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EMISSIONS OF POLYCYCLIC AROMATIC HYDROCARBONS IN THE ATMOSPHERE: AN INDIAN SCENARIO

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Introduction

Polycyclic aromatic hydrocarbons (PAHs) are organic compounds with two to eight aromatic rings that are formed during incomplete combustion from natural and anthropogenic sources which are non-essential for the growth of plants, animals or humans; yet, they are ubiquitous in the environment. When present in sufficient quantity in the environment, certain PAHs are toxic, mutagenic and carcinogenic to plants, animals and humans. PAH exhibit a wide range of physical-chemical properties i.e. vapor pressure and aqueous solubility. The PAH's recognized as carcinogenic are mostly associated with particulate matter (lyall et al., 1988). They undergo thermal decomposition and react with a number of atmospheric chemicals producing derivatives, which can be more toxic than the original compounds (Nicolaou et al., 1984). PAH are gaseous at the high temperature of combustion, but downstream of the combustion zone, during cooling, PAH condense onto the surfaces of soot particles (Wornat et al., 1990), which then serve as the vehicles of PAH transport and deposition in the environment.

Indian Scenario

Intensive use of biofuels, for domestic combustion, normally results in high emissions of PAH in India. This is related to the high volatile content of biofuels, which commonly leads to the higher possibility of incomplete burning. Fuelwood is normally burnt in traditional cookstoves with an efficiency of 10-15% (Gupta et al., 1998). A wide range of traditional and improved cookstoves, such as cookstoves and fixed chullahs, are also in use, which have efficiencies in the range of 25-80% (Kandpal et al., 1995). The low efficiency of cookstoves result in higher fuel consumption per capita for cooking in developing countries, which subsequently leads to high emission products of incomplete combustion including PAH. In India, a group was constituted by Central Pollution Control Board to propose Ambient Air Quality Standards for Benzo(a)pyrene for 2005, 2010. Following recommendations were made for long term ambient air quality standards for Benzo(a)Pyrene. Proposed ambient limits for PAH indicator parameter i.e. Benzo(a)pyrene in India may be 5 ng/m3 on 1st January 2005 and be reduced to 1 ng/m3 by 1st January 2010.

Raiyani et al. (1993a) found that more than 75% of the PAH emissions from biomass and coal-burning cooking stoves were in a respirable fraction of ≤ 2 μm size. Venkataraman et al. (2002) gives emission factors of PAH from combustion of biofuels like wood, briquette and dung cake, ranged 2.0 –3.2, 2.8–3.0 and 3.1–5.5 mg kg-1 respectively, with a predominance of fluoranthene, pyrene and benz(a)anthracene from all biofuels. Pandit et al. (2001) found that the concentration of the carcinogenic benzo(a)pyrene in the cooking environment using kerosene as fuel ranged between 0.2-17.6 ng m-3 which was lower than 33-186 ng m-3 of benzo(a)pyrene from other cooking fuels like coal, wood and cattle dung given by Raiyani et al. (1993a). Even then, it exceeds

the air quality standard of 1 ng m-3 specified by Central Pollution Control Board. Gupta et al (1998) compared the environmental and thermal performance of cooking biofuels and evaluated the emission factors for benzopyrene from biofuels i.e. 0.97 mg kg-1. Sushil Kumar et al. (2004) reported a study on environmental exposure to PAH's among economically underprivileged population of urban areas of Uttar Pradesh, India in the range of 23-185 ng m-3. Kulkarni et al. (2000) reported total PAH concentration in Mumbai city at Saki Naka as 38.8 ng/m3 and that at IIT as 24.5 ng/m3 with individual PAH species concentration ranging from 1-13 ng/m3. PAH profiles for cooking fuels in slum houses in Ahmedabad are presented in Table 1 (Raiyani et al., 1993b).
Table 1. PAH Profiles for Cooking Fuels.

Source/Fuel	Predominant PAH species (%)
Wood	Benzo(a)pyrene (35%), Dibenzo-anthracene (15%), Indeno(123-cd)pyrene (15%)
Cattle manure	Pyrene (18%), Benzo(a)pyrene (15%), Fluoranthene (12%)
Coal	Pyrene (21%), Dibenzo-anthracene (15%), Benzo(a)pyrene (12%)
Kerosene	Benzo(a)pyrene (22%), Pyrene (15%), Dibenzo-anthracene (15%)
LPG	pyrene (27%), Benzo(a)pyrene (15%), Dibenzo-anthracene (12%)

These profiles were developed from the measurements by normalizing each PAH species concentration to that of the total PAH concentration (all species), present in the particulate emissions.
Some preliminary studies have been initiated to assess the particulate PAH emissions from fuelwood burning in rural cookstoves. The preliminary budget estimates of particulate PAH from fuelwood emissions have been calculated and are shown in Table 2.

Table 2: Preliminary PAH emission estimates from fuelwood combustion in India.

Compound	Emission Factor (g/kg)	Budget Estimates (Gg)	Reference
PAH	0.02±0.01	5.6±2.8	Gadi et al., 2006

These estimates are based on the emission factors obtained from the analysis of five fuelwood samples. The major contribution in particulate PAH is from Fluorenthene, Pyrene, Benzo(e) pyrene, Benzo(a) pyrene, chrysene and Dibenzo(a,h)anthracene.
Further work is in progress to improve the reliability of all the emission estimates by conducting experiments on different biomass fuels being used as a fuel in the residential sector for cooking purposes in different regions of India.

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