Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 25(2): 75 – 88 (2021)
www.ejabf.journals.ekb.eg

Fluctuations of some physico-chemical parameters with depth in the Egyptian Mediterranean waters off Alexandria during winter 2016

Dalia Salem *, Mohamed Ibrahim , Laila Mohamed , Hoda Hemaida, Essam El-shorbagi

National Institute of Oceanography and Fisheries, NIOF, Egypt.
*Corresponding author: prof_dalia@yahoo.com

ARTICLE INFO

Article History:
Received: Nov. 5, 2021
Accepted: March 18, 2021
Online: March 21, 2021

Keywords:
Hydrographical parameters;
Mediterranean coast;
Alexandria city;
Seawater;

ABSTRACT

The current study presented a deep insight on water quality assessment of the Mediterranean Sea off Alexandria coast based on the data of the following hydrographical parameters; pH, salinity, dissolved oxygen (DO), oxidizable organic matter (OOM), and total alkalinity (T. Alk.) in nine sectors (Sidi-Krier, El-Mex, El-Dekhaila, Eastern Harbour, El-Shatby, San-Stefano, El-Montazah, Abu-Qir Bay Head and Abu-Qir Bay) represented by 41 stations along the Egyptian Mediterranean coast off Alexandria city during winter 2016. The overall averages of the hydrographical parameters at the surface and various seawater depths (10–200 m) revealed that the pH levels varied from 8.07 to 8.16, salinity values reflected the range of 38.00-38.66 PSU which is consistent with the Mediterranean water salinity (38.50 PSU). The overall average of the DO showed the range of 4.48-6.60 ml/L. In the meantime, the OOM and T. Alk. demonstrated the ranges of (1.02-2.37 mgO_2/L) and (2.87-3.16 mmol/L), respectively. Not many variations in the pH values with depths were observed. Also, the variations in the other parameters were minimal. The Principal Components Analysis (PCA) showed a good correlation between the pH and each of salinity as well as T. Alk. which is consistent with the reported data for the Mediterranean water.

INTRODUCTION

The quality of aquatic ecosystem is of a great interest to the entire world. Scientific interest in the quality of marine ecosystems is quite recent and has especially increased in the past 15 years in coinciding with application of the European Union (EU)'s Water Framework Directive (WFD) (**European Commission, 2000**). One of the main objectives of the WFD is achievement and preservation of "Good Chemical Status" of surface waters of the EU member states. Chemical analyses of water provide a good indication of the aquatic systems, but do not integrate ecological factors such as altered riparian vegetation or altered flow regime, and therefore, do not necessarily reflect the ecological state of the system (**Karr *et al.*, 2000**). The aquatic ecosystems are affected by some stressors that extensively deplete biodiversity. The loss of biodiversity and its

effects are predicted to be greater for aquatic ecosystems than for terrestrial ecosystems (**Sala *et al.*, 2000**). Physico-chemical parameters are responsible for the spatio-temporal variations of all aquatic organisms. The investigations of meteorological and hydrographical features are essential to assess the fertility and productivity of any ecosystem (**Rajasegar, 2003**).

The Egyptian Mediterranean coast extends from Rafah in the east to El-Sallum in the west for over 1200 km. The coastal areas are suffered from increasing pollution rates resulting from the rapid rates of population growth, agricultural and urban development. Therefore, excessive pollutant loads enter directly or indirectly into the coastal waters.

Alexandria city is locating at the western part of the Egyptian Mediterranean coast. It is the second largest city, a very important maritime port, as well as one of the main summer resorts in Egypt. The city is also one of the most important industrial centers, contains about 100 large factories and 260 smaller ones (**Abd-alla, 1993**) to cover ~ 40% of the nation's industry. Along the Mediterranean coast of Alexandria city, there are many areas with high activities of shipping and pleasure boating, incorporating numerous harbors and marina (**Shreadah *et al*., 2013**).

Several researchers have studied the physical and chemical characteristics of seawaters along the Egyptian Mediterranean coast to ascertain the water quality and productivity (**Fathy *et al*., 2012; Emam *et al*., 2013; Shaltout and Abd El-Khalek, 2014; Shreadah *et al*., 2016; El-Naggar *et al*., 2019**). To the best of our knowledge, there are no published studies concerned with studying the variation of the hydrographical parameters at surface and different seawater depths along the whole coast of Alexandria city to include nine sectors affected by different environmental stressors.

In this context, the aim of the present study was set to assess the water quality of Egyptian Mediterranean coast off Alexandria city from Sidi-Krir to Abu-Qir Bay during winter 2016. The work was achieved by collecting inshore and offshore seawater samples of surface and different depths (10–200 m), for studying the following hydrographical parameters; pH, salinity, dissolved oxygen (DO), oxidizable organic matter (OOM) and total alkalinity (T. Alk.).

MATERIALS AND METHODS

1. Study area

The locations under investigation were distributed along the Egyptian Mediterranean coast covering the whole coast of Alexandria city corresponding to different environmental situations. Nine sectors were selected representing fishing and shipping activities; oil transport sites in addition to sites affected by urban and industrial activities (Fig. 1, Table 1). Surfer program (version 10) was used to draw the map of sampling and allocate the stations along the area of study.

2. Sampling

Seawater samples at surface and different depths from the nine sectors represented by 41 stations were collected during winter 2016. In the field, all stations were positioned

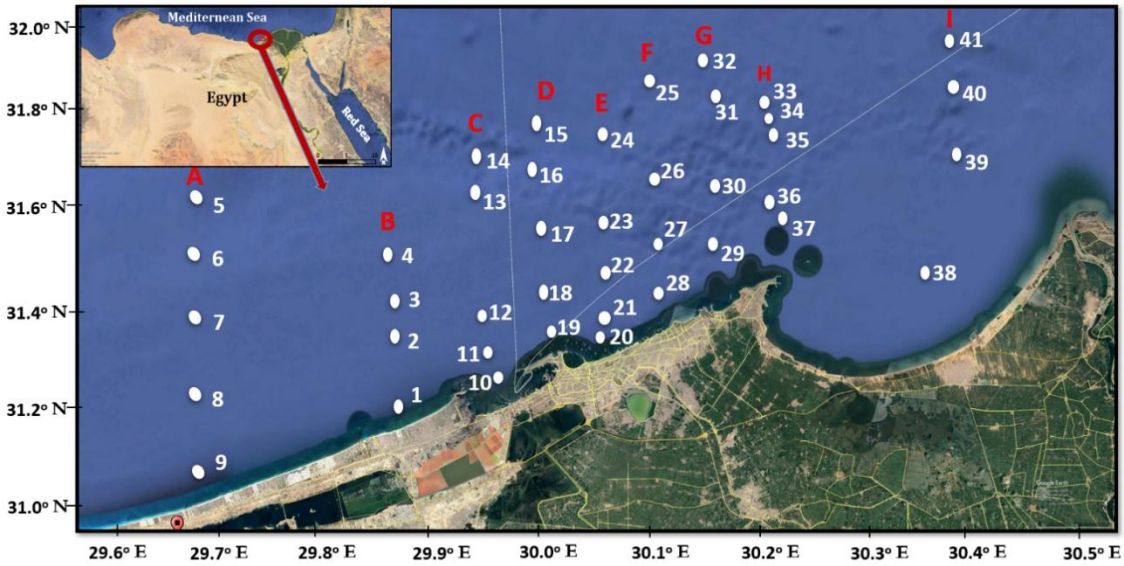


Fig. 1. Sampling locations along Mediterranean coast, off Alexandria, Egypt, during winter 2016. A: Sidi-Krir (stations 5–9); B: El-Mex (stations 1–4); C: Dekhaila (stations 10–14); D: Eastern Harbour (stations 15–19); E: El-Shatby (stations 20–24); F: San-Stefano (stations 25–28); G: El-Montazah (stations 29–32); H: Abu-Qir Bay Head (stations 33–37) and I: Abu-Qir Bay (stations 38–41).

Table 1. Description of the sampling locations.

Sector	Name	Coordination	Description	Source of impact
A	Sidi-Krir	31.125 N 29.658 E	Oil transport site (Mediterranean pipeline)	Direct impacts from the power station, petroleum pipe company (SUMED) and some tourist villages.
B	El-Mex	31.146 N 29.775 E	Industrial zone	Uncontrolled disposal of a huge amount of agricultural, industrial and sewage wastes from the nearest Lake; Mariut through El-Umoum drain.
C	El-Dekhaila	31.181 N 29.830 E	Commercial harbour	Wastewaters from El-Mex Bay through El-Umoum drain.
D	Eastern Harbour	31.221 N 29.875 E	Shallow semi-enclosed basin	Anthropogenic effects from human activities including fishing, yacht sport, land-based effluents and boats building.
E	El-Shatby	31.221 N 29.925 E	Swimming and recreational area	Anthropogenic impact from the local residents.
F	San-Stefano	31.263 N 29.975 E		
G	El-Montazah	31.319 N 30.030 E		
H	Abu-Qir Bay Head	31.350 N 30.075 E	Shallow semi-circular basin	Anthropogenic impact from shipping, commercial fishing, swimming and recreational boating.
I	Abu-Qir Bay	31.350 N 30.200 E		

using the Global Positioning System (GPS). The water samples were collected at different depths ranged from Surface to 200 m depth using five liters Niskin's plastic bottle. The pH and salinity parameters were measured *in situ* using CTD apparatus (Model: YSI 556). On the other hand, DO was analyzed according to the modified

Winkler method (**Grasshoff, 1976**) , OOM according to FAO method (**FAO, 1976**). T. Alk. was determined by titration against HCl using methyl orange as indicator (**Strickland and Parsons, 1972**).

3. Data Analysis

The statistical analysis was applied on the data set obtained to understand aspects of the chemical and physical processes prevailing in the present study. The data inputs including the physical and chemical variables which treated by factor analysis using the Principal Components Analysis (PCA). The PCA was made by IBM SPSS statistics version 22 computer package.

RESULTS AND DISCUSSION

Physico-chemical characteristics of seawater are shown in Table 2, Tables S1,S2 (Supplementary data), Fig. 2(a–f), and Fig. 3. The variations in the hydrographical parameters; pH, salinity, DO, OOM and T. Alk. of seawater samples off Alexandria coast with stations' depths, were recorded during winter 2016. It was noteworthy that, the hydrographical parameters' values for most of the stations at surfaces and different depths were of close proximity. Subsequently, the recorded and analyzed parameters were expressed as average values in order to minimize the number of the observed readings and to facilitate understanding the general trend within each sector as well as to gain overview for the water quality of the Mediterranean along Alexandria coast. Therefore, the term "average value" for each parameter represents the average of the values at each depth (surface, 10 m, 20 m, 50 m, 100 m or 200 m) for all stations in each sector, separately. However, each sector was represented by "an overall average value" for each hydrographical parameter which is the average for the values of the different depths in the sector.

1. Hydrographical parameters

Hydrogen ion concentration (pH) values play an important role in many marine life processes. It may reflect the redox potential, productivity, and pollution level of the aquatic environments. The surface seawater pH distribution of the present study is represented in Table 2 and Fig. 2a. The pH average values varied between a minimum of 7.97 at El-Mex sector and a maximum of 8.16 recorded at El-Montazah and Abu-Qir Bay Head sectors, while the rest of surface seawaters revealed a pH range of 8.09-8.15. The pH average value at El-Mex sector was the lowest one (7.97) as compared to the other sectors. This possibly due to the raining weather before the sampling period and the effect of the discharge of wastewater loaded with domestic agricultural and industrial wastes (**Shreadah *et al.*, 2016**). The maximum pH average one (8.16) as at El-Montazah and Abu-Qir Bay Head sectors may be attributed to the daily photosynthetic activity of phytoplanktons (**Das *et al.*, 1997**) which removes the carbon dioxide dissolved in water column thereby increases the pH level. As going far from the shore, no variation in the pH average values were recorded (Table 2, Fig. 2"b–f"). The overall pH average values

ranged from a minimum value 8.07 at El-Mex sector to a maximum value 8.16 at El-Montazah and Abu-Qir Bay Head sectors (Table 2, Fig. 3). In general, the pH range of the seawater in the present study was found on the slight alkaline side and lower than that of the open seawater due to geographical position (**Shreadah *et al*., 2016**).

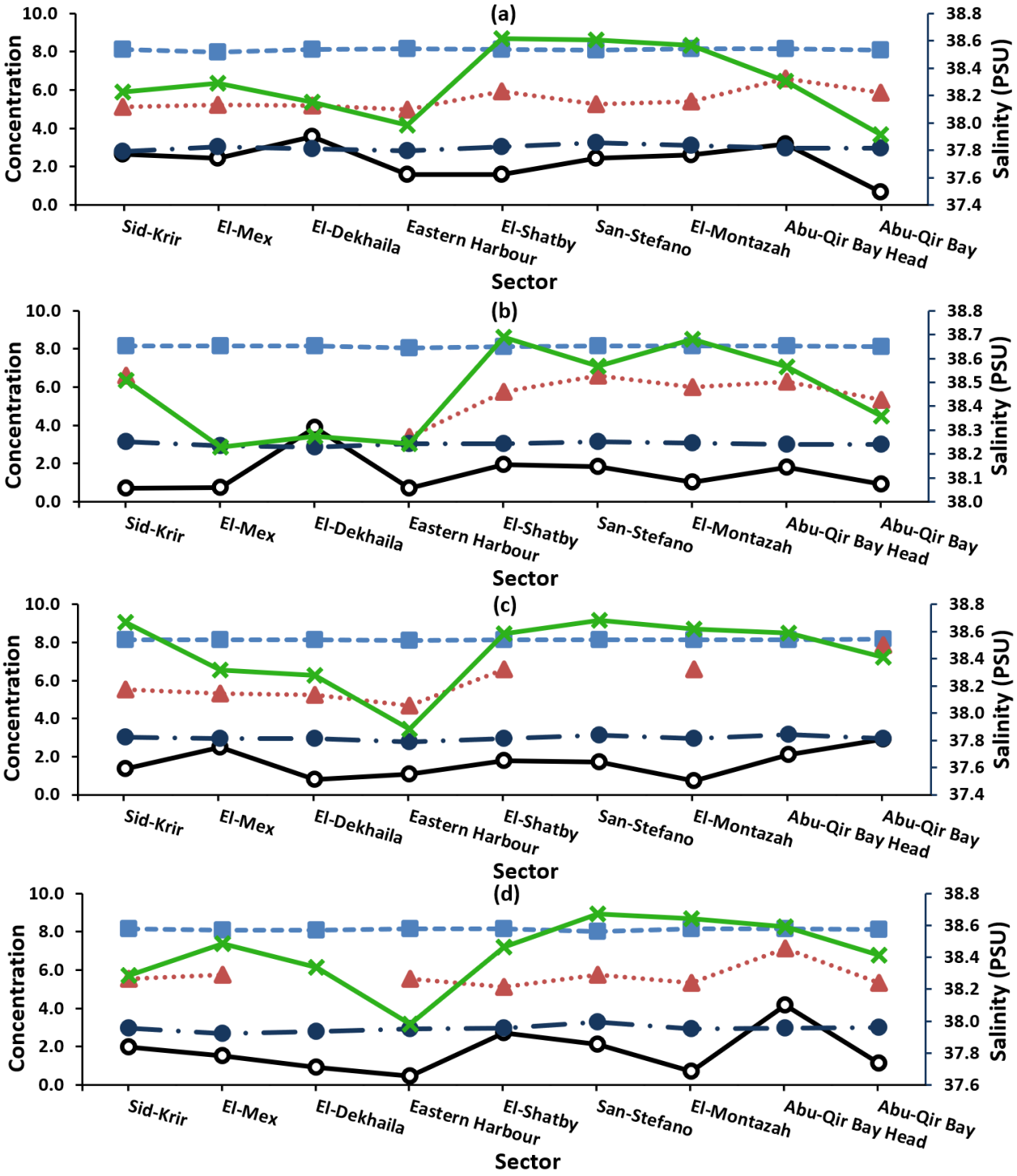
Table 2. The surface and different depth variations of the averages for each of pH, Salinity, DO, OOM and T. Alk. as well as their overall averages in the studied sectors.

Sector	pH Av. value						Overall Av. value	Salinity Av. value (PSU)						Overall Av. value
	S	10m	20m	50m	100m	200m		S	10m	20m	50m	100m	200m	
Sidi-Krir	8.14	8.15	8.15	8.16	8.06	NR	8.13	38.23	38.51	38.67	38.29	38.87	NR	38.51
El-Mex	7.97	8.14	8.15	8.08	8.01	NR	8.07	38.29	38.23	38.32	38.49	38.11	NR	38.29
El-Dekhaila	8.12	8.15	8.13	8.08	8.05	8.14	8.11	38.15	38.27	38.28	38.34	38.72	38.72	38.41
Eastern Harbour	8.15	8.07	8.09	8.14	8.14	8.15	8.12	37.98	38.24	37.88	37.98	37.99	37.95	38.00
El-Shatby	8.13	8.13	8.15	8.14	8.16	8.18	8.15	38.61	38.69	38.59	38.46	38.76	38.87	38.66
San-Stefano	8.10	8.17	8.16	8.00	8.09	8.13	8.11	38.61	38.57	38.68	38.67	38.68	38.49	38.62
El-Montazah	8.16	8.18	8.15	8.16	8.18	8.17	8.16	38.57	38.68	38.62	38.64	38.65	38.57	38.62
Abu-Qir Bay Head	8.16	8.16	8.15	8.16	8.18	8.15	8.16	38.30	38.56	38.59	38.59	38.64	38.87	38.59
Abu-Qir Bay	8.09	8.13	8.16	8.12	8.12	NR	8.12	37.92	38.36	38.41	38.42	38.34	NR	38.29

Sector	DO Av. value (ml/L)						Overall Av. value	OOM Av. value (mgO_2/L)						Overall Av. value
	S	10m	20m	50m	100m	200m		S	10m	20m	50m	100m	200m	
Sidi-Krir	5.11	5.53	6.60	5.53	5.11	NR	5.58	2.66	1.38	0.71	1.98	4.56	NR	2.26
El-Mex	5.23	5.32	NR	5.75	NR	5.32	5.41	2.43	2.49	0.76	1.52	0.53	NR	1.55
El-Dekhaila	5.19	5.25	NR	NR	5.11	4.89	5.11	3.56	0.79	3.90	0.91	0.76	NR	1.98
Eastern Harbour	4.98	4.68	3.40	5.53	2.98	5.32	4.48	1.58	1.06	0.72	0.46	0.46	1.82	1.02
El-Shatby	5.92	6.60	5.75	5.11	5.53	5.11	5.67	1.58	1.79	1.94	2.74	2.05	2.58	2.11
San-Stefano	5.27	ND	6.60	5.75	5.32	6.81	5.95	2.43	1.72	1.82	2.13	2.74	1.37	2.04
El-Montazah	5.40	6.60	6.01	5.32	5.85	NR	5.84	2.62	0.72	1.03	0.71	4.03	0.30	1.57
Abu-Qir Bay Head	6.62	ND	6.28	7.13	6.38	NR	6.60	3.19	2.10	1.79	4.15	2.05	0.91	2.37
Abu-Qir Bay	5.85	7.87	5.32	5.32	5.64	5.75	5.96	0.68	2.93	0.91	1.14	0.91	NR	1.31

Sector	T. Alk. Av. value (mmol/L)						Overall Av. value
	S	10m	20m	50m	100m	200m	
Sidi-Krir	2.78	3.15	3.02	2.95	3.30	NR	3.04
El-Mex	3.03	2.92	2.96	2.70	2.98	NR	2.92
El-Dekhaila	2.94	2.87	2.95	2.78	2.83	3.25	2.94
Eastern Harbour	2.84	3.03	2.76	2.92	2.90	2.80	2.87
El-Shatby	3.04	3.04	2.94	2.98	3.10	3.10	3.03
San-Stefano	3.25	3.15	3.11	3.28	3.10	3.05	3.16
El-Montazah	3.11	3.06	2.95	2.92	3.03	3.00	3.01
Abu-Qir Bay Head	2.96	3.01	3.15	2.97	3.05	3.10	3.04
Abu-Qir Bay	2.95	2.99	2.95	3.00	2.95	NR	2.97

Av.: Average; S: Surface; m: meter; NR: not recorded.


(a)
Concentration
Salinity (PSU)
Sid-Krir
El-Mex
El-Dekhaila
Eastern Harbour
El-Shatby
San-Stefano
El-Montazah
Abu-Qir Bay Head
Abu-Qir Bay
Sector
(b)
Concentration
Salinity (PSU)
Sid-Krir
El-Mex
El-Dekhaila
Eastern Harbour
El-Shatby
San-Stefano
El-Montazah
Abu-Qir Bay Head
Abu-Qir Bay
Sector
(c)
Concentration
Salinity (PSU)
Sid-Krir
El-Mex
El-Dekhaila
Eastern Harbour
El-Shatby
San-Stefano
El-Montazah
Abu-Qir Bay Head
Abu-Qir Bay
Sector
(d)
Concentration
Salinity (PSU)
Sid-Krir
El-Mex
El-Dekhaila
Eastern Harbour
El-Shatby
San-Stefano
El-Montazah
Abu-Qir Bay Head
Abu-Qir Bay
Sector

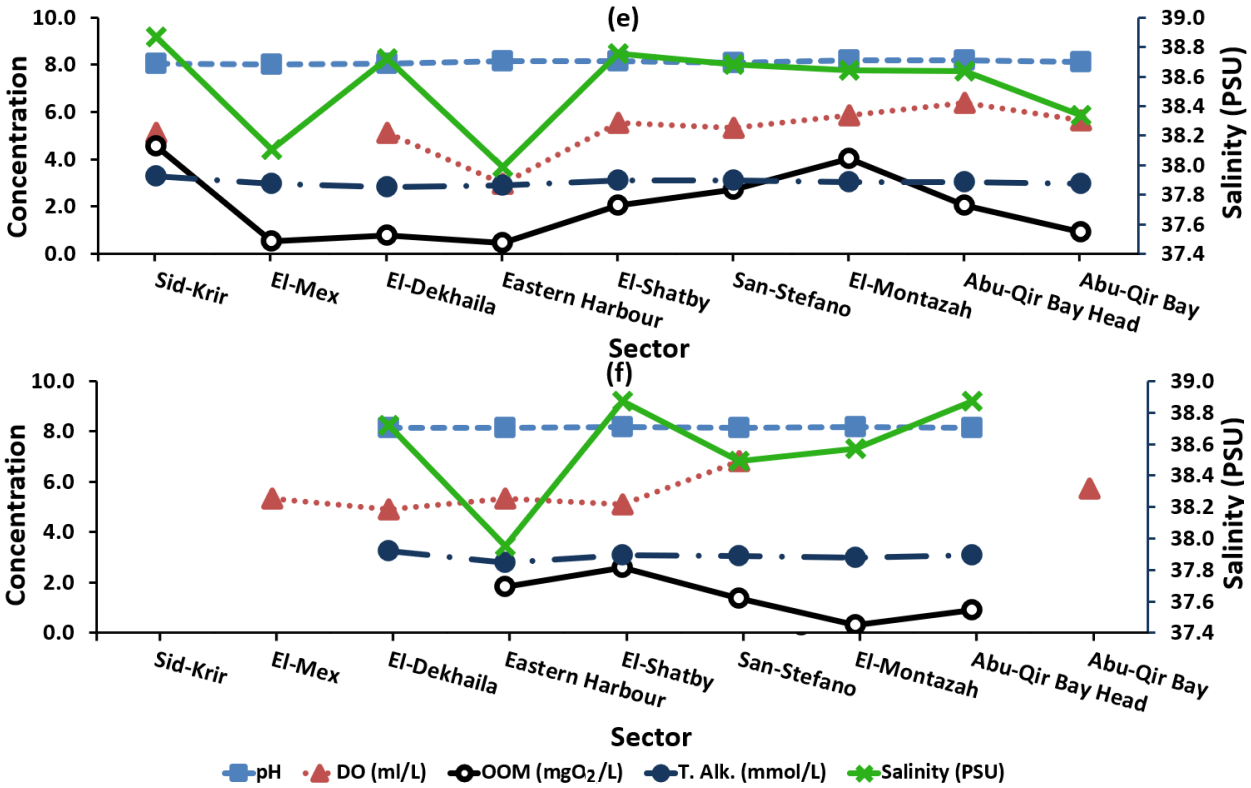


Fig. 2. The variations in the averages of hydrographical parameters at (a) surface water, (b) 10 m depth, (c) 20 m depth, (d) 50 m depth, (e) 100 m depth, and (f) 200 m depth, in different sectors of the present study.

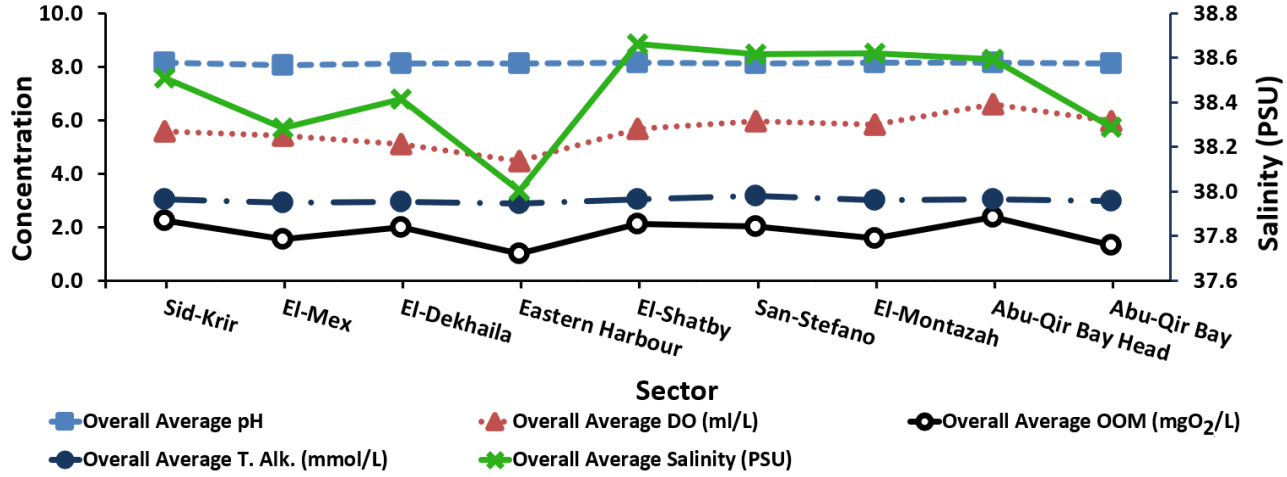


Fig. 3. The variations in the overall averages of the hydrographical parameters in different sectors of the present study.

Salinity is the main physical parameter that relates to the plankton diversity. It acts as a limiting factor and influences the distribution of planktonic community (**Vajravelu *et al.*, 2018**). Additionally, the salinity is considered as a sensitive parameter for measuring the rate of seawater dilution caused by land-based discharge. Subsequently, it reflects the degree of contamination in aquatic environment (**Zyadah *et al.*, 2004**). The distribution of surface seawater salinity average values in the marine sectors of the

present study varied between a minimum value 37.92 PSU at Abu-Qir Bay sector to a maximum value 38.61 PSU at El-Shatby and San-Stefano sectors (Table 2, Fig. 2a). The rest of salinity average values showed variations between 37.98 and 38.57 PSU (Table 2, Fig. 2a). The distribution of salinity average levels with depths depicted that, the minimum value 37.88 PSU was recorded at Eastern Harbour sector (20 m depth), while the maximum one 38.87 PSU was observed at Sidi-Krir sector (100 m depth), El-Shatby and Abu-Qir Bay Head sectors (200 m depth). The overall averages of salinity revealed ranges 38.00-38.66 PSU (Table 2, Fig. 3), which is consistent with the salinity of the Mediterranean water (38.50 PSU), **Copin-Montégut and Bégovic (2002)**.

Dissolved oxygen (DO) is one of the most important parameters in assessing the degree of water pollution with organic pollutants that influence the organisms' life within a waterbody through oxygen reduction or depletion (**Nessim *et al*., 2005**). The levels of the DO in surface and different seawater depths during winter 2016 are presented in Table 2 and Fig. 2(a–f). The lowest average values of DO were recorded at Eastern Harbour sector (2.98 and 3.40 ml/L) at 100 and 20 m depths, respectively. On contrary, the maximum DO average value of 7.87 ml/L (saturation 147.68%) was recorded at Abu-Qir Bay sector (10 m depth). The rest of sectors showed ranges varied between 4.68 and 7.13 ml/L. The low DO concentrations (2.98 and 3.40 ml/L, (saturation 65.65 and 68.61%, respectively) at the Eastern Harbour sector may be attributed to the decomposition and nitrification processes (**Patil *et al*., 2012**). The oil spills and wastes from sea vessels possibly minimize the sunlight penetrating into the surface seawater. This could affect the rate of photosynthesis of phytoplanktons and increase the decomposition rate and thus reduce the DO concentration (**Yap *et al*., 2011**). On the other hand, the higher DO values (4.68-7.87 ml/L) at other sectors can be attributed to the turbulent nature of the sea during winter season, triggers vertical mixing of water column (**Satpathy *et al*., 2009**).

Oxidizable organic matter (OOM) plays a major role in aquatic systems. It affects the biogeochemical processes, nutrient cycling, biological availability as well as chemical transport and interactions (**Cole, 1979**). It has been used as a basic parameter for water quality to assess pollution occurring by sewage and organic substances originated from agricultural and industrial applications (**Chester, 2000**). The OOM values in the studied sectors of the present study showed a wide range of variations. The average concentrations at the surface water ranged from 0.68 mgO_2/L at Abu-Qir Bay sector to 3.56 mgO_2/L at El-Dekhaila sector (Table 2, Fig. 2a). The variations of the OOM values with depths depicted that, the lowest average values of 0.30, 0.46 and 0.53 mgO_2/L were recorded at the following sectors: El-Montazah (200 m depth), Eastern Harbour (50, 100 m depths) and El-Mex (100 m depth**)**, while the maximum average concentration of 4.56 mgO_2/L was found at Sidi-Krir sector (100 m depth), Table 2, Fig. 2(b-f). The present results are in agreement with those of the previous studies (**Shaltout *et al*., 2014; Shreadah *et al*., 2014; Abdel-Halim *et al*., 2016; Shreadah *et al*., 2019**).

Total alkalinity is composed primarily of carbonate, bicarbonate, and hydroxides in seawater. It represents the buffering capacity of water and has the ability to resist the changes of water pH. During the present study, the average values of total alkalinity varied from 2.70 to 3.30 mmol/L (Table 2, Fig. 2"a–f"). The lowest value 2.70 mmol/L was recorded at El-Mex sector (50 m depth) while, the highest values were recorded at Sidi-Krir sector; 100 m depth (3.30 mmol/L) and San-Stefano sector; 50 m depth (3.28 mmol/L) as well as El-Dekhaila sector; 200 m depth and San-Stefano sector; surface water (3.25 mmol/L). The obtained results revealed relatively narrow variations in total alkalinity values either at surface waters or at different depths in all sectors of the present study. It was reported that the total alkalinity of the ocean surface water is controlled mainly by freshwater influx (**Brewer *et al*., 1986**). The results of the current study are in accordance with the findings of **Shaltout *et al*. (2014)**.

The present study results (Table 3) revealed that, the overall average values of pH at all sectors are slightly higher than those measured at Abu-Qir Bay sector (**Shreadah *et al*., 2019**). Higher pH values suggest that carbon dioxide, carbonate-bicarbonate equilibrium is more affected due to changes in physicochemical condition (**Karanth, 1987**). The overall average values of salinity in the present study are found to be higher than those observed by previous workers in Eastern Harbour and Abu-Qir Bay sectors (Table 3).

Table 3. Comparison between the overall averages of hydrographical parameters at the different sectors of the present study with those of the previous studies at the same locations.

Sector	pH	Salinity (PSU)	DO (ml/L)	OOM (mgO_2/L)	T. Alk. (mmol/L)	Reference
Sidi-Krir	8.03-8.35	38.44-38.57	7.52-8.00	0.32-1.60	ND	Abdel-Halim *et al*., 2016
	8.13	38.51	5.58	2.26	3.04	Present study
El-Mex	7.36-8.50	24.30-40.00	3.90-10.22	ND-24.80	ND	Shreadah *et al*., 2014
	8.07	38.29	5.41	1.55	2.92	Present study
El-Dekhaila	7.88-8.17	ND	5.65-7.54	0.16-3.84	2.54-2.97	Shaltout *et al*., 2014
	8.11	38.41	5.11	1.98	2.94	Present study
Eastern Harbour	8.09	37.19	8.15	0.86	3.49	Tadros *et al*., 2016
	8.12	38.00	4.48	1.02	2.87	Present study
Abu-Qir Bay	7.65-7.66	30.20-32.20	4.53-4.87	14.40-42.40	ND	Shreadah *et al*., 2019
	8.12	38.29	5.96	1.31	2.97	Present study

Nd: Not detected.

The direct comparison between the present results and the previously reported values cleared out that, the overall average values of DO at Sidi-Krir sector (5.58 mg/L) and Eastern Harbour sector (4.48 mg/L) are lower than those given by **Abdel-Halim *et al*. (2016)** and **Tadros *et al*. (2016)**, respectively. The overall average values of OOM in the present study were lower than those observed by **Shreadah *et al*. (2014)** at El-Mex sector and **Shreadah *et al*. (2019)** at Abu-Qir sector, while they were higher than the values measured by **Abdel-Halim *et al*. (2016)** at Sidi-Krir sector and **Tadros *et al*.**

(2016) at Eastern Harbour sector. On the other hand, the overall average value of T. Alk. in the present study (2.94 mmol/L) is comparable to that observed by **Shaltout *et al.* (2014)** at El-Dekhaila sector.

2. Statistical Analysis

Principal Components Analysis (PCA)

The obtained data of the hydrographical parameters such as pH, salinity, DO, OOM and T. Alk. in the nine sectors (Sidi-Krir, El-Mex, El-Dekhaila, Eastern Harbour, El-Shatby, San-Stefano, El-Montazah, Abu-Qir Bay Head and Abu-Qir Bay) represented by 41 stations were treated using the Principal Components Analysis (PCA). Based on eigenvalues higher than one and varimax rotation, the two extracted factors explained the relations between the studied physico-chemical parameters, water parameters distribution, association, and sources with cumulative covariance of 59.16% (Table 4).

Table 4. Rotated components matrix for the studied parameters of the Mediterranean seawater off Alexandria coast during winter 2016.

	Component	
Parameters	**PC 1**	**PC 2**
pH	0.756	-0.213
Salinity	0.738	0.281
DO	-0.082	0.770
OOM	0.122	0.637
T. Alk.	0.594	0.588
Variance %	29.798	29.359
Cumulative %	29.798	59.156

The analysis illustrated that while PC1 exhibited 29.79% of the total variance with positive loading on pH (0.75), salinity (0.73) and T. Alk. (0.59), PC2 exhibited 29.35% with positive loading on DO (0.77), OOM (0.63) and T. Alk. (0.58). Consequently, PC1 explained that both pH and T. Alk. decreased with decreasing salinity till 20 PSU value. Below 20 PSU level, the alkalinity increases with a further decrease in salinity, probably due to soil-water interaction at shallow water depths (**Saraswat *et al*., 2015**). In a previous work, **Copin-Montégut and Bégovic (2002)** reported that, T. Alk. and salinity in the Mediterranean water showed a good correlation according to equation (1). On the other hand, PC2 suggested that the surface alkalinity may affected by the construction and decomposition of organic matter (**Kim *et al*., 2006**).

$$\text{T. Alk.} = 79.84 \times \text{Salinity} - 510 \qquad (1)$$

CONCLUSION

The present study provides valuable information related to characteristics of surface and different seawater depths at nine sectors (41 stations) along the Egyptian Mediterranean coast off Alexandria city. Seawater samples in the present study are

described according to pH, Salinity, DO, OOM and T. Alk. Generally, the present study suggests that Mediterranean seawater off Alexandria has a good marine life suitable for biodiversity.

ACKNOWLEDGEMENT

The authors would like to express their sincere gratitude to National Institute of Oceanography and Fisheries, NIOF for financial support to accomplish this work.

REFERENCES

Abd-alla, M.A.M. (1993). Concentration of mercury in fresh, brackish, and saline waters in Alexandria region. M.Sc. Thesis, Institute of Graduate Studies and Research, Alex. Univ., 145pp.

Abdel-Halim, A.M.; Abdel Nabi, M.A.; Abdel Fattah, L.M.; Fahmy, M.A.; Abo-El-Khair, E.M.; Khaled, A.M. and Abu El-Soud, A. (2016). Bay (Alexandria, Egypt). Journal of Ecology and the Natural Environment, 8(8): 287–303.

Brewer, P.G.; Bradshaw, A.L. and Williams, R.T. (1986). Measurements of total carbon dioxide and alkalinity in the North Atlantic Ocean in 1981. In: "The Changing Carbon Cycle: A Global Analysis." Trabalka, J.R. & Reichle, D.E. (Eds). Springer, New York, pp. 348–370.

Chester, R. (2000). Marine Geochemistry, 2nd ed. Block Well Science Ltd., 493pp.

Cole, G.A. (1979). Text Book of Limnology, 2nd ed. C.V. Mosby Comoany, 426pp.

Copin-Montégut, C. and Bégovic, M. (2002). Distributions of carbonate properties and oxygen along the water column (0–2000 m) in the central part of the NW Mediterranean Sea (Dyfamed site): Influence of winter vertical mixing on air-sea CO_2 and O_2 exchanges. Deep Sea Res., Part II, 49(11): 2049–2066.

Das, J.; Das, S.N. and Sahoo, R.K. (1997). Semidiurnal variation of some physicochemical parameters in the Mahanadi estuary, east coast of India. Indian. J. Mar. Sci., 26: 323–326.

El-Naggar, N.A.; Mohamed, L.A.; Abdel-Halim, A. and Emara, H.E. (2019). Environmental Characteristics of the Egyptian Mediterranean Coast. Egyptian Journal of Aquatic Biology & Fisheries, 23(2): 475–490.

Emam, W.M.; Abd El-Halim, A.S.; El-Moselhy, K.M. and Owen, N.A. (2013). Evaluation of water quality of Abu-Qir Bay, Mediterranean coast. Egypt International Journal of Environmental Science and Engineering, 4: 47–54.

European Commission, "Directive of the European Parliament and of the Council 2000/60/EC Establishing a Framework for Community Action in the Field of Water Policy, Off", European Commission C513, 2000.

FAO (1976). Manual of Methods in Aquatic Environmental Research Part I: Permanganate value (oxidiability) of organic matter in natural waters. FAO Fisheries Technical paper, 137: 169.

Fathy, S.A.H.; Abdel Hamid, F.A.; Shreadah, M.A.; Mohamed, L.A. and El-Gazar, M. (2012). Application of Principal Component Analysis for Developing Water Quality Index for Selected Coastal Areas of Alexandria Egypt. Recourses and Environment Journal, 2(6): 297-305.

Grasshoff, K. (1976). Methods of Sea Water Analysis, Verlag Chemie Weinheim, New York, 317pp.

Karanth, K.R. (1987). Groundwater Assessment Development and Management, Tata McGraw Hill publishing company Ltd., New Delhi, pp. 725–726.

Karr, J.R.; Allen, J.D. and Benke, A.C. (2000). River conservation in the United States and Canada. In: "Global perspectives on river conservation." Boon, P.J.; Davies, B.R.& Petts, G.E. (Eds.). Science, policy, and practice. Wiley, New York, pp. 3–39.

Kim, H.C.; Lee, K. and Choi, W. (2006). Contribution of phytoplankton and bacterial cells to the measured alkalinity of seawater. Limnol. Oceanogr., 51: 331–338.

Nessim, R.B.; Masoud, M.S. and Maximous, N.N. (2005). Water characteristics of Alexandria hot spots. Egypt. J. Aquat. Res., 31 (special issue): 25–37.

Patil, P.N.; Sawant, D.V. and Deshmukh, R.N. (2012). Physico-chemical parameters for testing of water- A review. International Journal of Environmental Sciences, 3(3): 1194–1207.

Rajasegar, M. (2003), Physico-chemical characteristics of the Vellar estuary in relation to shrimp farming. J. Environ. Biol., 24: 95–101.

Sala, O.E.; Chapin, F.S.; Armesto, J.J.; Berlow, E.; Bloomfield, J.; Dirzo, R.; Huber-Sanwald, E.; Huenneke, L.F.; Jackson, R.B.; Kinzig, A.; Leemans, R.; Lodge, D.M.; Mooney, H.A.; Oesterheld, M.; Poff, N.L.; Sykes, M.T.; Walker, B.H.; Walker, M. and Wall, D.H. (2000). Global biodiversity scenarios for the year 2100. Science, 287: 1770–1774.

Saraswat, R.; Kouthanker, M.; Kurtarkar, S.; Nigam, R.; Naqvi, S.W.A. and Linshy, V.N. (2015). Effect of salinity induced pH/alkalinity changes on benthic foraminifera: A laboratory culture Experiment, Estuar. Coast. Shelf Sci., 153: 96–107.

Satpathy, K.K.; Sahu, G. and Mohanty, A.K. *et al*. (2009). Phytoplankton community structure and its variability during southwest to northeast monsoon transition in the coastal waters of Kal- pakkam, east coast of India. Int. J. Ocean. Oceanogr., 3(1): 43–74.

Shaltout, N.A. and Abd El-Khalek, D.E. (2014). Assessment of Seawater Quality of El-Dekhaila Harbor, Alexandria, Egypt. Asian J. of Adv. Basic Sci., 3(1): 206–216.

Shreadah, M.A.; Abdel Moneim, M.I.; Said, T.O.; Fathallah, E.M.I. and Mahmoud, M.E. (2013). PAHs in Seawater of the Semi-Closed Areas along the Alexandria Coast of Egyptian Mediterranean Sea. Journal of Environmental Protection, 4: 1307–1317.

Shreadah, M.A.; Masoud, M.S.; Khattab, A.M. and El Zokm, G. (2014). Impacts of different Drains on the Seawater Quality of El-Mex. Journal of Ecology and the Natural Environment, 8(8): 287–303.

Shreadah, A.M.; Said, O.T; Mansour, A.M.; El-Sharkawi, M.F. and Mohamed, A.M. (2016). POPs in Sediments from the Eastern and Western Egyptian Mediterranean Coast; a Comparative Study. Development in Analytical Chemistry (DAC), Vol. 3.

Shreadah, M.A.; El-Sayed, A.A.M.; Taha, A.A.; Ahmed, A.M. and Abdel Rahman, H.H. (2019). Evaluation of Different Anthropogenic Effluents Impacts on the Water Quality Using Principal Component Analysis: A Case Study of Abu-Qir Bay-Alexandria-Egypt. International Journal of Environmental Monitoring and Analysis, 7(3): 56–67.

Strickland, J.D. and Parsons, T.R. (1972). A Practical handbook of seawater Analysis, Ottawa, Canada, 311pp.

Tadros, R.Z.; Ibrahim, G.H.; El Zokm, G.M. and Okbah, M. (2016). A Multivariate analysis to investigate the organization of physicochemical parameters in the Eastern Harbour Alexandria, Egypt. International Journal of Contemporary Applied Sciences, 3 (3).

Vajravelu, M.; Martin, Y.; Ayyappan, S. and Mayakrishnan, M. (2018). Seasonal influence of physico-chemical parameters on phytoplankton diversity, community structure and abundance at Parangipettai coastal waters, Bay of Bengal, South East Coast of India. Manigandan Oceanologia, 60: 114–127.

Yap, C.K.; Chee, M.W.; Shamarina, S.; Edward, F.B.; Chew, W. and Tan, S.G. (2011). Assessment of surface water quality in the Malaysian Coastal Waters by using Multivariate Analyses. Sains Malaysiana, 40(10): 1053–1064.

Zyadah, M.; Ibrahim, M. and Madkour, A. (2004). Impact of environ-mental parameters on benthic invertebrates and zooplankton biodiversity of the Eastern region of Delta coast at Damietta, Egypt. Egypt. J. Aquat. Biol. Fish., 8: 37–52.

الملخص العربي

تقلبات بعض المتغيرات الفيزيائية والكيميائية مع العمق في مياة البحر المتوسط المصرية امام ساحل الاسكندرية خلال شتاء 2016

داليا محمود صدقي علي سالم ، محمد ابراهيم عبد المنعم ابراهيم ، ليلي عبد الفتاح محمد ، هدي حميدة ، عصام خميس الشوربجي
المعهد القومي لعلوم البحار والمصايد – مصر

قدمت الدراسة الحالية نظرة عميقة على تقييم جودة المياه لساحل الإسكندرية بناءً على بيانات المعاملات الهيدروغرافية التالية: الأس الهيدروجيني ، الملوحة ، الأكسجين الذائب ، المواد العضوية المؤكسدة والقلوية الكلية في تسعة قطاعات (سيدي كرير ، المكس ، الدخيلة ، الميناء الشرقي ، الشاطبي ، سان ستيفانو ، المنتزه ، راس خليج أبو قير ، وخليج أبو قير) ممثلة بـ 41 محطة على طول ساحل البحر المتوسط المصري امام مدينة الإسكندرية خلال شتاء 2016. أظهر متوسط النتائج الإجمالية للمعاملات الهيدروغرافية في مياه البحر السطحية والأعماق المختلفة (10-200 م) أن مستويات الأس الهيدروجيني تتراوح من 8.07 إلى 8.16 وأن قيم الملوحة تعكس نطاق 38.00-38.66 PSU وهو ما يتوافق مع ملوحة مياة البحر المتوسط (38.50 PSU). أظهر المتوسط الاجمالي لـ الاكسجين الذائب النطاق من 4.48-6.60 مل/ لتر. في غضون ذلك ، اظهرت كلا من المواد العضوية المؤكسدة والقلوية الكلية نطاقات (1.02-2.37 مليجرام اكسجين / لتر) و (2.87-3.16 ملي مول / لتر) على التوالي. لم يلاحظ اختلاف كبير في قيم الأس الهيدروجيني مع الأعماق. أيضًا ، كانت الاختلافات في المعاملات الأخرى ضئيلة. أظهر تحليل المكونات الرئيسية (PCA) علاقة جيدة بين درجة الحموضة والملوحة وكذلك القلوية الكلية والتي تتفق مع البيانات المسجلة لمياة البحر المتوسط.

Supplementary Data

Table of Contents

Table S1. Raw data of the hydrographical parameters (pH, Salinity, DO, OOM, and T. Alk.) at surface and different depths of seawater samples in the nine sectors along Alexandria coast-Egypt, winter 2016.

	Site	1		2			3				4					5					
pH	Sector / Depth	1S	10 m	2S	10 m	20 m	3S	10 m	20 m	50 m	4S	10 m	20 m	50 m	100 m	5S	10 m	20 m	50 m	100 m	200 m
	Sidi-Krir	8.14	8.11	8.16	8.17	8.15	8.09	8.15	8.13	8.15	8.15	8.16	8.16	8.16	8.06	NR	NR	NR	NR	NR	NR
	El-Mex	8.14	8.11	8.09	8.14	8.16	8.16	8.16	8.17	8.14	8.16	8.16	8.12	8.14	8.14	7.29	8.15	8.15	7.95	7.87	NR
	El-Dekhaila	8.14	8.13	8.17	8.15	8.13	8.16	8.16	8.13	8.15	8.02	8.14	NR	8.13	8.17	8.10	8.17	8.12	7.96	7.93	8.14
	Eastern Harbour	8.16	8.17	8.11	NR	8.10	8.17	7.89	8.11	8.15	8.16	8.05	8.04	8.14	8.14	8.15	8.16	8.10	8.14	8.14	8.15
	El-Shatby	8.10	8.14	8.16	8.14	8.16	8.16	8.19	8.14	8.15	8.09	8.10	8.14	8.13	8.19	8.12	8.10	8.16	8.15	8.13	8.18
	San-Stefano	NR	NR	8.02	8.18	8.17	8.18	NR	8.16	7.71	8.19	8.15	8.15	8.13	8.02	8.02	8.18	8.14	8.17	8.16	8.13
	El-Montazah	NR	NR	8.17	8.18	8.13	8.17	8.17	NR	8.19	8.12	8.17	8.17	8.10	8.18	8.16	8.18	8.16	8.18	8.17	8.17
	Abu-Qir Bay Head	8.10	8.11	8.15	8.15	8.15	8.18	8.16	8.17	8.18	8.18	8.18	8.12	8.14	8.18	8.17	8.18	NR	8.16	8.17	8.15
	Abu-Qir Bay	7.95	8.09	8.09	8.13	8.13	8.16	8.16	8.20	8.07	8.14	8.14	8.15	8.17	8.12	NR	NR	NR	NR	NR	NR
	Site	1		2			3				4					5					
Salinity (PSU)	Sector / Depth	1S	10 m	2S	10 m	20 m	3S	10 m	20 m	50 m	4S	10 m	20 m	50 m	100 m	5S	10 m	20 m	50 m	100 m	200 m
	Sidi-Krir	38.11	38.64	38.11	38.57	38.49	37.88	38.03	38.64	38.57	38.80	38.80	38.87	38.00	38.87	NR	NR	NR	NR	NR	NR
	El-Mex	37.88	37.95	37.95	37.95	38.03	38.72	38.80	38.87	38.87	38.57	38.57	38.57	38.64	38.26	38.34	37.88	37.80	37.95	37.95	NR
	El-Dekhaila	37.88	38.03	37.95	37.95	38.18	38.18	38.64	38.03	38.03	38.80	38.72	38.72	38.80	38.80	37.95	38.03	38.18	38.18	38.64	38.72
	Eastern Harbour	37.49	38.57	38.34	NR	37.88	37.80	37.80	37.88	38.11	38.18	38.34	37.88	37.95	38.03	38.11	38.26	37.88	37.88	37.95	37.95
	El-Shatby	38.80	38.80	38.72	38.64	38.64	38.57	38.64	38.64	38.57	38.87	38.80	38.49	38.18	38.64	38.11	38.57	38.57	38.64	38.87	38.87
	San-Stefano	NR	NR	38.72	38.72	38.80	38.80	NR	38.72	38.72	38.72	38.64	38.87	38.80	38.87	38.18	38.34	38.34	38.49	38.49	38.49
	El-Montazah	NR	NR	38.26	38.64	38.64	38.72	38.72	NR	38.80	38.41	38.72	38.72	38.64	38.72	38.87	38.64	38.49	38.49	38.57	38.57
	Abu-Qir Bay Head	38.26	38.41	38.18	38.64	38.64	38.41	38.64	38.64	38.80	38.18	38.64	38.49	38.64	38.41	38.49	38.49	NR	38.34	38.87	38.87
	Abu-Qir Bay	38.03	38.03	38.03	38.34	38.49	37.26	38.57	38.26	38.57	38.34	38.49	38.49	38.26	38.34	NR	NR	NR	NR	NR	NR

Table S1. Continued;

	Site	1		2			3				4					5					
DO (mg/L)	Sector / Depth	1S	10 m	2S	10 m	20 m	3S	10 m	20 m	50 m	4S	10 m	20 m	50 m	100 m	5S	10 m	20 m	50 m	100 m	200 m
	Sidi-Krir	5.11	5.53	5.11	NR	6.60	5.11	NR	NR	5.53	5.11	NR	NR	NR	5.11	NR	NR	NR	NR	NR	NR
	El-Mex	3.62	5.32	6.60	NR	NR	5.32	NR	NR	NR	5.53	NR	NR	NR	NR	5.11	NR	NR	5.75	NR	5.32
	El-Dekhaila	4.89	5.11	5.11	5.53	NR	5.32	5.11	NR	NR	5.32	NR	NR	NR	5.11	5.32	NR	NR	NR	NR	4.89
	Eastern Harbour	5.11	4.68	2.98	NR	3.40	5.96	NR	NR	5.53	5.11	NR	NR	NR	2.98	5.75	NR	NR	NR	NR	5.32
	El-Shatby	5.53	6.38	7.66	NR	5.75	5.11	6.81	NR	5.11	5.53	NR	NR	NR	5.53	5.75	NR	NR	NR	NR	5.11
	San Stefano	NR	NR	5.75	NR	6.60	5.53	NR	NR	5.75	4.26	NR	NR	NR	5.32	5.53	NR	NR	NR	NR	6.81
	El-Montazah	NR	6.60	5.32	NR	6.81	5.11	NR	NR	5.32	5.53	NR	NR	NR	5.96	5.64	NR	5.21	NR	5.75	NR
	Abu-Qir Bay Head	8.19	NR	6.28	NR	6.28	6.06	NR	NR	7.13	6.38	NR	NR	NR	6.38	6.17	NR	NR	NR	NR	NR
	Abu-Qir Bay	6.38	7.87	7.24	NR	5.32	5.53	NR	NR	5.32	5.64	NR	NR	NR	5.64	4.47	NR	NR	NR	NR	5.75
	Site	1		2			3				4					5					
OOM (mgO2/L)	Sector / Depth	1S	10 m	2S	10 m	20 m	3S	10 m	20 m	50 m	4S	10 m	20 m	50 m	100 m	5S	10 m	20 m	50 m	100 m	200 m
	Sidi-Krir	3.65	0.30	6.38	0.30	0.30	0.30	1.52	0.61	3.04	0.30	3.38	1.22	0.91	4.56	NR	NR	NR	NR	NR	NR
	El-Mex	3.65	1.22	1.52	3.04	0.30	1.82	0.30	0.30	2.13	0.30	5.47	0.61	0.91	0.46	4.86	2.43	1.82	1.52	0.61	NR
	El-Dekhaila	0.30	0.30	2.13	0.61	10.18	14.14	1.52	0.61	0.30	0.30	0.91	NR	1.22	0.91	0.91	0.61	0.91	1.22	0.61	NR
	Eastern Harbour	0.91	0.76	0.15	NR	0.76	1.37	2.43	1.06	0.15	0.76	0.76	0.76	0.15	0.15	4.71	0.30	0.30	1.06	0.76	1.82
	El-Shatby	4.56	1.37	1.06	0.15	0.46	0.91	6.08	3.19	4.71	1.06	0.30	3.50	1.37	2.89	0.30	1.06	0.61	2.13	1.22	2.58
	San Stefano	NR	NR	4.86	0.91	3.65	1.52	NR	1.98	2.28	1.82	1.82	0.91	3.95	4.86	1.52	2.43	0.76	0.15	0.61	1.37
	El-Montazah	NR	NR	6.08	1.22	1.22	2.43	0.61	0.91	1.06	0.76	0.91	0.76	0.46	1.82	1.22	0.15	1.22	0.61	6.23	0.30
	Abu-Qir Bay Head	2.58	2.13	8.36	5.32	1.82	1.06	0.91	0.61	0.76	1.67	1.52	3.50	6.84	1.98	2.28	0.61	1.22	4.86	2.13	0.91
	Abu-Qir Bay	0.30	2.43	0.61	1.22	0.91	1.22	7.60	0.61	1.06	0.61	0.46	1.22	1.22	0.91	NR	NR	NR	NR	NR	NR

Table S1. Continued;

T. Alk. (meq/L)	Site	1		2			3				4					5					
	Sector / Depth	1S	10 m	2S	10 m	20 m	3S	10 m	20 m	50 m	4S	10 m	20 m	50 m	100 m	5S	10 m	20 m	50 m	100 m	200 m
	Sidi-Krir	2.80	3.20	2.40	3.20	3.00	3.00	3.10	2.95	3.00	2.90	3.10	3.10	2.90	3.30	NR	NR	NR	NR	NR	NR
	El-Mex	2.95	3.00	2.90	2.90	3.00	3.20	2.90	3.00	3.15	3.20	2.90	2.90	2.80	3.05	2.90	2.90	2.95	2.15	2.90	NR
	El-Dekhaila	2.85	2.90	3.25	2.85	3.05	2.90	2.85	2.85	2.75	2.90	2.90	NR	2.75	2.85	2.80	2.85	2.95	2.85	2.80	3.25
	Eastern Harbour	2.80	2.90	2.95	NR	2.65	2.65	3.40	2.80	3.00	3.00	2.80	2.80	2.85	3.00	2.80	3.00	2.80	2.90	2.80	2.80
	El-Shatby	3.00	3.20	3.00	2.85	2.90	3.00	3.30	2.90	3.10	3.20	2.85	2.95	2.80	3.20	3.00	3.00	3.00	3.05	3.00	3.10
	San Stefano	NR	NR	3.20	3.10	3.20	3.10	NR	3.10	3.70	3.60	3.05	2.95	3.00	3.20	3.10	3.30	3.20	3.15	3.00	3.05
	El-Montazah	NR	NR	3.30	3.20	3.05	3.00	3.00	NR	2.90	3.10	3.10	2.90	2.85	3.05	3.05	2.95	2.90	3.00	3.00	3.00
	Abu Qir Bay Head	3.10	3.05	2.90	3.00	3.05	2.95	3.00	3.10	3.05	2.95	3.00	3.30	3.00	3.10	2.90	3.00	NR	2.85	3.00	3.10
	Abu Qir Bay	2.80	2.90	3.10	2.95	3.00	2.95	3.10	2.80	3.00	2.95	3.00	3.05	3.00	2.95	NR	NR	NR	NR	NR	NR

Table S2. Average values of the hydrographical parameters at surface and each depth of seawater samples in the nine sectors along Alexandria coast-Egypt, winter 2016.

pH										
Site	**Depth**	**Sidi-Krir**	**El-Mex**	**El-Dekhaila**	**Eastern Harbour**	**El-Shatby**	**San-Stefano**	**El-Montazah**	**Abu-Qir Head**	**Abu-Qir Bay**
1	**Surface**	**8.14**	**8.14**	**8.14**	**8.16**	**8.10**	**NR**	**NR**	**8.10**	**7.95**
2		**8.16**	**8.09**	**8.17**	**8.11**	**8.16**	**8.02**	**8.17**	**8.15**	**8.09**
3		**8.09**	**8.16**	**8.16**	**8.17**	**8.16**	**8.18**	**8.17**	**8.18**	**8.16**
4		**8.15**	**8.16**	**8.02**	**8.16**	**8.09**	**8.19**	**8.12**	**8.18**	**8.14**
5		**NR**	**7.29**	**8.10**	**8.15**	**8.12**	**8.02**	**8.16**	**8.17**	**NR**
Min.		**8.09**	**7.29**	**8.02**	**8.11**	**8.09**	**8.02**	**8.12**	**8.10**	**7.95**
Max.		**8.16**	**8.16**	**8.17**	**8.17**	**8.16**	**8.19**	**8.17**	**8.18**	**8.16**
Av.		**8.14**	**7.97**	**8.12**	**8.15**	**8.13**	**8.10**	**8.16**	**8.16**	**8.09**
1	**10 m**	**8.11**	**8.11**	**8.13**	**8.17**	**8.14**	**NR**	**NR**	**8.11**	**8.09**
2		**8.17**	**8.14**	**8.15**	**NR**	**8.14**	**8.18**	**8.18**	**8.15**	**8.13**
3		**8.15**	**8.16**	**8.16**	**7.89**	**8.19**	**NR**	**8.17**	**8.16**	**8.16**
4		**8.16**	**8.16**	**8.14**	**8.05**	**8.10**	**8.15**	**8.17**	**8.18**	**8.14**
5		**NR**	**8.15**	**8.17**	**8.16**	**8.10**	**8.18**	**8.18**	**8.18**	**NR**
Min.		**8.11**	**8.11**	**8.13**	**7.89**	**8.10**	**8.15**	**8.17**	**8.11**	**8.09**
Max.		**8.17**	**8.16**	**8.17**	**8.17**	**8.19**	**8.18**	**8.18**	**8.18**	**8.16**
Av.		**8.15**	**8.14**	**8.15**	**8.07**	**8.13**	**8.17**	**8.18**	**8.16**	**8.13**
2	**20 m**	**8.15**	**8.16**	**8.13**	**8.10**	**8.16**	**8.17**	**8.13**	**8.15**	**8.13**
3		**8.13**	**8.17**	**8.13**	**8.11**	**8.14**	**8.16**	**NR**	**8.17**	**8.20**
4		**8.16**	**8.12**	**NR**	**8.04**	**8.14**	**8.15**	**8.17**	**8.12**	**8.15**
5		**NR**	**8.15**	**8.12**	**8.10**	**8.16**	**8.14**	**8.16**	**NR**	**NR**
Min.		**8.13**	**8.12**	**8.12**	**8.04**	**8.14**	**8.14**	**8.13**	**8.12**	**8.13**
Max.		**8.16**	**8.17**	**8.13**	**8.11**	**8.16**	**8.17**	**8.17**	**8.17**	**8.20**
Av.		**8.15**	**8.15**	**8.13**	**8.09**	**8.15**	**8.16**	**8.15**	**8.15**	**8.16**
3	**50 m**	**8.15**	**8.14**	**8.15**	**8.15**	**8.15**	**7.71**	**8.19**	**8.18**	**8.07**
4		**8.16**	**8.14**	**8.13**	**8.14**	**8.13**	**8.13**	**8.10**	**8.14**	**8.17**
5		**NR**	**7.95**	**7.96**	**8.14**	**8.15**	**8.17**	**8.18**	**8.16**	**NR**
Min.		**8.15**	**7.95**	**7.96**	**8.14**	**8.13**	**7.71**	**8.10**	**8.14**	**8.07**
Max.		**8.16**	**8.14**	**8.15**	**8.15**	**8.15**	**8.17**	**8.19**	**8.18**	**8.17**
Av.		**8.16**	**8.08**	**8.08**	**8.14**	**8.14**	**8.00**	**8.16**	**8.16**	**8.12**
4	**100 m**	**8.06**	**8.14**	**8.17**	**8.14**	**8.19**	**8.02**	**8.18**	**8.18**	**8.12**
5		**NR**	**7.87**	**7.93**	**8.14**	**8.13**	**8.16**	**8.17**	**8.17**	**NR**
Min.		**8.06**	**7.87**	**7.93**	**8.14**	**8.13**	**8.02**	**8.17**	**8.17**	**8.12**
Max.		**8.06**	**8.14**	**8.17**	**8.14**	**8.19**	**8.16**	**8.18**	**8.18**	**8.12**
Av.		**8.06**	**8.01**	**8.05**	**8.14**	**8.16**	**8.09**	**8.18**	**8.18**	**8.12**
5	**200 m**	**NR**	**NR**	**8.14**	**8.15**	**8.18**	**8.13**	**8.17**	**8.15**	**NR**
Min.		**NR**	**NR**	**8.14**	**8.15**	**8.18**	**8.13**	**8.17**	**8.15**	**NR**
Max.		**NR**	**NR**	**8.14**	**8.15**	**8.18**	**8.13**	**8.17**	**8.15**	**NR**
Av.		**NR**	**NR**	**8.14**	**8.15**	**8.18**	**8.13**	**8.17**	**8.15**	**NR**

Salinity (PSU)										
Site	Depth	Sidi-Krir	El-Mex	El-Dekhaila	Eastern Harbour	El-Shatby	San-Stefano	El-Montazah	Abu- Qir Head	Abu-Qir Bay
1	Surface	38.11	37.88	37.88	37.49	38.80	NR	NR	38.26	38.03
2		38.11	37.95	37.95	38.34	38.72	38.72	38.26	38.18	38.03
3		37.88	38.72	38.18	37.80	38.57	38.80	38.72	38.41	37.26
4		38.80	38.57	38.80	38.18	38.87	38.72	38.41	38.18	38.34
5		NR	38.34	37.95	38.11	38.11	38.18	38.87	38.49	NR
Min.		37.88	37.88	37.88	37.49	38.11	38.18	38.26	38.18	37.26
Max.		38.80	38.72	38.80	38.34	38.87	38.80	38.87	38.49	38.34
Av.		38.23	38.29	38.15	37.98	38.61	38.61	38.57	38.30	37.92
1	10 m	38.64	37.95	38.03	38.57	38.80	NR	NR	38.41	38.03
2		38.57	37.95	37.95	NR	38.64	38.72	38.64	38.64	38.34
3		38.03	38.80	38.64	37.80	38.64	NR	38.72	38.64	38.57
4		38.80	38.57	38.72	38.34	38.80	38.64	38.72	38.64	38.49
5		NR	37.88	38.03	38.26	38.57	38.34	38.64	38.49	NR
Min.		38.03	37.88	37.95	37.80	38.57	38.34	38.64	38.41	38.03
Max.		38.80	38.80	38.72	38.57	38.80	38.72	38.72	38.64	38.57
Av.		38.51	38.23	38.27	38.24	38.69	38.57	38.68	38.56	38.36
2	20 m	38.49	38.03	38.18	37.88	38.64	38.80	38.64	38.64	38.49
3		38.64	38.87	38.03	37.88	38.64	38.72	NR	38.64	38.26
4		38.87	38.57	38.72	37.88	38.49	38.87	38.72	38.49	38.49
5		NR	37.80	38.18	37.88	38.57	38.34	38.49	NR	NR
Min.		38.49	37.80	38.03	37.88	38.49	38.34	38.49	38.49	38.26
Max.		38.87	38.87	38.72	37.88	38.64	38.87	38.72	38.64	38.49
Av.		38.67	38.32	38.28	37.88	38.59	38.68	38.62	38.59	38.41
3	50 m	38.57	38.87	38.03	38.11	38.57	38.72	38.80	38.80	38.57
4		38.00	38.64	38.80	37.95	38.18	38.80	38.64	38.64	38.26
5		NR	37.95	38.18	37.88	38.64	38.49	38.49	38.34	NR
Min.		38.00	37.95	38.03	37.88	38.18	38.49	38.49	38.34	38.26
Max.		38.57	38.87	38.80	38.11	38.64	38.80	38.80	38.80	38.57
Av.		38.29	38.49	38.34	37.98	38.46	38.67	38.64	38.59	38.42
4	100 m	38.87	38.26	38.80	38.03	38.64	38.87	38.72	38.41	38.34
5		NR	37.95	38.64	37.95	38.87	38.49	38.57	38.87	NR
Min.		38.87	37.95	38.64	37.95	38.64	38.49	38.57	38.41	38.34
Max.		38.87	38.26	38.80	38.03	38.87	38.87	38.72	38.87	38.34
Av.		38.87	38.11	38.72	37.99	38.76	38.68	38.65	38.64	38.34
5	200 m	NR	NR	38.72	37.95	38.87	38.49	38.57	38.87	NR
Min.		NR	NR	38.72	37.95	38.87	38.49	38.57	38.87	NR
Max.		NR	NR	38.72	37.95	38.87	38.49	38.57	38.87	NR
Av.		NR	NR	38.72	37.95	38.87	38.49	38.57	38.87	NR

Dissolved Oxygen (DO; mg/L)										
Site	Depth	Sidi-Krir	El-Mex	El-Dekhaila	Eastern Harbour	El-Shatby	San-Stefano	El-Montazah	Abu-Qir Head	Abu-Qir Bay
1	Surface	5.11	3.62	4.89	5.11	5.53	NR	NR	8.19	6.38
2		5.11	6.60	5.11	2.98	7.66	5.75	5.32	6.28	7.24
3		5.11	5.32	5.32	5.96	5.11	5.53	5.11	6.06	5.53
4		5.11	5.53	5.32	5.11	5.53	4.26	5.53	6.38	5.64
5		NR	5.11	5.32	5.75	5.75	5.53	5.64	6.17	4.47
Min.		5.11	3.62	4.89	2.98	5.11	4.26	5.11	6.06	4.47
Max.		5.11	6.60	5.32	5.96	7.66	5.75	5.64	8.19	7.24
Av.		5.11	5.23	5.19	4.98	5.92	5.27	5.40	6.62	5.85
1	10 m	5.53	5.32	5.11	4.68	6.38	NR	6.60	NR	7.87
2		NR	NR	5.53	NR	NR	NR	NR	NR	NR
3		NR	NR	5.11	NR	6.81	NR	NR	NR	NR
4		NR	NR	NR	NR	NR	NR	NR	NR	NR
5		NR	NR	NR	NR	NR	NR	NR	NR	NR
Min.		5.53	5.32	5.11	4.68	6.38	NR	6.60	NR	7.87
Max.		5.53	5.32	5.53	4.68	6.81	NR	6.60	NR	7.87
Av.		5.53	5.32	5.25	4.68	6.60	NR	6.60	NR	7.87
2	20 m	6.60	NR	NR	3.40	5.75	6.60	6.81	6.28	5.32
3		NR	NR	NR	NR	NR	NR	NR	NR	NR
4		NR	NR	NR	NR	NR	NR	NR	NR	NR
5		NR	NR	NR	NR	NR	NR	NR	NR	NR
Min.		6.60	NR	NR	3.40	5.75	6.60	5.21	6.28	5.32
Max.		6.60	NR	NR	3.40	5.75	6.60	6.81	6.28	5.32
Av.		6.60	NR	NR	3.40	5.75	6.60	6.01	6.28	5.32
3	50 m	5.53	NR	NR	5.53	5.11	5.75	5.32	7.13	5.32
4		NR	NR	NR	NR	NR	NR	NR	NR	NR
5		NR	5.75	NR	NR	NR	NR	NR	NR	NR
Min.		5.53	5.75	NR	5.53	5.11	5.75	5.32	7.13	5.32
Max.		5.53	5.75	NR	5.53	5.11	5.75	5.32	7.13	5.32
Av.		5.53	5.75	NR	5.53	5.11	5.75	5.32	7.13	5.32
4	100 m	5.11	NR	5.11	2.98	5.53	5.32	5.96	6.38	5.64
5		NR	NR	NR	NR	NR	NR	5.75	NR	NR
Min.		5.11	NR	5.11	2.98	5.53	5.32	5.75	6.38	5.64
Max.		5.11	NR	5.11	2.98	5.53	5.32	5.96	6.38	5.64
Av.		5.11	NR	5.11	2.98	5.53	5.32	5.85	6.38	5.64
5	200 m	NR	5.32	4.89	5.32	5.11	6.81	NR	NR	5.75
Min.		NR	5.32	4.89	5.32	5.11	6.81	NR	NR	5.75
Max.		NR	5.32	4.89	5.32	5.11	6.81	NR	NR	5.75
Av.		NR	5.32	4.89	5.32	5.11	6.81	NR	NR	5.75

Oxidizable organic matter (OOM; mgO_2/L)										
Site	**Depth**	**Sidi-Krir**	**El-Mex**	**El-Dekhaila**	**Eastern Harbour**	**El-Shatby**	**San-Stefano**	**El-Montazah**	**Abu-Qir Head**	**Abu-Qir Bay**
1	Surface	3.65	3.65	0.30	0.91	4.56	NR	NR	2.58	0.30
2		6.38	1.52	2.13	0.15	1.06	4.86	6.08	8.36	0.61
3		0.30	1.82	14.14	1.37	0.91	1.52	2.43	1.06	1.22
4		0.30	0.30	0.30	0.76	1.06	1.82	0.76	1.67	0.61
5		NR	4.86	0.91	4.71	0.30	1.52	1.22	2.28	NR
Min.		0.30	0.30	0.30	0.15	0.30	1.52	0.76	1.06	0.30
Max.		6.38	4.86	14.14	4.71	4.56	4.86	6.08	8.36	1.22
Av.		2.66	2.43	3.56	1.58	1.58	2.43	2.62	3.19	0.68
1	10 m	0.30	1.22	0.30	0.76	1.37	NR	NR	2.13	2.43
2		0.30	3.04	0.61	NR	0.15	0.91	1.22	5.32	1.22
3		1.52	0.30	1.52	2.43	6.08	NR	0.61	0.91	7.60
4		3.38	5.47	0.91	0.76	0.30	1.82	0.91	1.52	0.46
5		NR	2.43	0.61	0.30	1.06	2.43	0.15	0.61	NR
Min.		0.30	0.30	0.30	0.30	0.15	0.91	0.15	0.61	0.46
Max.		3.38	5.47	1.52	2.43	6.08	2.43	1.22	5.32	7.60
Av.		1.38	2.49	0.79	1.06	1.79	1.72	0.72	2.10	2.93
2	20 m	0.30	0.30	10.18	0.76	0.46	3.65	1.22	1.82	0.91
3		0.61	0.30	0.61	1.06	3.19	1.98	0.91	0.61	0.61
4		1.22	0.61	NR	0.76	3.50	0.91	0.76	3.50	1.22
5		NR	1.82	0.91	0.30	0.61	0.76	1.22	1.22	NR
Min.		0.30	0.30	0.61	0.30	0.46	0.76	0.76	0.61	0.61
Max.		1.22	1.82	10.18	1.06	3.50	3.65	1.22	3.50	1.22
Av.		0.71	0.76	3.90	0.72	1.94	1.82	1.03	1.79	0.91
3	50 m	3.04	2.13	0.30	0.15	4.71	2.28	1.06	0.76	1.06
4		0.91	0.91	1.22	0.15	1.37	3.95	0.46	6.84	1.22
5		NR	1.52	1.22	1.06	2.13	0.15	0.61	4.86	NR
Min.		0.91	0.91	0.30	0.15	1.37	0.15	0.46	0.76	1.06
Max.		3.04	2.13	1.22	1.06	4.71	3.95	1.06	6.84	1.22
Av.		1.98	1.52	0.91	0.46	2.74	2.13	0.71	4.15	1.14
4	100 m	4.56	0.46	0.91	0.15	2.89	4.86	1.82	1.98	0.91
5		NR	0.61	0.61	0.76	1.22	0.61	6.23	2.13	NR
Min.		4.56	0.46	0.61	0.15	1.22	0.61	1.82	1.98	0.91
Max.		4.56	0.61	0.91	0.76	2.89	4.86	6.23	2.13	0.91
Av.		4.56	0.53	0.76	0.46	2.05	2.74	4.03	2.05	0.91
5	200 m	NR	NR	NR	1.82	2.58	1.37	0.30	0.91	NR
Min.		NR	NR	NR	1.82	2.58	1.37	0.30	0.91	NR
Max.		NR	NR	NR	1.82	2.58	1.37	0.30	0.91	NR
Av.		NR	NR	NR	1.82	2.58	1.37	0.30	0.91	NR

Total Alkanility (T. Alk.; meq/L)										
Site	Depth	Sidi Krir	El-Mex	El-Dekhaila	Eastern Harbour	El-Shatby	San-Stefano	El-Montazah	Abu-Qir Head	Abu-Qir Bay
1	Surface	2.80	2.95	2.85	2.80	3.00	NR	NR	3.10	2.80
2		2.40	2.90	3.25	2.95	3.00	3.20	3.30	2.90	3.10
3		3.00	3.20	2.90	2.65	3.00	3.10	3.00	2.95	2.95
4		2.90	3.20	2.90	3.00	3.20	3.60	3.10	2.95	2.95
5		NR	2.90	2.80	2.80	3.00	3.10	3.05	2.90	NR
Min.		2.40	2.90	2.80	2.65	3.00	3.10	3.00	2.90	2.80
Max.		3.00	3.20	3.25	3.00	3.20	3.60	3.30	3.10	3.10
Av.		2.78	3.03	2.94	2.84	3.04	3.25	3.11	2.96	2.95
1	10 m	3.20	3.00	2.90	2.90	3.20	NR	NR	3.05	2.90
2		3.20	2.90	2.85	NR	2.85	3.10	3.20	3.00	2.95
3		3.10	2.90	2.85	3.40	3.30	NR	3.00	3.00	3.10
4		3.10	2.90	2.90	2.80	2.85	3.05	3.10	3.00	3.00
5		NR	2.90	2.85	3.00	3.00	3.30	2.95	3.00	NR
Min.		3.10	2.90	2.85	2.80	2.85	3.05	2.95	3.00	2.90
Max.		3.20	3.00	2.90	3.40	3.30	3.30	3.20	3.05	3.10
Av.		3.15	2.92	2.87	3.03	3.04	3.15	3.06	3.01	2.99
2	20 m	3.00	3.00	3.05	2.65	2.90	3.20	3.05	3.05	3.00
3		2.95	3.00	2.85	2.80	2.90	3.10	NR	3.10	2.80
4		3.10	2.90	NR	2.80	2.95	2.95	2.90	3.30	3.05
5		NR	2.95	2.95	2.80	3.00	3.20	2.90	NR	NR
Min.		2.95	2.90	2.85	2.65	2.90	2.95	2.90	3.05	2.80
Max.		3.10	3.00	3.05	2.80	3.00	3.20	3.05	3.30	3.05
Av.		3.02	2.96	2.95	2.76	2.94	3.11	2.95	3.15	2.95
3	50 m	3.00	3.15	2.75	3.00	3.10	3.70	2.90	3.05	3.00
4		2.90	2.80	2.75	2.85	2.80	3.00	2.85	3.00	3.00
5		NR	2.15	2.85	2.90	3.05	3.15	3.00	2.85	NR
Min.		2.90	2.15	2.75	2.85	2.80	3.00	2.85	2.85	3.00
Max.		3.00	3.15	2.85	3.00	3.10	3.70	3.00	3.05	3.00
Av.		2.95	2.70	2.78	2.92	2.98	3.28	2.92	2.97	3.00
4	100 m	3.30	3.05	2.85	3.00	3.20	3.20	3.05	3.10	2.95
5		NR	2.90	2.80	2.80	3.00	3.00	3.00	3.00	NR
Min.		3.30	2.90	2.80	2.80	3.00	3.00	3.00	3.00	2.95
Max.		3.30	3.05	2.85	3.00	3.20	3.20	3.05	3.10	2.95
Av.		3.30	2.98	2.83	2.90	3.10	3.10	3.03	3.05	2.95
5	200 m	NR	NR	3.25	2.80	3.10	3.05	3.00	3.10	NR
Min.		NR	NR	3.25	2.80	3.10	3.05	3.00	3.10	NR
Max.		NR	NR	3.25	2.80	3.10	3.05	3.00	3.10	NR
Av.		NR	NR	3.25	2.80	3.10	3.05	3.00	3.10	NR