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Atmospheric Research 88 (2008) 224–233

ATMOSPHERIC RESEARCH

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Polycyclic aromatic hydrocarbons (PAHs) associated with atmospheric particles in Higashi Hiroshima, Japan: Influence of meteorological conditions and seasonal variations

Yasmin W.F. Tham *, Kazuhiko Takeda [1], Hiroshi Sakugawa [1]

Graduate School of Biosphere Science, Hiroshima University, 1-7-1, Kagamiyama, Higashi Hiroshima, 739-8521, Japan

Received 29 June 2007; received in revised form 30 October 2007; accepted 30 October 2007

Abstract

This work studied the influence of meteorological conditions on particulate polycyclic aromatic hydrocarbons (PAHs) in the atmosphere of Higashi Hiroshima, Japan. The seasonal variation of particulate PAHs was also covered. It was found that ambient temperature, solar intensity and weekly rainfall had significant influence on the particulate PAH concentration based on correlation studies. Correlation of particulate PAHs with ambient temperature, solar intensity, weekly rainfall, wind speed and humidity was studied by using Pearson correlation analysis. Particulate PAHs had a strong negative correlation with ambient temperature and solar intensity. A moderate negative correlation with weekly rainfall was also observed. There was no significant correlation between particulate PAHs with wind speed as well as humidity. Besides, particulate PAHs were found to have significant positive correlation with sulfur dioxide and nitrogen dioxide while having a moderate negative correlation with ozone. The particulate PAHs in Higashi Hiroshima exerted distinct seasonal variation with a higher concentration in winter and lower concentration in summer. When compared among PAHs with different numbers of aromatic rings; 5-ring PAHs was found to exert the most distinct seasonal variation. The contribution of carcinogenic PAHs to total particulate PAH concentration was fairly constant at about 50% throughout the year.

Keywords: Polycyclic aromatic hydrocarbons; Meteorological conditions; Seasonal variations

1. Introduction

Polycyclic aromatic hydrocarbons (PAHs) are a group of ubiquitous environmental pollutants. PAHs are emitted into the atmosphere by incomplete combustion of organic materials and fossil fuels such as automobile fuel combustion, industrial combustion, wood and coal burning etc. This group of pollutants had been a major concern of environmental and health scientists due to the fact that some of them are proven to be mutagens and carcinogens (Kameda et al., 2005). PAHs in the atmosphere can be present either in the gaseous phase or adsorbed on atmospheric particles depending on their respective chemical and physical properties. Scientific research has proved that many higher molecular weight PAHs with 4 or more aromatic rings are carcinogenic and they are mostly attached to the particle phase in the atmosphere (Chetwittayachan et al., 2002). Therefore, the study of the occurrence of particulate PAHs and the processes governing their fate is

* Corresponding author. Tel./fax: +81 82 424 6504.
E-mail address: waifon@hotmail.com (Y.W.F. Tham).
[1] Tel./fax: +81 82 424 6504.

0169-8095/$ - see front matter © 2007 Published by Elsevier B.V.
doi:10.1016/j.atmosres.2007.10.015

undoubtedly of great importance. Particulate PAHs have been studied intensively for decades due to their potential health risks (Beak et al., 1991; Chetwittayachan et al., 2002; Fang et al., 2006; Tham et al., 2007). However, due to the extreme complexity of particle characteristics and the interaction of PAHs with meteorological conditions, the source and sink scenarios of particulate PAHs have yet to be fully understood.

Most of the studies on particulate PAHs have been focused on source identification with less attention given to the influence of meteorological conditions (Omar et al., 2002; Ravindra et al., 2006; Tham et al., 2007). Once released to the atmosphere, particulate PAHs are subjected to various atmospheric processes governing their sources and sinks in the air. Heterogeneous reactions including photo-oxidation and gas–particle partitioning appear to be major transformation processes of particulate PAHs along with long term transport, in certain cases. Photo-oxidation is highly dependent on meteorological parameters, especially solar irradiation (Hong et al., in press). Gas–particle partitioning could be influenced by ambient temperature and humidity (Hong et al., in press; Tham et al., 2007). Long term transport is subjected to the influence of mixing height, atmospheric stability as well as wind speed and wind direction. In order to reveal the atmospheric processes responsible for the source and sink mechanism of particulate PAHs, it is mandatory to analyze the influence of meteorological conditions such as ambient temperature, solar irradiation, wind speed and wind direction (Ravindra et al., 2006). The change of meteorological conditions in different seasons causes the observed seasonal variation of particulate PAHs, as reported in many cases (Fang et al., 2006).

The study of atmospheric PAHs in the Hiroshima prefecture of Japan is relatively scarce. Tham et al. (2007) reported the pollution scenario and source identification of particulate PAHs in Higashi Hiroshima. They reported that vehicular emission was the main source of particulate PAHs in Higashi Hiroshima with a mean concentration of 2.39 ng m^{-3}. However, the influence of meteorological conditions and seasonal variation of particulate PAHs has not been covered in detail. Thus, we aimed to study the influence of meteorological conditions on the particulate PAHs in the atmosphere of Higashi Hiroshima and the respective seasonal variation.

2. Materials and methods

2.1. Sampling sites

The sampling site is located at the campus of Hiroshima University in Kagamiyama, Higashi Hiroshima, Japan. Higashi Hiroshima is a core city in the central region of Hiroshima Prefecture, with a wide area of approximately 635 km^2 covering nearly 7.5% of the prefecture's space. The city has a population of approximately 178,000 people (2006). Fig. 1 shows the location of Higashi Hiroshima city and the sampling site.

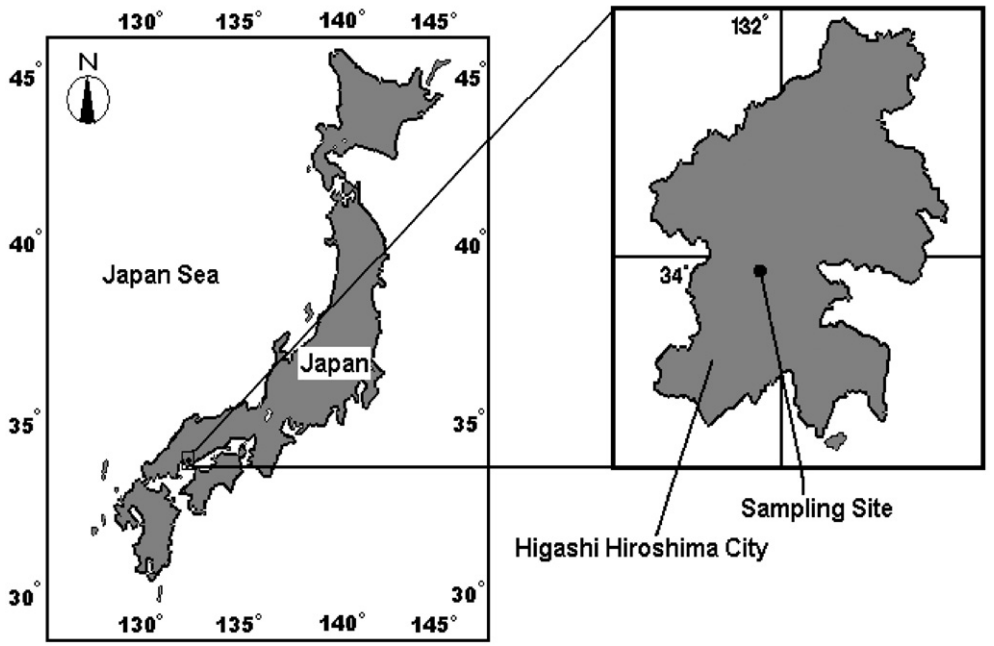

Fig. 1. Location of sampling site, Higashi Hiroshima City.