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Study on water quality along the coastal zone of Abu- Qir Bay, Mediterranean Sea, Alexandria, Egypt

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Abstract

The present study aims to determine the physico-chemical parameters of Abu-Qir Bay, and throw light on the effect of pollution on the area of study. The nutrient concentrations in the coastal zone of the bay were in the following ranges: 7.39-26.37 µmol./l for ammonium in summer and 3.23–18.67 µmol./l in winter, 0.12–1.40 µmol./l and 0.29–1.52 µmol./l for nitrite and 1.16-0.53 µmol./l, 0.29-0.99 µmol./l for nitrate during summer and winter seasons respectively. Dissolved inorganic phosphate ranged from 0.20 to 0.53 µmol./l, 0.41±0.15 µmol./l in summer and from 0.33 to 1.08 µmol./l, 0.76 ± 0.34 µmol./l in winter. Reactive silicate ranged from 0.09 to 0.19 µmol./l, 0.30 ± 0.21 µmol./l and 0.11-0.85 µmol./l, 0.76 ± 0.29 µmol./l during summer and winter seasons respectively. The results for ammonium concentrations showed a remarkable increase in the level of nitrogen. The different of inorganic nitrogen forms were in the following order: $NH_4 > NO_2 > NO_3$. The concentrations of dissolved oxygen ranged from 2.149 to 7.31 ml./l with a mean value of 5.01 ± 1.86 ml/l, during summer and 4.21-10.49 ml/l with an average of 6.79 ± 2.4 ml/l, in winter season. Biochemical oxygen demand had concentrations ranged from 1.98 to 3.50 mg/l, 2.99 ± 0.60 mg/l, 2.14 -3.71 mg/l with a mean value of 3.15 ± 0.70 mg/l during summer and winter seasons, respectively. The concentrations of chemical oxygen demand ranged from 6.39 to 17.15 mg/l, with a mean value of 7.99 ± 2.7 mg/l were determined during summer season. The averages of phosphate and silicate concentrations were 0.41 ± 0.15 µM/l, 0.30 ± 0.21 µM/l and 0.76 ± 0.34 µM/l, 0.76 ± 0.29 µM/l, during summer and winter seasons respectively. The dissolved inorganic nitrogen, reactive inorganic phosphate and silicate had ratios of 39.6:1:0.7. The maximum and minimum water temperature averages were measured in summer (26.34 ± 0.23ºC) and in winter (16.06 ± 0.31ºC) indicate that temperature is a seasonal dependant. Low pH values (7.72-8.07) and (7.34-7.42) during summer and winter seasons, respectively. The salinity levels were dependant on the amount of freshwater discharged from the effluents of land-based sources, reflecting low levels of salinity (28.70 psu) near the discharging points. The winter season showed higher values of salinity might be owed to; winter closure period (low flow), the shallowness of the bay with increasing the rate of evaporation and wind directions. Monitoring of Abu-Qir Bay water Quality is recommended for short and long term variations of water quality and mitigate outbreak of health disorders to determine the impacts on the aquatic ecosystem.

Keywords: Abu-Qir Bay, nutrient salts, hydrographic conditions.

1. Introduction

Abu-Qir Bay is located on the Mediterranean Sea to the west of the Nile delta of Egypt. It belongs to three provinces (Alexandria, Behaira and Kafr El sheikh) and it includes important historic cities Abu-Qir, Edku and Rosetta. Abu-Qir Bay is considered as one of the most important natural habitats for marine organisms in the region**.** It is a semi-enclosed Mediterranean basin in Egypt, receiving huge amounts of untreated sewage and industrial wastewaters (Saad and Younes (2006). The discharged wastes come from identified sources; industrial water of El- Tabia outfall, brackishwater of Lake Edku discharged through El-Maadyia outlet and freshwater from Rosetta Branch of River Nile. About $183x10^6$ m^3 of untreated domestic sewage and wastewaters are discharged annually from land-based sources into the coastal waters of Alexandria (Saad and Younes, 2006). Along the coast of Abu -Qir Bay there are about 22 different factories representing food processing and canning, paper mill, fertilizers, textile manufacturing and gas exhaust (Alam El-Din, 2001). These factories dump wastes through El-Tabia pumping station situated at the southwestern extremity of the bay (Aboul Naga,

et al. (2002). The water circulation in the bay is mainly wind dependent. Current measurements in the bay, carried out by El-Sharkawy and Sharaf El-Din (1974), during March, indicated a NW current with a speed of 50 $cm.s^{-1}$ at the inner bay and 5 $cm.s^{-1}$ in the outer bay. Mohamed (1981) illustrated that the monthly current measurements in the mid channel connecting the lake with the bay showed a predominant lake-bay flow all the year round, with a maximum speed between 60 and 100 $cm.s^{-1}$ along the axis. Several studies have been done on the water masses and transport of pollutants in the bay such as: El Samra (1973), Dowidar, *et al.* (1976), Mohamed (1981), Said (1989), Alam El-Din (2001), Abdel-Moati (2001), Aboul Naga, *et al*. (2002), Faragallah (2004), Saad and Younes (2006), Kamal (2008) and El-Gohary *et al.* (2011). A comparison between the averages obtained from the present study with the corresponding ones previously recorded in the other studies was carried out for illustrating the pollution status in the study area. The present study aims to investigate the hydro and physico-chemical parameters and throws light on the water quality of Egyptian Mediterranean coastal area.

2. Area of study

Abu-Qir Bay is a shallow semi-circular basin and is one of the most polluted area along the Egyptian Mediterranean coast and extends between Longitude 30º.07 and 30º 22/ E at Abu-Qir Peninsula and Latitude-31º.20/- 31º 29/ North at Rosetta Branch of River Nile, (Table 1 and Figure. 1). It runs along a shoreline of about 50 km. It has an area of 360 $km^2$and the maximum depth of the bay was 9 m with an average of 3.8 m (Saad and Younes, 2006). The bay is bordered from the west by Abu-Qir Peninsula and from the east by Rosetta Peninsula where Rosetta Branch of the River Nile flows into the sea (Nasr *et al*. 1997). The bay receives agricultural drainage water from the coastal Lake Edku through the narrow channel El-Maadya (about 200 m long and 2 m deep) and the annual average of discharged water is about $1000x10^6$ m^3 (Saad and Younes, 2006). In addition, freshwater discharged to the bay through Rosetta mouth at the extreme eastern edge was about $1.2x10^6$ m^3/d (Faragallah, 2004).

Table 1. Location of the marine sampling stations of Abu-Qir Bay.

Station No.	Latitude			Longitude		
1	31º	31´	76´´	30º	07´	04´´
2	31º	27´	06´´	30º	17´	50´´
3	31º	27´	31´´	30º	18´	72´´
4	31º	32´	05´´	30º	28´	42´´
5	31º	44´	38´´	30º	35´	86´´

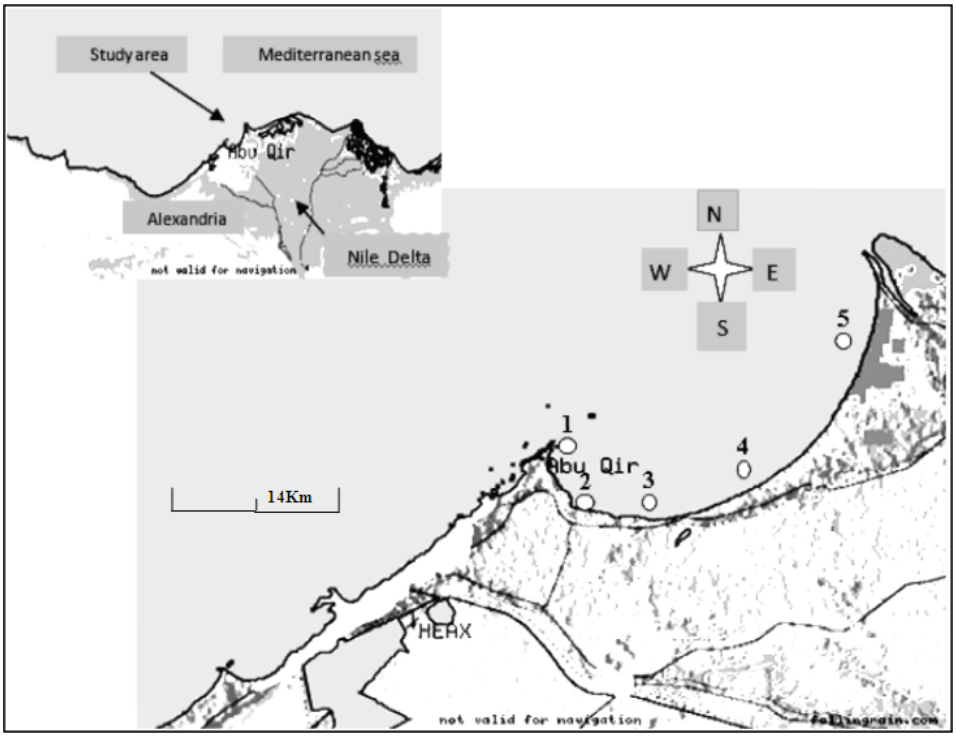

Figure 1. Location Map of water stations in Abu-Qir Bay-Alex.

3. Material and methods

Water samples were collected during summer 2009 and winter 2010, to explore the effect of pollutions (industrial, agricultural and land-based sources) on Abu-Qir Bay. Surface water samples were collected in duplicate from 5 stations, during summer 2009 and winter 2010, using pre-cleaned water sampler (1L), the water samples were drown to pre-cleaned plastic PVC bottles and preserved in an ice box for analyses. All laboratory equipments and containers were washed in HCl solutions and rinsed with de-ionized water prior each use. All reagents used were analytical reagent grade (merck - Germany). The water samples were subjected to determine; water temperature, pH, salinity (S psu) dissolved oxygen (DO) and ammonium NH_4-N. They were measured directly in situ using the Metter Toledo probes. These probe measurements were calibrated for each of the parameters. Dissolved oxygen was measured by the Azide modification of Winkler method according to APHA (1985). Nutrient salts (nitrite, nitrate, dissolved inorganic phosphate and reactive silicate SiO_4-Si were determined in filtered water samples (using GF/Cfilters), following the techniques described by Strickland and Parsons (1972). Chemical oxygen demand (COD) and Bio-chemical oxygen demand (BOD) were measured following the procedure described by Carlberg (1972). A shimadzue double beams spectrophotometer UV-150-02 was used for measurements.

R-mode factor analysis:

The raw data were objectively classified using factor analysis. The aim of factor analysis is to reduce the complexity within the similarity matrix of a multivariate data collection and transfer it into simpler and more easily interpreted factor matrix. In the present study the factor analysis was applied following the procedure mentioned by Davis (1973) and Jöreskog *et al*. (1978). During the present study, four factors have been obtained. The factors had eigenvalues greater than or equal to one. So the initial communality estimates have been set to assume that all of the variability in the data is due to those four common factors.

4. Results and Discussions

4.1. Physico-chemical parameters of water samples

4.1.1. Surface water temperature

(T ºC) was recorded in Abu–Qir Bay at five stations during summer and winter. The water temperature ranged from 26.0 to 26.6ºC in summer and 15.6-16.4ºC in winter. The mean values of water temperature were found to be 26.36 ± 0.23ºC and 16.06 ± 0.31ºC during summer and winter respectively, with a minimum value of 15.60ºC at station (2) in winter and a maximum value of 26.6ºC at station (2) in summer (Table 2 and Figure 2a). The homogeneity of water Temperature in each season might be attributed to the continuous discharged water from El-Tabia pumping station, El-Maadya outlet and Rosetta Branch of River Nile. The variations of water temperature were related to some factors: seasonal variations, time of samples collection, wind and current speed. Water circulations, as well as, pollutant in Abu-Qir Bay are largely affected by the wind regime (Alam El-Din, 2001). Seasonal averages of water temperature confirmed the role of seasonal variations as a controlling factor of temperature in the Bay. The seasonal ranges recorded in the present study were comparable to the previous investigations of the bay and some other coastal Mediterranean waters showed in (Table 3).

4.1.2. pH

pH value is an important factor in the chemical and biological system of natural waters. pH values are illustrated in Table 2 and Figure 2b. In the current investigation it ranged from 7.68 to 8.07 in summer at stations 5 and 8 respectively, and from 7.34 to 7.42 at stations 2,4,5 respectively for winter season. The highest pH values 8.07 and 7.68 were recorded at stations 4 and 5 during summer might be owed to locations of these stations were away from the points of discharges (El-Tabia pumping station and El-Maadya outlet), while the lowest values (7.34 and 7.35) were recorded at stations 2 and 3 during winter, might be due to the introduction of low-pH water in to the bay. pH values were greatly affected by drainage water (Khater, 2001). pH seemed to be slightly alkaline which could be owed to photosynthesis activities of phytoplankton and aquatic plants, temperature and the amount of organic constituents (Hutchinson, 1957). The ranges of pH recorded

during the present study compared to the previous investigations of Abu-Qir Bay, Eastern and Western Harbors and Egyptian Mediterranean Sea water were showed in Table 3.

4.1.3. Salinity (psu)

The values of salinity fluctuated between 28.7 to 39.9 psu at stations 2 and 1, respectively in summer and 37.4 to 40.5 psu at stations 3 and 5, respectively, in winter season with mean values of 35.1 ± 4.3 psu in summer and 38.66 ± 1.22 psu in winter (Table 2 and Figure 2c). In the present study, salinity shows a general trend to increase towards the offshore stations (40.5 psu) due to mixing with Mediterranean coastal waters. The variation of salinity was significant due to the effect of wastewater discharging to the bay via El-Tabia pumping station and El- Maadya outlet, as well as freshwater derived from land-based sources. Therefore, the salinity values near the points of discharges were low compared to those normally present. Abdel-Moati (1991) suggested that: during the low flow period (winter), the salinity values in the coastal area of Alexandria were more than 22 psu. He also reported that; at the line adjoining the headlands, salinity in both periods ranged between 35psu and 38psu. The salinity values recorded during the present study and some of the previous studies carried out on Abu-Qir Bay, Eastern and Western Harbors were presented in Table 3, reflecting the influence of freshwater discharges from the land based sources.

4.1.4. Dissolved Oxygen (DO)

DO is considered as one of the most important and useful parameters for the identification of different water masses and in assessing the degree of pollution in marine environment (Fahmy, 2001). The dissolved oxygen values of the study area are given in Table 2 and Figure 3a, 3b. It ranged from 2.15- to 7.31 ml/l in summer with an average value of 5.01±1.86 ml/l and from 4.21 to 10.49 ml/l during winter season with an average of 6.79±2.41 ml/l. The maximum concentration values of DO were (7.31 and 10.49 ml/l) at station 5 during summer and winter seasons, respectively. The oxygen measurement at this station indicated well oxygenated water might be owed to the outlet of Rosetta Branch of River Nile which is close to station 5. In addition to the great wind action increases the solubility of water oxygen (Stefansson, *et al.,* 1987). The lowest values 2.15 and 4.21 ml/l were recorded at stations 3 and 1 during summer and winter seasons respectively. The lower values could be attributed to the effect of the drainage water poor in oxygen due to consumption of oxygen through the oxidation of organic materials (Table2). Abbas *et al.* (2001) suggested that the average concentrations of DO in Lake Edku were 9.44, 7.40, 9.49 and 6.72 mgO_2/l (6.61, 5.18, 6.64 and 4.70 ml/l) during winter, spring, summer and autumn, respectively, he also found that the oxygen content in the water of Lake Edku attained its minimum values at the part near to the outlets of El-khairy and Barsik drains. Most of the previous studies concerned with the present investigation which indicates that the oxygen content in the surface water of Abu-Qir Bay attained its minimum values 4.9 ml/l (Abdel-Moati, 2001) near to outlets of El-Amyaa Drain and El-Maadya.

Table 2. Physic-chemical parameters of surface sea water in summer and winter seasons (2009-2010) of Abu-Qir Bay.

Season	Station	TÖºC	pH	S‰	DO ml /L	BOD mg/L	COD mg/L	$NO_{2\text{-}N}$ µM/L	$NO_{3\text{-}N}$ µM/L	$NH_{4\text{-}N}$ µM/L	DIN µM/L	$PO_{4\text{-}P}$ µM/L	$SiO_{4\text{-}Si}$ µM/L
summer	1	26.30	7.98	39.9	5.59	3.15	10.48	0.65	1.16	9.02	10.38	0.20	0.61
	2	26.60	7.98	28.7	5.05	3.50	11.78	1.16	0.34	26.37	27.87	0.52	0.21
	3	26.40	7.72	33.8	2.15	1.98	6.39	1.40	0.73	24.03	26.16	0.53	0.41
	4	26.00	8.07	35.0	4.95	3.32	11.25	0.47	0.26	7.39	8.12	0.47	0.09
	5	26.50	7.68	38.0	7.31	3.05	17.15	0.12	0.16	7.89	7.18	0.31	0.19
	Min.	26.00	7.68	28.7	2.15	1.98	6.39	0.12	0.16	7.39	7.18	0.20	0.09
	Max.	26.60	8.07	39.9	7.31	3.50	17.15	1.40	1.16	26.37	27.87	0.53	0.61
	Mean	26.36	----	35.1	5.01	3.00	11.41	0.76	0.53	14.94	16.23	0.41	0.30
	SD±	0.23	----	4.30	1.86	0.60	3.90	0.52	0.41	9.42	10.19	0.15	0.21
winter	1	16.30	7.40	40.5	4.21	2.69	NM	0.29	0.29	3.23	3.81	0.33	0.85
	2	15.60	7.34	37.4	5.64	2.14	NM	0.83	0.55	18.67	20.05	1.01	0.27
	3	16.40	7.35	37.7	5.94	3.65	NM	1.52	0.92	17.02	19.46	0.92	0.52
	4	16.00	7.42	38.8	7.68	3.71	NM	0.92	0.99	14.70	16.61	1.08	0.11
	5	16.00	7.42	38.9	10.49	3.55	NM	0.43	0.36	5.91	6.70	0.47	0.29
	Min.	15.60	7.34	37.4	4.21	2.14	------	0.29	0.29	3.23	3.81	0.33	0.11
	Max.	16.50	7.42	40.5	10.49	3.71	-------	1.52	0.99	18.67	20.05	1.08	0.85
	Mean	16.06	-----	38.66	6.79	3.15	------	0.80	0.62	11.85	13.27	0.76	0.76
	SD±	0.31	-----	1.22	2.41	0.70	------	0.48	0.32	6.91	7.34	0.34	0.29

Note: NM; not measured

Table 3. Values of water temperature ºC, pH and S psu in the present study compared with previous investigations.

Marine area	Depth	TºC	pH	S ‰	Reference
Abu-Qir Bay	Surface	15.6-26.6	7.34-8.07	28.7-41.9	Present study
Abu-Qir Bay	Surface	16.0-29.3	7.13-8.38	5.25-40.2	Saad, & Younes. 2006
Abu-Qir Bay	Surface	15.4-29.5	7.20-8.72	----------	El- Deeb, 1977
Eastern harbor	Surface	16.9-29.2	7.80-8.58	34.8-38.8	Aboul- Kassem,1987
Western harbor	Surface	15.1-27.8	7.00-8.81	26.2-39.4	Hemeda, 1982

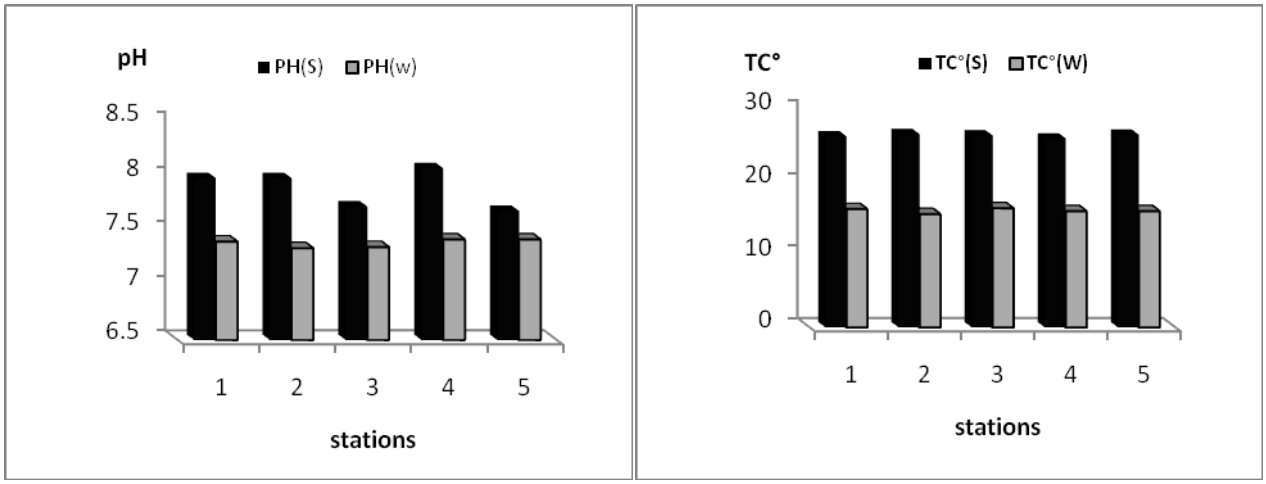

Figure 2a, 2b. Temperature and pH variations during summer and winter seasons.

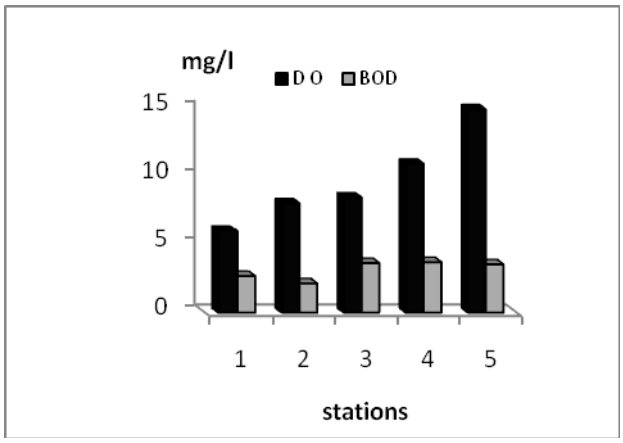

Figure 3b. DO and BOD variations during winter.

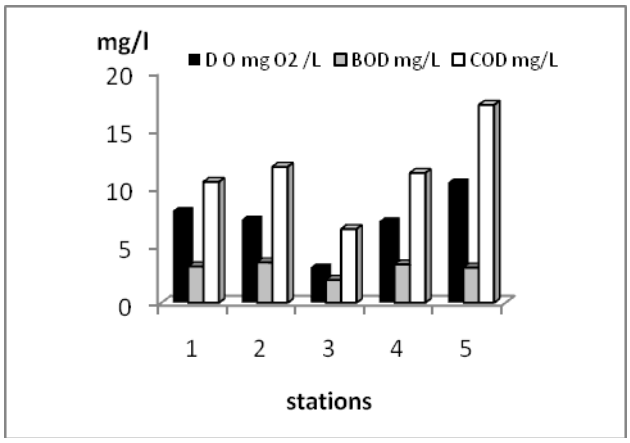

Figure 3a. DO and BOD variations during summer.

4.1.5. Chemical Oxygen Demand (COD)

Chemical oxygen demand is a measure of the capacity of water to consume oxygen during the decomposition of organic matter and oxidation of inorganic chemicals such as ammonia and nitrite. In our study, COD values ranged between 6.39 to 17.15 mg/l at stations 3 and 5, respectively in summer, with an average of 11.41 ± 3.90 mg/l in summer season (Table 2). The increase of COD may be attributed to industrial, agricultural and sewage drainage containing organic and inorganic compounds lead to oxygen consumption which appear in the concentration of biochemical oxygen demand and chemical oxygen demand (Zyadah, 1995). Station 3 showed reduction of: DO (2.15 ml/l), COD (6.39 mg/l) and BOD (1.98 mg/l), suggesting that, this station suffers from industrial, domestic and agricultural inputs.

4.1.6. Biochemical Oxygen Demand (BOD)

BOD represents the measurements of the amount of oxygen consumed by microbial oxidation and is most relevant to waters rich in organic matter. The concentration values ranged between 1.98 and 3.32 mg/l at stations 3, 4 respectively in summer season and from 2.14 to 3.71 mg/l at stations 2,4, respectively in winter season with an averages of 2.99 ± 0.60 and 3.15 ± 0.70 mg/l in summer and winter, respectively, (Figure 3a and 3b). The maximum values of BOD resulting from anthropogenic activities were recorded at stations 4 and 5 which are located near Rosetta Branch of River Nile. The decrease of BOD was observed at station 3 which is located near from the land-based sources, might be attributed to increase the levels of organic matter and nutrients. Station 5 showed an increasing in the three types of oxygen (10.44, 17.15 and 3.05 mg/l) DO, COD and BOD respectively, owing to the effect of mixing zone of the open sea and the bay, which is relatively less affected by the sources of pollution.

4.2. Nutrient salts: Inorganic nitrogen compounds

4.2.1 Ammonium NH_4-N

The data of ammonium, nitrite and nitrate are listed in Table2 and represented graphically in (Figure 4a and 4b). Ammonium is a nitrogenous end product, produced from bacterial decomposition of organic matter containing nitrogen. It is also an important excretory product. The nitrogen is first released in a reduced form as ammonium ions or ammonia depending on the ambient pH value (Vanloon and Duff, 2000). In the present investigation the levels of ammonium were generally high at most locations of Abu-Qir Bay surface water probably resulting from increasing level of human activity impact and drainage of wastewater. The maximum values 26.37 µM/l and 18.67µM/l) were detected at station 2 in winter and summer, respectively, and a minimum values of (7.39 and 3.23 µM/l) at stations (1,4,5) during summer and winter respectively. The mean values of (14.94 ± 9.2 µM/l and 11.85 ± .9 µM/l) were recorded in summer and winter respectively. Harvey (1974) stated that, most species of phytoplankton utilize ammonium ions in preference to other inorganic nitrogen species. This might explain the decrease of ammonium at some stations. Vanloon and Duff (2000) explained that the use of ammonium containing fertilizer is a source of ammonium ion in water.

4.2.2. Nitrite NO_2-N

NO_2 -N is the most unstable compound of inorganic nitrogen forms because of its intermediate position in oxidation /reduction processes between NH_4 and NO_3 (Riley and Chester, 1971; Fahmy, 2001). Moreover according to Abdel-Moniem (1977) nitrite results in the aquatic environment mainly from biochemical oxidation of ammonia (nitrification) or the reduction of nitrate (denitrification). In the area of investigation NO_2-N fluctuated between maximum values of 1.4 µM/l and 1.52 µM/l at station 3 during summer and winter, respectively, (Table 2 and Figure 4a and 4b). The highest values might be attributed to reduction of nitrate to nitrite by reductase enzyme, increase of nitrification of free ammonium into nitrite and denitrification of nitrate into nitrite and/or to the use of ammonium containing fertilizers. The lowest concentrations were 0.12 µM./l at station 5 in summer and 0.29 µM/l at station 1 in winter with mean values of (0.80 ± 0.48 and 0.76 ± 0.52 µM./l) in winter and summer, respectively. The depletion of nitrite at some stations may be due to increase the rate of oxidation of nitrite to nitrate or reduction of nitrite to ammonium and/or the uptake of nitrite by phytoplankton.

4.2.3. Nitrate NO_3-N

NO_3-N is the most stable form of inorganic nitrogen in oxygenated water. It is the end product of nitrification process in natural water (Abbas *et al.,* 2001). In the present investigation, NO_3-N revealed its maximum values of 1.16 and 0.99µM/l at stations 1 and 4 during summer and winter, respectively. The lowest concentrations were 0.16 µM/l at station 5 in summer and 0.29 µ M/l at station 1 in winter (Table 2 and Figure 4a and 4b). The seasonal nitrate averages were (0.53 ±0.41 µM/l) in summer and (0.62 ± 0.32 µM/l) in winter. These values decreased twice than those reported by Saad and Younes (2006) (1.36 ± 0.86 µM/l) during summer season. It can be explained on the bases of the increase in nutrient utilization by phytoplankton blooms during summer season. The highest values of nitrate may be attributed to the high content of organic matter discharged to the bay via El-Tabia Pumping station, El-Amyaa Drain and El-Maadya outlet containing sewage, industrial and agricultural effluents contains nitrate. Low concentration was observed at station 5 which is affected by open Mediterranean Sea water.

The obtained concentrations of dissolved inorganic nitrogen DIN (NH4-N, NO_3-N, and NO_2-N) from surface coastal water of Abu-Qir Bay indicate that nitrogen in the form of inorganic compounds is so high. The highest

values of DIN were 26.16 and 27.87 µM/l observed at stations 3, 2 in summer season and 20.05, 19.46 µM/l were showed at the same stations (2, 3), in winter season, these explain the impact of anthropogenic activities, as well as, El-Tabia Pumping station on the study area. The different inorganic nitrogen forms take the following order NH_4-N > NO_2-N > NO_3-N, reflecting increase the rate of NH_4 production or increase the rate of NO_3 consumption.

4.2.4. Reactive silicate SiO_4-Si

Silicate is a good indicator for fresh water and potential for diatom blooms. It is the second most abundant element in the earth's crust and there are innumerable mineral sourced of silica for natural water, but most are quite resistant to chemical processes (Faust and Aly, 1981; Abbas *et al*, 2001). In the present study, the concentrations of SiO_4-Si record their maximum values of 0.61 and 0.85 µM/l at station 1 in summer and winter, respectively, Table 2 and Figure 5a, b While the minimum values were (0.09 and 0.11 µM/l) at station 4 in summer and winter, respectively, with an average values of 0.3 0 ± 0.21 µM/l during summer and 0.76 ± 0.29 µM/l in winter. It is noted that the concentrations of reactive silicate were considerably high during the winter season. However SiO_4.Si concentrations in Abu-Qir Bay showed depletion of silicate in the summer season may be due to biological activity of diatoms (Hutchinson; 1957).

Fahmy (2001) recorded the annual average values of reactive silicate varied between 0.81 to1.04 µM/l, and owed the distribution pattern of silicate in the surface water of Aqaba Gulf to main factors: vertical mixing, biological consumption, solution of diatoms frustules and partial dissolution of quartz and clay particles transported to the sea.

4.2.5. Dissolved inorganic phosphate PO_4-P (DIP)

Phosphorus plays an important role for plants and micro- organisms. Also it is used as indicator for pollution from run-off in agricultural areas or domestic sewage. In the present investigation, the concentrations of phosphate recorded their maximum values of 1.08 µM/l at station 4 in winter and 0.53 µM/l at station 3 in summer. The minimum values of (0.2 and 0.33 µM/l) were recorded at station 1 in summer and winter respectively. The regional averages of DIP were (0.41 ± 0.15 µM/l and 0.76 ± 0.34 µM/l) in summer and winter, respectively, Table2 and Figure 5a, b. The low concentrations of DIP might be attributed to growth of macrophytic species and the availability of calcium in water (Vanloon and Duffy, 2000). Abbas *et al.* (2001) recorded the concentrations of PO_4-p in Lake Edku ranged from 1.04 to 32.98 µM/l under alkaline conditions. Saad *et al*. (2006) found that total phosphorous had role in introducing large amount of DIP through the intensive discharge of fresh water during the rainy season. In a study carried out by Younes (2000), the DIP values of surface water in southwestern part of Abu- Qir Bay in front of El-Tabia pumping station ranged from 0.20-1.75µM/l. This result confirmed with the measured values of the present investigation. Another study carried out by Saad and Younes (2006) on Abu- Qir Bay, " the regional average of DIP values for the surface water were ranged from 0.36 ± 0.42 µ M/l to 2.79 ± 1.05 µM/l. The increase of PO_4 might be attributed to production of effluents from the phosphate fertilizers factory and El-Tabia pumping station discharged into the bay. The decrease of phosphorous may be related to its adsorption on hydrous Fe_2O_3 and Al_2O_3 and its consumption by algae and bacteria or aquatic weeds (Kramer *et al.,* 1972).

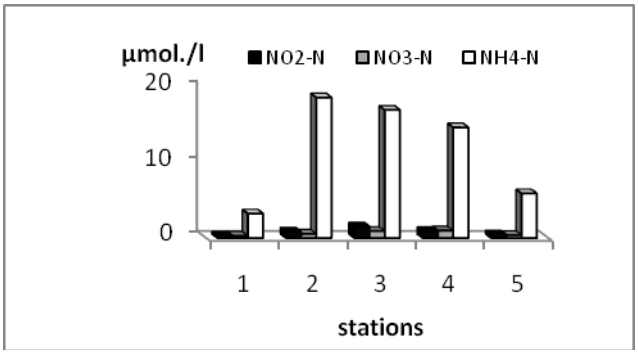

Figure 4b. Nitrogen variations in winter.

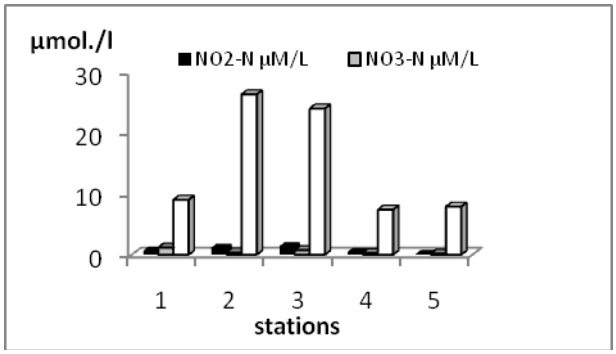

Figure 4a. Nitrogen variations during summer.

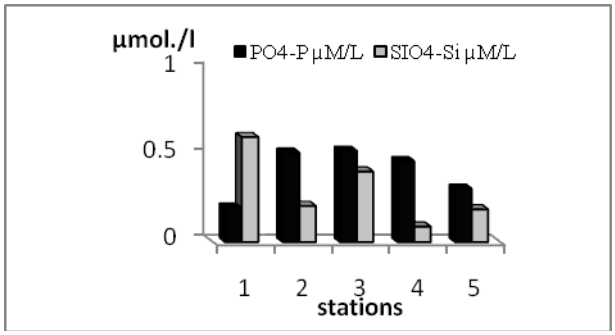

Figure 5b. PO4 and SiO4 variations in winter.

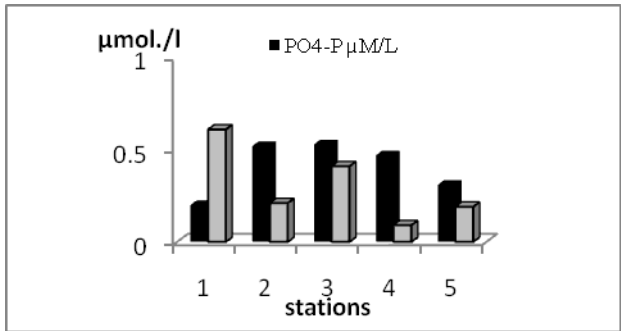

Figure 5a. PO4 and SiO4 variations in summer.

4.3. Statistical analyses

4.3.1. Correlation coefficient analysis

There are well established positive relationships between temperature and each of pH (r = 0.9) and COD (r = 0.92), refer to: with increasing temperature pH will increase and the capacity of water to consume O_2 during decomposition of organic matters will also increase. Significant negative correlations were recorded between pH and each of salinity (r = -0.74) and PO_4 (r = -0.58) indicating that phosphate increased in the coastal water and declined seaward. This may be due to decrease the anthropogenic effect in the offshore water and the uptake of phosphate by organisms. Meanwhile positive relation between DO and BOD indicating that biological activities will increase. Relationship of nitrite showed highly significant with ammonium, nitrate and phosphate, confirming that ammonium, nitrate, nitrite and phosphate derived from external sources: industrial discharges and production of fertilizers (Table 4).

4.3.2. Factor analysis

The results of factor analysis are given in Table (5). It shows that hydrographic parameters and nutrients are important factors affecting the characteristics of water quality of Abu-Qir Bay.

Factor 1:

Statistically, this factor accounts for about 40.84% of the total variance among the variables. It is characterized by the association of DO, COD and salinity. It represents an oxygenated factor in which the oxygen and salinity control the nutrient species. The inverse association is indicated by the negative loading on NO_2, NH_4 and PO_4. This factor explaining the effect of freshwaters discharged from land-based sources and El-Tabia pumping station on the salinity and living organism.

Factor 2: it accounts for about 25.91% of the total variance among variables and shows the association of NO_3 and SiO_4. The inverse association is indicated by the negative loading on DO, COD, BOD and PO_4 indicating biological activities. The present study shows that NO_3 and SiO_4 increase with decreasing each of NO_2, NH_4 and PO_4, explaining that ammonium, nitrate, nitrite and phosphate derived from external sources: industrial discharges and/or production of fertilizers factory.

Factor 3: This accounts for about 10.13% of the total variance among the variables. It is characterized by the association of temperature. In which the temperature controls each of pH and salinity. It increases with decreasing all other hydrographic parameters and nutrients except ammonium which increased due to biological activities and reduction of nitrate or nitrite.

Factor 4: It is about 6.22% of the total variance among the variables. It is characterized by the association of pH and BOD. The present data show that the pH and BOD increase with decreasing temperature, salinity, COD and nutrients.

Table 4. Correlation Matrix of various parameters in surface water of Abu-Qir Bay (level of significance 0.63 at p = 0.05).

parameter	T°C	pH	S‰	DO	BOD	COD	NO_2	NO_3	NH_4	PO_4	SiO_4
TC	1.00										
pH	0.90	1.00									
S%	-0.77	-0.74	1.00								
DO	-0.42	-0.34	0.50	1.00							
BOD	-0.11	0.09	0.03	0.62	1.00						
COD	0.92	0.81	-.65	-.18	0.03	1.00					
NO_2	-.03	-0.07	-.38	-.40	-0.04	-.28	1.00				
NO_3	-.14	-.10	0.18	-.08	0.10	-.31	0.55	1.00			
NH_4	0.21	0.10	-.66	-.42	-.21	0.02	0.84	0.25	1.00		
PO_4	-.062	-0.58	0.16	0.13	0.08	-.61	0.54	0.35	0.45	1.00	
SiO_4	-0.21	-0.24	0.40	-.35	-0.27	-.31	0.00	0.23	-.27	-.35	1.00

Table 5. Varimax rotated component matrix for nutrient salts and hydrographic conditions of Abu-Qir Bay.

Variables	Components			
	1	2	3	4
TºC	0.024	0.014	0.976	-0.215
pH	-0.123	0.045	-0.333	0.934
S ‰	0.640	0.536	-0.461	-0.302
DO	0.954	-0.130	0.151	0.226
BOD	0.495	-0.226	0.104	0.832
COD	0.893	-0.386	0.226	0.045
NO_2	-0.929	0.177	0.324	-0.017
NO_3	-0.219	0.972	-0.84	0.023
NH_4	-0.773	-0.082	0.628	-0.025
PO_4	-0.771	-0.631	0.088	-0.015
SiO_4	-0.108	0.981	0.091	-0.130
% of variance	40.844	25.909	10.126	6.221
Cumulative%	40.844	66.753	76.879	83.122

Conclusion and recommendations

- The results showed that the temperature ranges were seasonally dependent and comparable to previous record.
- The salinity values showed depletion near the discharges points and had trend to increase towards the offshore.
- pH values were greatly affected by drainage water and seemed to be slightly alkaline.
- The different inorganic nitrogen forms take the following order NH_4-N > NO_2-N > NO_3-N, reflecting increase the rate of NH_4 production or increase the rate of NO_3 consumption. Ammonium concentrations showed marked increase near the discharges points and had tendency to decrease away from land-based sources.
- Generally, there are gradual improvement in the water quality of Abu-Qir Bay have been noticed during this study and the last few years might be due to the Egyptian Environmental law No.4/1994. Constant monitoring of Abu-Qir Bay water Quality is recommended to record any alteration in the quality and mitigate outbreak of health disorders, as well as, the determination of impacts on the aquatic ecosystem. Pretreatment system must be done for industrial wastewaters depending on the type and the concentrations of pollutants.

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دراسة نوعية المياه في المنطقة الساحلية بخليج ابو قير الأسكندرية

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يهدف البحث الي تعيين العناصر الفيزيوكيمائية في خليج أبو قير كما يرمي الي القاء الضوء علي تأثير الملوثات علي منطقة الدراسة وقد تم تفسير انخفاض قيمة الأس الهيروجيني نتيجة لتأثير الصرف الصناعي من خلال محطة طلمبات الطابية كما ارتبطت درجة الملوحة بكمية المياه العذبة المنصرفة من المصارف المختلفة وقد وصلت الي ادني قيمة لها وهي 28.7 psu كما اتضح ارتفاع قيمة الملوحة خلال فصل الشتاء نتيجة لضحالة الخليج وزيادة معدلات التبخر وكذا تأثير الرياح.

وقد بينت الدراسة ان ترتيب تركيزات النيتروجين في صوره المختلفة كان كالتالي: الامونيوم> نيتريت> نترات.

وعلي وجه العموم فأن تركيزات العناصر المغذية كانت في حدود المسموح به طبقا لقانون البيئة المصري وقد اوصت الدراسة بضرورة اجراء رصد دوري علي المدي القريب والبعيد للتغييرات الفيزيوكيميائية التي تطرأ علي الخليج وذلك للوقاية من اي تأثيرات يمكن ان تسبب اختلالا في التوازن البيئي بمنطقة الدراسة.