CHARACTERIZATION OF $PM_{2.5}$-BOUND POLYCYCLIC AROMATIC HYDROCARBONS IN SEOUL AREA

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1. Introduction

Polycyclic Aromatic Hydrocarbons(PAHs) can be released to the atmosphere by natural and anthropogenic sources. In particular, anthropogenic sources may be responsible for more than 90% of the atmospheric pollution emission. Main anthropogenic sources emitting PAHs are related with combustion processes, transportation, power generation and other industrial activities (Smith, I.M., 1984)[1]. Especially the case of USA shows 21~25% of total PAHs is related with automotive exhaust gas. Therefore vehicle emission is considered one of main source specially in urban areas. PAHs are known to include the human carcinogenic compounds and many Persistent Organic Pollutants(POPs) that exist in air in the form of fine particles with the aerodynamic diameter less than or equal to 3μm. Especially IARC report in 2006 announced that the carcinogenic risk grade of fine diesel particles containing PAHs was changed from 2A to 1.

2. Materials and methods

In this study, sampling and analysis of PAHs were performed following US EPA TO-13A method. Sampling sites for ambient PAHs measurement were Sanggye-dong(1), Jeonnong-dong(2), Jeongwang-dong(3), Susong-dong(4), and Doksan-dong(5) in Seoul and suburban area, Korea during 2011. Sampling periods for each season were April 1-6 for spring, August 24-30 for summer, October 4-12 for fall, December 11~16 for winter. The sampling flow rate was 566L/min for 24 hours and total flow was approximately $815m^3$. After the extraction and enrichment by nitrogen the samples were concentrated to about 1mL and analyzed by GC/MS. GC of Agilent's 6890N and MS of Agilent's 5973N were used with the column of PH-5MS(30m, 0.25mm, 0.25 μm)

3. Results and discussion

3.1. Weather conditions

Precipitation was considered a major factor of concentration change of PAHs in Seoul area. Measurement was therefore performed 3 days after rain-fall in case of rain. AWS(Automatic Weather System) at Meteorological Agency was untilized for the meteorological variables such as temperature, humidity, wind velocity and wind direction. Meterological conditions at each site are shown in Fig. 2

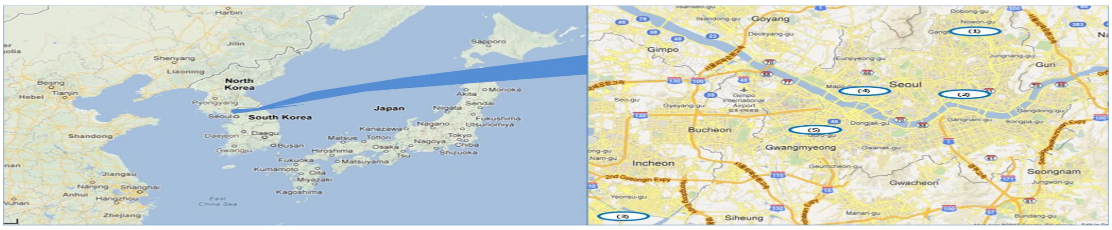

Fig.1 Measurement site locations in Seoul area

(1) Sanggye-dong, (2) Jeonnong-dong, (3) Jeongwang-dong, (4) Susong-dong, (5) Doksan-dong

(2)

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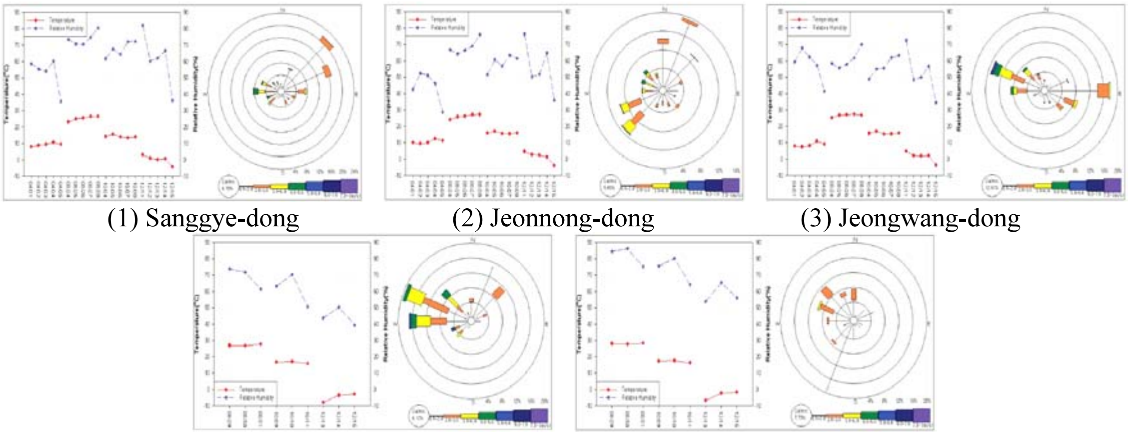


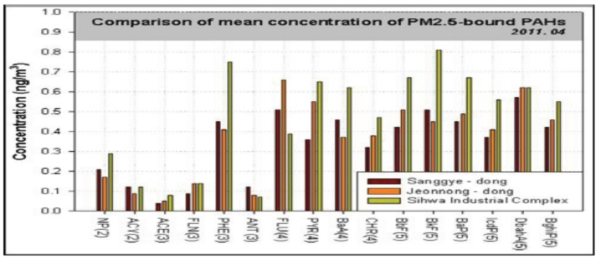
(1) Sanggye-dong (2) Jeonnong-dong (3) Jeongwang-dong

(4) Susong-dong (5) Doksan-dong

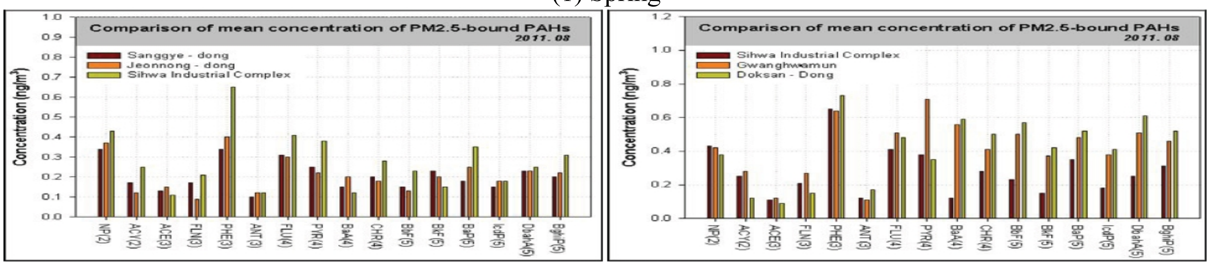
Fig.2 Meteorological conditions at each sampling site during study period

3.2 Airborne $PM_{2.5}$-bound PAHs Level by season

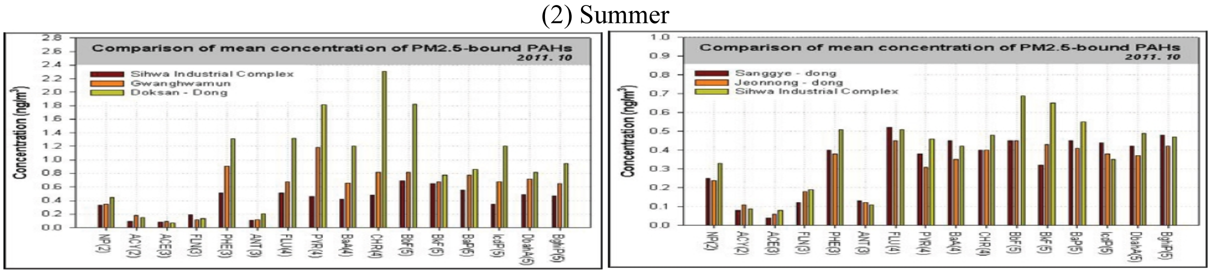
In spring season of 2011, only 3 representative sampling sites were chosen for feasibility study for different sampling sites for different land-use. Jeonnong-dong and Sanggye-dong sites were chosen for residential area and Sihwa Industrial Complex site was for industrial area. Samplers were also tested for their sampling performance. Sihwa Industrial Complex site showed the highest level, with average ∑PAHs of 7.46ng/m^3. Jeonnong-dong and Sanggye-dong showed similar level of 5.84 and 5.42ng/m^3 respectively.



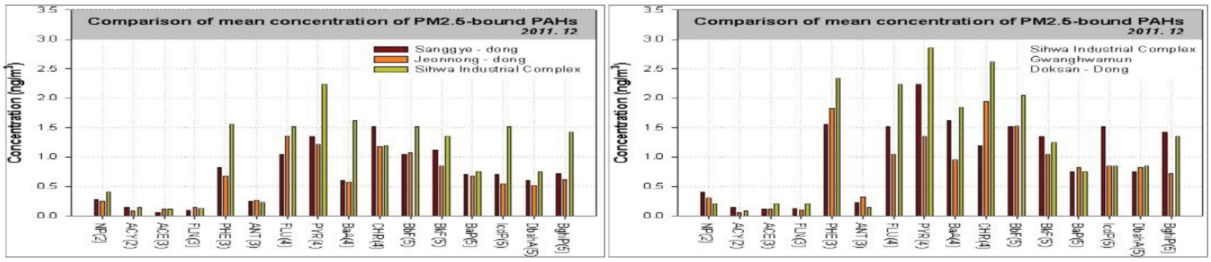
(1) Spring



(2) Summer



(3) Fall

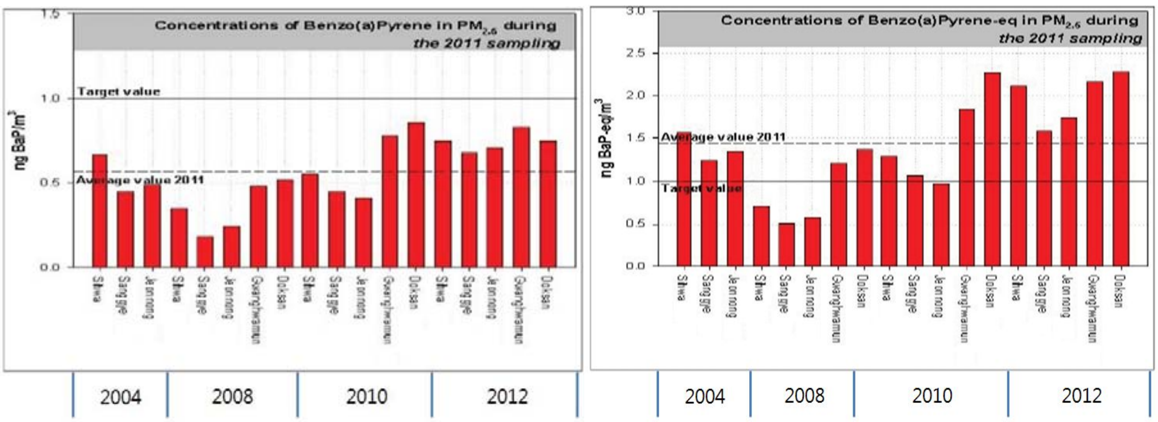


(4) Winter

Fig.3 PM2.5-bound PAHs distribution for different seasons, in Seoul area during 2011 campaign period

3.3 BaP & BaP-eq evaluation

The carcinogenic characteristics of the airborne $PM_{2.5}$ bound PAHs were studied for five sites during 2004~2012 by determining BaP equivalent (BaP-eq) levels. The average concentration of BaP-eq for total period was 1.39 ± 0.89 ng/m^3. Total of 14 out of 18 cases were observed to exceed the guideline value of 1.0 ng/m^3 during the sampling period.



(a) Average BaP level (b) Average BaP-eq level

Fig.4 Average airborne BaP and BaP-eq level at different sampling sites during 2004-2012

3.4 PAHs, $PM_{2.5}$ and meteorological variables.

The Pearson correlation coefficients were analyzed by SPSS of Windows version 11.5. The Pearson correlation coefficients were compared among the total PAHs, $PM_{2.5}$, the individual PAHs and the meteorological parameters including temperature, humidity, wind velocity and wind direction(Fig.5). It could be considered that there exist significant correlation between $PM_{2.5}$ level and most important PAHs. Also there exist weak negative correlation between PAHs level and wind speed.

Table 1. Pearson correlation coefficients among PAHs, the $PM_{2.5}$ and the meteorological variables

	NP(2)	ACY(2)	ACE(3)	FLN(3)	PHE(3)	ANT(3)	FLU(4)	PYR(4)	BaA(4)	CHR(4)	BbF(5)	BkF(5)	BaP(5)	IcdP(5)	DbahA(5)	BghiP(5)	Total PAHs	$PM_{2.5}$	T average	R Humidity	Wind speed	Wind direction
NP(2)	1.000																					
ACY(2)	0.665*	1.000																				
ACE(3)	0.667*	0.554*	1.000																			
FLN(3)	0.391	0.659*	0.304	1.000																		
PHE(3)	0.601*	0.279	−0.026	−0.024	1.000																	
ANT(3)	0.526	0.027	−0.075	−0.152	0.628*	1.000																
FLU(4)	0.241	−0.016	−0.375	−0.145	0.789**	0.672*	1.000															
PYR(4)	0.404	0.197	−0.152	−0.069	0.909**	0.526	0.908**	1.000														
BaA(4)	0.272	−0.040	−0.342	−0.153	0.861**	0.615*	0.860**	0.882**	1.000													
CHR(4)	0.411	0.021	−0.215	−0.143	0.877**	0.735**	0.953**	0.926**	0.893**	1.000												
BbF(5)	0.303	−0.063	−0.337	−0.116	0.873**	0.635*	0.940**	0.925**	0.947**	0.967**	1.000											
BkF(5)	−0.068	−0.273	−0.443	−0.207	0.629*	0.128	0.574*	0.675*	0.779**	0.610*	0.767**	1.000										
BaP(5)	0.160	−0.056	−0.415	−0.138	0.840**	0.377	0.763**	0.857**	0.895**	0.766**	0.879**	0.885**	1.000									
IcdP(5)	0.221	−0.079	−0.384	−0.228	0.866**	0.594*	0.922**	0.937**	0.961**	0.945**	0.972**	0.767**	0.899**	1.000								
DbahA(5)	−0.019	−0.140	−0.508	−0.214	0.726**	0.347	0.750**	0.769**	0.882**	0.890**	0.815**	0.844**	0.923**	0.842**	1.000							
BghiP(5)	0.209	−0.073	−0.452	−0.136	0.866**	0.581*	0.895**	0.901**	0.965**	0.896**	0.963**	0.797**	0.950**	0.974**	0.900**	1.000						
Total PAHs	0.365	0.056	−0.272	−0.101	0.928**	0.619*	0.928**	0.965**	0.959**	0.958**	0.985**	0.755**	0.908**	0.978**	0.841**	0.970**	1.000					
PM2.5	0.531	0.233	−0.080	0.024	0.890**	0.548	0.760**	0.857**	0.837**	0.818**	0.857**	0.695**	0.830**	0.809**	0.703**	0.827**	0.885**	1.000				
T average	0.737**	0.588*	0.798**	0.453	0.007	0.302	−0.241	−0.183	−0.275	−0.136	−0.281	−0.633**	−0.433	−0.352	−0.478	−0.354	−0.231	−0.111	1.000			
R Humidity	0.703**	0.259	0.499	0.137	0.299	0.624*	0.068	0.114	0.205	0.251	0.131	−0.231	−0.069	0.107	−0.124	0.079	0.155	0.111	0.741**	1		
Wind speed	−0.083	0.492	0.170	0.469	−0.302	−0.655*	−0.412	−0.207	−0.355	−0.520	−0.435	−0.162	−0.151	−0.413	−0.141	−0.333	−0.348	−0.178	0.029	−0.321	1	
Wind direction	0.188	0.042	−0.341	0.260	0.659*	0.286	0.516	0.571*	0.757**	0.516	0.680*	0.734**	0.817**	0.645*	0.813**	0.777**	0.695**	0.662*	−0.210	0.047	−0.033	1

*Correlation is significant at the 0.05 level(2-tailed).
** Correlation is significant at the 0.01 level(2-tailed).

4. Conclusion

The average concentration $PM_{2.5}$ bound PAHs was higher in order of winter, spring, fall and summer During 2011 campaign period in Seoul area. The high level of particulate PAHs is considered partly due to stationary and area emission sources because of very low temperature in December 2011. The higher concentrations of particulate fluoranthene and pyrene were observed. The major emission sources for overall high PAHs is considered mobile sources including high percentage of diesel vehicles. As a result of correlation among PAHs and meteorological variables, wind speed was the most predominant factor determing PAHs level as well as $PM_{2.5}$ level.

5. Acknowledgements

This research was supported by 2012 research fund of the University of Seoul.

References

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