Particulate Matters(PM_{10}) and Particle-Bound Polycyclic Aromatic Hydrocarbons(PAHs) in Indoor and Outdoor Air in New and Sick Houses

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Abstract

PM_{10} and 16 PAHs were measured in indoor and outdoor air of 5 different old houses, new and sick houses, respectively. PM_{10} concentrations measured in indoor of three different kinds of houses ranged from 23 to 43 $\mu g/m^3$ and in outdoor ranged in 40-64 $\mu g/m^3$. Sum of average concentrations of PAHs in old, new and sick houses indoor air were 3.7 ng/m^3, 6.6 ng/m^3 and 16.1 ng/m^3, respectively, which were lower than those of outdoors. Most of the indoor/outdoor ratio for PAHs in each house were less than 1.0 and significant correlation($p<0.05$) between indoor and outdoor samples was observed.

Introduction

PM_{10} is a particulate matter with an aerodynamic diameter < 10 μm. Epidemiological studies have demonstrated an association between PM_{10} pollution episodes and increased acute and chronic respiratory morbidity. [Takafuji, 2000]

PM_{10} also proved to be genotoxic in diverse test systems [Binkovál, 2003]. This may be partly explained by organic substances adsorbed on the particle surface, such as polycyclic aromatic hydrocarbons (PAHs), nitro-polycyclic aromatic compounds, dioxins, and metals. [Ethel, 2004]

Among these compounds, polycyclic aromatic hydrocarbons (PAHs) are a group of compounds that consist of two or more fused benzene rings. PAHs are considered potent carcinogenic and mutagenic compounds, by incomplete combustion of organic substances. And PAHs have also been found to increase allergic immune responses in human at low levels, and may act synergistically with other air toxics to cause adverse health effects.

Humans spend most of their lives indoors. Therefore, the spatial and temporal monitoring of pollutants are considered important for the evaluation of health risks for populations.

In the present study, we examine the distribution of PM_{10} and associated PAHs in indoor and outdoor air in new and old houses, and sick houses which were recently constructed in a year and in which people complained about the ordor or they had symptoms such as headache and nausea.

Experimental

Airborne particles were collected from both indoor and outdoor environment of each five houses for 24 hours using a low volume air sampler(Gilian, USA) with multi-stage cascade impactor, the flow rate for sampling was about 20 $Lmin^{-1}$. Teflon quartz filter((47 mm diameter, Graseby TEF-DISK^{TM}) were used for the collection of PM10 particles. Particle concentrations were calculated as the weight change of the filter divided by the volume of air passed through the sampler.

The analysis of PAHs associated with particles were conducted by compendium methods TO-13A. The target compounds for this survey were 16 species of 2- to 5-ring PAHs. For analysis, teflon quartz filter collected airborne dust were accurately weighed and spiked with the following deuterated internal standards (Supelco, EPA 525 PAHs internal std. Mix. 48242, U.S.A) : acenaphthene-d_{10}, chrysene-d_{12}, phenanthrene-d_{10}, perylene-d_{12}. Then samples were extracted by Soxhlet extractor with 10 % diethylether/hexane for 18 hours at the rate of at least 3 cycles per hour. After concentration the extracts were cleaned by column chromatography on activated silica gel. The cleaned extracts were reconcentrated and separated by gas chromatography(HP 6890N, U.S.A) and identified by mass spectrometry(HP 5973). Quantification was carried out using multi-stage calibration according to the deuterated internal standards after detection of the PAHs in single ion monitoring with 3 ions per component.

Result and discussion

PM_{10} concentrations measured in indoor of three different kinds of houses ranged from 23 to 43 ㎍/㎥ and in outdoor ranged in 40-64 ㎍/㎥ (Fig. 1). The outdoor mean concentrations of PM_{10} were no differences between houses, meanwhile PM_{10} in indoor air in new houses were measured higher than those of old houses($p<0.05$). The results of measurement for 16 PAHs in

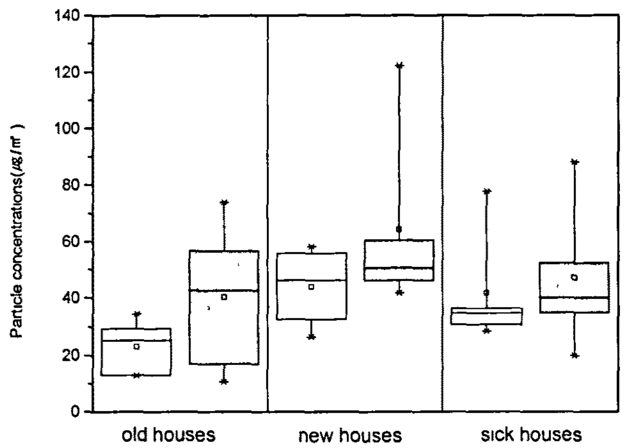

Fig. 1. Particle concentrations (PM_{10}) measured in houses. Boxes show 25th-75th percentiles, and lines inside the boxes show the median values. Indoor concentrations are shown in white and outdoor concentrations in gray.

indoor and outdoor of each different houses are shown in Table 1. Phenanthrene, fluorancene, pyrene and indeno(1,2,3-cd)pyrene were predominant for the most part of the houses air. Especially the three ring PAHs phenanthrene, anthracene occupied about 20-58% of sum of individual PAHs in indoor air.

Table. 1 Average indoor and outdoor PAH concentrations.(ng/m^3) and indoor/outdoor ratios for old, new and sick houses.

Compounds	Old houses(n=5)			New houses(n=5)			Sick houses(n=5)		
	indoor	outdoor	I/O	indoor	outdoor	I/O	indoor	outdoor	I/O
Naphthalene	0.182	0 05	3.64	0.09	0 03	3 0	0.135	0.034	3.97
Acenaphthylene	0.027	0.074	0.36	0.014	0	-	0.169	0.235	0.72
Acenaphthene	0.01	0.033	0.30	0.004	0	-	0.139	0.174	0.79
Fluorene	0.029	0.260	0.11	0.008	0.013	0.62	0 821	0.971	0.84
Phenanthrene	1.078	1.863	0.57	0.454	0.548	0.83	0.692	0	-
Anthracene	0.063	0.478	0.13	0.060	0.123	0.49	1.755	0	-
Fluoranthene	1.052	1.147	0.91	0.651	0.774	0.84	0.979	1.378	0.71
Pyrene	0.194	0.455	0.43	0.179	0.274	0.65	0.838	1.148	0.73
Benz(a)anthracene	0.095	0.220	0.43	0.197	0.388	0.50	0.475	0.752	0.63
Chrysene	0.124	3.050	0.04	0.257	0.476	0.54	0.470	0.814	0.58
Benzo(b)fluoranthene	0.322	0.793	0.40	1.374	2.013	0.68	1.025	1.713	0.59
Benzo(k)fluoranthene	0.065	0.15	0.43	0 247	0.498	0.49	0.289	0.423	0.68
Benzo(a)pyrene	0.119	0.339	0.35	0.651	0.858	0.75	0.823	1.249	0.66
Indeno(1,2,3-cd)pyrene	0.209	0.729	0.26	1.204	1.375	0.87	1.989	2.688	0.74
Dibenz(a,h)anthracene	0.081	0.178	0.45	0.239	0.257	0.92	0.328	0.435	0.75
Benzo(g,h,i)perylene	0.249	0.553	0.45	0.782	0.905	0.86	1.243	1.696	0.73
Total PAHs	3.899	10.372	0.36	6.411	8.532	0.78	12.170	13.710	0.88

A total of average concentrations of PAHs in old, new and sick houses indoor air were 3.7 ng/m^3, 6.6 ng/m^3 and 16.1 ng/m^3, respectively, which were lower than those of outdoors.
With the exception of naphthalene, most of the median indoor/outdoor ratio for PAHs in each house were less than 1.0 and significant correlation($p<0.05$) between indoor and outdoor samples was observed. However, naphthalene levels were approximately three times higher in indoor air than in outdoor, which was generally emitted from household products, such as mothballs.
These characteristics show that indoor PAHs concentrations were driven by outdoor levels. The average concentrations for individual PAHs measured in this study were similar to those reported elsewhere and a significant correlation with PM_{10} was found in indoor and outdoor air [Fromme, 2004].

Conclusion

The outdoor mean concentrations of PM_{10} were no differences between houses, meanwhile PM_{10} in indoor air in new houses were measured higher than those of old houses($p<0.05$).

Three ring PAHs phenanthrene, anthracene occupied about 20-58% of sum of individual PAHs in indoor air. Most of the median indoor/outdoor ratio for PAHs in each house were less than 1.0 and significant correlation($p<0.05$) between indoor and outdoor samples was observed

References

Takafuji. S, Nakagawa, T., Air pollution and allergy. *J. Invest. Allergol. Clin. Immunol.* **10**, pp. 5-10, 2000.

Binkovál. B., Černá, M., Pastorková, A., Jelínek, R., Beneš, I., Novák, J. and Šrám, R.J., Biological activities of organic compounds adsorbed onto ambient air particles: comparison between the cities of Teplice and Prague during the summer and winter seasons 2000-2001. *Mutat. Res.* **525**, pp. 43-59, 2003.

Ethel Brits, Greet Schoeters and Luc Verschaeve, Genotoxicity of PM_{10} and extracted organics collected in an industrial, urban and rural area in Flanders, Belgium, Environmental Research, 96, 109-118, 2004.

H. Fromme, T. Lahrz, M. Piloty, H. Gebhardt, A. Oddoy, H. Ruden : Polycyclic aromatic hydrocarbons inside and outside of apartment in an urban area, Science of the Total Environment, 326, 143-149 (2004).