the first tourist site and the site of oil exploration is due to the terrigenous sediments of the landfilling materials.

Table (5).Major elements of sediments of selected studied sites.

Site	Desert Rose site.			Master Line site			Hurghada Marina site.			Magwish Company site.			Total samples		
Element	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average
Ca %	0.14	18.50	5.11	2.87	28.41	17.55	8.75	32.60	22.34	6.00	21.36	14.26	0.14	32.60	15.00
Mg %	0.06	0.24	0.17	0.15	0.26	0.23	0.24	0.26	0.25	0.24	0.27	0.24	0.06	0.27	0.22
Sr %	0.001	0.10	0.03	0.03	0.15	0.10	0.06	0.17	0.13	0.03	0.13	0.09	0.001	0.17	0.14
Fe*	2337.76	3293.71	2920.09	179.91	3202.77	1551.97	75.78	2517.42	1213.80	1175.00	3176.16	2223.98	75.78	3293.71	1977.46
Mn*	79.42	536.51	272.40	5.23	334.81	112.24	12.73	219.05	77.00	125.43	1496.57	249.55	5.23	1496.57	177.80

(*) Concentration in µg/g

Table (6).Trace elements of sediments of selected studied sites.

Site	Desert Rose site.			Master Line site			Hurghada Marina site.			Magwish Company site.			Total samples		
Element	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average	Min	Max	Average
Cd*	0.30	1.94	0.77	0.08	1.88	0.52	0.21	0.98	0.45	0.04	1.17	0.32	0.04	1.94	0.51
Cu*	0.07	0.84	0.22	0.02	0.64	0.19	0.03	2.52	0.65	0.59	3.18	1.60	0.02	3.18	1.80
Zn*	3.01	9.71	5.51	0.50	10.06	3.65	1.25	13.03	5.48	0.24	23.18	4.01	0.24	23.18	4.70
Pb*	0.99	16.54	7.39	4.42	15.90	12.45	11.06	26.34	16.76	4.85	21.15	14.96	0.99	26.34	13.00
Ni*	0.11	3.33	1.43	0.04	4.17	1.17	0.40	2.38	1.26	0.08	6.50	3.76	0.04	6.50	1.91
Co*	0.70	1.58	1.05	0.80	1.61	1.11	0.62	1.77	1.23	1.04	2.46	1.71	0.62	2.46	1.30

(*) Concentration in µg/g

Magnesium (Mg)

Magnesium is associated with calcium in most recognized minerals such as pyroxenes, plagioclase, feldspars, amphiboles and carbonate minerals. It has its essential occurrence in dolomite mineral and also related to the carbonate occurrences in the marine sediments.

El-Sayed (1984) found that the magnesium contents of the reefal sediments of Hurghada average 5.01%. Mansour *et al*. (2000) found that, the Mg contents of marine sediments along the Red Sea coast from Hamata to Hurghada in Egypt range from 0.35 to 5.93% with an average of 1.55%. Mg content of the studied areas ranges from 0.06% to 0.27% with an average of 0.22% (Table 5). In the first tourist site it ranges from 0.06% to 0.24% with an average of 0.17% (Table 5) and from 0.15% to 0.26% with an average of 0.23% (Table 5) in the second tourist site. In the central marina Mg ranges from 0.24% to 0.26% with an average of 0.25% and from 0.24% to 0.27% with an average of 0.24% in the oil exploration site (Table 5). Low Mg values reflect the abundance of terrigenous materials from landfilling.

Strontium (Sr)

Carbonates contain a high proportional of strontium in marine sediments. El-Wakeel and Riley (1961) have pointed out that strontium is also associated with clay minerals either by ion-exchange or by incorporated in the clay minerals lattices. El-sayed (1984) found that the strontium contents of the reefal sediments of Hurghada average 0.82%. Most of strontium is biogeneous origin and the variations in the strontium content reflect variations in the Sr/Ca ratio in marine organisms (El-Wakeel and Riley, 1961). Mansour *et al*. (2000) reported that, Sr contents along the Egyptian Red Sea coast from Hamata to Hurghada range from 0.05 to 0.46%.

Strontium contents of the present study range from 0.001 to 0.17% with an average of 0.14% (Table 5). In the first tourist site Sr content ranges from 0.00 to 0.10% with an average of 0.03% (Table 5) and ranges between 0.03% and 0.15% with an average of 0.10% (Table 5) in the second tourist site. In the central marina Sr ranges from 0.06% to 0.17% with an average of **0.13**% (Table 5). In the oil exploration site it ranges from 0.03% to 0.13% with an average of 0.09% (Table 5). Similar to Ca and Mg the relative high content of Sr in the second tourist site and the central marina is because the dredged areas are tidal flat composed mainly of biogenic materials, and most landfill is from these materials.

Iron (Fe)

Riley and Skirrow (1965) pointed out that Fe may be incorporated directly in the hydrogenous phase of marine sediments. Iron is one of the most abundant elements in marine sediments of the Red Sea. It is also essential constituent of plants and has been considered as one of the substances that may limit the amount of plant production in the sea. Beltagy (1973) stated that precipitation with iron oxides is important for Mn and to lesser extent of Pb and Zn. Ostrofsky (1987) reported that iron content is highly correlated with phosphorus content of the sediments because of iron-bound phosphorus was large fraction of total inorganic phosphorus.

In Hurghada mixed sediments Fe is 0.19 – 0.60% (El-Sayed, 1984). El – Mamoney (1995) found that Fe content ranges from 0.03 to 2.17% in sediment from different areas along the Egyptian Red Sea coast. Mansour *et al*. (2000) found that Fe content ranges from 0.14 to 1.72% with an average of 0.59% in sediment from thirteen areas along the Egyptian Red Sea from Hamata to Hurghada.

Iron content of the present study ranges from 75.78 to 3293.71 µg/g with an average of 1977.46 µg/g (Table 5). Sediments of the first tourist site and the oil exploration site have high iron contents. They range from 2337.76 to 3293.71 with an average of 2920.09 µg/g in the first tourist site (Table 5) and from 11751 to 3176.16 with an average of 2223.98 µg/g (Table 5) in the oil exploration site. In the second tourist site Fe ranges from 179.907 to 3202.77 with an average of 1551.97 µg/g (Table 5) whereas in the central marine it ranges from 75.78 to 2517.42 with an average of 1213.8 µg/g (Table 5). This high iron content is related to the terrigenous materials of the landfilling and the presence of construction rubbish and pipelines rust. The mean concentration of Fe (1977.46 µg/g does not exceed the recommended values (41000.00 µg/g) of unpolluted sediments (GESAMP, 1982; Salomons and Froster, 1984; IAEA, 1989) (Table 7).

Table (7). Comparison of mean trace metal concentrations in marine sediments.

Locations / Element	Fe*	Mn*	Cd*	Cu*	Zn*	Pb*	Ni*	Co*	References
Hurghada, Red Sea	1270.90	105.00	0.51	1.80	4.70	13.00	1.91	1.30	present study
Knysna lagoon, South Africa	-------	-------	0.23	6.70	40.60	48.40	-------	-------	watling and watling, 1982a
Saint John, Harbor	-------	296.00	0.16	16.00	53.00	24.00	-------	-------	Ray *and Macknight*, 1989
Bay of Bengal, Chittagong, Bangladesh	5272.13	556.10	0.88	32.91	33.54	23.18	-------	-------	Azam Khan *et al.*, 2003
Red Sea, Egypt	970000.00	388.84	1.01	25.70	35.56	36.22	25.00	11.00	Mansour, *et al.*, 2000
Recommended values of unpolluted sediments	41000.00	770.00	0.11	33.00	95.00	19.00	-------	-------	Salomons and Froster, 1984

Manganese (Mn)

Manganese is relatively mobile in the sediments and its solubility is lowered when high redox potentials occur at sediment surface. The detrital Mn in the sediments is associated with biotite, chlorite and hornblende, where the relative abundance in the sediment component is related to silicates more than carbonates. Mn is an element of low toxicity having considerable biological significance. It is one of the more biogeochemical and active transition metals 'in aquatic environment (Evans *el al.,* 1977). Beltagy (1982) has shown that the concentration of Mn and Fe elements varies significantly, even over very short distance in the area of Hurghada. Mn concentration in the mixed sediments at Hurghada ranges from 0.012 to 0.036% with an average of 0.021% (El-Sayed, 1984). El Mamoney (1995) found that the manganese content ranges from 0.009 to 1.31% in the sediments of five areas in front of some wadis. Mansour *et al*. (2000) found that Mn concentration from thirteen areas along the Red Sea coast from Hamata to Hurghada averaging 0.38%.

In the study areas Mn ranges from 5.23 to 1496.57 with an average of 177.8 µg/g (Table 5). Sediments of the first tourist site have high Mn content ranging from 79.42 to 536.51 with an average of 272.4 µg/g (Table 5). Sediments of the central marina have low Mn content ranges from 12.73 to 219.05 with an average of 76.99 µg/g (Table 5). In the second tourist site Mn ranges from 5.23 to 334.81 with an average of 112.24 µg/g (Table 5). In the oil exploration site Mn ranges from 125.43 to 1496.57 with an average of 249.55 µg/g (Table 5). The high Fe and Mn concentration in the first tourist site and in the site of oil exploration is also regarded as a consequence of the contribution of the landfilling materials of terrigenous origin from the areas close to the high mountain of igneous and metamorphic rocks. The mean concentration of Mn (177.8 µg/g does exceed not the recommended values (770.00µg/g) of unpolluted sediments (Salomons and Froster, 1984) (Table 7).

Trace Elements:

Seven trace elements (Cu, Co, Zn, Pb, Cd, Ni and V) have been determined in the investigated sediments. These elements are important as polluted metals. Zn, Ni, Pb, Co and Cu are more abundant in deep-sea clays than in nearshore sediments (Riley and Skirrow 1965). These trace metals are introduced onto coastal waters by the intensive development of industries and urbanization. The trace metals are transported by physio-chemical processes, including scavenging by sinking particulate and organic matter. Trace elements, therefore, are initially supplied to the site of deposition from terrestrial sources via rivers, landfilling or the atmosphere from biological activity within the ocean and from ocean bottom waters. Beltagy (1982) attributed the variation in the metal content in Hurghada Red Sea water to; the selective utility of these elements by different marine organisms, decomposition of dead organic matter and air-borne material transported to the sea. The results of trace metal concentrations are shown in Table 6. The concentrations of different trace metals at all the stations are not uniform.

Copper (Cu)

Copper concentrations of the present study areas range from 0.02 to 3.18 µg/g with an average of 1.80 µg/g. Sediments of the oil exploration site have the highest copper concentration especially in the beach and intertidal samples due to the abundance of terrigenous sediments. This content ranges from 0.59 µg/g to 3.18 µg/g with an average of 1.60 µg/g (Table 6). Copper is usually concentrated in the soft parts of several marine organisms. High Cu concentrations are in samples of the beach at the central marina and the fishing port which involves the biggest shipyard in the region. This content ranges from 0.03 µg/g to 2.52 µg/g with an average of 0.65 µg/g (Table 6). El-Sayed (1984) found that the copper concentrations of sediments from Hurghada area range from 8.50 to 27.50 µg/g with an average of 21 µg/g. El-Mamoney (1995) found that the copper concentrations in the sediments of five areas in front of some selected wadis along the Red Sea coast in Egypt range from 1 to 59 µg/g. Mansour *et al*. (2000) found that the copper concentrations in sediments of thirteen areas along the Egyptian Red Sea coast from Hamata to Hurghada range from 6 to 249.90 µg.g-1. Cu concentration was lower than the recommended values (33.00 µg/g) of unpolluted sediments (GESAMP, 1982) (Table 7).

Cobalt (Co)

Cobalt is strongly concentrated in marine sediments relative to igneous rocks (El-Wakeel and Riley, 1961). Cobalt has arisen from two independent sources, namely detrital clay and dissolved material fed into the oceans by rivers (Riley and Skirrow, 1965). Cobalt concentrations of the studied areas range from 0.62 to 2.46 µg/g with an average of 1.3 µg/g. Sediments of the oil exploration site have the highest cobalt values range from 1.04 to 2.46 µg/g with an average of 1.71 µg/g (Table 6). Beltagy (1984) pointed that the average cobalt concentration in the sediments of the northern Red Sea is 48 µg/g. Mansour *et al*. (2000) found that, the cobalt concentrations along the Red Sea of Egypt from Hamata to Hurghada range from 0.01 to 27.10 µg/g with an average of 11 µg/g.

Zinc (Zn)

Zinc concentration of the investigated sediments ranges from 0.24 to 23.18 µg/g with an average of 4.7 µg/g. Sediments of the oil exploration site and the central marina have the highest zinc concentrations in the beach and tidal flat sediments due to the terrigenous materials. These contents range from 0.24 to 23.18 µg/g with an average of 4.01 µg/g (Table 6). El-Sayed *et al*. (1984) found that, zinc concentrations of the sediments from Hurghada areas ranges from 11 to 90 µg/g with an average of 31 µg/g. Mansour *et al*. (2000) found that, the zinc concentrations of sediments in front of thirteen areas along the Egyptian Red Sea coast from Hamata to Hurghada range from 8 to 164.4 µg/g. Zn concentration was lower than the recommended values (95.00 µg/g) of unpolluted sediments (Salomons and Froster, 1984) (Table 7).

Lead (Pb)

Lead was extensively used in marine paints as a spreading and sealing agent. About two-thirds of Pb in all Pleistocene sediments has been chemically precipitated from sea water solution and the remainder has been transported in detrital particle (Riley & Skirrow, 1965). Lead concentrations of the study areas range from 0.99 to 26.34 µg/g with an average of 13 µg/g. Sediments of the oil exploration site and the central marina have the highest lead concentrations. They range from 4.85 to 21.15 µg/g with an average of 14.96 µg/g (Table 6). El-Mamoney (1995) found that, the lead concentrations of sediments from different areas along the Egyptian coast range from 26 to 101 µg/g. Mansour *et al*. (2000) found that, the lead concentrations in front of thirteen areas from Hamata to Hurghada range from 0 .50 to 127 µg.g-1. However, in aquatic systems, lead tends to accumulate in aquatic organisms through the food-chain and by direct uptake (Kruus, 1991). In all sites Pb concentrations in many samples espesially in oil exploration and the central marina sites exceeded the recommended values (19.00 µg/g) of unpolluted sediments (Salomons and Froster, 1984) (Table 7).

Nickel (Ni)

Nickel concentrations of the investigated sediments range from 0.04 to 6.5 µg/g with an average of 1.91 µg/g. Sediments of the oil exploration site have the highest nickel concentrations ranging from 0.08 to 6.5 µg/g with an average of 3.76 µg/g (Table 6). The high concentration of nickel was observed in the beach samples of this area due to terrigenous origin. El-Mamoney (1995) found that, the Ni concentrations of sediments from different five areas in front of wadi El Hamara, Abu Shaar, El Gemal and Khasier range from 1 to 149 µg/g. Mansour *et al*.

(2000) reported that, the Ni concentration from different thirteen areas along the Red Sea range from 0.10 to 111.50 µg/g with an average of 25 µg/g.

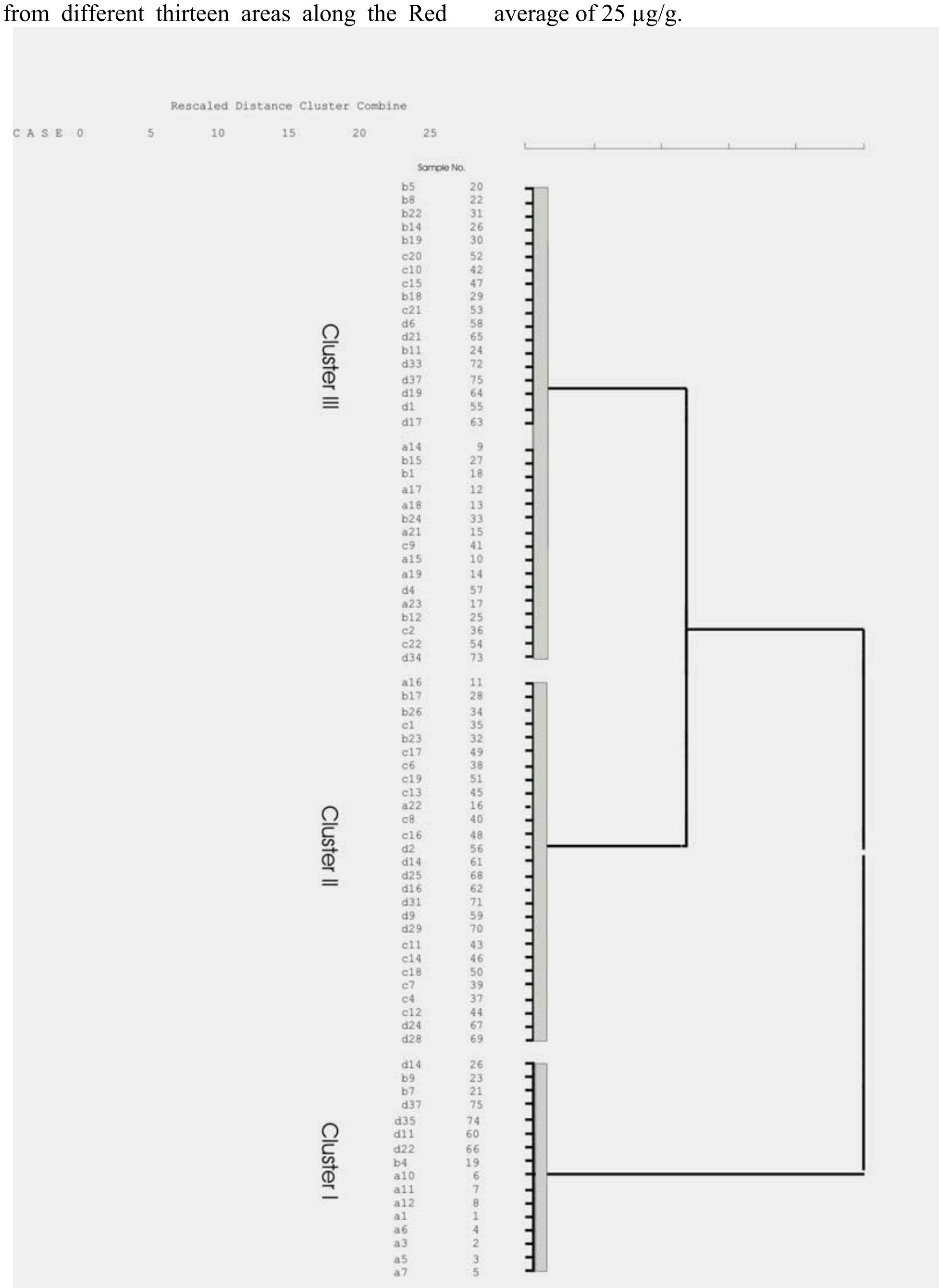

Fig. (7). Dendrogram of cluster analysis using Ward Method exhibiting cluster of trace metal.

Cadmium (Cd)

Cadmium concentrations of the investigated sediments range from 0.04 to 1.94 µg/g with an average of 0.51 µg/g. Sediments of the two tourist sites have the high cadmium concentrations due to the terrigenous origin and the increase of human activities in the regions. These contents range from 0.30 µg/g to 1.94 µg/g with an average of 0.77 µg/g in the first tourist site (Table 6) and from 0.08 µg/g to 1.88 µg/g with an average of 0.52 µg/g in the second tourist site (Table 6). El-Mamoney (1995) found that, the cadmium concentrations of sediments from different investigated regions along the Egyptian Red Sea coast range from 0.001 to 2.787 µg/g. Mansour *et al*. (2000) reported that, the Cd concentrations in different thirteen areas range from 0.0 to 3.10 µg/g. However, at the low redox potential with the presence of organic-bound metal, cadmium release from the underlying sediment layer to the water. The concentration of Cd was always higher in all the stations compared to the other metals. The mean value of Cd concentration was recorded as 0.51 µg/g which is about 5 times higher than the recommended value (0.11µg/g) of unpolluted marine sediments (GESAMP, 1982; Salomons and Froster, 1984; IAEA, 1989) (Table 7).

Cluster analysis; Based on metals (Cd, Co, Ni, Zn, Pb, V, Cu, Fe and Mn) concentration, 3 main clusters were obtained. The first cluster (33 samples) shows the lowest concentration of metals (Cd, Ni, Zn, Pb, V, and Cu) (fig. 7). This cluster includes 11 samples of the second tourist site, 9 samples of the oil exploration site, 7 samples of the central marina and 6 samples of the first tourist site. The third cluster (Fe & Mn cluster) includes 16 samples of the two tourist sites and the oil exploration site indicating that most of Fe and Mn are related to terrigenous origin due to the landfilling in the beach and intertidal area and to the pipelines rust. Cluster 2 includes 26 samples, 12 sample from the central marina, 9 samples from the oil exploration site, two samples from the second tourist site and 3 samples from the first tourist site. The highest concentration of Pb, Co, Zn, and Ni characterizes this cluster. This is probably related to the nearby harbor. The second cluster includes some samples in semi-enclosed areas which are sensitive to the anthropogenic activities. The shore of the study areas is occupied by harbor, tourist villages and oil Company. Oil production and heavy oil tankers in the Gulf of Suez and the NE-SW wave motion and southward currents are probably the reason for the increasing rate of Pb. 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). Concentration of Pb in the dredged parts of some sites is associated with fine sediments.

Toxicity criteria for sediments can be determined by exposing biota to varying levels of contaminants in sediments and comparing responses. However, unpolluted sediments can occasionally have metal (ex. Ni, Co) concentrations greater than or equal to the lowest recommended toxicity thresholds. Adverse effects in organisms may also depend on factors other than concentrations. The findings of this study are useful to establish natural variations in background levels of potentially toxic metals and organic contaminants, as well as sediment properties.

6. CONCLUSIONS AND RECOMMENDATIONS

The study area includes different aspects of coastal development such as tourist villages, constructing marinas, and oil exploration and production. Although all projects has executed an Environmental Impact Assessment study (EIA) all sites were subjected to severe coast destruction and shoreline change from landfilling and dredging of the beach and the tidal flat. Such activities increase turbidity and change sediment distribution patterns, and may destroy entire reef systems.

Sediment characteristics such as grain size, major and trace elements, total organic matter (TOM), organic carbon (OC), and carbonates are important in detecting the hazards of development activates along the Red Sea coast. Therefore, the obtained information helps managers to identify anthropogenic impacts and better asses of the needs for remediation.

The landfilling and dredging are the most significant environmental problems related to the existing coastal uses and human activities in Hurghada city. Such activities may increase turbidity, after water circulation and sediment distribution patterns, and may destroy entire reef systems. Two sources for the artificial land filling; 1) resulted from the beach and neighbor areas enhancement by removing the sand hills and sand piles from the areas of investment and 2) resulted from the near sand quarries.

Landfiling and dredging in Hurghada coastal areas have physical, chemical and biological impacts on the marine environment; therefore, the following recommendations should be taken in consideration:

1- Landfilling and other destructive activities throughout the Red Sea coastal Zone should be prohibited.

2- The coastal areas of Hurghada must by investigated continuously by numbers of environmental inspectors.

3- A regular monitoring program includes organic contaminants and toxicity tests, to detect environmental changes throughout the Red Sea coastal zone should be established.

4- Using the satellite images every year and the degree of change in the coastal areas, especially the shore line change should be examined.

5-Hurghada coastal zone requires integrated planning and management to achieve ecologically sustainable use of coastal resources and conservation of coral reefs.

6-Continuation of a comprehensive research and monitoring program is necessary to study the impact of the increased human activities.

7. Chemical and biologic measurements should be made to determine whether metal concentrations sufficiently high to cause toxic effects in test organisms.

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