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THE IMPACT OF ANTHROPOGENIC ACTIVITIES ON THE PHYSICAL AND CHEMICAL CHARACTERISTICS OF SURFACE SEDIMENTS IN SOME COASTAL LAGOONS ALONG THE EGYPTIAN RED SEA COAST

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ABSTRACT

Forty-two sediment samples were collected from Abu-Shaar, Abu-Galwa, Umm al-Huwaytāt and Marsa Shūni lagoons located along the Egyptian Red Sea coast. Several investigations including nature and geochemistry of surface sediments were carried out. Grain size characteristics reflect the restriction of sand rich with coral debris in Abu-Shaar and Abu-Galawa lagoons. Consequently, The sediments of Abu-Galawa and Abu-Shaar lagoons have the highest carbonate content due to the dominance biogenic sediments from surrounding coral reefs and relatively of terrigenious influx. The mud content recorded high values in Umm al-Huwaytāt and Marsa Shūni lagoons compared with the other two lagoons due to high contribution of terrigenous materials from wadies and some human activities especially near at Umm al-Huwaytāt lagoon by shipment activities in Abu-Tartour Harbour. The sediments of Marsa Shūni lagoon have the highest total organic matter content compared to the other three lagoons resulting from the high contribution of terrestrial input by Wadi El-Shūni . Grain size is the main controlling factor for the organic carbon enrichment. On other hand, The phosphorus content of sdiments sampled in Umm al-Huwaytāt lagoon recorded the highest values due to phosphate shipments operation in Abu-Tartour Harbour. The investigation of distribution of the heavy metals Fe, Zn, Cu, Pb and Cd in surficial sediments of the coastal lagoons indicated that the degree of metals pollution is caused by anthropogenic activities and or by natural impacts by wadies. This study provides knowledge about nature and geochemistry of sediments and the extent of the pollution degree of the metals to represent primary base line data efor managers to follow any anthropogenic impacts, and better assessing the needs for remediation by detecting any changes in future.

1. INTRODUCTION

Coastal lagoons and their adjacent nearshore zones are important for several living organisms. They also act as buffers to wave energy. Coastal lagoons ecosystem includes a great variety of habitats that comprise sabkha, salt marshes, mangrove forests, swamps, intertidal pools and seawater systems; all possessing a high biological diversity and a rich and complex food chain. These ecosystems constitute important fishery and nursey grounds, and some of which include small human settlements (Green-Ruiz and Paez-Osuna 2001). Generally the water and the bottom sediments of these lagoons suffer from natural contamination and man-induced pollution (De Pippo *et al.,* 2004 and Smith 2001).

The coastal lagoons of the Egyptian Red Sea Coast are extremely important ecologically and environmentally for the continued existence and maintenance of coastal fisheries, for the shoreline protection, a refuge for wildlife including birds, for sediment stabilization and shelterd nature allows many species of benthos to grow up in coincidence to each other. The Egyptian Red Sea coastal lagoons are being stressed due to over exploitation and have become very vulnerable to human related activites. Generally, the main environmental problems and threats to the Red Sea ecosystem and geosystem include, recreation and tourism activities, landfilling, dredging, oil pollution, water pollution, solid waste disposal, navigation activities, phosphate shipment pollution and fishing activities. As a result of the human activities, pollution extends along the shore, and is discharged to the nearshore waters. Some of these pollutants may directly or indirectly be captured by bottom sediments (Madkour 2004). In the case of successive concentrations of these pollutants in bottom sediments, the later will act as a reservoir for pollutants.

Several investigations on recent sediments and human impacts were carried out on the Egyptian Red Sea Coastal zone. Among of them are El-Sayed (1984); El- Askary *et al.,* (1988); Piller and Mansour (1990); Mansour (1995); El-Mamoney (1995); Frihy *et al.,* (1996); Mansour *et al.,* (1997); Nawar *et al.,* (1997); Mansour (1999); Mansour *et al.,* (2000); Dar (2002), Madkour (2004), Madkour and Ali (2005); Madkour (2005); Mohammed *et al.* (2005); Mansour *et al.,* (2005) Ahmed and Madkour (2006) and Madkour *et al.;* (2006).

This study was initiated to investigate the distribution, composition and dispersal patterns of surface sediments in coastal lagoons along the Egyptian Red Sea coast. Results of analyses for grain size characteristics, carbonate content, total organic matter, phosphours content and heavy metals concentration are used as finger prints to locate sites of sediment accumulation, and to identify sediment sources in the area. These measurements help managers to identify anthropogenic impacts, better assess the needs for remediation, to give data base for contaminants to identify sediment sources, to determine transport and dispersal paths and areas of extensive contaminants. Accurate documentation of existing levels is needed to permit detection of small changes expected with operation of future activities.

2. MATERIAL AND METHODS

In this study, Forty-two sediment samples were collected from four selected localities Abu-Shaar, Abu-Galwa, Umm al-Huwaytāt and Marsa Shūni lagoons along the Egyptian Red Sea coast. The location of these coastal lagoons and their position are shown in figure (1). The sampling was carried out by a grab sampler and Scuba diving. The later was used in areas rich with corals where grab sampler failed to collect samples. The collected samples were placed in labeled plastic bags and kept for analysis.

Grain size analysis provides basic information for the geochemical investigations of marine sediments. The sieving analysis was performed using the technique given by Folk and Ward (1957). All geochemical analyses were carried out on the bulk samples and the average data were considered. The total carbonate content was determined by treating the samples with one normal hydrochloric acid (1N HCL acid). The insoluble residue remaining after acid washing was determined and the carbonate percentage was calculated. Determination of organic matter was made by sequential weight loss at 550°C (Dean, 1974). Determination of total phosphorus was made according to the American Public Health Association ("APHA" 1995). Concentrations of the metals; Fe, Zn, Cu, Pb and Cd were determined according to Oregioni and Aston (1984). About 0.5 g of the prepared bottom sample was completely digested in a Teflon crucible by using a mixture of conc. nitric, perchloric and hydrofluoric acids, with the ratio 3: 2: 1, respectively. Acids were slowly added to the dried sample and left overnight before heating. Samples were heated for two hours on hot plate at temperature of approximately 200 °C, then left to cool and filtered to get rid of the nondigested parts. The solution was adjusted to volume of 25 ml, then the concentration of the elements was determined by Atomic Absorption Spectrophotometry (AAS) (GBC-932 Ver. 1.1). The analyses were carried out in the laboratories of the National Institute of Oceanography and fisheries, Red Sea branch.

The obtained data of the granulometric and geochemical analyses were dealt statistically in order to exclude the characteristic parameters. The statistical treatment includes the average, correlation coefficient and cluster analysis. The cluster analysis was performed using SPSS Package (Statistical Package for Social Sciences).

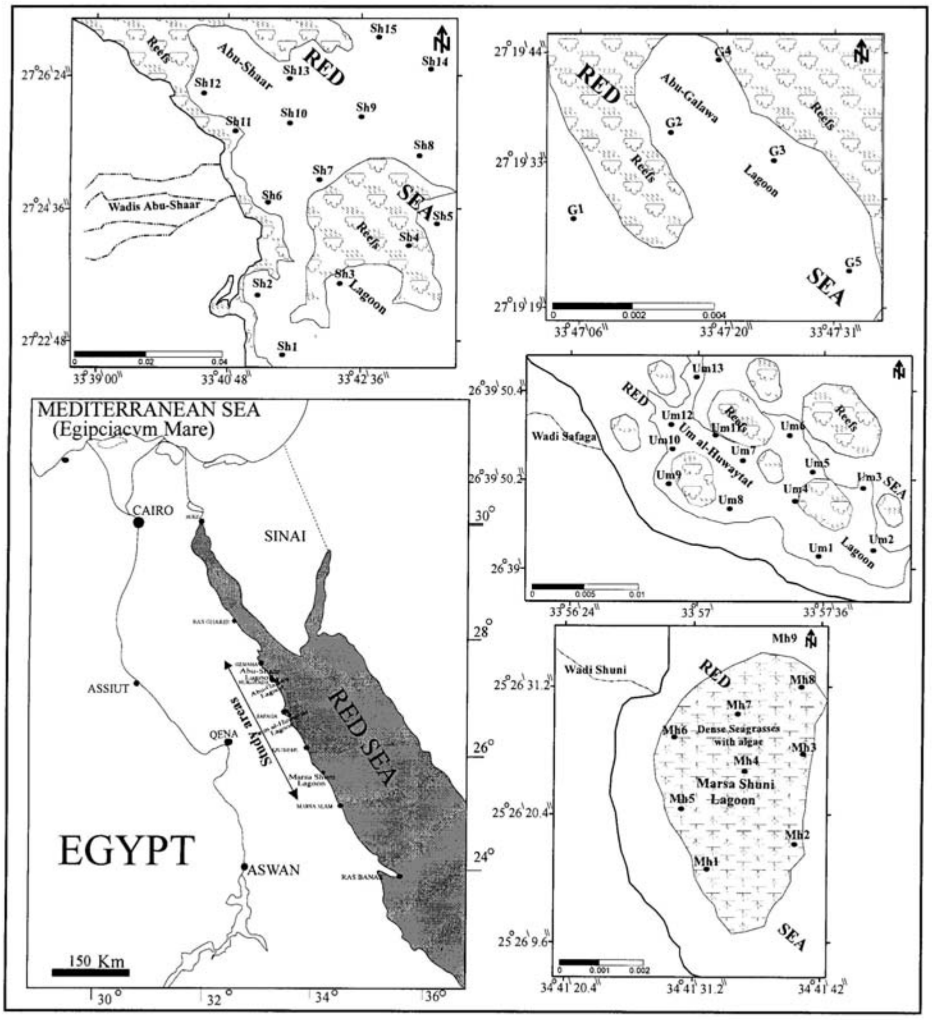

Fig. (1): Location maps of the studied coastal lagoons along the Egyptian Red Sea coast.

3. RESULTS AND DISCUSSION

3.1. Nature of surface sediments:

The purpose of the mechanical analysis for bottom sediments is not only to obtain the nature of sediments but also to understand the physical characteristics of these sediments and to reveal the relation and the influence of grain size, source material and depositional environment. Moreover, The grain size analysis is important to give good idea about the particle size and characteristics of sediments. Sediments in the coastal lagoons are composed of a mixture of terrigenous and biogenic materials.

The bottom sediments of the investigated lagoons were found to consist of a wide variety of texture classes, from coarse sand to sandy mud. Sediments of the coastal lagoons are composed of over 78% sand (Fig. 2). Coarse and medium sands are the most abundant fractions in Abu-Shaar and Abu-Galwa sediments, whereas fine and very fine sand fractions are the most dominant in Umm al-Huwaytāt and Marsa Shūni sediments (Fig. 2). In Abu-Shaar lagoon sand fraction ranges between 71.7% and 98.3%, averaging 86.4% while Abu-Galawa lagoon includes sand fraction between 67.3% and 94.6%, averaging 84.3% (Table 1; Fig. 2). Gravel is common in Umm al-Huwaytāt lagoon reaches up to 22.3% in the sediments with an average of 7.5%. On the other hand, the highest values of mud content is recorded in Umm al-Huwaytāt and Marsa Shūni lagoons (Fig. 2).

The areas under study receive sediments from two different sources; the terrigenous input from the hinterland mountains and skeletal carbonates from the sea (i.e., siliciclastic and carbonate sediments). In these mixed environments, the terrigenous components introduced from outside the depositional basin, whereas the skeletal carbonates originated mainly from the near depositional basin.

Generally, the particle size of the sediments changes from coarse sand near the beach to fine sand with increasing distance from the beach towards the sea. The results of mean size (Mz) indicate that, the sediments range from coarse sand to coarse silt. Sediments of Umm al-Huwaytāt lagoon vary from medium sand to coarse silt while sediments of Abu-Galawa and Marsa Shūni lagoons are coarse to very fine grained sand. The mean size generally increases and the sediment type changes from coarse sand to muddy sand and sandy mud. Poor sorting characterizes the sediments of Abu-Shaar and Abu-Galawa lagoons which the sediments of Umm al-Huwaytāt and Marsa Shūni lagoons are very poorly sorted. The dominance of mud fraction is responsible for the poor sorting in the remaining samples of the all lagoons. The results of skewness and kurtosis values of the bottom sediments in the coastal lagoons indicate that, the sediments are nearly symmetrical skewed in all studied lagoons except those of Marsa Shūni lagoon where the sediments are coarse skewed. The kurtosis varies from leptokurtic in Abu-Shaar, Umm al-Huwaytāt and Marsa Shūni lagoons to very leptokurtic in Abu-Galawa lagoon. This variation in character of sediments is produced in one side by types of flux of clastic sediments and in other side by diversity of biogenic grains and effectiveness of wave actions and currents.

Table (1): Physical and geochemical propperties of sediment samples from the studied coastal lagoons.

Variables	Abu-Shaar n= 15		Abu-Galawa n= 5		Umm al-Huwaytāt n=13		Marsa Shūni n= 9	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Gravel	0.3 -12.9	5.52	0.3 - 5.5	2.51	0.5 - 22.3	7.50	2.63 - 10.6	6.15
Sand	71.7-98.3	86.35	67.3 - 94.6	84.30	42.5 - 82.4	63.30	62.2 - 93.5	78.72
Mud	0.9 - 20	8.14	0.25 - 31.8	13.19	5 - 56.4	29.30	0.54 - 31.46	15.13
Mz	1.2 - 3.6	2.17	0.80 - 4.12	2.54	1.12 - 4.6	2.93	0.86 - 3.26	2..25
Sorting	1 - 2.42	1.62	1.2 - 1.4	1.28	1.44 - 2.81	2.24	1.23 - 2.77	2.01
SK*I*	-0.5 - 0.24	-0.09	-0.12 - 0.31	0.04	-0.17 - 0.41	0.09	-0.55 - -0.01	-0.16
K*G*	0.6 - 3.8	1.30	1.04 - 3.72	1.93	0.67 - 2.46	1.32	0.76 - 3.63	1.40
Carbonate%	58.8 - 95.6	81.12	69.1 - 98.2	91.76	53.4 - 96.2	74.56	70 - 88	78.08
TOM%	2.2 - 3.5	2.89	2.8- 3.2	3.01	1.91 - 4.19	2.86	2.5 - 5.60	4.00
P*	233 - 5828	3698.90	3328 - 5790	4795.20	994 - 9676	5420.80	3112 - 5066	4199.78
Fe*	235.6-1189.37	563.65	98.3 - 899.97	432.35	1063.2 - 2856.9	1876.53	978.3 - 1978.4	1485.89
Zn*	1.85 - 18.51	9.35	0.97 - 5.65	3.26	3.65 - 32.55	14.32	3.96 - 25.94	11.98
Cu*	0.65 - 4.39	1.30	0.08 - 1.93	0.38	1.53 - 12.53	5.08	0.98 - 3.53	1.38
Pb*	0.62 - 6.56	4.32	0.21 - 3.86	2.67	3.65 - 23.56	11.65	1.69 - 15.36	7.97
Cd*	0.36 - 0.95	0.65	0.09 - 0.56	0.37	0.83 - 1.93	1.06	0.46 - 1.34	0.56

*=values ppm TOM=total organic matter n= number of samples

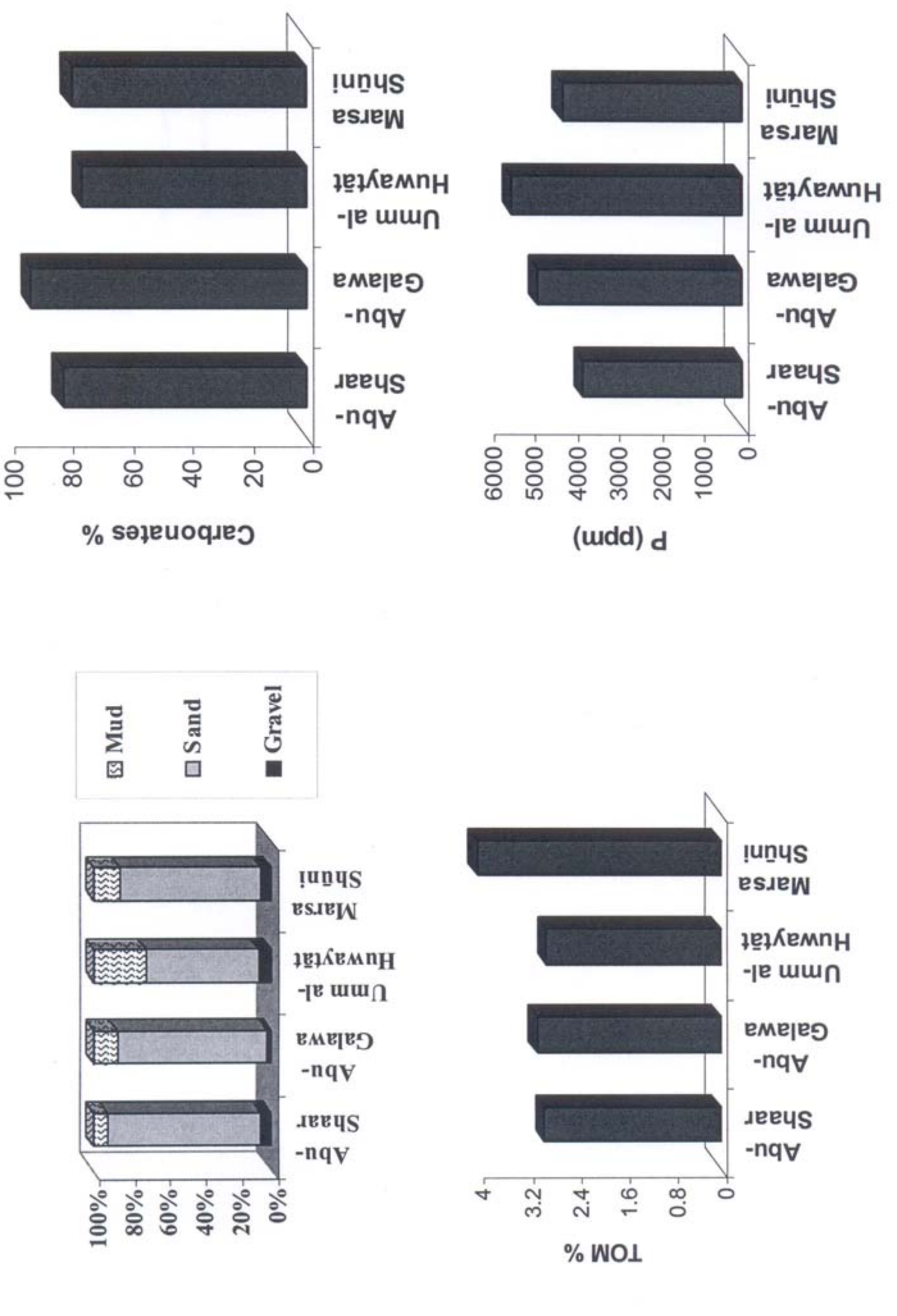

Fig. (2): Average distribution of texture, carbonate, total organic matter and phosphorus contents of sediments in the studied coastal lagoons.

3.2. Cluster analysis

Statistical computations (cluster analysis) were performed with the program SPSS using Ward's method on all grain size data obtained by sieving and pipette methods (Fig. 3) in order to obtain more objective results.

Cluster analysis revealed the presence of six main clusters according to the abundance of size fraction. The first cluster represents 14.3% of the total samples and is characterized by high sand fraction (84.8%), high gravel (12.12%) and low mud (3.04%). Cluster 2 includes 16.71% of the total samples and is characterized by very high sand fraction (95.98%) with low amount and mud contents. Most samples of cluster 1 and 2 fall in Abu-Shaar lagoon (Fig. 3). Cluster 3 have a high number of samples and represents 33.3% of the total samples. It is distinguished by the abundance of sand (81.8%) and high relative content of mud content (15.2%) , (Fig. 3). It includes a mixture of samples of the studied coastal lagoons. The sediment samples of cluster 4 belong to Umm al-Huwaytāt lagoon. Sediment samples in Umm al-Huwaytāt lagoon have the highest values of mud content compared with the other coastal lagoons. This is due to shipment of phosphate ore in Abu-Tartour Harbour and packing of cement in Safaga Harbour near this lagoon. Also, cluster 5 represents mixture of samples of the study areas and is distinguished by high mud fraction (26.6%).

The high values of mud content in the coastal lagoon may be attributed to the influence of terrigenous flux by wadies. The fine grains are transported by sea waves offshore. According to Mansour (1995), waves and currents redistribute terrigenous debris carried into the sea either via wadi or NW winds on the tidal flat, and most likely also sweep some of the fine terrigenous sediments from the submarine slopes into the deeps. The grain size of the sediments is generally different from the area near the beach and seaward in the same lagoon according to the variable percentage in three main constituents of these clastic sediments; gravel, sand and mud.

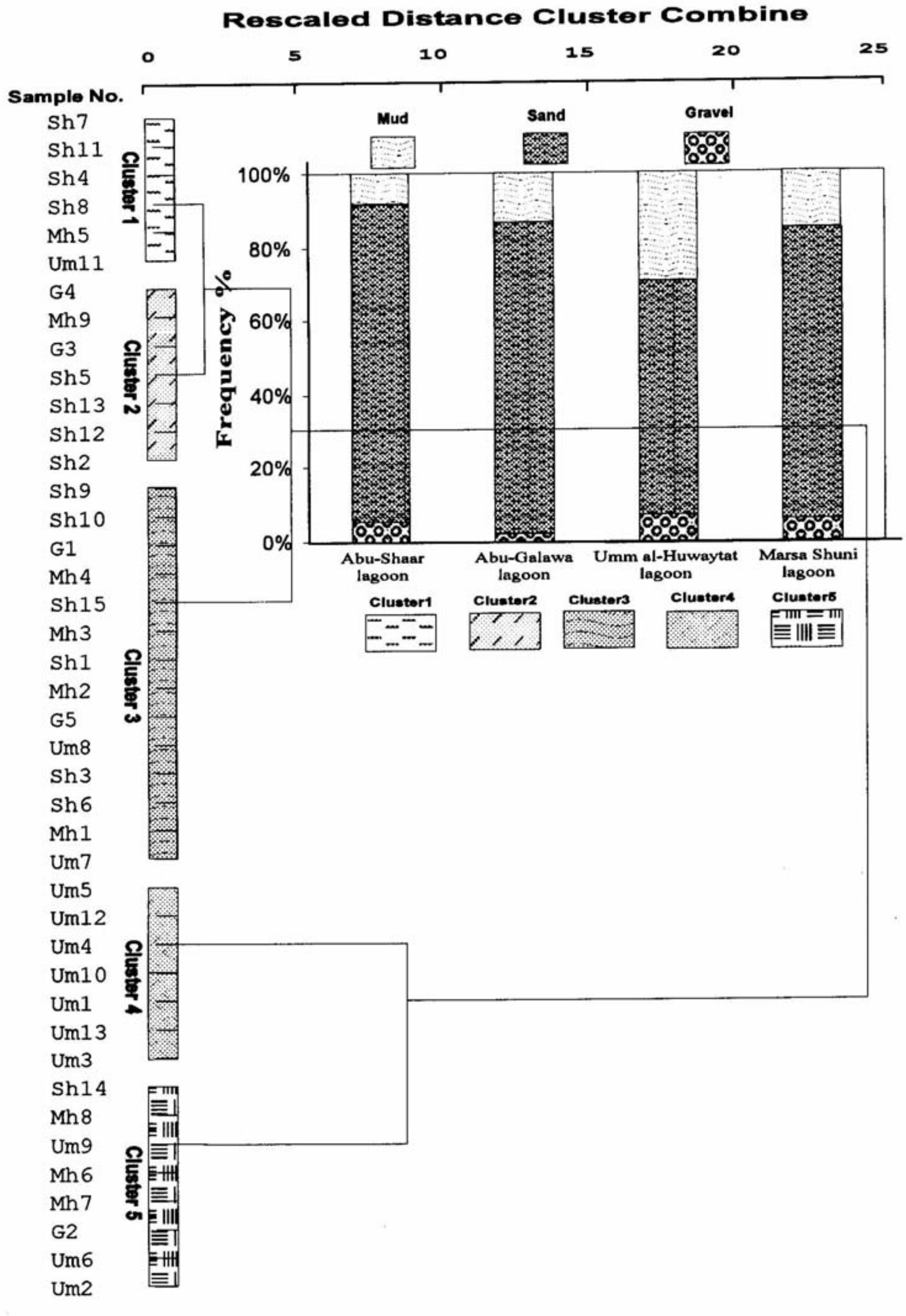

Fig. (3): Dendrogram from cluster analysis (ward's method) and histogramexhibiting cluster of component constituents.

4. GEOCHEMICAL PARAMETERS

4.1 Carbonates, Organic matter and Phosphours

The carbonate content, in the investigated bottom sediments of the coastal lagoons varies between 74.6% at Umm al-Huwaytāt lagoon and 91.8% at Abu-Galawa lagoon (Table 1; Fig. 2). The carbonates content in Umm al-Huwaytāt and Marsa Shūni lagoons is low to medium compared with the carbonates content of other two lagoons, indicating the over supply of terrigenous materials by wadies. Abu-Shaar and Abu-Galawa lagoons samples have the highest carbonates content (Fig. 2). These two areas are rich with coral reefs (Fig. 2).

Results of correlation coefficient of carbonates with gravel show positive correlation except in Abu-Shaar lagoon (Table 2). The carbonate contents show negative correlation with mud content.

The organic matter, is mainly derived from the autolysis of dead cells or actively excreted by diverse organsims as benthic algae, copepods, seaurchins, as well as planktic species (Kenneth, 1988). The average range of total organic matter content varies from 2.86% at Umm al-Huwaytāt lagoon to 4% at Marsa Shūni lagoon (Table 1; Fig. 2). The increasing in organic matter content of the bottom sediments is primarily due to high rate of sedimentation leading to the high input of sediment from wadies and anthropogenic activities. High productivity in some lagoons due to seagrasses and algae bottom facies are the main reasons for high organic matter content in the coastal lagoons, especially Marsa Shūni and Abu-Galawa lagoons (Fig. 2).

Moderate relationship is detected between the total organic matter and depth in Umm al-Huwaytāt and Abu-Galawa lagoons (r = 0.68 & 0.53 respectively), (Table 2). Very weak relationship is detected between the organic matter and mud fraction in the coastal lagoons except at Abu-Galawa lagoon which shows moderate positive correlation (r = 0.64), (Table 2). There is no relationship between the organic matter and carbonate content in Umm al-Huwaytāt and Marsa Shūni lagoons while carbonate content shows positive correlation in Abu-Shaar lagoon, (r = 0.53) and negative correlation in Abu-Galawa lagoon, (r = -0.61) (Table 2). Moderate positve coreelation between TOM and depth in Abu-Galawa and Umm al-Huwaytāt lagoons.

Phosphorus, is an essential and often limiting nutrient in marine ecosystem, yet its oversupply is of concern in many environments due to its role in eutrophication. The abnormal increase in this nutrient content cause a deflection in the environmental stability. The total phosphorus of the sediments sampled in the coastal lagoons is varied from 3698.9 ppm at Abu-Shaar lagoon to 5420.8 ppm at Umm al-Huwaytāt lagoon (Fig. 2).

The high values of phosphorus content in Umm al-Huwaytāt lagoon was found near the phosphate loading berth in Abu-Tartour Harbour, which decrease with increasing distance from the berth. Increasing of phosphorus content in most sediment samples of the coastal lagoons indicate that phosphorus meight be derived from terrestrial source to the sea through wadies draining the excavated upper Createaceous phosphate rock and by landfilling process. Also, the abundance of phosphorus content may be attributed to phosphatization of calcareous skeletons. Abu-Hilal (1985) stated that in the Gulf of Aqaba phosphorus shows a general distribution pattern similar to that of calcium content where phosphorus is co-deposited with calcium carbonates. This is supported by Klotz (1988) who proved that the rate of phosphate desorption from sediments was inversely related to the calcium concentration and adsorption was directly related to calcium. There is no direct relationship between phosphorus and carbonates and sediment types in the studied coastal lagoons (Table 2). This may be clarified by the fact that phosphorus in the investigated sediments is derived from the terrestrial materials and not as bound element in the marine carbonate sediments. On the other hand, P shows positive correlation with depth in Abu-Galawa lagoon while it shows weak relationship in the other lagoons (Table 2). This is attributed to phosphatization of calcareous skeletons

Table (2). Correlation coefficients between sediment types, grain size parameters, carbonate, total organic matter, phosphours and depth of sediment samples of the studied coastal lagoons.

Abu-Shaar Lagoon

	Gravel	Sand	Mud	Mz	Sorting	Skl	KG	Carbonate%	TOM%	P*	Depth
Gravel	1										
Sand	-0.45	1									
Mud	-0.18	**-0.79**	1								
Mz	**-0.63**	-0.21	**0.66**	1							
Sorting	**0.56**	**-0.87**	**0.58**	-0.12	1						
Skl	0.15	0.34	-0.48	**-0.55**	-0.22	1					
KG	-0.43	-0.27	**0.59**	**0.82**	-0.18	-0.51	1				
Carbonate%	-0.07	0.06	-0.02	-0.16	-0.04	**0.63**	-0.16	1			
TOM%	-0.25	0.29	-0.15	0.07	-0.34	**0.59**	-0.06	**0.53**	1		
P*	-0.07	0.38	-0.37	-0.26	-0.07	0.22	**-0.54**	0.35	0.15	1	
Depth	-0.17	**-0.59**	**0.77**	0.38	**0.58**	-0.27	0.24	0.22	-0.11	0.14	1

Abu-Galawa Lagoon

	Gravel	Sand	Mud	Mz	Sorting	Skl	KG	Carbonate%	TOM%	P*	Depth
Gravel	1										
Sand	**0.82**	1									
Mud	**-0.87**	-1.00	1								
Mz	**-0.97**	**-0.93**	**0.96**	1							
Sorting	-0.31	-0.50	0.48	0.39	1						
Skl	-0.40	**-0.81**	**0.76**	**0.59**	0.44	1					
KG	**-0.76**	**-0.53**	**0.58**	**0.71**	-0.35	0.26	1				
Carbonate%	0.42	**0.85**	**-0.79**	-0.61	**-0.72**	**-0.90**	-0.03	1			
TOM%	-0.34	**-0.68**	**0.64**	0.51	-0.10	**0.83**	**0.54**	**-0.61**	1		
P*	0.11	-0.06	0.04	-0.06	**0.79**	-0.04	**-0.71**	-0.37	-0.45	1	
Depth	0.46	0.22	-0.27	-0.36	**-0.57**	0.28	0.09	0.10	**0.53**	**-0.68**	1

Umm al-Huwaytāt Lagoon

	Gravel	Sand	Mud	Mz	Sorting	Skl	KG	Carbonate%	TOM%	P*	Depth
Gravel	1										
Sand	0.15	1									
Mud	**-0.61**	**-0.88**	1								
Mz	**-0.89**	**-0.56**	**0.88**	1							
Sorting	0.34	**-0.62**	0.33	-0.05	1						
Skl	**0.62**	0.23	-0.49	**-0.57**	-0.09	1					
KG	**-0.80**	0.10	0.31	**0.70**	**-0.61**	-0.22	1				
Carbonate%	**0.62**	-0.04	-0.27	-0.48	0.45	0.19	-0.50	1			
TOM%	0.28	-0.36	0.15	-0.10	0.19	0.31	-0.29	0.10	1		
P*	0.28	0.31	-0.39	-0.31	-0.21	0.22	0.10	0.15	0.22	1	
Depth	0.48	0.11	-0.32	-0.47	-0.05	0.17	-0.49	0.12	**0.68**	0.19	1

Marsa Shūni Lagoon

	Gravel	Sand	Mud	Mz	Sorting	Skl	KG	Carbonate%	TOM%	P*	Depth
Gravel	1										
Sand	-0.23	1									
Mud	-0.02	**-0.97**	1								
Mz	-0.38	**-0.73**	**0.84**	1							
Sorting	0.27	**-0.98**	**0.94**	**0.65**	1						
Skl	**0.60**	-0.36	0.22	-0.32	0.46	1					
KG	**-0.64**	0.30	-0.15	0.36	-0.41	**-0.90**	1				
Carbonate%	0.42	0.35	-0.47	**-0.69**	-0.34	0.24	-0.20	1			
TOM%	**0.54**	-0.11	-0.03	0.03	0.04	-0.20	0.01	0.18	1		
P*	0.11	-0.20	0.18	0.34	0.14	-0.46	0.29	0.11	**0.72**	1	
Depth	0.20	0.33	-0.39	-0.45	-0.29	0.07	-0.09	**0.56**	0.20	0.44	1

4.2 Heavy Metals Concentration

In the present work, marine sediments from Abu-Shaar, Abu-Galwa, Umm al-Huwaytāt and Marsa Shūni lagoons were analyzed to detect the concentration and distribution of five metals (Fe, Zn, Cu, Pb and Cd) in order to understand the effect of human action on the quality of marine sediments, (Table 1; Fig. 4).

Iron is an essential element in the marine ecosystem and consequently it is one of the most abundant elements in marine sediments of the Red Sea. It also performs an essential vital role in biogenic activities. Iron content recorded high concentration in the sediment samples of Umm al-Huwaytāt and Marsa Shūni lagoons compared with Abu-Shaar and Abu-Galawa lagoons, (Fig. 4). The high concentration of iron content in all studied sediment samples of Umm al-Huwaytāt and Marsa Shūni lagoons may be attributed to the high contribution of terrigenous fragments including mafic minerals.

Zinc plays an important role as essential trace element in living systems from bacteria to humans (Merian, 1991). On other hand, zinc concentration in the marine environment is least influenced by human impacts, but it will continue to rise leading to ecological damage, where zinc has very long residence time in the environment. The average concentration of zinc in the marine sediments in the coastal lagoons ranges between 3.01 ppm at Abu-Galawa lagoon and 14.3 ppm at Umm al-Huwaytāt lagoon. Sediments sampled of the coastal lagoons have high zinc concentration compared with those Abu-Galawa lagoon. This is due to the influence of terrigenous fragments rich in this element and principally derived from volcanic and metamorphic rocks. Also, this is attributed to phosphate shipment operations in Abu-Tartour Harbour near Umm al-Huwaytāt lagoon. Where McMurtry *et al*. (1995) found that phosphate rocks contain large amounts of zinc and cadmium as impurities. Moreover, human impact activities contribute to the flux of anthropogenic Zn.

Copper is an essential nutrient and is found in very low concentration in proteins identified in biological systems. Cu recorded the highest average value of 5.08 ppm in Umm al-Huwaytāt lagoon. The high concentrations of Cu in Umm al-Huwaytāt lagoon is attributed to the high and continuous incoming suspended and particulate sediments from the northward human activities in addition to the weak reworking effects in the lagoon (Dar 2004b).

The other metals; Pb and Cd generally recorded low cocentrations in the coastal lagoons, except in Umm al-Huwaytāt lagoon where it recorded the highest average of Pb and Cd contents, 11.7 ppm and 1.06 ppm respectively. Generally, the Cd concentration in the marine sediments reflects clearly anthropogenic inputs of Cd contained materials. Also, Marsa Shūni lagoon recorded high concentrations of Pb content, 7.97 ppm. The highest Pb contents in Umm al-Huwaytāt and Marsa Shūni lagoons are attributed to the local reducing conditions and the metal retention in these sediments. Hatje *et al*. (2003) reprted that the common increase in pH with increasing salinity, will favour the sorption of trace metals onto suspented particulate matter (SPM) that suggests the association of trace metals with particles and the metals retention.

Obviously, marine sediments in Umm al-Huwaytāt lagoon recorded high concentrations of heavy metals compared with the other coastal lagoons. The heavy metals enrichment in Umm al-Huwaytāt lagoon is mainly due to the huge fine particle income to the coastal areas mainly from the smoothers of phosphate shipment operations, cement packing industry, landfilling, shipyards, navigation activities. On other hand, Madkour and Ali (2005) stated that some foraminiferal species especially in Umm al-Huwaytāt lagoon display a wide variety of deformities caused by oathological morphogenesis including double aperture, aberrant chamber shape and extreme compression.

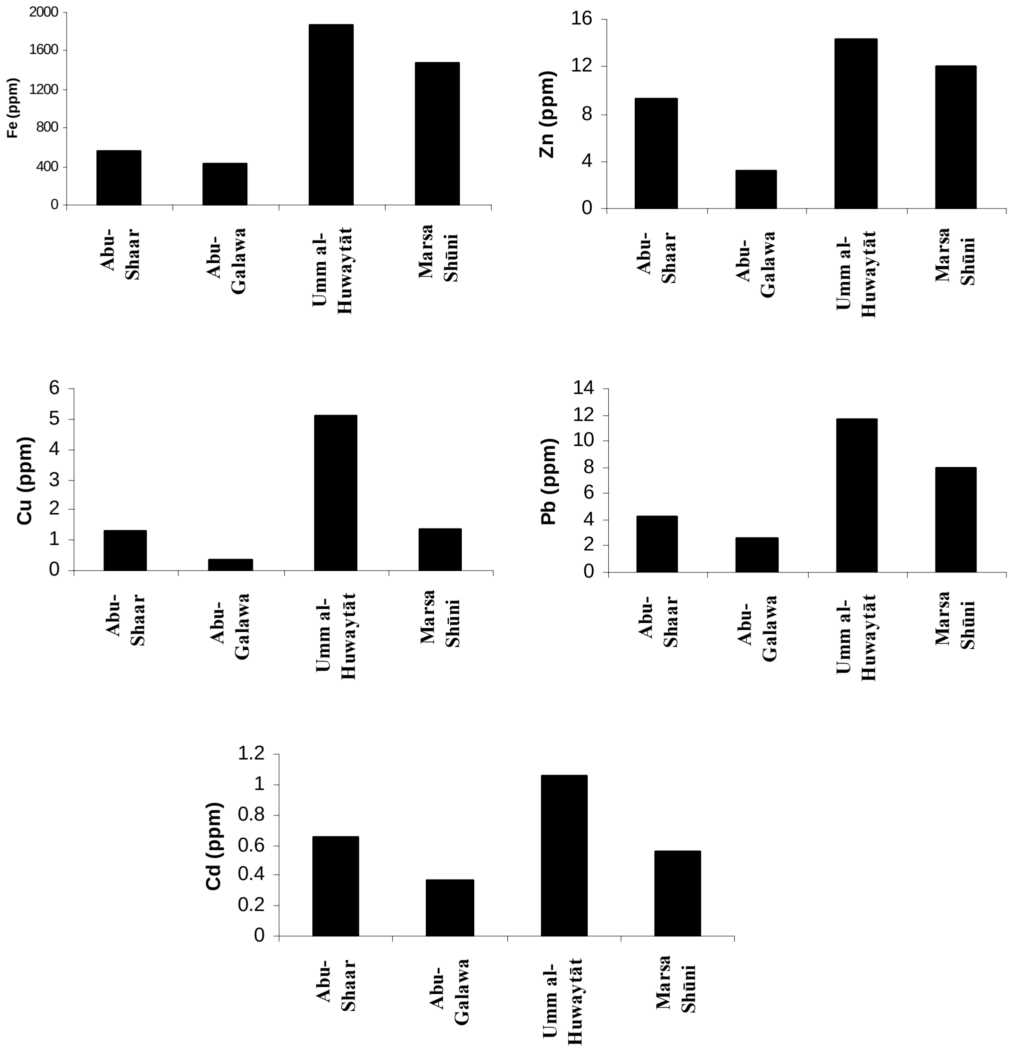

Fig. (4). Average distribution of heavy metals in surface marine sediments of the studied coastal lagoons.

5. CONCLUSION

The Egyptian Red Sea Coastal lagoons are being stressed due to overexploitation and have become very vulnerable to human related activites. Grain size characteristices revealed that the coastal lagoons receive sediments from two different sources; the terrigenous rock fragments from the hinterland mountains and the skelatel carbonates from the sea. However, terrigenous activity is regarded as the major source of sediments to coastal lagoons near the beach. The particle size of the sediments in the coastal lagoons changes from coarse sand near the beach to fine sand with increasing distance from the beach towards the deeper water.

The sediments are carbonate – low to medium in Umm al-Huwaytāt and Marsa Shūni lagoons while Abu-Shaar and Abu-Galawa lagoons contain higher amounts of carbonates. Skeletal materials are the main source of carbonate production. The disttribution of organic matter in the sediments is dependent upon the organic material supply and the hydrodynamic energy of the basin. The main source of phosphorus content in the coastal lagoons is derived from terrestrial materials, naturally by wadies or by anthropogenic inputs and the second source may be due to phosphatization of calcareous skeletals.

Generally, the behavior of heavy metals in the coastal lagoons is complex, and the human impact on some coastal lagoons is clearly reflected by their concentrations. In comparison with the concentrations of metals in sediments of the coastal lagoons along the Egyptian Red Sea with the other studies of the world, the Egyptian Red Sea coast is relatively uncontaminated.

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