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Assessment of PAHs in soil around the International Airport in Delhi, India

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Abstract

Present study was undertaken to determine the level of PAH contamination due to jet turbine exhaust in the peripheral soil of the International Airport in Delhi, India. Densely populated residential areas surrounding the airport come directly under both the landing and take-off flight paths. Twelve priority polycyclic aromatic hydrocarbons (PAHs) were analyzed in the <2 mm surface soil fraction. Identification and quantification of PAHs was done by high performance liquid chromatography (HPLC). The sum of 12 PAHs ranged from 2.39 $\mu g\,g^{-1}$ to 7.53 $\mu g\,g^{-1}$ with a mean concentration of $4.43 \pm 1.45\ \mu g\,g^{-1}$. PAH levels observed in the present study were found to be higher as compared to most of the literature values. Among the three sampling sites selected around the International Airport, the site near landing point revealed maximum concentration of PAHs, while minimum concentration was observed at the site near take-off point. Predominance of pyrene was observed in the airport soil. Factor analysis and isomer pair ratios suggest pyrogenic origin of PAHs in the study area.

Keywords: Airport; B(*a*)P; Delhi; PAH; Soil; Toxic equivalent factor (TEF)

1. Introduction

Little is known about the possible exposure of people living near airports to polycyclic aromatic hydrocarbons (PAHs). It has been conjectured that jet turbine exhaust near airplane flight paths may result in significant human exposure to PAHs. At major airports, aircrafts are routed through corridors or discrete pathways significantly localizing the distribution of any fallout, subject to meteorological effects. The plume could move directly to the ground as a cohesive unit due to electrostatic charge or saturation effects and get deposited on soil or pass into residential areas. Thus, posing risk of PAH exposure [1].

The primary aviation fuels are kerosene-range distillates [2]. The combustion of these fuels produces non-methane hydrocarbons (NMHCs) [3]. PAHs, a group of ubiquitous organic contaminants are included in the list of NMHCs. PAHs mainly originate from anthropogenic sources. They are a subject of public concern due to their demonstrated carcinogenic and mutagenic potential [4]. The United States Environmental Protection Agency (USEPA) has listed 14 hazardous air pollutants (HAPs), believed to be present in the aircraft exhaust. The list includes a group of 16 PAHs, as polycyclic organic matter (POM) [5].

Aircraft engines (piston and turbine) have been demonstrated to emit considerable amounts of benzo(*a*)pyrene ($2–10\ mg\,min^{-1}$), a known carcinogenic hydrocarbon associated with particulates [6]. So, particulate associated PAHs emitted from aircrafts [7], represent a source of carcinogenic pollution in the vicinity of airports [8]. Particulate associated PAH flux to soil is mainly influenced by their concentration in the atmosphere and by the effectiveness of wet and dry deposition fluxes [9]. PAH flux to soil correlates significantly with the corresponding levels in air [10] and urban street dust [11]. Therefore, PAH determination in soil may provide important information on the environmental pollution state [12]. Impact of aviation exhaust on carcinogenic environmental pollution is important because of its spread and distribution over a very wide area [13].

Few studies have reported PAH levels in ambient air at different locations in India, for example, Delhi [14], Mumbai [15], Kolkata [16] and Ahmedabad [17]. Some scattered information is available on PAH concentration in sediments [18–20], biodegradation of PAHs [21], in the field of PAH biomarkers

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[22] and seasonal biomonitoring of PAHs [23]. But, information on the PAH levels in Indian soils is very scarce [24].

The principal objective of the present study was to determine the concentration levels of PAHs in the surface soil around the Indira Gandhi International (IGI) airport, Delhi. The database generated from this study will be of immense importance in characterizing airport soils with respect to PAHs in India. The study may also be helpful in land-use planning of urban regions.

2. Materials and methods

2.1. Sampling sites

Delhi, the capital of India is situated at a latitude of 28°24′17″N to 28°53′N and the longitude of 76°20′37″E to 77°20′37″E with an altitude of 216 m above mean sea level. To the north the Himalayas are situated at a distance of 160 km and to the south are the central hot plains. To the west of Delhi is the Great Indian Desert (Thar Desert) of Rajasthan and the Gangetic plains lie in the east. North-west wind usually prevails, except during monsoon when south-east winds are pre-dominant [25].

Indira Gandhi International (IGI) Airport is located (Fig. 1) 23 km south of New Delhi and is a vital link between India and rest of the globe. It is one of the busiest airports in South Asia. The International Terminal has 35 airlines flying to the major cities across the world. It has a terminal capacity of 1150 aircrafts, while it operates about 250 flights per day [26]. The airport on an average currently handles cargo operations of all major international airlines, besides transporting 9500 international passengers daily. The runway is oriented in the east-west direction. The capital has a single 40 km long commercial air traffic corridor, which is oriented in the east to west direction for both incoming and outgoing flights [27].

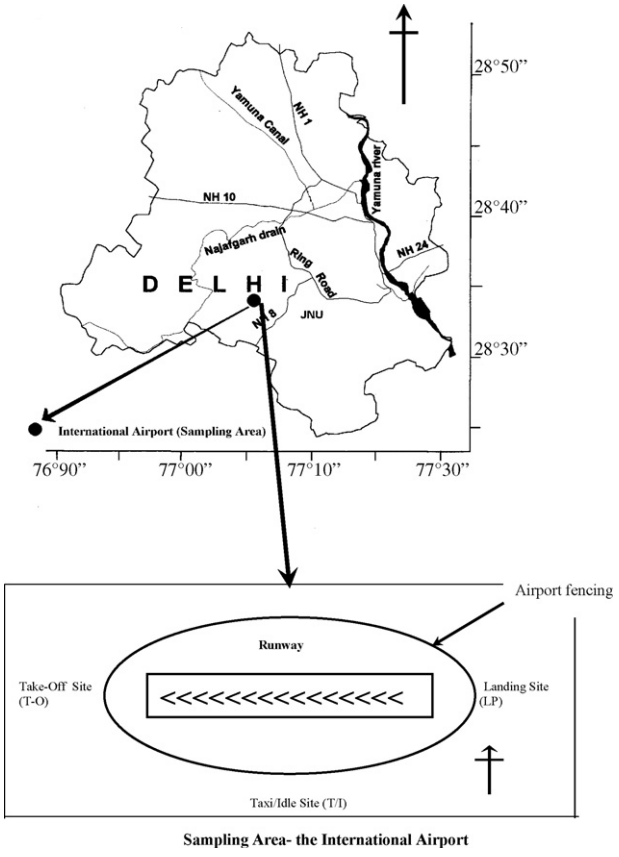

Fig. 1. Map of Delhi showing location of sampling area—the International Airport.

The major residential areas surrounding the International Airport are Palam, Dwarka, Mahipalpur, Pappan Kalan and Pahladpur. There are no industries and heavy traffic roads in the vicinity of the airport. The IGI airport is served by subsidiary thin traffic road emerging from National highway (NH-8). National highway (NH-8) having heavy traffic is at a distance of ∼4–5 km from the airport. So, the direct impact of vehicular emission from the highway is minimal on the sampling sites.

Location of sampling sites is depicted in Fig. 1. Three sampling sites were selected in the area surrounding the airport and one background site was chosen in a remote area. Site-I (LP) was selected near the landing point of the airport, while site-II (T/I) was located near the taxi/idle point (south of the runway). Site-III (T-O) was situated near the take-off point of the airport. The background (BG) sampling site was sited at a remote area at a distance of ∼10 km from the airport and there was no direct source of emission in the surroundings, i.e. no residential, industrial or vehicular emissions in the close vicinity.

2.2. Sample collection

Samples were taken on monthly basis, i.e. one sample in each month for a total period of 6 months (from November, 2005 to May, 2006). Samples were taken with the help of a stainless steel auger up to a depth of 5 cm. The samples were transferred into polythene bags, transported to the laboratory and were preserved at 4 °C till further processing. At each sampling site 8–10 samples were collected by grab sampling, within a distance of 50 m. In the laboratory the samples were dried in dark, twigs and stones were removed. Those grab samples were mixed thoroughly to make a composite sample. After homogenization, the soil samples were sieved through 2 mm sieve. Representative samples were obtained after quartering and coning.

2.3. Chemicals

Standard mixture containing 16 PAHs (16 compounds specified in USEPA method 610) and deuterated PAHs internal standard (IS) mixture (naphthalene-d_8; acenaphthene-d_{10}; phenanthrene-d_{10} and chrysene-d_{12}) were procured from Supelco (Bellefonte, PA, USA). All solvents (toluene, *n*-hexane, acetonitrile, etc.) used for sample processing and analysis, were of HPLC grade. High purity deionised water from Milli-Q system was used as the mobile phase during the HPLC analysis.

2.4. Sample extraction and clean-up

Soil samples were extracted by ultra-sonication, a method developed and recommended by various authors [28,29]. Details of extraction and clean-up method are described elsewhere [20].