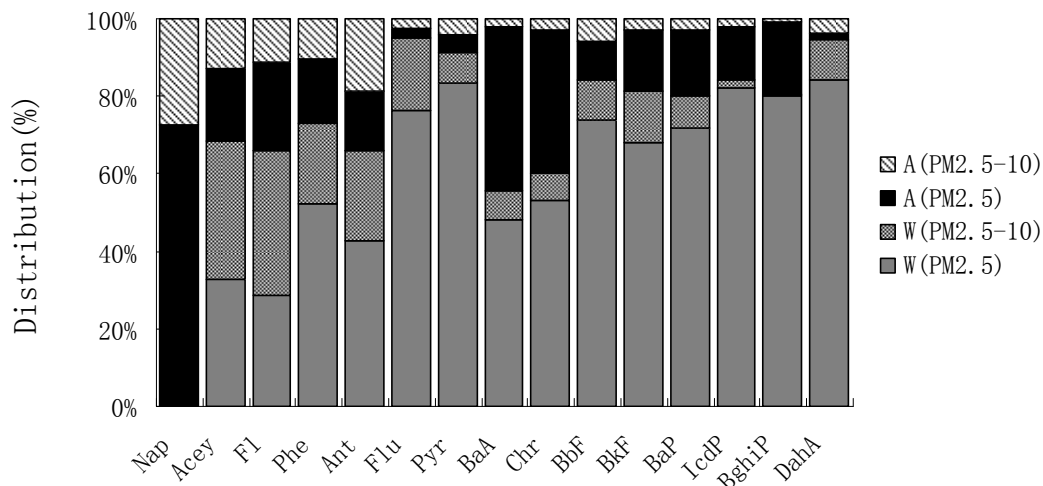
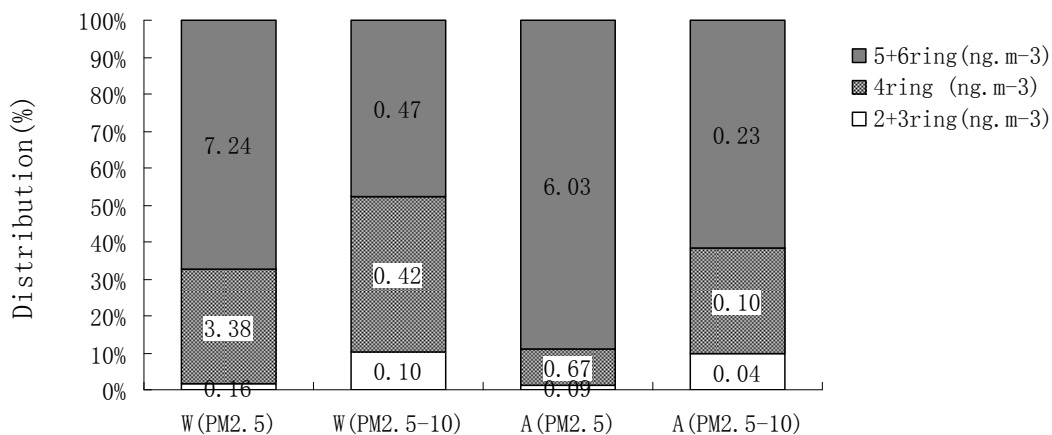
Fig. 2. The concentrations of PM_{2.5} and PM_{2.5-10} in winter and autumn.

Table 1. Maximum, minimum, mean concentration and related PAHs collected during the sampling period.

	PM _{2.5-10}	PM _{2.5}		PM _{2.5-10} ΣPAH	PM _{2.5} ΣPAH
Minimum (µg/m ³)	11.9	86.81	Minimum (ng/m ³)	0.01	0.11
Maximum (µg/m ³)	356.06	579.86	Maximum (ng/m ³)	90.89	1058.08
Mean (µg/m ³)	139.05	263.77	Mean (ng/m ³)	4.12	54.12
Sample number	42	42	Sample number	42	42
Sampling period	September 2010 –March 2011	September 2010 –March 2011	Sampling period	September 2010 –March 2011	September 2010 –March 2011

Table 2. Average concentrations (ng/m³) of PM_{2.5} and PM_{2.5-10}-bound PAHs in urban Urumqi in winter and autumn sampling.

	PM _{2.5} (Winter)	PM _{2.5-10} (Winter)	PM _{2.5} (Autumn)	PM _{2.5-10} (Autumn)
Nap	0.00	0.00	0.14	0.05
Acey	0.09	0.10	0.05	0.04
Fl	0.17	0.22	0.13	0.07
Phe	0.55	0.22	0.18	0.11
Ant	0.13	0.07	0.05	0.06
Flu	3.28	0.81	0.10	0.11
Pyr	1.30	0.13	0.07	0.06
BaA	3.15	0.48	2.76	0.13
Chr	1.97	0.26	1.38	0.11
BbF	3.47	0.47	0.47	0.28
BkF	3.42	0.67	0.79	0.15
BaP	2.21	0.25	0.53	0.09
IcdP	19.66	0.52	3.36	0.45
BghiP	7.58	0.03	1.76	0.09
DahA	7.12	0.89	0.14	0.30
ΣPAHs	54.11	5.12	11.90	2.10

**Fig. 3.** Distribution of 16 PAHs at autumn and winter in PM_{2.5} and PM_{2.5-10}.**Fig. 4.** Relative concentrations of 2 + 3-, 4- and 5 + 6-ring groups in 16 PAHs at Autumn and winter in PM_{2.5}, PM_{2.5-10}.

Carcinogenic Potency of PAHs

BaP, known as the most carcinogenic PAH, is the most investigated PAH and often regarded as an indicator of

carcinogenicity of total PAHs.

To evaluate the carcinogenic potency of PAHs, benzo(a) pyrene-equivalent carcinogenic potency (BaP_{eq}) was

calculated using the cancer potency equivalency factors (PEF) proposed by Yassaa *et al.* (2001) as the following equation (Gao *et al.*, 2011):

$$\text{BaP}_{\text{eq}} = \text{BaA} \times 0.06 + \text{BF} \times 0.07 + \text{BaP} + \text{DahA} \times 0.6 + \text{IcdP} \times 0.08 \quad (1)$$

The mean concentration of BaP_{eq} in $\text{PM}_{2.5}$ was 5.96 ng/m^3 and higher than WHO air quality guideline value of 1.0 ng/m^3 (Fig. 5). The exceedances were mostly taken place in winter, but only once in the no heating period. The highest level of BaP_{eq} was observed on January 21, 2011 with the value reaching 112.8 ng/m^3 , this day temperature, dew point, humidity, visibility and wind speed is -19°C , -22°C , 77%, 1.2 and 1 m/s .

Source Identification of PAHs

The ratios of PAH isomers are frequently employed as diagnostic tools to identify the sources of PAHs in ambient air. PCA is an important method to identify the major sources of air pollutants (Shi *et al.*, 2010). We used PAH ratios and PCA to further identify the sources of PAHs in Urumqi.

Ratio of PAH Isomers

Ratios of PAHs with similar molecular weights have been used for source identification (Tian *et al.*, 2009). The results of diagnostic ratios $\text{IcdP}/(\text{IcdP} + \text{BghiP})$, $\text{FluA}/(\text{FluA} + \text{Pyr})$, BaP/BghiP , and $\text{BaA}/(\text{BaA} + \text{Chr})$ are listed in Table 3.

The $\text{IcdP}/(\text{IcdP} + \text{BghiP})$ ratios of < 0.4 , > 0.5 and 0.35 – 0.47 indicates vehicle emission, coal combustion and mixed sources, respectively (Gu *et al.*, 2010). The ratios of $\text{IcdP}/(\text{IcdP} + \text{BghiP})$ in $\text{PM}_{2.5}$ and $\text{PM}_{2.5-10}$ were 0.72, 0.94 in winter and 0.66, 0.88 in autumn, suggesting that coal combustion

was the dominant source of PAHs at this site. PAHs from petrogenic sources have $\text{FLU}/(\text{Flu} + \text{Pyr})$ ratios < 0.4 , 0.4 – 0.5 is characteristic of liquid fossil fuel (automotive and crude oil) combustion and > 0.5 implies coal, grass or wood combustion (Yunker *et al.*, 2002). In this study, the $\text{FluA}/(\text{FluA} + \text{Pyr})$ ratios were above 0.5, indicating a strong contribution of coal and fossil fuel combustion, except the $\text{PM}_{2.5}$ samples in winter. For $\text{BaA}/(\text{BaA} + \text{Chr})$, a ratio higher than 0.35 means pyrolytic sources, lower than 0.2 indicates petrogenic sources and 0.2 – 0.35 could be either petrogenic or pyrolytic source (Soclo *et al.*, 2000). The values were 0.61, 0.65 in winter and 0.67, 0.56 in autumn for $\text{PM}_{2.5}$ and $\text{PM}_{2.5-10}$, indicating the pyrolytic sources. A BaP/BghiP ratio higher than 0.6 implies grass/coal/wood combustion, while lower than 0.6 indicates fuel combustion (Katsoyiannis *et al.*, 2007). In $\text{PM}_{2.5}$ and $\text{PM}_{2.5-10}$, the ratios of BaP/BghiP were 0.29 and 7.44 in winter, 0.3 and 0.95 in autumn, indicating that PAHs came from fossil fuel combustion in winter and grass/coal/wood combustion in autumn, respectively.

Principal Component Analysis (PCA)

Principal component analysis (PCA) is a widely used technique of multivariate linear data analysis (Wang *et al.*, 2010). We apportioned the sources of PAHs in the $\text{PM}_{2.5}$ and $\text{PM}_{2.5-10}$ in fall and winter using SPSS software. The results are shown in Tables 4 and 5. Different combustion sources can produce different compounds, therefore the factor loading of each component can be used to determine the source of PAHs.

In $\text{PM}_{2.5}$ during winter, contribution rate of factor 1 was 84%. BaA, Flu, Pyr and Chr are markers of coal combustion (Duval and Friedlander 1981; Wang *et al.*, 2010). BkF, BbF and BaP are markers of vehicle (gasoline and diesel) exhaust. So factor 1 represents the sources of coal combustion and

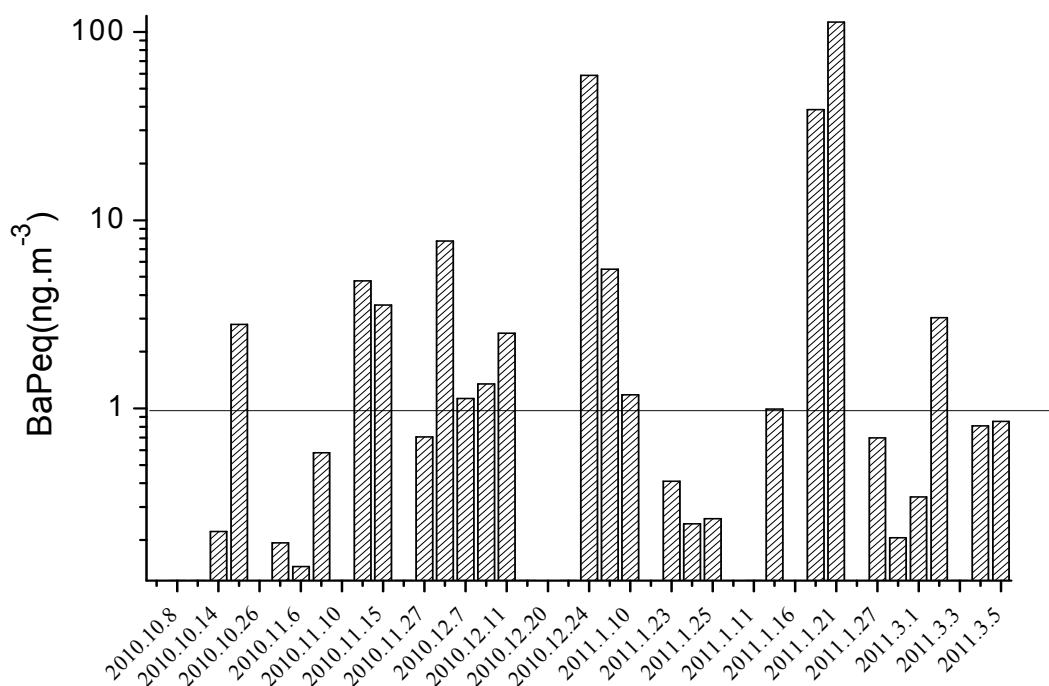


Fig. 5. Concentrations of BaPeq (ng/m^3) in the $\text{PM}_{2.5}$ during the September 2010–March 2011 sampling.

Table 3. The BaPeq concentrations of PAHs in fine fraction.

	Winter (PM _{2.5})	Autumn (PM _{2.5})	Winter (PM _{2.5-10})	Autumn (PM _{2.5-10})	Reference source emissions
IcdP/(IcdP + BghiP)	0.72	0.66	0.94	0.83	< 0.4 vehicles emission > 0.5 coal combustion 0.35–0.47 mixed sources
Flu/(Flu + Pyr)	0.11	0.65	0.64	0.51	< 0.4 petrogenic source 0.4–0.5 liquid fossil fuels > 0.5 coal, grass or wood combustion
BaA/(BaA + Chr)	0.61	0.67	0.65	0.56	> 0.35 pyrolytic sources < 0.2 petrogenic
BaP/BghiP	0.29	0.30	7.44	0.95	> 0.6 Grass/coal/wood combustion < 0.6 Fuel combustion

Table 4. PCA analysis of PAHs in PM_{2.5} and PM_{2.5-10} at winter.

	PM _{2.5}			PM _{2.5-10}		
	1	2	3	1	2	3
Acey	0.946	0.239	0.035	0.341	0.871	0.329
Fl	0.151	0.931	0.327	0.154	0.904	0.382
Phe	0.983	0.083	0.102	0.345	0.892	0.143
Ant	0.98	0.068	0.107	0.211	0.895	0.336
Flu	0.991	0.002	0.098	0.853	0.247	0.449
Pyr	0.978	0.024	0.136	0.1	0.584	0.764
BaA	0.988	0.015	0.055	0.973	0.208	0.064
Chr	0.995	0.002	0.086	0.287	0.559	0.753
BbF	0.945	0.115	0.12	0.972	0.211	0.067
BkF	0.974	0.05	0.045	0.943	0.178	0.029
BaP	0.913	0.083	0.147	0.975	0.189	0.037
IcdP	0.992	0.009	0.093	0.974	0.209	0.065
BghiP	0.985	0.012	0.09	0.928	0.217	0.075
DahA	0.62	0.436	0.616	0.969	0.203	0.062
Contribution rate %	84.015	8.204	4.303	54.31	29.82	12.6

Table 5. PCA analysis of PAHs in PM_{2.5} and PM_{2.5-10} at autumn.

	PM _{2.5}			PM _{2.5-10}		
	1	2	3	1	2	3
Acey	0.037	0.193	0.684	0.189	0.412	0.807
Fl	0.395	0.32	0.335	0.761	0.395	0.072
Phe	0.828	0.177	0.105	0.968	0.147	0.141
Ant	0.92	0.003	0.029	0.447	0.541	0.600
Flu	0.817	0.317	0.273	0.978	0.032	0.061
Pyr	0.507	0.563	0.567	0.998	0.000	0.027
BaA	0.584	0.042	0.634	0.665	0.638	0.190
Chr	0.172	0.983	0.023	0.823	0.534	0.138
BbF	0.157	0.984	0.034	0.987	0.105	0.065
BkF	0.886	0.006	0.13	0.964	0.081	0.060
BaP	0.816	0.049	0.231	0.543	0.659	0.375
IcdP	0.654	0.018	0.535	0.961	0.223	0.115
BghiP	0.138	0.988	0.011	0.961	0.224	0.114
DahA	0.034	0.991	0.072	0.936	0.226	0.157
Contribution rate %	37.69	29.9	11.94	68.434	13.015	10.617

vehicle (gasoline and diesel) exhaust. Factor 2 has the contribution rate of 8.2% with a high loading of Fl, which is a marker of vehicle exhaust. So factor 2 represents the emissions from coal-fired emissions.

In PM_{2.5-10} during winter, factor 1 has contribution rate of 54.3%, factor 1 Flu, BaA, BbF, BkF, BaP, IcdP, BghiP, DahA a high correlation coefficient. BaA, Flu heated to high temperatures to produce a large amount of markers are

coal-fired emissions, BkF, BaP marker of gasoline emissions and diesel emissions, BbF, vehicle emission markers. Factors determine the markers for coal-fired emissions and emissions of gasoline, diesel emissions, vehicle emissions. Factor 2, the contribution rate of 29.8% is a high correlation coefficient, Acey, Fl, Phe, Ant. Which Fl, Phe, Ant coal combustion and vehicle emission markers. Therefore, factor 2 to determine markers for coal combustion and emissions of gasoline (Wang *et al.*, 2010). Factor 3 of the contribution rate of 12.6%, a high correlation coefficient, Pyr and Chr, Pyr and Chr markers of the coal-fired emissions. So the factor of three coal-fired emissions. In general, winter PM_{2.5} and PM_{2.5-10} comes mainly from coal-fired emissions.

Table 5 shows that fall a total parse out the three factors, the fall of PM_{2.5} in the contribution of factor 1 was 37.69%, factor 1 Phe, Ant, Flu, BkF, BaP, a high correlation coefficient. Which Phe, Ant vehicle emission markers and coal combustion, BkF, BaP gasoline emissions and diesel emissions markers. Flu coal combustion markers, so the factors a judge for gasoline emissions and coal combustion markers. Factor 2, the contribution rate of 29.9%, a high correlation coefficient is the Chr, BbF, BghiP, DahA, factor 1 in Chr, BbF, coal combustion and vehicle emission markers, so the factor 2 judged as coal combustion and vehicle emission sources.

Autumn PM_{2.5-10} factor 1 contribution rate of 68.434%, factor 1 in Fl, Phe, Flu, Pyr, Chr, BbF, BkF, IcdP, BghiP, DahA a high correlation coefficient. Which Fl, BbF vehicle emission markers, Flu, Pyr coal combustion markers, Phe of coal combustion and vehicle emissions markers BkF gasoline emissions and diesel emissions markers. Therefore, the factor a judge for vehicle emissions, gasoline emissions, and diesel emission sources.

CONCLUSIONS

PAHs in PM_{2.5} and PM_{2.5-10} were measured in Urumqi city during autumn to winter to determine the compositions, temporal and spatial distribution and sources. The total PAHs concentrations in PM_{2.5} and PM_{2.5-10} were in the range of 0.11–1058.08 ng/m³ and 0.01 to 90.89 ng/m³, respectively. 90% of the PAHs were in PM_{2.5} with 3-, 4- and 5-rings dominant in both fractions. The BaP_{eq} was averagely 5.96 ng/m³ and much higher than WHO air quality guideline value of 1.0 ng/m³. Although, PM_{2.5} had higher PAHs concentrations than PM_{2.5-10}, they had similar spatial distribution of total PAHs and BaP_{eq} concentrations. Similarities of PAHs profiles between fine and coarse fraction were also compared by coefficient of divergence revealing that PAHs species concentrations and significant difference exists between fine and coarse fraction in Urumqi city.

PAH diagnostic ratios revealed that coal combustion and vehicle exhaust were the major sources of PAHs for both PM_{2.5} and PM_{2.5-10}. Correlation analysis on the concentrations of individual PAHs, correlation coefficients $r^2 > 0.90$, results indicated that PAHs with comparative ring sizes ($r^2 > 0.90$) had similar sources. Other sources like gas burning and wood combustion were identified as common sources in Urumqi city. To obtain insight into sources of PAHs in urban Urumqi,

a study is being conducted to determine gas- and particle-phases PAHs from different emission sources as well as in the ambient.

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