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Oil Contamination Along Oil Tanker Routes off the United Arab Emirates (The Arabian Gulf and the Gulf of Oman)

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More than half of all oil transported in the world are reported to pass through the narrow strait of Hormuz (B.P., 1979) and spills from transported oil are reported to be more than 1.5 Mt annually (Bedair, 1984). Golob and Brus (1984) estimated that 57.1 % and 22.4 % of the total oil contamination in the Gulf has originated from tanker and off-shore production contribution, respectively. In the Gulf region, oil tankers are normally kept to specific and well defined routes (Adam and Hollins, 1984) to and from oil terminals, and most of oil spills are found in shipping lanes. However; oil spills can be easily advected by current to coastal areas causing a destruction of living resources and contaminate the water that makes it useless for desalination.
As the study of dissolved and dispersed petroleum hydrocarbons concentrations in the water column is an important activity in the monitoring of petroleum hydrocarbons concentration, the present paper is aimed at examining the current state of oil contamination at offshore areas and along oil tanker routes in the Arabian Gulf and the Gulf of Oman.

MATERIALS AND METHODS

A total of about 288 seawater samples were collected bimonthly from surface, sub-surface (10 m depth), and bottom waters during the period from October 1995 to September 1996. The locations of the different sampling sites are indicated in Figure (1). Sampling, extraction, and measurements, taking all necessary precautions, to avoid any loss or contamination were done according to the International Oceanographic Commission (1984). Briefly, triplicate seawater samples were collected in pre-cleaned amber 4 liter bottles from surface, subsurface, and bottom layers. Total dissolved / dispersed petroleum hydrocarbons in seawater samples were extracted using a mixture of fluorescence-free hexane-dichloromethane (7:3; v/v) on board. The extracts from seawater samples were evaporated using a rotary evaporator, taken up in 10.0 ml n-Hexane into a vial and then cleaned by silica gel and aluminum oxide column chromatography (Law et al., 1988) to remove biogenic lipid compounds. Concentrations of Petroleum hydrocarbon were determined by fluorescence using the fixed excitation (310 nm) and emission (360 nm)

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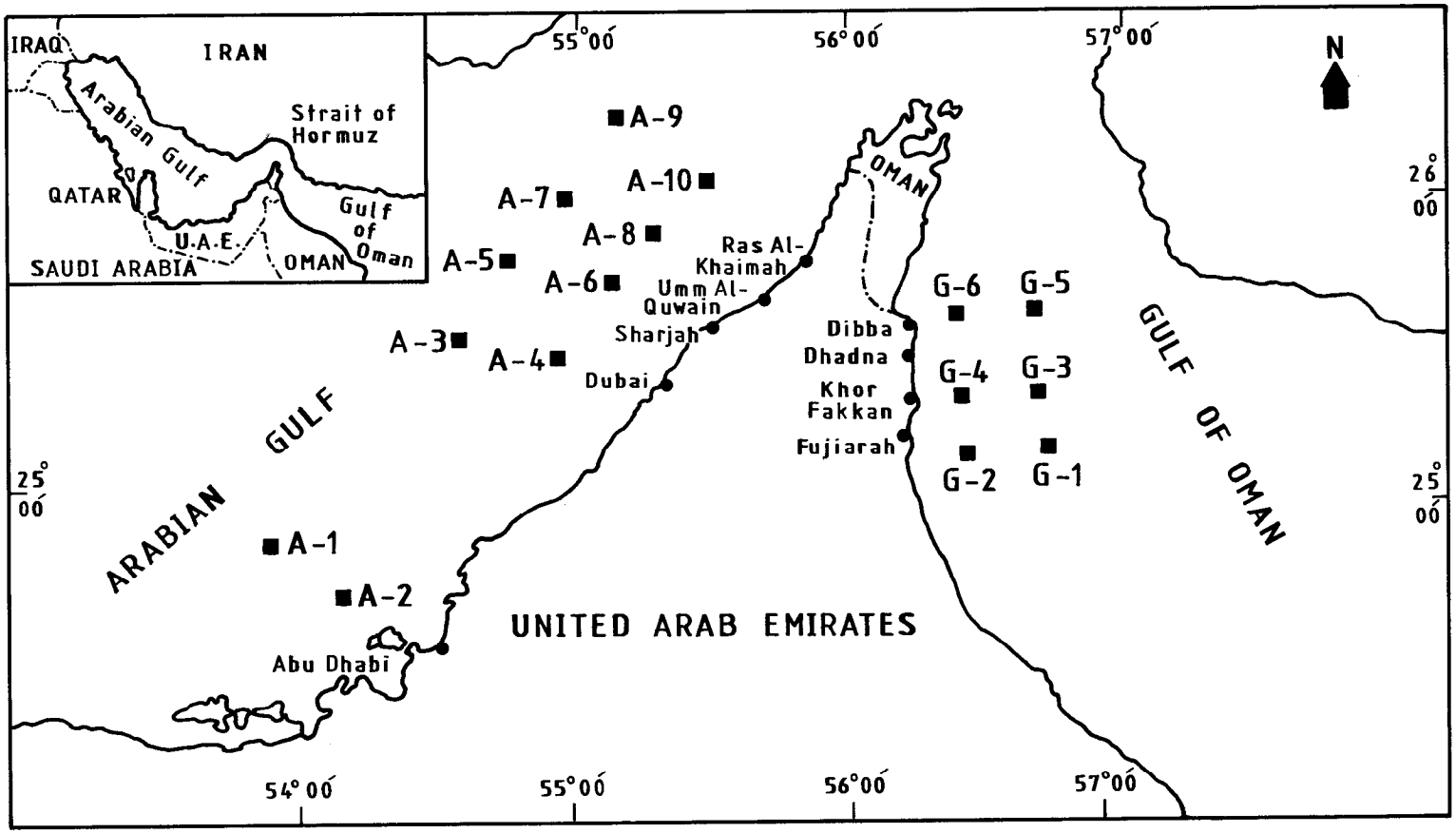
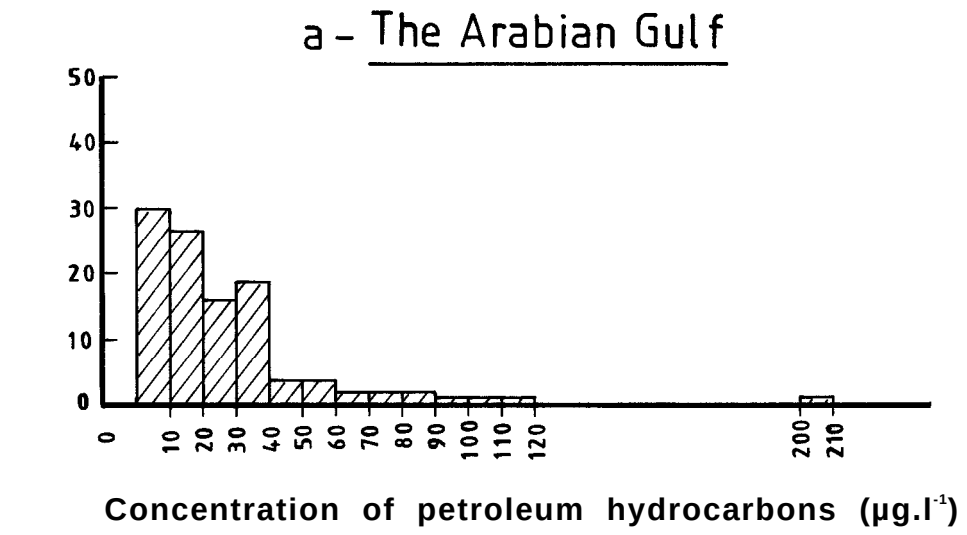


Figure 1. Locations of Sampling Stations.

Technique on a Shimadzu RF-5000 spectrofluorometer. Chrysene, as recommended in the method, was used as a standard reference compound. Duplicates, spikes, and blanks are treated identically using chrysene as the standard reference compound to test for precision, accuracy, and solvents purity in the analytical procedure, respectively. Percentage recovery for spiked samples ranged from 96 to 99 %, while precision agreed within 5%. Blank values were almost negligible.

RESULTS AND DISCUSSION

Over the world s ocean as a whole, the concentrations of hydrocarbons in surface and near surface water range from 1 to 100 µg l^{-1} (RCEP, 1981). In open sea, a value of 1 µg l^{-1} is considered to be typical of seawater without significant oil contamination (Marchand, 1980; Law, 1981; Weber and Bicego, 1990). However, in oil affected areas such as oil tanker routes concentrations reach to 500 µg l^{-1} (El-Samra et al, 1986). In the present study, petroleum hydrocarbons varied between 2.4 and 207.7 µg l^{-1} in the Arabian Gulf compared to 2.4 and 128.6 µg l^{-1} at the Gulf of Oman (Table 2). Percentage distributions of water samples in ranges of defined concentrations (Fig. 2) showed that 57 % of the analyzed samples from the Arabian Gulf area contained less than 20 µg l^{-1}. Of the remaining 43 %, about 22.8 contained petroleum hydrocarbons in concentrations exceeding 40 µg l^{-1}. At the Gulf of Oman, about 80 % of the analyzed samples contained less than 20 µg l^{-1}. Of the remaining 20 %, only 7 % contained petroleum hydrocarbons in concentrations exceeding 40 µg l^{-1}. Obviously, the concentrations of petroleum hydrocarbons in the Arabian Gulf waters were higher (1.6 times) than the Gulf of Oman indicating more oil contamination at the Arabian Gulf. The higher concentrations in seawater of the Arabian Gulf were mainly due the intense petroleum activity in the Arabian Gulf because of the large numbers of offshore oil terminals in addition to the huge numbers of oil tankers; the higher salinity of the Arabian Gulf compared to the Gulf of Oman; and the accreted oil pollution self-purification process at the Gulf of Oman (Shriadah, 1998). Horizontal distributions of petroleum hydrocarbons indicated increasing quantities of petroleum hydrocarbons in offshore samples from the Arabian Gulf (26.8 µg l^{-1}) and the Gulf of Oman (23.3 µg l^{-1}) compared to near shore samples (20.2 & 6.3 µg l^{-1}). Apparently; offshore stations in both areas are located close to tankers routes where oil tankers discharge their wastes, washings and balloting waters away from surveillance in addition to oil spill from offshore oil terminals at the Arabian Gulf. The distribution of petroleum hydrocarbons indicated a pronounced decrease towards the shoreline of the United Arab Emirates along the Gulf of Oman (5.7 µg $l^{-1}Km^{-1}$) compared to the Arabian Gulf (2.2 µg $l^{-1}Km^{-1}$) suggesting that major parts of oil spills at the Gulf of Oman are transported towards the Arabian Sea and the Northern Indian Ocean. Whereas; most oil spills are advected by current towards the coast of the United Arab Emirates along the Arabian Gulf resulting in increasing the concentrations of hydrocarbons at near shore stations. In the water column of the Arabian Gulf, vertical profile distribution of petroleum hydrocarbons



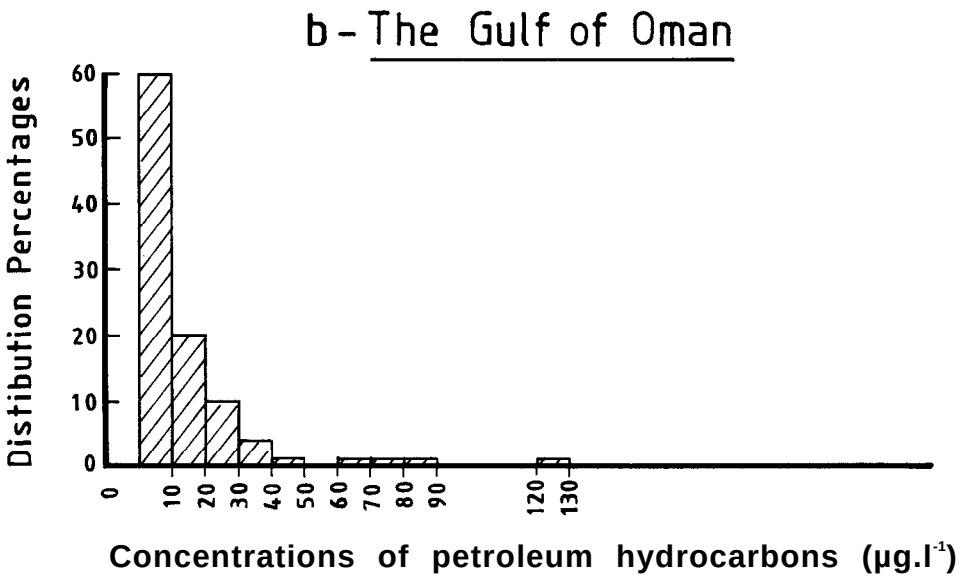


Figure 2. Distibution percentages of petroleum hydrocarbons in sea water of the Arabian Gulf and the Gulf of Oman.

Table 1. Ranges and mean (± SD) values of petroleum hydrocarbons (μg l^{-1}) in the Arabian Gulf and the Gulf of Oman during 1995-1996.

The Arabian Gulf			The Gulf of Oman		
Sts.	Range	Mean+SD	Sts.	Range	Mean+SD
A-1 S	9.8- 92.0	44.9± 7.8	G-1 S	6.0- 84.0	32.5± 10.8
10m	7.5-105.8	32.5± 7.8	10m	2.8- 70.5	36.0± 11.8
B	8.8- 21.8	14.2± 4.1	B	5.0- 27.5	15.9± 6.0
A-2 S	19.2- 45.8	29.8± 9.3	G-2 S	6.1- 9.1	8.1± 1.3
10m	8.6- 36.2	24.0± 7.5	10m	4.4- 9.7	7.1± 1.7
B	8.0- 26.8	15.2± 5.7	B	4.1- 6.8	5.5± 1.0
A-3 S	9.1- 87.2	42.9± 8.8	G-3 S	14.0- 29.6	21.7± 4.9
10m	11.7- 32.4	17.3+ 7.3	10m	2.4-128.6	34.4±12.5
B	4.7- 56.9	25.2± 5.2	B	14.3- 29.2	19.3± 4.8
A-4 S	12.9- 87.7	32.3±10.7	G-4 S	4.1- 9.0	6.5± 1.5
10m	2.8- 61.8	17.4± 7.2	10m	1.6- 8.4	5.5± 2.3
B	7.3- 54.2	20.7± 6.9	B	4.1- 7.0	5.3± 0.9
A-5 S	6.7-207.7	52.8±12.0	G-5 S	3.9- 35.6	22.0± 5.4
10m	2.6-116.6	27.6±14.3	10m	2.5- 34.0	15.2± 5.5
B	5.4- 39.2	18.7± 6.5	B	2.5- 20.1	12.5± 4.8
A-6 S	0.5- 48.9	25.1± 7.4	G-6 S	4.7- 9.2	7.4± 1.6
10m	5.2- 32.0	14.7± 5.9	10m	4.4- 8.4	6.0± 1.4
B	4.7- 24.4	13.6± 3.8	B	4.0- 6.1	5.1± 0.6
A-7 S	22.0- 38.0	30.8± 4.8			
10m	5.4- 44.9	18.2± 6.1			
B	4.6- 33.3	12.3± 5.6			
A-8 S	8.8- 36.3	23.5± 6.9			
10m	6.8- 45.6	15.0± 8.1			
B	9.4- 58.9	20.1± 9.1			
A-9 S	16.4- 57.2	32.1± 7.9			
10m	2.6- 35.0	16.3± 6.2			
B	2.4- 32.0	16.3± 6.9			
A-10 S	9.8- 66.6	26.1±10.2			
10m	3.1- 31.2	14.4± 6.0			
B	3.5- 21.5	11.3± 5.6			

S: Surface samples; B: Bottom samples.

showed a sharp decrease with depth. At the Gulf of Oman, hydrocarbons were nearly homogenous in the upper 10 meters layer due to a strong vertical mixing resulting from active winds. In more deep waters vertical distributions showed same trend as the Arabian Gulf, *i.e.,* a decrease with depth. The present study indicated also more clear vertical gradients (0.8 μg $l^{-1}m^{-1}$) at the Arabian Gulf compared to the Gulf of Oman (0.1 μg $l^{-1}m^{-1}$) reflecting larger rate of oil

dissolution at surface layers. The role of precipitation of thick residual oils after the evaporation of lower boiling point components was also important.

Comparing concentrations of petroleum hydrocarbons measured here with the previously reported concentrations for the Gulf region and other marine environments (Table 2), it is clear that the present concentrations are much

Table 2. Comparison between petroleum hydrocarbons levels (µg l^{-1}) in the study area and other marine environments.

References	Area	Petroleum hydrocarbons (µg l^{-1})	
		Range	Mean
Present study	Arabian Gulf; U. A. E.	2.4- 207.7	23.5
Present study	Gulf of Oman; U. A. E.	1.6- 128.6	14.8
Shriadah (1999)	Semi-closed areas; U. A. E. (Arabian Gulf)	0.2- 13.0	4.1
Shriadah (1999)	Coastal areas; U. A. E. (Arabian Gulf)	2.1- 12.5	6.0
Shriadah (1999)	Coastal areas; U. A. E. (Gulf of Oman)	3.4- 13.2	5.5
Lara et al., (1995)	Bahia Blanca Bay; Argentina	-	15.5
Al-Ghadban et al., (1994)	Arabian Sea	0.4-1448.4	235.4
Domenico et al., (1994)	Augusta Bay; Italy	0.1- 0.4	-
Badawy, MI (1993)	Coastal areas of Oman		
	Al-Gubra	0.2- 0.8	0.5
	Mina al-Fahal	1.6- 2.8	2.2
	Al-Bostan	0.2- 0.5	0.3
Corbin, J. (1993)	Open Oceans	0.9- 93.6	17.7
Emara (1990)	Southern Arabian Gulf and the Gulf of Oman	4.4- 63.0	15.0
Emara and El-Deeb (1988)	Southern Arabian Gulf	7.7- 373.0	54.8
Awad, H. (1988)	Red Sea; Saudi Arabia	6.0-1695.0	206.9
El-Samra et al., (1986)	North Western Arabian Gulf	1.2- 546.0	65.2
Marchand et al., (1982)	Gulf of Mexico	0.4- 66.8	3.9
Faraco and Ros (1979)	Western Mediterranean	1.0- 123.0	9.9
Sen-Gupta et al., (1978)	Arabian Sea (West Coast of India)	20.0-2440.0	114.0

lower than those reported for the Arabian Sea and Saudian Red Sea waters. Whereas, much lower concentrations than the present concentrations were also reported for other areas (Table 2). The higher concentrations measured here were confined mainly to the offshore areas located close to oil tankers routes. It therefore concluded that the area of study is one of the most hazardous sea area in the region as it is subjected to high inputs of oils, from oil spills, which can make water useless for desalination.

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