Some Chemical and Physical Characteristics of Alexandria Coastal Water, Egypt

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Abstract: Seasonal collection of water samples were carried out at Alexandria coast from 18 selected stations during 2004 – 2005. The study area was divided into three sections A, B, and C. The study areas A and C are clearly affected by brackish polluted water discharge from El-Ammia, Rakta, Bughas, Umum, and Noubaria drains which were studied too. The hydrographic parameters (pH, DO, salinity. and OOM) were studied. This work aimed at evaluating some major ions level (average of 434.6 mg/l, 1.39 g/l, 3.11g/l, and 67.32 mg/l for Ca, Mg, SO_4, and Br in surface water and 449.12 mg/l, 1.48g/l, 3.42 g/l, and 75.68 mg/l in bottom water, respectively) in Alexandria coastal water and their chlorinity ratios relevant to the corresponding normal oceanic ones. The influence of dilution effect resulted from the discharge of different types and amount of land–based effluents was discussed. By all, the average chlorinity ratios of cations deviations from the respective oceanic values can detect as a resulting from the discharging of land –based effluents; (average of 0.074, 0.023, 0.004, and 0.172 for Mg/Cl, Ca/Cl, Br/Cl and SO_4/Cl, respectively). The correlation coefficients between the major cations and the hydrographic parameters were computed and discussed.

Key words: Coastal water; Major ions; Drains; Alexandria; Egypt.

INTRODUCTION

Alexandria is the main summer resort in Egypt. It lies on the southern coast of the east Mediterranean, west to the Nile Delta. It is the second largest city and one of the Egypt's most important industrial centers and includes a wide variety of industries which comprises 100 large factories and about 200 small ones which cover about 40% of the nation's industry.[1] It has a population of about more than 5 million (about two million summer visitors).

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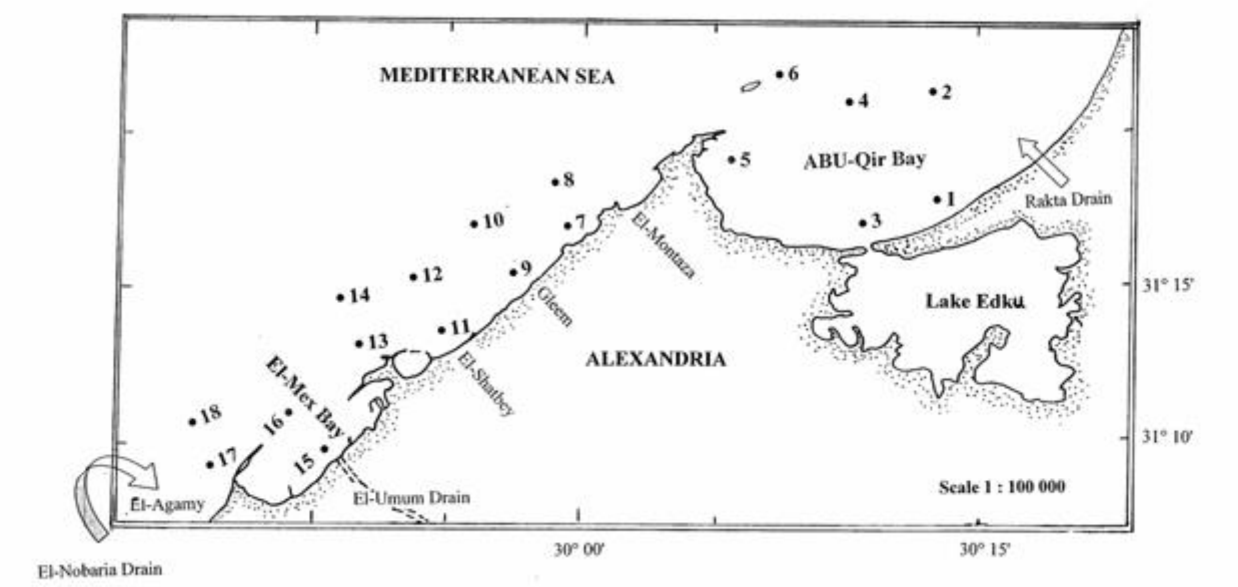

Figure 1: Coastal area of Alexandria, sampling stations and drains.

MATERIAL and METHODS

Investigation of some major ions (Ca, Mg, SO_4, and Br) as well as dissolved oxygen (DO), pH, salinity, and oxidizable organic matter (OOM) in the coastal seawater and some drain waters discharging its effluents to the sea are carried out at three investigated sections (A, B, and C). The total cumulative volume of wastewater disposed into the sea from all points sources along this coast is roughly 3.33 Km^3/year[2] The effect of wastewater and effluents discharge on the physicochemical characteristics of the coastal water of Alexandria were carefully studied and discussed.[3]

This work aimed at evaluating some major ions level (Ca, Mg, SO_4, and Br) in Alexandria coastal water and their chlorinity ratios relevant to the corresponding normal oceanic ones. The influence of dilution effect resulted from the discharge of different types and amount of land-based effluents was discussed.

Study area

The study area extends along the coast of Alexandria about 40 Km between Abu-Qir in the east (long. 30° 04' E and lat.

31° 19' N) and El-Agamy in the west (long. 29° 45' E and lat. 31° 08' N). The coast of the investigated area is more or less straight except for number of small embayment (El-Mex, Eastern Harbour, and Abu-Qir Bay). The investigated area can be divided into three regions:

Section A: Abu-Qir Bay, the most industrialized area in Alexandria which is situated at western side of Rosetta Nile Branch at lat. (31° 20' and 31° 30'N) and long. (30° 00' and 31° 31' E). It is semicircular and shallow area with an average depth of 8 m (Figure 1). It receives considerable amounts of wastewaters through different sources (El-Tabia Drain, El-Ammia (Racta) Drain, and Boughaz El-Maadya). Six stations were selected at three sectors (Ras Abu-Qir, El-Maadya, and Edku) from shoreline and at depth of about 10 m.

Section B: Which is situated in the mid-Alexandria zone lies between long. (29° 55' and 30 ° 04' E) and lat. (31° 13' and 31° 19' N). It extends for about 16 Km between El-Shatby in the west and El-Montazh in the east and from the shoreline seawards to depth about 10 m (Fig. 1). Region B is a suitable beach for swimming during summer. Six stations were selected in this region at three sectors (El-Shatby, Gleem, and Meyami). Each of these sites had small disposal outlet directly situated at the beach. Sewage discharge to these outlets was prohibited during summer.[4]

Section C: It is situated to the west of Alexandria and lies between long. (29° 45' and 29° 54' E) and lat. (31° 07' and 31° 15' N). It extends for about 12 Km between El-Agamy on the west and Ras El-Tin on the east, and from shoreline seawards to depth of 10 m. Six stations were selected in three different sectors (El-Agamy, El-Mex, and Ras El-Tin) (Fig.1). Region A receives a daily disposal effluents of about 6 – 10 millions m^3 of drainage water mixed with the industrial, agricultural, and sewage wastes from different sources (El-Umum Drain and El-Nobaria Drain).[5]

Water samples were collected during four seasons 2004 – 2005 from 18 sites which represent Alexandria coastal water and 5 drains discharging wastewater directly to the sea. Sampling was done at surface and bottom waters for seawater and at sub-surface water for the drains using Niskin bottle of 5 liters.

Temperature and pH were measured in situ using protected thermometer (0.01°C) and portable pH meter (Orion pH-meter), respectively. Salinity was calculated from the electric conductivity which was measured by induction Beckman Salinometer, (Model R. S. 7B) using standard tables and making temperature corrections.

Dissolved oxygen (DO) was analyzed according to the modified Winkler's method. Oxidizable organic matter (OOM) was estimated by boiling a known volume of water samples in the presence of alkaline potassium permanganate and titrating the librated iodine against standard thiosufate solution according to Ellis *et al*.,1946.[6]

Calcium and Magnesium were determined titrimetrically according to the method of Heron and Mackereth (1960)[7] using EDTA standard solution where Magnesium was computed as a difference between total hardness and calcium hardness value. Sufate was determined turbidimeterically according to Rossum and Villarruz (1961).[8] Bromide in sea water was estimated by iodometeric method.[9]

RESULTS AND DISCUSSION

Water Temperature

The surface water temperature at the coastal water of Alexandria varied between 18.0°C and 31.0°C during winter and summer, respectively. The average water temperature was 23.4±4.22. the bottom water temperature seems to be slightly cooler than surface water, the maximum average water bottom water temperature was 29.00 °C was observed as expected during summer and the lowest was 17.0 °C in winter.

Salinity

Salinity is considered as a sensitive parameter for measuring the rate of dilution of seawater caused by land-based sources discharge and subsequently it reflects the degree of contamination in the aquatic environment.[10] The variations of salinity in different sites of Alexandria coastal water and some drains are represented in Figs. 2 and 4. Water salinity at Alexandria coastal water showed wide seasonal variations (Fig. 2) which directly reflect the changes in the volume and dispersion of discharged wastewater through the different drains under investigations (Umum, Noubaria, El-Ammia, Rakta, and El-Boughaz). At Abu-Qir Bay (section A), the area was subjected to intensive dilution particularly during spring which reduces the surface and bottom salinity to reach 27‰ and 37.8‰ at station 3 in the surface and bottom water, respectively (Fig. 4). The seasonal variation values of salinity at Section C fluctuated between 4.47‰ at station 15 (in front of El-Ummum Drain) and 39.02‰ at station 17 during spring and winter, respectively. While in Section B the effect of both of El-Ummum and Noubaria-Drains was very weak, and it appears strong during spring when the salinity of this sector's water decreased. In general, the highest absolute salinity value (39.97‰) was recorded at station 9 (Section B) during autumn and the lowest salinity value was 4.47‰ recorded at station 15 (Section C). The annual average values of salinity in the Alexandria coastal water were 33.97‰ ± 2.65, 36.89‰ ± 1.02, and 2.98‰ ± 2.14 for surface, bottom, and drains waters, respectively.

Hydrogen Ion Concentration (pH)

The pH measurement is affected greatly by the photosynthetic activity of algal organisms as well as the amount of the sewage discharge in seawater.[10] The pH values of surface, bottom, and drains water are lying in the alkaline side and showed in Figs. 2 and 4. It ranged between 7.3 – 8.99, 7.44 – 8.41, and 7.04 – 8.83, respectively. The recorded annual average of pH values of Alexandria coastal surface water (8.16±0.22) showed relatively little higher level if compared with that recorded at drains (7.95±0.33) and bottom water (8.03±0.04). These results are in good agreement with those obtained by Nissem 1989[11], Nissem *et al*., 2005[10], Okbah and Tayel 1999[12]. the decrease in the pH value coincided with the drop in oxygen content due to the effect of accumulating organic pollutants[13] as well as the discharge of brackish water[10]. The increase in the pH values in the surface water may be explained by the photosynthetic activity at the surface water which consumes carbon dioxide, increasing pH, favoring the formation of carbonate ions.[14,15]

Dissolved Oxygen (DO)

The measurements of DO indicated well oxygenated surface water reaching the maximum value of 17.19 mL/L at stations 13 and 14 (Section B) during autumn (Fig. 2). The distribution pattern of DO content in the drains water showed oxygen reduction except for El-Boughaz. DO concentration in the drains water fluctuated between 1.86 mL/l during summer and 16.97 mL/L during autumn represented at Rakta Drain and El-Boughaz, respectively with an annual average of 6.53 mL/L ±0.85. The distribution pattern of DO at bottom water showed a wide seasonal variation and ranged between 1.31 in winter and 15.62 mL/L in autumn, at station 10 (Section B) and station 15 (Section C), respectively, Fig. 4. The annual average content of DO in the bottom water (6.50 mL/L ±0.97) is lower than that of surface water (7.08 mL/L ±1.33). DO is considered as one of the most important and useful parameters in identification of different water masses in assessing the degree of pollution especially with organic pollutants which affects fish and other marine life through oxygen reduction or depletion.

Oxidizable Organic Matter (OOM)

The distribution of the oxidizable organic matter (OOM) in Alexandria coastal water and some different drains are represented in Figs. 2 and 4. It reached up to 3.17 mg O_2/l during summer at station 7 (Section B), while it ranged between 0.16 mg O_2/l during spring at station 2 (Section A) and 4.96 mg O_2/l at station 11 (Section B) during winter in the bottom water. Of course, the drain waters were richer in organic matter than the seawater (Figs. 2 and 4). The OOM content in the drains waters ranged between 1.16 mg O_2/l and 5.58 mg O_2/l during winter in El-Ummum and El-Ammia Drains, respectively. Based on the annual average values of the OOM, it seems that the drains water was higher in organic matter content by 2.4 times than that of the surface water and 2.8 times than that of the bottom water. This may explain the higher concentrations of OOM in surface water which is mainly due to wastewater discharging from different drains as well as chemical pollution of organic origin. In addition, the main source of organic matter in the bottom water can be attributed to mixing with the bottom sediments which contain organic matter.

Calcium

The calcium content in surface water of Alexandria coastal area recorded the maximum value of 884.7 mg/l at station 8 (Section B) with chlorinity ratio of 0.044 during summer (Fig. 3, Table 1). The lowest value of 144.3 mg/l was measured at station 1 (Section A) in front of El-Boughaz during autumn with chlorinity ratio of 0.022. On the other hand, the calcium content in the bottom water of Alexandria coast ranged between a minimum of 160.32 mg/l at station 5 (Section A) during winter with chlorinity ratio of 0.012 and a maximum of 625.3 mg/l recorded at station 15 (Section C) during summer with chlorinity ratio of 0.0202. The calcium content in the drains water showed a noticeable decrease (Fig. 4) and it ranged between a minimum of 12.24 mg/l at El-Ammia Drain (Section A) during winter and a maximum of 737.47 mg/l recorded at El-Boughaz during winter. Based on the annual average content of calcium, it seems that bottom water content (449.12 mg/l ±26.19) is slightly higher than that of surface water content (434.6 mg/l ±37.57). The corresponding chlorinity ratio of surface water (0.045) is affected directly by the wastewater discharge and the bottom water (0.0182) is lying below the oceanic ratio (0.0216) recorded by Culkin and Cox (1966).[16]

Magnesium

Magnesium is the third most abundant ion in seawater, behind sodium and chloride. It is also intimately involved in a great many biological processes in every living organism. Based on the average magnesium contents of

Alexandria coastal surface water, it ranged between 0.214 g/l at station 15 (Section C) and 2.168 g/l at station 18 (Section C) during autumn and spring, respectively, (Fig. 2) which is about threefold that of calcium. The bottom water sustained relative higher level which fluctuated from 1.04 g/l at station 3 (Section A) and 1.80 g/l at station 17 (Section C) (Fig. 4). It is evident from the data that magnesium content tends to increase seawards away from the dilution effect caused by land-based sources as well as downwards. A slight lateral increase in magnesium content or decrease in it. Chlorinity ratio values from east to west could be detected starting from Edku till Agami area with respect to the magnesium chlorinity ratio of oceans reported by Culkin and Cox 1960[16] (0.0669). The total average of chlorinity ratio deviates negatively below it for bottom water (Mg/Cl = 0.0600) and deviates positively above for the surface water (Mg/Cl = 0.0745).Based on the seasonal average of Mg/Cl ratios (Table 1), it was found that: Spring (0.084) **>** autumn (0.076) **>** summer = winter (0.069), surface water Spring (0.537) **>** autumn (0.091) **>** Summer (0.076) > winter (0.061), drain water Spring (0.084) **>** autumn (0.074) > summer (0.067) **>** winter (0.068), bottom water. The lowest value of the Mg/Cl ratio was observed during winter resulting from the decreased salinity during this season. A direct strong positive correlation between magnesium and salinity was computed ($r=0.91$, $n=136$, $p<0.01$). The positive declination in Mg/Cl ratio reported by Kremling 1970[17] on the other hand in Baltic sea indicates a relative excess of magnesium ion.

Sulfate

A wide range of fluctuations in sulfate content of the coastal water of Alexandria could be found (0.35 – 9.69 g/l), (0.081 – 11.66 g/l), and (2.59 – 5.03 g/l) in surface, drains, and bottom waters, respectively, (Figs. 3 and 4). Owing to the relative high content of sulfate in the drain water (which includes mainly industrial and agricultural wastewater), its average chlorinity ratio (1.601) was recorded; which is increasing about twelve times that of seawater.[18] The sulfate chlorinity ratio (Table 1) of the surface coastal water could be a rised under the effect of dilution of the drains discharges. The sulfate chlorinity ratio of surface and bottom seawaters of the studied area shows a strong positive deviation above the normal oceanic one (0.14) reported by Morris and Riley, 1966[19] (Table 1). El-Samra (1973)[20] found an average of 0.1607 for Abu-Qir Bay. The averages of sulfate chlorinity ratio of the investigated area are given in Table 1 showing that 0.174, 0.1601, and 0.170 for surface, drain, and bottom waters, respectively. Since the main part of the combined fraction of magnesium and calcium are paired with sulfate[21], significant correlations between each of them with sulfate were deduced ($r=0.23$, 0.21, respectively, $n=136$, $p<0.01$), as reported previously by Nissem 2005[10]. A negative significant correlation between sulfate and OOM was computed ($r = - 0.15$, $n=136$, $p<0.01$).

Bromide

Bromide ion is one the trace constituents in natural water. it was identified as a chemical element in 1826. It is the eighth most abundant solute in seawater. Its average concentration in seawater is approximately 60 – 70 mg/l.[22-24] The obtained bromide content in surface seawater ranged between 9.06 and 99.63 mg/l at station 15 (Section C) and at station 3 (section A), respectively during autumn. In the bottom seawater, it ranged between 35.49 – 131.33 mg/l at station 13 (section C) during summer and at station 17 (section C) during autumn, respectively (Figs. 3 and 4). On the other hand, the bromide content in the drain waters shows markedly low concentrations which fluctuated between 5.46 and 52.08 mg/l determined at El-Ammia Drain during spring and Noubaria Drain during autumn, respectively, (Fig. 3). Bromide can combine with many kinds of organic pollutants present in natural seawater to form toxic compounds that can cause serious harm to human health and environment.[24,25] Organic matter accumulates Br and a strong negative correlation of Br and oxidizable organic matter has been reported ($r=-0.54$ $n=163$, $p<0.01$). The bromide chlorinity ratio is an important factor for defining different geological environments; it is assumed that the modern average bromide chlorinity ratio of approximately 0.0033 has not changed significantly with time.[26] A slight lateral increase in bromide chlorinity ratio of Alexandria coastal seawater was recorded, 0.004. On the other hand, the drain waters show a noticeable increase in bromide chlorinity ratio ranging between 0.009 and 0.028 (Table 1). A strong positive significant correlation between Br and SO4 was calculated ($r=0.71$, $n=163$, $p<0.01$) indicated that the similar chemical behavior of both of them in seawater.

CONCLUSION

The measured physico-chemical parameters showed so high significant variations in the drains in the study area. However, these gave higher content in surface water than bottom water reflecting the effect of land-based activities. Land-based sources at different sites along the coast possess a disturbance in the chlorinity ratios of the major ions. Calcium, magnesium, bromide, and sulfate ratios were greatly higher than the oceanic ratios as expected in drains waters. These ratios come near to the oceanic ratios in the surface and bottom waters in few cases.

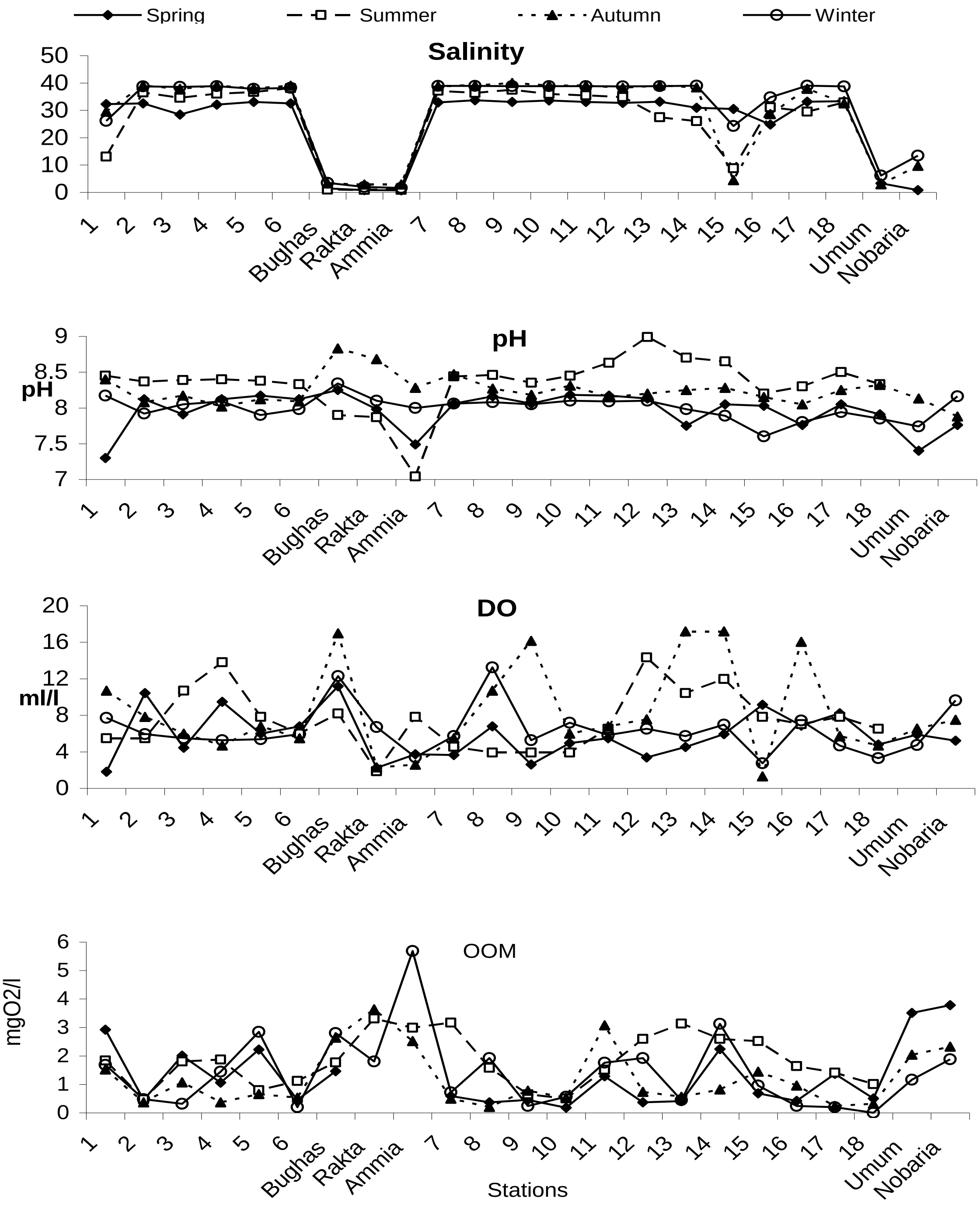

Figure (2): Seasonal variation of salinity, pH, Dissolved Oxgyen (DO) and OOM of Alexandria surface coastal water and some drains during 2004-2005

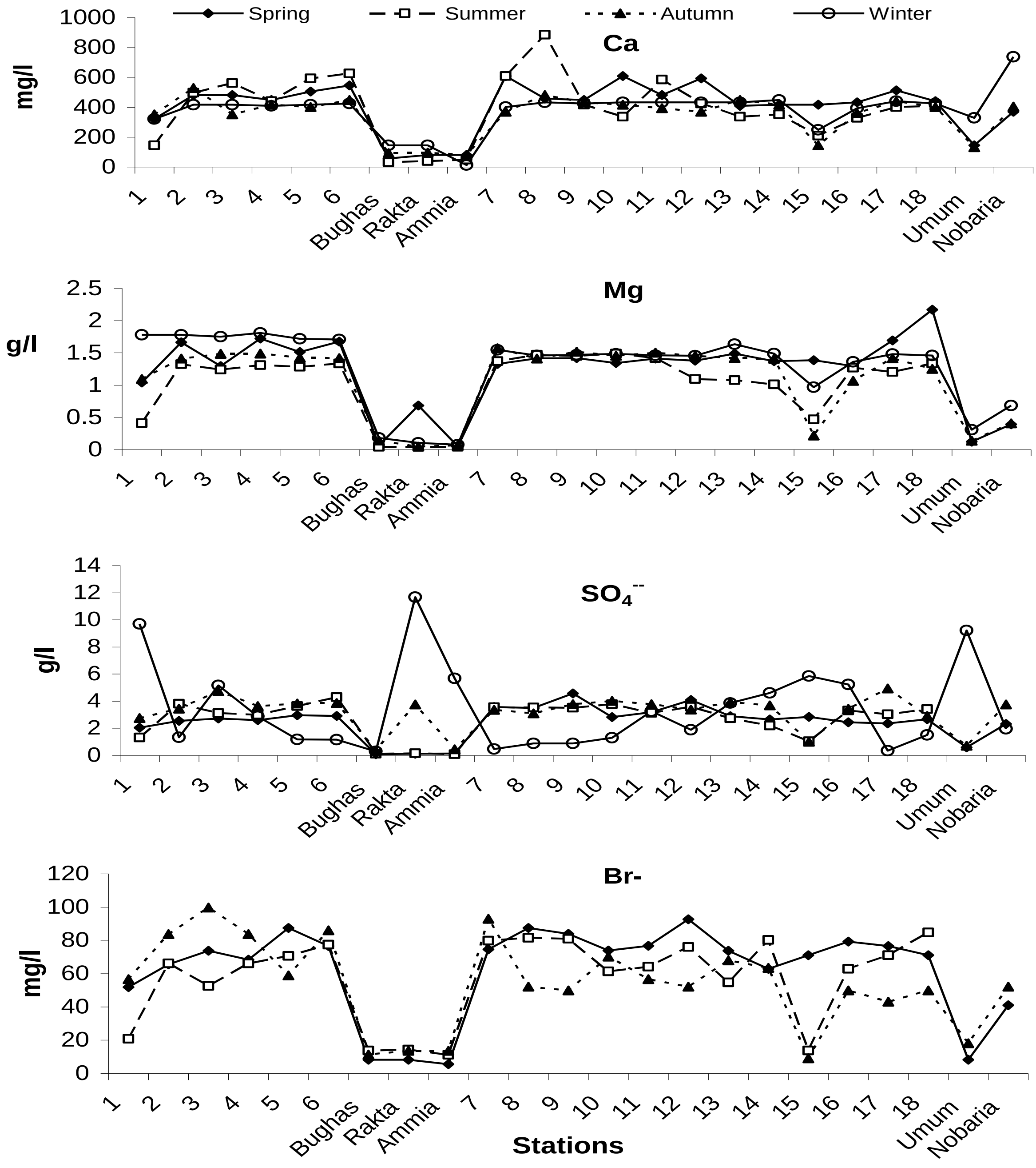

Figure (3): Seasonal variation of Ca,Mg, sulfate and Bromide of Alexandria surface coastal water and some drains during 2004-2005

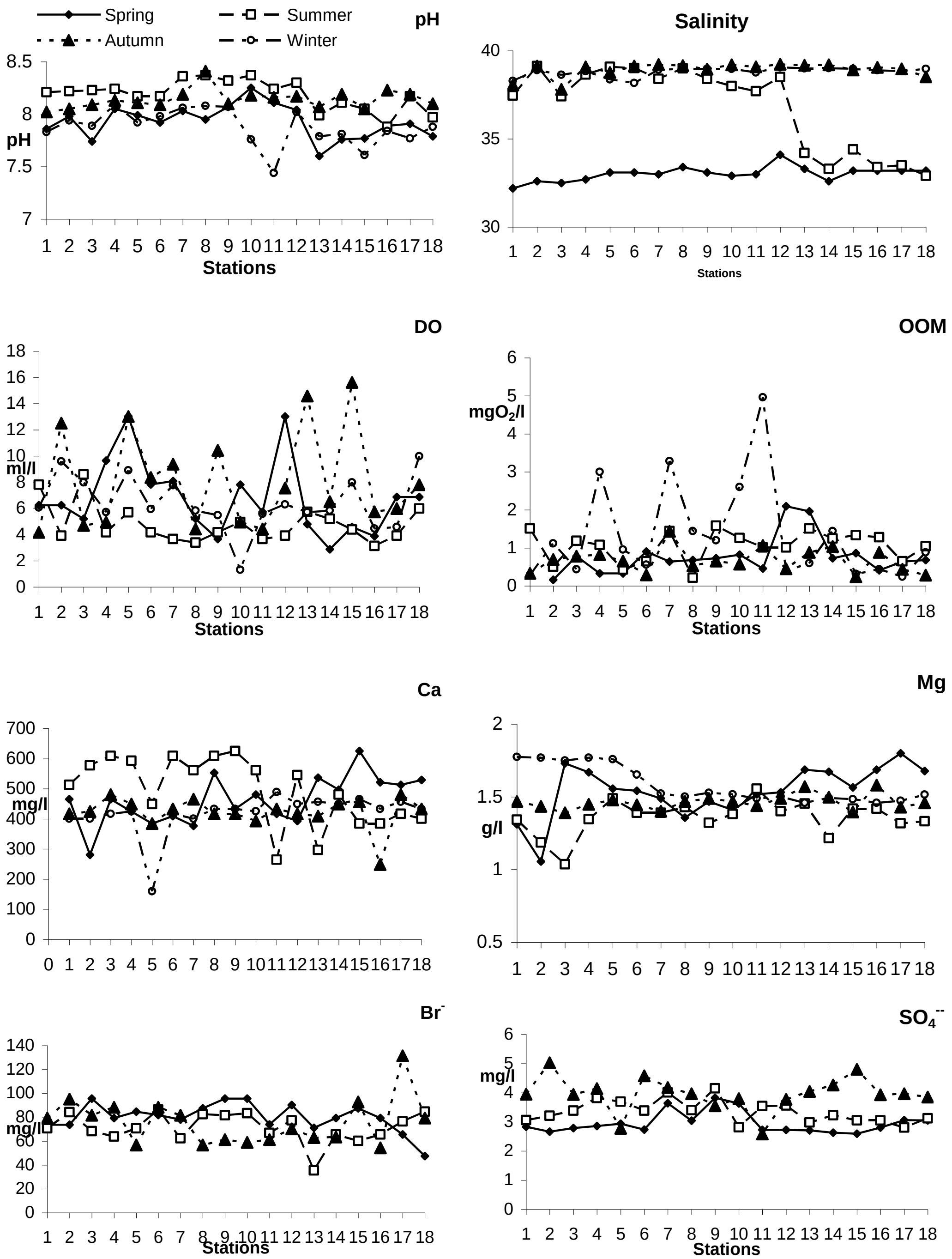

Figure (4): seasonal distribution of different physicochemical paramerters of Alexandria coasta bottom water during 2004 - 2005

Table 1: Seasonal averages of chlorinity ratios of Ca, Mg, SO_4, and Br of surface, drains, and bottom water of the investigated area during 2004 – 2005.

Surface Water				
	Mg/Cl	**Ca/Cl**	**Br/Cl**	**SO_4/Cl**
Spring	0.084	0.027	0.004	0.168
Summer	0.069	0.026	0.004	0.179
Winter	0.069	0.022	0.003	0.191
Autumn	0.076	0.020	-	0.156
Average	0.075	0.024	0.004	0.174
Drains Water				
	Mg/Cl	**Ca/Cl**	**Br/Cl**	**SO_4/Cl**
Spring	0.537	0.274	0.028	1.263
Summer	0.076	0.078	0.025	0.223
Winter	0.061	0.064	0.009	0.809
Autumn	0.091	0.084	-	4.108
Average	0.191	0.125	0.021	1.601
Bottom Water				
	Mg/Cl	**Ca/Cl**	**Br/Cl**	**SO_4/Cl**
Spring	0.084	0.025	0.004	0.162
Summer	0.067	0.024	0.004	0.164
Winter	0.068	0.020	0.004	0.183
Autumn	0.074	0.019	-	-
Average	0.073	0.022	0.004	0.170

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