

Petroleum hydrocarbons in intertidal ecosystem along the Bombay coast

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Received 11 July 1994; revised 16 February 1995

Petroleum hydrocarbon content in intertidal sediment and water samples collected at Madh, Worli and Colaba were in the ranges of 5.1-7, 5.8-7.4, 2.9-10.3 $\mu\text{g.g}^{-1}$, wet wt and N.D.-18.5, N.D.-93.5, N.D.-5.8 $\mu\text{g.l}^{-1}$ respectively. The concentrations in sediment were negligible and uniform. The contamination was less in seawater during September 1991 while high levels of 57.4 and 93.5 $\mu\text{g.l}^{-1}$ were observed in seawater samples from Worli during December 1990 and May 1991 respectively. The high level of petroleum hydrocarbons (153.8 $\mu\text{g.l}^{-1}$) in water sample collected near an outfall indicated that the intertidal ecosystem of Worli might be contaminated by the effluent discharges from the onshore industrial unit.

Bombay coast is vulnerable to contamination by petroleum hydrocarbons originated from domestic and industrial wastewater discharges, port activities and marine operations including tanker traffic and oil production. Contamination may affect the offshore, coastal and port ecosystems which have been investigated earlier¹⁻⁴. It is wellknown that the intertidal ecosystem where the residue may persist for a long time may experience great impact of the contamination. This paper reports the concentration of petroleum hydrocarbons in water and sediment at 3 locations in the intertidal environment of Bombay.

Intertidal sediments exposed during mid tide were sampled by scooping, at 3 spots along a 100 m stretch each at Madh, Worli and Colaba (M1, W1, C1, Fig. 1) during postmonsoon (December 1990), premonsoon (May 1991) and monsoon (September 1991) seasons. Surface water samples were collected simultaneously from sediment-water interface in glass bottles from these locations. Surface water samples were also collected at number of stations (M2-M5, W2-W4, C2-C5, Fig. 1) during postmonsoon season to get some information regarding inputs of petroleum hydrocarbons at these locations. Sediment samples were deep frozen until analysis while the water samples were analysed immediately.

The composite wet sediment sample (~100 g) was digested⁵ with KOH (3 g) and methanol (100 ml) for 30 min. The cool methanol solution was extracted with hexane and the organic layer was dried over anhydrous sodium sulphate. It was then reduced to

minimum volume and column chromatographed⁵ using alumina (grade I, 1.15 g) filled in pasteur pipette and solvent systems in following order: A-hexane (4 ml), B-hexane (4 ml), C-hexane: dichloromethane

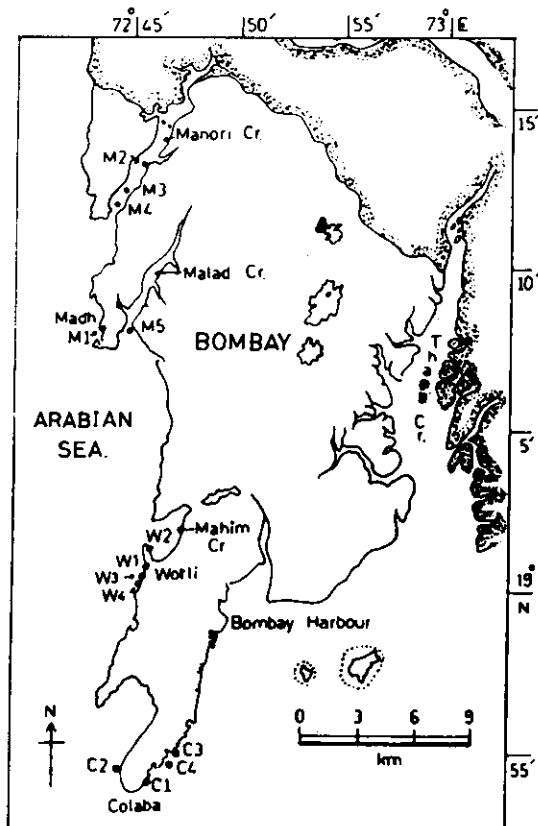


Fig. 1—Sampling stations along Bombay coast

(7:3, 4 ml) and D-dichloromethane (4 ml). Fractions C and D were combined, evaporated to dryness and fluorescence of its hexane solution (10 ml) was measured at 360 nm (excitation at 310 nm) on fluorescence spectrophotometer (Perkin-Elmer LS 3B). Water samples were extracted⁶ with hexane (50 ml × 2), dried over anhydrous sodium sulphate and fluorescence measurements of its reduced volume (10 ml) were taken as described above. The concentration values were calculated for sediments on wet weight basis and water using Saudi Arabian mix crude residue (bp > 100°C) as the standard, of which ratio to chrysene was 4.1. Efficiencies of the methods^{3,7} for sediment and water analysis were $91.5 \pm 6.5\%$ and $89.7 \pm 6.0\%$ respectively.

Madh (M1) beach does not possess any activity related to oil pollution. However, it may be vulnerable to pollution from wastewater discharges which are being added through Manori and Malad creeks. Contamination at Worli (W1) may originate due to the outfall of a sewage treatment plant, one more sewage outfall and an effluent outfall from an industrial unit. Colaba (C1) is being exposed to petroleum hydrocarbon contamination from port activities such as cargo handling, fish landing operations and loading-unloading of petroleum and its products as well as domestic and industrial wastewater discharges through Thana. Patalganga and Dharamtar creeks.

Petroleum hydrocarbon content in intertidal sediments from Madh, Worli and Colaba (M1, W1, C1, Fig. 1) were observed in the ranges of 5.7-7, 5.8-7.4 and 2.9-10.3 $\mu\text{g.g}^{-1}$ respectively (Table 1). The low range of 2.9-10.3 $\mu\text{g.g}^{-1}$ of the contents indicated that the contamination was negligible and

uniform along the coast and also independent of the vulnerability to the sources of the contamination. The low content may be attributed to the characteristics of the sediment of clay-silt and silt-clay types (Table 1) and the process of continuous exchange of the system with tidal water.

The concentrations of petroleum hydrocarbons in water were in the ranges of N.D.-18.5, N.D.-93.5 and N.D.-5.8 $\mu\text{g.l}^{-1}$ (Table 1) at sts M1, W1, C1 respectively. The contamination was not observed during September 1991 obviously due to large influx of fresh water. Highest values of 57.4 and 93.5 $\mu\text{g.l}^{-1}$ obtained at Worli during December 1990 and May 1991 respectively appeared to have originated from some minor but consistent source possibly an effluent outfall.

Rokade⁸ noticed average high content of petroleum hydrocarbons of 673 $\mu\text{g.g}^{-1}$ wet wt: in sediment of mud flats near an oil jetty in Bombay harbour, while Pelletier *et al.*⁹ reported concentration of polycyclic aromatic hydrocarbons in the range of 63-936 $\mu\text{g.g}^{-1}$ dry wt. for intertidal sediments in St. Lawrence estuary. According to Clark and MacLeod¹⁰ who documented reports on intertidal sediments of various locations worldwide, the content varied in a wide range of 0.2-1100 $\mu\text{g.g}^{-1}$. It has been recommended¹¹ that petroleum hydrocarbon level in polluted coastal areas may range from 100 to 12000 $\mu\text{g.g}^{-1}$ with most levels < 1000 $\mu\text{g.g}^{-1}$ while the content from unpolluted coastal areas and basins are usually below 70 $\mu\text{g.g}^{-1}$. It has been reported that the contamination may be higher nearshore¹². Considering the possibility of direct inputs from land based discharges of industrial and domestic wastewaters which contain used

Table 1 Petroleum hydrocarbon concentration in sediment and water along Bombay coast

Location/Period [†]	Characteristics of sediment			Petroleum hydrocarbon concentration	
	Type	Moisture content (%)	TOC* (%)	Sediment ($\mu\text{g.g}^{-1}$ wet wt.)	Seawater ($\mu\text{g.l}^{-1}$)
Station M1	Clay-silt				
A		56.3	2.6	7.0	2.1
B		54.8	2.5	7.0	18.5
C		57.6	2.0	5.7	ND**
Station W1	Silt-clay				
A		57.7	2.6	5.8	57.4
B		56.1	3.3	7.4	93.5
C		60.1	2.7	5.8	ND
Station C1	Clay-silt				
A		52.6	0.9	2.9	5.8
B		51.7	1.4	6.6	1.6
C		51.1	2.6	10.3	ND

*TOC-Total organic content. ** ND-Not detected

[†] A = Dec. '90 (postmonsoon); B = May '91 (premonsoon). C = Sept. '91 (monsoon)

Table 2—Details of possible sources of inputs and petroleum hydrocarbon concentrations at some stations around M1, W1 and C1

St. no	Possible source of inputs	Concentration in seawater ($\mu\text{g.l}^{-1}$)
M2	Domestic and industrial wastewater	29.5
M3	Domestic and industrial wastewater	11.5
M4	Domestic and industrial wastewater	20.1
M5	Domestic and industrial wastewater and fish landing.	20.9
W2	Domestic wastewater	19.3
W3	Industrial effluent	153.8
W4	Domestic wastewater	4.9
C2	Boat traffic	19.7
C3	Fish landing and port traffic	66.4
C4	Domestic wastewater and port traffic	52.5

crankcase oil and residual fuel from vehicles and equipment, value $> 70 \mu\text{g.g}^{-1}$ wet wt may be considered as an indicator of polluted area. It was reported¹¹ that the hydrocarbon content of surface water may be few micrograms per liter and values for seawater from areas suspected of having oil pollution can be as much as 100 times greater.

It was reported¹³ that the yearly average contamination in some species of intertidal gastropods at M1, W1 and C1 was 13.6, 679.9 and $17.4 \mu\text{g.g}^{-1}$ dry wt respectively. Comparison of these values and the data obtained in present study (Table 1) indicated that Madh and Colaba areas are not polluted, however the ecosystem at Worli appeared to be contaminated possibly due to the inputs through water.

The details of concentration values observed at sts M2-M5, W2-W4 and C2-C4 along with corresponding possible sources of inputs are summarised in Table 2. Concentration values observed at M2-M5 were in the range of 11.5-29.5 $\mu\text{g.l}^{-1}$ which suggested that the inputs from mostly untreated domestic and industrial wastewaters might be minor and their impact at M1 may be negligible. The levels which were in the range of 4.9-153.8 $\mu\text{g.l}^{-1}$ at sts W2-W4 revealed that though inputs of petroleum hydrocarbons from domestic wastewater at sts W2 and W4 were negligible, effluent discharges

which are being discharged directly in the intertidal environment from the onshore industrial unit at st. W3 appeared to be responsible for contaminating the ecosystem at st. W1. The petroleum hydrocarbon content at sts C2-C4 was observed in the range of 19.7-66.4 $\mu\text{g.l}^{-1}$ indicating that moderate contamination may be existing at st. C3 which is the busy landing centre for fisheries, possibly due to occasional leakage and spillage as well as operational discharges from fishing trawlers¹⁰. Moderately high level of 52.5 $\mu\text{g.l}^{-1}$ corresponding to the st. C4 at the mouth at Bombay harbour basin may be attributed to traffic of fishing trawlers, ships and tankers¹⁴. It appears that the above mentioned localized pollution did not affect the environment at st. C1.

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