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Ecological study of the impact of oil pollution on the fringing reef of Ras Shukeir, Gulf of Suez, Red Sea, Egypt

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ABSTRACT

During January 2001, certain ecological aspects of the fringing reef of Ras Shukeir was investigated. Since 1960s, this fringing reef has been chronically polluted, where Ras Shukeir area was used by Gulf of Suez Oil Company (GUPCO) for oil production. Its present status showed a moderate level of petroleum hydrocarbon pollution. Field survey showed that the reef was seriously degraded where about 99% of its coral cover was destroyed along the whole investigated shore. Only sporadic colonies (1% cover) of the genera *Acropora*, *Echinopora*, and *Platygyra* with some individuals of associated fauna especially the giant clam *Tridacna squamosa* and the sea urchin *Echinometra mathaei* could withstand such conditions. Meanwhile, the reef flat is sparsely covered by the seaweeds *Dictyosphaeria cavernosa*, *Caulerpa serrulata*, *Padina pavonica*, *Laurancia obtusa* and *Cystoseira merica*, whereas *Sargassum dentifolium, S. latifolium* and *Grateloupia filicina* are occasional. Besides, Damselfish of *Pomacentrus* spp. and *Chrysiptera* spp., Butterflyfish of *Chaetodon* spp., parrotfish of *Scarus* spp., and the surgeonfish *Acanthurus sohal* were sporadically reported along the investigated reef. Finally, no signs of coral recovery have been observed.

KEYWORDS: petroleum hydrocarbons, degradation, corals, fishes

INTRODUCTION

Coral reefs are of the most diverse and complex communities in the marine environment. Hermatypic corals play a key role in forming the structure of coral reefs and providing substrate and shelter for a wide variety of associated organisms. They represent important marine habitats, which are internationally recognized for their need for conservation, as well as scientific, economic and recreational value. Under the development and human activities, corals become susceptible to damage from a range of pollutants especially oil (Dicks 1984; Hodgson 1999). This damage may result in a collapse of the complex community of organisms which live in close association with the corals (Horler 1974)

Much concern has been expressed in recent publications on the possible damaging effect of oil spills and other industrial pollutants upon coral reefs (Connell 1970; Straughan 1970; Johaannes 1970,1971; Fishelson 1973; Eliser *et al*. 1974; Chabanet *et al*. 1995; Dubinsky 1996; Hodgson 1999). Most investigations on the short-term effects of oil spills provide no conclusive evidence of direct injury or damage to corals (Grant 1970; Rutzler & Sterrer 1970; Lewis 1971; Johannes 1972; Roberts *et al.* 1994; Mohamed & Al-Ssadh 1996) where corals could escape damage as they are usually submerged and do not come into direct contact with oil. Nonetheless, reef building corals and their associated biota can be seriously damaged if coated with oil (Johannes *et al*. 1972). On the other hand, there are many evidences of long-term effects of oil on corals (Dicks 1984; Gooding 1971; Loya 1975; Heinrichsen 1990). Heinrichsen (1990) stated that long-term effects (chronic) of oil spills completely change the entire coral community by killing all or a large proportion of its biota, with its situation thought to be beyond recovery.

Here, Ras Shukeir has been under environmental stress, due to oil development at this area since 1960s (GUPCO, pers. commun.). This stress includes oil discharges, construction and operation phases around offshore platforms and shore terminals. This paper investigates

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the chronic effects of oil pollution on the fringing coral community at Ras Shukeir with the associated biota which includes invertebrates, fishes, as well as seaweeds.

MATERIALS AND METHODS

Study area: The study was carried out during January 2001 at Ras Shukeir reef in the south of Gulf of Suez (Fig. 1). The geomorphology of this reef is a typical fringing coral reef with scleractinian corals as the most important hermatypic organism. The study area is about 10km long , encompassing the pipe line routes, harbour, the coastal oil processing terminal and offshore oil loading buoy system for tankers. The area is characterized by swells and waves propagating in a north easterly direction up the coast and usually creates rough sea at the study area.

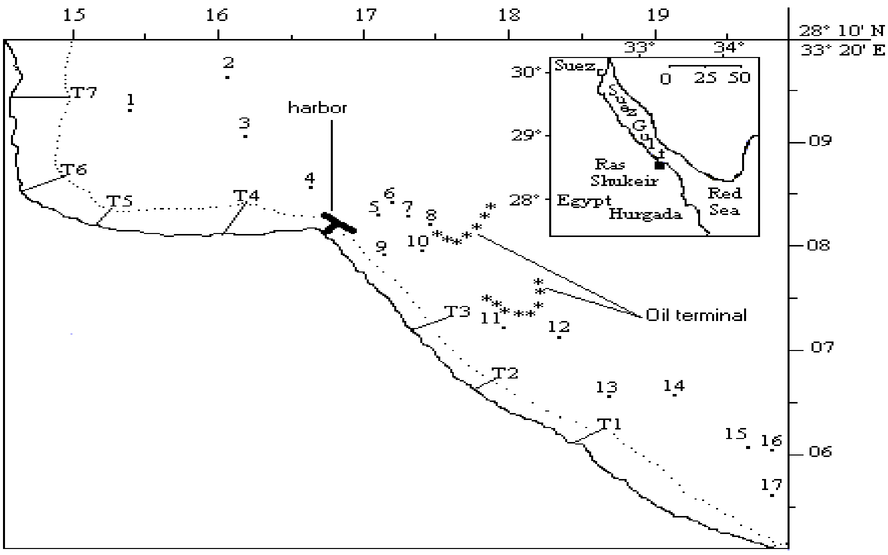

Figure1: A map shows different sampling sites.

Reef flat and lagoon: A belt transect technique was used from high water mark to the reef crest at roughly 90º to the coast line . Intertidal observations were made whenever possible at low tide . Subtidal reef flat and associated lagoons were surveyed by snorkeling, while the reef front and deeper near shore areas by SCUBA diving. The survey technique was done by observing and recording the distribution and coverage of corals, also the approximate abundance of conspicuous macro-faunal and macro-floral species (according to Tansley scale) along 10m wide belt transects (T1 – T7) over the investigated area (Table 1 & Fig. 1). Also, field description of upper-shore has been undertaken. The presence of oil, tar balls, tar pavements, or garbage was noted along the shore.

Off-reef sampling: was designed to provide quantitative data on the distribution of sediment grain size, organic matter, heavy metals as well as hydrocarbon concentrations. Samples of water and sediment were taken at a series of 17 stations along the investigated area (Fig.1). The position and depth of each station is listed in table 1.

Sediment particle size analysis was completed by dry sieving. Sediment organic matter content was determined by ignition at 480° C (Byers *et al.* 1978). Hydrocarbon analysis was carried out by a procedure involving solvent extraction according to UNEP / IAEA / IOC (1992) and detection by fluorometery. For heavy metals analysis, water and sediment samples were digested with nitric acid according to Loring and Rantala (1992). The analysis was performed on Atomic Absorption Spectrophotometer (Perkin-Elmer, Model 2380). The data validity were checked for the two metals Copper and Zinc, while the marine sediment SD-MED pol-1/TM was used as a certified sample.

Table 1: Latitude and longitude of all sampling sites (T1-T7: transects; 1-17: stations) at the area under investigation.

Site	Latitude	Longitude	Depth (m)	Site	Latitude	Longitude	Depth (m)
T1	28° 6` 10"	33° 18` 34"	1-1.5	6	28° 8` 32"	33° 17` 11"	15.0
T2	28° 6` 43"	33° 17` 53"	1-1.5	7	28° 8` 25"	33° 17` 17"	17.0
T3	28° 7` 15"	33° 17` 28"	1-1.5	8	28° 8` 21"	33° 17` 20"	13.5
T4	28° 8` 24"	33° 16` 11"	1-1.5	9	28° 8` 00"	33° 17` 07"	10.0
T5	28° 8` 22"	33° 15` 07"	1-1.5	10	28° 8` 04"	33° 17` 25"	22.0
T6	28° 8` 32"	33° 14` 42"	1-1.5	11	28° 7` 20"	33° 17` 57"	13.0
T7	28° 9` 39"	33° 14` 32"	1-1.5	12	28° 7` 17"	33° 18` 16"	15.0
1	28° 9` 20"	33° 15` 20"	10.5	13	28° 6` 39"	33° 18` 47"	23.0
2	28° 9` 42"	33° 16` 04"	10.0	14	28° 6` 43"	33° 19` 13"	19.0
3	28° 9` 05"	33° 16` 10"	11.0	15	28° 6` 11"	33° 19` 44"	22.0
4	28° 8` 41"	33° 16` 32"	17.0	16	28° 6` 13"	33° 19` 47"	20.0
5	28° 8` 22"	33° 17` 02"	15.0	17	28° 5` 46"	33° 19` 51"	19.0

RESULTS

According to the field observations, the area under investigation was divided into three regions (Fig.1). South to the harbour which has a moderate wave action and sandy shore. It is represented by transects T1, T2, and T3; North to the harbour which has a high wave action and rocky shore. It is represented by transects T4 and T5; The farther north lagoon which has a weak wave action and sandy shore. It is represented by transects T6 and T7.

The low water mark of the first and third regions is mainly fine sand, while it is a sedimentary rock covered by the seaweeds *Sargassum latifolium* and *S. dentifolium* at the second region.

An upper-shore gentle sand slope at about high water of spring tide level with large amounts of stranded debris, garbage, large number of tar balls and some layers of weathered oil which appeared rather like a tar pavement and included sedimentary material. A middle-shore coarse sand slope levelling to a fine sand at the low water mark (regions 1&3) or a sedimentary rock (region 2). The middle- shore usually has huge amount of the seaweeds *Sargassum dentifolium* and *S. latifolium* which are drifted at region 1 or fixed at regions 2 and 3. A shallow back-reef characterized by a sandy bottom with rock strips and bands. The sandy bottom has a community of polychaetes especially bamboo worms (Maldanidae) at region 1. At region 3 (farther north lagoon) *Sargassum dentifolium* and *S. latifolium* usually cover 60% of the rocks at the back reef and usually has a dense community of the economic mollusc *Pinctada radiata* (10 ± 3 individuals/m²).

A reef flat with dead corals, encrusting calcareous algae and rocks with many holes. These holes usually have swarms (30 ± 8 individuals/m²) of the black sea urchin *Echinometra mathaei* and associated giant clam *Tridacna squamosa* with a sporadic occurrence. A reef crest and a reef front are covered with extensive areas of dead corals and some sporadic live corals (1% cover) of the genera *Acropora, Porites, Echinopora* and *Platygyra* were recorded. Dead corals were usually covered by algal lawns and some species of seaweeds with sporadic occurrence especially *Dictyosphaeria cavernosa, Caulerpa serrulata, Padina pavonica, Laurancia obtusa* and *Cystoseira merica.* However, the seaweeds *Sargassium dentifolium, S. latifolium*, and *Grateloupia filicina* were found in small dense patches (0.5m^2). Some fishes were rarely recorded notably *Diplodus noct, Siganus rivulatus, Scarus* spp., *Acanthurus sohal, Chaetodon* spp. and some damsel fishes of *Pomacentrus* spp. and *Chrysiptera* spp. The reef front at the investigated transects usually slopes to sandy seabed with sometimes separate linear *Acropora* spp., extending parallel to the reef front. The collected deep water samples of corals were dead.

Sediment and total organic matter content: Sediments of the investigated area are sandy. According to Wentworth scale, sediment type ranges from very coarse to very fine sand with the predominant coarse sand at most stations. The rate of fine sand (<63μm in diameter) ranged from 0.1 to 24%. Different sites showed high rates of total organic matter content (TOC) with ranges between 6.2 and 9.5% (Table 2). No relation was found between texture of the bottom sediment and total organic matter content.

Hydrocarbon analyses: Data in Table 3 show that all locations were contaminated to different degrees by petrogenic hydrocarbons. However, the degree of contamination of water was low.

Table 2: Percentage of grain size (mm) and total organic carbon (% dry weight) of the bottom sediments of different sampling stations at Ras Shukeir. * Stations 13; 15 not sampled due to the rocky nature of the substrate.

Station No.	Pebbles > 2mm	Very Coarse sand 2 – 1mm	Coarse sand 1-0.5mm	Medium sand 0.5-0.25mm	Fine sand 0.25-0.125mm	Very fine sand 0.125-0.063mm	Silt & clay < 0.063mm	% TOC
1	01.4	23.8	57.4	16.0	01.4	00.0	00.0	8.2
2	02.6	05.6	44.6	16.8	27.8	01.2	01.4	7.5
3	13.8	16.8	33.4	22.8	11.0	01.2	01.0	9.1
4	02.2	03.6	02.8	05.0	26.4	36.0	24.0	8.3
5	08.6	30.8	25.4	18.0	13.0	02.4	01.8	9.3
6	21.8	15.4	35.2	14.2	09.8	03.0	00.6	7.0
7	03.8	06.6	25.2	17.0	29.8	15.2	02.4	7.5
8	07.8	21.6	49.4	18.0	03.0	00.2	00.0	6.2
9	03.8	06.0	20.0	53.0	15.8	00.8	00.6	8.9
10	05.0	12.8	12.4	17.8	26.0	11.0	15.0	9.5
11	01.6	08.0	36.2	49.2	05.0	00.0	00.0	7.2
12	20.8	17.2	34.6	17.8	09.4	00.2	00.0	8.9
14	04.4	22.0	49.1	17.2	06.4	01.0	00.1	7.9
16	13.8	21.4	35.0	26.0	03.8	00.0	00.0	8.0
17	02.0	18.4	52.8	20.8	05.2	00.4	00.4	7.7

The concentrations of total petroleum hydrocarbons (TPH) ranged from 35ppb to 128ppb, while the degree of contamination of sediment by petrogenic hydrocarbons ranged from low to moderate. The highest value recorded was 575ppm total hydrocarbons. Sediments near to the oil terminals showed a higher degree of contamination of petroleum hydrocarbons, with values of 221, 474, 575ppm at stations 6, 7, 8, respectively; and 239ppm at station 12. These relatively high values may be due to a continuous supply of petroleum inputs by oil terminals in this area. There was no correlation between TOC and TPH contents indicating that other organic matter rather than those of the hydrocarbons occur in the area

Heavy metals: In the water, trace metals showed an overall recorded averages of 0.05, 0.1, 0.48, 0.03, 0.06, 0.06 and 0.28ppm for Cu, Pb, Ni, Zn, Cr, Cd and Co, respectively (Table 4).

Table 3: Levels of total Hydrocarbons (THC) in the water (ppb) and sediment (ppm) on the different sampled stations

Station No.	Water (ppb)	Sediment (ppm)
1	050	084
2	128	098
3	052	026
4	065	059
5	062	363
6	-	221
7	-	474
8	-	575
9	042	147
10	035	266
11	055	129
12	-	239
13	093	-
14	-	432
15	086	-
16	-	011
17	077	111
Mean	67.7± 26.8	218.6± 170.8

- Not sampled stations.
Mean ± St Deviation

Table 4: Concentration of heavy metals in water and sediments samples (ppm) at different stations at Ras Shukeir. Mean ± St Deviation

Station #	Cu	Pb	Ni	Zn	Cr	Cd	Co
Water							
1	0.07	0.07	0.54	0.04	0.01	0.09	0.28
2	0.02	0.10	0.46	0.02	0.07	0.05	0.24
3	0.01	0.12	0.16	0.02	0.04	0.01	0.15
4	0.07	0.14	0.57	0.04	0.01	0.07	0.32
5	0.09	0.05	0.32	0.02	0.14	0.04	0.20
9	0.03	0.10	0.39	0.02	0.11	0.06	0.25
10	0.06	0.06	0.41	0.03	0.08	0.05	0.26
11	0.06	0.14	0.62	0.03	0.05	0.06	0.30
13	0.04	0.11	0.72	0.05	0.06	0.08	0.33
15	0.01	0.09	0.68	0.02	0.08	0.06	0.26
17	0.07	0.08	0.44	0.02	0.03	0.06	0.26
Mean	0.05±0.03	0.10±0.03	0.48±0.16	0.03±0.01	0.06±0.04	0.06±0.02	0.28±0.05
Sediment							
1	54.2	28.8	12.0	38.6	11.8	01.8	09.4
2	31.6	24.4	19.0	30.4	13.2	03.9	12.6
3	64.0	40.2	17.1	15.6	18.6	01.6	17.6
4	20.6	30.2	11.8	48.8	11.6	00.7	12.4
5	35.2	38.4	16.1	44.0	08.8	02.2	10.0
6	21.2	18.2	04.7	38.8	17.6	01.2	04.2
7	25.8	15.6	19.0	89.8	14.4	00.4	11.6
8	33.1	21.6	27.7	115.9	27.4	02.2	17.6
9	26.8	22.0	06.1	35.8	09.6	05.7	06.4
10	26.6	24.4	17.2	34.8	05.0	06.5	06.6
11	53.2	28.3	09.5	35.6	21.8	05.8	10.4
12	36.6	17.0	12.9	20.4	10.0	04.9	13.4
14	31.8	22.2	04.8	36.2	13.2	04.9	13.6
16	25.0	37.4	11.1	15.0	16.0	02.9	08.2
17	29.4	43.6	17.6	57.1	06.7	03.6	15.9
Mean	34.3±12.9	27.5±08.9	13.8±06.2	43.8±27.0	13.7±05.9	03.2±02.0	11.3±04.0

In sediment, trace metals showed higher values with an overall recorded averages of 34.34, 27.49, 13.81, 43.79, 13.71, 3.22 and 11.33ppm for Cu, Pb, Ni, Zn, Cr, Cd and Co, respectively (Table 4). It is clear that the concentrations of heavy metals in Ras Shukeir sediments were higher than the lowest effective levels.

DISCUSSION

The Gulf of Suez is one of the largest and most rapidly developing oil production areas of the world (Dicks 1984). Several offshore and inshore oil fields have been discovered and are being exploited at Ras Gharib, Ras Shukeir, Gimsha and Hurghada (Mansour 1986). This together with increasing tanker and cargo vessel traffic through the Red Sea, result in a chronic oil pollution along the Gulf of Suez coasts (Mourcy 1978; Awad *et al*. 1983; Hanna 1983; Mostafa 1995). Recently, Abdel-Maksoud (1997) mentioned that 18 accidental oil spills have occurred in the Northern Red Sea, Suez and Aqaba Gulfs from 1989 to 1994.

Oil developments can produce environmental stress during their construction and operation phases, notably around offshore platforms and shore terminals (Dicks 1984). Coral reefs are susceptible to damage from oil (Loya & Rinkveich 1980; Ray 1981; Johannes *et al*. 1977); drilling mud (Thompson & Bright 1977); dispersant (Knapp *et al*. 1983; Legore 1983). Effects ranges from mortality to abnormal responses and reduction of growth and reproduction processes.

During the present investigation at Ras Shukeir, the highest recorded levels of petroleum hydrocarbons were 128ppb in water and 575ppm in sediment. Tewenty years ago (Awad, unpublished), the concentrations of oil at Ras Shukeir area were 261ppb and 1424ppm in water and sediment respectively. Recent study by Emara *et al*. (1999) showed that the petroleum hydrocarbons in sediment of Gemsha area (near to Ras Shukeir) was 883 ppm.

The results concerning the present investigation also show that most of the investigated shores are oiled. These oily polluted shores are mainly due to activities related to oil production at Ras Shukeir or oil spills (Awad 1988). Tar balls, mats, and pavements are densely present at Ras Shukeir shore, and mostly of weathered type. This can be attributed to past oil production, refining, and transport which have resulted in chronic oil pollution at Ras Shukeir and along Gulf of Suez (IMCO 1971; Wenninck & Nelson-Smith 1977, 1979a,b; Mourcy 1978; Awad *et al*. 1983; Hanna 1983; Dicks 1984, 1987; Mostafa 1995).

This chronic oil pollution has serious environmental impacts on the gulf marine life. The investigated coral community of Ras Shukeir is seriously degraded. About 99% of coral coverage is destroyed. Also, most of associated invertebrates, fishes, and seaweeds are sporadic or rare. Many studies (Mironov 1968, 1972; Kunhold 1969; Blumer 1971; Wells 1972; Cohn 1973; Capuzzo 1987; Bender *et al*. 1988; Coccheri 1990; Balch 1995) reported that oil and oil products usually influence all groups of marine organisms in the various water layers and at the sea bottom through asphyxiation, poisoning, reducing natural resistance of organisms to infection, interruption of the marine food web propagation. It affects microscopic marine organisms, fishes, mammals and birds as well. Water soluble components of crude oils and refined products include a variety of compounds that are toxic to a wide spectrum of marine plants and animals. Eggs, larvae and young forms are generally more sensitive than adults. The effect may be acute (short-term) or chronic (long-term) depending on the characters of source of the spilled petroleum and characteristics of the marine environment. At sub-lethal concentrations, oil constituents cause physiological or behavioral abnormalities and possibly more importantly, may cause developmental abnormalities in fish and other animals, almost certainly resulting in their early death (Clark 1986).

On short-term basis with an immediate effect, many studies (Grant 1970; Spooner 1970; Shinn 1972; Rutzler & Sterrer 1970; Gooding 1971; Roberts *et al.* 1994; Mohamed & Al-Ssadh 1996) showed no damage on corals for the floating oil. But on long-term basis of chronic effects, corals are seriously damaged. Moreover chronic oil pollution prevents in some way, development of young coral colonies. This interference may be due to some chemical changes in the physical properties of the reef flat, or to some biological interference connected with the coral themselves. It is possible that oil damages the reproductive system of corals, which may interfere with coral larvae production, or there might be adverse effects on the viability of the larvae themselves, inhibiting them from successful settlement and normal development (Loya 1975).

One of the basic features of chronic man-made disturbances on coral reef is the risk of non-reversibility of this environment to its normal community structure. The frequent oil spills in the vicinity of Ras Shukeir area have caused catastrophic consequences on a wide variety of coral reef communities resulting in their nearly complete destruction with no signs of near future recovery. Johannes (1975) stated that " when a reef community is destroyed, the ecological conditions that follow can not be expected to coincide with those which preceded the initial development of the community". Thus, it cannot be granted that the community will ever replace itself. This was confirmed through a long-term study on corals in the Gulf of Aqaba (Loya 1976).

Also, oil pollution could lead to high heavy metal concentrations in the sediment. The present investigation showed highest levels of heavy metals with ranges of 34.34; 27.49; 13.81; 43.79; 13.71; 3.22; and 11.33 for Cu, Pb, Ni, Zn, Cr, Cd, and Co, respectively. These values are higher or very near to the lowest effective level as mentioned by El-Tokhi & Mostafa (1999). Emara *et al*. (1999) stated that the annual average concentrations values of heavy metals in sediments of Ras Shukeir were 2.56; 13.69; 79; 1.88 and 4 for Cu, Pb, Zn, Cd, Co, respectively. The recorded high levels could impose a threat to marine life.

Finally, it can be concluded that coastal pollution by oil along the Gulf of Suez is chronic at some sites (e.g. Ras Shukeir), has led to serious environmental impacts on its fringing coral reefs and the associated biota. Both, the short-term and the chronic effects should be considered. The slight day to day spills in coastal waters accumulate into chronic pollution that is much larger in total volume and probably has severe biological consequences. Community structure and species abundance of marine organisms may be changed for long periods of time following, a single oil spill and perhaps change more in areas subjected to chronic oil pollution.

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REFERENCES

Abdel-Maksoud MMH (1997) The accounting measurement of removal costs of marine pollution by petroleum resulting from ships under Arm's Length Standard. M. Sc. Thesis, Faculty of Commerce, Suez Canal university.

Awad H (1988) Potential and causes of accidental oil spills in the Red Sea and Gulf of Aden (1974-1986). *Bull. Inst. Oceangr. And Fish., ARE* 14(1): 293-296.

Awad H, Michel P & El-Shazly A (1983) Actual situation of oil pollution in the ecosystem along the Egyptian Red Sea coast. *Bull. Inst. Oceangr. and Fish. ARE* 9: 102- 108.

Balch GC, Metcalfe CD & Huestis SY (1995) Identification of potential fish carcinogens in sediments from Hamilton Harbour, Ontario, Canada. *Enviro. Toxicol. Chem*. 14(1): 79 – 91.

Bender ME, Hagris WJ, Hugget RJ & Roberts Jr (1988) Effect of polynuclear aromatic hydrocarbons on fishes and shellfish, an overview of research in Virginia. *Mar. Envir. Res.* 24: 237 – 241.

Blumer M, Sanders HL, Grassle FJ & Hampson GR (1971) A small oil spill. *Environment, St. Louis, Mo*. 13: 1-18.

Byers SC, Mills EL & Stewart PL (1978) A comparison of methods of determining organic carbon in marine sediments, with suggestions for a standard method. *Hydrobiological* 58: 43-47.

Capuzzo, JM (1987) Biological effects of petroleum hydrocarbons. Assessments from experimental results. In: Long-term environmental effects of offshore oil and gas development. (White HH, Ed.). Elsevier Applied Science, London. pp: 343 – 410.

Chabanet P, Dufour V & Galzin R (1995) Disturbance impact on reef fish communities in Reunion Island (Indian ocean). *J. Exp. Mar. Biol. and Ecol.* 188: 29 – 48.

Coccheri RW, Antonio A & Anna MM (1990) Polycyclic aromatic hydrocarbons in marine organisms from Italian central Mediterranean coasts. *Mar. Poll. Bull.* 22(1): 15 – 18.

Cohen Y (1973) Effects of crude oil on the Red Sea alcyonarian *Heteroxenia fuscescens*. MSc Thesis. The Hebrew University of Jerusalem. 49pp.

Connell DW (1970) Protecting the Great Barrier Reef . *Mar. pollut . Bull.* 1: 51-52.

Dicks B (1982) Monitoring the biological effects of North Sea platforms. *Mar. pollut. Bull.* 13: 221-227.

Dicks B (1984) Oil pollution in the Red Sea – Environment monitoring of an oil field on a coral area, Gulf of Suez. *Proc. of Mabahiss / John Morray Syposium: Marine science of the North-West Indian Ocean and adjacent waters. Sept. 1983 Alexandria, Egypt, UAR.*

Dicks B (1987) Pollution: In Red Sea Key Environment*. (*Edwards AJ & Hread SM, Eds.). Pergamon Press, 441pp.

Dubinsky Z & Stambler N (1996) Marine pollution and coral reefs. *Glob. Chan. Biol*. 2(6): 511 – 526.

Eisler R, Kissil GW & Cohen Y (1974) Summary of recent studies on biological effects of crude oils and oil dispersant mixtures to Red Sea macro fauna. In : EPA seminar on methodology for monitoring the marine environment. (Verner SS, Ed.). U.S. Enviro. Monit. Ser.: 156- 179.

El-Tokhi MM & Mostafa YM (1999) Heavy metals and petroleum hydrocarbons contamination of bottom sediments of El Sukhna area, Gulf of Suez, Egypt. *Proceeding of the 3rd International Conference on Petroleum and the Environment, 4-6 December 1999.*

Emara AMM (1999) Surveillance and biological studies on the intertidal mollusks along the western coast of the Gulf of Suez, Egypt. PhD Thesis, Faculty of Science, Tanta University, 218pp.

Fishelson L (1973b) Ecology of coral reefs in the Gulf of Aqaba (Red Sea) influenced by pollution. *Oecolog. (Berl.)* 12: 55-67.

Gooding RM (1971) Oil pollution on Wake Island from the tanker R.C. stoner. *Spec. Scient. Rep. U.S. Fish wildl . Serv. (Fish)* 636: 1-10.

Grant EM (1970) Notes on an experiment upon the effect of crude oil on live corals. *Fish. Notes Dept. prim. Ind., Brisbane* 1: 1-13.

Hanna RM (1983) Oil pollution on the Egyptian Red Sea coast. *Mar. Pollut. Bull.* 14: 268-271.

Heinrichsen D (1990) Our common seas. Coasts in crises. Earthscan publications, London, U.K., 184pp.

Hodgson G (1999) A global assessment of human effects on coral reefs. *Mar. Pollut. Bull.* 38(5): 345 – 355.

Horler KM (1974) The oil exploration industry's role in the royal commissions into oil drilling on the Great Barrier Reef. In*:* Second international symposium on coral reefs, Vol. 2. (Camerom AM et al., Eds.). Great Barrier Reef Commission, Brisbane, Australia. pp. 703 – 714.

IMCO (1971) International conception on the establishment of an international fund for compensation for oil pollution damage. IMCO, London.

Johannes RE (1970) How to kill a coral reef - *I. Mar. Pollut. Bull.* 1: 186-187.

Johannes RE (1971) How to kill a coral reef *-II. Mar. Pollut. Bull.* 2: 9-10.

Johannes RE (1972) Coral reefs and pollution. In: Marine pollution and sea life, (Ruivo M, Ed.). London, Fishing News (Books) Ltd. 624 pp.

Johannes RE (1975) Pollution and degredation of coral reef communities. In: Tropical marine pollution. (Ferguson Wood EJ & Johannes RE, Eds.). Elsevier, Amsterdam. pp: 13-51.

Johannes RE, Maragos J & Coles SL (1972) Oil damages corals exposed to air. Mar. *Pollut. Bull*. 3: 29-30.

Knapp AH, Sleeter TD, Wyers SC, Frith HR, Smith SR & Dodge RE (1983) The effects of oil spills and dispersant use on corrals: a review and multidisciplinary experimental approach. *Oil and Petrochem. Pollut.* 1: 157- 170.

Kunhold WW (1969) Der Einfluss wasserloslicher bestandteile von Roholen und Roholfraktionen auf die entwicklung von heringsbrut. *Ber. Dt. Wiss. Kommn meeresforsch.* 20: 165-171.

LeGore RS (1983) A field experiment to assess impact of chemicals dispersed oil on Arabian Gulf corals. In: *Proceeding of Middle East Technical Conference of the Society of Petroleum Engineers, Manama, Bahrain.* : 51-59.

Lewis JB (1971) Effects of crude oil and oil-spill dispersant on reef corals. *Mar. Pollut. Bull*. 2: 59-62.

Loring DH & Rantala RTT (1992) Manual for geochemical analysis of marine sediments and suspended particulate matter. *Earth Sci. Rev*. 32: 235-283.

Loya Y (1975) Possible effects of water pollution on the community structure of Red Sea corals. *Mar. Biol.* 29: 177-185.

Loya Y (1976) Recolonization of Red Sea corals affected by natural catastrophes and man-made perturbations. *Ecol.* 57:278-289.

Loya Y & Rinkevich B (1980) Effect of oil pollution on coral reefs communities. *Mar. Ecol., Prog. Ser*. 3: 167-180.

Mansour TMS (1986) Contribution to the study of pollution by oil on some regions of Gulf of Suez. PhD Thesis, Faculty of Science, Ain Shams University, Egypt.

Mironov OG (1968) Hydrocarbon pollution of the sea and its influence on marine organisms. *Helgol. Wiss. Meeres.* 17: 335 – 339.

Mironov OG (1972) The effect of oil pollution on the flora and fauna of the Black Sea. In: Marine pollution and sea life. (Ruivo M, Ed.). London: Fishing News (Books) Ltd. 624pp.

Mohamed SZ & Al-Sadh S (1996) Coral reef grounds and its associated biota in the western side of the Arabian Gulf (ROPME Sea Area) with respect to 1991 Gulf war oil spill. *Indian J. Mar. Sci.* 25: 35-40.

Mostafa YM (1995) Studies on the hydrocarbon pollutants in the marine environment of the Red Sea Gulfs and Suez Canal. PhD Thesis, Faculty of Science, Ain Shams University.

Mourcy A (1978) A field study of oil pollution of the Egyptian coast of the Red Sea. National Research Center, Cairo, Egypt.

Ray JP (1981) The effects of petroleum hydrocarbons on corals. *In: Proceedings of petromar 80 conference, petroleum and the marine environment, Monaco, Graham and Trotman.* : 705-726.

Roberts CM, Downing N & Price RG (1994) Oil on troubled waters: impacts of the Gulf war on coral reefs. In: Proc. Colloquium on Global Aspects of Coral Reefs: Health, Hazards and History. (Ginsburg RN, Ed.). RSMAS Miami 1993. pp: 214-219.

Rützler K & Sterrer W (1970) Oil pollution: Damage observed in tropical communities along the Atlantic Seaboard of Panama. *Biosci*. 20: 222-224.

Shinn EA (1972) Coral reef recovery in Florida and the Persian Gulf. Environmental Conservation Dept. Shell Oil Company, Houston, Texas.

Spooner M (1970) Oil spill in Tarut Bay, Saudia Arabia. *Mar. Pollut. Bull.* 1: 86-87.

Straughan D (1970) Redressing the balance on the reef. *Mar. Pollut. Bull*. 1: 86-87.

Thompson JH & Bright TJ (1977) Effects of drill mud on sediment clearing rates of certain hermatypic corals. In: *proceeding of 1977 oil spill conference, New Orleans. Environmental Protection Agency/ American Petroleum Institute / United States coast Guard: 495- 498.*

UNEP/ IAEA/ IOC (1992) The determination of petroleum hydrocarbons in sediments. Reference Methods for Marine Pollution Studies, No. 20, 75pp.

Wells PG (1972) Influence of Venezuelan crude oil on lobster larvae. *Mar. Pollut. Bull.* 3: 105-106.

Wenninck CJ & Nelson-Smith A (1977) Coastal oil pollution evaluation study for the Kingdom of Saudia Arabia, 1. Red Sea coast, 2. Gulf coast. International Maritime consultative organization, London.

Wenninck CJ & Nelson-Smith A (1979a) Coastal oil pollution studyfor the Gulf of Suez and the Red Sea coast of the Republic of Egypt. International Maritime consultative organization, London. Part A: p. 89.

Wenninck CJ & Nelson-Smith A (1979b) Coastal oil pollution evaluation study for the Gulf of Aqaba coast of the Hashemite Kingdom of Jordan. International Maritime consultative organization, London.

الملخص العربى

دراسة بيئية لتأثير التلوث البترولى على الشعاب المرجانية بمنطقة رأس شقير بخليج السويس - البحر الأحمر - مصر.

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بدراسة الشعاب المرجانية بمنطقة رأس شقير بخليج السويس والظروف المحيطة بها تبين أن مايقرب من 99% من الغطاء النسبى للشعاب المرجانية قد تدهور ومات حيث يوجد بمنطقة الدراسة قليل جدا من المستعمرات المرجانية من جنس *الأكروبورا، أكتينوبورا، بلاتيجيرا* ممثلة بحوالى 1% من الغطاء النسبى للشعاب المرجانية. كذلك أظهرت اللافقاريات المصاحبة للشعاب المرجانية ندرة بالغة حيث تم فقط تسجيل قنفذ البحر *اكينومترا ميثاي* ومحار البصر *ترايداكنا سكواموزا*. وقد أظهرت الطحالب البحرية ندرة للأنواع *ديكتيوسفريا كفرنوسا، كوليربا سيريولاتا، بادينا بافونيكا، اورانسيا أوبتوسا*، بينما أظهرت الأنواع *سارجسم دانتفوليم، سارجسم لاتفوليم*، و *جراتيلوبيا فيليسينا* بقع كثيفة ذات مساحة صغيرة بمنطقة الرصيف المرجانى. كما سجلت على واجهة الشعاب بكثافات قليلة كل من أسماك العصافير من أجناس *بوماسنترس, كريزيبترا*, وأسماك الفراشات من جنس *كيتودون*, و أسماك الجراح من جنس *أكانسس*، وأسماك الببغاء من جنس *أسكارس*. وبرغم أن الحالة البيئية الراهنة تشير الى أن مستوىالتلوث البترولى لمنطقة رأس شقير يتراوح بين منخفض الى متوسط نتيجة لتطبيق القواعد البيئية بشركة جابكو, فأن حالة الشعاب المرجانية والأحياء المصاحبة لها تعانى من تدهور شديد ولا يوجد أى دلائل على قرب استعادة المنطقة لحالتها البيئية الطبيعية نظرا لتلوث المنطقة بالبترول منذ أمد بعيد.