OCCURRENCE OF PAHs IN THE ATMOSPHERE AND INCENSE BURNING AREA IN HA NOI ASSOCIATED WITH HEALTH RISK ASSESSMENT

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ABSTRACT

The presence of polycyclic aromatic hydrocarbon compounds (PAHs) was investigated through the particulate matter of samples air samples collected in the ambient air and the incense burning area in Ha Noi. The concentration of PAHs in the incense burning area was higher than that in the ambient air. The mixture of PAHs in both sites was predominantly composed of PAHs containing 4 and more than 4 aromatic rings. Benzo(a)pyrene, (BaP), regarded one of the most toxic PAHs, was found in all samples, with the concentrations higher than the maximum concentrations defined by several EU Countries. The health risk assessment was conducted using the toxic equivalent factor (TEF) that was obtained by comparing the toxicity of individual PAHs to BaP. Derma contact was the main routes of exposure in the studied area. The incremental lifetime cancer risk (ILCR) model was used to find the risk level for human. The ILCR was higher than $10^{-3}$, indicating high health risk to community. The incense burning activity increases the risk to exposure human.

Keywords: PAHs, incense burning, health risk, Ha Noi.

1. INTRODUCTION

PAHs containing at least two fused aromatic rings have been found to be widely distributed in the atmosphere. PAHs are produced from incomplete combustion of fossil fuels and organic materials. Burning incense in the home and temples is an important religious ritual in oriental society. Incense typically smolder and combusts incompletely, producing incense smoke that contains particulate embedded PAHs [1, 2].

Ha Noi, in recent years, the increase in private means of transport have resulted in the increase of PAHs emission into the atmosphere. Studies on PAH in the atmosphere in Ha Noi showed that PAH level in the particulate matter was relatively high. The total concentration of 16
EPA-PAH in the period 2002-2003 was 29.41 - 119.09 ng/m³ [3]. The total concentration of 10 PAHs having 4-6 rings in the TSP in 2010-2011 was 9.6 - 3.7 pmol /m³[4]. In addition, Ha Noi also the center of culture of Vietnam. There are hundreds of pagodas, temples, and religious points where the incense activities occur. However, data about the PAHs released from incense burning has been limited.

PAHs belong to a toxic chemical group, some of which are mutagenic or carcinogenic [5]. Exposure of PAHs from the atmosphere is associated with many adverse health effects including cancer [6, 7]. Due to the high content of PAHs in the ambient air as well as the emission of PAHs from incense burning in Ha Noi, it is necessary to investigate the health risk of PAHs to protect local resident health. However, little information about the health effect from PAHs exposure is available in Ha Noi. The current study was conducted to determine particle bound PAHs in the ambient air and the incense burning area in Ha Noi to assess the health risk under PAHs exposure.

2. EXPERIMENT AND METHODS

**Sampling site:** Particulate matter samples were collected in ambient air at the roof top of a five-story building at Ha Noi University of Science and Technology (BK) (Height: 22.5 m, N: 20°00′17.7″; W: 105°50′49.4″) during the period from January - May 2015. For incense burning area, samples were collected at Hai Ba Trung Temple (HBT) and To Hoang Shrine (TH) located in Hai Ba Trung District, Ha Noi during the period from February to March 2015.

**Sampling:** TSP in ambient air were collected using quartz fiber filters (8 × 10 inches) and a high-volume air sampler - KIMOTO with flow rate of 60 m³/h for 24 h. For incense burning samples PM₂.₅ in were collected using quartz fiber filters (dia.47 mm) and a MiniVol™ TAS sampler with Airmetrix impactor of a flow rate of 5 L/min for 5h.

**PAHs analysis:** PAHs in filter samples were ultrasonically extracted twice with dichloromethane (DCM) and followed by evaporation and refilled to 1 mL with methanol for analysis. The 16 US-EPA PAHs were analyzed using GC/MS.

**Health risk assessment:** Individual PAH potency equivalency factors (PEF) relative to BaP were used to estimate multi-component PAH exposure [8]. PEFs for the 16 target PAHs were obtained from previous study [9, 10]. Lifetime average daily dose (LADD) was calculated separately for each PAH and for each exposure pathway [11]. The incremental lifetime cancer risk (ILTCR) was estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen using the following formula ILTCRᵢ = LADDᵢ × CSFᵢ, where ILTCRᵢ is the incremental lifetime cancer risk for an exposure route, LADDᵢ is the lifetime average daily dose for an exposure route and CSFᵢ is the cancer slope factor for an exposure route. The cancer slope factors (CSFs) for BaP used in the present study for the dermal [10], inhalation and ingestion [12] exposure routes were 30.5, 3.9 and 236 12 mg/kg/d respectively. The total incremental lifetime cancer risk (ILTCRₑ) was calculated by summing the risks associated with each exposure route.
3. RESULTS AND DISCUSSION

3.1. Concentration of PAHs in ambient air in Ha Noi

It was found that concentration of 16 investigated PAHs over the study period varied between 43.4 - 49.0 ng/m³. The total concentration of PAHs with 4 or more rings was 30.0 - 35.6 ng/m³, accounting for 69 – 73 % of the total PAHs. Regarding toxicity and persistence, BaP concentrations at the surveyed site ranged from 9.8 - 11.0 ng/m³ nearly ten times higher than the recommended limit in several European air quality guidelines (0.5 - 1.0 ng/m³). In addition, PAHs with high toxicity such as DBA, BkF, BaA were also present at significant concentrations. This result is consistent with the previous study on PAHs in Ha Noi [3, 4].

3.2. Concentration of PAHs in incense burning area

Total concentration of PAHs in incense area were in the range of 186.6 - 363.3 ng/m³, more than four times higher than that in the ambient air. The PAHs measured in Hai Ba Trung Temple was higher than those in To Hoang Shrine. This difference in PAH concentration between the two sites can be attributed to the difference in the amount of burned incense during the study period. During sampling period, the recorded number of visitors coming to Hai Ba Trung Temple and To Hoang Shrine was 120 - 200 and 25 - 40 visitors respectively. The dominant PAHs found in this study were DbA, BaP, BkF. Similarly, Navasumrit et al. [13] reported that BaA, BbF, BaP and DbA were the dominant carcinogenic PAHs in Thai temples, and Lin et al. [14] found that the dominant PAHs in Taiwanese temple were BaP, BPER, DbA and BbF. The average concentrations of carcinogenic PAHs (c-PAHs) and non-carcinogenic PAHs (nc-PAHs) were 148.9 - 306 and 37.8 - 57.4 respectively. The c-PAHs were BaA, Chr, BkF, BbF, BaP, IND, and DbA while nc-PAHs were Nap, Acy, Ace, FIA, Phe, Ant, Flu, Pyr and BPER [11]. Carcinogenic PAHs was accounted for 80 % of total PAHs in incense burning area, posing a significant potential for public health risks.

3.3. Health risk assessment of PAHs

Table 1. Calculated LADD (mg/kg/d) exposure path way of PAHs.

<table>
<thead>
<tr>
<th>Exposure pathway</th>
<th>LADD_{inh}</th>
<th>LADD_{ing}</th>
<th>LADD_{der}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambient air</td>
<td>1.26×10^{-6}</td>
<td>3.21×10^{-3}</td>
<td>2.67×10^{-5}</td>
</tr>
<tr>
<td>Incense burning area</td>
<td>9.05×10^{-5}</td>
<td>4.79×10^{-5}</td>
<td>4.00×10^{-5}</td>
</tr>
</tbody>
</table>

Table 2. Calculated ILCR for exposure path way

<table>
<thead>
<tr>
<th>Exposure path way</th>
<th>Ambient Air</th>
<th>Incense burning area</th>
</tr>
</thead>
<tbody>
<tr>
<td>ILCR_{inh}</td>
<td>4.91×10^{-6}</td>
<td>3.53×10^{-3}</td>
</tr>
<tr>
<td>ILCR_{ing}</td>
<td>3.85×10^{-3}</td>
<td>5.75×10^{-4}</td>
</tr>
<tr>
<td>ILCR_{der}</td>
<td>8.17×10^{-4}</td>
<td>1.22×10^{-3}</td>
</tr>
<tr>
<td>ILCR_{total}</td>
<td>1.21×10^{-3}</td>
<td>1.83×10^{-3}</td>
</tr>
</tbody>
</table>

Figure 1. Distribution of PAHs in samples.
The estimated LADD (Table 1) showed that greater possibility of adverse health effects (LADD_{d}), followed by the ingestion exposure route (LADD_{ing}), and finally the inhalation exposure route (LADD_{inh}) regardless whether the exposure was to PAHs in ambient air or in the incense burning areas. The calculated ILTCR_{tot} at all sites (Table 2) were higher than 10^{-3}, which exceed the US-EPA acceptable level of 10^{-6} [11] indicating high potential carcinogenic health risk. It was found that the dermal contact exposure route was the major contributor to the total lifetime cancer risk, comprising > 99 % of the calculated values of ILTCR_{tot}. The calculated ILTCR_{tot} of the population with exposure PAHs in the incense burning areas was higher than that for the population with with the exposure to PAHs in the ambient air. This result indicates that incense burning activity can increase the risk to exposed population. Concerning the individual toxicity of the target PAHs, the compounds that contributed most to the total estimated were BaP (44 %) and DbA (50 %) in the case of exposure to ambient air, and BaP (31 %) and DbA (64 %) in the case of exposure to incense burning area.

4. CONCLUSIONS

The concentration of PAHs in incense burning area were 3 - 7 time higher than those in ambient air in Ha Noi. In both sites, toxic PAHs were the dominant compounds among the detected PAHs. Carcinogenic PAHs accounted for 80 % of total PAHs in incense burning area. The estimated ILTCR indicated that high potential carcinogenic risk to the population and the dermal contact exposure route was the major contributor to the total lifetime cancer risk. BaP and DbA were the compounds that contributed most to the total estimated risk in ambient air as well as in the incense burning area. Incense burning activity poses higher the health risk to exposed population.

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REFERENCES


