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Assessment of water quality in the Red Sea using *in situ* measurements and remote sensing data

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Received 7th October 2009, Accepted 8th November 2009

Abstract

The coastal areas of the north Red Sea are characterized by a wealth of natural heritage and resources that presents attractive elements for tourist in Egypt. At present, the areas are witnessed extensive and diverse activities such as; tourism, industries, harbors and fisheries. These anthropogenic activities may significantly impact the water sea quality. In this study a monitoring program and estimation of the water quality parameters particularly: Chlorophyll a concentration (Chl-a), Total Suspended Matter (TSM) and Sea Surface Temperature (SST), in the surface water of the northern Red Sea were made during the period between 1998 and 2008. We employ this by using the modern applications of remote sensing observations on calculation and retrieval of these water quality parameters. Fifty six field trips were performed during 1998-2008. Thirty nine stations were selected to represent the different conditions of the study areas Suez Gulf, Aqaba Gulf and the Egyptian Red Sea side. Accidently, the Moderate Resolution Imaging Spectrometer (MODIS) satellite covers the study area in July 2006. The present work is a comparison between the data obtained by MODIS with their counterpart taken directly in the field. The results from both sources agreed that the levels concentrations of chlorophyll-a and total suspended matters in the coastal waters of Suez Gulf are higher at the sites on the sample stations around the urban areas of Suez City relative to those in the rest of studied areas, Red Sea proper and Aqaba Gulf.

Keywords: Red Sea -Chlorophyll-a -Water quality – hydrographic parameters – MODIS satellite

1. Introduction

The Red Sea is a major international shipping lane linking eastern and southern Asia with the Middle East and Europe. Because the economic repercussions on the fishing and tourist trades depend, to a great extent, on the degree of deterioration of environmental conditions, the Environmental Information and Monitoring Program (EIMP) were initiated to assess the aesthetic quality of these coastal areas due to their importance for tourism and consequently national income. This program is directed by a steering committee with representatives from the Egyptian Environmental Affair Agency (EEAA) and Danish International Development Assistance (DANIDA). The present work of the coastal water monitoring program for the Suez Gulf, Aqaba Gulf and Red Sea proper is a part of collaboration between the EEAA and National Institute of Oceanography and Fisheries (NIOF), Egypt. The Strategic approach of the EIMP has been taken to initiate the monitoring and database system of the coastal water quality in Egypt and to improve data quality through the train of the monitoring institution staff in quality assurance and quality control work. The understanding of the cause - effect relationship between pollution sources and environmental impact will be emphasized.

Monitoring, protecting and improving the quality of waters are critical for targeting conservation efforts and improving the quality of environment. Methods used to monitor water quality across the landscape consist of in situ measurements or collection of water samples for analysis in the laboratory and also usage of remote sensing techniques.

The Chl-a concentration provides a measure of phytoplankton abundance and biomass (Martin, 2004). It is a key input to the primary ocean production product and a good trace of oceanographic currents, jets, and plumes. The accurate measurement of chlorophyll-a concentration in coastal areas is problematic and affected by an almost unlimited number of substances of anthropogenic and inland origin present in the water (ABDMAP, 2001). These substances affect the spectral radiance along the entire visible range. The main component of coastal waters is usually suspended matter (SM). The latter shifts the spectrum towards longer wavelengths (Hooker *et. al.*, 1980, Bukata *et. al.*, 1983 and Barghava *et. al.*, 1990). Remote sensing can give information about the configuration and composition of water quality about the biophysical parameters of the seas and oceans in which they occur and about the changes over time of these elements.

The new generation ocean color sensors (sea-viewing wide field-of-view sensor (SeaWiFS), moderate resolution imaging spectroradiometer (MODIS), and medium resolution imaging spectrometer (MERIS)) provide daily global monitoring of water quality. Although originally designed to monitor the oceans at moderate spatial resolution (in the order of 1 km), these instruments have the capability (band settings and sensitivity) to deliver surface concentrations of chlorophyll and suspended sediments in coastal waters (Sathyendranath, 2000 and Mann and Lazier, 2006).

Several studies have investigated the water quality in the Red sea (Beltagi, 1984 Bricaud and Morel, 1987, Edwards, 1987 and Okbah *et. al.*, 1999) and the usage of remote sensing for detecting the water quality (Esaias *et. al.*, 1998 and ABDMAP, 2001).

Fahmy (Fahmy, 2003) studied the water quality in the Red Sea coastal waters and found that the levels of suspended solids (as total suspended matter, TSM) and chlorophyll-a (Chl-a) were generally low and showed a homogeneous distribution in coastal Red Sea.

Acker (Acker *et. al.,* 2008) analyzed data from the Moderate Resolution Imaging Spectroradiometer (MODIS) with the Goddard Earth Sciences Data. The data indicated low chlorophyll-a concentrations (0.1–0.2 mg m^{-3}) in this area.

The aim of this study is to monitor and estimate some water quality parameters (Chl-a, TSM and SST) in the surface water of the Red Sea during the period from 1998 to 2008. These followed by comparison the in situ measurements parameters for 2006 by their corresponding satellite images to detect the correlation between both techniques.

2. Study area

Study area is located between Lat. 29° 57' N, Long 34° 53' E, and Lat 23° 10' N, Long 35° 36' E. The area of study includes three regions: Suez, Aqaba Gulves and Red Sea Proper, as shown in Figures 1-a, 1-b and 1-c, respectively.

Names, site code and locations of different stations for the three regions are shown in Tables 1 (a-c). The investigated areas were selected to represent different locations situated under the direct effect of human activities and public resort beaches.

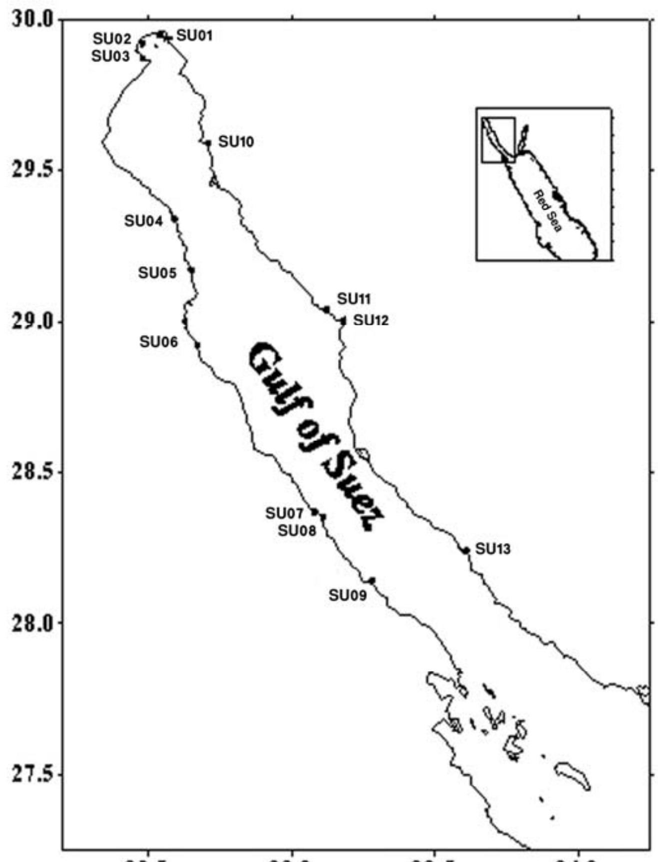


Figure 1-a: Map showing the location of sampling sites for Suez Gulf.

Table 1-a: List of name, site code and position of different sampling locations of Suez Gulf.

Name	Site Code	Latitude			Longitude		
Suez North	SU01	29°	57'	0"	32°	32'	24"
Suez Middle	SU02	29	55	12	32	28	48
Suez South	SU03	29	52	12	32	28	48
Mena Sukhana	SU05-A	29	10	12	32	38	40
Ain Sukhana North	SU05	29	10	12	32	38	60
Ras Gharib City	SU07	28	22	12	33	4	48
Ras Shukheir	SU09	28	8	24	33	16	48
El-Tour	SU13	28	14	24	33	36	36

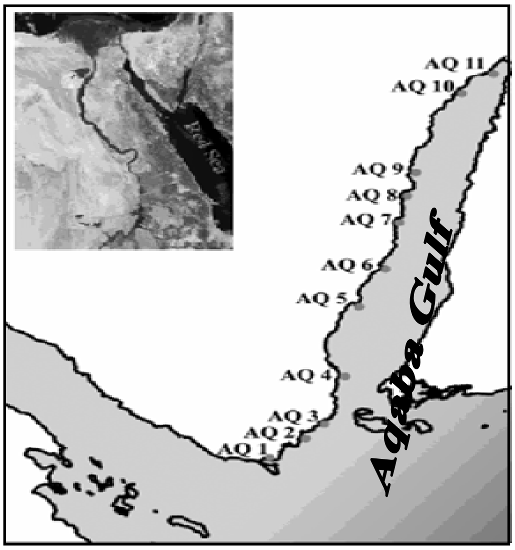


Figure 1-b: Map showing the location of sampling sites for the Aqaba Gulf.

3. Material and methods

Within the framework of the EIMP, fifty six field trips were performed in the period from 1998 to 2008. Thirty nine stations were selected to represent the different conditions of Suez Gulf (13 stations), Aqaba Gulf (11 stations) and Red Sea proper (15 stations). Ein El Sukhna Port (SU5a) was added during the investigation started from year 2003 due to its importance. Chlorophyll-a, total suspended matter and water temperature were investigated.

The concentration of chlorophyll-a was determined by filtering the water samples through 0.45 µm membrane filters, extracting the pigments with 90% acetone and measuring the absorption at the wave lengths 630, 645, 665 and 750 nm. Then the values of chlorophyll-a were calculated using the equation: Chl-a= (Abs 665*11.6-(Abs.645*1.31+Abs 630*0.14))* 10/Volume) (Strickland and Parsons, 1972).

To determine the TSM concentration in the sea water, samples were filtered through pre-weighted 0.45 µm membrane filters and the filters membrane were dried to a constant weight at a fixed temperature (103 - 105 °C). The increase in the filter weight indicates the SM concentration in the water sample (Strickland and Parsons, 1972).

In situ water temperature is measured directly in the field using CTD (YSI-6000).

In this study we used the results of Moderate Resolution Imaging Spectrometer (MODIS) which launched on AQUA satellite in May 2002. It is a passive, imaging spectroradiometer with 36 spectral bands that cover the visible and infrared spectrum. The study area is covered by one MODIS satellite scene acquired at 24 July 2006. The results of MODIS satellite image analyzed by Ayman (Ayman *et. al*, 2007) were compared with those obtained from the field trip at the same period of the EIMP results for the coastal areas of the Red Sea.

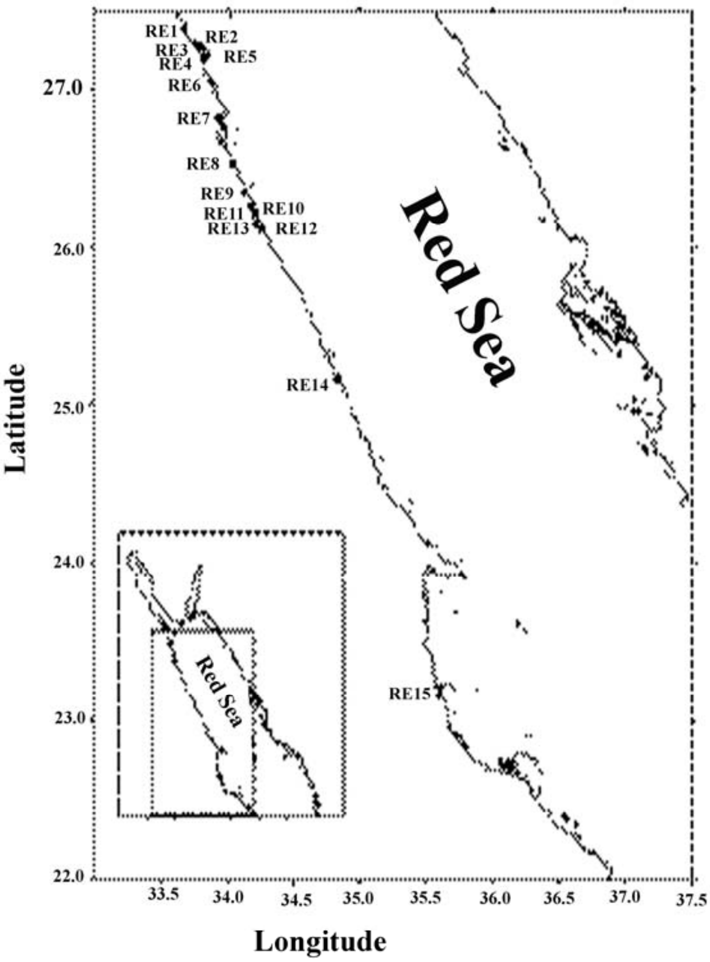


Figure 1-c: Map showing the location of sampling sites for the Egyptian Red Sea side.

4. Results and discussions

Chlorophyll-a, TSM and SST for Suez Gulf from 1998 till 2008, are presented in Figure 2 and Tables 2-a, b and c. The maximum, minimum and average values during the sampling periods are given in Table 3. It is obvious that chlorophyll-a concentrations ranged from 0.07 to 5.23 mg/m^3. The lowest value was recorded in 2001 (station SU08), and the highest one was in 2006 at the station SU03 which was closest station to the Suez port (Figure 2). The high values were also found at stations SU01 (2006), SU02 (2004, 2006 and 2008), SU03 (2004).

Station SU03 has the maximum Chl-a value 5.23 mg/m^3 in 2006. SU03 (Suez–Adabia harbor) has the high chlorophyll-a distributions this is mostly due to the cargo-ships anchored closed to maritime platform (where the samples were taken). The rich supply of nutrient salts discharged with untreated wastewaters into the northern area of Suez Gulf, is essentially responsible for the relative increase in phytoplankton biomass and consequently Chl-a concentrations at these locations. While this station show a low value (0.40 mg/m^3) in 1999. Station SU02 has also high Chl-a value (4.8 mg/m^3) at 2006 and showed low value (0.68 mg/m^3) in 2001.

SU01 (Suez–Kabanoon beach) was affected by the kabanoon drain (slaughter-sewage discharge), situated just north of the beach (the sampling site). Chl-a value in SU01 has 3.5 mg/m^3 at 2006 and showed the lowest value of 0.75 in 2001. The above three stations were recorded a significant decrease in 2007 and 2008 (as shown in the Figure 2 and the Tables 2-a, b and c) except SU02 in 2008 which was 4.8 mg/m^3. Station SU08 has the lowest Chl-a value in 2001. Also Station SU09, Station SU010 has the value of 0.08 mg/m^3 in 2001 and station SU12 has 0.00 mg/m^3 in 2001. These four stations gradually increased in the period during 2002 to 2004.

Table 1-b: List of name, site code and position of different sampling locations of Aqba Gulf.

Name	Site Code	Latitude	Longitude
Sharm El Sheikh Ras Mohamed	AQ01	27° 47' 40	34° 12' 51
Sharm El Sheikh Harbour	AQ02	27 51 23	34 16 50
Sharm El Sheikh Na'ama bay	AQ03	27 54 39	34 19 47
Dahab	AQ05	28 28 39	34 30 44
Nuweiba harbour-El Saiadin	AQ08	28 58 15	34 39 12
Taba	AQ11	29 29 17	34 53 34

Table 1-c: List of name, site code and position of different sampling locations in Red Sea.

Name	Site Code	Latitude			Longitude		
Hurghada-Sheraton	RE04	27	11	37.5	33	50	48.4
Safaga North	RE07	26	47	34.9	33	56	12.6
Safaga Middle	RE08	26	30	20	34	0	20
El Hamarawein	RE10	26	15	9	34	12	5
Quseir North	RE11	26	12	15	34	13	15
Quseir Middle	RE12	26	8	30	34	14	30
Marsa Alam	RE14	25	4	6.1	34	45	0.4
Bir Salatin	RE15	23	9	9.9	35	36	48.3

Table 2-a: Chl-a data for Suez Gulf during the sampling period 1998-2008.

St. / Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
SU01	0.94	0.40	0.98	0.48	0.90	0.62	1.55	0.78	3.51	1.07	0.62
SU02	1.53	1.07	2.03	0.68	0.83	0.94	4.03	1.44	4.80	1.25	4.66
SU03	1.21	1.05	2.61	0.75	1.14	0.88	3.78	0.85	5.23	0.83	2.22
SU04	0.21	0.14	0.21	0.15	0.16	0.21	0.20	0.44	0.87	0.23	0.27
SU05A			0.15				0.33	0.39	0.97	0.30	0.27
SU05	0.22	0.14	0.19	0.12	0.16	0.26	0.46				0.27
SU06	0.24	0.17	0.15	0.14	0.21	0.12	0.21				0.22
SU07	0.22	0.19	0.21	0.16	0.23	0.15	1.32	0.64	2.60	1.83	0.95
SU08	1.04	0.13	0.23	0.07	0.14	0.10	0.43				0.20
SU09	0.37	0.23	0.49	0.24	0.30	0.23	1.47	0.29	0.94	0.43	0.17
SU10	0.22	0.15	0.12	0.08	0.27	0.10	0.25				0.15
SU11	0.65	0.16	0.09	0.08	0.13	0.13	0.21				0.19
SU12	0.25	0.10	0.14	0.09	0.17	0.10	0.25				0.17
SU13		0.14	0.15	0.12	0.23	0.14	0.39	0.44	0.75	0.25	0.20

Table 2-b: TSM data for Suez Gulf during the sampling period 1998-2008.

St. / Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
SU01	13.01	14.94	12.26	11.62	12.53	14.98	22.06	27.56	17.65	28.59	34.90
SU02	14.36	13.94	15.01	11.33	11.51	18.05	19.25	27.14	19.71	25.49	38.56
SU03	13.43	18.44	13.72	13.03	15.63	14.63	20.84	25.31	18.21	27.63	34.55
SU04	6.16	6.85	5.73	5.59	6.17	8.83	8.10	10.18	8.89	9.17	23.27
SU05A			6.67				7.52	8.68	9.10	8.79	20.59
SU05	5.40	7.48	6.16	5.98	5.66	8.50	8.37				19.55
SU06	7.82	7.19	6.67	6.87	5.30	8.41	8.69				18.73
SU07	9.86	5.29	15.56	5.10	6.79	7.16	8.93	12.99	9.79	8.18	20.72
SU08	6.66	5.05	5.83	5.43	5.34	7.19	8.17				21.71
SU09	11.61	6.47	7.47	7.06	6.60	6.82	8.19	12.28	12.49	7.78	21.09
SU10	9.25	4.84	6.94	5.05	11.09	6.51	9.22				20.39
SU11	7.74	5.60	5.03	5.35	6.07	6.35	7.99				19.34
SU12	9.69	5.76	9.44	5.31	6.84	7.04	10.98				19.02
SU13		7.32	6.71	5.47	8.26	6.77	7.40	12.11	9.47	9.36	20.42

Table 2-c: SST data for Suez Gulf during the sampling period 1998-2008.

St. / Year	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
SU01	22.96	23.22	23.48	22.80	22.57	21.53	23.63	26.49	23.60	27.94	25.50
SU02	22.97	23.56	23.68	22.92	22.93	22.23	23.74	26.48	23.36	28.37	25.48
SU03	23.58	24.03	23.99	23.74	23.31	22.38	24.06	25.90	23.01	27.81	25.49
SU04	23.66	24.72	23.97	24.10	23.62	22.61	23.67	26.59	23.47	28.24	25.93
SU05A			23.92				24.44	26.24	22.91	28.12	26.35
SU05	23.73	24.89	24.32	24.40	23.80	22.52	24.84				26.75
SU06	23.67	24.79	24.14	24.12	23.72	22.79	24.14				26.68
SU07	24.17	23.13	23.66	23.20	23.25	22.30	23.69	24.64	22.86	27.73	24.89
SU08	23.79	23.15	23.69	23.23	23.02	22.35	24.08				24.66
SU09	20.17	22.99	23.73	23.35	23.33	22.45	24.02	25.29	23.07	26.40	25.62
SU10	22.99	22.85	23.31	22.25	23.32	21.22	23.20				26.49
SU11	23.53	23.07	23.32	22.85	22.90	21.50	23.78				25.76
SU12	24.22	23.29	23.34	22.64	22.95	21.69	24.17				25.69
SU13		25.86	24.28	23.93	24.00	22.57	24.92	25.62	24.12	27.20	25.06

TSM varied between 4.8 and 38.6 mg/l (Table 2-b). The lowest value was recorded in 2008 at station SU02, in addition, stations SU01 and SU03 recorded 34.9 and 34.6 mg/l respectively (Figure 2), this is the area in the northern side which is characterized by the relative increasing in TSM, due to the rich supply of nutrient salts discharged with untreated wastewaters to this area.

Also, stations SU07 and SU08 have the next maximum values between 20.8 and 21.8 mg/l respectively, because station SU07 (Ras Gharib – City), was accompanied with obvious sources of sewage disposal materials. And, station SU08 (Safaga – Harbor) which may be affected by the petroleum harbor company. The lowest TSM (4.8 mg/l) was found in 1999 at station SU10, but the same station recorded 20.4 mg/l in 2008 (Table 2).

Total suspended matter showed increase from 1998 to 2008 except in 2006. These findings show the consequent increase in the concentrations of TSM in this area with time.

The lowest SST was measured in 1998 (20.2 °C) station SU09 and the highest (28.4 °C) in 2007 at station SU02, as shown in Figure 2. The next maximum values between 28.2 and 28.1 and 27.2 °C were detected at stations SU04 (2007), SU05A (2007) and SU13 (2007) respectively.

Figure 3 represents Chl-a, TSM and SST in the Gulf of Aqaba. Because Aqaba Gulf has many protectorate areas along its coast (AQ1, AQ4, AQ6, AQ7 and AQ10), the values of investigated TSM were very low except in 2008. In Taba (AQ11), the beach of Sunesta Hotel (AQ2) (Sharm El-Sheikh – Marina Sharm), the increase in boats numbers (more than 100 boats anchored in the area), in addition to security system for collecting the sewage wastes of boats working by 50% of its capacity, may be the reasons of high Chl-a concentrations. The highest SST was measured in 2007 (28.2°C) station AQ2, as shown in Figure 3.

Figure 4 shows Chl-a, TSM and SST distributions in the Red Sea according to the MODIS satellite analysis results (Ayman *et. al.*, 2007).

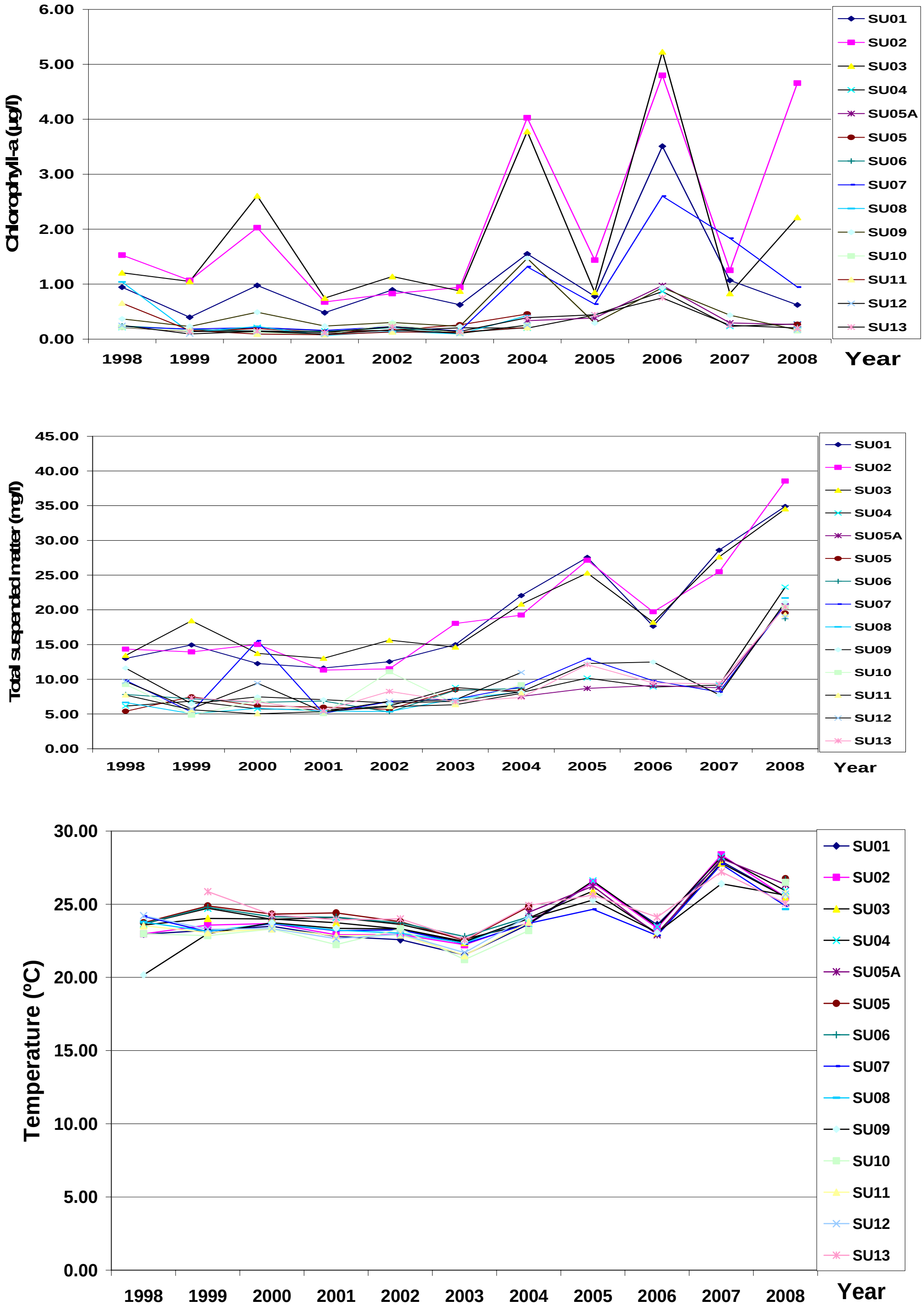


Figure 2: Concentration of chlorophyll-a, total suspended matter and water temperature in the Suez Gulf

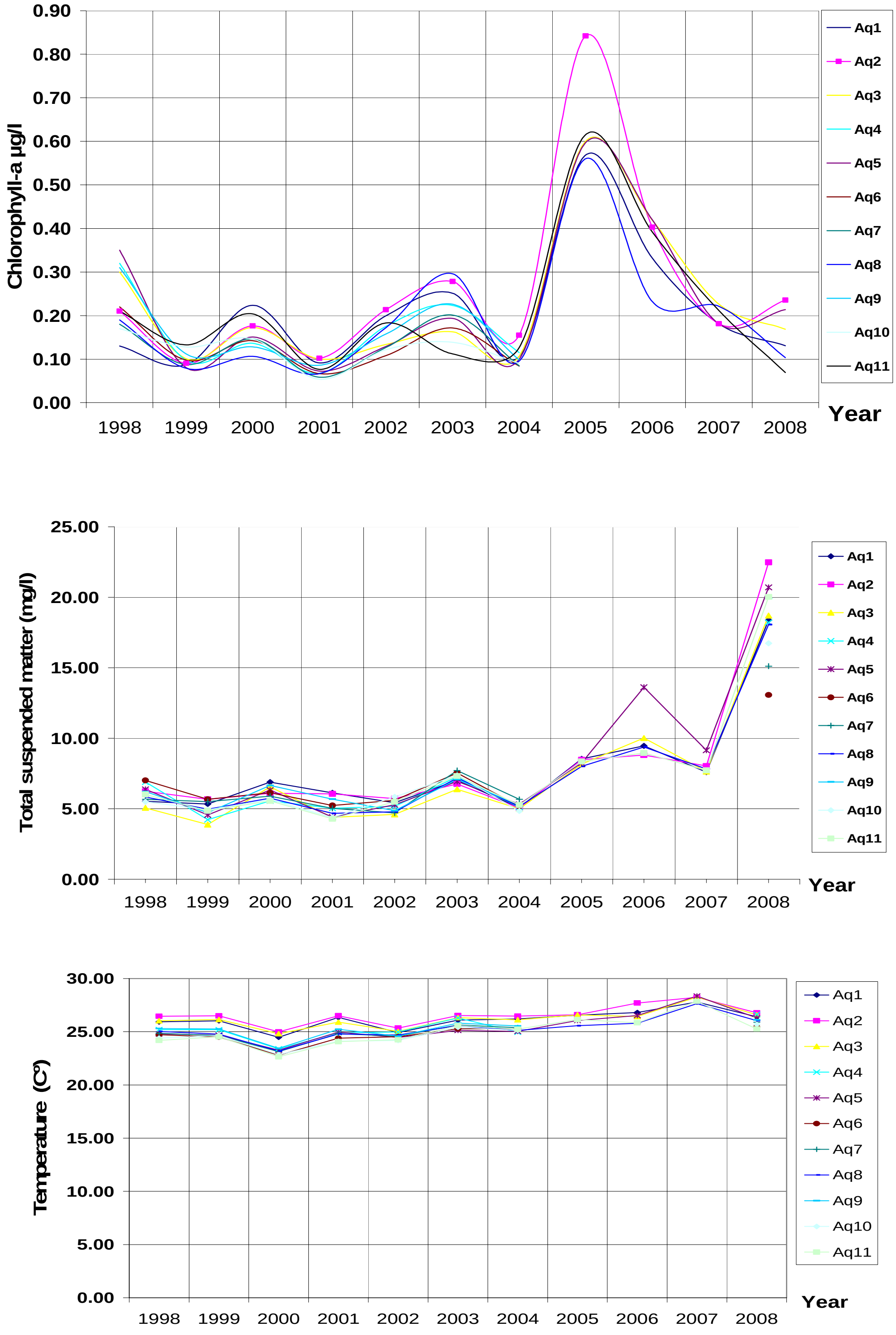
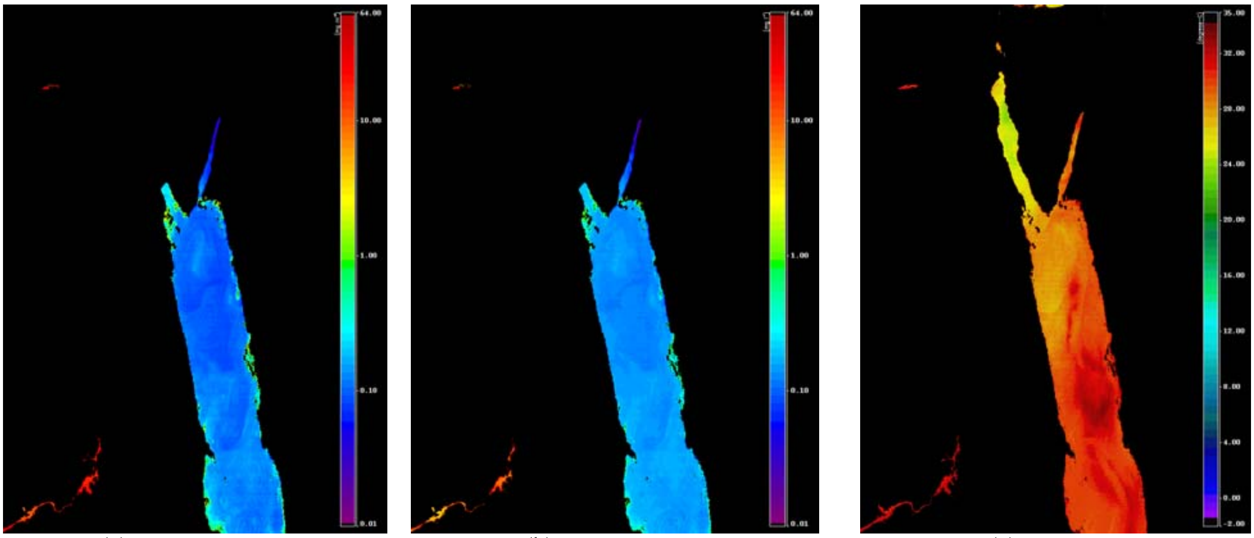


Figure 3: Concentration of chlorophyll-a, total suspended matter and water temperature in the Aqaba Gulf.



(a) (b) (c)

Figure 4: Concentrations of Chlorophyll-a (a), distributions of total suspended matter (b) and sea surface water temperature distribution (c) in the Red Sea at 24 July 2006

Table 4-a shows that, along the Red Sea coast, the values of detected Chl-a and TSM concentrations were very low except at RE04 Hurghada (Chl-a = 0.49 µg/l), this station was affected by the increase of tourists/visitors numbers in addition to the marine sports activities (swimming, snorkeling, diving ……..). In Safaga at RE08 (Phosphate Co.) TSM had the highest value 5.04 mg/l, this station may be affected by Safaga Harbor's activity situated just north of sampling area.

Table 3: The maximum, minimum and average values of chl-a, TSM and SST for Suez Gulf during the sampling period 1998-2008.

		1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Chl-a	**Max.**	1.53	1.07	2.61	0.75	1.14	0.94	4.03	1.44	**5.23**	1.83	4.66
	Min.	0.21	0.10	0.09	**0.07**	0.13	0.10	0.20	0.29	0.75	0.23	0.15
	Av.	*0.59*	*0.31*	*0.55*	*0.24*	*0.37*	*0.31*	*1.06*	*0.66*	*2.46*	*0.78*	*0.75*
TSM	**Max.**	14.4	18.4	15.6	13.0	15.6	18.0	22.1	27.6	19.7	28.6	**38.6**
	Min.	5.4	**4.8**	5.0	5.0	5.3	6.3	7.4	8.7	8.9	7.8	18.7
	Av.	*9.6*	*8.4*	*8.8*	*7.2*	*8.3*	*9.3*	*11.1*	*17.0*	*13.2*	*15.6*	*23.8*
T °C	**Max.**	24.2	25.9	24.3	24.4	24.0	22.8	24.9	26.6	24.1	**28.4**	26.7
	Min.	**20.2**	22.8	23.3	22.2	22.6	21.2	23.2	24.6	22.9	26.4	24.7
	Av.	*23.3*	*23.8*	*23.8*	*23.3*	*23.3*	*22.2*	*24.0*	*25.9*	*23.3*	*27.7*	*25.7*

Table 4-a: The in situ measurements values for the studied parameters in Red Sea in July 2006.

Name	**Site Code**	**Latitude**		**Longitude**		**Chl-a (µg/l)**	**TSM (mg/l)**	**T (ºC)**
Hurghada-Sheraton	RE04	27º	11′	33º	50′	0.49	4.39	27.06
Safaga North	RE07	26º	47′	33º	56′	0.18	4.56	27.18
Safaga Middle	RE08	26º	30′	34º	0′	0.09	5.04	27.24
El Hamarawein	RE10	26º	15′	34º	12′	0.13	4.84	27.35
Quseir North	RE11	26º	12′	34º	13′	0.19	4.69	27.51
Quseir Middle	RE12	26º	8′	34º	14′	0.12	4.57	28.25
Marsa Alam	RE14	25º	4′	34º	45′	0.15	4.06	28.94
Bir Salatin	RE15	23º	9′	35º	36′	0.18	4.29	29.47

Table (4-b): MODIS derived values for the same studied parameters in the Red Sea in the same time (July 2006).

Name	Site Code	Latitude		Longitude		Chl-a (µg/l)	TSM (mg/l)	T (ºC)
Hurghada-Sheraton	RE04	27º	11′	33º	50′	0.54	0.39	28.33
Safaga North	RE07	26º	47′	33º	56′	0.32	0.24	28.60
Safaga Middle	RE08	26º	30′	34º	0′	0.09	0.14	28.69
El Hamarawein	RE10	26º	15′	34º	12′	0.09	0.15	28.80
Quseir North	RE11	26º	12′	34º	13′	0.08	0.14	28.90
Quseir Middle	RE12	26º	8′	34º	14′	0.13	0.15	29.92
Marsa Alam	RE14	25º	4′	34º	45′	0.15	0.13	30.30
Bir Salatin	RE15	23º	9′	35º	36′	0.16	0.22	33.00

Tables 4-a and 4-b represent the water quality parameters the *in situ* measurements and values derived from MODIS respectively. After exploring the individual results, the range and the form were vary per parameter.

1- For the first parameter Chl-a, to verify and validate the implementation and to see if it performs well, a comparison between the *in situ* measurements and the MODIS derived values was carried out and depicted in figure 5. One can see a reasonable agreement between them with no significant differences. The correlation between *in situ* measurements and the MODIS derived values was 86.38% (R^2= 0.7462), as shown in Figure 5. It is acceptable result.

2- For the second parameter TSM, Figure 6 shows that the range of the MODIS, TSM distributions is underestimated (0.13 to 0.39 mg l-1). Although the *in situ* measured values are relatively higher than the retrieved MODIS, we can make a special model in the future to achieve good correlation. From Figure 6 the correlation was not so good.

3- For the last parameter SST, Figure 7 depicts a very well correlation and almost identical pattern. The accuracy of derived SST, assessed by comparing MODIS results against in situ measurements, it is less than 1°C, which is acceptable. The correlation between *in situ* measurements and the MODIS derived values was 67.54% (R^2= 0.4561), as shown in Figure 7.

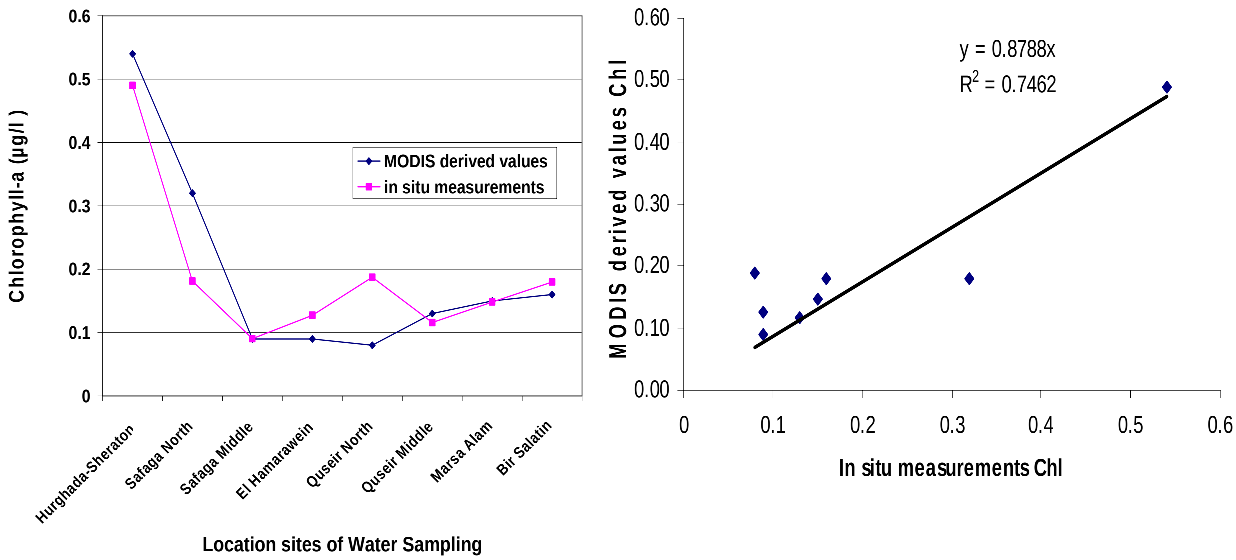


Figure 5: Relationship between MODIS derived Chl-a and the in situ measurements values

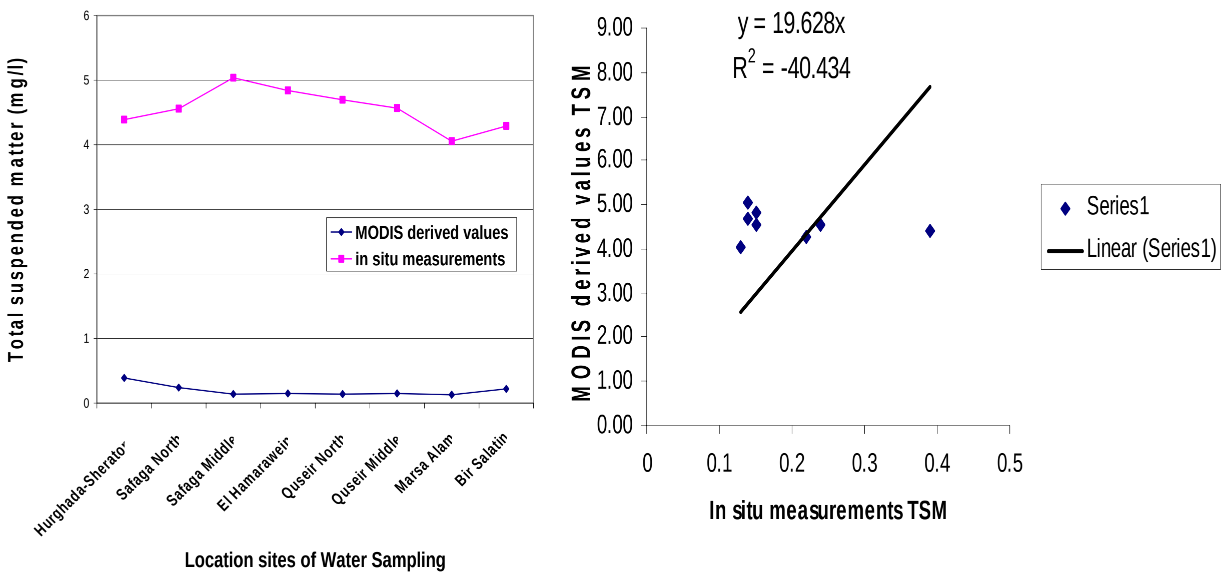


Figure 6: Relationship between TSM retrieved from MODIS and the in situ measurements values.

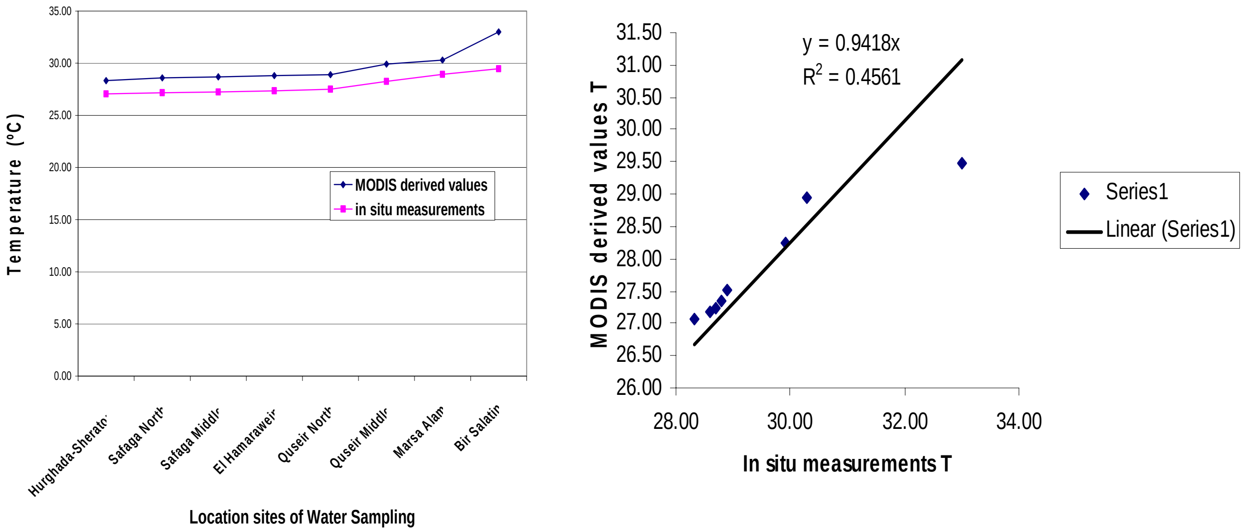


Figure 7: Relationship between MODIS derived SST versus the in measurements values.

5. Conclusion

Chlorophyll-a concentration in the coastal waters of Gulf of Suez showed increased values at different sites on the stations around the urban areas of Suez City (SU03) in comparison to the rest of the Gulf. The high levels of autotrophic biomass recorded in the upper part of Gulf of Suez may be explained by wastewater discharged to the area, providing nutrients favorable for the growth of phytoplankton.

The level of TSM in the Gulf of Suez is relatively high as compared with those which found in the Red Sea proper and Gulf of Aqaba Regions. The high values were usually recorded at stations (SU03, SU06 and SU09). The difference in TSM between the Red Sea proper and Gulf of Aqaba Regions was not pronounced.

The Chl-a and temperature values are presented within a realistic range with MODIS results. The correlation between *in situ* measurements and the MODIS derived values were 86.38% and 67.54%

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دراسة وتقييم نوعية المياه باستخدام القياسات الحقلية و بيانات الأقمار الصناعية بالبحر الأحمر ـ مصر

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المعهد القومى لعلوم البحار والمصايد ـ فرع الإسكندرية

اعتمدت هذه الدراسة على القياسات الحقلية التي تمت فى الفترة من 1998 حتى 2008 (برنامج الرصد البيئي) لمناطق خليج السويس وخليج العقبة و الساحل المصري للبحر الأحمر و ذلك للمتغيرات الآتية : - تركيز الكلورفيل (Chl-a) و المواد الصلبة العالقة (TSM) و درجات الحرارة السطحية. (SST) و كذلك تم عمل مقارنة للنتائج بين القياسات الحقلية لنفس المتغيرات لرحلة يوليو 2006 مع صور أقمار صناعية للقمر الصناعي (MODIS) لنفس المنطقة فى نفس التاريخ.

و قد أظهرت النتائج ارتفاع قيم الكلورفيل و المواد العالقة فى خليج السويس و خاصة عند ميناء الأدبية و شاطئ الكابنون و منطقة الشاليهات و قد بلغت ذروته عام 2006 و تناقص تدريجيا عامي 2007 ،2008.

أما بالنسبة خليج العقبة فبسبب وجود العديد من المحميات الطبيعية على طول شاطئه مما جعل قيم الكلورفيل و المواد العالقة تكون فى أدنى مستوياتها باستثناء عام 2008 فى منطقتي شاطئ فندق سونستا (طابا) و مارينا شرم (شرم الشيخ) و ذلك نظرا لوجود عدة أنشطة بحرية (يخوت و مراكب و سباحة و غطس ....).

أظهرت المقارنة التي أجريت بين القياسات الأرضية و صور الأقمار الصناعية على الساحل المصري للبحر الأحمر أن معامل التوافق بين كلا القياسين قد جاء كالتالي بالنسبة للكلورفيل86 % و درجات الحرارة 67 % و هذا يدلل على إمكانية التعامل مع هذين المتغيرين من خلال صور الأقمار الصناعية لارتفا معامل التوافق.