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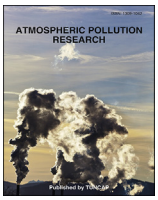

Original Article

First evidence of high urinary 1-hydroxypyrene level among rural school children during smoke haze episode in Chiang Mai Province, Thailand

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ABSTRACT

Smoke haze from biomass burning has been a crisis in northern Thailand. There have been plenty of reports on ambient PM_{10} and PAHs but not on individual exposure during smoke haze episodes. The present study aimed to quantify urinary 1-OHP, a predominant biomarker of PAH exposure, among 200 rural school children in Om Koi and Mae Chaem districts, Chiang Mai Province, northern Thailand. Questionnaires for information regarding environmental exposure and health diaries were given out. Urine samples were collected to measure 1-OHP using high-performance liquid chromatography-fluorescence detection, HPLC-FLD (HP1100 Series/HP1046A). Proficiency testing materials were obtained from the participation of German External Quality Assessment Scheme (G-EQUAS, Erlangen, Germany) and analyzed as part of the method validation of our urinary 1-OHP method. The median urinary 1-OHP level in the school children from Om Koi District was significantly higher than that in Mae Chaem District (0.70 versus 0.24 μmol/mol cr). The present study showed the evidence that urinary 1-OHP level among school children from the selected study sites during haze episode in northern Thailand is higher than those reported in other region of Thailand and other countries.

1. Introduction

Urinary 1-hydroxypyrene (1-OHP), a metabolite of pyrene, is a predominant biomarker of exposure to polycyclic aromatic hydrocarbons (PAHs) (Jongeneelen, 1994). It was used in many environmental and occupational studies of exposure to PAHs from outdoor air pollution (Chen et al., 2015; Pérez-Maldonado et al., 2014; Ruchirawat et al., 2002; Ochoa-Martinez et al., 2016; Yu et al., 2016), indoor burning (Epton et al., 2008; Ruiz-Vera et al., 2015a; Singh et al., 2016), vehicle traffic (Fan et al., 2012; Freire et al., 2009; Ruchirawat et al., 2005), industrial pollution (Ruchirawat et al., 2007; Xia et al., 2013), cigarette smoke, and smoked food consumption (Buratti et al., 2000, Ke et al., 2016).

Exposure to PAHs determined by urinary 1-OHP level is associated with many health effects such as impaired lung function (Wang et al., 2016), kidney and vascular dysfunction (Ruiz-Vera et al., 2015a; Singh et al., 2016), decline in cognitive function in the elderly (Best et al., 2016), alteration of male thyroid hormone (Zhu et al., 2009), inhibition of immune response (Laupeze et al., 2002), DNA damage (Jasso-Pineda et al., 2015) and increased risk of cardiovascular diseases (Pruneda-Alvarez et al., 2016) and lung cancer (Shen et al., 2014; Xia et al., 2013) which is highest from wood burning (Sarigiannis et al., 2015). Moreover, prenatal exposure to PAHs also adversely affects early neurodevelopment in children (Perera et al., 2015).

In most studies in Thailand, urinary 1-OHP levels were investigated and reported from urban populations. The occurrence levels of urinary 1-OHP among children in Bangkok (0.23 μmol/mol cr) were found to be two times higher than those in Chonburi (0.11 μmol/mol cr) (Ruchirawat et al., 2005, 2007). In Thai adults, the levels of urinary 1-OHP in street vendors and bus drivers were similar (0.15 μmol/mol cr and 0.12 μmol/mol cr, respectively).

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Surprisingly, the 1-OHP level in non-smokers who were not occupationally exposed to PAHs in Chiang Mai Province (0.91 μmol/mol cr) were 6–7 times higher than those in street vendors and bus drivers in Bangkok (Chetiyanukornkul et al., 2004; Petchpoung et al., 2011; Ruchirawat et al., 2005). However, the level and related effects on children in northern Thailand where has smoke haze pollution is still scarce.

In northern Thailand, smoke haze pollution, has been a serious cause of air pollution since 2007. Extremely increasing number of hotspots (which were derived from the satellites and represented locations with possible active fires) during dry season (especially in the smoke haze period: February–April) means, invariably, open biomass burning spread over this region (GISTDA, 2015). Open biomass burning produces lots of smoke which contains many air pollutants including particulate matters (PMs) and polycyclic aromatic hydrocarbons (PAHs), and leads to visibility impairment (shown in Fig. 1). The elevated levels of these two pollutants in the smoke haze period have been previously reported by many groups (Chantara, 2012; Pengchai et al., 2009; Wiriya et al., 2013). It was also found that there exists a correlation between ambient PM concentrations and agricultural activities and forest fires in this region (Phairuang et al., 2016). However, based on current knowledge, there have been no reports yet on individual exposure levels during the smoke haze period in Thailand.

Children tend to be more vulnerable to the harmful effects of ambient air pollutants than adults because 1) their lung function increases linearly with age and height until they age 10 years in females and 12 years in males (Wang et al., 1993), 2) children particularly school-aged children spend lots of time in outdoor environments and have more exposure to ambient air pollutants than adults and 3) children's larger lung surface area per body weight causes they gain more air pollutants than adults under normal breathing (Schwartz, 2004). The previous reports suggested that ambient air pollutants may cause chronic, adverse effects on lung development in children such as impaired lung function (Gauderman et al., 2004) and exacerbation of asthma (Tzivian, 2011).

In the present study, Om Koi and Mae Chaem districts which had intensive open biomass burning, as indicated by the number of hotspots detected by the satellites, were selected to be the study sites. Therefore, the present study aimed to investigate urinary 1-OHP levels among school children in these areas during the smoke haze period. We assumed the school children in these areas having higher levels of urinary 1-OHP. Besides the lifestyles of the people of these sites, we also investigated other factors such as outdoor PM_{10} levels, indoor cooking, smoking habits, and diets which might affect the exposure and health.

2. Materials and methods

2.1. Study site

The present study was carried out in two rural districts, Om Koi and Mae Chaem, in Chiang Mai Province, Thailand (Fig. 2). These two districts were selected based on the high number of hotspots from open biomass burning in these areas (Table 1). School children were recruited from schools in Ban Yang Krok village in Om Koi District and Ban Na Hong village in Mae Chaem District where reportedly having the highest hotspot number of these districts. The only one secondary school in each selected village was invited to participate in the study.

2.2. Study population

Two hundred school children were recruited from Ban Yang Krok village in Om Koi District (n = 137) and Ban Na Hong village in Mae Chaem District (n = 63) in March 2015. Children from the Ban Na Hong and the Ban Yang Krok villages were attending Pratom 4–6 classes (grades 4–6) and Pratom 4-Mattayom 6 classes (grades 4–9), respectively. All the children were informed about the study, and written consent was obtained from a parent and assent from the child before they participated in the study. The characteristics of the study populations are shown in Table 2.

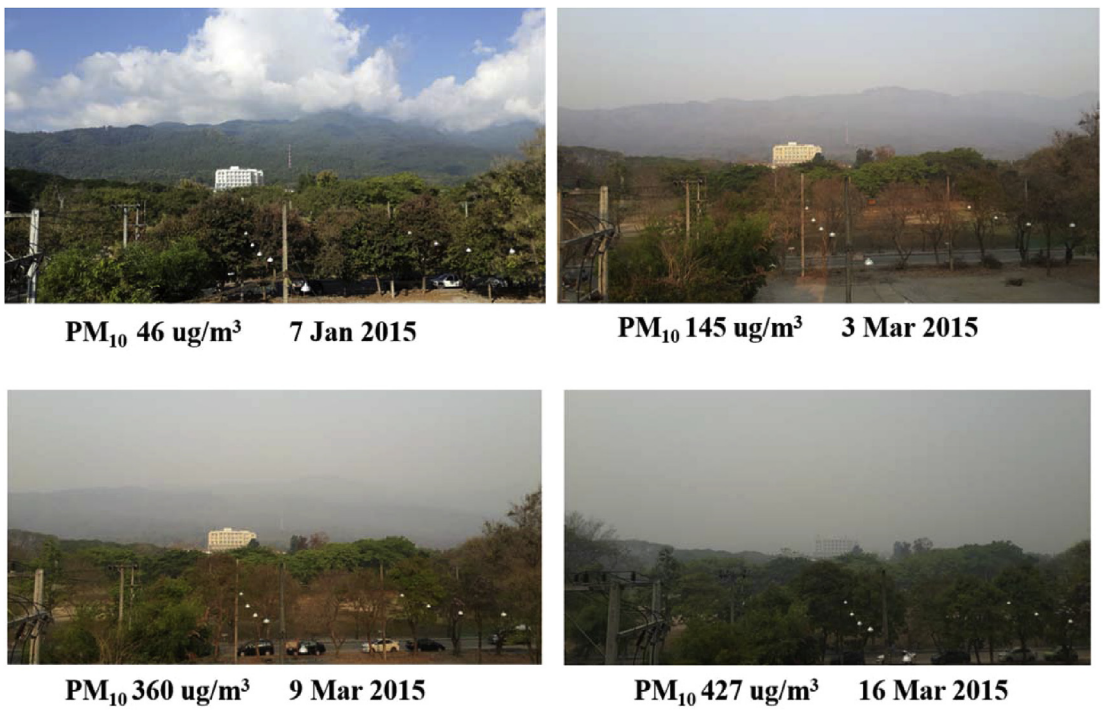

Fig. 1. The effect of air quality on the visibility of Doi Suthep mountain, west of Chiang Mai City, and real-time PM_{10} levels ($\mu g/m^3$) from Yupparaj Wittayalai School Air Monitoring Station during smoke haze episode in March 2015.

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