JKAU: Mar. Sci., **Vol. 21**, No. 2, pp: 89-108 (2010 A.D. / 1431 A.H.)
DOI : 10.4197/Mar. 21-2.7

Assessment of Marine Ecosystem Degradation Based on Studying the Geological Significances of Bottom Sediments in Sharm Obhur, North Jeddah, Saudi Arabia

Amin M. Gheith and **Mohamed S. Hariri***
Faculty of Science, Geology Department,
Mansoura University, Mansoura, Egypt
**Faculty of Marine Science, King Abdullaziz University,*
Jeddah, Saudi Arabia

Abstract. Our investigations focus on the significance of texture, fauna, minerals and chemical characteristics of bottom sediments of Sharm Obhur. The back reef zones were subjected to filling, dredging and cutting processes for constructional and urbanization purposes. Shores morphology and sediment properties are changed.

The geological study emphasized the nature, composition and chemical characteristics of sediment veneer in addition to the impact of human activity on the environmentally sensitive area like Sharm Obhur. Sediments are believed to be the last sink for contaminants that reach the sea. It is therefore, sedimentary regime to investigate and understand the depositional pattern of sediments.

The study proved that Sharm Obhur bottom environment and its shores suffered deterioration due to uncontrolled development. Heavy metals; Zn, Cu, Ni, Cd beside minor elements; Fe and Mn have been increased in bottom sediments most probably due to human activities. The fine sediments are favourable site for the fixation of organic matter and trace elements.

Introduction

Sharm Obhur lies to the north of Jeddah (Fig. 1) and it has a total length of about 10 km. Geologically, Sharm Obhur was the ancient mouth of Wadi Al Kura (Skipwith, 1973) and opens into the Red Sea through a narrow oulet. The bottom depth at the outlet is about 40 meters and gradually decreases landward. The Sharm has a broad flat bottom that gradually becomes narrower towards the sea (Behairy, 1980). Most of the sediments in the Sharm are carbonates mixed with the terrigenous material.

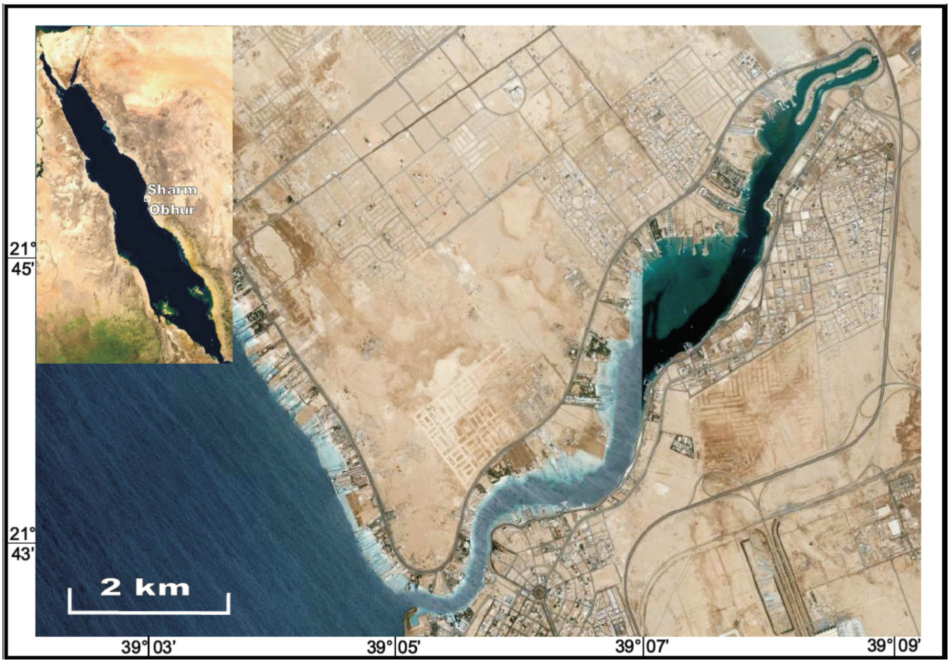

Fig. 1. Quick Bird Satellite Images, 2008 showing the location of Sharm Obhur and its surrounding.
(Source, Quickbird images in Google Earth™, http://earth.google.com).

The banks of the Sharm are characterized by the coral limestone which occurs as raised terraces about 3 m high from the present sea level in the Sharm (Behairy, 1980).

Land reclamation around the Sharm and construction of coastal hotels also affect sediment loading of the water which causes serious losses of coastal habitats. In particular, the semi-enclosed nature of Sharm Obhur together with the low water exchange with the Red Sea. Sewage inputs in the Sharm may result increasing nutrient and suspended solid loading.

Most previous studies on Sharm Obhur are concerned with textural and mineralogical characteristics of the bottom surficial sediments (El-Sabrouti, 1983 and Basaham and El-Shater, 1994), hydrography and water budget (El-Rayis and Eid, 1997), spatial distribution of heavy metals (Fahmy and Saad, 1994). Lately Bantan and Rasul (2003) and Basaham *et al*. (2006) studied the impact of development on shore configuration of Sharm Obhur and the characteristics of its bottom sediments. They concluded that human interference has distinctly changed the configuration of Sharm Obhur. The area of the Sharm has been decreased by 800,000 m² between 1986 and 2000 due to filling processes. This leads to loss of coral reef ecosystem and its particular habitats. Furthermore, the bottom is densely covered with litter composed of plastic, bottles, cans and tyres.

In general, the type of fauna is influenced by seawater salinity, temperature and light. The flora are controlled by the light. The penetration of light is affected by the turbidity of seawater. While benthonic life depends on the nature of the substrate upon which they live. On hard rocks, multitude of organisms are requiring a firm substrate on which to attach their tests, shells or colonies. While in the bottom sediments different types of organic community, many animals burrow in the sediment, either for protection or for food. Plants occur in the shallower areas and form thick carpets of vegetation.

Published literatures on the impact of pollutants on Sharm Obhur habitats are scarce. Behairy *et et al.,* (1983) carried out an investigation on certain heavy metals in water, sediments and plankton from Obhur Creek. They mentioned that the creek was receiving little fresh water input and has restricted water exchange with the Red Sea. Fahmy and Saad (1994) dealt with the temporal and spatial distribution of heavy metals in both surface water and plankton i in Obhur Creek. Their work showed that the increase in the concentrations Mn, Cu, Zn and Cd is due mainly to the human activities.

Physiography, Hydrography and Geology

Obhur creek is a crevasse eroded in the coral reef that has a length of about 10 km inland with a general trend N45˚E. It is considered to be drowned river valley formed during lowered sea level and at time when the rainfall was greater in the region (Chapman, 1978). The water depth at the inlet is about 40 meters and gradually decreases landward (Behairy *et al.,* 1983). It has a broad flat bottom that gradually becomes narrower toward the sea. It opens into the Red Sea at its southwestern end through a narrow outlet having a width of 264 m (Fig.2). Very little terrigenous material is supplied to the lagoon bottom from the adjacent land that mixed with the carbonate sediments, while the nearshore shelf sediments is an active carbonate depositional region with wide spread fringing coral reefs. The seawater temperature in Sharm Obhur varied from 24.4˚ C in winter to 32.2˚ C in summer while salinity ranged between 39.1 and 40.2 (Ahmed and Sultan, 1993). Two layers flow at the entrance; inflow of low salinity water at both surface and intermediate depths and outflow of more saline water at the bottom (El-Rayis and Eid, 1997).

Fig. 2. QuickBird Satellite Images, 2008 showing the outlet of Sharm Obhur at its southwestern extremity. (See rapid development of Obhur and its surrounding area).

Sharm Obhur is located in the western and lower part of the Red Sea coastal plain of Saudi Arabia known as Tihama. To the east of the Sharm lies the upper section of Tihama, which is a pediment cut on Tertiary and Precambrian rocks. Obhur creek divides the area into a northern and a southern part. On the southern Obhur, the lower Tihama consists of a gently sloping flat surface of coralline limestone sometimes covered by a thin layer of coralline and shelly silty sand. In the north Obhur, a coastal strip of raised reefal limestone about 0.5 km wide lies between the coast and relatively lower inland areas covered with soil. This area has a salt encrusted surface and together, they constitute a coastal sabkha, as defined by Kinsman (1969). Basaltic lava flows ranging in age from Eocene to the present occur in abundance and cover sedimentary sequence to the east of the area. The flow is extended also into the coastal plain, where it now caps the ridge of Tertiary sediments within the north-eastern part of Obhur. The coralline limestone in the Jeddah area may be considered to be Late Pleistocene and associated with the last period of higher sea level in the west coast of Saudi Arabia (Skipwith, 1973).

Materials and Methods

A reconnaissance survey of the Sharm was carried out to select the sampling locations. For sediment sampling, consideration was given to the locations that are extensively used by the people as recreational area and to the areas nearer to the anthropogenic activity. Bottom sediment samples were collected using a grab sampler (24 samples have been collected along 8 transects through the Sharm, Fig.3). Samples are collected especially from the shore and from the centre of the Sharm (*i.e.* 3 samples along each transect). The aim of the present work is to compare our data with results obtained by others. It serves as an assessment of the current state of the conditions in the Sharm.

The sediment samples are air-dried and portions from each sample are investigated under the binocular microscope. Carbonate content and total organic matter were determined using dilute HCl and the modified Walkely and Blacks method as described by Black (1965), respectively. Grain size analysis was carried out on the collected sediment samples using the dry sieving method. The grain size statistical parameters; median diameter, sorting and skewness after Trask (1930) are calculated. The bulk minerals- and clay minerals contents are determined using X-ray diffractometry (Schimadzu XRD-600). Concentrations of heavy metals; Fe, Mn, Zn, Co, Ni, Cr and Pb are determined using atomic absorption spectrophotometry technique (Perkin Elmer A. Analyst 800). Benthic fauna are identified under the binocular microscope.

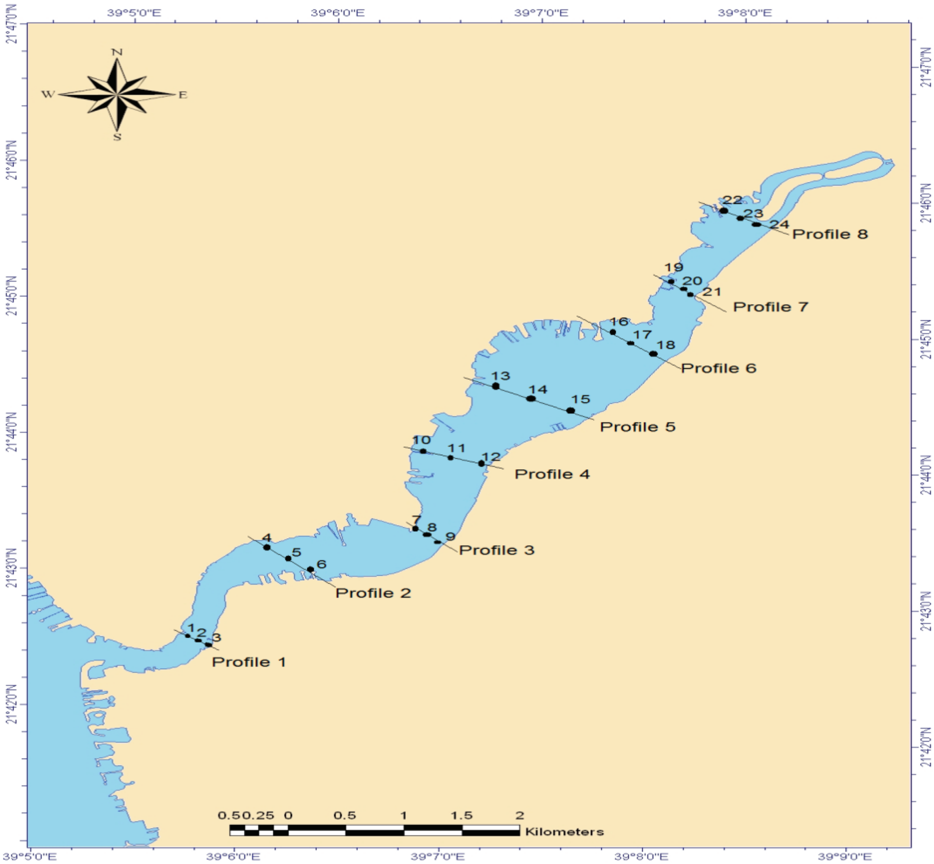

Fig. 3. Location map for the transects and the sampling Stations.

Results and Discussion

Nature and Composition of the Bottom Sediments

Table 1 shows the biogenic composition of sediment samples. The biogenic composition reflects the sedimentation conditions. The sediment samples are either pure biogenous especially on the northern border or mixed with little siliciclastic grains. The central part of the Sharm is covered with calcareous mud. The biogenous particles are rounded fine grains coral reef debris, benthic foraminifera, cerithidia, radiolarian, diatoms, petropod shell fragments, fish skeletal parts, algal grains, siliceous sponge spicules and various shell fragments. The sediment samples covering the southern border of the Sharm contains gravels and coarse-grained asphaltic materials. Most of the grains are coated with gray clay material. The siliciclastic constituents include well rounded fine to very fine quartz and feldspar sand grains with pitted surface textures indicating their aeolian origin.

Table. 1. Lithological description of the sediment samples under the binocular microscope.

S.No.	Description
1	Pure biogenous sediments, medium-grained with few coarse particles, enriched with microfossils; benthic, cerithidia, radiolarian, diatom, siliceous sponge spicules, petropod shells and shell fragments.
2	Calcareous muddy sands, greenish gray, rich with benthic foraminifera species.
3	Biogenous calcareous sediments, mostly fine-grained rich with benthic foraminifera. Asphaltic particles of dark gray and aeolian fine quartz grains are noticed.
4	Biogenous calcareous sediments, very fine-grained sands rich with sponge spicules, fish skeletal parts, shell fragments, clear benthic foram.
5	Grayish calcareous biogenous sediments mostly medium grained with clay rich materials, benthic foram and shell fragments.
6	Biogenous coral grains medium grained, petropods, shell fragments, radiolarian, diatoms and sponge spicules.
7	Biogenous clear components, very fine grained rich with radiolarian, shell fragments, siliceous sponge spicules, with few benthic foram.
8	Light gray calcareous muddy sediments.
9	Biogenous sediments, coral rich particles, benthic foram, petropods, gastropods, fish particles, siliceous spicules, mixed with coarse sand and dark fine materials.
10	Rounded coral fine particles, fine to very fine- grained.
11	Pure calcareous muddy sediments.
12	Biogenous sediments, formed of coral particles, rich with benthic foram,gray particle materials, grains coated by calcareous mud.
13	Biogenous fine-grained sediments rich with rock and shell fragments.
14	Pure calcareous muddy sediments.
15	Biogenous fine to coarse- grained sediments rich with benthic foram.
16	Fine-grained calcareous sediments rich with coral particles and shell fragments.
17	Calcareous muddy sediments.
18	Biogenous sediments, gravelly to coarse grained rich with gray particles, most grains coated by calcareous mud.
19	Biogenous sediments, medium to coarse grained rich with shell fragments, benthic foram and recent bivalves.
20	Calcareous muddy sediments.
21	Absent of sediments due to hard coral reef bottom.
22	Gravelly shell fragments and coral particles. Biogenous sediments rich with cerithides, gastropods, most of the grains are coated by calcareous fine mud.
23	Calcareous muddy sediments.
24	Mixed carbonate siliciclastic materials rich with feldspar, quartz, mica, benthic foram, aeolian sands and dark gray particle materials.

Carbonate and Organic Matter Contents

The percentages of carbonate content and organic matter are shown in Table 2. All sediment samples show high concentrations of carbonates (76.6% to 100%) with an average of 79.1%. The contents of organic matter range between 1.7% and 11.6% with an average 4.7%. However, the high content of organic matter in the Sharm is probably related to its confined nature.

On the other hand, the nearshore sediments in the northern Cornish of Jeddah had an average organic carbon equal 0.38% . However very high values with an average of 7% were reported by El-Sayed (1987) in Ras Hatiba lagoon, north of Jeddah, probably due to the formation of algal mats on the lagoon bottom. The highest organic carbon concentration (with an average of 9.54%) was recorded in Al-Arbaeen lagoon and Albankalah sediments.

Table. 2. Carbonate contents and total organic matter contents in Sharm Obhur sediments.

S.No.	Carbonate %	Organic matter %
1	77.8	3
2	77.6	4.6
3	78.6	3
4	78	3.6
5	79	5.2
6	78.4	3.6
7	77.6	3
8	80.6	11.6
9	78.2	3.4
10	78.2	3
11	76.6	7.6
12	77	4.2
13	-	-
14	78.6	6.8
15	77.6	4
16	77.4	3.8
17	78.2	8.2
18	77.8	3.8
19	77.8	3.8
20	78.4	7.2
21	100	-
22	78.4	3
23	79.6	5.8
24	78.2	1.8
average	79.1	4.7

Grain Size Analysis

The data of grain size analysis are given in Table (3). Gravels occur in low amounts with a maximum content of 19.2%. Sand content dominates and varies from 80.76% to 98.98%. Clay dominates in the central part of the Sharm which agrees with observation carried out by Basaham and El-Shater (1994).

Table 3. The bottom sediment texture in Sharm Obhur.

Sa.No.	Gravel	Sand	Mud	Texture classification (After Folk, 1968)
1	1.7	96.02	2.28	Sand
2	9.56	90.44	0	Sand
3	1.32	98.36	0.32	Sand
4	0.12	88.64	11.24	Clayey sand
5	1.02	98.98	0	Sand
6	0.0	90.48	9.52	Clayey sand
7	0.08	91.96	7.96	Clayey sand
8	-	-	100	Mainly mud
9	14.42	84.70	0.88	Gravelly sand
10	11.0	88.76	0.24	Gravelly sand
11	-	-	100	Mainly mud
12	0.44	92.08	7.48	Clayey sand
14	-	-	100	Mainly mud
15	19.12	80.76	0.12	Gravelly sand
16	0.12	99.68	0.2	Sand
17	-	-	100	Mainly mud
18	12.6	87.34	0.06	Gravelly sand
19	0.22	99.62	0.16	Sand
20	-	-	100	Mainly mud
22	8.64	91.04	0.32	Gravelly sand
23	-	-	100	Mainly mud
24	2.8	92.48	4.72	Gravelly clay sand

The weight percentages of different size fractions are represented in Fig. (4). It was observed that all histograms have asymmetrical unimodal distribution with dominant modal class falling in the very fine-grained, the fine-grained and the medium-grained sizes. Few histograms exhibit addition of coarse material.

In order to describe median diameter, sorting and skewness; the grain size parameters of Trask (1930) have been applied for giving simple and quick description for the sediments. Results obtained are listed in Table (4). Sediment samples from Sharm Obhur have median diameters varying from very fine-grained, fine-grained to medium-grained. Only 3 samples exhibit coarse–grained median diameter. Sediments in Sharm Obhur are mostly coarse skewed and well sorted except one sample can be described ill sorted. The coarse grained median diameter on the other hand, indicates material eroded near the site of meandering shores.

Table. 4. Grain size parameters after Trask (1930).

Sa.No.	Median Diameter	Sorting	Skewness
1	2.2 fine-grained	1.6 well sorted	0.74 coarse skewed
2	2.6 ,, ,,	3.3 ill sorted	0.15 ,, ,,
3	1.9 medium-grained	1.4 well sorted	0.90 ,, ,,
4	3.5 v. fine-grained	1.2 ,, ,,	0.84 ,, ,,
5	3.1 ,, ,, ,,	1.3 ,, ,,	0.78 ,, ,,
6	2.8 fine-grained	1.3 ,, ,,	0.94 ,, ,,
7	2.8 ,, ,,	1.2 ,, ,,	0.88 ,, ,,
9	0.8 coarse-grained	1.7 ,, ,,	-2.19 ,, ,,
10	1.6 medium-grained	2.3 ,, ,,	0.80 ,, ,,
12	2 fine-grained	1.5 ,, ,,	0.87 ,, ,,
15	0.6 coarse-grained	1.9 ,, ,,	-1.66 ,, ,,
16	2.7 fine-grained	1.1 ,, ,,	0.99 ,, ,,
18	0.9 coarse grained	1.7 ,, ,,	-1.7 ,, ,,
19	2.3 fine-grained	1.2 ,, ,,	0.94 ,, ,,
22	0.6 coarse-grained	1.5 ,, ,,	-2.66 ,, ,,
24	3.2 v. fine-grained	1.2 ,, ,,	0.78 ,, ,,

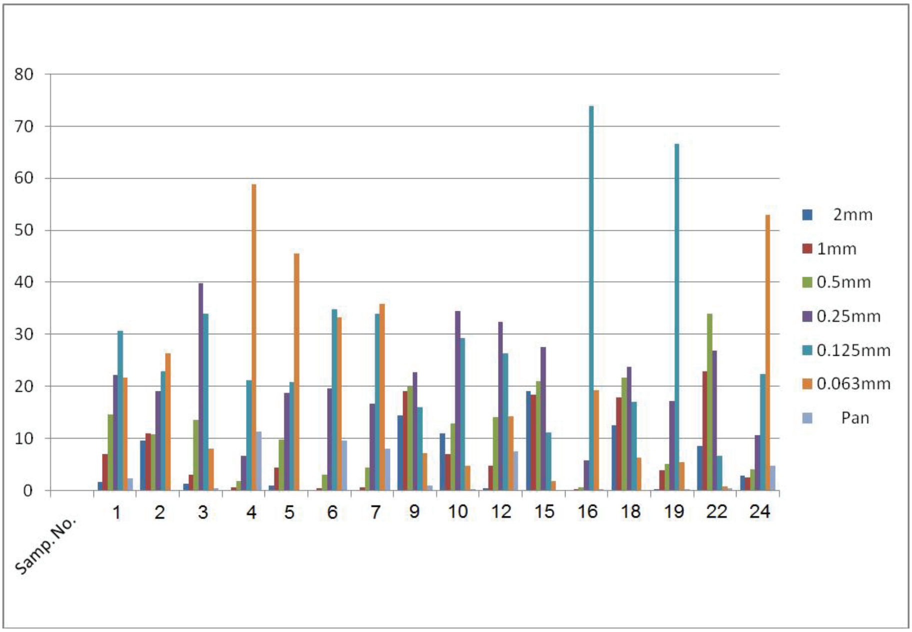

Fig. 4. Histograms showing the frequency distribution of different grain size fractions in Sharm Obhur sediments.

Mineralogy of Sediments

X-ray diffractometry analysis was used to determine the bulk mineral content in the studied sediment samples from Sharm Obhur. Data given in Table (5) are determined from interpretation of X-ray diffraction patterns following the procedures given in Milliman (1974), Tucker (1988) and Chen (1977).

Sharm Obhur bottom sediments consist mainly of aragonite, high Mg-calcite and calcite. The terrigenous minerals are represented by small amounts of quartz and feldspar. Traces of amphiboles are recorded. In general, abundant cerithid gastropods contribute to the high concentrations of aragonite.

It was observed that sediments from the central part of the Sharm are characterized by dominance of aragonite over high Mg-calcite and/or calcite indicating more fine-grained materials similar to the findings given by Durgaprasada Rao and Behairy (1984). In recent marine calcareous beach sands, Falls and Textoris (1972) also noticed a relationship between carbonate mineralogy and grain size and biogenic constituents which in turn are environmentally sensitive. Thus variation in high Mg-calcite and aragonite concentrations in the skeletal sediments of the shallow marine environments are usually attributed to differences in the composition of the sediment- producing organic communities according to Nelson *et al.*, (1982) and Gheith (2000). Calcareous red algae, benthic forams, echinoids and bryozoans contribute to high Mg-calcite, whereas green algae, molluscs and coral fragments are responsible for aragonite. Durgaprasada Rao and Behairy (1984) report such a movement of fine-grained sediments in the reef flat increasing the aragonite contents in the lagoon sediments at El Qasr, north of Jeddah. On the other hand, calcite (with low Mg content) occurs also in considerable amounts, it was derived from the erosion of Pleistocene raised coral reef terraces in the coastal plain. The vadose diagenesis leads to alteration of Mg-calcite and aragonite in the sub-aerially exposed Pleistocene reef carbonates to stable calcite with low Mg concentration. Friedman (1964) and Land (1970) assumed that Mg-calcite was the first carbonate phase to be altered to calcite and followed by later alteration of aragonite. In addition to the significant increase in both temperature and salinity in the Sharm water from the mouth towards the landward margin resulting more precipitation of inorganic aragonite in the Sharm relative to the nearshore marine environment (Behairy, 1980).

Table 5. Bulk minerals of Sharm Obhur bottom sediments.

S.no.	Aragonite	Mg-calcite	Calcite	Quartz	Feldspar	Amphibole
2Θ	26.2˚ 27.2˚	29.6˚	29.2˚	20.8˚- 26.5°	27.8˚	10.5˚
2	++	++++	++++	+++	+	
3	+	++	++	++++	++	
4	+		+	++++		
5	++++	++++	+++	+++	+	
6	+++	++++	++++	++++	++	
7	++++	++	+			++
8	++	+++	++++	+	+++	
10	++++	++				
11	++++	+++	++++	++++	+++	++
12	++++	++				
14	++++	++++	++	+++	+	
16	++++	++				
17	++++	+++	+++	++	+	
18	++++	+++	++	+	+	
19	++++	++	+			
20	++++	+++	+++	++++	+	
22	++++	++	+++			

++++ Very high +++ High ++ Moderate + low

Clay minerals present in Sharm Obhur muds are determined using X-ray diffraction technique. Eight mud samples were dispersed to separate clay fraction by using the pipette method. Then mud slides were prepared and three treatments were carried out, an untreated sample, glycolated sample and a sample combusted at 550˚C. The samples are then subjected to X-ray diffraction analysis. Slides were run at rate of half minute through interval from 2° to 15° 2Θ using copper radiation with a scanning speed of 2° 2Θ. Clay minerals were identified from the diffraction charts based on table of keylines mentioned by Chen (1977). The relative percentages of clay minerals are calculated following the method of John *et al.,* (1954). Calculated values of clay mineral analysis are summarized in Table (6) and represented in fig. 5 and 6.

The clay sediments from Sharm Obhur consist of smectite, vermiculite, kaolinite and illite. Smectite occurs in dominant amounts only in 2 samples especially at the mouth of the Sharm then disappears landward. Smectite is originated from weathering of basic rocks (basalts).Vermiculite and kaolinite occur in relatively high amounts varies from 24 to 53% for vermiculite, while kaolinite ranges between 14 and 51%. Vermiculite is considered as degraded mica originated from mechanical weathering of metamorphic and basic source rocks (Weaver, 1958). However, abundant kaolinite, mixed layer chlorite-vermiculite and illite are the clay mineral assemblage of the modern and Quaternary reef sediments in the coastal plain north of Jeddah (Behairy, 1980). The low grade metamorphic rocks (green mica schists) of the Jeddah group form the main source. kaolinite is considered to have been formed during the humid condition. While illite is formed in arid climatic condition. The Pliocene, Late Pleistocene and Holocene in the western Saudi Arabia are characterized by such climatic phases.

Bantan (2006) analyzed the clay fraction separated from the carbonate reef raised rocks in Wadi Al-Kura (the natural extension of Sharm Obhur inland). He found that the clay minerals consist of attapulgite, kaolinite, chlorite and montmorillonite, indicating climatic conditions vary from arid to humid phases.

Table 6. Relative proportions of clay minerals in Sharm Obhur sediments. (Values calculated from X-ray diffraction analysis).

S.No	Smectite	Vermiculite	Kaolinite	Illite
2	75	-	14	11
5	70	-	19	11
8	-	24	40	36
11	-	53	25	22
14	-	50	23	27
17	-	51	19	30
20	-	16	51	33
23	-	35	35	30

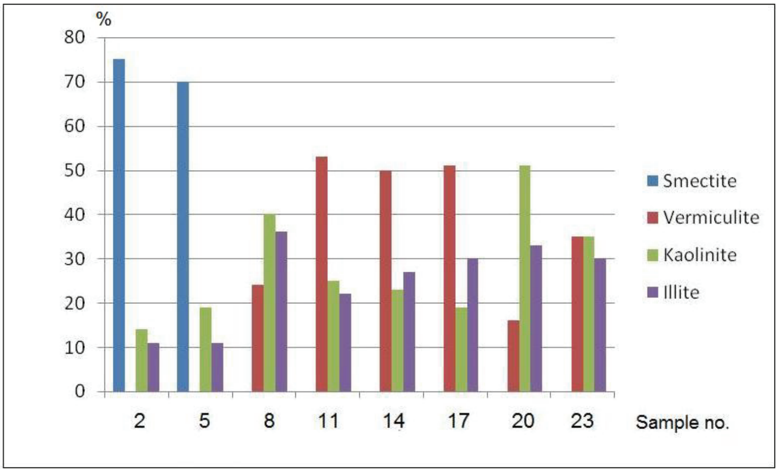

Fig. 5. Bars graph diagram showing the relative percentages of clay minerals in Sharm Obhur sediments.

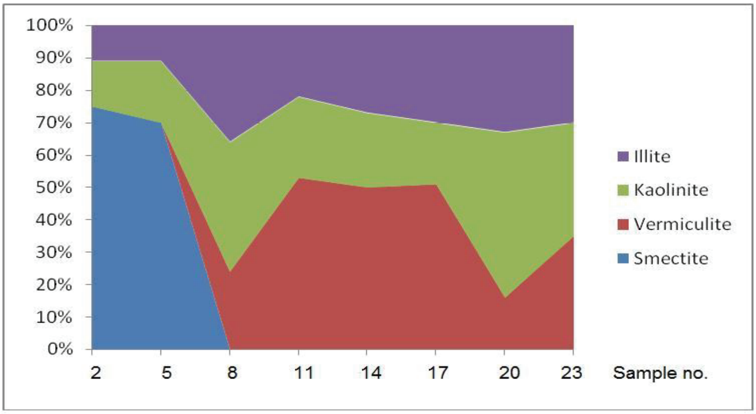

Fig. 6. Lateral distribution of clay minerals in sediments from Sharm Obhur.

Chemical Characteristics of Sediments

Heavy metals immobilized in the bottom sediment constitute a potential hazard to water quality and aquatic life since they may be released as a result of chemical changes (Förstner, 1979).

The data of analyses of heavy metals in sediments from Sharm Obhur are shown in Table (7) and Fig. (7). Zn occurs in concentration varies from 9 to 117ppm with an average 47 ppm, Cu exhibits values range from 3 to 33 ppm and an average 14 ppm, Ni is varied from 24 to 53 ppm and has an average 33 ppm, while Cd shows values ranging between 7 ppm and 11 ppm with an average 7 ppm. Fe content varies from 0.2 to 2.19% and has an average 0.73%, while Mn content ranges between 8 and 342 ppm with an average 118 ppm. It was noticed that all the sediment samples occur in the central part of the Sharm Obhur reflect higher concentrations for these metals than those determined in the sediment samples near the borders of the Sharm. Most sediment samples from the central area of the Sharm have fine-grained sizes indicating calm conditions. On the other hand, Sharm Obhur receives wastewater of domestic sewage which creates anoxic conditions and resulted in heavy metal accumulation in the sediments (El-Sayed and Basaham, 2004). However, in the last few years filling operations are activily taking place and brought large quantities of lithogenic materials rich in Fe and Mn compared to the natural biogenic carbonate sediments (El-Sayed and Basaham, 2004)

Comparison between the present concentrations and similar data from other regions in the nearshore sediments of the Red Sea (Table 8) proved that sediment samples analysed from Sharm Obhur exhibit high concentrations for Zn, Cu, Ni and Cd than those given by others in the nearshore environment in front of Jeddah coastal area and/or in Sharm Obhur. This behavior could be attributed to the impact of human activities.

Mud and organic materials are considered as the factors controlling the distribution of trace and minor elements in Sharm Obhur sediments. This agree with results given by El-Sayed (1993) who mentioned that Fe, Zn and Cu preferred association with clay and to a lesser extent with silt materials, while Mn, Pb and Cd associated with calcareous shells. In spite of this the possibility of the incorporation of these elements in biogenic carbonate constituents or their precipitation as carbonates in reducing conditions are considered. Moreover, Förstner (1977) found a positive relation between highly polluted areas and concentrations of such heavy metals. It was related to the accumulation of organic substances.

Table 7. Concentrations of trace and minor elements in Sharm Obhur bottom sediment samples.

S.No.	Zn ppm	Cu ppm	Ni ppm	Cd ppm	Fe %	Mn ppm
1	17	3	26	8	0.15	32
2	52	0.0	37	8	1.32	182
3	67	23	32	8	1.16	209
4	20	5	24	7	0.44	84
5	59	18	38	8	0.90	175
6	29	8	29	9	0.52	90
7	57	5	26	8	0.20	35
8	117	28	46	8	1.54	264
9	20	7	30	9	0.12	21
10	9	4	27	9	0.08	10
11	58	24	43	7	1.39	206
12	37	20	26	11	0.26	39
13	-	-	-	-	-	-
14	102	20	41	8	1.13	160
15	28	7	27	11	0.08	8
16	0.0	3	28	9	0.14	20
17	64	26	45	8	1.4	203
18	17	4	28	11	0.15	22
19	22	4	29	9	0.13	19
20	65	25	45	7	1.51	224
21	-	-	-	-	-	-
22	13	4	29	9	0.16	26
23	97	33	53	8	2.19	342
24	45	15	27	11	1.02	219
Aver.	47	14	33	7	0.73	118

Table 8. Comparison of the average element concentrations in Sharm Obhur sediments and those given by other authors in the near shore sediments from different areas.

Location	Zn	Cu	Ni	Fe	Fe	Mn
Sharm Obhur sediments (Present study)	47	14	33	7	0.73	118
Northern Corniche (El-Sayed et al, 2002)	26	9.6	7.4	4.8	1.21	169
Southern Corniche (El-Sayed *et al.*, 2002)	21.4	7.5	4.2	5.3	0.99	148
Sharm Obhur sediments (Behairy *et al.,* 1983)	12	9	-	2.6	0.22	38

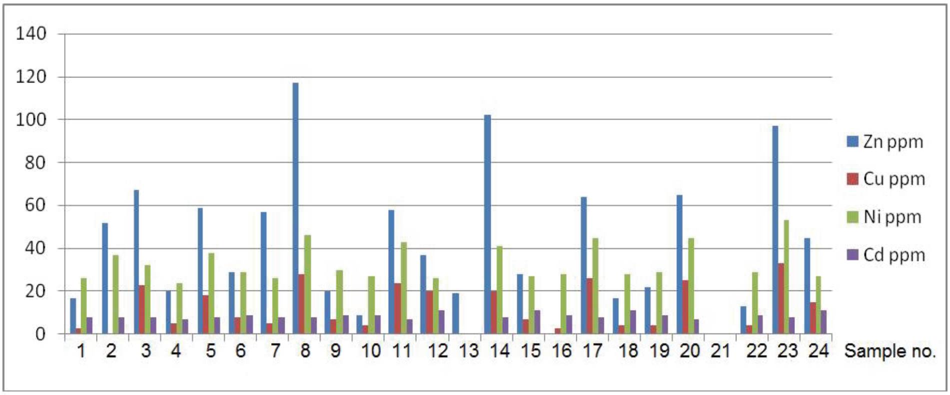

Fig. 7. Bar chart for trace element concentrations in Sharm Obhur bottom sediments.

Conclusions

Sharm Obhur bottom sediments are composed mainly of skeletal carbonate particles of different sizes mixed with little siliciclastic grains indicating that the Sharm is influenced by the aeolian transportation. Sediments consist of fine grains coral debris, benthic foraminifera, molluscs, algal fragments, radiolarian, petropod shell fragments, fish skeletal parts and siliceous sponge spicules. Although Sharm Obhur consists of sand sized materials, the central localities are mainly covered with finer calcareous mud. Anthropogenic activities on its shores are clearly distinct and the Sharm exhibits considerable changes since 1986 till now.

It was found that aragonite and high Mg-calcite are the dominant carbonate minerals in the sediments. There is an increase in aragonite content in the central localities related to the characteristic increase of fine carbonate mud. The dominant clay minerals in the mud materials are smectite and vermiculite with subordinate kaolinite and illite. Semictite recording at the outlet is related to marine origin, while the other clay minerals are contributed by the coastal regions from the erosion of the high exposures of metamorphic Jeddah series. Contribution from the land by wind action plays additional role of transportation.

Sharm Obhur sediments exhibit high concentrations for Zn, Cu, Ni and Cd than in sediments of the other localities in front of Jeddah coastal area. The fine mud materials and organic matter are the factors controlling the distribution of these metals.

Acknowledgments

The authors wish to express their appreciation to the king Abdulaziz University at Jeddah, Scientific research Council for the financial support. We also wish to acknowledge Faculty of Marine Science, King Abdulaziz University, Jeddah for assistance.

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مراقبة تدهور النظام البيئي البحري عن طريق دراسة الخصائص الجيولوجية لرواسب القاع في شرم أبحر، شمال جدة، الشاطيء الشرقي للبحر الأحمر

أمين غيث، و محمد صالح حريرى[*]

كلية العلوم جامعة المنصورة – مصر

[*]*كلية علوم البحار – جامعة الملك عبد العزيز، جدة – المملكة العربية السعودية*

المستخلص. تعتمد هذه الدراسة على فحص نسيج الحبيبات، محتوى الأحافير، الصفات المعدنية والعناصر الكيميائية في رواسب قاع شرم أبحر والتي تعتبر عوامل مفيدة لعمليات تغير النظام المائي داخل الشرم. لقد عانت مناطق الشعاب الخلفي من عمليات الحفر والملأ والتقطيع لأغراض الاستجمام فتغيرت جيومورفولوجية الشاطيء وخصائص الرسوبيات. هذا وقد بينت الصور الفضائية عمليات التطور والتحضر.

كما أوضحت الدراسة الجيولوجية مظهر خصائص طبقة الرسوبيات وتأثير نشاط الإنسان في تلك البيئة الحساسة لشرم أبحر. لذلك تعتبر الرواسب حوضاً كبيراً للتلوث والتي تحكم صحة البيئة. لهذا فإن طبقة الرسوبيات درست بعناية لفهم نموذج الترسيب بالإضافة إلى المعاملات المعدنية والجيوكيميائية والنسيجية

ولقد بينت الدراسة أن بيئة قاع شرم أبحر وشاطئيها تعرضتا للإفساد نتيجة التطور غير المحكوم. ولذلك زادت نسبة المعادن الثقيلة لكل من الزنك، النحاس، النيكل والكاديوم بالإضافة إلى الحديد والمنجنيز في رواسب القاع نتيجة للنشاط البشري. هذا وتعتبر الرواسب الدقيقة مكانًا مناسبًا ومفضلاً لتثبيت المواد العضوية والعناصر الثقيلة.