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Overview on the effect of tourism development on the coastal zone, of Red Sea, Egypt

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Abstract

The Red Sea coast is fringed by one or more rows of shallow reef ridges varying in widths from a few meters to 500 meters or more. The nearshore may be considered as a good nursery ground for many economically important fishes as well as many faunal and floral providing a rich source of nutrients for ocean-dwelling organisms. The coastal ecosystem of the Red Sea contains some of the most biologically diverse and productive habitats but they are also the most vulnerable one. The coastal stretch consists of an area of interest to the Red Sea sustainable development of the country. However, a little attention has been paid in the past to understand this sort of fragile environment, and the interactions with the marine ecosystem. Additionally, the effect of development inland to the coastal environment was not thought to be of great concern to the coastal areas.
Various environmental stresses implicated with tourism activities can be grouped in the following types; landfilling, dredging, power and desalination plants, sewage treatment stations and coastal construction.

Keywords: Coastal zone, Marine environment, Tourism activities, Red Sea, Egypt.

1. Introduction

The Egyptian Red Sea has a long coast (≈ 1080 Km) with marked variations in topography, geology and marine ecology. The Red Sea coast of Egypt extends from Suez (Lat. 30ºN) to Marsa Halaib (Lat. 22º N) at the Sudano-Egyptian border (Figure 1). The nearshore zone stretch is often bordered from the seaward side by many patches of coral reefs and some lagoons separating it from the open sea and coastal plain bounded it from the landward.

The land adjacent to the Red Sea shore is bounded on the western side by a strip of coastal mountains, whereas a gently sloping plain extends between the shoreline and the highlands with varying width from 5 to 30 Km. In certain parts of the west coast of the Gulf of Suez: the coastal plain is practically not-existed and the mountains almost directly rise from the water of the sea (El-Sorogy *et al.,* 2003). This plain is covered with sand and rock detritus cover which the drainage system (wadis) meander with their shallow courses.

Many areas of the coast are virgin, especially those south Marsa Alam. However, increasing population densities, and activities along the coast are on the rise, and unless such activities are well planned, they would have serious environmental consequences. The majority of the previous works on the Red Sea coast are mainly concerned with morphology, biology, geology, marine environment have been studied by many authors. Among of them, there are Medio, *et al.* (1997); Abd El Wahab (2003); Dar (2003); Mansour (2003); Madkour and Mohamed (2005); Ismail *et al*. (2005); Madkour *et al.* (2006 & 2008).

Recently research studies on the Red Sea environment and tourism projects and their impact on coastal zone are based on the ecological analysis were done by several authors, such as Kotb (1996); Hawkins and Roberts (1997); UNEP (1997); GEF (1998); Reeve *et al.* (1998); Reigl and Luke (1998); GRBP (1999); Hodgson (1999); Jameson *et al.* (1999); Shackley (1999); Kotb *et al.* (2001); Abu Zeid (2002); Cesar (2003); Wielgus *et al.* (2004); Kondolf *et al.* (2005); Farouk (2005); Shaalan (2005) and Dar and Mohamed (2009). The present work is an attempt to illustrate some of the important problems facing both coastal area and marine environment and their relations with the tourism development. Recommendations are to be taken so that management and conservation strategies can be set and implemented.

2. Materials and Methods

The studied area covers most of the Egyptian Red Sea coast (≈ 1080 km) from Suez northward to Marsa Halaib southward. Twenty localities include: Al Adabyia port, Abu El Darag, Zafarana, Ras Gharib, El Zeit Bay, Ras El Behaar, Hurghada, Makkadi Bay, Sharm El Naja, Um El Hwaytat (10 km south Safaga), El Quaih, El Hamrawein, Quseir, Sharm el-Bahari, Marsa Shuni, Abu Dabab, Marsa Alam, Wadi El Gemal, Qola'an, and Shalatein (Figure 1).

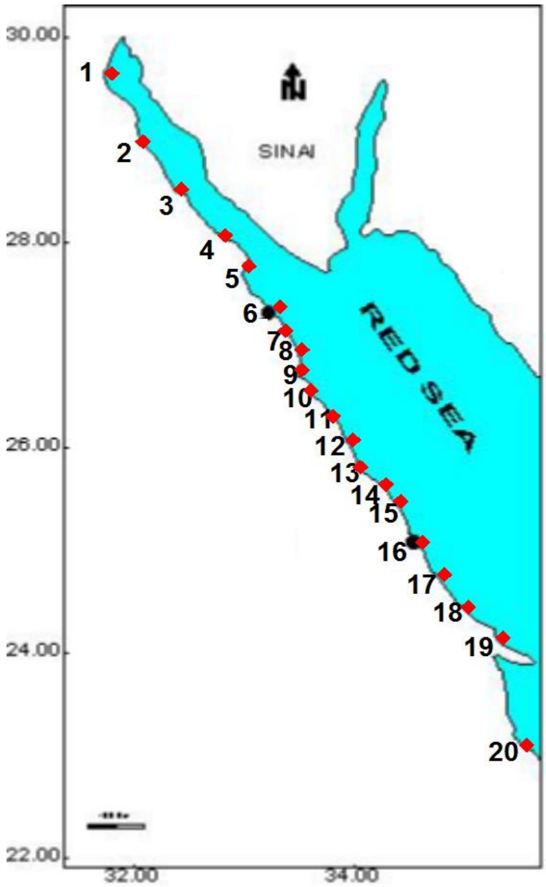

Figure 1. Location map.

One hundred and eighty sediment samples (nine samples from each above mentioned location) were collected during the summer 2008. Sediment samples represent beach, intertidal and subtidal zones, the samples were taken by pushing a steel box about 10 cm deep into the sediment, or by diving till 30m depth. The collected samples were placed in labeled plastic bags and returned to the laboratory. In the laboratory: the sediment samples were washed with fresh water then dried in the sunlight to avoid any change in the physical properties. The grain size analysis was done using sieves technique according to Folk and Ward (1957) at the National Institute of Oceanography and Fisheries, Red Sea Branch, to provide the basic information for the sediment characteristics.

Also, the latitude and longitude of each location were detected using Global Positioning systems (GPS). Cluster analysis was carried out using Spss 11 program to find groupings of similar samples along the coast.

3. Environmental setting

The weather in Red Sea region is hot and dry in summer but in winter tends to warm. There are four main climatic parameters have been discussed here. The air temperature varies between 37.66 - 23.04 ºC in summer and 29.34 - 6.86 ºC in winter. The wind over the Red Sea is controlled by the complicated topography where the prevailing wind is mainly NNW allover the Red Sea coast of Egypt, also, occasional winds from this direction are slightly more frequent in summer than in winter (Morcos, 1970). Humidity is dependent on the activity of the wind regime over this area, especially in the summer. It ranges from 86.2 % to 13.25 % with an average of 54.26% in summer and varies between 96.5 % and 0.84 % with an average of 55.31% in winter (El-Saman, 2000). Evaporation is the mainly factor in forming the high salinity water of the Red Sea, where the Red Sea loses much water through evaporation than it gains by precipitation and run off owing to its position in arid zone between two great deserts. Most of the estimates calculating the evaporation value fluctuate between 183 cm/yr and 250 cm/yr (Maiyza, 1988).

There are many oceanographic parameters that control the coastal features of the Red Sea. Its average water temperature varies between 20 ºC in winter and 27.49 ºC in summer. An important feature of the Red Sea is its salinity in comparison to the open ocean. The surface water salinity varies from 39.79 ‰ to 41.52 ‰ off Hurghada area (Hanna *et al*., 1988).

The Red Sea is essentially an oscillatory system of semidiurnal type and the tidal range from 65 to 95cm (Morcos, 1970). The currents in the Red Sea are predominantly weak. It is much influenced by the local topography and sometimes by tidal streams which are themselves much affected by local conditions. The velocity of the tidal currents of the mean lunar semidiurnal wave as 2 cm/sec in the northern part of the Red Sea.

4. Beach zone description

4.1. Surface features of the beach

Geomorphologically, the beach of the Red Sea varies in shape and composition; it varies from rocky to sandy, with low or high relief topography of cliffs and headlands. Mostly, the beach is backed by a wide coastal plain followed by rocky mountains belonging to the Eastern Desert. The Red Sea coast is fringed by one or more rows of shallow reef ridges of widths varying from a few meters to a half kilometer or more. They are interrupted at the mouth of valleys, where indentation of the beach in some places, give rise to the deep natural embayment known as "sharms", this is attributed to the fact that during the formation of these coral reefs in the interglacial periods, the valleys were active during these periods. The high load of terreigenous deposits transported to the Red Sea shore by these valleys and hence the high turbidity of seawater prevented the formation of coral reefs off these valleys. Along the shore, there is a continuous band of emergent reef terraces and a sandy gravel surface which is inclined towards the sea.

4.2. Nature of the beach

The Red Sea Beach of Egypt varies from place to place in width, sediments and topography. Miocene rock units constitute considerable amounts of the beach sediments and beach rocks in many parts of the Red Sea shoreline especially the wadi mouths (El Sorogy, *et al.*, 2003). Recently, there are some man-made modifications in many parts of the Red Sea e.g. landfill and dredging. The sediments of the beach zone may be considered to consist of three components: lithogenic, biogenic and authigenic. According to the type of constituent materials, the beach could be briefly classified into the following types:

4.2.*1. Sandy beaches*

These types are mostly present along the entrance of large wadis, they are formed of friable sandy and locally gravelly sediments (Pl. 1/1). Shells and fragments of mollusks, corals and Foraminifera are drifted by waves and tidal currents above these beaches. The biogenic fragments may form up to 25% of the beach component in some localities (Mansour, 2000).

4.2. *2. Gravelly beaches*

Beaches formed of non-consolidated pebbles to cobbles of different origin (igneous or metamorphic rocks or even of sedimentary origin), (Pl. 1/2). These clasts are transported to the beach from the hinterland "mountains". Sea water covers these beaches during high tide time (El Sorogy *et al.*, 2003).

4.2. *3. Rocky beaches*

Sand sediments are consolidated to form hard rocky shore (grit stone). The fissures and cracks in such these rocky shore contain water during low tide period (Pl. 1/3). They are similar to many areas of rocky beach all around the sea ((El Sorogy *et al.*, 2003).

4.2. *4. Reefal beaches*

These beaches are composed of hard; massive algal coralline limestone of the youngest Pleistocene raised coral reefs (Pl. 1/4). Along the Red Sea coast, most of the tourist villages and resorts were built above this unit. Reefal beaches are found in two forms; the first form consists of walls facing the sea, 0.5 - 9m height, sea water reaches during high tide, they are vertical or strongly sloped (60-90^{o}). The second form is low, flat coral heads up to 2m width, of hard coral species (El Sorogy *et al.*, 2003).

4.2. *5. Mangrove beaches*

Mangrove stands are found only as; ***Avicennia marina*** and ***Rhizofora mucronata***, (Pl. 1/5-6) where the first species grows in most localities on the Red Sea coast while the second one occurs in few localities. They become more frequent and extensive towards the south. Its roots are nurseries and provide nests for several species of fish, shrimps, bivalves and other crustaceans. The trees form breeding habitats and nesting sites for brides. The sediments between mangrove stands are very fine due to trapping away from strong waves (Madkour and Mohamed, 2005).

5. Characteristics of the marine area

The distribution of the coastal and marine resources such as saltpan, sabkhah, coral reefs, seagrass and mangroves are controlled by the physical and biological processes present in the region as briefly mentioned below, (Figure 2).

5.1. Mangrove Swamps

Mangrove communities occur on the beach or in the intertidal zone, growing along the edges of brackish and sea water shores (Pl. 2/1), and include plants able to colonize waterlogged and saline soils. Mangrove also controls shoreline coastal erosion and contributes to shoreline accretion. Mangroves in turn protect reefs from sedimentation and eutrophication, only small parts of the Red Sea shore are suitable for mangrove developments with a northern latitudinal limit determined largely by extremes in temperatures, arid nature of the region and influence of local physical factors such as tidal amplitude, wave exposure, topography (affecting sediment retention) and sediment supply.

5.2. Seagrasses

They are flowering plants able to live permanently in soft marine soil environments and they extend from the mid-intertidal zone to greater than 50m depth (Pl. 2/2), although they grow best in water 0.5-1.5m deep in near tidalless conditions but usually occur in shallow, sandy silt, soft-bottom habitats (Mcroy & Helff-Erich, 1977).

5.3. Coral Reefs

Coral reefs are among the beautiful ecosystems on the earth, they are widespread and well-developed in the Red Sea (Pl. 2/3). Reefs create sheltered lagoons and protect coastlines and mangroves against wave damage. In spite of their significance to human as a coastal protecting structure, a potential source of new medicines, a recreational area, a feeding ground for fish and other creayures, about 60% of the world's reefs are at risk due to human activities (Bryant *et al.*, 1998).

The local continuity and quality of reefs in Red Sea are dependent on the distribution of those coastal and offshore features which cause local variations to the physical environment (e.g. exposure, turbidity, substrate type, salinity). The importance of these factors varies not only latitudinaly, but also inshore and offshore.

Ismail *et al.* (2005) stated that the Red Sea has about 200 species of hard coral reefs and 125 species of soft corals representing about 6.3% as endemic, and approximately 400 fish species use the corals for shelter and food.

5.4. Sharmas and Bays

Sharms and bays are very small areas with variable facies, that can provide excellent sites for the study of the effect of siliciclastic input on reef environments (Pl. 2/4). Most sharms and bays sediments: gravel, very coarse, medium and fine sand fractions are low, whereas coarse sand is highly frequent in areas between sharms. The different facies of sharms and bays are nearly restricted to extreme shallow water and are arranged in zones. Fringing reef is the seaward extension of the coastal plain in which depressions, mostly valley mouths, locally called "Sharms" or "Marsas" and some lagoons were formed by the drainage systems during glacial lowstands of the sea level. Other sediment facies e.g. rock bottoms, sand bottoms and mud bottoms are also distributed in sharms and bays.

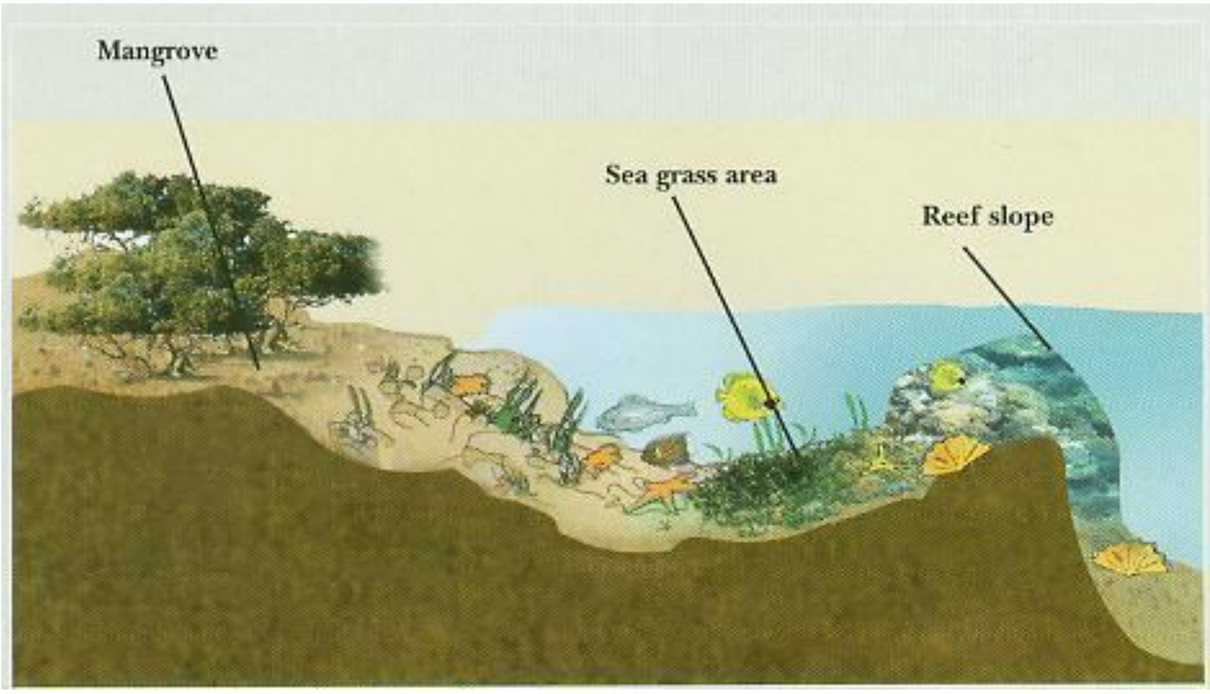

Figure 2. Sketch showing ecosystem zone along the Red Sea coast.

6. Tourism activity in Red Sea

The rapid expansion of tourism especially in the northern part of the Red Sea, has inevitably resulted in conflicts with biodiversity conservation and goals of ecological sustainability. At the present time, the Red Sea governorate has 250 hotels and resorts with a total capacity of 104814 beds. The existing number of rooms is 52407 and it represents 23.2% of the total hotel accommodation capacity. The target for 2012 is planned to attain 140000 rooms, primarily by constructing new resorts and secondly by expansion of the existing ones (Information Bank of Red Sea Governorate, 2006). The massive tourism development is expected to create more than one million jobs by 2012 to represent 14% of the total employment in Egypt, (GEF, 1998).

Tourism development along the Red Sea coast will undoubtedly affect the socio-economic framework of the adjacent urban areas (close to the cities). Tourism has both direct and indirect impacts on coral reefs. Snorkeling, diving and boating can cause direct physical damage to reefs, while over fishing can contribute to over exploitation of coral reefs and threaten local survival of endangered species. Indirect impacts related to the development, consruction and operation of tourism infrastructure as a whole (resort, marinas, ports, …etc), (ICZM . 1996).

The various environmental stresses associated with tourism can be grouped in the following types:

1. Permanent structures directly related to tourism e.g. resorts, golf courses, roads, water and sewage treatment plants, and power generation plants.
2. Recreational activities such as diving, boating and aqua sports.
3. Effect on population dynamics or induced impact of tourism.
4. The tendency to develop facilities very close to the coast threatens the coral reefs, mangroves, beaches and aquatic species.
5. The construction and operation of marinas for resorts are usually accompanied by destruction of tidal flat zone and changes in shorelines.
6. The construction activities of hotels and infrastructure generate considerable quantities of wastes, which in most cases are improperly disposed of.

7. Results and discusion

7.1. Sediment types

The grain size analysis is necessary in order to give an idea about the petrographical and their physical characteristics, the source material and the depositional environment. The surface bottom sediments in the studied localities have a little variation in the sediment type.

Gravel has the highest ratio (47.61%) at Ras Gharib, this as a result of the abundance of shell fragments and coral debris. Sand recorded the highest value of sediment type along the all localities especially at Qola'an, while mud has the highest ratio (34.84%) at Safaga locality, this is related to that samples collected from an area of mangrove environments (Table 1 and Figure 3).

7.2. Grain size parameters

The variation in the grain size parameters of the studied sediments reflect different effects of the water current along the intertidal and subtidal zones and conditions operating in these different localities (eg. presence of mangrove facies). The mean size recorded the highest average value at Adabyia Port and the lowest average value at Quseir. The sorting shows the highest average ratio at Quiah and lowest ratio at Quseir. There are no variations in skewness and kurtosis values between the studied zones (Table 1 and Figure 4).

7.3. Cluster analysis

Using ward's method includes gravel, sand and mud separating all samples (180 samples) into 2 main clusters (Figure 5). Clusters from 1 to 4 contain 10 localities, distinguished by the abundance of gravel (8.82%) and mud (16.09%) contents. Clusters from 5 to 7 represent the rest 10 localities are characterized by abundance of sand (89.17%) content with low gravel (5.83%) and mud (5.0%) contents (Figures 5&6).

Among the first four clusters, cluster 1 (Zafarana and El Quiah localities) includes the highest content of mud (17%), also, cluster 2 (6 localities) is characterized by the abundance of mud content (13.36%). Clusters 3 and 4 are completely different from each other, where cluster 3 (Ras Gharib locality) has highest ratio of gravel (27.4%) and lowest ratio of mud (1.0%) compared with other clusters, while cluster 4 (Safaga locality) has highest value of mud (34.84%), (Figures 5 & 6).

Among the second main clusters group; cluster 5 (4 localities) is characterized by the highest abundance of sand (93.01%) and lowest content of mud (2.84%). Cluster 6 (3 localities) is characterized with highest gravel content (10.15%), while cluster 7 (3 localities) has low ratio of gravel (3.74%), (Figures 5 & 6). The reason for high mud content in clusters 1, 2, and 4 are the presence of mangrove forest and terrigenous origin, while the high gravel content in clusters 3 and 6 attributed to the abundance of shell fragments and coral debris.

7.4. Main source of pollution

Tourism industry was located along the Red Sea coast and causing a negative impact. Here, the severity of negative impact was assessed on the basis of coastal and marine resources:

a- Land filling activities which have been worked as effective category in the coastal reef damage. Two sources for the artificial landfilling in the urban zone are recognized. The first one resulted from the beach and neighbor areas enhancement (removing the sand hills and sand piles from the areas of investment). The second source is from the near sand quarries. In Hurghada, 2.900.000m^2 reef flat was landfilled and the sediments plume from this activity several km from shore between 1994 and 1997 (Pl. 3/1).

b- Power and Desalination Plants discharged their brine effluent into the sea (Pl. 3/2), which likely has resulted in considerable local damage ca. 1.5% to marine life (VDP, 2008).

c- Dredging has been carried out to construct boat channels, causeways, artificial lagoons and port facilities such as the jetties at many places along the coast (Pl. 3/3). Also, dredging of tidal flat would have a negative effect on the stability of the beach causing losses and damage for the recreation facilities (Frihy, *et al.*, 2004).

d- Solid waste disposal such as broken bottles, remain steel, cans, rubber tiers, plastic bags, tissue paper, woods and other trash represent a serious health hazard on beaches and in shallow waters (Pl. 3/4).

e- Recreational and tourism activities create incidental damage to corals by divers is becoming increasingly significant as environmental affecting coral reefs (Pl. 4/1). The diving impacts on the coral reefs were indicating by the decrease in living coral coverage and increase in both percentage of dead corals and coral rubbles (Abu Zeid and Kotb, 2000).

f- Coastal alteration; the suspended sediments resulting from coastline alteration can travel great distances, driven by the prevailing water currents, spreading death and destruction to coral reefs, seagrass beds and other marine life over distances of dozens of kilometers away (Pl. 4/2).

g- Sedimentation from the development activity increases the water turbidity and poor water visibility (Pl. 4/3). Chronic exposure to higher concentrations of sediment can have a variety of negative impacts on corals, many of which can be attributed to reduced light levels, (Rogers, 1990).

h- Water pollution is a rising problem, particularly that from urban centers and organic pollution from harbors, coastal villages and tourist facilities. The increase of contaminants is probably due to nearby phosphate deposits, sewage sludge discharge to the sea and lead in gasoline of motor boats. The beach zone is highly affected due to a high concentration of oil spill and hydrocarbon materials that are thrown out to the beach by waves and currents (Pl. 4/4).

Table (1). Characteristics of sediment samples from the studies localities.

S.N.	Location	Lat.	Long.	Sediment types						Grain size parameters							
				Gravel	Av.	Sand	Av.	Mud	Av.	Mz	Av.	So	Av.	Sk	Av.	Kg	Av.
1	Al Adabyia port	29 52 27.96	32 28 44.30	2.55 - 7.66	5.6	61.05 - 92.36	75.72	3.54 - 33.46	18.67	2.43 - 5.5	4.3	0.94- 2.5	2.02	-0.31- 0.51	0.11	0.86-2.19	1.66
2	Abu El Darag	29 25 50.69	32 31 26.60	2.63 - 8.59	5.8	72.16 - 93.46	86.8	8.84 - 11.46	7.4	0.62-2.83	1.23	0.58- .47	0.64	-0.08- 1.58	-0.2	054- 1.58	0.97
3	Zafarana	29 17 12.76	32 36 20.60	2.63 - 8.86	5.2	42.11 - 83.44	72.3	0.0 - 25.17	22.5	0.22-4.43	2.41	0.52-2.0	1.02	-0.25 - 0.5	1.75	0.82 - 3.11	1.75
4	Ras Gharib	28 21 44.43	33 05 42.22	2.60 - 8.33	5.5	55.16 - 89.75	78.27	4.28 - 23.36	1.0	1.09-4.25	1.01	0.68-.99	0.88	-0.45- 0.86	0.07	0.74 - 2.29	1.11
5	El Zeit bay	27 45 49.93	33 28 59.16	0.8 - 100	5.5	0.0 - 98.34	80.07	1.1 - 4.91	12.9	-0.1-3.02	0.95	0.11-1.4	0.97	-0.28- 0.51	0.05	0.73 - 1.59	1.03
6	Ras El Behaar	27 17 02.08	33 46 20.97	0.8- 27.73	7.8	70.77 - 98.34	91.02	0.0 - 4.91	1.18	0.19 - 1.8	0.91	0.64-.35	0.91	-0.28 -0.32	0.0	0.73 - 1.59	1.17
7	Hurghada	27 17 01.33	33 46 20.95	2.0 - 33	10	45 - 95	76.57	2.0 - 50.0	13.3	1.74-3.04	2.34	1.18-.57	2.25	-0.03- 0.41	0.07	1.3 - 1.7	1.46
8	Makkadi bay	26 59 46.1	33 54 17.5	0 - 15.55	2.7	84.45 - 98.55	92.72	0.0 - 9.8	4.54	0.38-3.21	2.31	0.6-1.52	1.13	-0.33- 0.11	-0.17	0.8 - 1.62	1.25
9	Sharm El Naja	26 53 56.64	33 57 44.69	0.04 - 6.18	3.11	66.85 - 99.96	86.4	0.55 - 8.63	4.59	1.16-2.11	1.86	0.27-.99	0.63	-0.52- 0.14	-0.33	0.85 - 1.06	0.96
10	Safaga	26 38 05.85	33 59 00.16	0.45 - 0.84	6.17	42.47 - 81.7	58.99	11.37-56.37	34.8	1.12 - 4.6	3.27	1.56-.81	2.16	-0.17- 0.41	0.04	0.67 - 1.84	1.33
11	El Quiah	26 22 39	33 08 00	1.16 -17.14	5.08	4.71 - 92.96	72.46	4.34 - 50.84	22.5	0.24-7.42	3.04	0.83-.51	2.57	0.1 - 0.76	0.41	0.69 - 2.7	1.7
12	El Hamrawein	28 21 54	33 05 20	0.0 - 27.94	10.8	68.36 - 97.82	83.8	0.05 - 13.74	5.3	-0.1-3.24	1.7	0.71-1.79	1.2	-0.36- 0.51	0.0	0.63 - 2.5	1.3
13	Quseir	26 06 12.32	34 17 09.05	1.33 - 4.66	3	82.56 - 97.12	88.17	5.35 - 16.23	8.83	-0.14-1.89	0.11	0.53-1.53	0.04	-0.01- 0.22	0.95	0.25 - 0.9	0.75
14	Sharm el-Bahari	25 52 07	34 24 49	0.0 -42.44	10.5	56.89 - 98.58	85.64	0.38 - 13.68	3.82	-0.38-6.0	2.44	0.3-1.71	1.1	-0.33- 0.58	0.07	0.66 - 4.07	1.47
15	Marsa Shuni	25 28 04.05	34 40 39.49	2.63 - 0.59	6.15	62.16 - 93.46	78.72	0.54 - 31.46	15.1	0.86-3.26	2.25	1.23-.77	2.01	-0.55- 0.01	-0.16	0.76 - 3.63	1.4
16	Abu Dabab	25 20 14	34 44 15	0.0 - 16.79	2.98	81.25 – 99.77	92.53	0.0 - 17.79	4.49	0.60-3.06	2.09	0.53-1.86	1.2	-0.42-0.1	-0.15	0.9 - 2.91	1.59
17	Marsa Alam	25 28 48.30	34 53 25.25	0 - 14.55	5.5	58.69 – 93.46	83.15	0.0 - 41.31	11.4	0.34 - 3.7	1.89	0.9 -3.14	1.67	-0.3-0.16	-0.1	0.71 - 1.97	1.17
18	Wadi El Gemal	24 39 38.7	35 09 52.3	0.1 -10.3	2.31	89.5 - 99.60	86.39	0.8 - 4.94	10.29	0.96-2.81	1.81	0.54-1.45	0.91	-0.21 - 0.2	-0.03	0.81 - 1.39	1.12
19	Qola'an	24 21 33	35 17 46	0.13 - 6.79	3.09	82.83- 98.67	95.78	0.25 - 3.11	1.14	0.6 - 2.31	1.45	0.13-1.45	1.18	-0.33-0.52	0.05	0.8 - 1.99	1.07
20	Shalatein	23 09 05	35 36 51	0.3 - 8.24	2.42	78.75 -95.67	88.84	2.45 - 19.08	8.74	1.66-2.97	2.21	1.31-2.05	1.65	-0.48-0.01	-0.19	0.72 - 1.91	1.18

N.B
S. N. = Station number, Lat. = Latitude, Long. = Longitude, Av. = Average,
M_z = Mean size, S_o = Sorting, S_k = Skewness, K_g = Kurtosis.

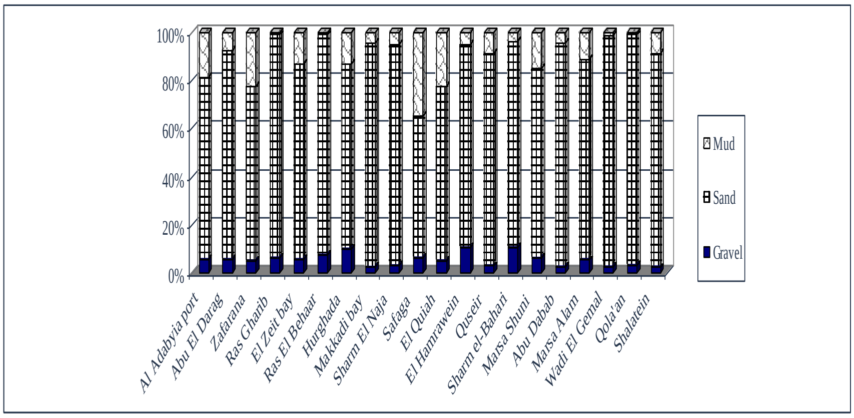

Figure 3. Distribution of sediment types through the studied localities.

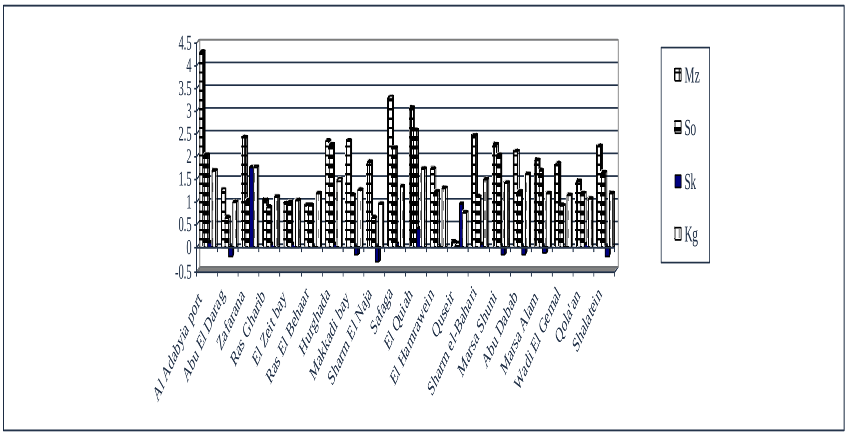

Figure 4. Distribution of grain size parameters through the studied localities.

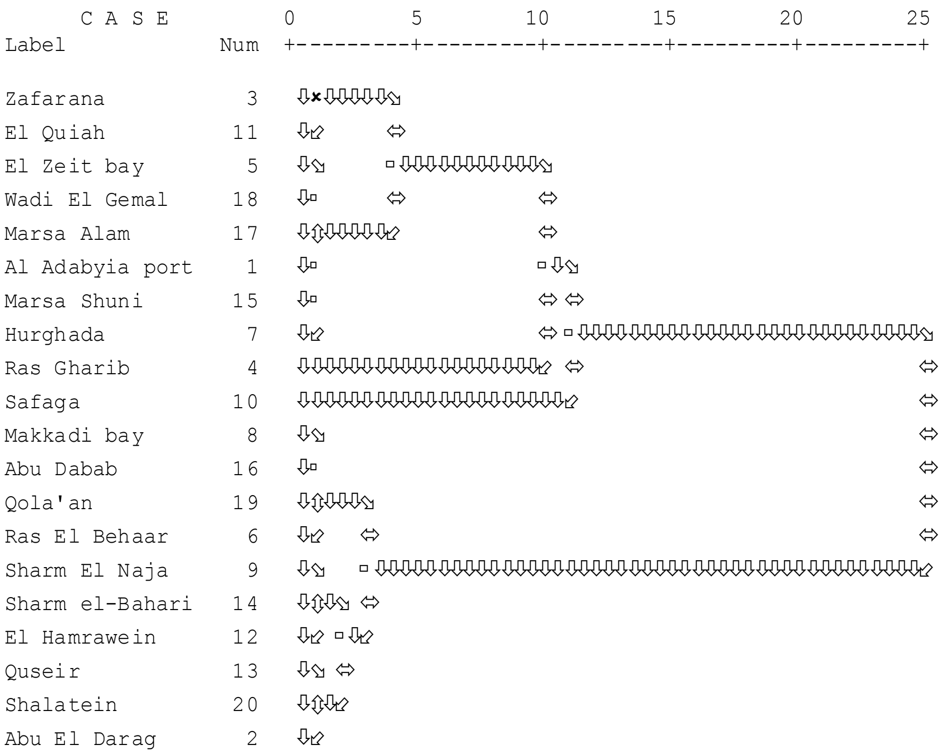

Figure 5. Dendrogram of cluster analysis using Ward's method exhibiting cluster of grain size parameters.

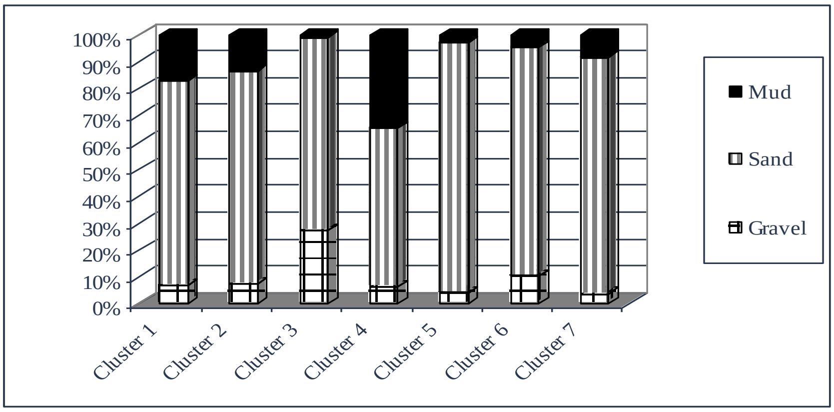

Figure 6. Average distribution of sediment texture in the studied localities.

Plate 1: Type of Beach along the Red Sea: 1) Sandy beach, 2) Gravelly beach; 3) Rocky beach; 4) Reef`al Beach; 5) and 6) Mangrove beach.

Plate 2: Coastal features: 1) Mangrove swamp at Qola'an locality; 2) Seagrass bed at Abu Dabab bay, 3) Coral reefs community, Makkadi bay and 4) Sharm contributes to the sea, Marsa Shuni.

Plate 3: 1) Landfilling processes at Hurghada, 2) Reject pipeline from the desalination and power plants, 3) Dredging operation inside Hurghada, and 4) Solid waste disposal at Quiah locality.

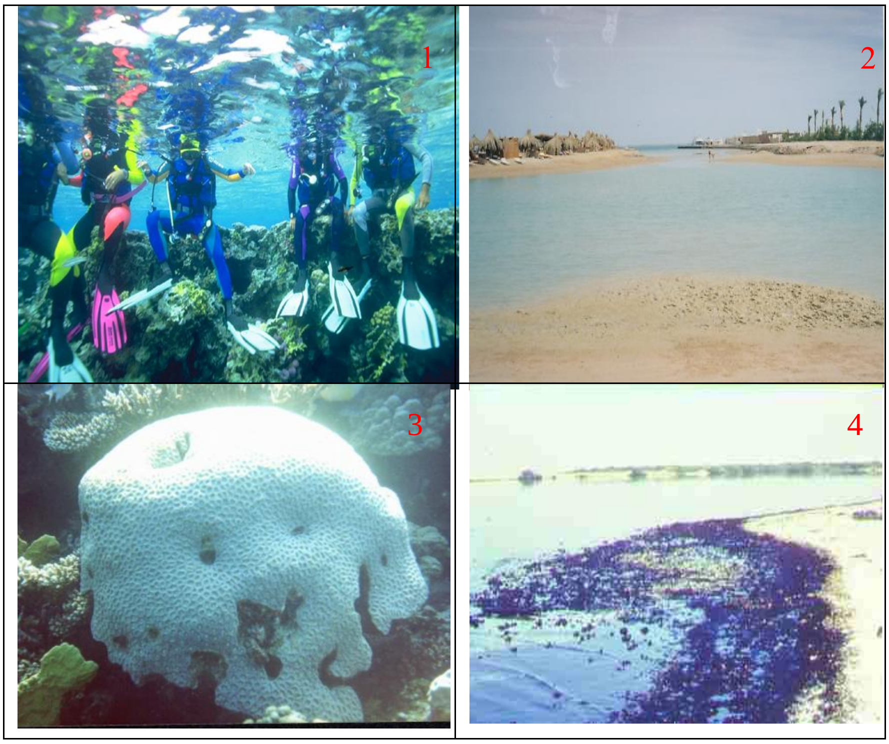

Plate 4: 1) Recreational tourism activities at Safaga, 2) Coastal alteration inside tourist village, 3) Bleaching corals due to sedimentation, and 4) Oil spill at Ras Gharib locality.

8. Summary and conclusions

The present study covers twenty localities along the Red Sea coast, some of them exposed to higher environmental problems such as; Adabyia Port, Ras Gharib, Hurghada, Hamrawein harbour, and Shalatein and other localities are suffered from a number of stresses due to tourism activities that caused observable reduction in environmental quality. The source of pollution can summarize as landfilling, dredging, power and desalination plants, waste disposal and sewage, recreational activities, coastal construction, sedimentation, and water pollution.

Grain size analysis explained that mud recorded the highest average in Safaga, Quiah, Shuni, Zafarana and Adabyia localities. This is related to the presence of terrigenous inputs from different wadis off these localities and also presence of mangrove swamps e.g. Quiah locality. The highest ratio for sand in Ras El Behaar, Makkdi Bay and Abu Dabab is a result of long extent of sandy beaches. The highest ratio for gravel in Ras Gharib, Hurghada and Hamrwein localities is related to shell fragments and coral debris. The most common causes of the environmental degradation can be summarized in the following:

1) Sediments released through beach enhancement, coastal constructions and dredging.

2) Heavy metals, acids and petrochemicals from industrial wastes.

3) Heated and chemically treated effluent water from power and desalination plants.

4) Nutrient enriched pathogen human sewage.

9. Recommendations

The following recommendations should be taken in consideration:

1. Programmes and policies should be developed to control the adverse impacts of the tourist industry and developments of the marine environment.
2. An integrated coastal zone management plan should be established and implemented to ensure sustainable development of the coast and to reduce conflicts between the coast users.
3. The deleterious effects of continued shoreline alteration, dredging and land-filling on the coastal and marine environment should be prevented.
4. Touch control, public awareness and continuous shore patrolling to the activities of divers coming from the clubs and residents nearby cities are urgent.
5. An Environmental Impact Assessment (EIA) report should be submitted with the request/application for all new projects or expansions of existing projects to Egyptian Environmental Affaires Agency (EEAA) for reviewing and approval through the Competent Administrative Authorities as

being applied according to the law No. 4 of 1994.

6. The coastal and marine park or even a zoning plan to control human activities along the Red Sea of Egypt is important and necessary to minimize the negative impact of human activities.
7. Encourage hotels and resorts to apply the concept of eco-tourism.

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