Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 25(2): 573 – 589 (2021)
www.ejabf.journals.ekb.eg

Environmental and Geological Study of the Suggested Marine Port Site at Sahl Hasheesh area, Hurghada, Red Sea coast, Egypt (A case study).

Yasser A. Temsah[1], Ahmed W. Mohamed[2], Ahmed M. Saad[1], Hussein N.M. Hussein[2], Ashraf S. Mohammad[2]*

1- Geology Department, Faculty of Science, Al-Azhar University, Cairo, Egypt
2- National Institute of Oceanography and Fisheries, Egypt

***Corresponding Author: ashrafgro@yahoo.com**

ARTICLE INFO

Article History:
Received: March 1, 2021
Accepted: March 30, 2021
Online: April 22, 2021

Keywords:
Environment,
Geological,
suggested marine port,
sediments,
Sahl Hasheesh,
Red sea

ABSTRACT

This study deals with the geochemical nature of distribution, enrichment of total trace metals (Fe, Mn, Cr, Cu, Ni, Co, Pb, Zn, Cd) in bulk sediments and its association with sediment texture, carbonates and organic carbon. Grain size and geochemical analyses have been carried out on 27 surface marine sediment samples collected from Sahl Hasheesh suggested marine port site on red sea coast. Grain size distribution and chemical characteristics of (27) sediments samples using some statistical methods reveal the dominance of muddy sediments in the dredging areas with abundance of organic matter and trace elements reflect the negative impact on the biologic life and humans. Furthermore, the high concentration of Fe, Mn, Pb, Cd and Ni in these sediments were attributed to the contribution of terrigenous materials due to coastal development including land filling to provide sites for resorts and recreation, and dredging of tidal flat to create marine ports and outlet of desalination. The study area is a very wide reef flat ranging from 160-350 m wide. Due to the nature of this reef flat and the extreme exposure during low tide, only few living organisms exist, such as brown algae *Lurancia* sp., *Cystoseira* sp., and sometimes mixed with *Padina* sp. The reef morphology changes from narrow reef flat (160 m) and gentle reef slope, with low relief (1 m) in the northern part, to a very wide reef flat (355 m) and steeper reef slope with higher relief (15 m). Reasonable recommendations have been outlined by this study to offer guidelines to mitigate the impact on the marine environment.

INTRODUCTION

The Red Sea constitutes a unique ecosystem with high biological diversity **(EEAA, 2016)**. Its natural resources provide a substantial economic in addition to the fishery industry, which has ensured food security to many people of the region and created jobs for others **(EEAA, 2016)**. The Red Sea tourism is an ever growing and increasingly important industry for commerce and other economic activities. With increasing the urban occupations along the Red Sea coast due to the progressive development in the tourism and related industries throughout the last three decades, the rapid and uncontrolled human activities along the Red Sea coast increased intensively in some places causing a series of disturbances and demolish stresses on the tidal flat zones of the Red Sea **(EEAA, 2016)**.

The coastal and marine environments of the Egyptian Red Sea constitute a relatively distinctive set of habitats and species in both the intertidal and subtidal areas. In subtidal areas, coral reefs and seagrass are the important habitats. Several investigations on the surface marine sediments were carried out on the Egyptian Red Sea coast, including the impact of development activities along the Egyptian Red Sea coast area **(El-Askary *et al*., 1988; Frihy *et al*., 1996; White *et al*., 2000; Dar, 2002; Mohamed, 2005; Madkour & Dar, 2007; Madkour, *et al*., 2013, 2014, 2015; Sawall & Al-Sofyani, 2015; Dawoud *et al*., 2016; Sharaan *et al*., 2020; Youssef *et al*., 2020)**.

In Egyptian marine water, lots of studies have been conducted on the heavy metals in the Red Sea. **Dar and Abdel-Wahab (2005)** monitored the coastal alterations and related them to the artificial lagoons at Red Sea. **Nasr *et al*. (2006)** measured the environmental assessment of heavy metal pollution in bottom sediments of Aden port, Yemen. **Madkour and Dar (2007)** measured the anthropogenic effluents of human activities on the Red Sea coast at Hurghada harbor.In addition, **Turki (2007)** estimated the metal speciation (Cd, Cu, Pb and Zn) in sediments from Al-Shabab Lagoon in Jeddah (Saudi Arabia). Some of them, as the prominence constructions, have altered the depositional-hydrodynamic pattern as a result of blocking the littoral currents by the protruded constructions **(Frihy *et al*., 2004)**.

Frihy *et al*. (1996) summarized the major hazards to the marine environment, which have been carried out in the Red Sea coast, being dumping sediments for constructing marina jetties, green areas irrigation with treated wastewater, oil waste pollution resulting from tankers and motorboats, and the discharge of brine effluents from the desalination stations. **Madkour and Dar (2007)** attributed the main sources of pollution in the tidal flat areas to the activities related to boat constructions, maintenances and operations in the area including marine ports and shipyards. They added, the resulting wastes of these operations are known to be intensively hazardous to the marine environment especially those conservative wastes. In this context, the previous authors mentioned some wastes as; the released heavy metals through paints remains, and the solid wastes of construction remains, iron pipe rusts, hydrocarbons, plastic bags, metal and wood remains. Therefore, studies of recent sediments in the near shore and the offshore zone along the Egyptian Red Sea coast are very important to assess potential environmental hazards resulting from the irrational human activities. Hence,the present study was conducted to study the negative environmental effects that can result from the establishment of the suggested marine port in this region. Moreover,the study aims to characterize the current environmental situation of the region by studying physicochemical parameter, grain size analysis, organic matter, carbonates (CO_3%), trace elements, geochemical analysis, heavy metals and coral reef distribution of Sahl Hasheesh at the suggested marine port site.

MATERIALS AND METHODS

Study area (Sahl Hasheesh):

Sahl Hasheesh bay is located on the Red Sea coast of Egypt, approximately 18 km south of Hurghada International Airport. The Sahl Hasheesh Bay and island were the home of many coral reefs where sports of diving and snorkeling can be seen. Sahl Hasheesh Island is a natural protectorate containing many communities of marine life. Sahl Hasheesh area is located at (latitudes of 33o 50' 49.84" and 33o 53' 53.11" North and longitudes of 26o 59' 39.85" and 27o 2' 55.18" East). Figure (1) presents the regional location of Sahl Hasheesh south of Hurghada, Red Sea, Egypt.

According to the site survey, the ground slope is from the west to the east. The study area is a protected site in Sahl Hasheesh bay, and located at the south of the development area. 27 samples were collected around the suggested marine port area, that lies at the southern boundary of Sahl Hasheesh , and distributed along a distance of 425 m from the shoreline, with a depth of 18 m. Samples were subjected to study with respect to the following items: grain size analysis, sediment texture, grain size parameters, organic matter, carbonates (CO_3%) and trace elements of Sahl Hasheesh in sediments at the suggested marine port site (Figure 2).

Two sectors were taken in the marine region, around the suggested marine port area for coral reef distribution study. The first sector (250 m long, depth from (0.2 m) to (15 m)) was in the southern side (27°00'27.69"N, 33°54'34.65"E and 27°00'30.88"N, 33°54'42.24"E), and the second sector (410 m long, depth from (0.2 m) to (15 m)) was in the northern side (27°00'30.11"N, 33°54'22.55"E and 27°00'37.31"N, 33°54'35.32"E). Figure (2, 3) shows the distribution of sediment samples for Sahl Hasheesh study area.

Physicochemical parameter:

Using portable automatic water sampler (HANA) to record the physicochemical parameters (Temp, pH, Cond., T.D.S, SAL, S.P, ORP and D.O) of the water samples that were collected at 0.0 m to 18 m of the studied sample depth.

Fig. 1. Google earth image for Sahl Hasheesh bay (study area), Red Sea, Egypt.

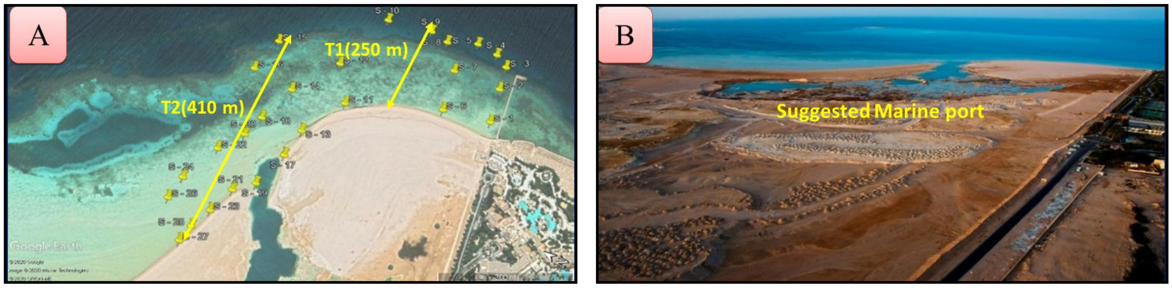

Fig. 2. Google earth image for the study area and sediment samples (A), photograph image for the study area in Sahl Hasheesh bay (B), Red Sea, Egypt.

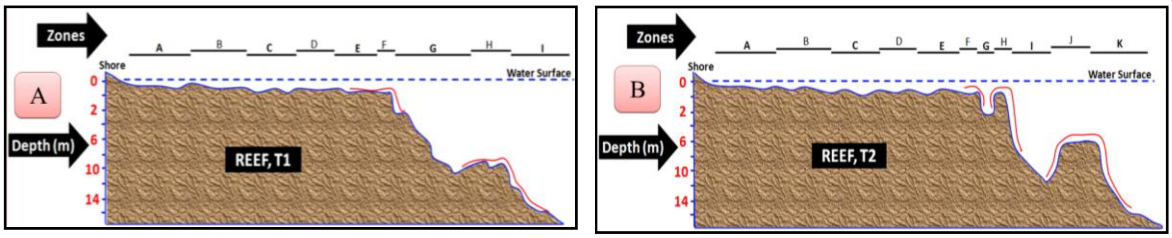

Fig. 3. Drawings show approximate topography bottom depths, the first sector (A) and the second sector (B). The red lines indicate the places that have corals density at the bottom.

Geochemical analysis of Sahl Hasheesh (suggested marine port):

1. **Carbonates content (CO_3%)**: given as percentage of the total weight **(Basaham & El-Sayed, 1998)**.

$$(CO_3\%) = \frac{wt.\ of\ sample - wt.\ of\ residue}{wt.\ of\ sample} \times 100$$

2. **Total organic matters (TOM):** total organic matter was estimated in powdered sediments, **(Dean, 1974; Brenner & Binford, 1988)** according to the following formula:

$$(TOM\%) = \frac{wt.\ of\ sample - wt.\ of\ ash}{wt.\ of\ sample} \times 100$$

3. **Total organic matters (TOM):** total organic matter was estimated in powdered sediments, **(Dean, 1974; Brenner & Binford, 1988)** according to the following formula:

$$(TOM\%) = \frac{wt.\ of\ sample - wt.\ of\ ash}{wt.\ of\ sample} \times 100$$

4. **Granulometric analysis (Grain size analysis):**

The sediment samples were air dried and disaggregated. Then, about 100 gm of sediment were sieved through a stainless steel mesh to differentiate the particle by dry method; each one (Ø) interval , using want worth scale **(Folk, 1974)**. Seven fractions were obtained: gravel ($Ø_{-1}$ > 2 mm), very coarse sand ($Ø_0$ = 2: 1 mm), coarse sand ($Ø_1$=

1: 0.5 mm), medium sand ($Ø_2$ = 0.5: 0.25 mm), fine sand ($Ø_3$ = 0.25: 0.125 mm), very fine sand ($Ø_4$ = 0.125: 0.063 mm), and silt or clay ($Ø_5$ < 0.063 mm).

Heavy metals measurement:

0.5 gm of each sediment samples were collected and digested using10ml mixture of nitric acid (HNO3) and per chloric acid (HClO4) (3:1) to the complete digestion. The residue of each sample was dissolved into 2ml of 12N HNO3 after that, diluted to 25ml with distilled water and filtered using a filter paper. The bio-available Fe, Mn, Zn, Cu, Ni, Pb, and Cd concentrations were measured using a flame atomic absorption spectrophotometer, and the results were expressed as µg/g **(Chester *et al*., 1994)**.

Coral reef distribution:

The fieldwork was well performed using SCUBA equipments, under water digital camera and snorkeling. Line intercept transect method (LIT) **(English *et al*., 1997)** was used to estimate the percentage cover of corals and other marine habitats in the study sites.In addition, a 100 m long graded tape was used as transect. This method depends on calculating the fraction of the length of the line that is intercepted by the object. The LIT method was laid down along the depth contour, parallel to the shore. Percentage of living corals (hard and soft), dead corals and other taxa (algae, sponge, sand and rock) were also calculated. The percentage cover of a given species or taxa underlying transect was calculated following the formula:

$$\text{Percentage cover (\%)} = \frac{\text{Intercepted lengths}}{\text{Total lengh of transect}} \text{X100}$$

RESULTS AND DISCUSSION

Physicochemical parameter:

Temperature levels observed in this study ± 22.82 C˚ was in agreement with the results of previous studies, 20.7 - 28.2 C˚ (Impacts of human activities and natural inputs on heavy metal contents of many coral reef environments along the Egyptian Red Sea coast) ,and 22.8 - 30.5 C˚, **(Dorgham *et al*., 2012)** . The pH values, recorded in the present study (± 8.45) were within the preferred pH levels (7.0 - 8.5) for biological productivity **(Abowei, 2010)**. Salinity is an important ecological variable which is important in some chemical processes, as it has a strong effect on the levels of the nutrients at the coastal areas . In the present study, salinity recorded a value of ± 39.95, a result which is similar to that of **Abdel-Halim *et al*. (2007)**. According to the obtained results, DO concentrations were generally upper the threshold value (± 2.01 mgl^{-1}) during the seasons of both spring and autumn. Measured DO values in this study were within the range reported in previous studies conducted in the Red Sea as shown in Table (1).

Grain size analysis of Sahl Hasheesh samples:

Grain size helps to determine the textural and depositional characteristics of the environment. Particle size distribution in sediments possesses a function of availability of different sizes of particles in the parent material and the processes operating, where the particles were deposited **(Ali *et al*., 1987)**.

1. Sediment texture:

Gravel fraction varies from 0.0 to 61.0 % with average of 12.8 %. Gravel occurs only in tidal zone samples due to the abundance of terrigenous fragments, while they are absent in the other samples with increasing water depth. Sand fraction varies from 37.8 to 98.9 % with an average of 83.4 %. It decreases seawards. Mud fraction varies from 0.0 to 21.9 % with an average of 3.40 %. It was very low towards the tidal zone while reaching the highest value (21.9 %) towards the deeper part.

2. Grain size parameters:

The particle size changes from medium and fine sand near the beach to coarse silt with the increasing depth and distance from the shoreline. Sediments of this area had mean size (M_Z) values that ranged from -0.80 φ to 3.3 φ with an average of 1.2 φ (Table 2). Sorting of sediments (σ_I) ranged from 0.5 to 2.4 φ, recording averages of 1.1 φ (Table 2), which mean poorly sorted sediments. The sorting values show that the sediments vary from moderately and well sorted near the beach to poor sorted with the increasing water depth and distance from the shoreline. Skewness (SK_I) of these sediments varied from -0.6 to 0.9, with averages 0.03 (Table 2), which means nearly symmetrical skewness. Generally, the sediments of this transect change from coarse and symmetrical skewness near the beach to fine and very fine skewness with the increase of the distance from the shoreline and water depth. Kurtosis (K_G) of these sediments varied from 0.6 to 2.6, recording an average of 1.2 (Table 2) and indicating very leptokurtic sediments. Generally sediments were leptokurtic at the beach change to very leptokurtic with increasing water depth and distance from shoreline.

Organic Matter:

The total organic matter content of the investigated sediments of Sahl Hasheesh suggested marine port project ranged from 3.9 to 11.9, with an average of 7.8 and organic carbon content with ranges from 2.2 to 6.7, with an average of 4.5 (Table 3 & Figure 4). The increasing of total organic matter and organic carbon in most samples of Sahl Hasheesh area may be due to seagrass bottom facies and litter production. The present values of total organic matter were slightly higher than that recorded by **Dar (2002)**, **Madkour *et al*. (2006)** and **Mansour *et al*. (2013)** and within the same range of that recorded by **Dar *et al*. (2016)**.

Carbonates (CO_3%):

In the present study, the total carbonate in the sediments was between 16.9 % and 88.5 % with an average of 54.0 %. High carbonate content was recorded in samples away from the beach (Table 3 & Figure 4). Carbonate sediments was poor at the beach and intertidal area, while the deep water was proved to contain higher amounts of carbonate. The carbonate contents were comparable to those in the study of **El-Mamoney (1995)**, **Dar (2002)**, **Madkour (2004)** and **Mansour *et al*. (2013)**. The carbonate percentages of the current work were higher than those recorded by **Mansour *et al*. (2007)**. Whereas, they showed lower percentages than that recorded by **El-Askary *et al*. (1988)**.

Trace Elements of Sahl Hasheesh sediments:

In the present study, Fe and Mn were highly negatively correlated to carbonates, the Fe was 1865 – 2733 ppm, with an average of 2463 ppm which reflects the derivation from the terrigenous or mixed (carbonate and siliciclastic) sources (Tables 3, 4 & Fig. 5). While in Hurghada mixed sediments, the Fe was 0.19 - 0.6% **(EI-Sayed, 1984)**. The high Fe content in the present sediments was mostly due to the contribution of terrigenous sediments **(Mansour *et al*., 2000)**. Fe concentrations of the shallow marine sediments in different transects along the Red Sea coast were relatively high; indicating the terrigenous contamination.

In the present study, Mn ranges were between 115 and 696 ppm, with an average of 354 ppm. The high Mn concentration in the present sediments was also regarded as a consequence of the contribution of terrigenous materials, a positive relationship was found between the Fe and Mn in the studied sediments (Tables 3, 4 & Figure 5). While in Hurghada reefal sediments, the average of Mn was 0.02 % **(El-Sayed, 1984)**. Consequently, the highest Mn contents in the studied sites with the high mud content sediments indicate a terrigenous origin **(Dar, 2002)**.

It was noticed that Ni was negatively correlated to carbonates and positively correlated to organic matter (Tables 3, 4 & Figure 5), the Ni ranges were between 5 and 12 ppm, with an average of 7 ppm. In the present study, Ni value was near to that recorded in the studies of **Masoud *et al*. (2012)** and **Salem *et al*. (2014)**.

Findings revealed that Zn ranges were between 9 and 37 ppm, while the ranges of Cu was recorded from 1 to 43 ppm. In addition, the high concentration of Zn and Cu elements were found in the fine sediments rich with non-carbonates due to the influence of terrigenous sediments (Tables 3, 4 & Fig.5). These elements were principally derived from volcanic and metamorphic rocks in pure carbonate sediments, where both Zn and Cu were relatively lower than in the mixed sediments **(EI-Sayed, 1984)**. **El-serehy *et al*. (2012)** recorded similar values of Cu, while other studies detected Cu values higher than those in the present study **(Abouhend & El-Moselhy, 2015; El-Metwally, 2015; Dar *et al*., 2016; Tantawy, 2017; Khalafallah *et al*., 2019)**.

Results showed that Pb was positively correlated with trace elements rich in non-carbonates (Tables 3, 4 & Fig. 5), the Pb ranges were between 6 and 13 ppm, averaging 9 ppm. The high content of Pb can be attributed to tourism activities in the beach and intertidal area, in addition to dredging and landfilling operations **(Mansour *et al*., 2013)**.

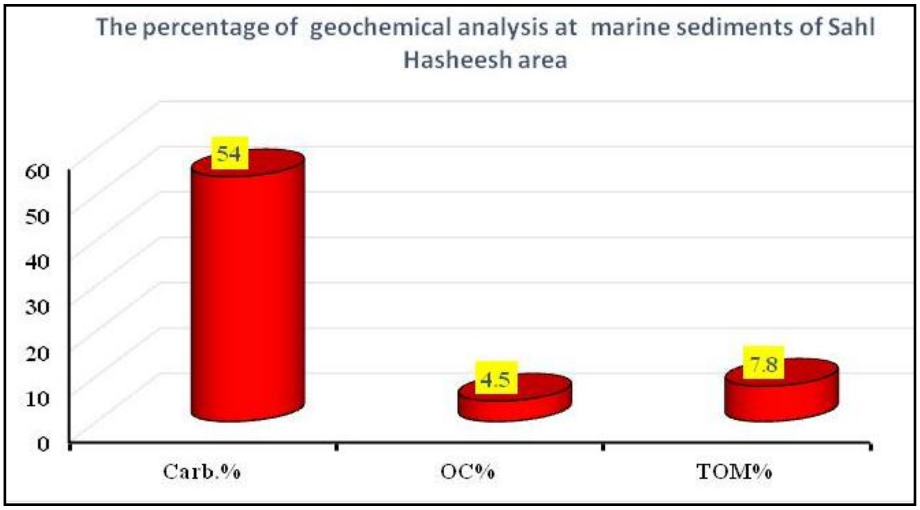

Fig. 4. The percentage of geochemical analysis of marine sediments of the suggested marine port site at Sahl Hasheesh area, Red Sea, Egypt.

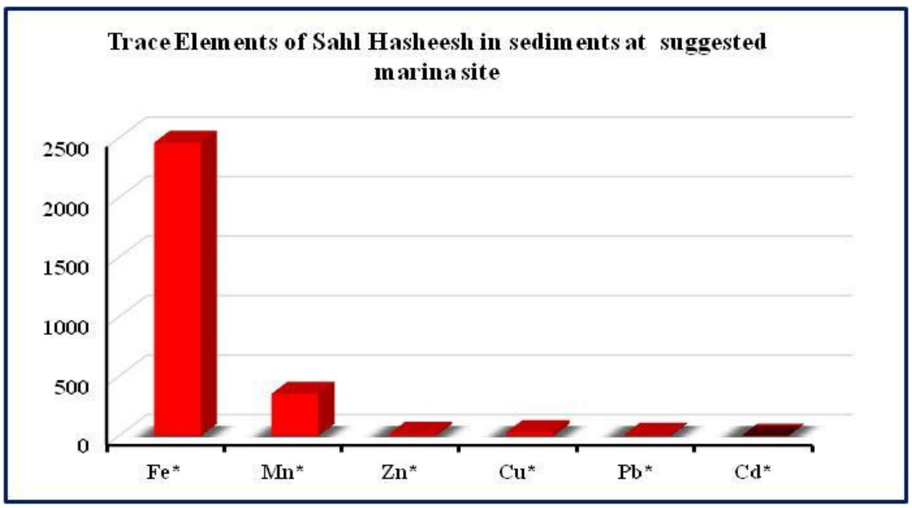

Fig. 5. Trace Elements of sediments of the suggested marine port at Sahl Hasheesh area, Red Sea, Egypt.

Table 1. Oceanographic parameters and depths (min., max., ave., stdv.) of water in different sampled sediments collected from Sahl Hasheesh, Red Sea Egypt.

Parameters	**Depth (m)**	**Physical Water Parameter**					
		PH	**Temp ◦C**	**Spec (ms/cm)**	**TDS (g/l)**	**S ‰**	**Do (mg/l)**
Min.	0.50	8.27	22.53	59.18	29.57	39.70	1.56
Max.	18.00	8.56	23.15	59.94	29.96	40.19	2.39
Aver.	5.138	8.449	22.819	59.543	29.765	39.958	2.015
Stdv.	6.144	0.093	0.199	0.313	0.159	0.219	0.340

Table 2. Sediment types and grain size parameters of different sediment types collected from Sahl Hasheesh, Red Sea Egypt.

Parameters	Depth (m)	Sediment types					Grain size parameters (Folk&Ward,1957)			
		Gravel	Sand	Silt	Clay	Mud	M_Z	σ_I	SK_I	K_G
Min.	0.5	0.00	37.8	0	0.00	0.5	-0.8	0.5	-0.6	0.6
Max.	18	61	98.8	21.9	1.4	22.5	3.3	2.4	0.9	2.6
Avg.	4.7	12.8	83.4	3.4	0.1	3.9	1.2	1.1	0.03	1.2
Stdv.	5.90	18.78	17.99	6.94	0.35	6.95	1.26	0.53	5.90	0.53

M_Z = mean size, σ_I = Sorting, SK_I = skewness, K_G = kurtosis

Table 3. Geochemical analysis and heavy metals concentrations of the marine sediments collected from Sahl Hasheesh, Red Sea, Egypt.

Parameters	Geochemical analysis				Heavy metals concentrations					
	Depth (m)	Carb. %	OC %	TOM %	Fe*	Mn*	Zn*	Cu*	Pb*	Cd*
Min.	0.5	16.9	2.2	3.9	1864.9	114.6	9	1	5.6	0.7
Max.	18	88.5	6.7	11.9	2733	695.5	37.3	42.7	12.7	1.6
Avg.	4.7	54	4.5	7.8	2463	354.1	17.1	30.6	8.8	1.1
Stdv.	5.90	22.11	1.45	2.55	214.99	154.24	8.53	9.48	2.11	0.24

Carb. = carbonate content, OC = organic carbon, TOM =total organic carbon, * = values ppm

Table 4. Correlation coefficients for (grain size, total organic matter, organic carbon, carbonate content and trace elements) of marine sediments collected from Sahl Hasheesh, Red Sea, Egypt.

	Carb.%	OC%	TOM%	Fe*	Mn*	Zn*	Cu*	Pb*	Cd*	Ni*	Gravel	Sand	Mud
Carb.%	1.0												
OC%	0.763	1.0											
TOM%	0.727	0.985	1.0										
Fe*	-0.239	-0.148	-0.119	1.0									
Mn*	-0.182	-0.086	-0.061	0.907	1.0								
Zn*	-0.685	-0.620	-0.583	0.157	0.150	1.0							
Cu*	-0.235	-0.261	-0.241	0.004	-0.011	0.368	1.0						
Pb*	-0.212	-0.363	-0.373	-0.007	-0.103	0.404	0.268	1.0					
Cd*	0.785	0.664	0.606	-0.269	-0.223	-0.540	-0.006	-0.119	1.0				
Ni*	-0.156	-0.205	-0.190	0.428	0.571	0.149	0.323	-0.094	0.017	1.0			
Gravel	0.368	0.306	0.246	-0.389	-0.246	-0.369	-0.329	-0.510	0.281	-0.194	1.0		
Sand	-0.242	-0.200	-0.148	0.321	0.181	0.212	0.217	0.379	-0.192	0.097	-0.928	1.0	
Mud	-0.335	-0.200	-0.260	0.199	0.170	0.431	0.329	0.448	-0.243	0.266	-0.316	-0.055	1.0

Coral reef distribution:

The reef is still in good condition so far; the back reef is wide and shallow, less than 0.5 m in depth, and usually uncovered at low tide.This area is tidal flat, with a rock bottom and a depth of 0.2 m to 0.3 in tide times, and reaches a distance of 220 m inside the water, and all this distance is fully exposed in the islands. This part of the sector was characterized by a rock bottom with a thick layer of fine sand marine algae that were brown and red with densities up to 50 %.This section also shows fossilized reefs with a thick, soft layer of sand and the appearance of sea grasses.

The shore line of the study area is fossilized and scattered coral rocks are observed with marine algae up to 80%. After tidal flat area were appears several natural lagoons the edge of lagoons spread by many live reef colonies of branch and mass species with coral cover of about 60 to 80%, as well as high diversity of reef fish. After natural lagoons were appears back reef area and spread by some colonies scattered coral reefs, and followed by the back of the reef area reef edge area and a depth of 4 m and then reef area at a depth of 6 m to 9 m It has a high diversity of marine environments, especially coral reefs, reef fish and marine invertebrates. The sector is fossilized scattered coral rocks with marine algae up to 80%. After the tidal flat, several natural lagoons appear at the edge of which many live reef colonies of branch and mass species are spread with coral cover of about 60 to 80%, as well as high diversity of reef fish. After natural lagoons, the back reef area appears with a spread of some colonies scattered coral reefs, and followed by a reef edge area with a depth of 4 m, and then the reef area is found at a depth of 6 m to 9 m. It has a high diversity of marine environments, especially coral reefs, reef fish and marine invertebrates (Figure 6). While the reef edge is sharp and dropped down to about 12 m depth towards a sandy bottom that decline rapidly to a great depth (Figure 6).

Along the Egyptian Red Sea coast, coral reef degradation has increased dramatically during the last three decades as a result of enhanced anthropogenic disturbances and their interaction with natural stressors **(Ali *et al*., 2011)**. These stressors were thought to cause coral diseases and bleaching leading to a loss of coral cover **(Al-Hammady, 2005)**. **Burke *et al*. (2011)** found that, nearly 60% of the Red Sea reefs are at risk due to landfilling and dredging, port activities, sewage, pollution, and other tourism activities. Worldwide declines in coral coverage and overall reef degradation can be attributed to a variety of anthropogenic and natural causes **(Pandolfi *et al*., 2003; Côté *et al*., 2005)**.

The present study examined two sectors (T1 = 250 m, T2 = 410 m) from the shore line and towards the sea, notind that each sector was in a different direction to cover different areas of the reef. The area was characterized by rocky sandy beaches with a large number of beach dunes. Additionally, the studied area was a very wide reef flat ranging from 160-350 m wide. Due to the flat nature of this reef and its extreme exposure during low tide, only few living organisms exist, such as *brown* algae *Lurancia* sp., *Cystoseira* sp., and sometimes mixed with *Padina* sp. The reef morphology change from narrow reef flat (90 m) and gentle reef slope with a low relief (1 m) in the northern part to a very wide reef flat (375 m) and a steep reef slope with a high relief (14 m). The fore reef is dominated by low coral cover of branched hard coral *Stylophora* sp.

Table 5. Description of transect 1 and the percent cover of marine environment at the studied sites.

No.	T1 Distance 250 m	Depth from (0.2 m) to (15 m)	Description	Types	Percentage
1	80 m	0.2 to 0.3 m	Tidal flat rocky shore with fine sand	1- marine algae 2- sea grasses 3- coral reef	1- 30 to 50 % 2- 50 to 80 % 3- 0%
2	40 m	0.5 m	Rocky reef with over growth of algae	1- Life coral 2- Dead Corals	1- 50 to 80% 2- 30 to 50%
3	30 m	0.5 m	Rocky sea bed covered with coral	1- Coral reef 2- Algae	1- 60 to 70% 2- 40%
4	20 m	6 to 10 m	Lagoon area characterized with sandy and rocky sea bed covered with coral reef	1- Coral reef 2- Marine Fishes	1- 75% 2- 50%
5	60 m	4 to 9 m	Rocky sea bed and reef edge and reef slope	1- Coral reef 2- Marine fishes 3- Marine algae 4-Marine invertebrates	1- 80% 2- 60% 3- 10% 4- 20%
6	20 m	10 to 15 m	Sandy sea bed with rare marine environment	1- Coral reef 2- Marine fishes 3- Sea grasses 4- Algae	1- 1% 2- 40% 3- 20% 4- 4%

Acropora sp., and calcified algae near the reef crest. Coral communities change with the reef profile; branched corals *Acropora* sp. and *Pocillopora* sp. dominate the reef slope with other massive *Platygyra* sp., *Fauites* sp., and soft coral *Sinularia* sp. In the middle part of this zone, the depth of the reef slope increases (7-9 m.), covered by *Acropora* tables, Fire coral *Millepora* sp., *PocilLopora* sp., *Porites* sp., and *UthoJungia* sp. There is also a small coral patch (about 1 m 2 diameter) covered with *Acropora* sp. In the southern part of this zone where the reef flat becomes wide, a very large lagoon extends about l km. parallel to the shoreline with average depth of 3 m. Inside the lagoon, different coral species occupy the shallow edges as: *Millepora* sp. *Stylophora* sp., and *Porites* sp., which can stand the very high turbidity of the lagoon. Whereas the upper reef slope is dominated by *Acropora* tables, very big *massive: Colonies* of *Porites* sp. branched coral *Pocillopora* sp., soft coral *Lithophyton* sp., *Xenia* sp., and massive coral *PLatygyra* sp. Seagrass found in the area are represented by a light bed of *HalophilaJualis* that extends for 10-20 m as shown in (Tables 5, 6 & Figure 6).

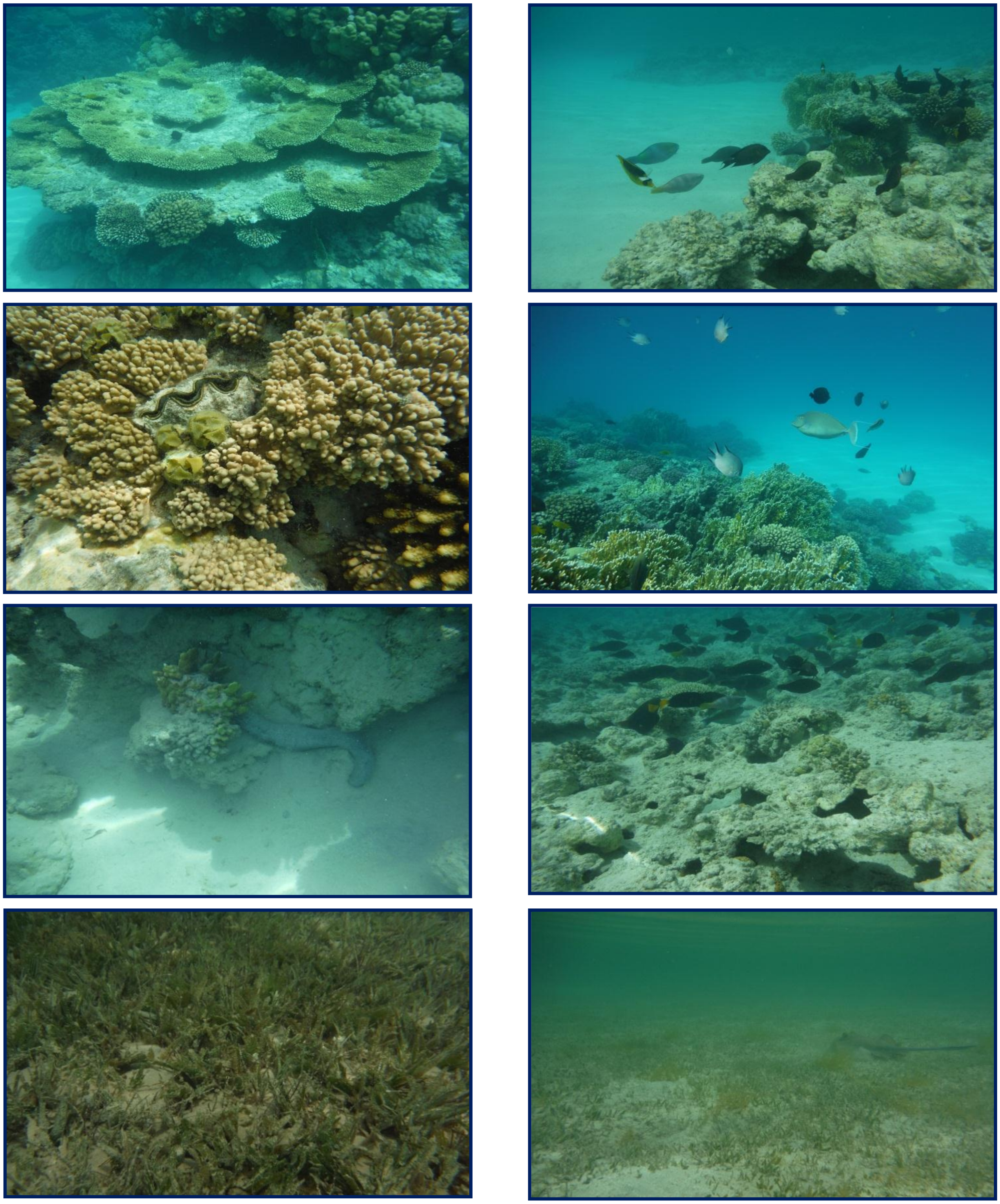

Fig. 6. The biological diversity of the marine region for the first and second sectors, showing the percentage of the biological cover in the tidal area, the natural lakes, the back reef area, the reef edge region, and determining the density of the biological diversity from algae, fish and coral as well as benthic organisms at Sahl Hasheesh area, Red Sea, Egypt.

Table 6. Description of transect 2 and the percent cover of marine environment at the studied sites.

No.	T2 Distance 410 m	Depth From (0.2 m) to (15 m)	Description	Types	Percentage
1	30 m	0.2 to 0.3 m	Tidal flat rocky shore covered with thick fine sand	1- marine algae	1- 30 to 50 %
2	30 m	0.2 to 0.3 m	Tidal flat rocky shore covered with thick fine sand	1-Seagrass	1- 80%
3	140 m	0.5 m	Rocky sea bed	1-Coral reef 2- marine algae	1- 60 to 80% 2- 5%
4	50 m	1 m	small Lagoon characterized by sandy and rocky sea bed covered with coral reef	1- Coral reef 2- Marine Fishes	1- 10 to 15% 2- 5%
5	60 m	1.5 to 2 m	Big lagoon characterized by sandy and rocky sea bed covered with coral reef	1- Coral reef 2- Marine Fishes 3- Marine algae	1- 40 to 60% 2- 80% 3- 20%
6	50 m	4 to 8 m	Biggest lagoon characterized by sandy and rocky sea bed cover with coral reef	1-coral reef 2-marine fishes 3-Sea grasses 4- Algae	1- 85% 2- 80% 3- 5% 4- 5%
7	40 m	12 to 15 m	Sandy sea bed with rare marine environment	1-coral reef 2-marine fishes 3-Sea grasses 4- Algae	1- 1% 2- 20% 3- 10% 4- 0%

CONCLUSION

- Evidents from the present study revealed that the southern region of the Sahl Hasheesh Touristic Center is characterized by the existence of a living coral reef with density that ranges from medium to high. Thus, it was necessary to open the entrance channel to the suggested marine port to avoid any slight damage with respect to these reefs.
- Moreover, it became clear that the area under investigation is protected from the marine currents due to the presence of Abu Hasheesh Island, situated in front of it, as well as the presence of the coral barrier along the coast of Sahl Hasheesh.
- Hence, this study would be a database of the concerned area, that may enrich the scientific researchers, government agencies specialists, and all concerned with environmental protection with the essential informations needed to discuss the positive/ negative results of establishing the proposed marine port.

- Despite the good condition of the coral reefs in the study area it is required to creat Sahl Hasheesh suggested marine port to help the guests of the tourist village and hotels around Sahl Hasheesh bay to arrive to the diving site with low effect on coral reef hebetate. This may necessitate a great concern to the environment preservation, the transport and cultivation of the coral reef site which may be exposed to death by the suggested marine port.

REFERENCES

Abdel-Halim, A.; Aboel-Khair, E.; Fahmy, M. and Shridah, M. (2007). Environmental assessment on the Aqaba Gulf coastal waters, Egypt. Egy. J. Aqu. Res., 33 (1): 1–14.

Abouhend, A.S. and El-Moselhy, K. (2015). Spatial and Seasonal Variations of Heavy Metals in Water and Sediments at the Northern Red Sea Coast. American J. of Water Resour., 3 (3): 73-85.

Abowei, J. (2010). Salinity, dissolved oxygen, pH and surface water temperature conditions in Nkoro River, Niger Delta, Nigeria. Adv. J. Food Sci. Technol., 2 (1): 36–40.

Al-Hammady, M.A.M (2005). Coral reef, distribution, impacts and rehabilitation at three sites Hurghada, Safaga and Marsa Alam, Red Sea, Egypt. Scie. Facu., Al-Azh. unive., 106 p.

Ali, A.A.M; Hamed, M.A and Abd El-Azim. H. (2011). Heavy metals distribution in the coral reef ecosystems of the Northern Red Sea.Helgoland Marine Research 65: 67-80.

Ali, Y.A.; Beltagy, A.I. and Lotfy, I.H., (1987). Grain size analysis and environmental of deposition of tidal and bottom sediment from Ghardaqa region, Red Sea area. Bull. Inst. Oceanogr. Fish. ARE, 13: 147–167.

Basaham, A.S. and El-Sayed, M.A. (1998). Distribution and phase association of some major and trace elements in the Arabian Gulf sediments. Estuarine Coast and Shelf Sci. Academic Press limited, 46 (2): 185-194.

Brenner, M. and Binford, M.W. (1988). Relationships between concentrations of sedimentary variables and trophic state in Florida Lakes. Can. J. Fish. Aquat. Sci. 45: 294-300.

Burke, L.; Reytar, K.; Spalding, M. and Perry, A. (2011). Reefs at Risk Revisited. Washington, DC: World Resources Institute.

Chester, R.; Lin, F.G. and Basaham, A.S. (1994). Heavy metals solid state speciation changes associated with the down-column fluxes of oceanic particulates. J. of the Geo. Soci. of Lond., 151: 351-360.

Côté, I.M.; Gill, J.A.; Gardner, T.A. and Watkinson, A.R. (2005). Measuring coral reef decline through meta-analyses. Philosophical Transactions of the Royal Society, 360: 385-395.

Dar, M.A. (2002). Geological bases to study the environmental defect in the marine ecosystem as a result of touristic activities in Hurghada area and surroundings, Red Sea, Egypt. Ph. D. Thesis, Science Faculty, Suez Canal Univ., Egypt, 218p.

Dar, M.A. and Abdel-Wahab, M. (2005). Monitored the coastal alterations due to the artificial lagoons, Red sea. Egy. J. of Aqua. Res. Vol. 31 Special Issue: 57-68.

Dar, M.A.; El-Metwally, M.E.A. and El-Moselhy, K. (2016). Distribution patterns of mobile heavy metals in the inshore sediments of the Red Sea. Arab J. Geosci, 9: 221.

Dawoud, W.A.; Negm, A.S.; Saleh, N.M. and Bady, M.F. (2016). Impact Assessment of Offshore Pile Driving Noise on Red Sea Marine Mammals. International Journal of Environmental Science and Development, 7 (1): 10-15.

Dean, W.E. (1974). Determination of carbonate and organic matter in calcareous sediments and sedimentary rocks by loss in ignition: comparison with other methods. J. Sediment. Petrol., 44: 242-248.

Dorgham, M.; El-Sherbiny, M. and Hanafi, M. (2012). Environmental properties of the southern Gulf of Aqaba, Red Sea, Egypt. Mediterranean Marine Science, 13 (2): 179–186.

EEAA (2016): Egyptian Biodiversity Strategy and Action Plan (2015 – 2030). UNDP, GEF, PIMS no. (4864), 83 p.

El-Askary, M.A.; Nasr, S.M.; Moussa, A.A. and El-Mamony, M.H. (1988). Geochemical approach to the beach and bottom sediments of the Jubal area at the entrance of the Gulf of Suez. M. Sc. Thesis, Ain Shams Univ. Egypt, 304 p.

El-Mamoney, M.H., (1995). Evaluation of terrestrial contribution to the Red Sea sediments, Egypt, Ph.D. Thesis, Faculty of science, Alexandria University, 146 p.

El-Metwally, M. (2015). Monitoring of heavy metals pollution in the Egyptian Red Sea Coast and response of marine organisms. Ph.D. Thesis, faculty of Science, Mansoura University.

El-Sayed, M.Kh., (1984). Reefal sediments of Al-Ghardaqa, Northern Red Sea Egypt, Mar. Geol., 56: 259-271.

El-Serehy, H.A.; Aboulela, H.; Al-Misned, F.; Kaiser, M.; Al-Rasheid, K. and Ezz El-Din, H. (2012). Heavy metals contamination of a Mediterranean Coastal Ecosystem, Eastern Nile Delta, Egypt. Turki. J. of Fishe. and Aqua. Sci. 12: 751-760.

English, S.; Wilkinson, C. and Baker, V. (1997). Survey manual fir tropical marine resources 2nd Edition, 385 p.

Folk, R.L. (1974). Petrology of sedimentary rocks. University of Texas, Hemphill Pub. Co.,182 p.

Folk, R.L. and Ward, W.C., (1957). Brazos River bar: a study in the significance of grain size. Jour. Sed. Petrol. Tulsa, Oklahoma, 27 (1): 3-26.

Frihy, O.; El Ganaini, M.A.; El Sayed, W.R. and Iskander, M.M. (2004). The role of fringing coral reef in beach protection of Hurghada, Red Sea of Egypt. Ecological Engineering, 22: 17-25.

Frihy, O.E.; Fanos, A.M.; Khafagy, A.A. and Abu Aesha, K.A. (1996). Human impacts on the coastal zone of Hurghada, northern Red Sea, Egypt:Geo-Marine. Letters, 16: 324-329.

Khalafallah, A.A.; Salem, E. and El Wahab, M.A. (2019). Contamination and Hazard Indices of Heavy Metals and Natural Radionuclides Activity in Mangrove and Seagrass Habitats, Red Sea Coast, Egypt. *Sciences*, 9 (02) 502-523.

Madkour, H.A., (2004). Geochemical and environmental studies of recent marine sediments and some invertebrates of the Red Sea, Egypt. Ph.D. Thesis, Faculty of Science, South Valley University, 317 p.

Madkour, H.A. and Dar, M.A. (2007). The anthropogenic effluents of the human activities on the Red Sea coast at Hurghada harbour (case study). Egy. J. Aqua. Res., 33: 43-58.

Madkour, H.A.; Ahmed, N.A. and Mohamed, A.W. (2006): Coastal sediments and their polluting metals of El-Hamrawein Harbour, Egyptian Red Sea coast: clues for monitoring environmental hazards. Sedimentol. Egypt 14: 131–155.

Madkour, H.A.; Ebdelhalim, M.A.; Obirikorang, K.A.; Mohamed, W.A.; Ahmed, N.A., and El-Taher, A.M. (2015). Environmental Implications of Surface Sediments from Coastal Lagoons in the Red Sea coast, J. of Env. Biology, 36: 1421-1427

Madkour, H.A.; Mansour, A.M.; Ahmed, N.A. and El-Taher, A. (2013). Environmental texture and Geochemistry of the sediments of a subtropical mangrove ecosystem and surrounding areas, Red Sea coast, Egypt. Arabian Journal of Geosciences, 7: 3427-3440.

Madkour, H.A.; Mansour, A.M.; Ahmed, N.A., and El-Taher, A. (2014). Environmental texture and Geochemistry of the sediments of a subtropical mangrove ecosystem and surrounding areas, Red Sea coast, Egypt. Arabian Journal of Geosciences, 7: 3427-3440.

Mansour, A.M.; Askalany, M.S.; Madkour, H.A. and Assran, B.B. (2013). Assessment and comparison of heavy-metal concentrations in marine sediments in view of tourism activities in Hurghada area, northern Red Sea, Egypt. Egyptian Journal of Aquatic Research, 39: 91–103.

Mansour, A.M.; Mohamed, A.W.; El Dien, G.K. and Sayed, S.M. (2007). Sedimentological and environmental impacts of development projects along the coast of Hurghada, Red Sea, Egypt. Egypt. J. Aquat. Res. 33 (1): 59–84.

Mansour, A.M.; Nawar, A.H. and Madkour, H.A. (2011). Metal pollution in marine sediments of selected harbours and industrial areas along the Red Sea coast of Egypt. Ann. Naturhist. Mus. Wien Ser. A., 113: 225–244.

Mansour, A.M.; Nawar, A.H. and Mohamed, A.W. (2000). Geochemistry of coastal marine sediments and their contaminant metals, Red Sea, Egypt: a legacy for the future and a tracer to modern sediment dynamics. Sedimentol. Egypt 8: 231–242.

Masoud, M.S.; Said, T.O.; El-Zokm, G. and Shreadah, M.A. (2012). Assessment of heavy metals contamination in surface sediments of the Egyptian Red Sea coasts. Australian Journal of Basic and Applied Sciences, 6 (6): 44-58.

Mohamed, A.W. (2005). Geochemical and Sedimentology of core sediments and the influence of human activities; Qusier, Safaga and Hurghada Harbors, Red Red Sea, Egyptian Jour. of Aquatic Research, 31 (1): 92-104.

Nasr, S.M.; Okbah, M.A. and Kasem, S.M. (2006). Environmental Assessment of Heavy Metal Pollution in Bottom Sediments of Aden Port, Yemen. Int. J. of oceans and oceano. 1 (1): 99-109.

Pandolfi, J.M.; Bradbury, R.H.; Sala, E.; Hughes, T.P.; Bjorndal, K.A.; Cooke, R.G.; McArdle, D.; McClenachan, L.; Newman, M.J.H.; Paredes, G.; Warner, R.R. and Jackson, J.B.C. (2003). Global trajectories of the long term decline of coral reef ecosystems. Science 301: 955-958.

Salem, D.M.S.A.; Khaled, A.; El Nemr, A. and El-Sikaily, A. (2014). Comprehensive risk assessment of heavy metals in surface sediments along the Egyptian Red Sea coast. Egy. J. of Aqua. Res. 40: 349-362.

Sawall, Y. and Al-Sofyani, A. (2015). Biology of Red Sea Corals: Metabolism, Reproduction, Acclimatization, and Adaptation. Springer Earth System Sciences, Book ISBN: 978-3-662-45200-4, Chapter 28: 487-509.

Sharaan, M.; Somphog, C. and Udo, K. (2020). Impact of SLR on Beach - Tourism Resort Revenue at Sahl Hasheesh and Makadi Bay, Red Sea, Egypt; A Hedonic Pricing Approach. J. Mar. Sci. Eng. 8 (432): 1-13.

Tantawy, A.S.A.M. (2017). The long term impacts of the mega cities on the marine environment along the northern Red Sea, Egypt. Ms.C thesis, Zoology Department**,** Faculty of Science, Al-Azhar University, Assiut.

Turki, A.J. (2007). Metal Speciation (Cd, Cu, Pb and Zn) in Sediments from Al Shabab Lagoon, Jeddah, Saudi Arabia. JKAU: Mar. Sci. 18: 191-210.

White, A. T.; Vogt, H.P. and Arin, T. (2000). “Philippine coral reefs under threat: the economic losses caused by reef destruction.” Marine Pollution Bulletin 40 (7): 598– 605.

Youssef, M.; Madkour, H.; El Attar, R.; Mansour, A. and Badawi, A. (2020). Assessment of metal contamination in coastal marine sediments of Makadi Bay on the Red Sea, Egypt. Marine and Freshwater Research. 71 (10) DOI: 10.1071/MF19306.