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Oil Pollution in Waters, Fish and Sediments in Gulf of Oman Environment

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ABSTRACT. To assess the development of oil pollution in a part of Gulf of Oman ecosystem, surface waters, 5 species of economic fish and sediments samples were collected from 3 areas covering the part of Sultanate of Oman, where all petroleum activities are concentrated. Analysis of samples for their contents in total hydrocarbons (THC) and concentration of 5 persistent polyaromatic hydrocarbons (PAH) were carried out. The results show high level of oil contamination in all samples, especially in the area nearest the Hormuz Strait. High values, as 125 $\mu g\ l^{-1}$ of THC as well as concentration >1000 ng l^{-1} total PAH contents, were detected in waters. Sediments show higher contents of THC and PAH exceeding 250 $\mu g\ g^{-1}$ and 3000 ng g^{-1} in the surficial layers and more in the layer underneath. THC show also high level in fish flesh and liver ($> 500\ \mu g\ kg^{-1}$) and 110 ng kg^{-1} as a minimum concentration for PAH. The major constituent of PAH is Benzo-3, 4-Pyrene-like compounds.

Introduction

Many of the marine ecosystems of gulf areas are seriously threatened by oil pollution which is representing, in some part of them, a serious problem (Unesco 1976). Regarding the rates of marine oil production and density of oil transport, potential and risks of oil contamination in the Arabian Gulf should be the highest among those in the gulf areas anywhere. Actually, 50% of world's oil is produced and passed through this gulf and his approaches.

Arabian Gulf as a semi enclosed area, with little natural fresh water drainage makes the spilled oil to accumulate in its environment rather than being dispersed and degraded in the open gulf. Indeed, the general pattern of water circulation and prevailing current and winds enhance oil to move and accumulate along the South West shores. However, the gulf marine environment, especially the more sensitive coastal communities of coral reefs and mangroves, should be existing under a chronic oil pollution stress. In fact, it was found that vessels reports of oil slicks in the Arabian Gulf and approaches during 1978 show an increase in number and percentage of positive reports towards the Strait of Hormuz at the eastern end of Gulf of Oman (Oostdam 1980). From other side, survey of tar balls along the Omani beaches shows that all of them are suffering from severe rates of tar depositions (Burns *et al* 1982). These rates were found to be among the highest reported for any world area (Unep 1981). This phenomenon was attributed to the tankers being discharging ballast waters well down the Omani coast so that the ships are nearly empty upon entering the Gulf (Taylor 1983).

In front of a part of Omani coast (around Mina al Fahal), the present work is carried out in order to assess the situation of oil contamination in waters, sediments and some species of economic fish. In this area, beside it showed the highest results for tar ball deposition reaching a value 1 kg/m^3 (Burns *et al.* 1982), all of petroleum activities (loading, stocking and refining) in the Sultanate of Oman are concentrated. However, Mina Al Fahal waters receive oil wastes from various sources: water from tank drains, refinery's processing waters and ballast waters.

In the present work, level of oil contamination in various considered ecosystem elements is expressed in total hydrocarbon contents (THC) either as Omani crude oil or as chrysene equivalent units. On the other hand, the persistent polycyclic aromatic hydrocarbons: phenanthrene, chrysene, pyrene, benzo-3, 4-pyrene and benzo-8, 9-perylene were measured in all samples.

Material and Methods

Within the period from September 1986 to February 1987, 24 of 1-m depth water samples, 5 of 25-cm cores of sediments and 10 samples of 5 fish species were collected from the coastal area from Mina Qaboos to Al Seeb (20 km South-East and 50 km North-West of Mina Al Fahal, respectively). Figure 1 represents the distribution of each type of collected samples in the study region which is divided into the following three areas :

Area A: Al Seeb, from which water, sediments and fish were collected.
Area B: Mina Al Fahal; collected samples as these from zone A.
Area C: Mina Qaboos, from which water samples were only collected.

Sampling of waters and extraction of their organic material containing hydrocarbons were followed precisely according to the standard method of MAPMOPP (IOC/WMO 1976).

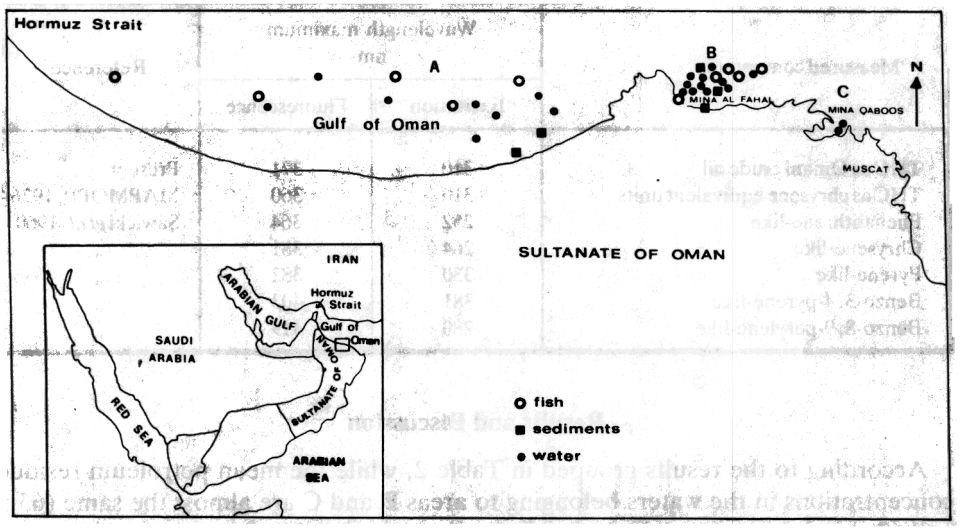

FIG. 1. Sampling sites.

Using a 25-cm acrylic core tube, sediments were collected, air-dried and splited in three 8-cm length fractions. Organic containing hydrocarbon contents in each fraction of the five collected cores were extracted in soxhlet during 24 hours by *n*-hexane acetone (2:1) using the method of Awad (1980). Following the same reference, flesh and liver samples of fish samples were dried at 70°C, saponified by 10% KOH in MeOH and the non-saponifiable fractions containing hydrocarbon were isolated in *n*-hexane. Organic extracts produced from water, sediments and fish samples were purified over florisil columns and hydrocarbons were eluted by 5% benzene in *n*-hexane.

Spectrofluorometrically, total hydrocarbon contents (THC) of each sample were measured using Omani crude oil as reference beside the standard (chrysene equivalent units) reference of MAPMOPP (IOC/WMO 1976). Concentrations of the five polycyclic aromatic compounds were measured using the best excitation and fluorescence wavelengths mentioned in Sawicki *et al.* (1960). Table 1 includes the used excitation and fluorescence wavelength in the measurement of THC and the individual PAH compounds concentrations in all samples. The instrument used in this work is Bairo Fluoripoint spectrofluorometer, Ratiometric RC 200.

TABLE 1. Used excitation and fluorescence wavelengths for measurement of THC and PAH in *n*-hexane.

Measured compounds	Wavelength maximum nm		Reference
	Excitation	Fluorescence	
THC as Omani crude oil	310	371	Present
THC as chrysene equivalent units	310	360	MAPMOPP, 1976
Phenanthrene-like	252	364	Sawicki *et al.* 1960
Chrysene-like	264	381	"
Pyrene-like	330	382	"
Benzo-3, 4-pyrene-like	381	403	"
Benzo-8, 9-perylene-like	280	419	"

Results and Discussion

According to the results grouped in Table 2, while the mean petroleum residue concentrations in the waters belonging to areas B and C are almost the same (65.5 and 67 $\mu g\ l^{-1}$, respectively), the concentration measured in the waters of area A is nearly the double of those found in the former areas (125 $\mu g\ l^{-1}$ as Omani crude oil). This is, although area B is continuously receiving petroleum wastes with an oily water discharge from the refinery situated in the area and illegal spills of ballast waters and bilges from tankers loading crude oil from the area (Dames & Moore 1985). The results obtained are coincident with the patterns of both strended tar balls distribution on beach (Burns *et al.* 1982) and oil slicks dispersal (Oostdam 1980). In fact, the geographical configuration of Al Seeb bay (Area A) with the prevailing southwards current might help the spilled oils and ballast waters to accumulate in the waters near the entrance of Hormuz Strait, where this area is located (Fig. 1). Comparing the overall mean of petroleum residue concentrations in the waters for the study region with those obtained in neighbouring ones, it could be concluded that the Omani coastal waters are the more polluted by oil. While the majority of oil concentrations in the Northwestern Arabian Gulf did not exceed 8 $\mu g\ l^{-1}$ (El Samra *et al.* 1986 and IAEA 1985), the overall mean of oil residue in the investigated region is about 60 $\mu g\ l^{-1}$, both expressed as chrysene equivalent units. Moreover, this mean value is near to that measured along the West coast of India (85 $\mu g\ l^{-1}$) and considered to be the highest value found so far in the world oceans (IOC/WMO 1981).

Results concerning the measured concentrations of polyaromatic hydrocarbons (PAH) confirm the heavily oil pollution situation in waters. The presence of such persistent compounds ranging in structure from 3 benzene rings (phenanthrene) to 7 ones (benzo-8, 9-perylene) could indicate the long-term nature of oil contamination in the region. Among studied areas, area A shows the highest content of total PAH in which a value of 1279 $ng\ l^{-1}$ was detected as a mean concentration corresponding to 2 times concentrations detected in the two other areas. Hence, such measured PAH

are not natural constituents in petroleum and produced during high temperature pyrolysis of oils (IOC/WMO 1981), discharge of machine bilges could be added as a source of oil pollution in the region beside spillage of ballast waters and refinery oily water discharge.

TABLE 2. Concentrations of total and polyaromatic hydrocarbons in water, fish and sediments in the study region.

			Mean THC conc. as:		Mean PAH conc. in ng					
Samples	Area	No. of samples	Omani crude oil	chrysene equivalent units $\mu g\,l^{-1}$	phenanthrene -like	chrysene -like	pyrene -like	benzo-3,4-pyrene -like	benzo-8,9-perylene -like	Total PAH ng
WATER	A	8	125	84.3	129	338	675	67	70	1279
	B	14	67	45.5	131	201	189	33	16	570
	C	2	65.5	47.6	79	166	254	0	0	499
FISH										
Sphyraena sp. (flesh)	A	2	555		0	0	0	0	0	0
Trachintus blochi (flesh)		1	513		0	0	0	0	0	0
Upeneus vittatus (flesh)		1	531		0	0	0	0	0	0
Epinephelus		1								
(flesh)			1067		0	0	0	0	0	0
(liver)			1110		0	0	14	134	0	148
Sword Fish	B	1								
(flesh)			512.4		0	0	0	0	0	0
(liver)			896.7		48	0	75	123	0	246
Sphyranea sp.		2								
(flesh)			603		14	0	0	710	0	724
(liver)			1025		25	0	0	803	0	828
Trachintus blochi		2								
(flesh)			683		0	0	0	110	0	110
(liver)			9125		183	0	13	651	0	847
SEDIMENTS	A	a	258		40	558	1703	79	775	3155
		b	156.5		69	316	1555	147	666	2753
		c	103.2		90	566	615	0	0	1271
	B	a	466.2		120	654	2040	167	558	3539
		b	368.6		127	771	3665	306	1643	6512
		c	61.6		0	450	1200	0	0	1650

- a, b and c are sediment layers in the cores representing 0-8, 8-16 and 16-25 cm sediment depth respectively.
- THC concentration expressed as Omani crude oil are in $\mu g\,l^{-1}$, $\mu g\,g^{-1}$, $\mu g\,kg^{-1}$ for water, sediments and fish respectively.
- PAH concentrations are in $ng\,l^{-1}$ for water, $ng\,kg^{-1}$ for fish and $ng\,g^{-1}$ for sediments.

As shown in Table 2, all the analyzed fish samples are characterized by high contents of THC burden in their flesh ($> 500\ \mu g\,kg^{-1}$, dry wt.) and liver ($> 1000\ \mu g\,kg^{-1}$, dry wt.). These detected contents are situated among the range of oil contents in fish

living in areas where high petroleum input exists. Hence, biogenic hydrocarbon concentrations in marine organisms is 1 to 2 $\mu g\ kg^{-1}$ or less (Portmann 1976) and concentrations of THC in fish samples are several orders of magnitude than in the surrounding waters of the study region, the origin of detected hydrocarbon in fish could be attributed fairly to accumulation from waters.

Except in the case of *Epinephelus* sp., PAH compounds are absent in flesh and liver of fish caught from area A contrary to the fish from area B. In this later area, high concentrations of PAH are detected in both flesh and liver of all species except in the flesh of the sword fish sp. Benzo-3, 4-pyrene is the major constituent of PAH contents in all fish species in this area. Because of known carcinogenecity of this compound, consumed fish from area B should be subjected to continuous chemical analysis for BaP detection. This result might be correlated to the composition of the outfall of oily wastes in area B where these fish individuals were fished in its vicinity.

In the case of sediments, the results obtained showed a gradual decrease in THC contents from superficial to subsurface sediments in areas A and B with a superiority of concentration in the second area in the upper 16 cm depth of sediments. Comparing THC in surface sediments of the region of study with that in the sediments at the northwestern of the Arabian Gulf off Kuwait (Kisr 1985) where oil field are concentrated, the mean concentration in Omani sediments is more than 3 folds that of the Kuwait sediments (362 $\mu g\ g^{-1}$ against 110 $\mu g\ g^{-1}$).

As the sediments are the ultimate sink of pollutants in the waters, the high concentration of THC in the sediments of the study area is an indication of the high magnitude of oil pollution in the region. Indeed, the high concentrations of persistent aromatic compounds along the sediment column (Table 2) confirm the previous statement.

Conclusion

All survey of tar balls strended on the Omani coasts and oil slicks dispersal in offshore waters in the Gulf of Oman indicate the severity of oil pollution in this region. The situation is attributed mainly to the dense illegal discharge of ballast waters well down this coast so that the tankers are nearly empty upon entering the Arabian Gulf. Within this region, Mina Al Fahal, where all of the petroleum activities in the Sultanate of Oman are existing, was found to be the heaviest polluted area by oil in the region. The aim of the present work is to evaluate the level of oil pollution in surface waters, sediments and some species of economic fish in the area of Mina Al Fahal and its surroundings. The obtained results of both total hydrocarbon (THC) and polyaromatic hydrocarbon contents (PAH) in the collected samples support the previous statements in the area of study that this region is suffering from a high chronic potential of oil pollution. However, the means THC are ranged in between 65.5 and 125 $\mu g\ l^{-1}$ in waters, from 513 to 1067 $\mu g\ g^{-1}$ (dry wt) in fish flesh and from 896.7 to 1110 $\mu g\ g^{-1}$ (dry wt) in fish liver and in superficial sediments from 258 to 466.2 $\mu g\ g^{-1}$ (dry wt), all expressed as Omani crude oil. Indeed, PAH contents show

high concentrations in all types of samples, especially for samples collected off Mina Al Fahal. Among the measured 5 polyaromatics, chrysene and pyrene were the major constituents. Abnormal high concentrations of benzo-3, 4-pyrene attaining values 710 and 803 ng g^{-1} (dry wt) in fish flesh and liver were detected respectively. The presence of such polyaromatic compounds indicates that both discharge of refinery's processing waters and ship bilges are main contributors polluting the area beside the known ballast waters discharge phenomenon.

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التلوث البترولي في السفه البحر لسلطنه عمان

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مستخلص

لتقويم التلوث البترولي خليج جمع

السطحية الر ساب وبعض الأ ذوات القيمة الاقتصاديه من

مناطق تغطي السو العمانية التي فيها النشاطات البترولية

تخزين بوريع ونكرير أظهر تحليل العينات لمحتو

الهيدروكربو الكلية من المر التي بتأثيراتها السر

ة محتويات عالية نسبيا وصلت لأكثر جرام

نانو المواد الهيدروكربونيه الكلية والسرطانية الكلية

على كا صلت كميات أعلى سوبيات ٢٥ جرام

جرام أكثر نانو جرام أكباد

الأسماك محتو الهيدرو الكلية

ميكروجر لكل كجم من إم الهيدروكربو

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