EGYPTIAN JOURNAL OF AQUATIC RESEARCH ISSN 1110-0354
VOL. 31., 1. 2005

GEOCHEMISTRY AND SEDIMENTOLOGY OF CORE SEDIMENTS AND THE INFLUENCE OF HUMAN ACTIVITIES; QUSIER, SAFAGA AND HURGHADA HARBORS, RED SEA COAST, EGYPT

AHMED W. MOHAMED

Marine Geologist (Researcher), National Institute of Oceanography and Fisheries, Hurghada Research Station, Red Sea branch.

Keyworads : Grain size, trace elements , carbonate, total phosphorus, organic carbon, total organic matter, Contamination, anthropogenic impacts and remediation.

ABSTRACT

The grain size distribution and parameters, major and trace elements, carbonate, total phosphorus, organic carbon and total organic matter has been assessed for core sediments collected in the intertidal area of Qusier, Safaga and Hurghada harbors in July 2002. Mud is the dominant fraction in almost all samples of Qusier core and some samples of Safaga and Hurghada cores. The reason for the high mud content of all Qusier core samples and some samples of Safaga and Hurghada cores is due to the terrigenous flux of wadies, phosphate deposits, landfill and dredging in these areas. Metals concentrations in the core sediments vary between sites within a wide range for Cu, Zn, Pb, V, Ni and Cd. Concentration of metals in the sediments at the top of cores is the highest. The highest concentration of P, V in Quseir, Pb, Zn in Safaga, Cd, Co,Ni in Hurghada may be attributed to anthropogenic inputs from the surrounding areas and harbors. Contamination with fine-grained terrigenous material and organic matter are recorded in Quseir and Safaga core samples. The increase in observed contaminants in these areas is probably due to phosphate deposits, sewage sludge discharge to the sea and lead in gasoline of motor boats. Concentrations of trace metals and physical properties measured in core samples will help in identifying anthropogenic impacts and better assessment the needs for remedial measures by detecting any changes, from the existing level expected with future operation activities.

INTRODUCTION

The Red Sea comprises a wide range of tropical marine habitats that include conservation, scientific, economic and recreational values. These receive either local or more widely, a variety of stresses as a result of human activities. Along the Red Sea coast of Egypt, the nearshore marine ecosystem and geosystem (as defined by Soliman, 1994) are dynamic having variable bottom sediment types, diverse biologic habitats, and localized depositional and transportation processes. They are impacted by many activities, as phosphate mining, oil industry, recreation, housing, sewage and waste disposal and shipping. The nature and magnitude of pollution problems in the Red Sea do not necessarily follow trends elsewhere applied in the world. Much of the input of contaminants is limited to geographically localized areas around urban and industrial development areas such as tourist villages and harbors.

Hurghada is located 150 Km south of Ras Ghareib and 60 Km north of Safaga, Hurghada is the capital of the Red Sea governrate. Two decades ago Hurghada was a modest little fishing village. At present it is home for more than 40,000 people. Hurghada port is used mainly to serve fishing and toursitic activities (Fig. 1).

Safaga is located on the western coast of the Red Sea, about 60 Km south of Hurghada, 80 Km north of Quseir and 160 Km east of Qena. In modern times, in 1911, it became important for exporting phosphate. At present, Safaga port is used to serve the pilgrims going to and from Saudi Arabia, to export aluminum and phosphate and to import wheat. The area consists of many bays, and Safaga is located on the largest one of them, opposite Safaga Island, which acts as a natural barrier against large waves. During the last few years, Safaga has experienced a remarkable development in tourism, and it has become a tourist center extending for many kilometers, that includes many hotels, tourists villages and entertainment centers (Fig. 1).

Quseir is situated on the western coast of the Red Sea, about 140 km south of Hurghada and about 160km east of the Nile Valley. The ancient city of Quseir enjoys a unique richness of historic and natural treasures. Quseir presents an opportunity to attract special kind of tourists intreseted in marine, desert and antiquities attractions, also the city's historic port location as well as its link to the interior desert regions, and the ile valley drains tourist's attention. However, Quseir also suffers from industrial pollution due to nearby out-moded and inefficient industries and from general urban neglect. The potential for developing new urban lodging facilities in Quseir will be explored, possibly utilizing renovated historic structures and designed to attract tourists who wish to enjoy a variety of tourist experiences (Fig. 1).

Several investigations on recent sediments and human impacts were carried out on the Egyptian Red Sea coast (ex. Beltagy, 1984; El-sayed, 1984; El-Mamony, 1995; Frihy *et al.,* 1996; Mansour, 1999 & 2003; Mansour *et al.* 1997 & 2000; Dar, 2002 and Madkour, 2004). However, studies on the Red Sea sediments are still few and there are defects in the sedimentological and geochemical studies in its shelf and coast at the Egyptian part. Therefore, and after the increasing of human activities and the rapid development in the area, the present study will be very important and necessary.

MATERIALS AND METHODS

Thirty-four soft to semi-soft sediment core samples were collected manually from three cores in the intertidal flat area. The first core was taken at the front of Qusier Harbor area ($26^{0}\ 06^{/}\ 16^{//}$ N and $34^{0}\ 17^{/}\ 08^{//}$ E) whereas the second core was collected at Safaga Harbor area ($26^{0}\ 43^{/}\ 42^{//}$ N and $33^{0}\ 56^{/}\ 20^{//}$ E) and the third core was taken at Hurghada Harbor area ($27^{0}\ 13^{/}\ 46^{//}$ N and $33^{0}\ 50^{/}\ 34^{//}$ E) (Fig.1). Each core was cut into different samples at 10-cm intervals. Hurghada core consists of 8 samples. Safaga core 11 samples and Qusier core 15 samples. Visual observation of the freshly opened cores reveals no distinct bedding or any other sedimentary structures.

Oceanographic parameters that control the coastal features of the Red Sea, such as water temperature (Temp), pH, salinity (S), total dissolved salts (TDS), specific conductivity (Spec), dissolved oxygen (Do), and oxidation reduction potential (Eh) were measured at each studied localities in the area by using hydrolab surveyor-4 model instruments of the Institute of Oceanography and Fisheries, Hurghada.

The grain-size distribution of desalted sediments was determined by wet sieving of sand and gravel and by the pipette technique for silt and clay fractions (Folk, 1974). The analyses were carried out in the Inst. Oceanography and Fisheries, Hurghada. All chemical analyses were carried out in duplicates and the average data were determined. Total P is determined after digestion using the method of Apha (1995). The total organic matter and organic Carbon were determined following the method described by Dean (1974). Carbonate content was determined by treating the samples with HCl acid. The insoluble residue was separated and the carbonate percentage was calculated. Concentrations of 14 major and trace elements (Fe, Mg, Ca, P, Mn, Co, Pb, Cu, Ni, Pb, Sr, V, Cd, and Zn) were determined using a computerized flame Atomic Absorption Spectrophotometer (GBC model 932) at the Institute of Oceanography and Fisheries, Hurghada.

Correlation and cluster analyses to determine associations among elements, and to objectively find groupings of similar samples along the coast were carried out through multivariate analysis of data. Analyses are carried out on the data using the computer programs of the SPSS system available in the National Institute of Oceanography and Fisheries, Red Sea branch, Egypt.

Climate and Oceanographic Influences

The climate of the Red Sea is largely controlled by the distribution of winds and change in atmospheric pressure over a very wide area. During winter, the northern part of the Red Sea is subjected to a more variable weather than the southern part, due to the influence of the nearby Mediterranean disturbances. This may cause a little rainfall in association with low-pressure troughs moving from the north and accompanied by changes in wind, temperature, humidity and clouds.

A close relationship is observed between air and sea surface temperature. Both increase southwards from Suez to a maximum in the southern Red Sea and then decrease towards Bab El Mandeb (Morcos, 1970). The Red Sea region is hot and dry in summer but in winter the weather tends to be warm. The temperature varies between 37.66 - 23.04 ºC in summer and 29.34 - 6.86º C in winter (Meteorological station of the Red Sea branch, 1998; Mohamed, 2000).

The wind over the Red Sea is controlled by the complicated topography where the high mountains and plateaus on both sides control the atmospheric circulation to follow in parallel the sea axis on almost all days. In the northern part of the Red Sea, the prevailing wind is northerly throughout the year, whereas in the southern part, it is northerly in summer and southerly in winter (Wasef *et al.* 1983). Mohamed (1988) reported that wind speeds are usually less than 10 m/sec and only in a few days southerly winds across the south. During the year 1998, the prevailing wind was N 49 W in summer and N 84 W in winter and the wind direction speeds usually ranged between 66.07 km/h to 0.129 km/h with an average of 22.04 km/h in summer, while it ranges between 62.93 km/h to 0.09 km/h with an average of 19.26 km/h in winter (Meteorological station of the Red Sea branch, 1998; Mohamed, 2000).

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 (Meteorological station of the Red Sea branch, 1998; Mohamed, 2000) (Table 1). The lowest mean relative humidity between Quseir and Hurghada is recorded in June with an average of 43.5 %. The highest mean relative humidity in the same area is recorded in October and November with an average value of 54.5 % (Meteorological Authority, Egypt, 1978-1979).

The rainfall over the Red Sea is extremely small, mostly in the form of short duration winter showers, amounting to some 10-15 mm/year (Morcos, 1970). Wadies are occasionally active. Their mouth are usually emphasized by a small shoreline-retreat which indicates a low influence of continental sediments. A close relationship is observed between air and sea surface temperatures. Water temperature clearly reflects seasonal changes (summer: 28-29°C, winter: 21-23°C). In extreme shallow areas higher values were measured due to solar radiation. In July, 2002 the most oceanographic parameters were measured, (Table 1).

Table 1. Oceanographic parameters measured in July, 2002 at different localities along the Red Sea coast of Egypt.

Location	Do (mg/l)	S (‰)	PH	Eh (mv)	Temp (°C)	TDS (g/l)	Spec (ms/am)
Hurghada	4.59	39.96	8.27	319	29.39	38.2	59.67
Safaga	6.39	41.05	8.55	406	26.7	39.42	61.56
Quseir	5.42	39.67	8.42	431	25.2	37.97	59.29

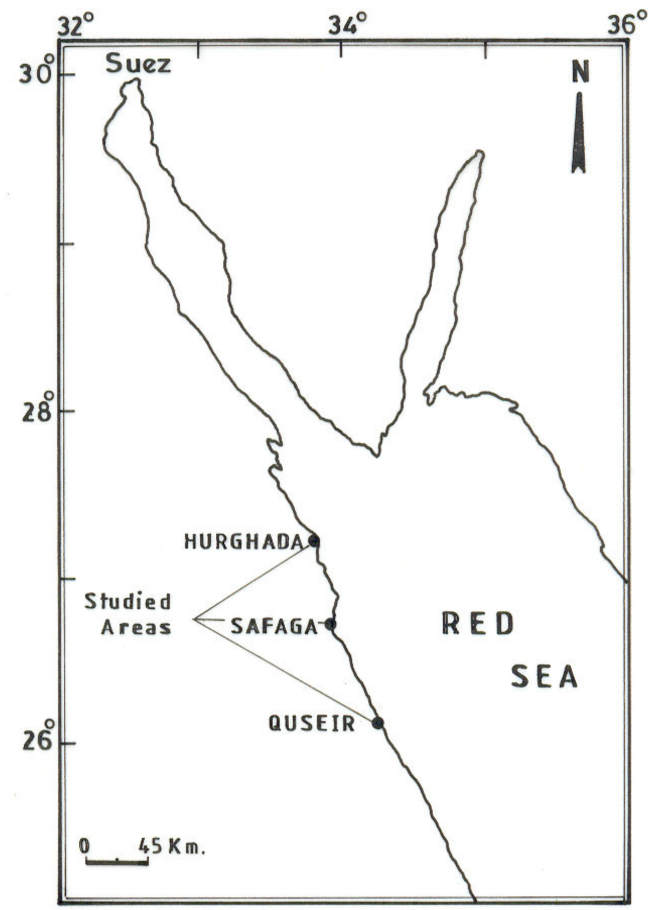

Fig. 1. Location map of the selected areas along the Red Sea Coast of Egypt.

GRAIN SIZE DISTRIBUTION

The mean grain size distribution and parameters are given in Table 2. The coastal Red Sea sediments are the result of interplay of aeolian, fluvial and marine influx of the sedimentary material. The influence of these sources is more or less localized resulting in a particular textural and compositional distribution, especially in the nearshore area.

Mud is the dominant grain size fraction in almost all samples of Qusier core, while the sand is the dominant sediment fraction in the rest sediments of Safaga and Hurghada cores. Generally in the Qusier core sediments, gravel and sand contents decrease, whereas mud content increases from the top towards the base of the core. The reason for the high mud content of Qusier core samples and partially some samples of Safaga and Hurghada cores is due to the terrigenous flux of wadies, phosphate deposits (Qusier and Safaga), landfill and dredging in these areas. The increasing of gravel content in some samples of Safaga and Hurghada cores reflects the abundance transported terrigenous sediments and biogenic fragments.

Generally the mean grain size of the Qusier core sediments ranges between 3.67 to 5.31Φ with an average of 4.45Φ. While the average mean grain size of the Safaga core sediments is 2.43Φ and ranges from 0.41 to 3.37Φ and the average mean grain size of the Hurghada core sediments is 1.67Φ and ranges between 0.48 to 3.46 Φ (Table 2).

Generally, most investigated core sediments are poorly sorted. As shown in table 2, the sorting of the Qusier core sediments ranges between 0.78 to 1.84Φ with an average of 1.39Φ indicating poorly sorted sediments. Two samples are moderately sorted and all other samples fall in the poorly sorted field. The sorting of the Safaga core sediments varies from 0.59 to 1.87Φ with an average of 1.05Φ, five samples are poorly sorted, three samples are moderately well sorted and four samples are well sorted. The average of sorting values of the Hurghada core sediments is 1.27Φ indicating poorly sorted sediments and range between 0.87 to 1.73 Φ. Nearly all samples fall in the poorly sorted field, except two samples are moderately well sorted.

Table 2, also shows that the skewness of the Hurghada core sediments ranges between –0.38 to +0.11with an average of –0.11 indicating coarse skewed mode, except three samples are nearly symmetrical and one sample is fine skewed (Table 2).

From table 2 the kurtosis values of the sediments sampled from Qusier core varies from 1.06 to 2.37 with an average of 1.61 indicating leptokurtic sediments. Nearly all samples are very leptokurtic, except two samples are mesokurtic. While the kurtosis of the Safaga core sediments ranges between 0.69 to 1.92 with an average of 1.4 indicating leptokurtic sediments. Nine samples are very leptokurtic and two samples are platykurtic. However the kurtosis of the Hurghada core sediments ranges between 0.65 to 2.53 with an average of 1.27. Two samples are very leptokurtic, two samples are mesokurtic, one sample is leptokurtic and three samples are very platykurtic (Table 2).

GEOCHEMICAL ANALYSIS

Distribution of Carbonates

Carbonate content in the samples of all cores is significantly low indicating the influx of terrigenous materials. It tend to have a uniform distribution for most core samples and ranges between 17.93% to 47.91% (Table 3).

El-Mamoney, (1995) found that the carbonate content of marine sediments along a distance of 500 m in the sea of areas in front of Wadi El-Hamara, El-Ash, Abu Shaar and Khasier, Red Sea, varies from 21.75 % to 98.29 %. Mansour et al., (1997) recorded that the average carbonate content is 63.26 % for the beach and intertidal sediments allover the coastal area from Gemsa to Marsa Alam.

Carbonate content of the sediments of Qusier core ranges from 13.3% to 22.0% with an average of 17.93%. The sediments of this core have low carbonate contents due to the terrigenous input sediments from wadi ElAmbeji, phosphate sediments from the nearby harbor and the scarcity of corals in the area. The sediments of Safaga core have high carbonate contents ranging from 42.0% to 57.0% with an average of 47.91%. The relatively high carbonate content is due to the presence of corals in the area. The sediments of Hurghada core have low carbonates content due to the terrigenous influx, landfilling and the scarcity of coral in the tidal flat area. It ranges from 15.5 % to 23 % and averaging 19.66% (Table 3).

Organic Carbon (OC) and Total Organic Matter (TOM)

Total organic matter (TOM) and organic carbon (OC) contents in the samples of the cores are significantly high indicating the influx of terrigenous materials. TOM and OC contents tend to be of uniform distribution in most samples of each core. The average concentrations of TOM content of all cores samples ranges between 2.34% to 4.39% and OC content that varies from 1.3% to 2.44% (Table 3). Mohamed, (2000) recorded that the total organic matter content of near shore sediments allover the coastal area from Gemsa to Marsa Alam ranges from 0.3 to 9.5 with an average of 3.4% and organic carbon content ranging from 0.1 to 5.3 with an average of 1.9%.

The sediments of Qusier core have high TOM content, it ranges from 3.2% to 5.5% with an average of 4.39%, and OC content that varies from 1.78% to 3.06% with an average of 2.44% (Table 3). The abundance of OC and TOM in Quseir is partially from the terrigenous flux of W. Ambaji and probably due to pollution from sewage of Quseir City and harbor.

Also phosphate dust and sewage of Safaga City and harbor are the reason for the high content of OC and TOM in the sediments of Safaga core. TOM content ranges from 2.9% to 4.6% with an average of 3.94%, and OC content that varies from 1.61% to 2.56% with an average of 2.19%. The sediments of Hurghada core have low TOM and OC content compared with the other two areas. It ranges from 1.1% to 3.1% and averaging 2.34%, and OC content varies from 0.61% to 1.72% with an average of 1.3% (Table 3).

Table (2). Sediment types, grain size ditribution parameters of sediments from El-Qusier, Safaga and Hurgada Harbors cores.

Station	El-Qusier Harbor Core			Safaga Harbor Core			Hurgada Harbor Core		
Rock type	Average	Min.	Max.	Average	Min.	Max.	Average	Min.	Max.
Gravel	0.06	0.00	0.23	0.06	0.00	0.23	7.11	0.43	15.74
Sand	43.99	11.78	76.04	43.99	11.78	76.04	88.74	75.78	98.46
Mud	55.95	23.73	88.19	10.45	0.88	37.21	4.16	0.19	21.61
Mz Φ	4.45	3.67	5.31	2.43	0.41	3.37	1.67	0.48	3.46
Sort. Φ	1.39	0.78	1.84	1.05	0.59	1.87	1.27	0.87	1.73
SkI	0.32	-0.16	0.55	0.08	-0.26	0.39	-0.11	-0.38	0.11
KG	1.61	1.06	2.37	1.40	0.69	1.92	1.27	0.65	2.53

Mz= Mean grain Size Sort= Sorting SKI= Skewness KG= Kurtosis

Table (3). The results of chemical analysis of surface core sediments from El-Qusier, Safaga and Hurgada Harbors.

Station	El-Qusier Harbor Core			Safaga Harbor Core			Hurgada Harbor Core			Min. aver.	Max. aver.
Element Cont.	Average	Min.	Max.	Average	Min.	Max.	Average	Min.	Max.		
Ca %	21.09	17.70	25.36	25.14	21.10	31.00	13.84	10.50	21.73	13.84	25.14
Mg %	3.11	2.30	4.80	1.28	1.10	1.77	0.48	0.18	0.80	0.48	3.11
Sr %	0.30	0.14	0.46	0.78	0.59	1.11	0.28	0.19	0.36	0.28	0.78
Fe %	2.32	1.55	2.61	2.32	2.13	2.84	1.70	1.22	2.30	1.70	2.32
Mn*	537.27	415.00	649.00	646.82	383.00	1505.00	348.88	53.00	775.00	348.90	646.80
P*	4570.00	1538.00	8080.00	3776.55	540.00	7570.00	1305.88	1130.00	1600.00	1305.90	4570.00
Cd*	1.09	0.10	3.14	1.01	0.29	1.85	1.89	1.57	2.30	1.01	1.89
Co*	14.92	10.70	20.00	7.25	5.30	11.50	15.90	12.00	20.00	7.25	15.90
Ni*	36.46	27.00	56.00	28.82	24.00	38.00	103.63	94.00	111.50	28.82	103.60
Zn*	72.25	20.00	113.30	58.75	32.00	139.30	59.24	37.10	101.00	58.75	72.25
Pb*	31.36	18.00	46.70	62.77	51.10	77.00	44.10	31.00	64.00	31.66	62.77
V	129.49	88.00	177.00	42.91	31.00	57.00	69.46	39.00	130.00	42.91	129.49
Cu*	22.12	10.00	37.30	24.95	20.00	28.00	39.25	30.00	66.00	22.12	359.25
Carb. %	17.93	13.30	22.00	47.91	42.00	57.00	19.66	15.50	23.00	17.93	47.91
TOM %	4.39	3.20	5.50	3.94	2.90	4.60	2.34	1.10	3.10	2.34	4.39
OC %	2.44	1.78	3.06	2.19	1.61	2.56	1.30	0.61	1.72	1.30	2.44

* values in ppm   Min= Minimum   Max=Maximum   OC = Organic carbon   TOM= Total Organic Matter

Carb.= Carbonate

Major Elements

Ca, Mg, Fe, and Sr elements arranged in decreasing abundance were determined in the studied core sediments. Average concentration varies from 25.14-13.84% for Ca, 3.11-0.48 for Mg, 2.32-1.7 for Fe and 0.78-0.28 for Sr. The highest concentration of Ca and Sr are observed in Safaga core sediments due to the increase in biogenic constituents. The highest Mg content is observed in Qusier core sediments due to the abundance of terrigenous flux. Ca and Sr show a high positive correlation (r=0.54 and r=0.86) with carbonates reflecting the biogenic origin. Fe shows low positive correlation (r=0.16) due to its derivation from terrigenous and biogenic contributions (Table 4).

The negative correlation between the elements derived from biogenic and terrigenous sources, reflects the presence of two different sediment sources namely marine and terrestrial. Low correlation is mostly observed between elements and carbonates and sediment type showing the presence of appreciable amount of carbonates in fine fraction as well as in coarse fractions. The presence of relatively high Sr concentrations is indicative of important proportions of aragonite. This is good agreement with the biogenic origin of most carbonate deposits (Mansour et al., 2000).

Trace Metals

Average trace metal concentrations in the sediments ranges 349-647 ppm for Mn, 1306-4570 for P, 1.0-2 for Cd, 7-16 for Co, 29-104 for Ni, 59-72 for Zn, 32-63 for Pb, 43-130 for V, and 22-359 ppm for Cu (Table 3). The highest concentrations may be related to the terrigenous input and anthropogenic influence where the cores represent at harbor sediments. In Quseir core sediments, P content is very high compared with other areas. P is positively correlated to TOM, OC (r= 0.39) and mud (r= 0.34) indicating that part of P is related to phosphate dust reaching the harbor. Contaminants (Cd, Co, Ni, Zn, Pb, Cu) show very low correlation either positive correlation or negative to carbonates related to source rocks and/or sewage of Quseir and Safaga Cities (Table 4).

The high Cd, Ni and Co concentration of Hurghada core sediments is probably due to industrial waste waters and source rocks. The high Pb concentration of the sediments of Safaga core is probably due to industrial waste waters and anthropogenic source. The anthropogenic impact concept includes urbanization, construction of harbors and seaports, development of natural resources, marine aquaculture, shipping, recreation and many other activities. Pb is high positively correlated to carbonate (r= 0.79 Table 4). This may be due to the uptake of Pb from surface seawater by marine organisms as suggested by Bender and Gagner (1976), however Pb is generally thought to be associated with inorganic particulate (Turekian, 1977).

Cluster analysis

Using Ward's method includes contaminant Cd, Co, Ni, Zn, Pb, V, Cu metal concentrations, carbonate, TOM, OC, gravel, sand and mud, separates the 34 studied samples into 3 main clusters: The Pb and carbonate cluster (11 samples), Cd, Co, Ni cluster (8 samples) and TOM, OC and P cluster (15 samples) (Fig. 2). The first cluster (Pb and carbonate cluster) includes all samples of Safaga core except one sample in addition to bottom sample of Qusier core. The highest concentration of carbonate is related to the abundance of biogenic constituents. The highest concentration of Pb may be due to contaminstion from exchanges the harbor motor boats of tourists and fisheries and waste from hotels and tourist villages widely distributed in this area. The high positive correlation between Pb concentration and carbonate is probably related to the contamination from sea. Contamination from oil production and oil tankers in the Gulf of Suez and the Red Sea, reaching the studied sediments by NE-SW wave motion and southward currents are probably the reason for the increase Pb content. Motor boats are the largest source of Pb enrichments in sediments. It originates from the combustion and aeolian distribution of the tetraethyl lead added to automobile gasoline since 1945 (Chow et al., 1973).

The second cluster (Cd, Co, Ni cluster) includes all samples of Hurghada core and is characterized by the highest concentration of Cd, Co, Ni, and Cu. The highest concentration of Ni, Cd and Co may be due to the presence of port, motor boats of tourists and fisheries, waste and sewage contamination from hotels and tourist villages widely distributed in this area

The thrid cluster (TOM, OC and P cluster) includes all samples of Qusier core except one sample and the bottom sample of Safaga core (Fig. 2). This cluster, shows the highest concentration of TOM , OC, V and P (Table 4). The abundance of OC and TOM in Quseir is partially due to terrigenous influx of Wadi Ambaji and probably due to sewage of Quseir City and the harbor. The concentration of P of this cluster is related to the dust of phosphate deposits exported from the harbor (Table 5).

CONCLUSIONS AND RECOMMENDATIONS

Core sites were selected to include areas representative of particular sedimentary regimes taking into account the influence of urban and industrial wastes near harbors. The areas near Qusier, Safaga and Hurghada harbors are impacted by many activities, as phosphate mining, oil industry, recreation, housing, sewage and waste disposal, and shipping. Results of analyses for grain size, carbonate, major and trace elements, total organic matter (TOM), organic carbon (OC), are used as fingerprint to locate sites of sediment accumulation, and to identify sediment sources in the area. These measurements help policy makers to identify anthropogenic impacts and better assess the needs for remediation.

The relative abundance of the fine sediments in some samples of the different cores is not only due to the abundance of terrigenous fine sediments but also to the landfilling and dredging in these areas. Moreover, phosphate deposits exported from the harbors also contribute in the high mud content of Qusier and Safaga cores. Distribution of mean grain size depends mainly on the source of the sediments. The study areas receive sediments from biogenic and terrigenous sources and by different agents of transportation from both the seaside and the landside, so that nearly all sediments are poorly sorted and are characterized by a wide range of skewness and kurtosis.

The chemical analyses reveal the presence of an inverse relationship between carbonate and terrigenous mineral associations. This illustrates that two environments are affecting the dominant sediment types. Terrestrial environment accounts for the dominance of terrigenous material in the sediments. The marine environment is responsible for the predominance of carbonates in the sediments.

Concentrations of metals (Pb, P, Cd, Ni, Cu and Zn) and physical properties (grain size, OC, and TOM) measured in core samples will help managers to identify anthropogenic impacts and better assess the methods for remediation by detecting any changes, from the existing level expected with future activity.

Table (4). Correlation coefficient of grain size, total phosphours, total organic matter, organic carbon. Carbonet content, major and trace elements of all core sediments.(*=ppm)

	Ca %	Mg %	Sr %	Fe %	Mn*	P*	Cd*	Co*	Ni*	Zn*	Pb*	V	Cu*	Carb. %	TOM %	OC %	Gravel	Sand	Mud
Ca %	1.00																		
Mg %	0.20	1.00																	
Sr %	**0.59**	-0.37	1.00																
Fe %	**0.64**	0.12	0.35	1.00															
Mn*	**0.54**	0.11	0.34	0.18	1.00														
P*	0.33	**0.59**	0.14	0.07	0.27	1.00													
Cd*	-0.43	0.04	-0.35	**-0.69**	-0.02	-0.08	1.00												
Co*	**-0.62**	0.34	**-0.83**	-0.41	-0.31	-0.20	0.45	1.00											
Ni*	**-0.75**	**-0.52**	-0.47	**-0.61**	-0.41	**-0.52**	0.46	0.48	1.00										
Zn*	0.17	0.44	-0.28	-0.08	0.12	0.28	0.35	0.29	-0.07	1.00									
Pb*	0.44	-0.44	**0.66**	-0.11	0.25	-0.05	0.16	**-0.54**	-0.08	0.09	1.00								
V	0.04	**0.67**	**-0.57**	0.18	-0.02	0.31	-0.04	**0.52**	-0.12	0.43	**-0.55**	1.00							
Cu*	-0.32	-0.30	-0.16	-0.49	-0.22	-0.18	**0.53**	0.30	**0.65**	0.24	0.26	-0.02	1.00						
Carb. %	**0.54**	-0.35	**0.86**	0.16	0.29	0.02	-0.17	**-0.76**	-0.41	-0.16	**0.79**	**-0.69**	-0.13	1.00					
TOM %	0.40	**0.59**	0.16	0.49	0.09	0.39	-0.47	-0.17	**-0.76**	0.01	-0.30	0.22	**-0.65**	0.11	1.00				
OC %	0.40	**0.59**	0.16	0.49	0.09	0.39	-0.47	-0.17	**-0.76**	0.01	-0.30	0.22	**-0.65**	0.11	**1.00**	1.00			
Gravel	-0.15	-0.36	-0.02	-0.33	-0.18	-0.35	0.22	-0.11	0.30	-0.18	0.25	-0.28	0.30	0.25	-0.27	-0.27	1.00		
Sand	-0.10	**-0.67**	0.43	-0.26	-0.14	-0.26	0.13	-0.43	0.34	-0.33	**0.57**	**-0.70**	0.35	0.43	-0.37	-0.37	0.19	1.00	
Mud	0.13	**0.70**	-0.39	0.32	0.17	0.32	-0.17	0.43	-0.38	0.35	**-0.59**	**0.71**	-0.39	-0.46	0.41	0.41	-0.42	**-0.97**	1.00

Table (5). Distribution of grain size,total phosphours carbonate content, organic carbon and trace elements of the different clusters.(*=ppm)

Cluster No.		P*	Cd*	Co*	Ni*	Zn*	Pb*	V	Cu*	Carb. %	TOM %	OC %	Gravel	Sand	Mud
Cluster III	Average	4570	1.1	14.9	36.5	72.3	31.4	129.5	22.1	17.9	4.4	2.4	0.1	44.0	55.9
	Min.	1538	0.1	10.7	27.0	20.0	18.0	88.0	10.0	13.3	3.2	1.8	0.0	11.8	23.7
	Max.	8080	3.1	20.0	56.0	113.3	46.7	177.0	37.3	22.0	5.5	3.1	0.2	76.0	88.2
Cluster I	Average	3777	1.0	7.3	28.8	58.8	62.8	42.9	25.0	47.9	3.9	2.2	4.5	85.1	10.4
	Min.	540	0.3	5.3	24.0	32.0	51.1	31.0	20.0	42.0	2.9	1.6	0.0	60.0	0.9
	Max.	7570	1.9	11.5	38.0	139.3	77.0	57.0	28.0	57.0	4.6	2.6	33.7	97.6	37.2
Cluster II	Average	1306	1.9	15.9	103.6	59.2	44.1	69.5	39.3	19.7	2.3	1.3	6.4	62.4	36.1
	Min.	1130	1.6	12.0	94.0	37.1	31.0	39.0	30.0	15.5	1.1	0.6	0.0	11.8	0.9
	Max.	1600	2.3	20.0	111.5	101.0	64.0	130.0	66.0	23.0	3.1	1.7	33.7	97.6	88.2

Rescaled Distance Cluster Combinbe

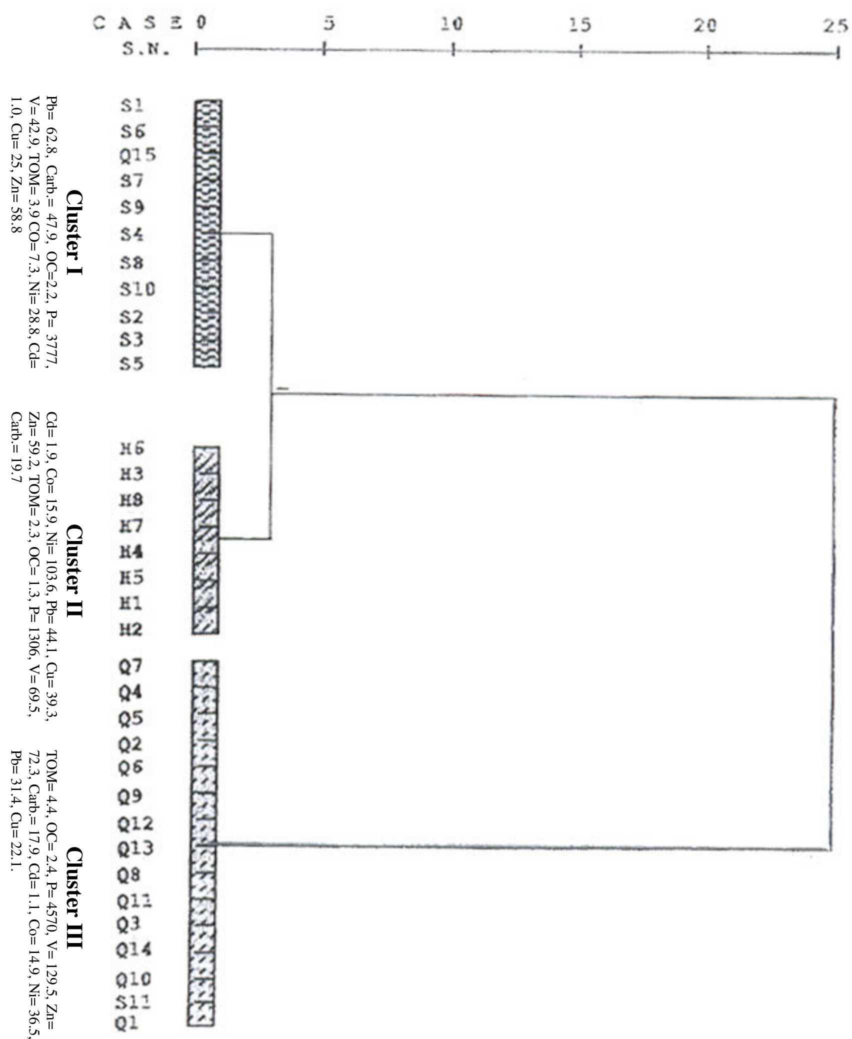

Fig. (2). Cluster analysis (Ward's method) using grain size, carbonate content, total organic matter (TOM) organic carbon (OC), total phosphorus and trace elements of core sediments

REFERENCES

Apha, (1995). Standard method for the examination of water and waste water: Am. Bub. Health Ass., Am., Water Work Ass., Water Env. Federation, 1200 p.

Beltagy, A. I., (1984). Elemental geochemistry of some recent marine sediments from Red Sea. Bull. Nat. Inst. Oceanogr. and Fish., Egypt, 10: 1-12.

Bender, M.L., and Gagner, C., (1976). Dissolved copper, nickel and cadmium in the Sargasso Sea: J. Mar. Res., vol. 34, p. 327-339.

Chow, T.J., Bruland, K.W., Bertine, K., Soutar, A., Koide, M., and Goldberg, E.D., (1973). Lead Pollution: Records in Southern California coastal sediments. Science (Washington, D.C.) 181, p. 551-552.

Dar, M. A, (2002). Geological basis of 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, Faculty of Science, Suez Canal Univ., Egypt. 218 p.

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

El-Mamony, M. H., (1995). Evaluation of trrestrial contribution on the Red Sea sediments, Egypt, Ph. D. Thesis, Faculty of Science, Alex. Univ., 146p.

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

Folk, R.L., (1974). Petrology of sedimentary rocks: Hemphill Publ. Co., 192 p.

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.

Madkour, H. A., (2004). Geochemical and environmental studies of recent marine sediments and some invertebrates of the Red Sea, Egypt. Ph.D. Thesis, South Valley Univ. Qena 319p.

Mansour, A.M., Nawar, A. H. and Mohamed, A. M., (1997). Recent intertidal sediment negative impacts of human activities, Red Sea coast, Egypt. Egyptain Jour. of Geo., 41/2A:239-272.

Mansour, A.M., (1999). Changes of sediment nature by environmental impacts of Sharm Abu Makhadeg area, Red Sea, Egypt: Sedimentology of Egypt, vol. 7, p. 25-36.

Mansour, A.M., (2003). Pressures and Impact of Coastal Zone of Abu Minkar and Giftun Islands, Hurghada, Red Sea, Egypt: A management Priority, Fifth International Conference on the Geology of the Middle East, Ain Shams University, Cairo, Egypt. January 2003, p. 417-430.

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. Sedimentology of Egypt, vol. 8, p. 231-242.

Mohamed , E.E., (1988). Circulation patterns and hydrographic structure of the Southern Red Sea and Gulf of Aden. Ph. D. Thesis, Alex. Univ., 220p.

Mohamed, W. A., (2000). Sedimentological and Geochemical studies on recent shallow water sediments, Red Sea, Egypt. Ph.D. Thesis South Valley Univ. Qena 198p.

Morcos, S. A., (1970). Physical and chemical oceanography of the Red Sea: Oceanogr. Mar. Bial. Ann. Rev., vol. 8, p. 73-202.

Soliman, Soliman M., (1994). Field sedimentary geology... Important Egyptian Mohole... A future necessity: Sedimentology of Egypt, vol. 2, p. 1-12.

Turekian, K.K., (1977). The fate of metals in the oceans: Geochim. Cosmochim. Acta, vol. 41, p. 1139-1144.

Wassef, R.K.; Gerges, M.A. and Soliman G.F., (1983). Wind-driven circulation in the Red Sea as a homogenous basin. Bull. Nat. Inst. Oceanogr. and Fish., Egypt, 9: 48-57.