

Assessment of Oil Pollution Situation in Sharm El-Maiya Bay, Sharm El-Sheikh South Sinai, Egypt

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ABSTRACT

Sharm El-Maiya bay is bounded by multi million pounds tourism investments in Sharm El-Sheikh area. The key stone for investments in this area is the water sports and amenities. All of this was hindered by the presence of a persistent oil film covering the sea surface as well as an oily smell especially noticeable in hot and windy days. The purpose of this work was to identify sources and level of petroleum hydrocarbons as well as to establish a data-base for future monitoring and defining mitigation measures for rehabilitation program. In total, 17 sites plus a control site were investigated. Water and sediment samples were collected, extracted, purified and analyzed using spectro-fluorometry and Gas chromatography (GC). Results indicated that chronic oil pollution was prevalent in the surface sediments (0-20 cm depth) in confined areas of the western and south-western sites of the bay. The average hydrocarbons concentrations recorded in deep (> 20 cm depth) and surface sediment varied between (20.3 to 1263.5 µg/g), the most contaminated sediments were restricted to the intertidal flat just outside the place of an old Power Plant. The spilled oil was found to be originated from different sources such as fuel leakage and dumping of oil wastes as well as other types of hydrocarbons from the disembarked power plant, creating the existing problem of permanent oil pollution. However, the GC analysis has indicated that oil degradation was processing very well.

Key words: Marine pollution, Red Sea, hydrocarbons, gas chromatography, spectrofluorometry.

INTRODUCTION

Oil pollution is the almost inevitable consequences of our dependence on an oil based technology. The use of a natural resource without losses or wastes is nearly impossible and marine oil pollution occurs through intentional disposal or through inadvertent losses in production, transportation, refining and use (GESAMP, 2004). Petroleum hydrocarbons are a complex mixture of aliphatic and aromatic compounds, which are the more constituents of crude oil. Crude oil differs markedly in composition and physical properties as well as in the relative concentrations of their individual components.

The total world oil consumption is attained now about 11 million ton per day (NRC, 2003). Undoubtedly, the problem of Red Sea pollution is a result of man's interest and activities, i.e. urbanization, tourism, oil exploration, and other industrial inputs in view of the extensive and increasing oil production in the northern Red Sea (Awad 1995).

The annual discharge of oil into the world oceans estimated 3.3 million ton per year (GESAMP, 1993). Out of this figure, 6836 tons discharges annually into the Red Sea environment (Awad 1995). In comparison, the Red Sea receives annually approximately 1.5 times more of oil discharge per Km² rather than the world oceans (14.61 and 9.17 kg/m² respectively, Awad 1995). It is also estimated that while each km² of the world oceans receives 0.56 kg/y from refining activities only, each km² in the Red Sea receives 6.64 kg/y from the same type of source. Although, the estimated inputs of oil to the world oceans from marine transportation activities in 1989 dropped to one third of that estimated for 1981 (IMO, 1990), this trend seems to be reversed

for the Red Sea due to the continuous intensification of oil transportation and exploration across the area.

Beside the ecological value of Sharm El-Maiya Bay as a nursery ground for many fish species (Ahmed, 1989), Sharm El-Maiya Bay is considered as very valuable tourism destination. The huge investment on the bay was under great threats due to oil pollution which severely contaminated the most beauty beaches, water and even air. This investigation aimed to determine the sources and levels of oil pollution as base line data for monitoring the pollution levels and recommend a plan for recovery.

MATERIALS AND METHODS

Limits of investigated area

Sharm El-Maiya Bay is located in Sharm El-Sheikh, at Southern Sinai area, on Gulf of Aqaba (Figure 1). The bay is situated approximately at 34° 17' 30" East and 27° 51' 36" North. The bay is shallow and small (approximately, 2150 m²). It is opened to the sea in the south west through narrow opening (300m width), Figure (1). The bay is relatively shallow and surrounded by sandy tidal flat along most of the shoreline area.

For the purpose of this investigation, a total of 17 sites were selected to represent the entire geographical habitats/sites of the bay. In addition, one site was selected outside the bay as a control site (Figure 1). Out of the 17 sites taken into the bay, 11 sites were selected inshore and 6 sites were taken in the middle of the bay. At each inshore site, 3 transects perpendicular to the shoreline were surveyed and each transect was divided into 4 distinct zones, i.e. splash zone (A), intertidal zone

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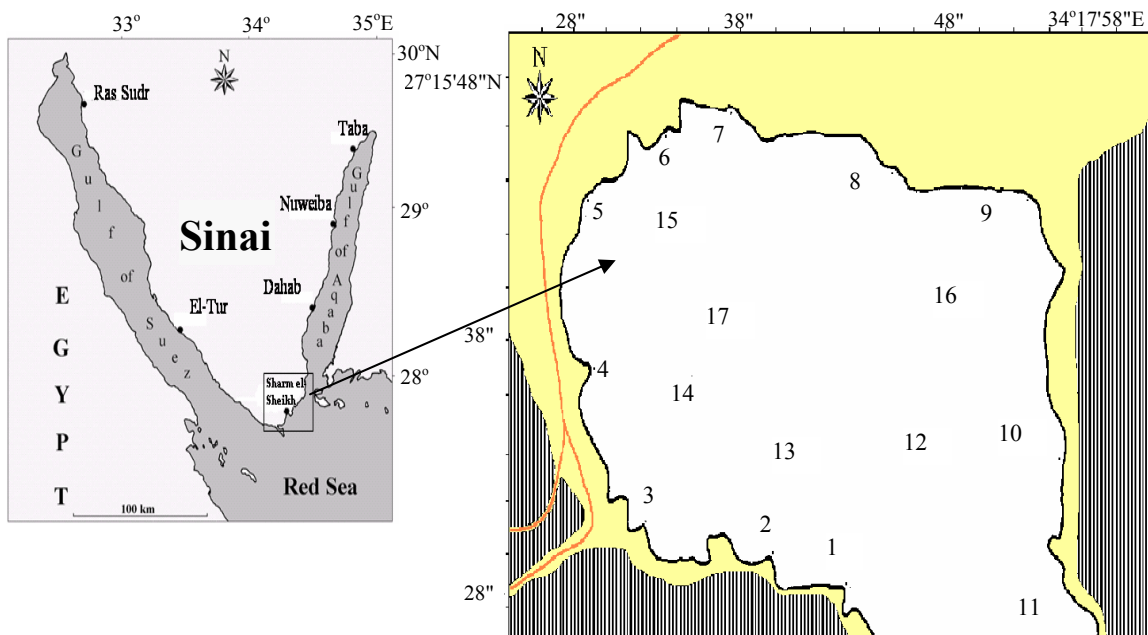


Figure (1): Map of the southern Sinai Peninsula, showing the location of Sharm El-Sheikh (indicated by the rectangular) and sampling sites in Sharm El-Maiya bay.

(B), shallow subtidal zone (i.e. less than 0.5m depth, C), and deep subtidal zone (more than 1m depth, D). The investigation was carried out to estimate the petroleum hydrocarbons in water and sediments in comparison to the control site.

Collection of samples

Water samples were collected by a weighed bottle holder with a clean amber glass bottle (2.8 litres) using the dichloromethane as a preservative. All the necessary precautions were taken as recommended by UNESCO (1976) during sampling as well as during extraction and analysis.

Sediment samples were collected by the core sampler. The core contents from each site and zone were splitted into two samples, surface sample (i.e. from 0-20cm depth) and deep sample (i.e. from 20-40cm depth). Each sample was spooned into a clean sheet of aluminium foil, which was wrapped and kept in insulated icebox. Upon arriving to the laboratory the samples were kept frozen (-20°C) till their analysis.

Fluorescence analysis of total hydrocarbons (THCs)

(1) THCs in water

The procedure followed was that given in the Standard Methods of UNESCO (1976). Hydrocarbon extraction from water samples was performed immediately after collection by adding 100ml of dichloromethane in three successive 50, 25, and 25 ml extractions. The combined extracts were dried over anhydrous sodium sulphate and evaporated to dryness in a rotary evaporator at 45°C. Fluorescence was measured (excitation at 360 nm, and emission at 415 nm) using a digital spectrofluorometer (Sequoia-Turner Corporation type, model 450). Chrysene was used as reference

standard and the “chrysene equivalent” concentration of extractable THCs was calculated by comparison with the fluorescence of known concentrations of chrysene in hexane. Results were expressed as Chrysene Equivalent Units (CEU) in µg/l.

(2) THCs in sediments

For sediment samples, organic materials were extracted and analysed following the technique recommended by UNEP (1992). Samples were thoroughly homogenised and dried with anhydrous sodium sulphate in a mortar. A 10 gm from each sample was soxhlet extracted by methanol for 5 hours followed by saponification process (KOH / NaCl), then the extraction was continued for another two hours. The obtained solution was partitioned using hexane then dried in rotary evaporator and kept in dark till the purification step. The obtained sediment extracts were cleaned up according to Awad (1980). Purification was carried out over a florisil column. The dried organic extract was eluted from column by 60 ml of n-hexane containing 5% benzene volumetrically. THC contents were determined spectrofluorometrically using the same technique for water analysis except that results were expressed in µg/g against the chrysene standard.

Gas Chromatography (GC) analyses

The hydrocarbons in sediment were determined using gas liquid chromatography (GC) as it is a precise method for the analysis of the extremely complex mixtures of hydrocarbons as well as oil fingerprinting (Zafrou *et al.*, 1973). The used GC was (AMS type, model 92) equipped with a flame ionisation detector (FID) and coupled with a spectra physics integrator programmed to calculate automatically the signal peak areas and corresponding concentration. A splitless

injection mode was used to analyse the individual components of total aliphatic and aromatic hydrocarbon fractions. The separation was carried out using the conditions grouped as follows: a G and WDB-1 fused silica column 30 m x 0.32 mm, film thickness 1.0 μm was used, carrier gas was Nitrogen under 1.5 ml/min, injector and detector temperatures were set at 260 $^{\circ}\text{C}$ and 300 $^{\circ}\text{C}$ respectively, temperature programming was started at 110 $^{\circ}\text{C}$ for 0 min with a constant gradient temperature at 10 $^{\circ}\text{C}/\text{min}$ and a final temperature at 280 $^{\circ}\text{C}$ for 30 min. Hydrocarbon identification was based on comparison with GC retention times of reference standard mixture composed of n-alkanes (ranging from n-C₁₀ to n-C₃₀). For the precise quantification of total individually hydrocarbons, internal standards were used from the beginning of sample analysis. The internal standards were n-C₃₀ and chrysene.

RESULTS

THCs using Fluorometric technique

(1) THCs in water

The levels of total hydrocarbon in surface and deep water of the bay are given in table (1). In the bay, the estimated overall means of THCs were 351.3 and 295.3 $\mu\text{g}/\text{l}$ in surface and deep water layers, respectively. Lower values of 43.1 and 32.2 $\mu\text{g}/\text{l}$ were recorded at control site for surface and deep waters respectively. The highest values of THC in the surface layer were recorded at sites 14 and 15 (being 454.6 and 419.6 $\mu\text{g}/\text{l}$) respectively (table 1) as well as the sheltered site 16 (591.8 $\mu\text{g}/\text{l}$). In addition the highest value of 618.7 $\mu\text{g}/\text{l}$ was recorded at site 14, off the dismantled power station.

Table (1): Levels of total hydrocarbons (THC) in the surface (S) and bottom (B) water of Sharm El-Maiya bay.

Sites	Depth	Conc. ($\mu\text{g}/\text{l}$)
12	S	185.6
	B	384.6
13	S	204.4
	B	282.4
14	S	454.6
	B	618.7
15	S	419.6
	B	201.7
16	S	591.8
	B	149.7
17	S	251.8
	B	134.5
Mean	S	351.30
	B	295.27
overall mean	S	323.28
	B	43.1
control	S	43.1
	B	32.2

(2) THCs in sediments

Total Hydrocarbons levels recorded in surface (<20 cm) and deep sediments (>20 cm) collected from different zones along the studied sites are presented in table (2). Mostly the surface sediments contained higher values rather than in the deep sediments at all sites

including the control site as well. This is obviously explained in the splash zone (i.e. zone A), where high levels of THC were recorded in the surface sediment rather than in the deep sediment with an estimated overall means of 116 $\mu\text{g}/\text{g}$ and 29 $\mu\text{g}/\text{g}$, respectively. On the other hand, the control site recorded the minimum concentrations in the surface and deep sediments (14 $\mu\text{g}/\text{g}$ and 6 $\mu\text{g}/\text{g}$, respectively).

The intertidal zone (i.e. zone B) was the most polluted area, but likewise the other zones the most contaminated sediments was found in the surface layer (<20 cm depth) and the overall means of the THC levels estimated in the surface and deep sediments of all the inshore sites were 1263.5 $\mu\text{g}/\text{g}$ and 19.5 $\mu\text{g}/\text{g}$, respectively. In accordance, the highest levels of THC were determined in the surface sediments at sites 2, 3 and 4 (11625 $\mu\text{g}/\text{g}$, 779 $\mu\text{g}/\text{g}$, and 1160 $\mu\text{g}/\text{g}$, respectively). In the deep subtidal zone (i.e. zone D), the THC levels followed the same pattern of higher values in the surface sediment than in the deep sediment with an overall means of 88.8 $\mu\text{g}/\text{g}$ and 17.6 $\mu\text{g}/\text{g}$, respectively.

Table (2): THC levels recorded in surface (<20 cm) and deep sediments (>20 cm) collected from different zones along the studied sites.

Sites	Zones							
	A		B		C		D	
	<20	>20	<20	>20	<20	>20	<20	>20
1	R	R	32	R	57	19	28	22
2	349	R	11625	R	412	43	58	18
3	211	96	779	2S	496	122	65	15
4	149	25	1160	37	268	39	99	5
5	29	18	56	17	52	48	89	72
6	32	12	63	24	98	21	87	63
7	13	9	48	18	39	18	21	18
8	29	14	42	10	45	16	26	R
9	R	R	33	11	22	R	53	R
10	R	R	17	R	42	R	62	R
11	R	R	43	R	24	R	40	R
Average	116.0	29.0	1263.5	19.5	141.4	40.8	57.1	30.4
12	-	-	-	-	-	-	291	R
13	-	-	-	-	-	-	83	37
14	-	-	-	-	-	-	45	22
15	-	-	-	-	-	-	56	10
16	-	-	-	-	-	-	18	7
17	-	-	-	-	-	-	40	12
Average	-	-	-	-	-	-	88.8	17.6
Control	-	-	-	-	-	-	14	6

A: Splash zone, B: Intertidal zone, C: Shallow subtidal, and D: Deep subtidal

Gas chromatographic analyses (GC)

(1) Origin of oil pollution and chromatogram comparison

As shown in Figure (2A), the baseline of crude oil chromatogram seems to be straight and the saturated hydrocarbons are standing at equal distance above the baseline. The saturated hydrocarbons are homologous distributed covering the range of n-C₈ to n-C₃₀. The odd and even carbon chains are close to one in this pattern of distribution. GC-spectra of diesel and power fuel oil (Figs 2B and 2C) showed the same pattern of crude oil in addition to presence of an unresolved complex mixture (UCM) on the baseline of the chromatograms.

Comparing these reference chromatograms with the chromatograms representing different types of hydrocarbon pollution in sediments from different sites and zones (B and D) of the bay and the control site (Fig. 3A-H) did not show clear indication for the origin of oil contamination. However, the chromatograms representing oil pollution at site 2, 3, 4 and site 2 in particular are seemed to be different from each other and from the other sites of the bay and the control site.

The gas chromatograms in Figure 3 (A-I) represent different types of chromatograms in different sites and zones. Figures 3A, 3B and 3C show the chromatograms of hydrocarbons in surface sediment of the intertidal zone (B) of sites 2, 3 and 4 respectively.

The GC spectra of surface sediments in the intertidal zone (B) of site 5 off the old jetty of Marine Sport Club (Fig. 3D), showed smaller peaks of straight chain aliphatic hydrocarbons very similar to the peaks found in the intertidal zone (B) of sites 7, 8, 9 and 11 (Fig. 3E); surface sediments of the all bay sites (Fig. 3G) and also similar to surface sediments of the middle sites (Fig. 3F). These GC spectra characterised by small UCM covered by n-alkanes in the range from n-C₁₅ to n-C₂₆ with maximum peaks at C₁₆, C₁₇ and C₁₈ respectively. Another type of chromatogram (Fig. H) was recorded for the deep sediments (> 20 cm depth). The chromatograms showed slight UCMs comparing with the surface sediments. In addition, the n-alkanes found to be distributed uniform with visible peaks in the range of n-C₁₄ to n-C₂₉ with a maximum at n-C₁₆, n-C₁₇ and n-C₁₈. Pristane and phytane are somewhat resolved. Unlike the bay sediments, GC-spectra of the surface sediments of the control site (Fig. 3I) showed to some extent a straight baseline without prominent UCM with small projecting peaks of n-alkanes covering the range from n-C₁₅ to n-C₂₉ with maxima of n-C₁₆, n-C₁₇, and n-C₁₈. The Carbon Preference Index (CPI) values of the bay sites were very close to unity (Table 3) while, CPI value of 4.4 was estimated for the control site.

(2) Weathering situation

Additional parameters were estimated from the gas chromatographic analyses to correlate the sources and evaluate the weathering status of spilled oil. These included the CPI and percentage of aliphatic and aromatics to total hydrocarbons (Table 3).

The percentages of aliphatic and aromatic in the surface sediments of the intertidal zone (B) and the deep water (D) averaged 24.7 and 75.2, and 34.5 and 65.5%, respectively (Table 3). Also, the data indicated that the biodegradation in the surface sediments of the intertidal zone is lower than that of the subtidal zone, as indicated by the lower occurrence of the aliphatic hydrocarbons. In contrast, the percentages of both types of hydrocarbon in the deep sediments of the intertidal and subtidal zones found to be very close (being 47.3 and 42.8, and 53.0 and 47.0%, respectively). This is likely to be related to the rate of biodegradation due to the poor condition of oxidation. In addition, the situation in the control site is seemed to be similar to the surface

sediments of the intertidal zone. As in the total aromatic hydrocarbon (using Fluorometric technique), the highest total aliphatic hydrocarbon (TAH) concentration was recorded in the surface sediments of the subtidal zone of site 2 (2931.9 µg/g sediment). The lowest concentration of aliphatic hydrocarbon was recorded in the control site and the surface sediments of the intertidal zone (B) of site 8 (4.1 and 6.6 µg/g sediment, respectively).

A comparison of GC analysis for n-C₁₇ / pristane and n-C₁₈ / phytane ratios was done and a relative estimation of the biodegradation percentage in the surface and deep sediments of the investigated sites of the bay and the control site are given in Table (4). Generally, highest biodegradation ratio (30-40 %) was recorded in the surface sediment. However, in the deep sediment layer, the biodegradation ratio was (10-20%) and the lowest biodegradation ratio was recorded at the surface sediments of site 5 (0-10%).

Discussion

THCs using Fluorometric technique

The higher level of total hydrocarbon in the surface layer comparing with the deep layer is mainly related to the accumulation of lighter oil component (Diesel) on the surface water. A clear trend of increasing THC levels was noticed towards the southern side of the bay and surprisingly towards the north-west side. This obviously attributed to the continuous exchange of pollutants between water and chronically contaminated sediment as well as the accumulation of pollutant in the south and south-west of the bay under the influence of wind direction and the sheltering condition characterized this part of the bay.

In comparing the present results with similar studies conducted on the Middle east environments, it was noticed that the fluorometric determined concentrations were comparable to those found in surface waters of the Saudi Red Sea coastal waters (35-612 µg/l) by Awad, (1988 and 1990) and were lower than or sometimes within the ranges of hydrocarbons concentrations measured gravimetrically in the Red Sea Gulfs (170-910 µg/l) and Suez Canal environment (33-1243 µg/l) by Mostafa (1995).

The elevated concentration of THC recorded in sediments at site 2, 3 and 4 may be attributed to the close vicinity to the dismantled power plant and also due to previous dumping activities in the area represented by dumping the army camp wastes including small oil containers and even barrels containing heavy fuel oil (Field observations). Further more the heavy fuel discharging through two underwater pipelines. Concentrations of petroleum hydrocarbons measured in sediments by spectro-fluorometer are consistent with that measured in Saudian Red Sea sediments (10-803 µg/g) by Ehrhardt and Burns 1993. On the other hand, they are much higher than those recorded for Arabian Gulf sediments of Bahrain (0.6-3.6 µg/g), UAE (1-1.4 µg/g) and Oman (0.2-2.3 µg/g) by Fowler *et al*, (1993).

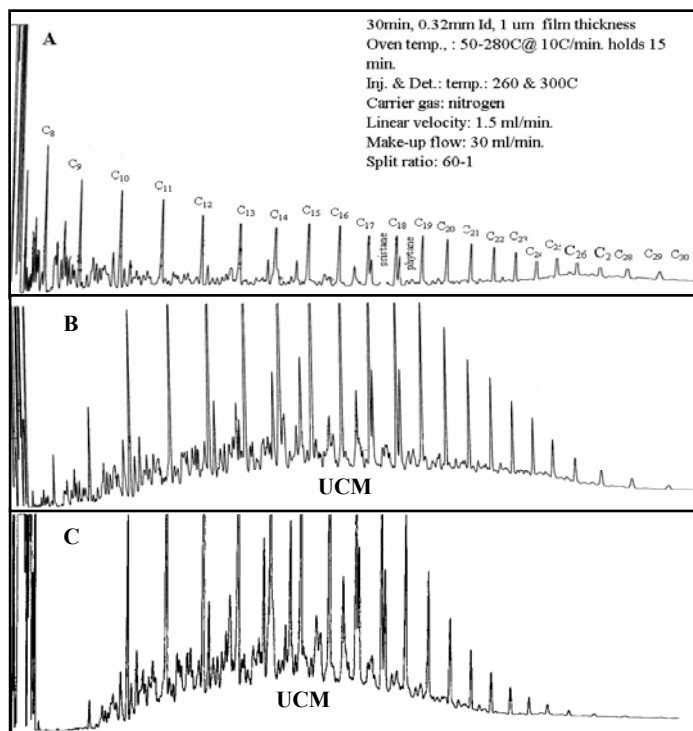


Figure (2): FID-gas chromatograms of reference samples of Egyptian crude oil (A), Diesel fuel oil (B) and Power fuel oil (C).

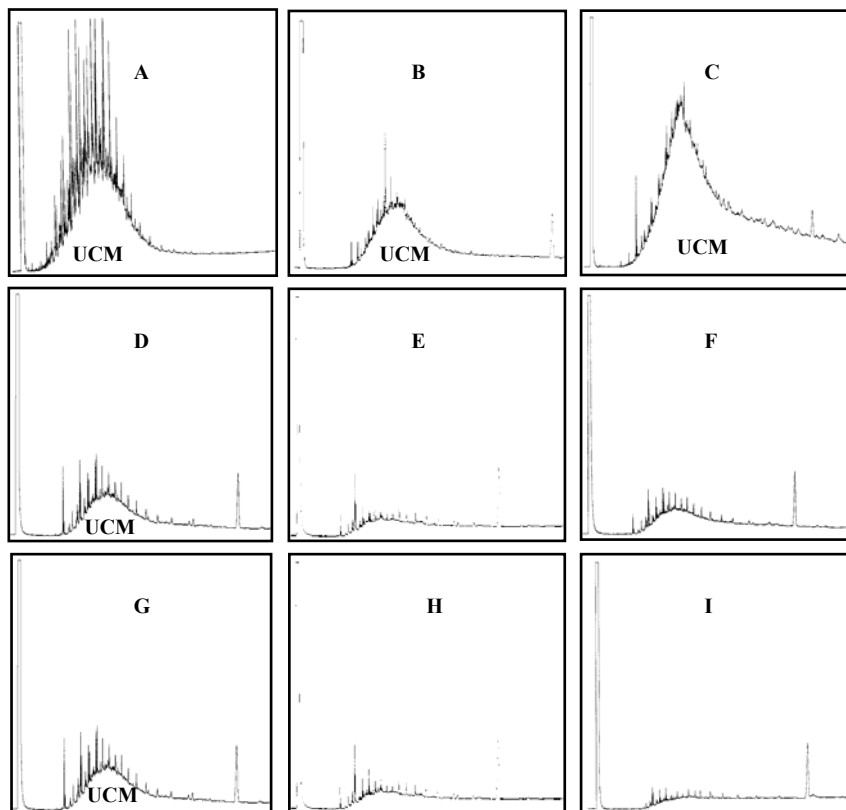


Figure (3): FID-gas chromatograms of hydrocarbons extracted from sediments collected from different investigated sites. A- zone B surface sediment of site 2; B- zone B surface sediment of site 3; C- zone B surface sediment of site 4; D- zone B surface sediments of site 5; E- zone B surface sediments of site 8; F- zone B surface sediments of the all bay sites; G- surface sediments of the middle sites; H- Deep sediments of all bay sites; I- surface sediment of the control site.

Table (3): Gas chromatographic results for surface (s=<20cm) and deep (d=>20cm) sediments, and calculated carbon preference Index for hydrocarbon extracted from sediments of some selected sites and zones (B=intertidal, D=deep subtidal) of Sharm El-Maiya Bay and control site.

Sites	Zone	Depth	Total Aliphatics (µg / g)	Total Aromatic (µg / g)	Total µg / g	Aliphatics (%)	Aromatic (%)	CPI
2	B	s	2931.9	11,625	14556.9	20.1	79.9	0.8
	D	s	43.9	58	101.9	43.1	56.9	1.3
3	B	s	34.7	779	813.7	4.3	95.7	2.2
	B	d	13.4	25	38.4	34.9	65.1	0.92
	D	s	42.4	62	104.4	40.6	59.4	1.2
4	D	d	10.5	15	25.5	41.1	58.9	0.85
	B	s	100.5	1160	1260.5	8	92	
	B	d	10.5	3.7	14.2	74	26	0.38
	D	s	39.9	99	138.9	28.7	71.3	1.4
5	D	d	12.4	5	17.4	71.2	28.8	1.3
	B	s	27.0	56	83.0	32.5	67.5	1.2
	B	d	11.5	17	28.5	40.2	59.8	1.1
8	D	s	40.7	89	129.7	31.4	68.6	1.1
	B	s	13.1	42	55.1	23.8	76.2	0.98
	B	d	6.6	10	16.6	39.9	20.1	0.87
11	D	s	11.9	26	37.9	31.4	68.6	0.89
	B	s	24.3	43	67.3	36.1	63	0.97
	D	s	18.5	40	58.5	31.6	68.4	1
12		s	11.2	291	302.2	3.7	96.3	1.2
13		s	23.7	83	106.7	22.2	77.8	0.8
14		s	93.2	45	138.2	67.4	32.6	0.5
15		s	23.1	56	79.1	29.2	70.8	1
		d	8.8	10	18.8	46.8	53.2	0.76
Mean	B	s	328.3	1418.0	1746.3	24.7	75.2	1.1
	B	d	10.5	13.9	24.4	47.3	42.8	0.8
	D	s	32.9	62.3	95.2	34.5	65.5	1.1
	D	d	10.5	10.0	20.5	53.0	47.0	1.0
Control	0.2	s	4.1	14	18.1	22.7	77.3	4.4

Table (4): Characteristic data of biodegradation (Biodeg.) stage determined roughly as recommended by Fuesy and Oudot, (1984) for surface (s) and deep (d) sediments of some selected sites in Sharm El- Maiya Bay.

Sites	Zone B						Zone D					
	n-C ₁₇ /pr		n-C ₁₈ /phy		Biodeg (%)		n-C ₁₇ /pr		n-C ₁₈ /phy		Biodeg (%)	
	s	d	s	d	s	d	s	d	s	d	s	d
2	0,47	-	0,44		30-40	-	1,8	-	0,8	-	10-30	-
3	0,3	1,7	0,2	1,1	30-40	10-20	1,6	1,8	1,3	1,4	10-20	-
4	0,4	2,5	0,8	2,3	30-40	0-20	1,9	2,2	0,9	1,8	10-30	10-20
5	3,4	2,3	2,7	4	0-10	0-20	2,5	-	1,1	-	10-20	10-20
8	1,6	2	1,4	1,6	10-20	10-20	2	-	1,1	-	10-20	-
11	1,8	-	1,4	-	10-20	-	0,9	-	1	-	10-30	-
12	0,2	-	2,5	-	0-40	-	-	-	-	-	-	-
13	2,5	-	1,1	-	10-20	-	1,8	-	1,6	-	10-20	-
14	1	-	2	-	10-20	-	-	-	-	-	-	-
15	1,7	-	1,3	-	10-20	-	2,3	-	2,2	-	10-20	-
Control 18	-	-	-	-	-	-	1	-	2	-	-	-

Gas chromatographic analyses (GC)

(1) Origin of oil pollution and chromatogram comparison

In order to identify the origin of petroleum hydrocarbons, whether it is a result of spilled crude oil, or either discharged from boats during oil changing process or from the dismantled power plant; three reference samples of fresh Egyptian crude oil and its refined distillates (boat diesel oil and power plant oil) were analysed chromatographically. At site 2, oil contamination is likely to be from different sources, including; (a) residuals from a crude oil as a result of

the 700 tons oil spill incident of the Ship “ Lanya” in strait of Tiran in 1987 during which main part of the oil was trapped mainly in the Sharm El-Maiya Bay at site 2 specifically; (b) heavy fuel oil and other waste oil from the dismantled power station; and (c) accumulation of floating oil in the sediment of the intertidal area of this site.

The presence of UCM designates high level of degradation, while the high peaks of straight chain hydrocarbons from n-C₁₂ to n-C₃₀ point to chronic oil pollution. In addition, the presence of peaks of the low molecular weight n-C₁₂ and n-C₁₃ refers to the main

accumulation area for floating film of light oil. The GC spectra of the hydrocarbons in surface sediments of sites 3 and 4 may indicate that the oil pollution is older and more degraded than that recorded in surface sediments of the intertidal area of site 2. Indeed the presence of the unresolved complex mixture (UCM) in the hydrocarbons isolated from oil-polluted sediments is a criterion used to differentiate polluted from unpolluted sediments (Farrington and Quinn 1973; Brassel and Eglinton, 1980). Similar unresolved complex mixture (UCMs) or humps in the gas chromatograms of hydrocarbons isolated from oil-polluted sediments have been noted in the Egyptian Red Sea coasts (Mansour, 1986), Red Sea Gulfs and Suez Canal sediments (Mostafa, 1995) and also of the Eastern Harbour of Alexandria-Mediterranean coasts (Aboul-Kassim and Simoneit, 1995). Generally, the UCMs are usually taken as indicators for biodegraded or chronic oil pollution (Thompson and Eglinton, 1978).

CPI denotes the carbon preference index, where odd carbon preference indicates biologically derived hydrocarbons while CPI approaching unity indicates petroleum derived hydrocarbons (Simoneit, 1978). The CPI values of the bay sites were very close to unity, indicating that the contamination in the bay is likely to be derived from anthropogenic origin. In contrast, CPI value of 4.4 estimated for the control site gives a clear indication of the biogenic nature of the hydrocarbons outside of the bay.

(2) Weathering situation

Because of the aliphatic hydrocarbons are degrading faster than aromatics, therefore the presence of high level of aliphatics indicates that the contamination either is recently occurred or the degradation is slow. Consequently, the general lowest occurrence of aliphatic compared with aromatic hydrocarbons in the surface sediments proves that the oil contamination in the bay is old and the degradation is going in a proper way.

The lowest biodegradation ratio recorded at the surface sediments of site 5 (0-10%) may be attributed to the existing of very thin layer of silt covering the sediment, lowering the oxidation potential of the sediments, and reducing the rate of biodegradation. Ratios of $n\text{-C}_{17}$ /pristane and $n\text{-C}_{18}$ /phytane have been frequently used to estimate the degree of the microbial degradation. Therefore low values of these indices suggest the presence of degraded oil and higher index tends to reflect less degraded or fresh inputs of oil (Fusey and Oudot, 1984). In fact, these parameters were used to confirm the petrogenic nature of spilled oil and also to show the biodegradation status of this oil.

Conclusions

- (1) Chronic oil pollution is prevalent in the surface sediments (0-20 cm depth) in confined areas of the western and south-western sites of the bay.
- (2) The most contaminated sediments were restricted to the intertidal flat just outside the place of an old Power

Plant.

- (3) The spilled oil was found to be originated from different sources such as fuel leakage and dumping of oil wastes as well as other types of hydrocarbons from the disembarked power plant.
- (4) The GC analysis has indicated that oil degradation is processing very well.
- (5) Future monitoring program was proposed for the bay and the obtained data was considered as a baseline for any future studies.

REFERENCES

- ABOUL-KASSIM, T.A.T., AND B.R.T. SIMONEIT. 1995. Petroleum hydrocarbon fingerprinting and sediment transport assessed by molecular biomarker and multivariate statistical analyses in the Eastern Harbour of Alexandria, Egypt. *Marine Pollution Bulletin* **30(1)**: 63-73.
- AHMED, I.A. 1989. Ecological and Biological studies on the juvenile fishes, South Sinai, Red Sea. M.Sc. thesis, Suez Canal University, Egypt.
- AWAD, H. 1980. Methode etablie pour doser les hydrocarbures dans les sediments et les organismes marins. In proceeding of the joint CIESM/UNEP workshop on pollution of the Mediterranean, Cagliari, Italy, October 1980.
- AWAD, H. 1988. Oil in Saudian Red Sea territorial waters. *Marine Pollution Bulletin* **19(6)**: 287-290.
- AWAD, H. 1990. Survey of some persistence polyaromatic hydrocarbons in Saudian Red Sea coastal waters. *Bulletin National Institute of Oceanography and Fishery, Egypt* **16**: 41-50.
- AWAD, H. 1995. Assessment of oil pollution potentials, impacts and risks in the Middle East marine environments. Environmental risk assessment, legislation and technology in (International Symposium under the Auspices of Oskar Lafontaine prime Minister, Saarland), June, 6th-8th. Burgerzentrum Saarbridchen-Dudweiler, Germany.
- AWAD, H., M.A AL-MOHARAMY, AND S.A. AL-EISA. 1990. Omani land-based oil inputs to the Gulf of Oman. *Oil and Chemical Pollution*, 6.
- BRASSEL, S.C., AND G. EGLINTON. 1980. Environmental chemistry- An interdisciplinary subject. Natural and pollutant organic compounds in contemporary aquatic environments. In J. Albaiges, [ed.], *Analytical Techniques in Environmental Chemistry*. Pergamon Press, Oxford. United Kigdom.
- DICKS, B. 1984. Oil pollution in the Red Sea- Environmental monitoring of an oil field on a coral area, Gulf of Suez. Proceedings. of Mabahiss/John Murray Symposium: Marine science of the North-West Indian Ocean and adjacent waters. September 1983, Alexandria, Egypt.
- EHRHARDT, M.G., AND K.H. BURNS. 1993. Hydrocarbons and related photo-oxidation products in Saudi Arabian Gulf coastal waters and hydrocarbons in underlying sediments and bioindicator bivalves. *Marine Pollution Bulletin* **27**: 187-197.

- FARRINGTON, J.W., AND J.G. QUIN. 1973. Petroleum hydrocarbons in Narragansett Bay. 1. Survey of hydrocarbons in sediments and clams, Mercenaria mercenaria. Estuarine and coastal marine science **1**: 71-79.
- FOWLER, S.W., J.W. READMAN, B.J.P.V. OREGIONI, AND K. MCKAY. 1993. Petroleum hydrocarbons and trace metals in nearshore Gulf sediments and biota before and after the 1991 War. Marine Pollution Bulletin **27**: 171-182.
- FUSEY, P., AND J. OUDOT. 1984. Relative influence of physical removal and biodegradation in the depuration of petroleum contaminated seashore sediments. Marine Pollution Bulletin **15(4)**:136-141.
- GESAMP. 1993. Impact of oil and related chemicals and wastes on the marine environment". GESAMP Report 50.
- GESAMP. 2004. Estimates of oil entering the marine environment from sea-based activities. GESAMP Reports and Studies No. 75.
- IMO. 1990. Petroleum in the marine environment. Document MEPC 30, INF. 13, Submitted by the United state International Maritime Organization, London.
- MANSOUR, T.M.S. 1986. Contribution to the study of pollution by oil on some regions of Gulf of Suez. Ph.D. Thesis, Faculty of Science, Ain Shams University, Cairo.
- MOSTAFA, Y.M. 1995. Studies on the hydrocarbon pollutants in the marine environment of the Red Sea Gulfs and Suez Canal. Ph.D. Thesis, Faculty of Science, Ain Shams University, 168.
- NATIONAL RESEARCH COUNCIL. 2003. Oil in the Sea III: Inputs, Fates, and Effects. National Academy Press, Washington DC.
- SIMONEIT, B.R.T. 1978. The organic chemistry of marine sediment In J.P. Riley and R. Chester [eds.], Chemical Oceanography, 234-311. Academic Press, New York. USA.
- THOMPSON, S., AND G.S. EGLINTON. 1978. The fractionation of recent sediment for organic geochemical analysis. Geochimica Cosmochimica Acta **42**: 199-207.
- UNEP/ IAEA/ IOC .1992. The determination of petroleum hydrocarbons in sediments. Reference methods for marine pollution studies, No. 20.
- UNESCO .1976. Guide to operational procedures for the IGOSS pilot project on marine pollution (petroleum) monitoring. UNESCO, Manual and Guides, No 7.
- ZAFIROU, O.C., J. MEYERS, R. BOURBONNIERE, AND F.J. FREESTONE. 1973. Oil spill-source correlation by gas chromatography; an experimental evaluation of system performance. Proceeding of the Joint Conference on Prevention and Control of Oil Spills, March 13-15, 1973, American Petroleum Institute, Washington, D. C., 153-159.

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تقييم لحالة التلوث البترولي في خليج شرم الميه بمدينة شرم الشيخ بجنوب سيناء

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المخلص العربي

يعتبر خليج شرم الميه أحد خلجان شرم الشيخ والمميزة بالاستثمارات السياحية المتدفقة، وقد توقف هذا التدفق بسبب وجود طبقة من الزيت البترولي ذات رائحة غير مستحبة على سطح مياه الخليج. يهدف هذا العمل إلى التعرف على مصادر التلوث البترولي، وتقييم مستويات ومحتوى هذا التلوث في الخليج بالإضافة إلى عمل قاعدة بيانات تهدف إلى الرصد مستقبلاً لحالة التلوث البترولي في الخليج، ووضع الحلول المقترحة لإعادة الخليج لوضعه الطبيعي.

في هذه الدراسة تم اختيار عدد 17 موقع داخل الخليج هذا بالإضافة إلى موقع آخر خارجه لتحديد أنواع وكميات هذا التلوث البترولي، وقد تم إستخلاص المحتوى البترولي لعينات من المياه والرسوبيات وتنقيتها بطرق كروماتوجرافية مناسبة والتعرف عليها مستخدماً تقنيتي التحلل الطيفي والتحليل الكروماتوجرافي. أوضحت النتائج وجود تلوث بترولي مزمن في الطبقة السطحية للرسوبيات 0-20 سم (في مناطق معينة بكل من المواقع الغربية والجنوبية الغربية للخليج. وتراوحت تراكيز الهيدروكربونات البترولية بين 20-1264 ميكروجرام لكل جرام وأكثر الرسوبيات تلوثاً وجدت بمنطقة المد والجزر بمواجهة محطة الكهرباء القديمة. وقد اتضح أن التلوث المسكوب ناتج عن مصادر متنوعة مثل وقود الماكينات وإلقاء مخلفات بترولية أخرى من محطة الكهرباء القديمة مما سبب في تواجد هذه البقعة البترولية بمياه ورسوبيات الخليج. وفي النهاية نود أن نشير إلى أن نتائج التحليل الكروماتوجرافي للعينات أشارت إلى وجود تحلل بترولي طبيعي لمخلفات هذا التلوث البترولي.