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Environmental Parameters of Alexandria Inshore North Western Coastal Area, Egypt

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Abstract: The study area was located in the north western coast of Alexandria, Egypt. Seven sectors were chosen for environmental study; El Dekhela, Kilo 21, Sidi Krir, Sumid, Marakia, El Hammam and Marbilla village. Seawater samples were collected from both surface and bottom coastal stations during winter, spring and summer seasons during 2006 from 5m, 10m and 20m depth. Physicochemical parameters: temperature, pH, salinity ‰, total alkalinity, nutrient salts (nitrite, nitrate, phosphate and silicate) and major cations (calcium and magnesium) were measured. The obtained results showed that the study of the temperature reveals very small changes in seawater of the studied sectors for winter season and ranged between 19.8°C-20°C, in spring season, temperature varied between 21.9°C -22.7°C while in summer season temperature fluctuated between 29°C-32°C. pH values in winter were 8.2, in spring season pH fluctuated between 7.35 and 8.35 and in summer season pH lied in the range 7.65-8.15. Total alkalinity and dissolved oxygen concentrations were higher in summer season than in spring season. This is contrary to the oxidizable organic matter and nutrient salts (nitrite and nitrate) concentrations as they showed the highest concentrations in spring followed by summer and the lowest concentrations were recorded in winter season. The results also showed that, nutrient salts of the three sectors; El Dekhela, Kilo 21 and Sidi Krir were characterized by high concentrations of nutrients (nitrite, nitrate, phosphate and silicate), while the other sectors (Sumid, Marakia, El Hammam and Marbilla) have low nutrient concentrations. This may be attributed to the effect of water current direction from the east to the west carrying heavy load of nutrients from agriculture water discharge of west Nubaria drainage canal at Kilo 21. The major cations concentrations were recorded very slight variation during the three studied seasons. The average values of calcium concentrations were relatively slight higher in summer season comparing with spring and winter season. However, the average values of magnesium concentrations were almost the same.

Key words: Alexandria western area · Hydrographic parameters · Major cations · Nutrient salts · Inshore samples · Egypt

INTRODUCTION

The studied area is located in the western coast of Alexandria, Egypt, from El Dekhela to Marbilla village. It lies between Longitudes 29° 20` E to 29° 55`E and Latitudes 29° 50`N and 31° 10`N (Figure 1).

Previous studies showed that El Dekhela Harbour water is subjected to several sources of waste water. A huge volume of brackish water (7.7 x 10^6 m^3/day) loaded with domestic, agricultural and industrial wastes is discharged to El-Mex Bay through El Umoum Drain. The study reveals also that; the surface water of El Dekhela was characterized by high nutrient load particularly phosphate, nitrate also total and specific alkalinity and oxidizable organic matter while the water salinity had low values [1and2]. The water current affects on Kilo 21 sector by the agriculture water discharge of Nubaria drainage canal. The region from El-Agamy to Ras El-Tin receives a daily disposal effluents of about 6-10 millions m^3 of drainage water mixed with industrial, agricultural and sewage wastes from different sources (El Umoum Drain and El Nubaria Drain) [3and4]. Gehan and Ahmed [5] focused on the monitoring results in the Mediterranean Sea of Egypt during 2006 for the water quality (including hydrographical conditions and Eutrophication parameters). Their study was extended from El-Saloum to Rafah and found low concentration of nutrient salts observed in the western region except Sidi Krir and

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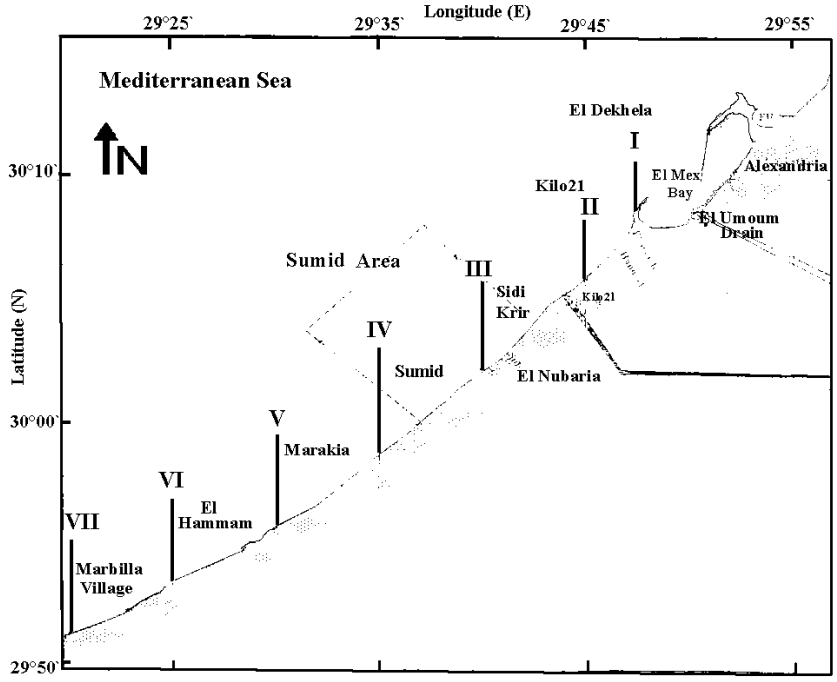

Fig. 1: Sampling location along the north western coast of Alexandria

El Nubaria which reflected oligotrophic conditions, pH values were slightly on the alkaline side and low salinity value was observed in El Nubaria which was affected by El Nubaria canal and El Dekhela which was affected by El-Mex outfall and El Umoum drain.

The aim of this work is to study the distribution of the physicochemical parameters; temperature, pH, total alkalinity, salinity ‰, dissolved oxygen and oxidizable organic matter, nutrient salts (nitrite, nitrate, phosphate and silicate concentrations) and the major cations (calcium and magnesium) in Alexandria coastal north western seawater. Also, it aims to study the impact of different discharged waters on the seawater characteristics of the selected seawater sectors.

MATERIALS AND METHODS

Seawater surface samples of (5m, 10m and 20m) depth and bottom (5m, 10m and 20m) depth were collected along Alexandria western coast from El Dekhela to Marbilla village (7sectors) (Figure 1) during winter, spring and summer seasons (2006).

Physical Parameters Measurements of Seawater

Temperature: Water temperature was measured using an inductive portable thermometer (range 0-50°C).

Salinity: Salinity was measured using Salinometer model Beckman RS-10-X3.

Chemical Parameters Measurements of Seawater

Hydrogen–Ion Concentration: The pH-value of water samples were measured to about 0.1 unit in situ by using a portable pH- meter (Orion Research model 210 digital pH- meters) after necessary precautions in sampling and standardization processes.

Alkalinity: The alkalinity is determined according to standard Methods [6]. Alkalinity is calculated from the following equation:

$$\text{Total alkalinity} = \frac{\text{ml of HCl} \times 1000 \times N_{HCl}}{\text{ml of sample}}$$

Dissolved Oxygen (DO): DO was determined according to the classical Winkler's method modified by Grasshoff [7]. The amount of dissolved oxygen in each sample was calculated by applying the following equation.

$$O_2\ \text{ml/l} = (N \times V \times 32000/4)/4(b-2) \times 1.43$$

N= Normality of sodium thiosulphate
V= Volume of sodium thiosulphate
B= Volume of oxygen bottle

Oxidizable Organic Matter (OOM): (OOM) was determined by permanganate oxidation method [8] and it is calculated from the following equation

$$\text{OOM mgO}_2\text{/L} = \frac{(\text{V blank} - \text{V sample}) \times 8 \times 1000 \times \text{N } Na_2S_2O_3}{\text{V of sample}}$$

Nutrient Salts: The most important dissolved inorganic forms of nitrogen (nitrite and nitrate), phosphate (PO_4^{3-}) and silicate (SiO_3^-) were determined colorimetrically according to the methods described by Parsons *et al.* [9]. Their absorbance's were measured by using a Double-Beam spectrophotometer model Shimadzu UV-150-02. The values were expressed as μmol/l.

Calcium and Magnesium: Calcium and magnesium were determined titrimetrically according to Heron and McCarthy method [10] using EDTA standard solution and EBT indicator.

Chlorinity was calculated from salinity values according to the empirical formula:

$$S\text{ ‰} = 1.80655\ Cl\text{ ‰}$$

RESULTS AND DISCUSSION

Physico-Chemical Characteristics in Seawater at Different Seasons of Alexandria Inshore Western Coastal Area During 2006

Winter Season: Samples were collected from three sectors; Kilo-21, Sidi Krir and Sumid (Figure 1). Temperature varied between 19.8°C and 20°C for all stations, this narrow range of change is due to the effect of turbulence of seawater during winter season, also surface and bottom waters were homogeneous for pH values. pH values recorded 8.2 except the value of 8.1 of 10m surface sample of Kilo-21 sector. These values are on the alkaline side reflecting the highest buffer capacity of seawater in these stations. Salinity ‰ differed between 39.05 ‰ and 39.541 ‰ at surface and bottom seawater samples of 20m depth, respectively of Sidi Krir sector. The dissolved oxygen values ranged between 3.415 ml/l at both surface and 5m depth of Kilo-21 sector and 4.438 ml/l in surface seawater samples of the depths (10m and 20m) at Kilo-21 sector and surface and bottom samples of 5m depth at Sidi Krir sector. It was noticed that dissolved oxygen concentrations was increased by increasing the distance and depths from the shore in both Kilo 21 and Sumid sectors. The oxidizable organic matter (OOM) ranged between 0.144 mg O_2/l in surface water samples of 20m depth at (Kilo-21, Sidi Krir and Sumid)-sectors, surface water of 5m depth at Sidi Krir sector and 0.96 mg O_2/l in bottom water sample of 5m depth at Sumid sector (Table 1: a, b). Bottom waters were higher in oxidizable organic matter than the surface waters at all sectors except in the bottom water of 20m depth at Sumid sector. These high values might be attributed to the mixing with the bottom sediment which contain organic matter [2], also the obvious maximum value (0.96 mg O_2/l) at Sumid sector reflect the effect of petroleum activity at this area. It was noticeable from Table 1: a, b that the dissolved oxygen and the oxidizable organic matter concentrations were inversely proportional to each other in all sectors in accordance with their depths and their concentrations in bottom seawaters were higher than their corresponding surface seawaters. Undetected phosphate concentrations were observed at surface seawater samples of (10m and 20m) depth at Kilo 21 sector, surface water sample of 5m depth of Sidi Krir sector and bottom seawater samples of (5m, 10m and 20m) depth of Kilo-21 sector. The maximum value at surface water of 5m depth, Kilo-21 sector may be attributed to the effect of agricultural water discharge from El Nubaria canal [5]. Silicate fluctuated between 0.399μmol/l in surface sample of 5m depth at Sumid sector and high value of 23.484μmol/l in bottom sample of 10m depth at Kilo-21 sector. Noticeable high concentrations of silicate were observed at the bottom samples of all stations except 20m depth at Sidi Krir sector. Silicate is a good conductor of fresh water dispersion and of the potential of diatoms [11]. Nitrite concentration varied between 0.6μmol/l in surface sample of 10m depth at Sumid sector and in bottom sample of 5m depth at Kilo-21 sector and 1.15μmol/l in bottom samples of 10m depth at Sumid sector. High concentrations (0.725-1.1 μmol/l) of nitrite were found in surface samples of Kilo-21 and Sidi Krir sectors accompanied by low concentrations of nitrate. The low nitrate concentration indicates its consumption during winter season. This note agreed with that stated by Harvey 1953; who stated that when the forms of nitrogen becomes severely depleted in the water (i.e., total N < 10μg/l), nitrogen deficient organisms are produced before cell division finally ceases. These deficient cells are able to take up ammonia and nitrate, but not nitrite, in the dark converting them to organic compounds including chlorophyll [12]. However bottom waters at Sumid sector characterized by high concentrations of both nitrite and nitrate. The minimum value of nitrate concentration (0.318μmol/l) was observed in surface sample of 5m depth at Kilo-21 sector, while the maximum value (1.936μmol/l) was recorded in bottom water of 10m depth at Sumid sector. It is noticeable that the inshore surface samples of 5m depth at the three sectors (Kilo-21, Sidi Krir and Sumid) have low nitrate concentrations which may reflect the biological activity in these waters.

The calcium content in surface water recorded its minimum value of 0.396 g/l in both Kilo-21 and Sumid sectors at surface water of 5m depth as shown in Table (1 a). However the maximum value of 0.411 g/l was

Table 1a: Physicochemical parameters of surface seawater samples during winter 2006

Sectors	Depths m	Temp. °C	pH	Salinity ‰	DO ml/l	OOM mgO_2/l	NO_2^- µmol/l	NO_3^- µmol/l	PO_4^{3-} µmol/l	SiO_3^- µmol/l	Ca^{++} g/l	Mg^{++} g/l	Ca/Cl	Mg/Cl
Kilo21	5m	19.9	8.2	39.281	3.415	0.216	0.725	0.318	1.97	1.37	0.396	1.422	0.0182	0.0654
	10m	19.8	8.1	39.409	4.438	0.192	0.875	0.347	0	2.17	0.411	1.436	0.0189	0.0658
	20 m	20	8.2		4.438	0.144	0.925	0.723	0	2.85				
Sidi Krir	5m	19.9	8.2		4.438	0.144	1.1	0.376	0	2				
	10m	19.9	8.2		3.755	0.168	0.725	0.665	0.05	1.31				
	20 m	19.9	8.2	39.050	3.926	0.144	0.9	0.636	0.82	2.45	0.411	1.424	0.0190	0.0659
Sumid	5m	20	8.2	39.094	4.097	0.288	0.625	0.52	0.35	0.4	0.396	1.410	0.0183	0.0652
	10m	19.9	8.2	39.135	4.097	0.432	0.6	1.445	0.72	2.45	0.411	1.424	0.0190	0.0658
	20 m	19.9	8.2	39.243	4.268	0.144	0.75	1.445	0.43	0.86	0.411	1.424	0.0189	0.0656
Average		19.91		39.202	4.1	0.21	0.8	0.72	0.48	1.76	0.406	1.423	0.0187	0.0656

Table 1b: Physicochemical parameters of bottom seawater samples during winter 2006

Sectors	Depths m	Temp. °C	pH	Salinity ‰	DO ml/l	OOM mgO_2/l	NO_2^- µmol/l	NO_3^- µmol/l	PO_4^{3-} µmol/l	SiO_3^- µmol/l	Ca^{++} g/l	Mg^{++} g/l	Ca/Cl	Mg/Cl
Kilo21	5m	19.9	8.2	39.249	3.415	0.288	0.6	0.578	0	2.51	0.388	1.450	0.0179	0.0667
	10m	19.8	8.2	39.453	3.926	0.312	0.75	0.725	0	23.5	0.426	1.450	0.0195	0.0664
	20 m	19.9	8.2	39.397	3.585	0.192	0.95	0.925	0	6.1	0.426	1.427	0.0196	0.0654
Sidi Krir	5m	20	8.2	39.409	4.438	0.432	1.05	1.532	0.53	2.74	0.434	1.434	0.0199	0.0657
	10m	19.9	8.2	39.449	3.585	0.408	0.65	0.867	0.43	2.68	0.426	1.427	0.0195	0.0653
	20 m	19.9	8.2	39.541	3.926	0.36	0.7	1.214	0.24	0.51	0.434	1.445	0.0198	0.0660
Sumid	5m	19.9	8.2	39.371	3.926	0.96	0.95	1.243	0.36	2.62	0.434	1.410	0.0199	0.0647
	10m	19.9	8.2	39.168	3.926	0.192	1.15	1.936	0.67	3.48	0.426	1.438	0.0197	0.0663
	20 m	19.9	8.2	39.124	4.097	0.144	0.825	1.705	0.34	3.31	0.426	1.404	0.0197	0.0648
Average		19.9		39.351	3.87	0.37	0.85	1.19	0.29	5.27	0.424	1.432	0.0195	0.0657

found with increasing the depth of surface water in Kilo-21 at surface water of 10m depth, Sidi-Krir at surface water of 20m depth and Sumid at surface water of 10m and 20m depth, which also reflect the highest chlorinity ratio of 0.0190. However, the values of calcium content in bottom water ranged from 0.388 g/l in Kilo-21 at depth of 5m to 0.434 g/l in both Sidi-Krir at 5m and 20m depth and Sumid at 5m depth shown in Table (1 b). In addition the lowest calcium chlorinity ratio of 0.0179 was also in Kilo-21 at water of 5m depth. On the other hand the maximum calcium chlorinity ratio of 0.0199 was recorded for both Sidi-Krir and Sumid sectors at 5m depth. The lowest concentration of calcium at Kilo-21 near the shore at both surface water (0.396 g/l) and bottom water (0.388 g/l) of depth 5m may be due to the effect of dilution caused by El Nubaria drainage canal that connected to the Mediterranean Sea at Kilo-21 of Alexandria in addition to calcium consumption by calcareous organisms [13].

Respect to magnesium content of surface water recorded very slight increased with increasing the distance from the shore as shown in Kilo-21 and Sumid sectors. Both sectors recorded the values of 1.422 g/l, 1.436g/l and 1.410 g/l, 1.424 g/l for surface water of 5m and 10m depth respectively. Increasing trend of magnesium content for surface water with increasing the depth may be due to the dilution effect caused by land sources [13]. On the other hand, the magnesium content of bottom water showed irregular trend with lowest value of 1.404 g/l in Sumid at depth of 20m and the highest value of 1.450 g/l in Kilo-21 at both depth of 5m and 10m Table (1 b). In addition the same sectors which have the minimum and maximum values of magnesium content recoded the minimum and maximum magnesium chlorinity ratio as it ranged from 0.0647 in Sumid at depth of 5m to 0.0667 in Kilo-21 at depth of 5m.

Generally surface water of 5m depth for Sumid sector recoded the minimum values of both calcium and magnesium content. However the surface water of 10m depth for Kilo-21 recorded the maximum values of calcium and magnesium content. The average value of calcium content of 0.424 g/l for bottom water was slight higher than the average value of 0.406 g/l for surface water. This may be attributed to the decrease in water temperature and the effect of microorganisms which play an important role in calcium exchange between sediment and overlying water [14].

Spring Season: In this season, water samples were collected from 7 sectors (El Dekhela, Kilo-21, Sidi Krir, Sumid, Marakia, El Hammam and Marbilla village) (Figure 1).

Temperature varied between 21.9°C and 22.8°C for both surface and bottom seawater samples. pH values fluctuated between 7.35 in surface sample at El Dekhela and 8.4 in bottom samples of 20m depth at the same sector (Table 2: a, b). It was noticeable that nearly half of the surface water samples have pH value less than 8.00. However, the bottom water samples at almost all depths have stable pH value of 8.35. Total alkalinity varied between 3.8 meq/l for bottom water samples of 20m depth and 4.3 meq/l for surface seawater samples of (5m and 10m) depth of Kilo 21 sector and bottom seawater sample of 5m depth of El Dekhela sector with average value of 4.124 meq/l. Salinity ‰ fluctuated between 37.520‰ at surface seawater sample of 5m depth, Marakia sector and 39.180 ‰ at bottom seawater sample of 5m depth, Sidi Krir sector. It was noticed that salinity ‰ in surface water samples were less than their corresponding bottom water samples.The lower salinity ‰ were accompanied by lower

Table 2a: Physicochemical parameters of surface seawater samples during spring 2006

					NO_2^-	NO_3^-	PO_4^{3-}	SiO_3^-	Ca^{++}	Mg^{++}		
	Depths	Salinity	DO	OOM	----------	----------	----------	----------	----------	----------		
Sectors	m	‰	ml/l	mgO_2/l	µmol/l				g/l		Ca/Cl	Mg/Cl
El Dekhela	5m	38.350	5.32	0.749	0.4	1.2	1.34	2	0.416	1.426	0.0196	0.0672
	10m	38.360	5.84	1.373	0.48	2.45	0.67	3.42	0.440	1.424	0.0207	0.0671
	20 m	38.250	5.57	0.374	0.43	11.65	0.43	6.1	0.440	1.400	0.0208	0.0661
Kilo21	5m	37.860	5.14	0.125	0.68	13.5	1.15	15.85	0.432	1.369	0.0206	0.0653
	10m		5.32	0.874	0	4.03	0	1.37				
	20 m	38.160	9.04	1.373	0.38	10.81	0.29	4.62	0.432	1.393	0.0205	0.0660
Sidi Krir	5m	39.070	8.87	0.25	1.33	2.52	0.19	3.31	0.456	1.569	0.0211	0.0726
	10m	39.170	4.08	0.874	0.2	5.19	0.19	3.25	0.440	1.412	0.0203	0.0651
	20 m	38.970	4.47	0.749	0.15	1.54	0.14	2.91	0.440	1.412	0.0204	0.0655
Sumid	5m	38.310	4.43	2.995	0.05	1.65	0.1	1.71	0.456	1.462	0.0215	0.0690
	10m	38.270	6.2	0.749	0	1.11	0.29	2.91	0.432	1.429	0.0204	0.0674
	20 m	38.370	5.14	2.746	0.05	1.92	0.29	1.37	0.416	1.450	0.0196	0.0683
Marakia	5m	37.520	4.43	0.25	0.03	0.42	0.34	2.11	0.456	1.444	0.0219	0.0695
	10m	38.320	5.52	2.246	0.03	0.48	0.24	1.08	0.424	1.405	0.0200	0.0662
	20 m	38.490	4.78	0.25	0.03	3.2	0.24	1.65	0.440	1.430	0.0206	0.0671
El Hammam	5m	38.370	6.03	0.998	0.05	1.38	0.24	2.22	0.440	1.384	0.0207	0.0652
	10m	38.400	4.97	2.246	0	1.17	0.14	1.14	0.448	1.460	0.0211	0.0687
	20 m	38.210	4.96	0.499	0.05	0.73	0.38	2.05	0.448	1.414	0.0212	0.0668
Marbilla	5m	38.200	4.08	0.25	0.03	8.07	0.29	2.28	0.456	1.467	0.0215	0.0694
	10m	38.450	4.08	1.248	0.05	0.61	0.14	0.8	0.424	1.416	0.0199	0.0666
	20 m	38.170	3.91	1.248	0.1	1.81	0.34	2.05	0.432	1.389	0.0204	0.0657
Average		38.364	5.34	1.07	0.215	3.592	0.354	3.057	0.438	1.428	0.0206	0.0672

Table 2b: Physicochemical parameters of bottom seawater samples during spring 2006

								NO_2^-	NO_3^-	PO_4^{3-}	SiO_3^-	Ca^{++}	Mg^{++}		
	Depths	Temp.		T.Alk.	Salinity	DO	OOM	----------	----------	----------	----------	----------	----------		
Sectors	m	°C	pH	meq/l	‰	ml/l	mgO_2/l	µmol/l				g/l		Ca/Cl	Mg/Cl
El Dekhela	5m	22.7	8.3	4.3	39.010	4.08	0.749	0.28	2.09	0.29	3.65	0.396	1.410	0.0183	0.0653
	10m	22.1	8.35	4.2	39.030	6.03	0.374	0.18	3.82	1.09	3.65	0.419	1.408	0.0194	0.0652
	20 m	21.8	8.4	4	39.180	5.85	0.25	0.18	2.9	0.82	15.1	0.411	1.482	0.0190	0.0683
Kilo21	5m	21.9	8.3	4.2	39.100	5.69	0.998	0.15	13.6	0.48	4.1	0.396	1.422	0.0183	0.0657
	10m	22.1	8.3	4.1	39.130	5.96	0.7469	0.1	6.53	1.25	3.59	0.396	1.410	0.0183	0.0651
	20 m	21.9	8.3	3.8											
Sidi Krir	5m	22.1	7.4	4	39.180	6.02	0.749	0.15	7.34	0.29	11.4	0.396	1.445	0.0183	0.0666
	10m	21.9	8.35	4	39.130	6.57	0.749	0.18	3.19	0.19	3.08	0.404	1.429	0.0186	0.0660
	20 m	22.1	8.35	4.1	39.150	5.16	0.749	0.48	3.19	0.53	7.92	0.381	1.466	0.0176	0.0676
Average		22.07		4.078	39.114	5.67	0.67	0.21	5.33	0.62	6.56	0.400	1.434	0.0185	0.0662

pH values. Dissolved oxygen (DO) concentration varied between 3.91 ml/l in surface water of 20m depth at Marbilla sector and 9.04 ml/l in surface water of 20m depth at Kilo-21 sector. In this season, surface and bottom waters are more enriched with DO comparing with winter season. Oxidizable organic matter fluctuates between 0.125 mg O_2/l in surface seawater of 10m depth at Kilo 21 sector and 2.995 mg O_2/l in surface seawater sample of 5m depth at Sumid sector. Low concentrations of oxidizable organic matter were observed in bottom water of 10m depth in both El Dekhela and Sidi Krir sectors, 20m depth of El Dekhela sector. This may be attributed to the algal consumption during spring season. However, it is clearly that, high concentrations of oxidizable organic matter were found in most surface water samples at Sumid and Marbilla village sectors. This may reflect the effect of petroleum activities in these sectors. Samples of other sectors, (Sidi Krir, Marakia, El Hammam and surface water of 5m depth Kilo-21 sector) showed also high oxidizable organic matter concentration. Phosphate ranged from 0.1µmol/l to 1.34µmol/l in surface seawater of 5m depth at Sumid and El Dekhela sectors respectively. Surface seawater sample of 10m depth of Kilo 21 sector recorded undetected phosphate concentration. High concentration of phosphate was found at El Dekhela sector for both surface and bottom seawaters which may be resulted from the effect of domestic water discharge from El Umoum drainage. These results agreed with those obtained by Gehan *et al.* [5]. However low concentrations of phosphate was observed at Sidi Krir sector for both surface and bottom seawaters. Although this sector locates near El Nubaria drainage canal, it didn't affect by polluted water discharged from this canal due to the direction of the water current (from west to east) as shown from water current results carrying the loaded water mass far from this area passing to El Dekhela sector. Silicate concentration varied between 0.8µmol/l in surface seawater (10m depth) at Marbilla sector and obviously high value of 15.85µmol/l in surface seawater of 5m depth at Kilo-21 sector. In general, for surface seawater samples more than half of the silicate concentrations lie between 2 and 3µmol/l. It was also noticed that, high concentrations of silicate were found in most bottom seawater samples as in surface seawater, during spring season, the spring outburst of phytoplankton growth causes a rapid decrease in the concentration of silicon, although considerable amount still remain in the water [12]. El Dekhela sector showed relatively high concentrations of silicate (2-15 µmol/l) in both surface and bottom seawaters. The variations of silicate concentrations were related to the supply of silicate from El Umoum drain water on one hand and the consumption by diatoms on the other hand [1]. Nitrite showed low concentrations for both surface and bottom seawater samples in this season compared with winter season. The values fluctuated between 0.03µmol/l for surface samples of Marakia sector and inshore surface sample of 5m depth, Marbilla sector and 1.33µmol/l for surface water of 5m depth of Sidi Krir sector. Undetected nitrite concentration was found at 10m for three locations (Kilo-21, Sumid and El Hammam). The trend of nitrite concentration distribution in surface waters showed two regions, one of high concentrations (0.15-1.33 µmol/l) from El Dekhela to Sidi Krir sectors and the other of low concentrations (0.03-0.10 µmol/l) from Sumid to Marbilla village sectors.

Contrary to nitrite; accumulation of nitrate was observed for all water samples in regard to winter season. This means that in spring season, nitrite was the consumption nutrient; however in winter season nitrate was used as nutrient source for primary protection. Nitrate concentration varied from 0.23µmol/l to 6.99µmol/l in surface seawater samples at El Dekhela and El Hammam, respectively.

For the major cations the calcium content of surface water recorded its minimum value of 0.416 g/l in El Dekhela and Sumid sectors at surface water of 5m and 20m depth, respectively as shown in Table (2 a). Sumid sector recorded also the minimum value in winter season (Table 1 a). On the other hand, the maximum calcium content value of 0.456 g/l was recorded at surface water of 5m depth for Sidi-Krir, Sumid, Marakia and Marbilla village. In addition, in these sectors (Sidi-Krir, Sumid, Marakia and Marbilla village) the calcium content of surface water was decreased with increasing the distance from 5m to 10m depth. Surface water for Marakia of 5m depth was only station that its high content of calcium reflect the highest calcium chlorinity ratio of 0.0219 which is due to the relative lower salinity value comparing with other stations Table (2 a). However the lowest calcium chlorinity ratio was 0.0196 in El Dekhela for surface water of 5m depth, the same station of lowest calcium content. Respect to the bottom water the values of calcium content were relatively slight lower than the values of surface water and recorded a minimum of 0.381 g/l in Sidi-Krir at depth of 20m and a maximum of 0.419 g/l in El Dekhela at depth of 10m with an average of 0.400 g/l Table (2 b). In general, the calcium content for surface water in spring season recoded slight relative higher minimum, maximum and average values comparing with winter season. On the other hand, for bottom water the calcium content in winter season recorded relative slight higher minimum, maximum and average values comparing with spring season. The lower values of calcium content of bottom water in spring

could be due to the ability of phytoplankton to extract carbon dioxide from water which raises pH and calcium carbonate precipitates on sediment. However, the higher values of calcium content of bottom water during winter, mainly due to the organic matter oxidation, where carbon dioxide is released under anoxic condition and hence pH is decreased leading to dissolution of calcium carbonate from sediment [15,16].

Respect to magnesium content for surface water the values in general showed very slight decrease with increasing the surface water depth from 5m to 10m for all sectors except both Kilo-21 and El Hammam sectors as the opposite behavior were recorded. The values of magnesium content of surface water fluctuated between a minimum of 1.369 g/l in Kilo-21 at depth of 5m and a maximum of 1.569 g/l in Sidi-Krir at surface water of 5m depth which, also recorded the highest magnesium chlorinity ratio of 0.0726 Table (2 a). On the other hand, the magnesium content for bottom water as shown in Table (2 b) was slightly increased at depth of 20m comparing with the depth of 5m for all studied sectors except Kilo-21 sector, which may be due to the lowest temperature at 20m depth that facilitate the dissolution of magnesium element from sediment [17]. This trend in general was the opposite behavior that recorded for surface water of same sectors. Magnesium content of bottom water recorded its minimum value of 1.408 g/l in El Dekhela at depth of 10 m and the maximum value of 1.482 g/l in the same sector but at the depth of 20 m. In addition, as shown in Table (1 b), Table (2 b) the magnesium content of bottom water showed almost the same average values of 1.432 g/l and 1.434g/l in both winter and spring seasons, respectively.

Generally the maximum surface water values of the major cations (calcium and magnesium) were recorded in Sidi Krir sector at 5m depth. However, the maximum bottom water values of calcium and magnesium content were recorded in water of El Dekhela sector at depth of 10m and 20m respectively. In Sidi-Krir, Sumid, Marakia and Marbilla sectors the calcium and magnesium content of surface water was decreased with increasing the distance from 5m to 10m depth. Respect to the bottom water showed irregular distribution through different depths for both calcium and magnesium content.

Summer Season: Temperature varied between 29°C and 32°C and as known its values are higher than their corresponding values in both winter and spring seasons.

pH distribution along different sectors showed a slight variation, with minimum value of 7.65 in bottom seawater of 5m depth at Marbilla sector and maximum value of 8.15 in surface seawater of 5m and 10m depth at Kilo-21 sector. pH values differ in narrow range for all stations in the same sectors. Total alkalinity fluctuated between a minimum of 4.08 meq/l in surface water sample of 20m depth at Sidi Krir sector and bottom water samples of both (10m and 20m) depth El Dekhela sector and a maximum of 4.94 meq/l of 20m depth bottom water at Kilo 21 sector. Total alkalinity of El Dekhela ranged between 4.08-4.89 meq/l. These values are higher than those obtained by Abdalla *et al.* [1] which were 2.8-3.6 meq/l. This increase may be attributed to the water discharge that increased in El Dekhela sector. It is noticeable that total alkalinity values in summer season are slightly higher than their corresponding values in spring season. Salinity ‰ fluctuated between 35.551‰ in surface seawater sample of 5m depth at El Dekhela sector and 39.891‰ in surface water sample of 20m depth at Sumid sector. S ‰ of El Dekhela, Kilo 21 and Sidi Krir sectors during summer season were less than their corresponding during spring season. This may be attributed to the fresh water discharged in these sectors during summer season. Surface and bottom seawaters are still rich with oxygen in this season, except the minimum value of 2.23 ml/l in surface sample of 5m depth at El Dekhela sector. The maximum concentration of dissolved oxygen of 9.59 ml/l and 9.58 ml/l were found in surface water samples of (20m and 10m) depth, respectively at Kilo-21 sector. It was noticeable that the bottom water samples were higher in dissolved oxygen than surface water at most stations of the four studied sectors (El Dekhela, Kilo 21, Sidi Krir and Sumid). Oxidizable organic matter concentration ranged between 0.025mgO_2/l in surface seawater sample of 20m depth at Sumid sector and 1.048mgO_2/l in surface seawater sample of 20m depth at Kilo 21 sector. Higher oxidizable organic matter concentration was noticed in surface seawater values than their corresponding bottom water values during summer season indicating higher discharges in that season. Undetected phosphate concentrations appeared at surface seawater samples of (20m depth, Sumid sector and 10m depth Marbilla sector) and also at bottom samples of 20m depth, Sumid sector, (5m and 10m) Marakia sector and 5m depth, Marbilla sector (Table 3a,b). However, bottom water showed an extremely high phosphate concentration of 18.72µmol/l and relatively high value of 2.54µmol/l at Kilo-21 (20m and 10m) depth, respectively. The presence of these high concentrations of phosphate at different stations of Kilo-21 sector is due to the strong effect of agricultural water discharge from El Nubaria canal other than the effect of El Umoum drainage because of water current direction which is from west to east. This trend of water current direction causes the decrease of phosphate content at Sidi Krir in spite of its relative close position to Kilo-21 which has high phosphate concentration. The relatively high values of

Table 3a: Physicochemical parameters of surface seawater samples during summer 2006

Sectors	Depths m	Temp. °C	pH	T.Alk. meq/l	Salinity ‰	DO ml/l	OOM mgO_2/l	NO_2^- µmol/l	NO_3^- µmol/l	PO_4^{3-} µmol/l	SiO_3^- µmol/l	Ca^{++} g/l	Mg^{++} g/l	Ca/Cl	Mg/Cl
El Dekhela	5m	30.75	8.1	4.725	35.551	2.23	0.998	0.125	0.376	0.24	23.83	0.401	1.293	0.0204	0.0657
	10m	30.5	7.95	4.67	37.229	6.02	0.849	0.05	0.231	0.24	17.61	0.408	1.324	0.0198	0.0643
	20 m	30.5	7.95	4.89	36.357	6.20	0.449	0.1	0.982	0.336	5.64	0.416	1.319	0.0207	0.0656
Kilo21	5m	31	8.15	4.67	37.878	8.27	0.4	0.05	0.347	0.384	13.17	0.456	1.355	0.0217	0.0646
	10m	30.75	8.15	4.94	37.214	9.58	0.948	0.01	0.549	0.48	9.35	0.456	1.367	0.0221	0.0664
	20 m	30.5	8.1	4.21	37.134	9.59	1.048	0.175	0.52	0.53	4.5	0.440	1.400	0.0214	0.0681
Sidi Krir	5m	30	7.85	4.67	37.850	5.57	0.449	0.175	4.305	0.336	8.04	0.479	1.341	0.0229	0.0640
	10m	32	7.85	4.54	38.021	7.12	0.349	0.2	3.698	0.19	11.69	0.463	1.362	0.0220	0.0647
	20 m	31	7.8	4.08	39.024	8.69	0.948	0.1	2.196	0.38	8.44	0.463	1.422	0.0215	0.0658
Sumid	5m	31	7.9	4.89	39.409	5.35	0.099	0.05	2.976	0.19	3.48	0.463	1.457	0.0212	0.0668
	10m	30	7.9	4.89	39.448	5.79	0.847	0.075	3.005	0.05	5.59	0.440	1.424	0.0201	0.0652
	20 m	29.5	7.95	4.62	39.891	8.24	0.025	0.025	0.433	0	39.5	0.456	1.498	0.0206	0.0678
Marakia	5m	30	8.05	4.67	39.433		0.649	0.05	2.918	0.43	3.25	0.424	1.481	0.0194	0.0679
	10m	29	8	4.81	39.441		0.624	0	0.867	0.05	2.28	0.432	1.512	0.0198	0.0693
	20 m	29.5	8.05	4.81	39.289		0.225	0	2.34	0.24	4.16	0.416	1.462	0.0191	0.0672
El Hammam	5m	32	8	4.67	39.589		0.674	0.025	6.991	0.096	1.94	0.432	1.417	0.0197	0.0647
	10m	30.5		4.64				0	1.184	0.04	9.29				
	20 m	29.5		4.64				0	0.433	0.05	12.88				
Marbilla	5m	31		4.54			0.275	0	0.693	0.05	1.82				
	10m	31	7.8	4.54	39.480	4.90	0.25	0.075	0.982	0	2.68	0.432	1.429	0.0198	0.0654
	20 m	30	7.9	4.54	39.517		0.05					0.511	1.655	0.0233	0.0757
Average		30.48		4.65	38.431	6.73	0.535	0.064	1.801	0.216	9.457	0.444	1.418	0.0209	0.0666

Table 3b: Physicochemical parameters of bottom seawater samples during summer 2006

Sectors	Depths m	Temp. °C	pH	T.Alk. meq/l	Salinity‰	DO ml/l	OOM mgO_2/l	NO_2^- µmol/l	NO_3^- µmol/l	PO_4^{3-} µmol/l	SiO_3^- µmol/l	Ca^{++} g/l	Mg^{++} g/l	Ca/Cl	Mg/Cl
El Dekhela	5m	30	8	4.81	38.992	4.98	0.05	0.225	2.66	1.968	12.03	0.440	1.448	0.0204	0.0671
	10m	31	8.05	4.08	39.393	4.43	0.05	0.175	1.79	0.288	4.16	0.440	1.388	0.0202	0.0637
	20 m	30	8	4.08	38.876	4.97	0.05	0.25	1.13	1.92	66.86	0.440	1.376	0.0204	0.0640
Kilo21	5m	30.5	8.1	4.54	38.420	6.02	0.7	0.1	0.61	0.96	11.4	0.440	1.388	0.0207	0.0653
	10m	30.25	8	4.81	39.000	6.24	0.8	0.1	0.4	2.54	17.27	0.424	1.434	0.0197	0.0664
	20 m	29	7.9	4.94	39.132	7.35	0.2	0.125	0.61	18.72	57.57	0.432	1.429	0.0199	0.0660
Sidi Krir	5m	31	7.95	4.81	39.008	5.56	0.45	0.425	4.51	1.34	126	0.432	1.417	0.0200	0.0656
	10m	31	7.95	4.67	39.457	6.90	0.2	0.025	0.98	0.24	7.41	0.448	1.431	0.0205	0.0655
	20 m	30	7.95	4.81	39.208	8.69	0.45	0.1	3.47	0.34	10.83	0.440	1.424	0.0203	0.0656
Sumid	5m	32	7.95	4.81	39.385	6.25	0.33	0.05	1.1	0.67	89.21	0.448	1.407	0.0205	0.0646
	10m	30.5	7.95	4.65	38.968	4.90	0.55	0.05	0.55	0.05	4.85	0.432	1.393	0.0200	0.0646
	20 m	28.5	8.05	4.64	39.208	4.68	0.03	0.125	2.14	0	77.69	0.424	1.422	0.0195	0.0655
Marakia	5m	30	8	4.54	39.610	5.59	0.26	0	4.88	0	9.35	0.432	1.429	0.0197	0.0652
	10m	29	8	4.67	39.746	4.90	0.47	0	0.98	0	2.85	0.432	1.453	0.0196	0.0660
	20 m	29.5	8.05	4.67	39.168		0.15					0.424	1.446	0.0196	0.0667
El Hammam	5m	31	7.75	4.13	39.529	5.14	0.13	0.1	1.07	0.48	85.61	0.432	1.429	0.0197	0.0653
	10m	30.5	7.75	4.27	39.449	4.46	0.25	0.025	0.4	0.24	1.31	0.432	1.453	0.0198	0.0665
	20 m	29.5	8.05	4.54	39.180	4.45	0.23	0	0.69	0.05	4.96	0.424	1.446	0.0196	0.0667
Marbilla	5m	30.5	7.65	4.54	39.461	4.91	0.2	0.025	0.43	0	5.02	0.440	1.448	0.0201	0.0663
	10m	31	7.85	4.54	39.409	8.01	0.25	0.05	0.69	0.05	15.22	0.448	1.431	0.0205	0.0656
	20 m														
Average		30.24		4.578	39.230	5.71	0.29	0.1	1.53	1.57	32.08	0.435	1.425	0.0200	0.0656

1.968μmol/l and 1.92 μmol/l of phosphate found in bottom water samples of 5m and 20m depth at El Dekhela sector may be due to the effect of domestic water discharge from El Umoum drain. Silicate fluctuated between low value of 1.31μmol/l at bottom water of 10m depth, El Hammam sector and very high value of 126.0μmol/l at bottom water of 5m depth at Sidi Krir sector. Other noticeable high concentration of 89.21μmol/l and 85.61μmol/l were also observed at bottom water samples of 5m depth at Sumid and El Hammam sectors, respectively.

Generally, bottom waters are kept clearly high concentrations of silicate than surface waters. Also, bottom waters are characterized by high variations in silicate at different stations within one sector which might be due to the reflux of silicate from bottom sediments of different characteristics. The first four stations from El Dekhela to Sumid showed high concentrations of silicate than the other sectors. Distribution of nitrite showed the same trend as in silicate i.e., high concentrations appeared in the bottom seawater samples other than surface water. The regional concentration of nitrite was found to be higher in the first three sectors from El Dekhela to Sidi Krir coincided with the presence of other high nutrient salts concentrations (phosphate and silicate). Undetected nitrite concentration was recorded at different surface and bottom seawater samples of three sectors at Marakia, El Hammam and Marbilla village. The maximum concentration of nitrite (0.425μmol/l) was observed at bottom water of 5m depth at Sidi Krir coincided with the maximum value of silicate concentration.

In summer season nitrate concentrations in surface seawater samples were decreased in El Dekhela, Kilo-21 and Sidi Krir than that observed in spring season. However, high concentrations of surface seawaters were found at Sumid and Marakia which may be related to the increase of touristic activities during summer season as well as the petroleum industries wastes. Regarding to bottom water, it was found that nitrate concentrations was low in this season at El Dekhela, Kilo-21 and Sidi Krir. In summer season the calcium content of surface water characterized with the highest value of 0.511 g/l in Marbilla sector at surface of depth 20m comparing with other surface and bottom water in different seasons Table (3 a). This may be due to the relative increase of the dissolved oxygen during this month [18]. As shown in Table (3 a) and Table (3 b) in Kilo-21, Sumid and Marakia sectors the calcium content for both surface and bottom water decreased with increasing the depth from 5m to 20 m. The same behavior occurred in Sidi-Krir for surface water and El Hammam for bottom water. The values of calcium content varied from 0.401 g/l to 0.511 g/l for surface and from 0.424 g/l to 0.448 g/l for bottom water, respectively. The average values of calcium chlorinity ratio are almost the same for bottom and surface water and recorded values of 0.0200 and 0.0209, respectively. However the minimum and maximum values of calcium chlorinity ratio were 0.0191, 0.0233 for surface water and 0.0195, 0.0207 for bottom water, respectively.

The magnesium content in summer season in El Dekhela sector recorded the lowest value of 1.293 g/l for surface water of 5m depth and 1.376 g/l for bottom water of 20 m depth comparing with other surface and bottom water in other studied winter and spring seasons. In addition during the three studied seasons the magnesium content in summer recorded its lowest average values of 1.418 g/l and 1.425 g/l for surface and bottom water, respectively. This could be attributed to biogenic precipitation of aragonite and calcite by aquatic organisms, which build their shells from calcium and magnesium carbonate at high temperature and pH values [17]. However, the maximum magnesium content in summer was 1.655 g/l for surface water of 20m depth in Marbilla Village sector and 1.453 g/l for bottom water of 10 m depth in El Hammam and Marakia sectors. The maximum value of magnesium content for surface water of 20m depth in Marbilla Village sectors reflected also the maximum magnesium chlorinity ratio of 0.0757.Generally in summer season the minimum values of both calcium and magnesium content for surface water were recorded in El Dekhela sector at surface of 5m depth. However the maximum values were recorded in Marbilla sector at surface water of 20m depth. Respect to bottom water the minimum and maximum values of calcium and magnesium content were observed in different sectors for both of them.

CONCLUSION

The results obtained showed that the temperature ranged between a minimum of 19.8 °C during winter and a maximum of 32°C during summer. pH value fluctuated between 7.35 in surface sample of 5 m depth and 8.4 in bottom sample of 20 m depth in El Dekhela during spring season. Total alkalinity fluctuated between 3.8meq/l in bottom water sample of 20 m depth during spring season and 4.94meq/l in both surface and bottom water samples of (10 m and 20 m) depth in Kilo 21 during summer season. Salinity ‰ fluctuated between 35.551‰ in surface seawater sample of 5m depth at El Dekhela sector and 39.891‰ in surface water sample of 20m depth at Sumid sector during winter season. Dissolved oxygen fluctuated between 2.23 ml/l in surface sample of 5 m depth of El

Dekhela sector and 9.59 ml/l in surface sample of 20 m depth in Kilo 21 sector during summer season. Oxidizable organic matter ranged between a minimum of 0.025 mg O_2/l in bottom water of 20 m depth of Sumid sector during summer and a maximum of 2.995 mg O_2/l in surface water sample of 5 m depth in Sumid sector during spring season. Nitrite concentrations differed between depletion in surface waters of 10 m depth in Kilo 21, Sumid and El Hammam sectors during spring season and surface waters of (10 m and 20 m) depths in Marakia and El Hammam sectors and surface water of 5 m depth in Marbilla village sector during summer season and 1.33µmol/l in surface seawater sample of 5 m depth in Sidi Krir sector during spring season. Nitrate concentration differed between 0.231µmol/l in surface seawater sample of 10 m depth of El Dekhela sector during summer season and 13.6µmol/l in bottom water of 5 m depth of Kilo 21 sector during spring season. Phosphate differed between depletion during all seasons in Kilo 21, Sidi Krir, Sumid, Marakia and Marbilla sectors and (18.72µmol/l and 2.54µmol/l) in bottom samples of both 20 m and 10 m, respectively of Kilo 21 sector during summer season. Silicate varied between 0.399µmol/l in surface water sample of 5 m depth in winter and extremely high value of 89.21µmol/l in bottom water of 5 m depth during summer season in Sumid sector and a high value of 23.484µmol/l in bottom water of 10 m depth in Kilo 21 sector during winter. The study reveals the effect of temperature on silicate concentration;

The pH value was in the alkaline side. The highest pH values was observed in the first four sectors indicating that the hydrogen ion isn't only a potential pollution in itself, but it is also related intimately to the concentration of many other substances, particularly the weakly dissociated acids and bases. DO concentrations indicate that these sectors were oxygenated except the value of 2.23 ml/l in surface sample of 5 m depth of El Dekhela sector during summer season which may be attributed to different discharges in El Dekhela sector. OOM was high in Sumid sector during spring season indicating its high pollution in that time. OOM is also related to the nutrient concentrations.

In general, the results of nutrients concentrations (silicate, phosphate, nitrite and nitrate) showed that the studied area is divided into two regions, the first region from El Dekhela to Sidi Krir have high concentrations of nutrient salts due to the effect of both El Nubaria drainage canal and El Umoum drainage. North West water current direction was the dominant current which causes the increase of mixing water in this area. The second region is from Sumid to Marbilla village showed lower concentrations of nutrients due to the effect of opposite water current which is north east direction that decreases the effect of polluted water from El Nubaria canal and El Umoum drainage in this second region, but they are affected by the petroleum industry pollution and the tourism activities.

In winter season, the average values of calcium and magnesium content in bottom water (0.424 g/l, 1.432 g/l) were slight higher than surface water of (0.406 g/l, 1.423 g/l), respectively. In spring season, the values of calcium content for surface water were relatively higher than in winter. However for bottom water the opposite trend was occurred as the calcium content in spring was slightly lower than in winter. The average values of calcium content in spring were (0.438 g/l, 400 g/l) however for the magnesium content were (1.428 g/l, 1.434 g/l) for surface and bottom water, respectively. In summer season, the calcium content of surface water in Marbilla village recorded the highest value of (0.511 g/l) comparing with other surface and bottom water in different seasons. On the other hand, the lowest values of Magnesium content of (1.293 g/l, 1.376 g/l) during all three studied season were in summer at El Dekhela sector for both surface and bottom water respectively. In addition during the summer season the magnesium content recorded also its lowest average values of (1.418 g/l) and (1.425 g/l) for surface and bottom water, respectively.

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