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Baseline

Polycyclic aromatic hydrocarbon pollution in the surface water and sediments of Chabahar Bay, Oman Sea

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ABSTRACT

In the present study, the concentrations and distribution of 16 polycyclic aromatic hydrocarbons (PAHs) in the water and surface sediments from the Chabahar Bay, Oman Sea, were investigated in May (premonsoon) and December (postmonsoon) 2012. The concentrations of PAHs in the surface water samples ranged from 1.7 to 2.8 ng l⁻¹ and from 0.04 to 59.6 ng l⁻¹ in pre- and postmonsoon, respectively. In general, the PAH levels of the water samples from Chabahar Bay were higher in postmonsoon than in premonsoon ($p < 0.05$). The concentrations of PAHs in the sediment samples varied from undetectable levels to 92.8 ng g⁻¹ d.w. in both seasons. The seasonal comparison of the results in sediment samples showed that the overall concentration of PAH compounds was higher in the postmonsoon season ($p < 0.05$).

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Polycyclic aromatic hydrocarbons (PAHs) constitute a relatively large proportion of noxious pollutants released into the marine ecosystems. Consequently, the toxicity of PAHs to all organisms, including humans (Nacci et al., 2002; Armstrong et al., 2004), and their source inputs, distribution, and fate in the environment have been studied intensively (Baussant et al., 2009; Brooks et al., 2011).

Among the 100 polycyclic aromatic compounds identified by the US Environmental Protection Agency (EPA), 40 PAHs have been included as prioritized pollutants with carcinogenic and mutagenic characteristics in animals and human beings (Siu et al., 2004; Kumosani et al., 2013). The lipophilic characteristics of the PAHs accelerate their accumulation in soil, sediments, and oily materials, such as marine organism's tissues. Oil leaches to marine environment through natural sources, maritime transport, offshore oil operations, intentional or accidental oil spills, ballast water discharge, dredging and infilling for coastal development, and uncontrolled sewage and industrial wastewater discharges (Essa et al., 2005). PAHs affect productivity, growth, and behavioral characteristics of benthic organisms that are largely the

prime victim of oil pollution. Despite the self-purification of the marine environment, high oil pollution can affect the oxidation state of sediments and seabed contour water, which in turn causes toxic compounds and heavy metals to shift from solid to liquid phase.

Oman Sea is an extension of the Indian Ocean through the Strait of Hormuz; it is bounded on the north by Pakistan and Iran in three directions and the Indian Ocean in one direction. Its maximum and minimum water temperatures are 33 °C (July–August) and 19.8 °C (December–January), respectively, with an average salinity of 37%. The direction of water currents in winter is from east toward the Persian Gulf, whereas it is in the opposite direction in summer. The difference between ebb and tide is approximately 2 m (in the eastern part) and 3.5 m (in the western parts, near Strait of Hormuz).

Chabahar Bay, which is situated on the Makran coastline in Sistan and Baluchestan Province, Southeast of Iran, is a free port and relatively industrial zone on the coast of the Oman Sea. The special importance of Chabahar Bay is because of its Ω shape and limited water circulation. The main pollution sources in oilfield marine areas such as the Persian Gulf and Oman Sea are oil extraction, oil leakage from tankers during oil transport, outbreak of wars in the recent decades, natural events, marine incidents, intentional and unintentional discharge of waste oil, etc.

The main objectives of the present study were to (1) investigate the distribution of 16 PAHs in water and surface sediments of Chabahar Bay,

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Table 1
Sampling geographical locations in Chabahar Bay.

| Sampling periods | No. | Stations | Depth (m) | Geographical locations |
|------------------------------------|-----|------------------------------|-----------|-------------------------|
| Sampling stations in December 2012 | 1 | Tiss | 3.8 | 25°21'46" N 60°35'40" E |
| | 2 | Tiss | 9.0 | 25°22'50" N 60°33'59" E |
| | 3 | Konarak | 5.0 | 25°19'58" N 60°15'44" E |
| | 4 | Konarak | 10.5 | 25°22'23" N 60°28'30" E |
| | 5 | Desalination plant | 5.8 | 25°26'3" N 60°30'14" E |
| | 6 | Entrance of the Chabahar Bay | 13.6 | 25°17'44" N 60°32'12" E |
| | 7 | Posm | 12.10 | 25°19'58" N 60°15'44" E |
| | 8 | Posm | 6.0 | 25°22'54" N 60°15'21" E |
| | 9 | Ramin | 4.5 | 25°15'42" N 60°46'18" E |
| | 10 | Ramin | 13.2 | 25°15'33" N 60°46'14" E |

Oman Sea, (2) detect the pollution source(s) of PAHs, and (3) compare the 16 PAHs' combined pollution levels with those of other marine ecosystems.

To assess the PAH levels in Chabahar Bay, water and surface sediments were collected from 9 and 10 stations in the bay in May (premonsoon) and December (postmonsoon) 2012, respectively (Table 1, Fig. 1). The selected sampling sites represent the most important harbors, desalination plant, and industrial regions in Sistan and Baluchestan Province (southeast of Iran). In addition, they represent coastal areas that may have a relatively higher pollution due to high population. Triplicate surface water and sediment samples were collected using Niskin bottle (2-l capacity) and Van Veen grab, respectively. Water and sediment samples were placed into prelabeled dark jars and aluminum vessels, respectively, shipped to the laboratory on ice, and kept at $-20\text{ }^{\circ}\text{C}$ prior to the analysis (Moopam, 1999).

Sediment samples were lyophilized (freeze-drier Model: OPR-FDB-5503, Korea) at $-40\text{ }^{\circ}\text{C}$ for 24 h to a constant weight. The dry sediment was sieved, and fractions smaller than 63 μm

were transferred to pre-cleaned dark glass labeled bottles and frozen (at $-20\text{ }^{\circ}\text{C}$) prior to analyses (Wolf-Welling et al., 2001).

In total, 16 PAH compounds were extracted from 1-l water samples by liquid-liquid extraction method using hexane solvent. Seven gram of activated copper was added to the samples to remove sulfur compounds for 24 h. Sample volumes were adjusted to 2 ml using rotary instrument. Samples were concentrated using dry nitrogen, and the PAH compounds were redissolved in acetonitrile (National –IR standard 7608) and finally were injected to HPLC.

To extract PAHs from the sieved sediment sample (5 g), dichloromethane and ultrasonic water bath at $30\text{ }^{\circ}\text{C}$ were used for 1 h and 24 h, respectively, (standard method, 3550B, 1996). For recovery, Sarogit was added to the samples, which were then refrigerated for 24 h. The final extract was filtered using glass wool. A column filled with dehydrated silica gel in dichloromethane and pentane solvents was used to perform clean up procedures for sediment samples (EPA method 3630 C, 1996). The output of the column was concentrated

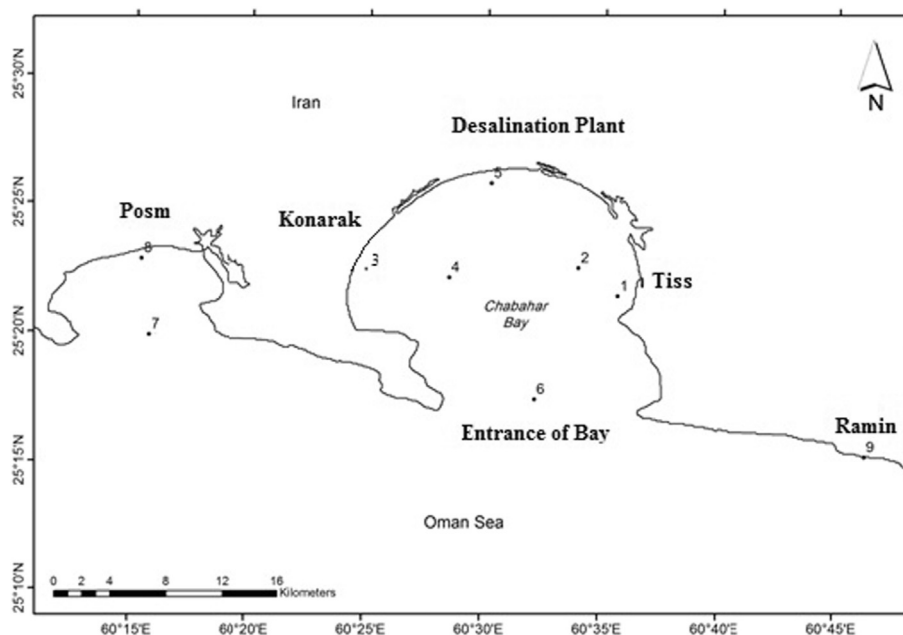


Fig. 1. Location of the sampling sites at Chabahar Bay.

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