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Monitoring and assessment of polycyclic aromatic hydrocarbons in roadside particulate matter of Yokohama, Japan

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Introduction

Polycyclic Aromatic Hydrocarbons (PAHs) resulting from the incomplete combustion, are of special interest due to their toxicity, carcinogenicity, mutagenicity and ubiquitous presence in the environment. Major PAH sources to the atmosphere include motor vehicles, home heating, fossil fuel combustion in energy and industrial process. Vehicle emissions have been associated with adverse health effects in multiple epidemiological studies but specific constituent or source relationships have not been fully established. Characterization of roadside particulate matter exposures requires detail information on spatial and temporal trends of various pollutants. The present study sought to explore distribution pattern of SPM associated PAHs and the impact of the emission regulations for automobiles in large Japanese cities which were enacted during 2002 and 2003 from the road side samples in Yokohama.

Materials and methods

Roadside particulate matter samples were collected at Mineoka, Hodogaya ward of Yokohama, very close to Route 16. The SPM samples were collected with Shintaku Low Volume Air Sampler (Shintaku Co. Japan) at 20 L/min on quartz filter paper. Eighty two sampling events, twice in a month was conducted from April, 1999 to May, 2005. The samples for the year of 2003 were lost. Ultrasonic extraction was performed with dichloromethane and the concentration of ten SPM associated PAHs such as fluoranthene, pyrene, benz[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[e]pyrene, benzo[a]pyrene, indeno[1,2,3-cd]pyrene and benzo[ghi]perylene were determined using gas chromatography-mass spectrometry (GC/MS). QA/QC was conducted to minimize and quantify sampling and measurement errors.

Results and discussions

The individual PAHs concentration ranged from 0.008 to 2.42 ng/m^3. The most abundant PAHs were found benzo[b]fluoranthene, indeno[1,2,3-cd]pyrene, chrysene, benzo[e]pyrene and benzo[ghi]perylene and exhibited average concentrations accounting for 0.53, 0.37, 0.35, 0.32 and 0.31 ng/m^3. Basically, 5- and 6-ring PAHs were found to be dominant which are known to be highly carcinogenic and mutagenic in humans while 4-ring PAHs show the least contribution. This result is in good agreement with the findings of studies in Japan (Ohura et al, 2004). Distinct seasonal variation with a higher concentration in cold months (November to February) and lower concentration in warmer months (May to September) were also observed. Particulate matter associated PAHs were used to assess the impact of emission regulation for automobiles in large Japanese cities enacted during 2002 and 2003. Based on total PAHs (ΣPAHs) concentration, emission reduction was found 38.7%. Considering concentration of individual target PAHs, shown in Table 1, the magnitude of the emission reduction were in the following order: Benzo[b]fluoranthene (60.1%) > Chrysene (53.5%) > Benzo[a]pyrene (50.1%) > Benzo[k]fluoranthene (43.8%) > benzo[ghi]perylene (36.7%) > Indeno[1,2,3-cd]pyrene (30.9%) > Benz[a]anthacene (9.9%). The concentration of pyrene and fluoranthene were found higher after the enforcement of the regulations than before. These compounds have been identified as a source marker of diesel engine emission indicating that heavy duty vehicles run by diesel engine was intensified at sampling stations.

Table 1. Concentration of SPM associated PAHs before and after the enforcement of emission regulations in 2002 and 2003

Compounds	Before (ng/m^3)	After (ng/m^3)	Reduction (%)
Fluoranthene	0.104	0.136	-
Pyrene	0.097	0.128	-
Benz[a]anthracene	0.130	0.117	9.9
Chrysene	0.447	0.208	53.5
Benzo[b]fluoranthene	0.712	0.284	60.1
Benzo[k]fluoranthene	0.263	0.148	43.8
Benzo[a]pyrene	0.401	0.200	50.1
Benzo[e]pyrene	0.116	0.124	-
Indeno[1,2,3-cd]pyrene	0.416	0.304	26.9
Benzo[ghi]perylene	0.380	0.240	36.7

Reference

Ohura, T., Amagai, T., Fusaya, M., Matsushita, H., Environ. Sci. Technol., 38, 49-55, 2004.