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Impact of anthropogenic activities and natural inputs on oceanographic characteristics of water and geochemistry of surface sediments in different sites along the Egyptian Red Sea Coast

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The surface sediments and sea water interactions were studied in five different sites along the Egyptian Red Sea coast. There are commutative and correlative relations between these constituents, therefore, any alterations occur in the sediments and sea water will be directly reflected on the marine environment. Sixty-five sediment samples were collected and also the oceanographic characteristics of surface sea water such as salinity, pH and total dissolved salts (TDS) were measured *in situ* for the same five localities (El-Hamrawein Harbour, Sharm el Bahari, Abu Dabab, Qola'an and Shalatein). The oceanographic properties of sea water show high salinity (42.55 and 42.59 psu) and total dissolved salts values (31.77 and 31.73 mg/L⁻¹) in both Qola'an and Shalatein, also Abu Dabab and Qala'an areas shows high pH values (8.00 and 8.04) due to the presence of dense sea grass cover. The sediment types generally changes from sand to slightly gravelly sand or muddy sand, also the surface sediments are mainly medium sand, moderately to poorly sorted. Geochemically, the factor controlling the carbonate content of studies sediments includes material supply of biogenic and terrigenous components. Therefore, sediments of El-Hamrawein, Sharm el-Bahari, Abu Dabab and Shalatein areas are terrigenous sediments, while sediments of Qola'an area south Marsa Alam are highly carbonates. In general, organic matter (4.82%) is higher in the sediments relative to adjacent areas due to high contributions of terrestrial materials by wadis and anthropogenic factors.

Key words: Grain size, geochemistry, oceanographic, sediments, seawater, Red Sea, Egypt.

INTRODUCTION

Shallow bays, sharms and semi closed areas are a common feature of coastal environments along the Red Sea, where these bays, sharms and semi closed areas in particular play an important ecological role, because of their high primary and secondary productivity. Therefore, the nature and geochemistry of surface marine sediments and oceanographic characteristics of surface sea water

were studied in five different sites along the Egyptian Red Sea coast. They are very important in assessing the possible influence of anthropogenic activities and natural inputs on the composition of the marine sediments as well as the characteristics of sea water. The present study covers five different sites; El Hamrawein Harbour (15 km north Quseir city); Sharm el- Bahari (30 km south Quseir city); Marsa Abu Dabab (30 km north Marsa Alam city); Qola'an (85 km North Hamata city) and Shalatein fishing harbor (Marsa Shalatein).

Several investigators on recent sediments and physical characteristics of seawater were carried out on the Egyptian Red Sea coast. Among of them are (Hanna et al., 1988; Soliman et al., 1993; Jameson et al., 1995; Abd

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Abbreviations: TDS, Total dissolved solids; TOM, total organic matter.

El Wahab, 1996; Reeve et al., 1998; Mansour, 2003; Fahmy, 2003; El-Shenawy and Farag, 2005; Mansour et al., 2006; El-Saman, 2000, 2006; Madkour et al., 2006; Madkour and Dar, 2007 and Madkour et al., 2008).

This study provides idea to make baseline information on the anthropogenic impacts and natural inputs on oceanographic characteristics of sea water and geochemistry of surface sediments of the Red Sea environments. Hence, it could be useful for the management and sustainable development of the Red Sea environments.

Geomorphology and the environmental setting of the study areas

El-Hamrawein Harbour is considered as one of the old phosphate harbor on the Egyptian Red Sea coast. It is located at about 20 km north of Quseir city. The study area lies between latitudes 26°15'02"N and 26°15'17"N and longitudes 34°12'07"E and 34°12'00"E (Figure 1). This harbor lies at the mouth of Wadi El-Hamrawein. Terrigenous sediments have been transported to the marine environment through this wadi. Vegetated coastal dunes and sabkha occupy the lowland areas at its mouth. The supratidal area represents sabkha area while the shoreline occupied by fine to coarse beach sands. The tidal flat is very narrow and extends smoothly with gently slope seaward. Most sediment samples have brown color due to phosphate shipment operations (Figure 2).

Sharm el-Bahari represents protected mangrove swamp. It is located at 103 km north Marsa Alam and 33 km south Quseir between latitude 25°52' 07"N and longitude 34°24'49"E (Figure 1). The mangrove swamp is healthy and the density increases at the entrance of sharm and also at the northern side. The sharm is surrounded with raised beach from both north and south wards (Figure 2).

Abu Dabab is considered bay surrounded with raised beach from both the north and south wards. This bay is situated at 30 km north Marsa Alam between latitude 25°20'14"N and longitude 34°44'15"E (Figure 1). It lies off wadi Abu Dabab which extends to about 17.5 km tell to Abu Dabab well inside the eastern desert. The marine area is relatively shallow and the depth increases sea ward, where the nearshore zone is flanked with coral reefs from the southern and northern sides, while the middle part is famous with big seagrass bed (Figure 2).

Qola'an area is located in the southern part of Hamata area. It is lying at latitudes 24°21'31"N - 24°21'33"N and longitudes 35°18'23"E - 35°18'18"E (Figure 1). This area represents a small bay at the mouth of Wadi Qola'an. Terrigenous sediments have been transported to marine environment by Wadi Qola'an especially in the southern part of the area. The coastal zone has gentle slope creating a wide sabkha with accumulations of sands in form small dunes covered by some higher plants (Figure

2), also the northern part of the coast inhabited with high density of mangroves.

Along the shore, its southern part is rocky (raised reefs) followed by a wide tidal flat about (300–500 m) rich in biodiversity of seagrasses, algae, crustaceans, pelecypods, gastropods, foraminifera and some eggs belonging to marine organisms.

Shalatein site represents semi closed area. It is located at 700 km south Hurghada between latitude 23°09'05"N and longitude 35°36'51"E (Figure 1). This area is shallow crowded with the ships and boats, also the suction pumps room of main Shalatein desalination plant was created on the metal jetty situated in the middle of the harbor in addition to, the reject pipeline is fixed at the middle beach (Figure 2).

MATERIALS AND METHODS

Field work

During the spring of 2009 and winter 2010, sixty-five sediment samples have been collected from Hamrawein Harbour, Sharm el-Bahari, Abu Dabab, Qola'an and Shalatein areas. Surface sediment samples were collected by hand, grab sampler. Three different environmental features; beach, intertidal zone and offshore zone until 30 m water depth represent these localities.

All the submarine photographs were taken with a Sea life Marine Camera. The salinity, pH and total dissolved salts (TDS) were measured *in situ* using Hanna Instrument (Hi 9828) during the sample collection at the studied localities. The positions were recorded by two Global Position System GPS (Magellan, 1000, 5000 pro).

Laboratory methods and treatment of data

Grain size analysis provides basic information for the geochemical investigations of marine sediments. The analysis was performed using the sieving technique according to Folk and Ward (1957). All geochemical analyses were carried out in duplicates 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; Flannery et. al., 1982; Brenner and Binford, 1988).

The obtained data of the granulometric and geochemical analyses and oceanographic parameters were dealt statistically in order to exclude the characteristic parameters. The distribution maps of all variations were plotted by Golden Software Surfer Program (ver. 8).

RESULTS AND DISCUSSION

Oceanographic parameters

The regional variations of physical parameters

Total dissolved solids (TDS) are naturally present in water or are the result of mining or some industrial

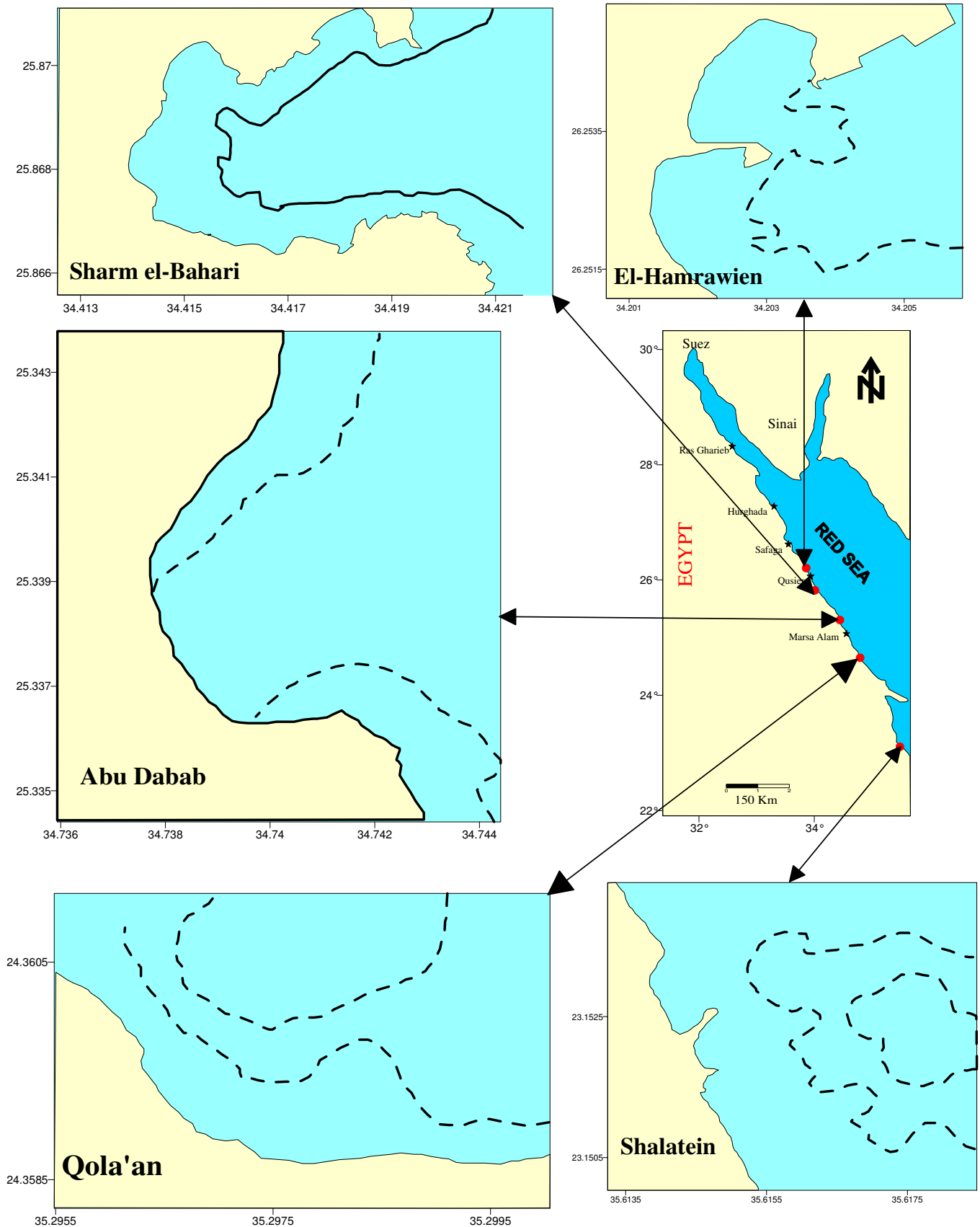


Figure 1. Study areas along the Red Sea Coast, Egypt.



Figure 2. Different environment types of study areas (a) shipment operations of El-Hamrawein, (b) entrance of Sharm el-Bahari, (c) beach area of Abu Dabab, (d) general view of Qola'an and (e and f) drainage of reject water of desalination water plant and nature of bottom character of Shalatein area.

treatment of water. TDS contain minerals and organic molecules that provide benefits such as nutrients or contaminants e. g. toxic metals and organic pollutants. Water with total dissolved solids concentrations greater than 1000 mgL^{-1} is considered to be “brackish” (El-Sama, 2000). Changes in TDS concentrations in natural waters often result from industrial effluent, changes to the water balance by (limiting inflow, or increased water use or increased precipitation), or by salt-water intrusion (Phyllis et al., 2007). The water salinity and TDS variations are harmonious in the studied areas, where the average value of salinity and TDS are 41.83 psu, 31.14 ppt in

El-Hamrawien, 41.8 psu, 31.18 ppt in Sharm el Bahari, 42.19 psu, 31.77 ppt in Abu Dabab, 42.55 psu, 31.77 ppt in Qola'an and 42.6 psu, 31.74 ppt in Shalatein, respectively (Table 1).

The maximum concentrations of salinity and TDS were recorded in Qola'an and Shalatein areas while the minimum values were in El-Hamrawien and Sharm el-Bahari areas as shown in Figures 3, 4 and 6. The high values of water salinity and TDS in Qola'an affecting by the shallowness water and presence the mangrove forest, while the semi closed, shallow area and the presence of desalination plant outlet led to raising them in

Table 1. Physical and geochemical properties of surface water and sediment samples from the studied localities.

Variable		EI-Hamrawein area		Sharm el-Bahari		Abu-Dabab area		Qola'an area		Shalatein area	
		n= 18		n= 10		n= 13		n= 9		n= 15	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Sediment types	Gravel	0.0 - 33.01	12.06	0.0 - 42.44	9.53	0.0 - 16.79	3.06	0.13 - 16.79	3.09	0.27 - 8.24	3.54
	Sand	66.53 - 97.8	86.09	56.89 - 98.58	86.34	0.3 - 99.87	86.35	82.83 - 98.68	95.78	74.71 - 95.67	87.96
	Mud	0.0 - 13.7	2.47	0.38 - 13.68	4.14	0.0 - 17.79	3.18	0.25 - 3.11	1.14	1.86 - 19.08	7.47
Grain size parameters (Folk and Ward, 1957)	Mz	(-0.11 - 3.2)	1.74	(-0.26 - 6.0)	2.53	(0.28 - 3.06)	1.97	(0.6 - 2.31)	1.45	(1.3 - 2.97)	1.97
	6 _i	(0.62 - 1.8)	1.19	(0.3 - 1.71)	1.07	(0.53 - 1.86)	1.11	(0.93 - 1.45)	1.18	(1.31 - 2.05)	1.66
	Sk _i	(-0.64 - 0.5)	-0.08	(-0.33 - 0.58)	0.05	(-0.42 - 0.10)	-0.12	(-0.33 - 0.52)	0.05	(-0.48 - 0.17)	-0.18
	K _G	(0.51 - 2.5)	1.21	(0.66 - 4.07)	1.65	(0.3 - 2.91)	1.38	(0.8 - 1.99)	1.07	(0.72 - 1.91)	1.07
Oceanographic parameters	Salinity	40.88 - 42.15 psu	41.81 psu	41.47- 41.99	41.68	41.6 - 42.7	42.20	42.28 - 43.27	42.55	42.29 - 42.77	42.59
	TDS	30.46 - 31.32	31.13	30.95 - 31.29	31.10	31.08 - 31.87	31.48	31.57 - 32.24	31.77	31.53 - 31.85	31.73
	pH	7.7 - 8.04	7.96	7.91 - 8.07	7.91	8.1 - 8.3	8.00	7.97 - 8.10	8.04	7.91 - 7.96	7.94
CaCO ₃ (%)		17.63 - 84.58	53.57	8.87 - 94.03	42.42	22.95 - 93.48	54.40	31.87 - 88.47	70.64	22.29 - 74.45	48.95
TOM (%)		1.93 - 6.73	4.82	2.04 - 4.90	4.00	1.15 - 8.83	4.50	3.25 - 5.54	4.38	2.29 - 6.08	3.59

n = number of samples, Mz = mean size 6_i = sorting SK_i = skewness KG = kurtosis, CaCO₃=carbonate content TOM = total organic matter.

Shalatein. The salinity and TDS recorded low values in both EI-Hamrawien and Sharm el-Bahari compared to the other three studied areas resulting from stronger mixing water with the sea water, in addition to associate the natural reasons as the shallowness, the local current system and arid climate.

The ion hydrogen (pH) fluctuated in narrow limit in the area under study; it averaged between 7.92 and 8.11 (Table 1 and Figures 5 and 6). The maximum values of pH were recorded in Abu Dabab while the low values were recorded in Shalatein (Figure 6), the differences of pH values affecting by seagrasses that spread in Abu Dabab, Qola'an and Sharm el-Bahari areas.

Granulometric analysis

Sediment distribution

Grain size distribution is considered as a one potentially informative fundamental property of the sediment. This distribution explains to certain extent the depositional process and the depositional environments of the clastic sediments. Particle sizes distribution in sediments is a function of availability of different sizes of particles in the parent material and the processes operating, where the particles were deposited (Folk, 1968). The distribution of recent shallow marine sediments was studied by Mansour et al.

(2000) as well as environmental factors influencing textural pattern of coastal beach sediments of northern Red Sea was studied by Refaat et al., (2001).

The surface sediments in the studied localities have a little variation in the sediment type. Gravel has the highest ratio in EI-Hamrawein location and the lowest ratio in Abu Dabab location due to the abundance of terrestrial sediments at wadi EI-Hamrawein downstream (Table 1 and Figure 7). Sand recorded the highest value of sediment type along the five localities (Table 1 and Figure 8). Mud has the lowest ratio between sediment types and the highest ratio is recorded in Shalatein locality. This may be related to presence of fine

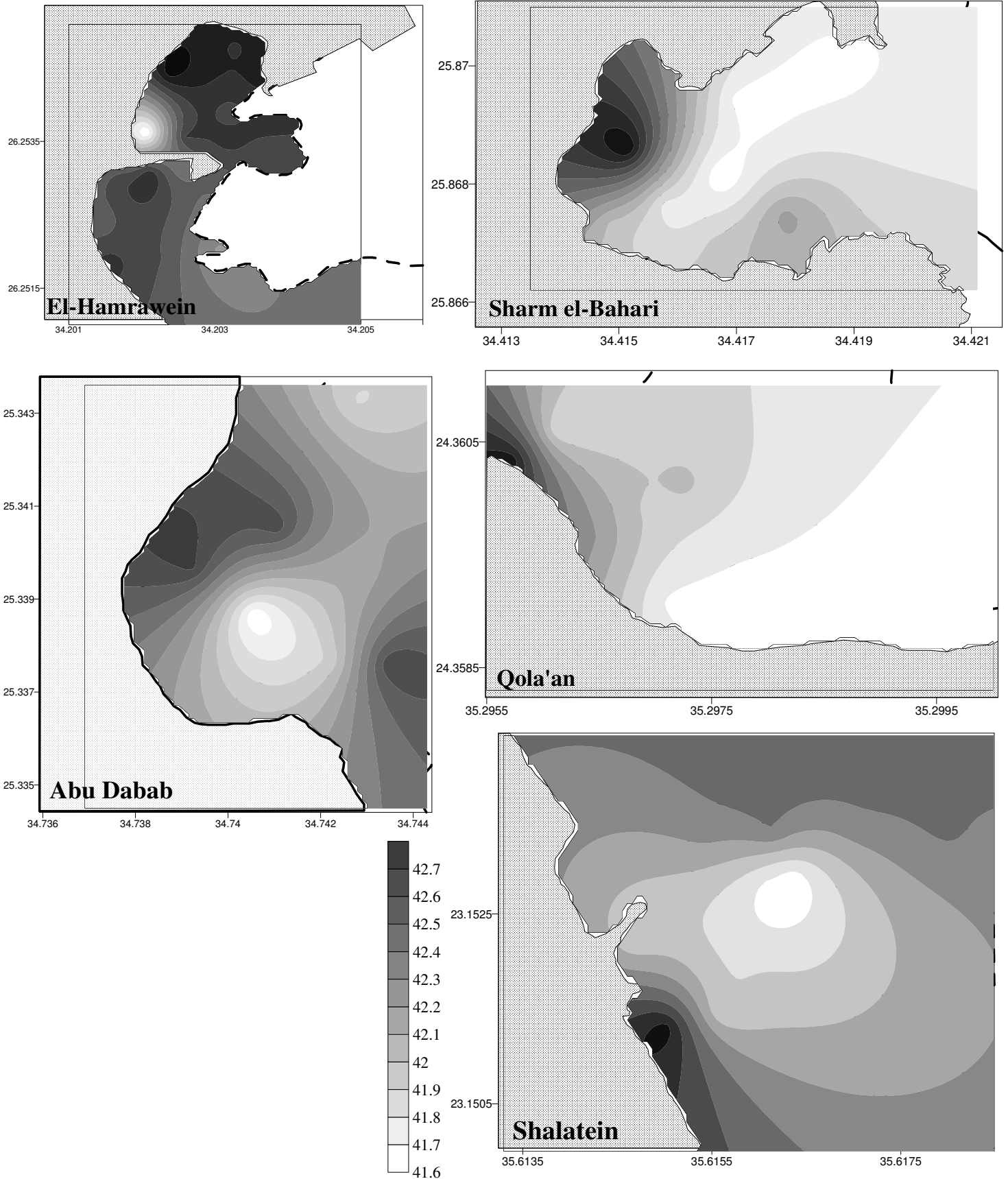


Figure 3. Distribution map of salinity values at the study areas.

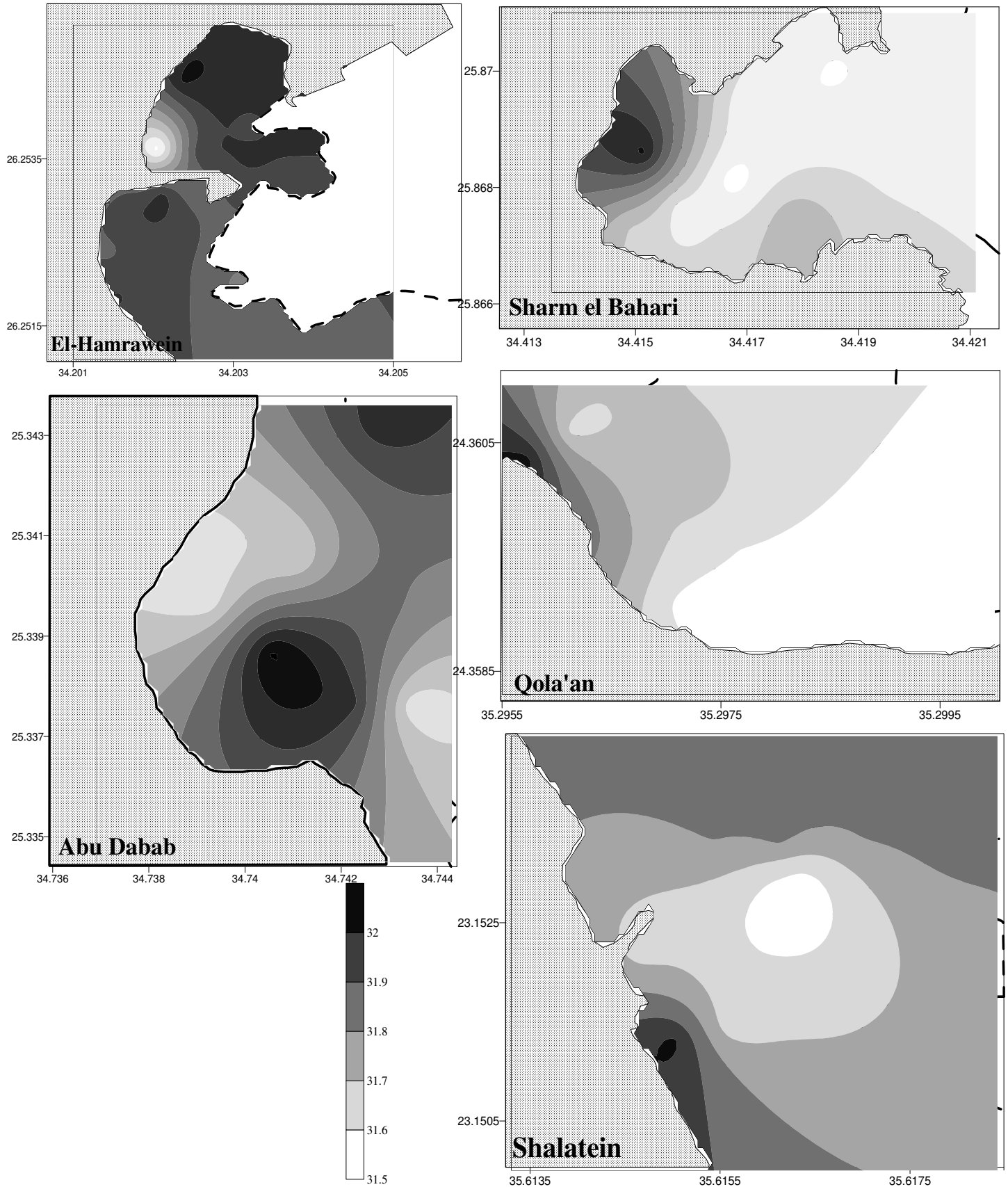


Figure 4. Distribution map of total dissolved salts values at the study areas.

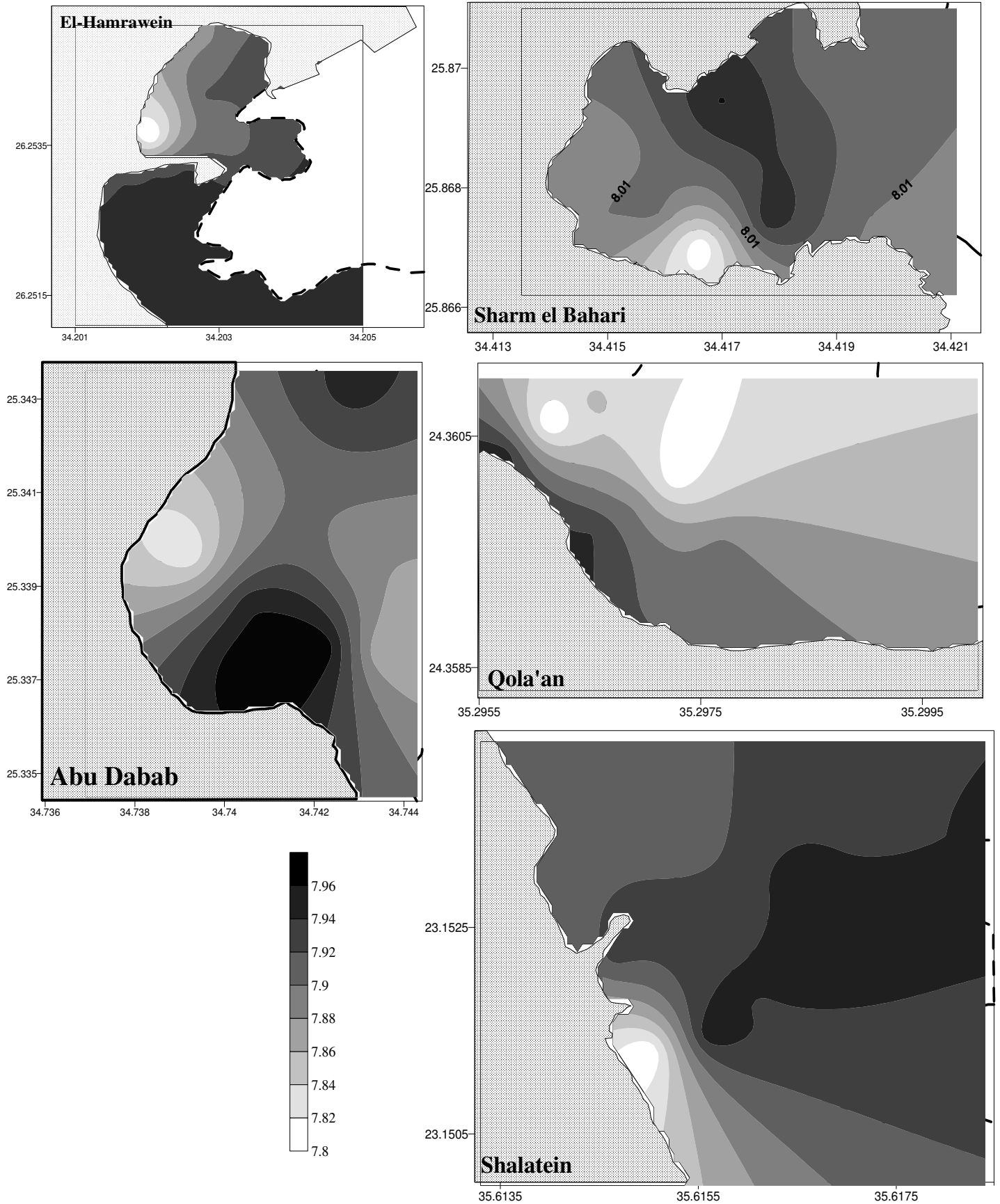


Figure 5. Distribution map of pH values at the study areas.

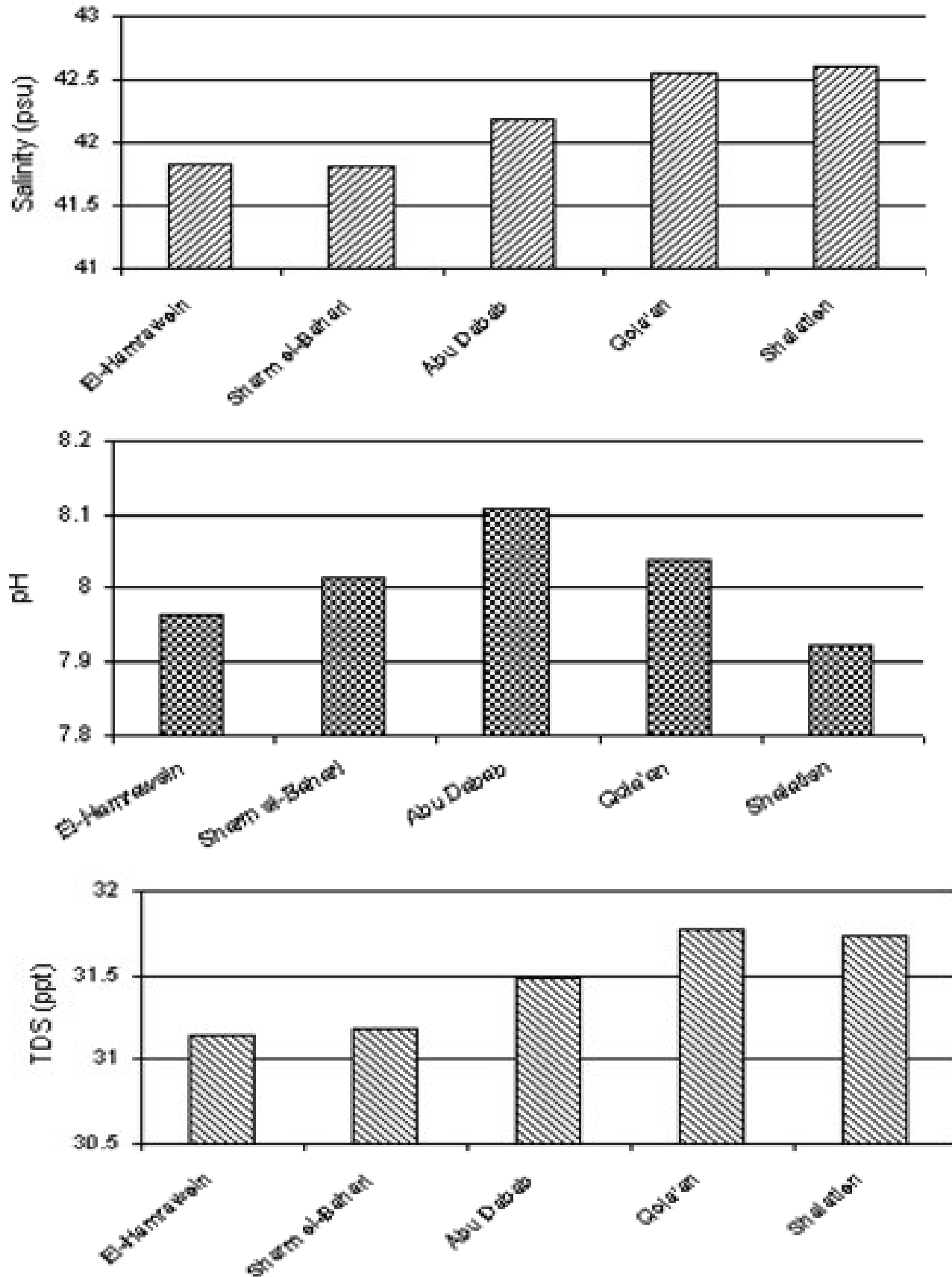


Figure 6. Distribution of pH, total dissolved salts (TDS) and salinity in surface water at the study areas.

carbonate particles resulting from the breakdown of calcareous materials, (Table 1 and Figures 9 and 10).

Grain size parameters

The difference in the grain size parameters of the studied sediments reflects different effects of the physical and oceanographical characteristics of sea water and conditions operating in these different localities such as (presence of mangrove forests in both Sharm el Bahari and Qola'an sites).

The mean size ranges from fine sand in Sharm el Bahari site to medium sand in Qola'an site. Whereas, the area under study receives sediments from different sources (biogenic and terrigenous) from both the sea side as well as the land side, poorly sorted sediments dominate the studied areas. Sediments of the investigated areas show a mixture of negatively skewed to positively skewed nature (Table 1 and Figure 11). Skewness varies from near symmetrical in Qola'an site to coarse skewed in Shalatein site. Duane (1964) recorded that negative skewness is produced by winnowing action as long beach and tidal inlets, where erosion or non deposition and high energy conditions prevail as in Abu Dabab and Shalatein sites, while positive skewness is found in sheleterd area such as Sharm el Bahari and Qola'an sites, whereas fine materials may accumulate. There is no difference in kurtosis values among all samples from five localities but the relatively highest value is recorded in Sharm el Bahari locality, (Table. 1 and Figure 11).

Geochemical analysis

Carbonates

The principal sources of carbonates in marine sediments are: 1) authigenic resulting from inorganic chemical precipitation; 2) residual from weathering of limestone rock on the sea floor; 3) terrestrial from erosion of boundary limestone rock and 4) biogenic from accumulation of skeletal parts of marine animals and plants (Madkour, 2004). The latter of these is quantitatively the most important source of calcareous sediments especially at most sediment sampled in Qola'an area. The greater part of carbonate content in other studied localities (El-Hamrawein, Sharm el-Bahari, Abu Dabab and Shalatein) seem to result from more than one source, that is, mixed from 2, 3 and 4 (Madkour, 2004).

The environmental parameters controlling carbonate deposition are: temperature, light, sedimentation, salinity, pressure and water depth. The two most important parameters are temperature and water depth (Milliman, 1974). Maxwell (1968), classified sediments based on

carbonate content to high carbonate (>80%), impure carbonate (80 – 60%), transitional (60 – 40%), terrigenous (40 – 20%) and high terrigenous (<20%). Following this classification most sediment samples of El-Hamrawein, Sharm el-Bahari, Abu Dabab and Shalatein areas belonging to transitional carbonates (with averages 53.57, 42.42, 54.40 and 48.95%, respectively), while most sediments samples of rich biogenic materials Qola'an area are impure carbonate (average 70.64%) (Table 1, Figures 12 and 14).

El-Mamoney (1995) stated that the carbonate content of the marine sediments along a distance of 500m in front of Wadis El-Hamra, El-Esh, Abu-Sha'ar and Khashir are 30.81, 59.30, 46.21 and 88.50%, respectively. Mansour et al. (1997) recorded that the average carbonate content is 63.2% of the beach and intertidal sediments all over the coastal area from Gemsha to Marsa Alam. Mansour et al. (2000) found that the carbonate content of shallow marine sediments between Hamata and Gemsha varies from 39.98 to 84.40% with an average of 77.56%. Madkour (2004) recorded that the carbonate content of the marine sediments in Safaga and Quseir Harbors is low, 33.13 and 53.74%, respectively, compared to Hurghada Harbour and El-Esh areas. The carbonate percentages of Hurghada region as recorded by Dar (2002) are similar to the carbonate percentages of shallow marine sediments in Hurghada Harbor and El-Esh area (78.61 and 73.38%, respectively).

Generally, most samples of beach and intertidal zone have low carbonates content resulted from different human activities and natural inputs by wadis (Mansour et al. 2000).

Organic matter

The organic matter is mainly derived from the autolysis of dead cells or actively excreted by diverse organisms as benthic algae, copepods, sea urchins, as well as planktonic species (Kenneth, 1988). Organic matter is composed of light-weight materials, and there is a close connection between the presence of fine sediments and the contents of organic matter (El-Askary et al., 1988). Accumulation of organic matter in the sediments usually affects by the size of the depositional basin, the width of the tidal flat, the bottom relief, the amount of sediments in the tidal flat, the current strength in the area of accumulation and other morphological features.

In addition, the decrease in organic matter after sedimentation is mainly due to decomposition and transformation. Organic matter also serves as a source of food for several animal groups such as (Sea cucumber). Moreover, the decomposition of organic matter in such an environment leads to the release of phosphorus and various trace elements.

The average distribution content of total organic matter (TOM) varies from 3.59% at Shalatein area to 4.82% at

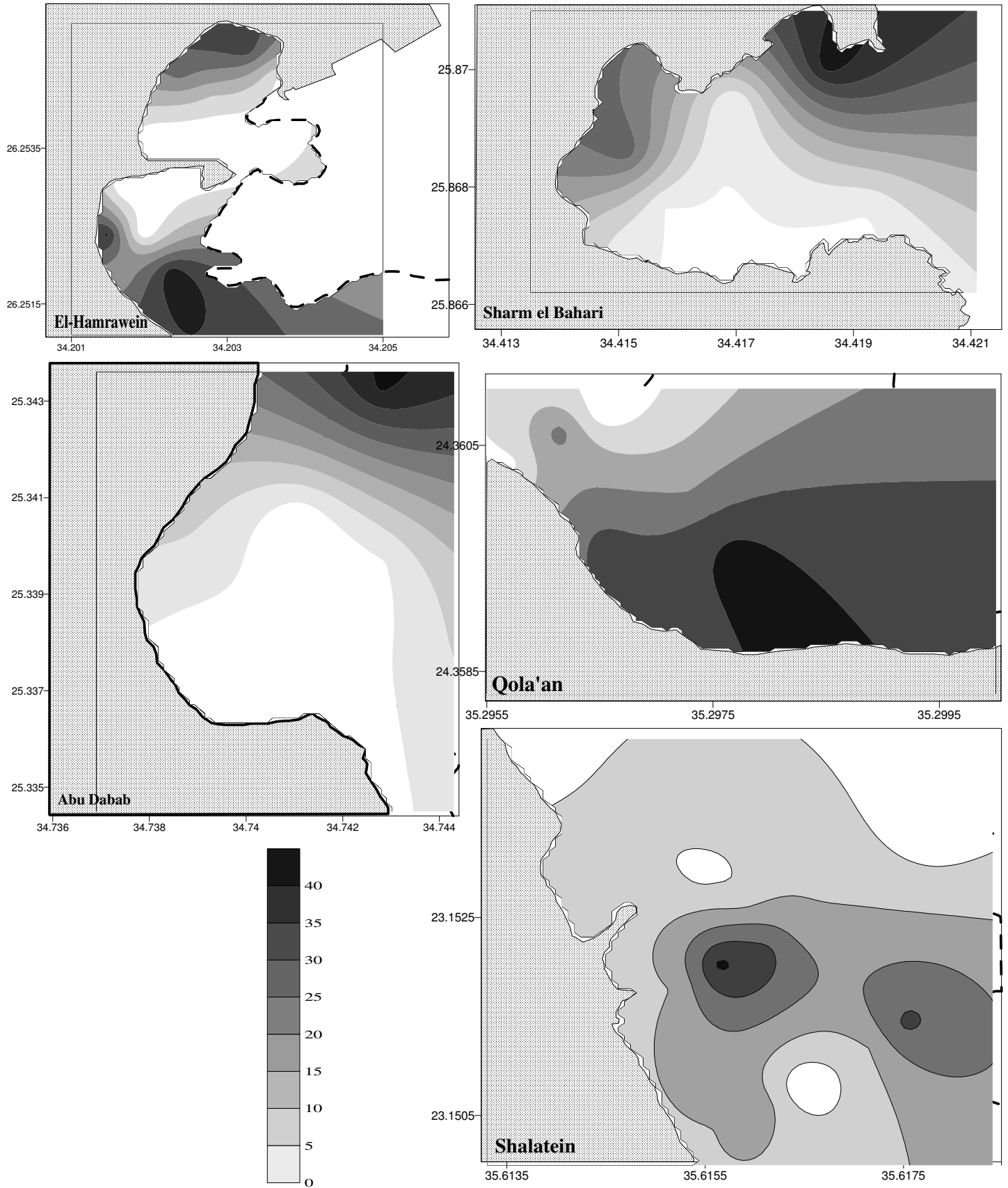


Figure 7. Distribution map of gravel content at the study areas.

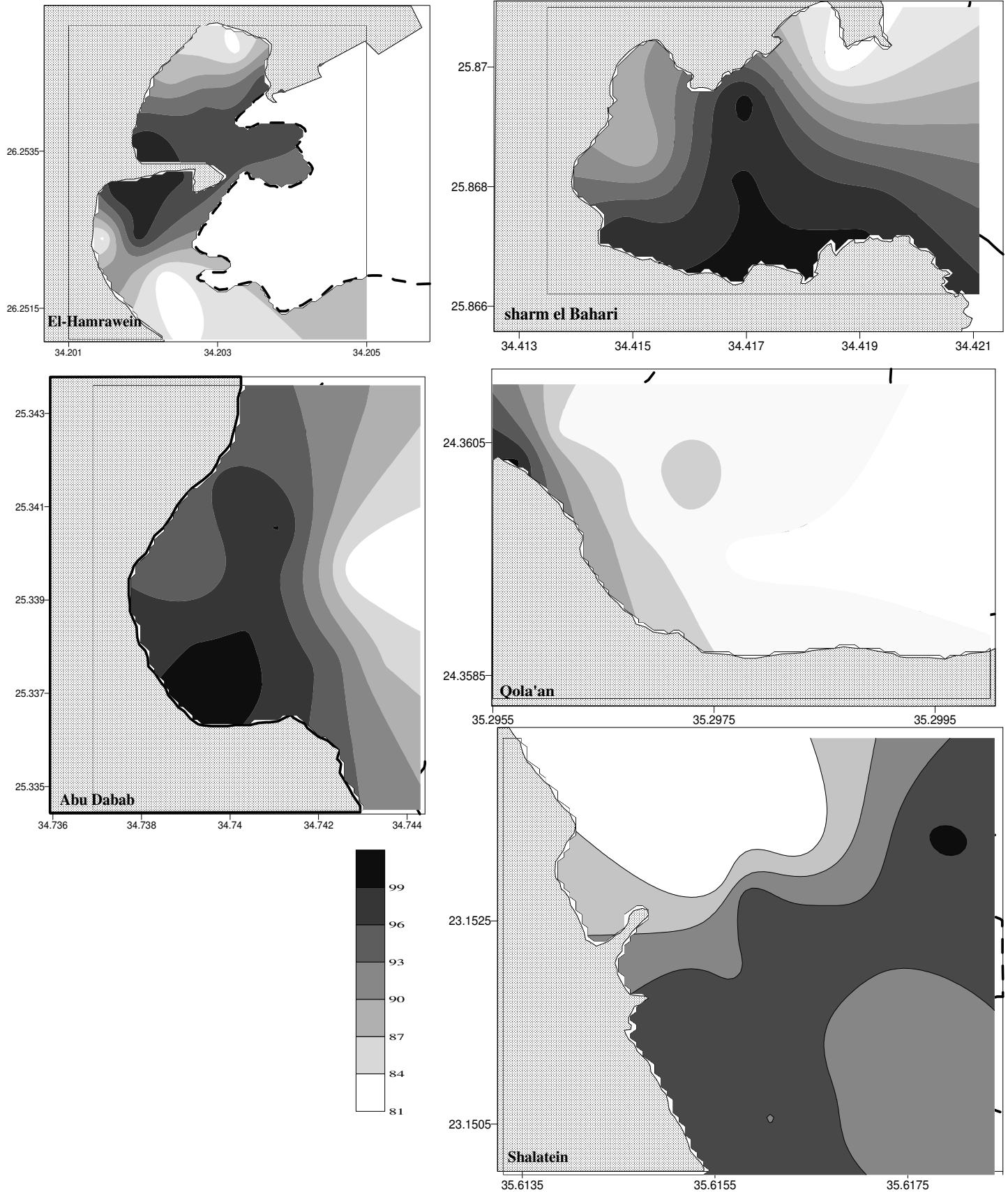


Figure 8. Distribution map of sand content at the study areas.

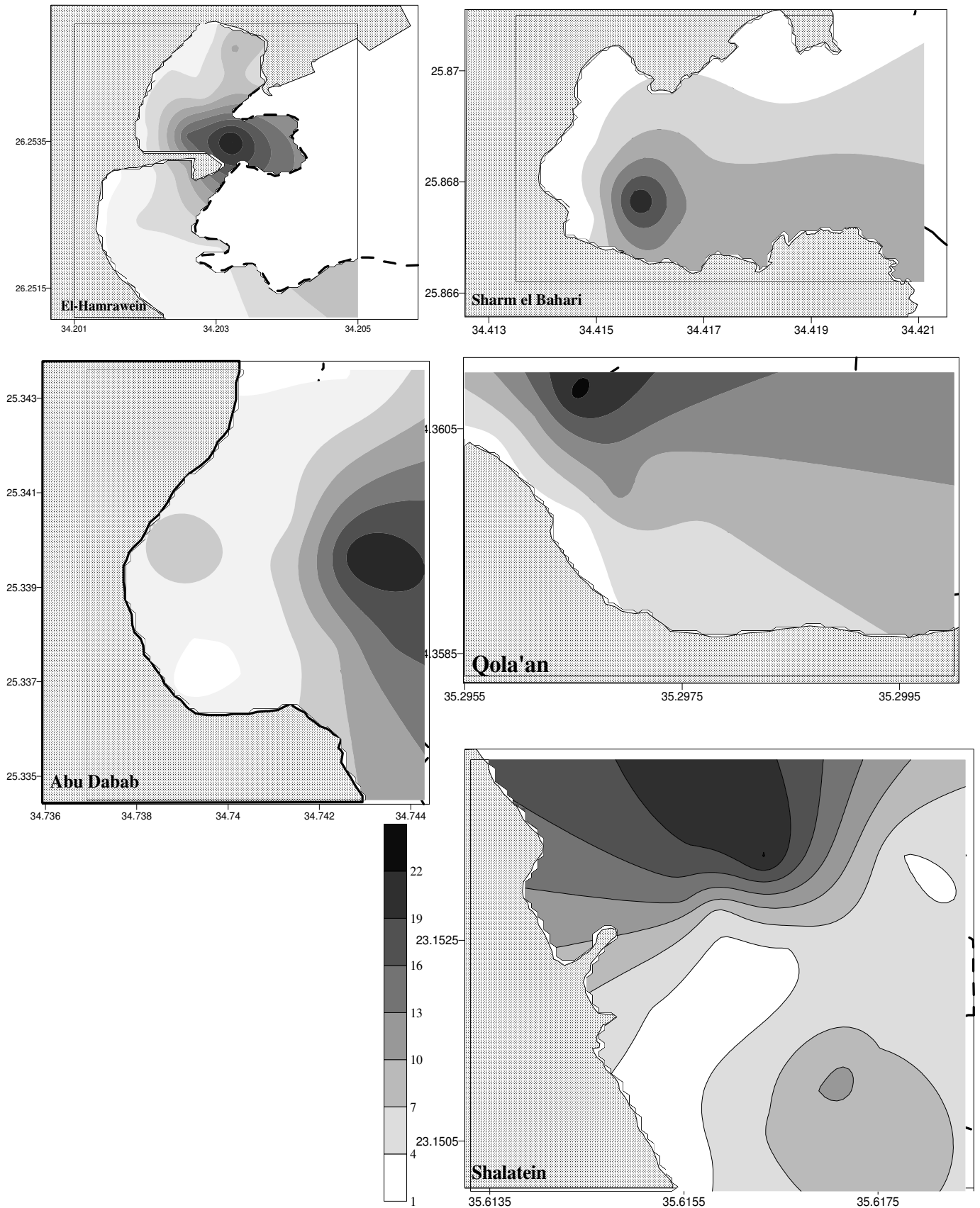


Figure 9. Distribution map of mud content at the study areas.

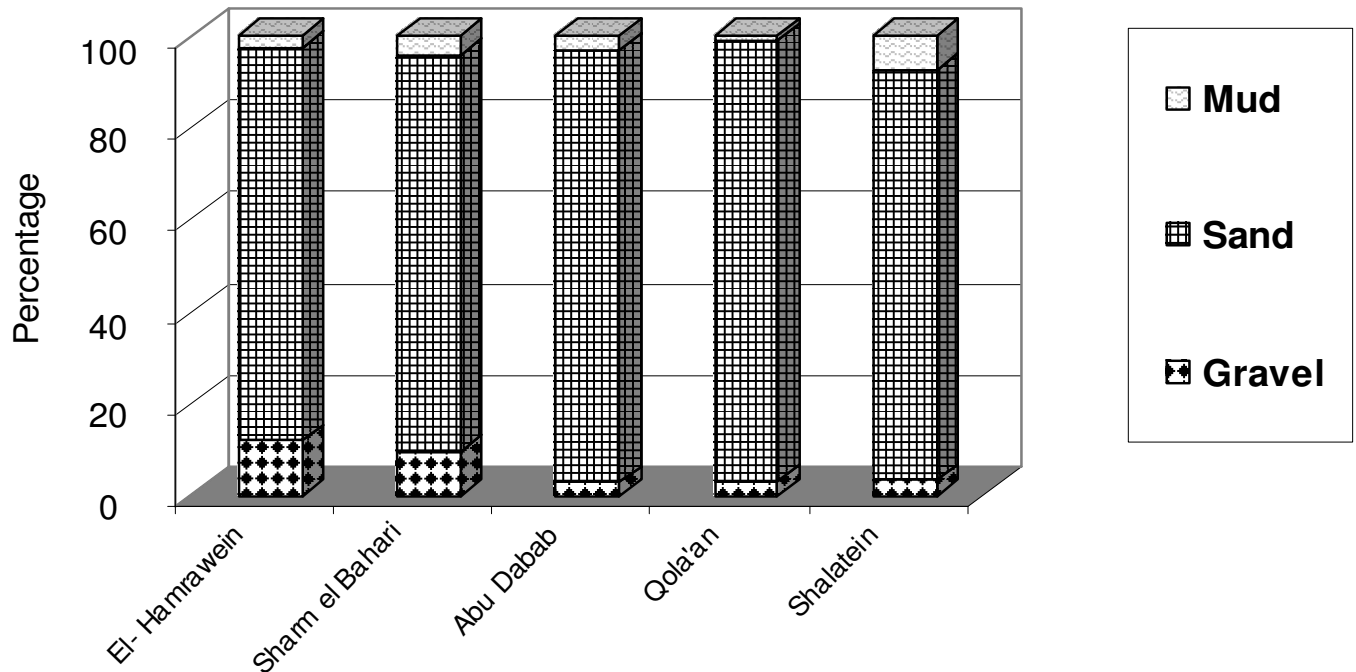


Figure 10. Distribution of gravel, sand and mud fractions of the sediment samples at the study areas.

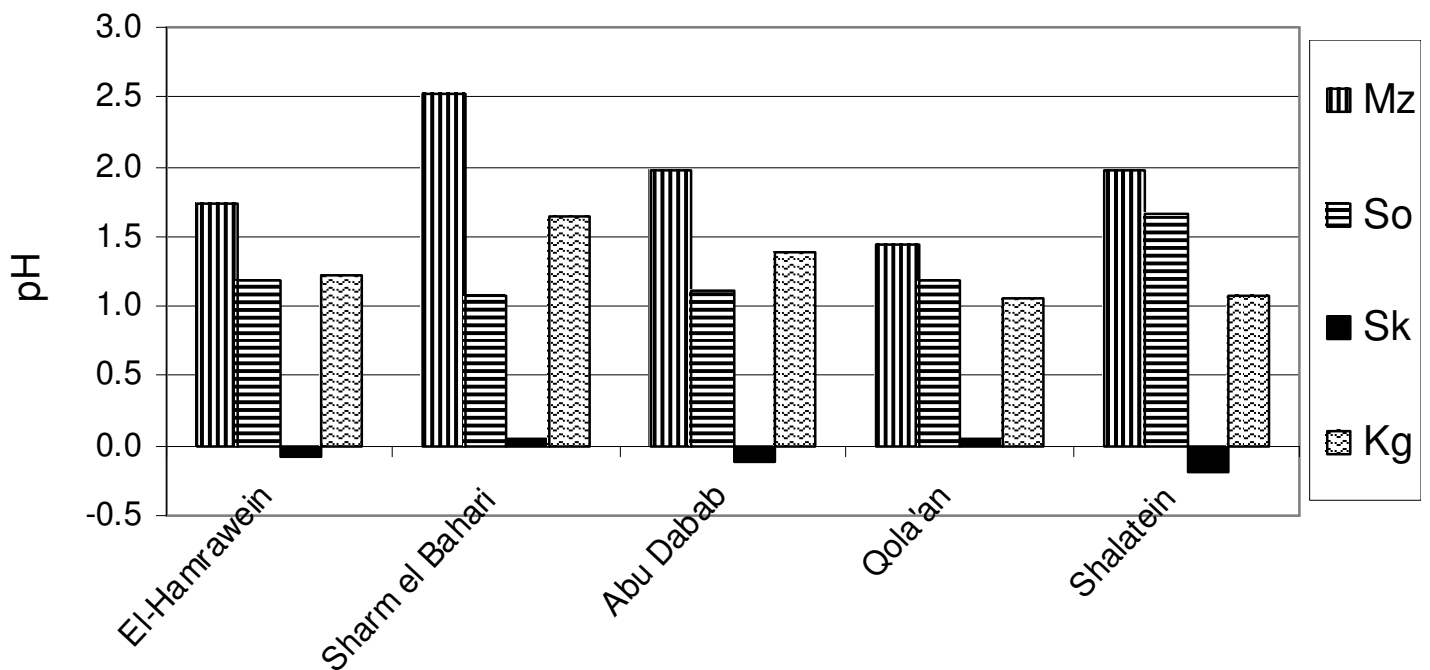


Figure 11. Distribution of grain size parameters of the sediment samples in the study areas.

El-Hamrawein area. The TOM content of samples of El-Hamrawein Harbor ranges from 1.93 to 6.73, averaging 4.82%. The TOM of sediments of Sharm el-Bahari ranges from 2.04 to 4.9%, averaging 4.00%. In Abu Dabab samples, it varies from 1.15 to 8.83%, averaging 4.50%,

also in the sediments of Qola'an area it ranging from 3.25 to 5.54%, with an average of 4.38%, while the in Shalatein samples it varies between 2.29 and 6.08%, averaging 3.59% (Table 1 and Figures 13 and 14).

The variation in organic matter content of the bottom

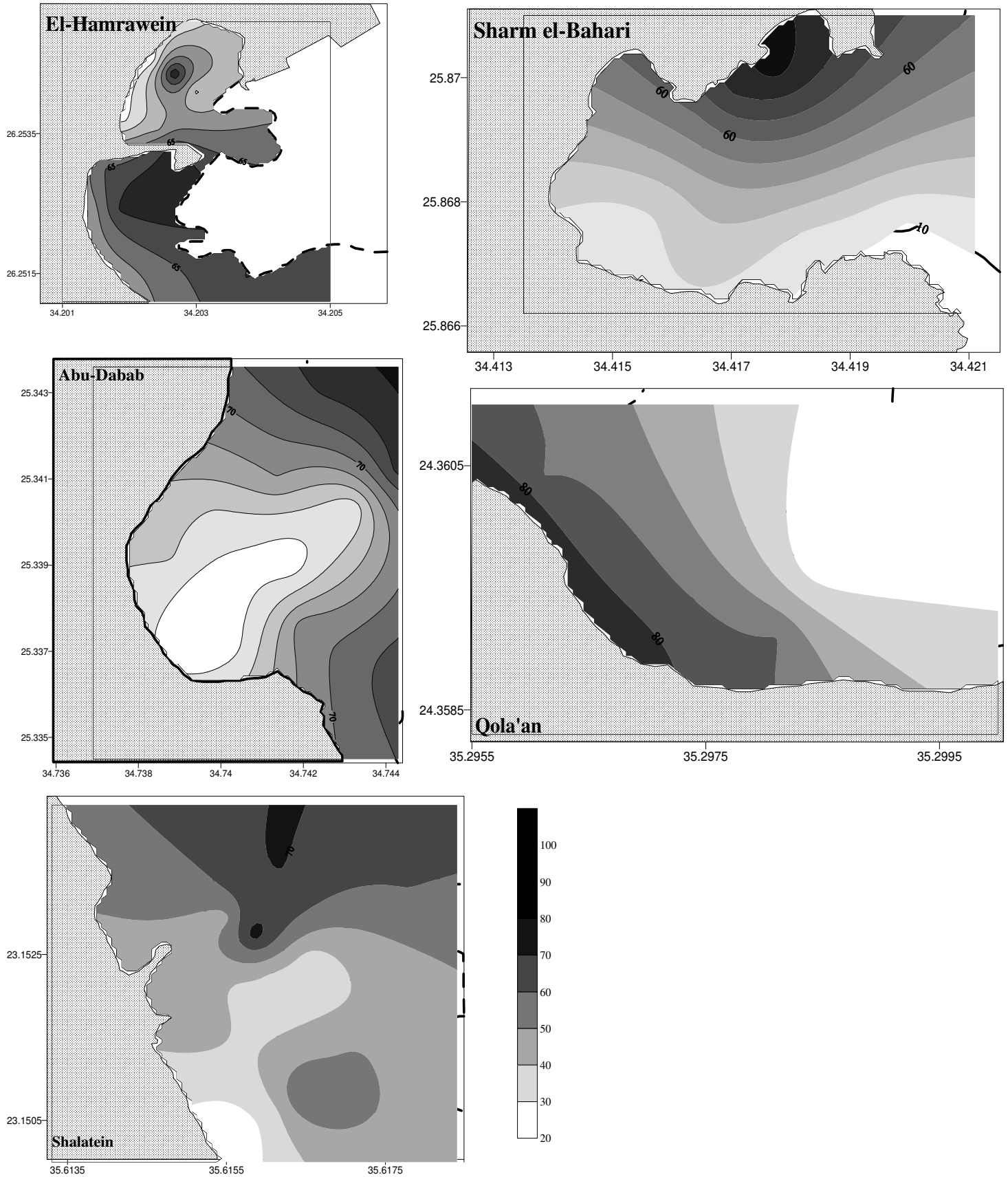


Figure 12. Distribution map of carbonate content at the study areas.

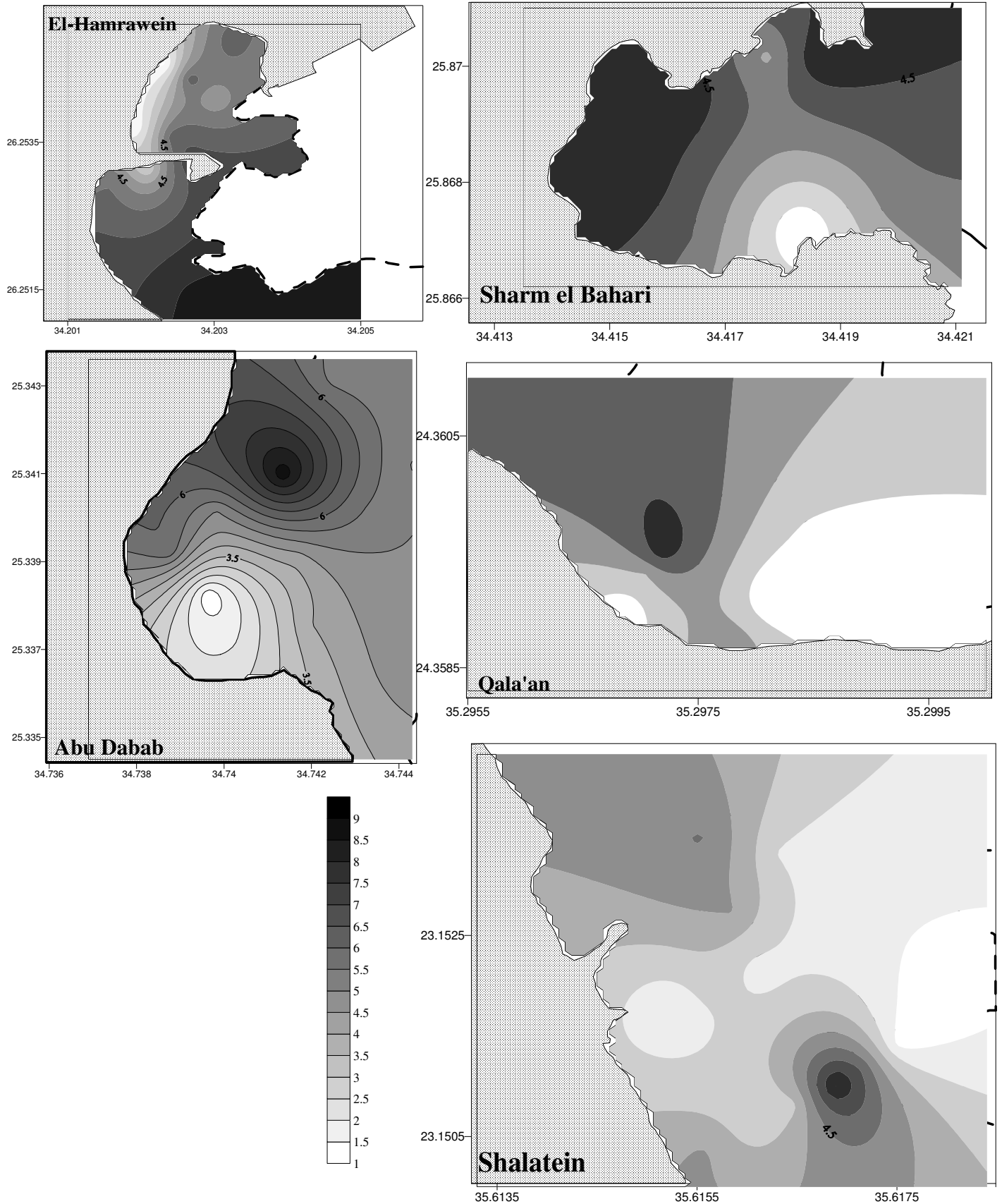


Figure 13. Distribution map of total organic matter content at the study areas.

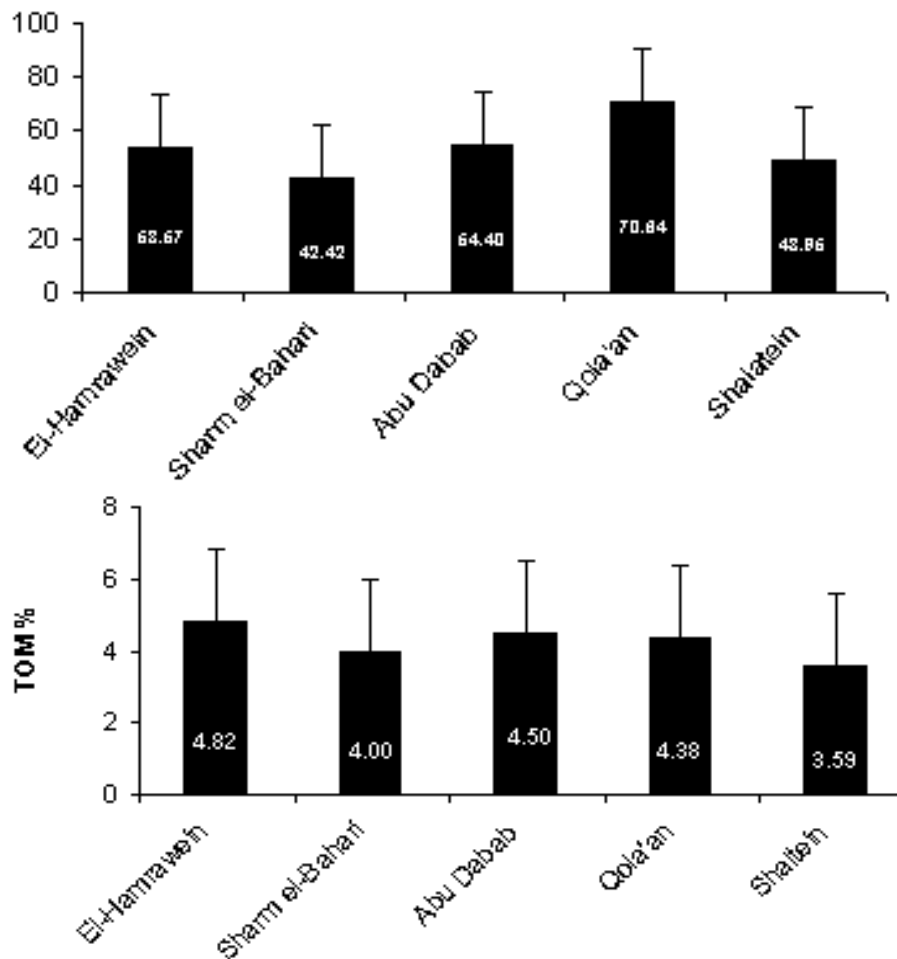


Figure 14. Distribution of carbonate content and total organic matter content in marine sediments at the study areas.

sediments is primarily due to local hydrodynamic influence which transport and scatter particulate organic materials brought from inside the sea, from the other side. The high rate of sedimentation due to the increasing input of sediment from wadis, increasing the fine particles due to human activities, probably some spots to direct discharge of domestic waste and sewage of some areas. High productivity in some areas due to seagrass and algae bottom facies are the main reasons for high organic matter content in the most studied areas.

Mansour (1999) and Mansour et al. (2000), found that the higher content of the organic matter in tidal flat sediments attributed to the terrigenous flux. Also, they recorded that the terrestrial materials rich in organic matter and the high organic productivity are the two main reasons for the higher organic matter content. Dar (2002) stated that the high content of total organic matter content of sediments from Hurghada area and surrounding is about 3.61%, this value is lower than in the present study. In the same manner, Mansour (1999), Masour et al. (2000b) and Madkour et al. (2006) recorded

that the average total organic matter of sediments is lower than that of sediments from the present study.

CONCLUSIONS AND RECOMMENDATIONS

The present study covers five different sites along the Egyptian Red Sea coast namely: El-Hamrawein Harbour, Sharm el-Bahari, Abu Dabab area, Qola'an area and Shalatein fishing harbor. The most important conclusions of the present study can be summarized as follows:

1. There are commutative and correlative relations between physical and geological parameters.
2. The water salinity and TDS values increase in Shalatein and Qola'an areas resulting to the presence of desalination plant outlet in Shalatein area and due to shallowness water in Qola'an area.
3. The ion hydrogen recorded high values in Abu Dabab and Qola'an areas due to dense cover of seagrasses.

4. Two main sources supply sediments are common in the studied areas; terrigenous flux through the wadis and biogenic fragments from the sea.
5. Grain size analysis explained that the sand recorded the highest ratio of sediments type along the five studied locations compared to the other sediment types but mud content recorded the high values in Shalatein area while gravel has the highest ratio in El-Hamrawein site.
6. The carbonate content in El-Hamrawein, Sharm el-Bahari, Abu Dabab and Shalatein areas samples is low indicating the over supply of terrigenous materials while Qola'an area samples recorded relatively high average carbonate content, due to the abundance of biogenic materials.
7. The high organic matter content is due to the high sedimentation rate from wadis, which increase the fine particles in some spots. In some areas; the seagrass covers the tidal flat zone which is the main reason for high organic matter content in the studied areas.

This study provides idea to make baseline information's on the anthropogenic impacts and natural inputs related to oceanographic characteristics of sea water, nature and geochemistry of surface marine sediments of the Red Sea environments.

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REFERENCES

- Abd El Wahab M (1996). Studies on the recent sedimentary environments and the benthic foraminifera in the intertidal zone of the area between Gemsha and Marsa Alam, Red Sea, Egypt. M. Sc. Thesis, Faculty of Science (Qena), South Valley University, p. 172.
- Brenner M, Binford MW (1988). Relationships between concentrations of sedimentary variables and trophic state in Florida Lakes. *Can. J. Fish. Aquat. Sci.*, 45: 294-300.
- Dar AM (2002). Geological basis to study the environmental defect in the marine ecosystem as a result of tourist activities in Hurghada area and surroundings, Red Sea, Egypt. Ph.D. Thesis, Suez Canal University, Egypt, p. 218.
- Dean WE Jr. (1974). Determination of carbonate and organic matter in calcareous sediments and sedimentary rocks by loss in ignition: Comparison with other methods. *J. Sed. Petrol.*, 44: 242-248.
- Duane DB (1964). Significance of skewness in recent sediments, Western Pamlico Sound, North California. *J. Sed. Petrol.*, 34: 864-874.
- El Saman MI (2000). "Hydrographic studies of some lagoons near Hurghada." M.Sc. thesis, Aswan, South Valley University.
- El Saman MI (2006). Seasonal Hydrographic And Radon Level Variations In The Northern Safaga Bay. Physics Department, Faculty of Science, Zagazig University, p. 170.
- El-Askary, MA, Nasr SM, Moussa AA, El-Mamony MH (1988). Geochemical approach to the beach and bottom sediments of Jubal area at the entrance of the Gulf of Suez. M. Sc. Thesis, Alex. University, Egypt, p. 304.
- El-Mamoney MH (1995). Evaluation of terrestrial contribution to the Red Sea sediments, Egypt. Ph. D. Thesis, Faculty of Science, Alex. University, p. 146.
- Flannery MS, Snodgrass RD, Whitmore TJ (1982). Deepwater sediments and trophic conditions in Florida Lakes. *Hydrobiol.*, 92: 597-602.
- Folk RL, Ward WC (1957). Brazos River bar: a study in the significance of grain size. *J. Sed. Petrol.*, 27(1): 3-26.
- Hanna RGM, Saad MAH, Kandeel MM (1988). Hydrographical studies on the Red Sea water in front of Hurghada. *Marina Mesopotamica*, 3(2): 139-156.
- Jameson SC, McManus JW, Spalding MD (1995). State of the reefs: Regional and global perspectives. International Coral Reef Initiative, US Department of State, Washington, DC, p. 32.
- Kenneth P (1988). Sediment transport and depositional processes. Postgraduate Research Institute For Sedimentology, University of Reading, White Knights, UK, p. 397.
- Madkour HA (2004). Geochemical and environmental studies of recent marine sediments and some invertebrates of the Red Sea, Egypt. Ph.D. thesis South Valley University, Qena, p. 317.
- Madkour HA, Ahmed NA, Mohamed AW (2006). Coastal sediments and their polluting metals of El-Hamrawein Harbour, Egyptian Red Sea coast: Clues for monitoring environmental hazards. *Sedimentol. Egypt*, 14: 155-131.
- Madkour HA, Dar MA (2007). The anthropogenic effluents of the human activities on the Re Sea coast at Hurghada Harbour (Case study). *Egypt. J. Aquat. Res.*, 33(1): 43-58.
- Madkour HA, Mohamed AW, Ahmed NA (2008). The impact of anthropogenic activities on the physical and chemical characteristics of surface sediments in some coastal lagoons along the Egyptian red sea coast. *Egypt. J. Aquat. Res.*, 34(1): 53-68.
- Mansour AM (1999). Changes of sediment nature by environmental impacts of Sharm Abu Makhadeg Area, Red Sea, Egypt: *Sedimentol. Egypt*, 7: 25-36.
- Mansour AM (2003). Pressures and impact of coastal zone of Abu Minqar 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. pp. 417-430. January.
- Mansour AM, Mohamed AW, Osman MR, Nasr El Dien A, Tahon MA (2006). Sedimentological and geochemical studies on some island sediments of the Red Sea, Egypt. *Egypt. J. Aquat. Res.*, Special Issue, (32): 105-130.
- Mansour AM, Nawar AH, Mohamed AM (1997). Recent intertidal sediments and negative impact of human activities, Red Sea Coast, Egypt. *Egypt. J. Geo.*, 41/2A: 239-272.
- Mansour AM, Nawar AH, Mohamed AW (2000). Geochemistry of coastal marine sediments and their contaminant metals, Red Sea, Egypt: A legacy for the future and a tracer to modern sediment dynamics. *Sedimentol. Egypt*, 8: 231-242.
- Maxwell WGH (1968). Atlas of the Great Barrier Reef. Elsevier Amsterdam. *Mar. Pollut. Bull.*, 28/4, April 1994, p. 268.
- Milliman JD (1974). Marine carbonates. Springer Berlin Heidelberg, New York, p. 375.
- Phyllis KW-S, Lawrence KD (2007). Effects of Total Dissolved Salts on Aquatic Organisms: A Review of Literature and Recommendation for Salmonid Species. *Am. J. Environ. Sci.*, 3(1): 1-6.
- Reeve SM, Abdel-Fattah SC, Riegl RS, Hassan R, Newman AP (1998). Best practices for tourism center development along the Red Sea coast: Tourism Development Authority, Cairo, p. 107.
- Refaat AA, Aref A (2001). Environmental factors influencing textural pattern and mineralogical composition of coastal beach sediments of Ras El-Behar, Gemsha area and adjacent Islands, northern Red Sea, Egypt. *Sedimentol. Egypt*, 9: 43-55.
- Soliman MA, Ahmed EA, Purser BH (1993). Evolution of the Pliocene sediments in the NW part of the Red Sea rift, Egypt. *Geol. Soc. Egypt., Spec. Publ.*, 1: 233-251.