Marine Pollution Bulletin 101 (2015) 232–242

Contents lists available at ScienceDirect

Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

# Studies on polycyclic aromatic hydrocarbons in surface sediments of Mithi River near Mumbai, India: Assessment of sources, toxicity risk and biological impact

Pravin U. Singare

*Department of Chemistry, Bhavan's College, Munshi Nagar, Andheri (West), Mumbai 400058, India*

A R T I C L E I N F O

*Article history:*
Received 24 August 2015
Received in revised form 25 September 2015
Accepted 30 September 2015
Available online 6 October 2015

*Keywords:*
Carcinogenic PAHs
Toxicity
Biological risk
Surface sediments
Mithi River

A B S T R A C T

This study investigated the levels, sources and potential risks of 17 polycyclic aromatic hydrocarbons in surface sediment samples collected along the Mithi River of Mumbai. The concentration level of ΣPAHs found in the present study was in the range of 1206–4735 ng/g dw. The composition patterns of PAHs by ring size in sediment were surveyed which indicate the dominance of four rings followed by five and three ring PAHs. In the study it was observed that the high molecular weight PAHs (HMW PAHs) made greater contributions of 90.83% as compared to that of low molecular PAHs (LMW PAHs) contributing to 9.17% to the total PAH concentrations. Toxicity and biological risk were assessed using toxic equivalent quantity and sediment quality guideline quotient. It is feared that the pollution level of PAHs in the sediments might increase in coming times resulting in an unconspicuous risks for the environment and humans through food chains.



## 1. Introduction

Polycyclic aromatic hydrocarbons (PAHs) are a group of anthropogenic chemicals that are ubiquitously distributed in the environment. They are characterized by high toxicity, high stability in the environment and high lipophilicity, resulting in their transport through the trophic chain with final destination the human organism (Okay et al., 2000; Vagi et al., 2005). PAHs consist of two or more fused benzene rings in various arrangements (Blumer, 1976). There are two types of anthropogenic source of PAHs, that is, petrogenic and pyrogenic sources. Crude and refined petroleum contain PAHs (i.e., petrogenic PAHs). They are introduced to aquatic environments through accidental oil spills, discharge from routine tanker operations, municipal and urban runoff, and so on. The combustion of fossil fuels (coal and petroleum) and biomass also produces PAHs (i.e., pyrogenic PAHs), which are released into the environment in the form of exhaust and solid residues (Zakaria et al., 2002). Some PAHs are released to the environment through natural processes. For example, perylene is thought to be produced through in situ conversion of perylenequinone pigment by fungi (Jiang et al., 2000). PAHs form an important class of environmental contaminants, because some exhibit carcinogenic or mutagenic potential. There are several reports of increased incidence of cancer in marine animals from the vicinity of oil spills (Al-Yakoob et al., 1994; Colombo et al., 2005). Concern about PAHs in the environment arises also from the fact that many of them are persistent (IARC, 1983). PAHs constitute a major environmental concern because of their adverse health effects on organisms, including endocrine disrupting activity (Zaghden et al., 2007; Catsiki et al., 2003). Several of them are known to be potential human carcinogens including benzo[a]anthracene, chrysene, benzo[b]fluoranthene, benzo[a]pyrene and benzo[ghi]perylene. Therefore they have been included in the priority list of the Water Framework Directive, 2000/60/EC and also sixteen of them have been regulated by the US EPA as priority pollutants, and their distributions in the environment and potential human health risks have become the focus of much attention.

In recent years, the environmental behavior of PAHs in estuarine and bay systems obtains increasing attentions, since these areas act as transition zones in which land-based pollutants caused by numerous human activities are transmitted to ocean via river (Tian et al., 2013; Pozo et al., 2011; Wang et al., 2013a, 2013b). In contrast to the seawater, the occurrence of PAHs, which are very hydrophobic compounds in other aqueous matrices such as wastewater, river water and sediments, varies in the range from 1 ng $g^{-1}$ to or greater than 100 ng $g^{-1}$ per dry weight (Filipkowska et al., 2005). The concentration of PAHs in sediments of coastal embayments, estuaries and continental shelves are often much higher due to greater pressures of specific anthropogenic inputs (Shi et al., 2007), suggesting a direct influence of these sources on the pollutant distribution patterns (Sprovieri et al., 2007). Due to their hydrophobic character, PAHs tend to adsorb onto the particulate matter resulting in their transport and accumulation in the sediments. Marine sediments consist an important source of information regarding the human activities in the coastal area as well as the fate of xenobiotics

*E-mail address:* pravinsingare@gmail.com.

http://dx.doi.org/10.1016/j.marpolbul.2015.09.057
0025-326X/

during long-term time intervals. Although no relevant regulation has been established, the monitoring of pollutants in sediments can provide information for the assessment of the potential toxic effects of these compounds as well as for the support of decision-making from management authorities.

Despite of the importance of Mithi River, information on PAH levels in the sedimentary system has not been studied in detail. Hence the present paper attempts to address this deficit and presents the results of a comprehensive survey of persistent PAH levels in the surface sediments of the Mithi River, and compared with other estuaries and seas to carry out an investigation for understanding the current status of their contamination to prevent biological hazards. It is no doubt that the distribution of persistent PAHs in the sedimentary environment of India is of great significance in the context of global distribution and accumulation of these compounds.

## 2. Materials and methods

### *2.1. Area of study*

The sampling of surface sediments was done from three different sampling stations along the flow of Mithi River namely Airport (*L1*), CST Kalina (*L2*) and BKC Taximen's Colony (*L3*). Airport site near Jari Mari area is thickly populated and has many small scale industries including scrap dealers. Previous short term study conducted by Maharashtra Pollution Control Board shows the presence of cyanide, consistent high COD, oil and grease found at this station indicating some chemical activity in that area (MPCB, 2004). Unauthorized encroachments by illegal industrial units, scrap dealers and oil mixing business at CST road near Kalina, have further resulted in discharge of solid waste, organic waste, industrial waste, heavy metals, oils and tar in the river (Singare et al., 2011, 2012). This sampling point is surrounded by many small scale industries including recyclers, barrel cleaners, workshops and other units. This area has thick density of population. Illegal activities like washing of oily drums have resulted in discharge of unauthorized hazardous waste which is carried out along the bank of this river. Development of Bandra–Kurla Complex has resulted in diversion and unnatural turn along the Mithi River at few places thereby affecting natural flow of the river and seriously affected the drainage. This part of the river is a dumping ground for garbage and it is reflected in higher values of suspended solids. The organic waste, sludge and garbage dumping has reduced the carrying capacity of the Mithi River (Singare, 2012). The solid wastes which is discharged in to the Mithi river from the surrounding illegal industries and the slums has resulted in sever water logging during 26/7 deluge in Mumbai. The map showing flow of Mithi River is shown in Fig. 1. The area is located along western Arabian coast of India from 18°53′ north to 19°16′ north latitude and from 72° east to 72°59′ longitude. The area experiences tropical savanna climate. It receives heavy south west monsoon rainfall, measuring 2166 mm on an average every year. The temperature ranges from 16 °C to 39 °C with marginal changes between summer and winter months, whereas relative humidity ranges between 54.5 and 85.5%.

### *2.2. Sampling of surface sediment and sample preparation*

The surface sediment samples were collected by using plastic scoop randomly four times in a month in morning, afternoon and evening session from three different sampling stations along the flow of Mithi River (Fig. 1). The samples were collected and subsequently analyzed for a span of two years starting from October 2009 to August 2011. The sampling was done in three shifts i.e. morning shift between 07:00 a.m. and 09:00 a.m., afternoon shift between 02:00 p.m. and 04:00 p.m. and evening shift between 07:00 p.m. and 09:00 p.m. The surface sediment samples thus collected were wrapped in aluminum foil, stored in sealed polythene bags and freeze dried at −20 °C before extraction.

### *2.3. Chemicals and reagents*

All solvents used for sample processing and analyses (dichloromethane, acetone, n-hexane and methanol) were analytical grade and redistilled twice before use. The silica gel (80–100 mesh) and alumina (120–200 mesh) were extracted for 72 h in a Soxhlet apparatus, activated in the oven at 150 °C and at 180 °C for 12 h, respectively, and then deactivated with distilled water at a ratio of 3% (m/m). Deionized

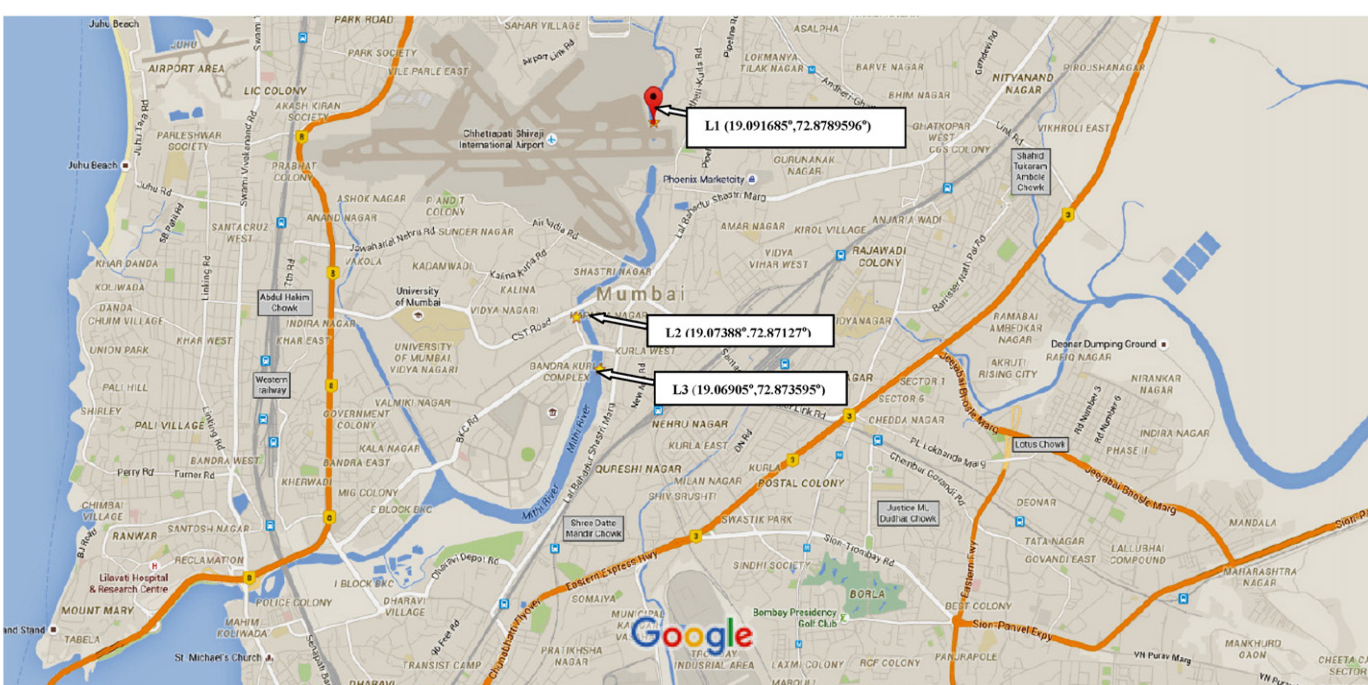


**Fig. 1.** Geographical map showing the sampling locations along the flow of Mithi River.