

A Survey of Petroleum Hydrocarbon Concentrations in the Shelf Regions & Adjacent Waters of the West Coast of India

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Petroleum hydrocarbons in the upper 10 m of the Arabian Sea, up to a maximum distance of 160 nautical miles from the coast, were measured using UV spectrophotometry. Their concentrations varied between 0.12 and 2.44 mg/litre (av. 1.14 mg/litre). Petroleum hydrocarbon levels were higher in the region north of 15°N latitude (av. 1.5 mg/litre) than from the south of this latitude (av. 0.8 mg/litre), indicating a greater degree of oil pollution in this region.

TRANSPORT of crude oil and its products across the Arabian Sea amounts to 756×10^6 tonnes/yr¹. This is about 54% of the total marine transport of oil in the world. Of this 340×10^6 tonnes are carried to the Far East and Japan. The effect of transport of the latter amount is of direct concern to India. Oil spilled annually at sea has been estimated as 2.2 to 4.9 million tonnes²⁻⁴. If the oil spill has a relationship with its total transport then the Arabian Sea should be highly contaminated.

As part of a programme on pollution studies in the Arabian Sea, the petroleum-derived hydrocarbon contents in water samples collected during the 16th cruise of *RV Gaveshani* in March 1977 have been examined. The stations are on 2 transects along the 100 and 1000 fm isobaths at distances varying between 60 and 160 nautical miles off the Indian coast. Cruise data are reported in the present paper.

Materials and Methods

In all 36 samples were collected at 24 stations along the 2 transects (Fig. 1).

Water samples from the surface were collected using a hexane-cleaned plastic bucket while the ship was coming to a halt at the station. This is important because the ship normally expels some oily-water from its engine immediately after stopping. Samples from 10 m depth were collected by a device (Fig. 2) which was free from any influence of grease. Before sampling started, all discharges from the ship were stopped.

After collection, 400 ml aliquot of the water sample was transferred to a glass bottle which had been cleaned beforehand with hexane. Hexane (10 ml) was added to the sample which was shaken well before storage at -5°C on board. In the shore laboratory, after separation from the aqueous layer the hexane extract was freed from residual water by treatment with anhydrous sodium sulphate. To remove biogenic hydrocarbons, the hexane extract was passed through a column of silica gel (60-120 mesh) which had been treated and deactivated

before use⁵. The column was then washed with 30-40 ml hexane. The combined hexane extract was evaporated and the final volume made up to 10 ml.

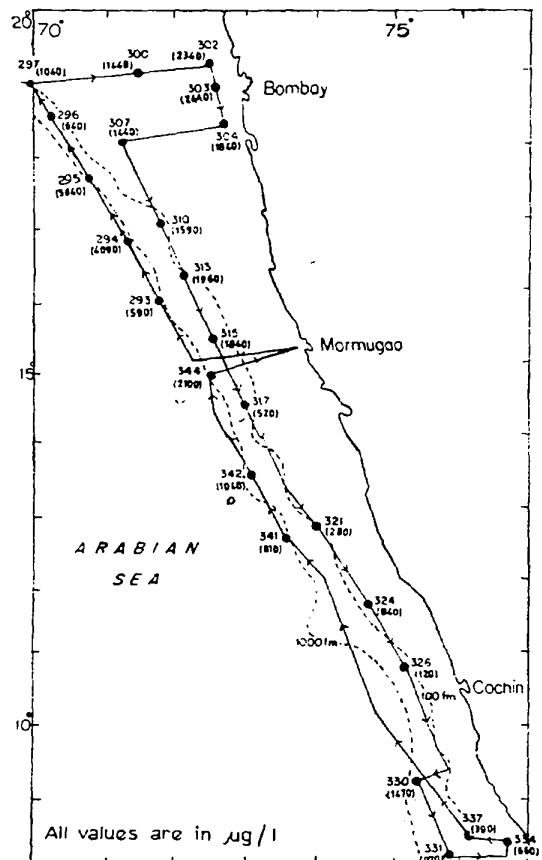


Fig. 1 — Network of Observation Stations [Numbers within brackets indicate concentrations of petroleum hydrocarbons in µg/litre at the surface]

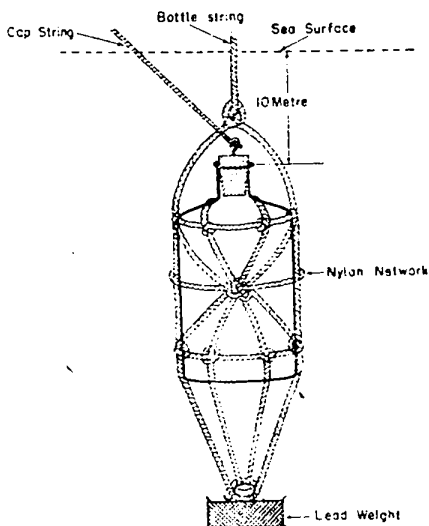


Fig. 2 — Device used for sampling at 10 m depth

Blank used was hexane treated the same way as the samples.

Absorbance of the samples was measured using the scanning mode of a Beckman ACTA-C III double-beam spectrophotometer in the UV region. Maximum absorbance was observed at 205 nm. Concentrations were calculated by integrating the areas enclosed by the curves at peak absorbance using a planimeter, with reference to known concentrations of furnace oil—the heaviest petroleum fraction available with us. An example of the curves is presented in Fig. 3. As the second peak at 256 nm disappeared after the column chromatographic treatment of the samples, it was concluded that this must have been due to the absorbance of biogenic hydrocarbons. The similarity of wavelengths of peak absorbances between furnace oil and the samples indicate that the contents in the samples were dominated by petroleum products. With the instruments and reagents available, a standard deviation of $\pm 0.6\%$ by replicate analysis of a few samples was obtained.

The average value of 1.14 ± 0.17 mg/litre is higher than the normal oceanic range of 0.1 mg/litre. We, therefore, make the following reservations before starting our interpretation of the data: (i) Peak absorbance was calculated at 205 nm while the recommended wave length is fluorescence at 360 nm⁵. (ii) Measurement of UV-absorbance was made in the absence of a suitable instrument to measure UV-fluorescence. (iii) Heavy furnace oil was used as reference standard instead of chrysene recommended by UNESCO⁶.

Results and Discussion

Petroleum hydrocarbon concentrations in the Arabian Sea varied from 0.12 to 2.44 mg/litre at the surface (av. 1.20 mg/litre), and from 0.44 to 2.39 mg/litre at 10 m (av. 1.04 mg/litre), given in Table 1. The average of all the values was

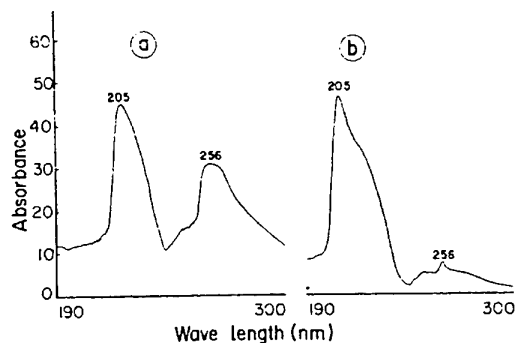


Fig. 3 — Typical UV spectra of sea water (a) before silica-gel column chromatography and (b) after chromatographic treatment [Note the almost complete disappearance of the peak at 256 nm after chromatography!]

1.14 mg/litre. Present values were higher than those from the other oceanic regions⁶⁻⁸.

To analyse the data the area of study was divided as north and south of 15°N lat. The transects were quite close to the oil-tanker route north of 15°N whereas south of this latitude the transects moved towards the Indian coast.

North of 15°N—In this region the concentration of petroleum hydrocarbons varied from 0.52 to 2.44 mg/litre (av. 1.5 mg/litre). The concentration is greater (av. 1.06 mg/litre) along the 100 fm isobath. This is possibly because of the nearness to the coast which receives petroleum-derived pollutants from discharges from fishing trawlers, harbours and other industrial activities of man.

At the stations 293 (10 m depth), 294 (surface) and 295 (surface) the values are 3.64, 4.09 and 5.84 mg/litre respectively. These are much higher than the other values and represent the first 3 stations sampled. The only possible reason for this may be contamination during sampling. Therefore, these values were omitted from detailed studies but were given in Fig. 1 and Table 1.

Off Bombay (stations 300, 302, 303, 304 and 307), the surface concentrations were high and varied between 1.44 and 2.44 mg/litre. The average of these (1.9 mg/litre) is much greater than the overall average of 1.14 mg/litre. This region is near the coast and adjacent to one of the busiest ports and industrial areas of the country. This area is also close to the Bombay High which is the site for exploration of petroleum. Therefore, some

TABLE 1 — CONCENTRATIONS OF PETROLEUM HYDROCARBONS AT 10 m DEPTH

Station No.	Conc. mg/litre	Station No.	Conc. mg/litre
295	0.64	326	0.44
297	2.39	330	1.01
303	1.49	334	0.76
310	1.89	337	0.69
315	0.52	344	0.74
321	0.84		

natural seepage can also be expected to occur in this area.

South of 15°N — This region does not appear to be very much affected by the tanker traffic as compared to the region north of 15°N. The concentration of petroleum hydrocarbons varied from 0.12 to 2.1 mg/litre (av. 0.8 mg/litre). In this area, the concentration was less along the 100 fm isobath (av. 0.58 mg/litre) than that along the 1000 fm isobath (av. 1.16 mg/litre). In other words, the condition in this region was found to be reverse of what was observed north of 15°N, where the concentration was greater along the 100 fm isobath. The 1000 fm isobath is not very far from the tanker route.

At the station 344, the concentration of hydrocarbon at the surface was 2.1 mg/litre, which is the highest value recorded in this region.

Sediment samples, collected at 20 stations by a snapper were also analysed. Only 3 of these samples indicated the presence of petroleum hydrocarbons. The peaks ranged from 224 to 235 nm (ref. 9). As these did not agree with the peak wave lengths for both petroleum and biogenic hydrocarbons, it is concluded that these were formed due to the presence of degradation products of petroleum hydrocarbons in the samples.

Petroleum and its products change their character in a short time in the sea. C₁ to C₁₂ hydrocarbons are the first to evaporate followed by fractions up to C₂₁ (ref. 10). The heavier fractions above these are almost undecomposable. Dissolution, chemical oxidation, volatilization, biodegradation, light-induced reactions are the other processes which contribute to change the nature of oil in the sea¹¹. All these factors have to be considered in assessing petroleum hydrocarbon concentrations in the sea.

This survey is the first of its kind in Indian waters. It reveals significant levels of concentration of petroleum hydrocarbons. The values are, however, higher than those reported from other oceanic

areas. Oceanic values range from 0.1 mg/litre. Present values fall in the range 0.12 to 2.44 mg/litre with 53% of the values lying above 1 mg/litre. The values are high presumably because more than half of the world's marine transport of petroleum and its products is carried across the Arabian Sea.

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