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CHEMICAL CONDITIONS IN BARDAWIL LAGOON : 2- THE MAJOR ANIONS.

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ABSTRACT

The water of Bardawil Lagoon collected along six seasons showed anomaly in sulphate. The anions sulphate, bromide and bicarbonate alkalinity, except chloride, are higher in the main Lagoon than in the western arm. The anions chlorinity ratios are higher in the Lagoon than in normal seawater. The high values of bicarbonate and sulphate are index to the productivity of the Lagoon waters.

INTRODUCTION

In spite of the considerable importance of Bardawil Lagoon as a fishing center in north Sinai, no detailed chemical investigations of its waters had been done before. Yitzhak (1971) determined the major ions of the Lagoon water and minerals of the sediments.

In previous work, Morcos et al.(1969), El-Samra (1973); Meshal (1973 and 1977); realized that the doctorine of constancy of composition of sea water does not apply to lake water. But they deduced formula which can be applied for water of Mariut, Edku and Quarun Lakes, respectively, the same ionic composition of these lakes. Cole (1975 and 1979), stated also that, the empirical formula for sea water differs from lake to another.

With regard to the chemical composition, the water body of lakes, show marked differences among themselves on one hand and depart basically from accepted formula applied to determine salinity for seawater on the other hand (Mahlis et al., 1970). The most obvious difference lies in the enrichment of both major anions and cations and in the chloride content and like other waters have higher sulphate chlorinity ratio than seawater (El-Wakeel et al., 1970).

A knowledge of the chemical composition of the waters of the Egyptian lakes is desirable. The present study is carried out to determine the major anions namely, sulphate and bromide, their distribution and their chlorinity ratios beside, the alkalinity and the specific alkalinity of the lagoon water.

MATERIAL AND METHODS

a- Material

Twelve stations were chosen to represent the different regions of the lagoon. The Lagoon is connected with Mediterranean Sea through two inlets, one in the western arm (Yitzhak, 1971) (Fig. 1), and the new one is for the main Lagoon observed during carrying out this investigation, (Fig. 2). Water samples were collected by standard water sampler regardless of the depth of water of each station. They were collected in well stoppered polyethylene bottles of one liter capacity and alkalinity determination was carried out in the field after collection. The other elements were analysed at Barrage chemist laboratory.

The methods described ny the American Public Health Association (Anon., 1965), were followed for the determination of chlorosity, carbonate and bicarbonate alkalinity; chlorosity by titration against $AgNO_3$ using K_2CrO_4 as indicator, and alkalinity by titration using phenolphthaline and methyl orange as indicators for determination of carbonte and bicarbonate, respectively. Sulphate was determined following the method of Merk and Sinke (1981). The analysis was carried out on a filtered water sample (0.5 ml) diluted 100- fold to bring the sulphate below 50 mg/l. The determination of bromide was carried out according to Morries and Riley (1966), through substitution against $Na_2 S_2 0_3$.

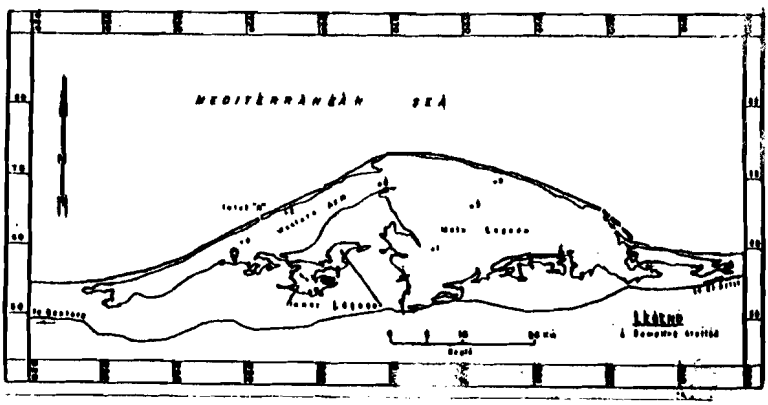

Fig. (1)
Index map of Dabkhat el Bardawil

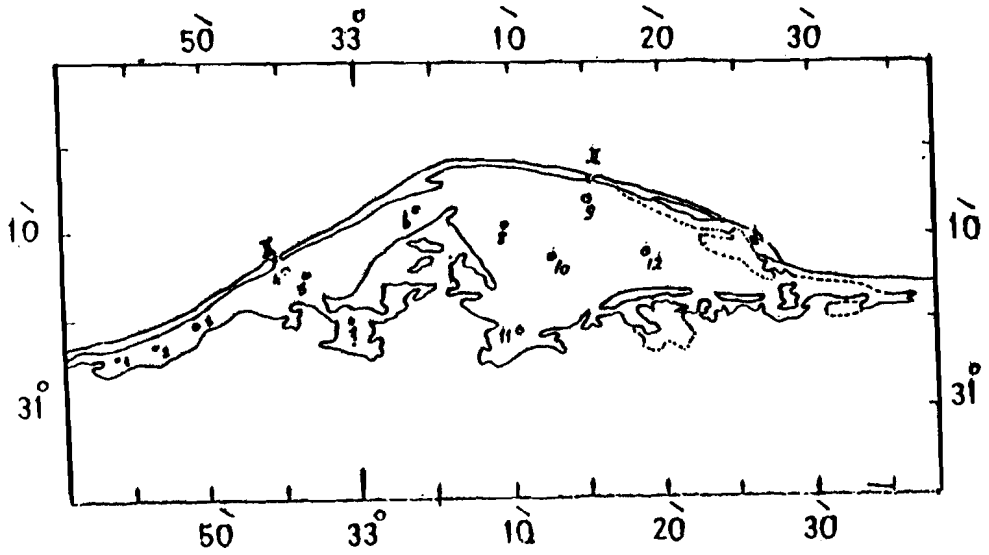

Fig. (2)
Map location of stations at Bardawil Lagoon.

RESULTS AND DISCUSSION

Chlorosity

The values of chloride content expressed in g/l for the twelve stations during autumn, winter 1985 and through 1986 as well as the annual average values are shown in table 1.

According to Yitzhak (1971), chlorosity variations in the Lagoon are high in the inner Lagoon ranging from 32.95 to 44.7 g/l at the surface and 41.5 to 45.0 g/l at the bottom. At the western arm, the chlorosity is much lower than that at the inner Lagoon and the main lagoon. So, the values range between 23.08 to 27.48 g/l and 26.45 to 35.45 g/l for the surface and bottom waters, respectively. The main Lagoon shows a slight variation to the inner lagoon, it ranges between 33.95 to 42.25 g/l at surface and 39.4 to 42.6 g/l near the bottom.

Chlorosity determined by the author is slightly lower than that found by Yitzhak (1971). This is mainly due to the inrush and the dilution of the Lagoon water by a sea water less in chloride content as a result of the continuous digout of the Boughazes I and II. The annual average value was 26.77 g/l at surface and 36.05 g/l near the bottom. The annual average value was 26.77 g/l at surface and 30.23 g/l at the bottom (Table 1).

TABLE 1
The chloride Content in g/l^{-1} in the Bardawil Lagoon water

		STATIONS												Seasonal
		1	2	3	4	5	6	7	8	9	10	11	12	Average
August	S	-	45.44	34.08	27.34	27.19	26.5	37.86	-	29.94	34.42	37.86	30.64	33.06
1985	B	_	51.98	52.25	31.67	43.37	47.5	44.4	-	35.8	35.45	38.21	30.64	38.16
November	S	22.58	22.58	22.58	18.06	21.61	19.36	33.87	28.07	16.13	36.15	33.87	24.52	24.87
	B	32.9	31.61	29.03	21.94	27.74	25.81	40.32	30.65	32.26	37.53	33.57	26.77	31.57
January	S	26.13	26.13	27.09	18.98	19.35	21.29	30.98	27.59	18.39	22.74	24.19	17.42	23.36
1986	B	26.13	26.13	30.00	18.98	21.78	21.29	45.48	29.04	19.35	26.61	25.16	18.39	25.78
Apr.	S	32.66	28.49	27.1	23.75	24.67	21.54	37.87	29.53	23.45	24.67	22.93	22.41	26.26
	B	32.66	32.66	29.53	28.92	28.14	28.84	38.91	30.57	31.27	24.67	24.67	25.01	29.65
July	S	87.86	34.42	37.15	-	29.25	26.85	34.42	27.54	27.54	30.29	32.7	28.14	31.38
	B	39.58	40.96	47.16	-	34.42	29.26	35.11	29.6	30.29	30.98	33.05	30.29	34.24
October	S	36.17	31.99	29.91	20.86	20.87	28.52	25.73	27.82	23.66	27.12	31.3	27.82	30.08
	B	36.56	34.78	31.3	28.17	21.56	29.91	36.17	27.82	24.34	29.20	32.69	29.82	30.08
Annual	S	31.02	31.5	29.67	21.8	23.85	24.03	33.46	28.12	23.19	25.9	27.15	25.17	27.75
Average value	B	33.61	37.01	36.52	25.91	29.4	30.40	40.05	29.52	28.86	30.72	31.25	26.45	31.56

S = surface.
B = bottom.

Sulphate Determination

The values of sulphate content expressed in mg/l during the period of investigation, as well as, the annual average values, are shown in table 2. During 1986, the sulphate content reached its maximum values of 4920 and 5100 mg/l at the surface and the bottom layers in April, while the minimum values of 1260 and 2100 mg/l were at the surface and bottom respectively, as a result of the majority inrushing of seawater in January. The average values of sulphate content are higher at station 7 which are consequently higher than that of seawater amounts to more than 2.6 g/l. The great variation in sulphate content is probably of biological significance which is confirmed by Riley and Skirrow (1965). Bond (1935) refers to inland salt lakes which are rich in anions other than chloroide and often in cations other than sodium in contrast to the waters of marine origin. The higher sulphate values observed in such brine waters, as stated by Rawn and Moore (1944) and Hutchinson (1957), are due to saturation only with respect to alkaline earth carbonates and in few cases to gypsum as a result of excess of high calcium present (see under calcium) and intense evaporation. Yitzhak (1971) and Cole (1968 and 1975), confirmed that, high sulphate usually reflect the presence of old marine sediment due to the arid conditions.

Bromide Determination

The average seasonal values of bromide content, together with the annual average values expressed in mg/l are given in table 3. The maximum bromide contents are 138 mg/l and 140 mg/l in July at station 7 at surface and near bottom and the minimum values of 66 mg/l at surface and near bottom and the minimum values of 66 mg/l at surface of stations 5 and 6, in January, and 81 mg/l near the bottom at station 1 in April. These values are higher than those amounted for normal sea water (64.2 mg/l) (Sverdrup et al., 1942). Yitzhak (1971), stated that, bromide variations in the Lagoon are high, as chloride content, in the inner Lagoon ranging from 112 to 140 mg/l at the surface and 112 to 114 mg/l at the bottom. The western arm bromide content is lower than the inner Lagoon and the main Lagoon. So, the values range between 86 to 120 mg/l and 105 to 122 mg/l for the surface and bottom, respectively for the main Lagoon. For the western arm the values range between 66 to 101 mg/l and 97 to 105 mg/l for the surface and bottom, respectively.

Alkalinity Determination

The alkalinity values for the Lagoon water are given in tables 4 and 5. It is clear from the data obtained that, the alkalinity increases during spring and decreases towards summer to reach its minimum during autumn. The absolute maximum values of 344 mg/l and 340 mg/l in the Lagoon occurred at the surface and bottom water at station 6 in April. While the minimum value of 133 mg/l for both surface and bottom layers at station 2 was recorded in November (Tables 4 and 5).

TABLE 2
The Sulphate content in mg/l in Bardawil Lagoon.

		STATIONS												Seasonal
		1	2	3	4	5	6	7	8	9	10	11	12	Average
August	S	-	2310	2260	1990	3315^{+}	2760	2575	-	1850	2110	1840	1350^{-}	2236
1985	B	-	2650	2875	2550	3900^{+}	2750	3120	-	2875	2235^{-}	2600	2250	2786.5
November	S	2600^{+}	2550	2310	990	840^{-}	1380	1680	1840	1440	2040	1380	2250	187.0^{-}
	B	2750	2550	2750	1380	840^{-}	1680	890	1840	1500	2160	1840	3600^{+}	1065.0^{-}
January	S	2250	2250	2430	1440	1260^{-}	3120^{+}	2575	2040	2550	2575	2675	2675	2376.25
1986	B	3720^{+}	2575	3000	2100^{-}	2675	3390	2675	2160	2600	2675	3390	2675	2802.92
April	S	3240	3600	3240	2720	2750	3720	3720	3000	2650	3000	2750	4920^{+}	3275.83
	B	3600	3600	3720	2840	3000	5100^{+}	3930	3600	3000	3390	3390	5100^{+}	3689.17
July	S	2680	2680	2680	-	2675	2760	4740^{+}	3390	3800	2760	2760	2620^{-}	3058.64
	B	2750	2750	2750	-	2675	2850	4600^{+}	4200	4200	4200	4600	3150	3466.67^{+}
October	S	2850	2850	2850	3150	2100	2850	4600^{+}	4200	4200	4200	4600	3150	3466.67^{+}
	B	2850	3450	3450	2474^{-}	3150	2850	4200	4200	5100^{+}	3750	4600	4200	4139.5^{+}
Annual Average Value	S	2724	2756.67	2756.67	2158	2156.67	2765	3315	2894	2715	2780.53	2667.5	2877.5	2713.9
	B	3134	2929.17	1919.17	2268.8	2706.67	3098.33	3455.83	3038	3132.5	2838.33	3106.67	34175	3096.11

N.B. The maximum values are designated by "+" and the minimum by (-)
S = Surface B = Bottom

TABLE 3
The Bromide content in mg/l in Bardawil Lagoon.

		STATIONS												Season
		1	2	3	4	5	6	7	8	9	10	11	12	Averag
August 1985	S	-	-	-	-	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-	-	-	-
November	S	-	-	-	-	-	-	-	-	-	-	-	-	-
	B	-	-	-	-	-	-	-	-	-	-	-	-	-
January 1986	S	90	95	98	86	66⁻	66	112⁺	86	82	80	74	70	83.75
	B	92	96	94	95	95	98	114⁺	110	98	95	96	92	97.08
April	S	81	88	90	79⁻	85	86	115⁺	120	110	107	105	101	96.58
	B	81	85	89	90	92	90	125⁺	120	118	115	110	112	102.25
July	S	96	96	101	-	70⁻	78	138⁺	122	125	128	130	130	110.27
	B	98	98	105	-	90⁻	105	140⁺	130	132	136	132	130	117.73
October	S	80	85	90	85	85	50	110⁺	100	98	99	94	90	91.33
	B	87	90	91	88	85	97	108⁺	105	102	103	98	96	94.33
Annual Average Value	S	86.75	90.75	94.75	83.33	76.5⁻	77.5	118.75⁺	103.75	105	103.75	100.75	97.75	96.48
	B	89.5	92.25	94.75	91.0	90.5	93.0	121.75	113.75	112.5	112.0	109.00	107.5	102.85

N.B. The maximum values are designated by (+) and the minimum values by (-)
S = Surface B = Bottom

TABLE 4

Carbonate and Bicarbonate alkalinity (mg/l) in Bardawil Lagoon Water.

			STATIONS												Seasonal
			1	2	3	4	5	6	7	8	9	10	11	12	average
August 1985	S	$CO_3^=$	-	15.4	8.0	0.0	10.4	16.0	0.0	-	0.0	0.0	0.0	0.0	4.98
		HCO_3^-	-	200	232	241	260	241	183	-	251	245.6	234.4	251	233.9
	B	$CO_3^=$	-	0.0	0.0	10.0	9.0	16.0	0.0	-	0.0	20.8	0.0	0.0	5.58
		HCO_3^-	-	200	200	229	254	248	313.6	-	252	245.6	239.6	251	242.28
November	S	$CO_3^=$	0.0	0.0	14	14	0.0	0.0	14	0.0	0.0	31	0.0	0.0	6.88
		HCO_3^-	140	133	133.64	133	140	142.8	133	150.64	154	205	142.24	184	146.71
	B	$CO_3^=$	0.0	0.0	14	14	0.0	0.0	14	0.0	0.0	20	0.0	0.0	517
		HCO_3^-	139	133	121.5	140	140	151.2	126	156.2	147	215	142.24	147	146.51
January 1986	S	$CO_3^=$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		HCO_3^-	244	230	234	265	254	246	232.8	265.6	248	260	264	258	250.37
	B	$CO_3^=$	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
		HCO_3^-	236	238	240	258	254	236.8	247.6	260	248	264	266	260	250.7
April	S	$CO_3^=$	0.0	18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	38.2	0.0	4.68
		HCO_3^-	264.2	263.2	275.2	304	303.6	344	266	326	307.6	326	272	296	296.23
	B	$CO_3^=$	0.0	19.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	31.8	0.0	5.32
		HCO_3^-	263.2	280.8	283.6	311	304	340	263.6	324	281.2	317.6	276.8	304	295.82
July	S	$CO_3^=$	24	20	34	-	32	32	36	32	22	38	24	46	30.91
		HCO_3^-	220	220	240	-	272	274	224	276	288	276	252	258	252.91
	B	$CO_3^=$	18	29	36	-	35	30	24	42	16	26	16	40	27.82
		HCO_3^-	218	218	228	-	262	272	236	280	286	784	252	268	254.91
October	S	$CO_3^=$	30	16	21	18	15	13	10	14	23	12	26	28	20.33
		HCO_3^-	189	127	122	288	145	145	140	144	129	290	115	131	157.17
	B	$CO_3^=$	11	9	13.	28	10	26	10	22	18	24	20	16	16.58
		HCO_3^-	127	130	122	284	148	122	129	124	128	270	128	122	162.17
Annual Average Value	S	$CO_3^=$	10.8	11.56	12.83	6.4	4.24	10.17	10.0	232.85	7.5	13.5	14.7	11.0	11.36
		HCO_3^-	201.64	195.53	200.4	246.8	229.1	232.13	196.47	9.2	225.43	265.43	213.27	224.67	222.88
	B	$CO_3^=$	5.8	8.03	10.5	8.8	9.5	12.8	8.0	12.8	8.77	15.13	11.3	9.33	10.16
		HCO_3^-	196.44	199.97	198.18	244.4	227	226.67	219.3	228.84	223.7	266.83	236.11	225.33	222.75

S = Surface B = Bottom

TABLE 5

Total alkalinity, the Bicarbonate alkalinity in mg/l in Bardawil Lagoon Water.

		STATIONS												Seasonal average
		1	2	3	4	5	6	7	8	9	10	11	12	
August	S	-	215.4	240	241	270.4	257	183*	-	251*	245.6*	234.4*	251*	238.88
1985	B	-	200 *	200*	239	263	254	313.6*	-	252*	266.4	239.6*	251*	247.86
November	S	140*	133	147.64	147	140*	142.8*	147	150.64*	154*	236	142.24*	154*	152.86
	B	139*	133	135.5	154	140*	151.2*	140	156.2*	147*	235	142.24*	147*	151.68
January	S	244*	230*	234*	265*	254	246	232.8*	265.6*	245*	260*	264*	258*	262.94
1986	B	236*	238*	240*	258*	254*	236.8*	266*	326*	307.6*	326*	310.2	296*	302.0
April	S	284.2*	281.2*	275.2*	304*	303.6*	344*	266*	326*	307.6*	326*	310.2	296*	302.0
	B	263.2*	300*	283.6*	311*	304*	340*	263.6*	324*	300.0*	317.6*	308.6	304*	301.63
July	S	244	240	274	-	304	306	260	310	290	314	276	304	283.82
	B	236	238	274	-	300	302	260	312	302	310	261	308	282.73
October	S	150*	143*	143*	306*	160*	158*	150*	158*	152*	292*	141*	151*	175.33
	B	138*	139*	135*	304*	158*	148*	139*	146*	146*	294*	140*	148*	169.58
Annual Average Value	S	212.44	207.1	218.97	253.2	238.67	242.3	206.47	242.05	233.77	278.93	227.97	235.67	235.97
	B	202.44	208	211.35	253.2	236.50	238.67	227.3	239.64	232.5	881.17	229.41	236.33	237.03

N.B Bicarbonate alkalinity is designated by (*)
Total alkalinity ($HCO^{+} + CO_3^{=}$) is not designated.
S = Surface B = Bottom.

TABLE 6

Sulphate, Bromide, and Alkalinity/chlorinity ratio for stations 2 and 6 in Bardawil Lagoon.

		STATION 5					STATION 6				
		Cl ‰	SO_4/Cl‰	Br/cl‰	alk./cl‰	alk./cl‰	Cl‰	SO_4/cl‰	Br/cl‰	alk./cl‰	alk.cl‰
August	S	41.44	0.0557	-	5.1979	0.1732	25.56	0.10798	-	10.05477	0.3350
1985	B	47.98	0.0552	-	4.1684	0.1389	43.5	0.06322	-	5.83908	0.1946
November	S	21.93	0.1162	-	6.0647	0.2021	19.04	0.0725	-	7.5000	0.2499
	B	30.31	0.0841	-	4.38799	0.1462	24.89	0.0675	-	6.0747	0.2024
January	S	25.3	0.10079	0.00375	9.09091	0.3029	20.72	0.15058	0.00318	11.8726	0.3956
1986	B	25.3	0.10178	0.00379	9.40711	0.3135	20.72	0.16361	0.00472	11.4286	0.3828
April	S	27.3	0.1314	0.00322	10.300	0.3432	21.51	0.1729	0.003998	15.4925	0.5329
	B	31.21	0.11534	0.00272	9.6123	0.3203	27.84	0.824	0.00323	12.1264	0.4041
July.	S	32.72	0.08191	0.00290	6.3626	0.2120	25.96	0.10632	0.00301	11.7874	0.3928
	B	36.96	0.0744	0.00265	6.4394	0.2146	28.15	0.10018	0.00375	10.7282	0.3928
October	S	30.62	0.0931	0.00277	4.6701	0.1556	27.47	0.10375	0.00291	5.7517	0.1917
	B	33.02	0.1045	0.00272	4.20957	0.14027	28.71	0.0993	0.00275	10.5190	0.3505
Annual Average Value	S	30.18	0.0913	0.00323	6.8618	0.2287	23.30	0.11867	0.003326	6.7811	0.2260
	B	35.8	0.0818	0.00258	5.8100	0.1936	29.20	0.10611	0.00318	5.0685	0.1689

S = Surface B = Bottom

These data are higher than those determined by Yitzhak (1971), who found that the main Lagoon is higher than both western arm and the inner Lagoon. It ranges between 195 to 205 mg/l for surface and bottom, respectively at the main Lagoon. While the western arm ranges between 180 to 187 mg/l $CaCO_3$ and 170 to 197 mg/l $CaCO_3$ for both surface and bottom, respectively and from 134 to 168 mg/l and 134 to 163 mg/l at the inner Lagoon for surface and bottom layer, respectively.

Carbonate alkalinity shows irregular variations. In winter, the carbonate ranged from a lower values of 4.68 and 5.82 mg/l at surface and bottom in spring to maximum values of 30.41 and 27.82 mg/l for the same layers, respectively in summer 1986.

The change in alkalinity observed in analogous to variation in calcium content of the water (sea under Ca) (Moberg and Revell, 1937; Sverdrup et al., 1942; Hutchinson, 1957 and Cole 1975 and 1979).

Sulphate/ Chlorinity Ratio

The sulphate/ chlorinity ratio was calculated from the determined values of sulphate and chlornity. The data of the average values of sulphate/ chlorinity ratios are tabulated in table 6. Table 6 shows that the sulphate/ chlorinity ratio increases with the decrease of chlorinity or in other words, the sulphate content decreases with the increase of chlorinity and vice versa. The sulphate/ chlorinity ratio for the Lagoon water varies from the absolute average maximum of 0.12061 at surface of station 9 to a minimum of 0.0913 at station 2. At bottom, it varies between a maximum of 0.12969 at station 12 to a minimum of 0.0818 at station 2 with annual average value of 0.10138 and 0.10241 at surface and bottom, respectively.

For sea water and oceans, the sulphate/ chlorinity ratio is 0.1400 (Morris and Riley, 1966). According to Thompson et al. (1931), the sulphate/ chlorinity ratio for the Mediterranean waters averages 0.1396. Bather and Riley (1954) gave an average sulphate/ chlorinity ratio of 0.1399 for the Irish Sea. At PortSaid, Morcos (1967) found the sulphate/ chlorinity ratio for the sea water to be 0.1405. Thompson et al. (1931) found the sulphate /chlorinity ratio to be 0.1414. This confirms the idea that the sulphate/ chlorinity ratio increases in some regions and decreases in the others according to their salinities.

Seasonal Variation of Sulphate /Chlorinity Ratio

A seasonal variation in the sulphate/ chlorinity ratio in the Lagoon water is expected due to the seasonal variation in chlorinity which is due to the intense evaporation at that desert Lagoon of the arid climatic conditions (See under chlorosity). Table 7 shows the seasonal and regional variations of sulphate/chlorinity ratios in the Lagoon. The average sulphate/ chlorinity ratio for the Lagoon water varies seasonaly from a maximum of 0.13042 and 0.14322 during early autumn for the surface and bottom layers,

0.06833 during summer and autumn of 1985, at the surface and bottom layers, respectively. This is due to the increase of sulphate as mentioned earlier The data for seasonal variation of the sulphate chlorinity ratio for station 2 and 6 (Table 7) are presented graphically in Fig. 3, compared with salinity values at the same stations during the same time.

It is clear from the figure that the sulphate/ chlorinity ratio is inversely proportional to chlorinity and consequently salinity.

Rgional Variation of Sulphate/ Chlorinity Ratio

Table 7 shows the regional variation of sulphate/chlorinity ratio of the Lagoon during 1986. Station 2 which is far from the direct effect of inflowing of sea water through Boughaz I shows a maximum sulphate /chlorinity ratio of 0.1314 (Cl ‰ = 27.3) and a minimum sulphate/chlorinity ratio of 0.0552 (Cl ‰ = 47.98). While station 6 which is close to the direct effect of sea water in front of Boughaz I has a maximum sulphate/chlorinity ratio of 0.1824 (Cl ‰ = 27.84) and a minimum ratio of 0.0632 (Cl ‰ = 43.5). Regional variations of sulphate/chlorinity ratio are attributed to the effect of sea waters of less sulphate content in comparison to the Lagoon intense evaporation of the arid condition Lagoon and to the marine sediment of calcium sulphate.

Bromine /Chlorinity Ratio

The average bromine/chlorinity ratio deduced from the determined bromide and chlorinity values are given in table 6. The average bromine/chlorinity ratios for Bardawil Lagoon water are 0.003555 and 0.003556 at the surface and bottom layers, respectively. The ratio for Bering sea, the Antractic and Pacific Oceans is 0.00347 (Thompson and Korpi, 1942). Morris and Riley (1966) gave a an average value of 0.00348 for all oceans. A high ratio of 0.00353 for inshore waters collected around the coasts of the British Isles was obtained by Gibson and Haslam (1950). The average bromine/chlorinity ratio for the Lagoon water is slightly higher than that of the oceans and seas.

Seasonal and Regional Variation of Bromine/Chlorinity Ratio

Table 7 shows the seasonal and regional variation of the bromine /chlorinity ratio. The bromine/chlorinity ratio decreases with increasing chlorinity (Fig. 3). A seasonal variation in the bromine/chlorinity ratio is observed, a summer of lower ratio and being higher in winter (Fig. 3).

Specific Alkalinity of Bardawil Lagoon Water

The averages for alkalinity and specific alkalinity (alkalinity / chlorinity ratio) are given in table 7. Fig. 4 shows that the alkalinity/ clorinity ratio follows more or less the increase in the clorinity at the surface water of

TABLE 7

Regional and seasonal average variations of sulphate, Bromine and alkalinity /chlorinity ratio in Bardawil Lagoon Waters.

			Regional Average Value Variations												
			STATIONS												
			1	2	3	4	5	6	7	8	9	10	11	12	
Sulphate	Annual	S	0.0916	0.0913⁻	0.09216	0.10179	0.09316	0.11867	0.1039	0.10679	0.1206⁺	0.11105	0.10177	0.11812	0.10138
SO_4^{2-} = Br	Average	B	0.0978	0.0818⁻	0.0869	0.09057	0.0957	0.10611	0.09586	0.10705	0.1127	0.09627	0.10373	0.12969⁺	0.10241
	Value														
Bromine	Annual	S	0.00292	0.0030	0.0033	0.0039	0.0033	0.0033	0.0037	0.0034	0.0046⁺	0.0035	0.0034	0.0040	0.003555
Br^{1-}	Average	B	0.00279	0.00258	0.00275⁻	0.00353	0.0032	0.0032	0.0034	0.0040	0.0041	0.0038	0.0037	0.0048⁺	0.003556
	Value														
Alkalinity	Annual	S	0.2379	0.2287	0.2558	0.3979	0.3435	0.3465	0.2157	0.2976	0.0346	0.3712	0.2898	0.3224	0.39373
	Average	B	0.2107	0.136	0.2047	0.3368	0.2787	0.2724	0.2101	0.2514	0.2788	0.3178	0.2530	0.299	0.2613
	Value														

	Seasonal Average Value					
	Sulphate		Bromine		Alkalinity	
	S	B	S	B	S	B
August 1985	0.07087⁻	0.07826	-	-	0.2523	0.0324⁻
November	0.07737	0.06833⁻	-	-	0.2107⁻	0.1673
January 1986	0.10459	0.13270	0.0037	0.0039	0.3856	0.3359⁺
April	0.12892	0.12944	0.0038⁺	0.0036	0.360⁺	0.3527
July	0.101717	0.09525	0.0037	0.0036	0.3145	0.2595
October	0.13042⁺	0.14322⁺	0.0034⁻	0.0033⁻	0.2198	0.1955
Annual Average Value	0.101378	0.102422	0.063555	0.003556	0.29373	0.2613

N.B. The maximum values are designated by (+) and the minimum values by (-)

S = Surface B = Bottom

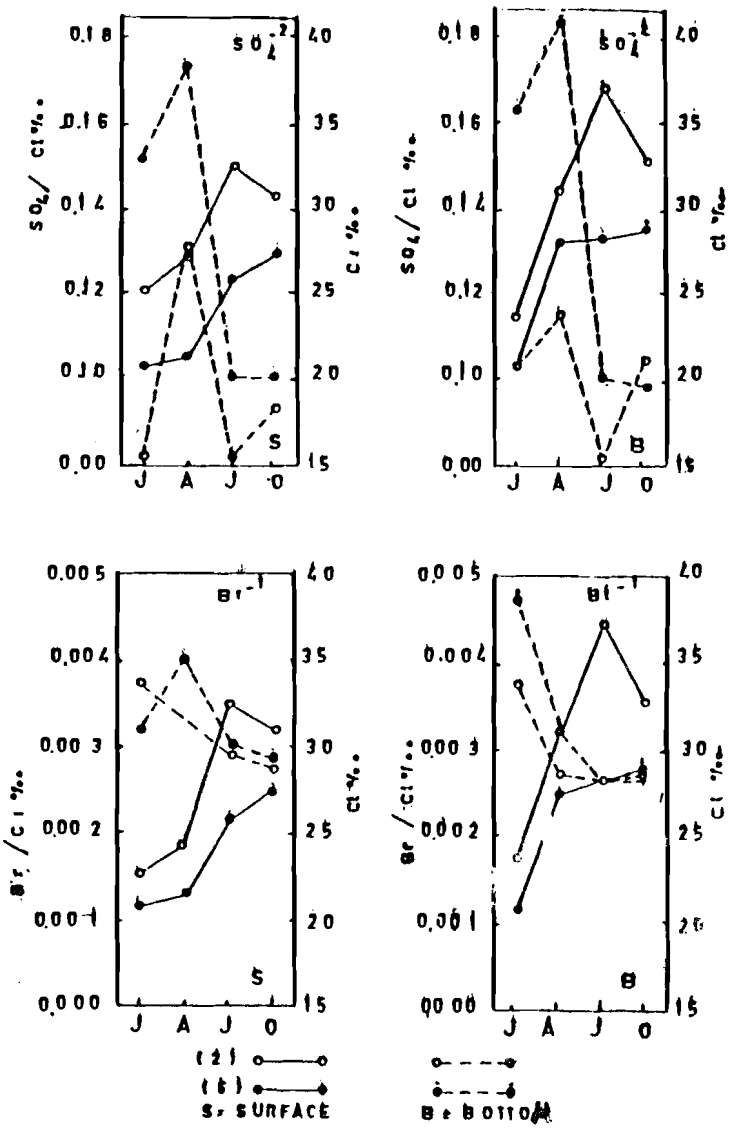

Fig. (3)
Seasonal variation of anions chlorinity ratio (SO_4 & Br) and chlorinity at stations 2 & 6 in Bardawil Lagoon surface and bottom waters.

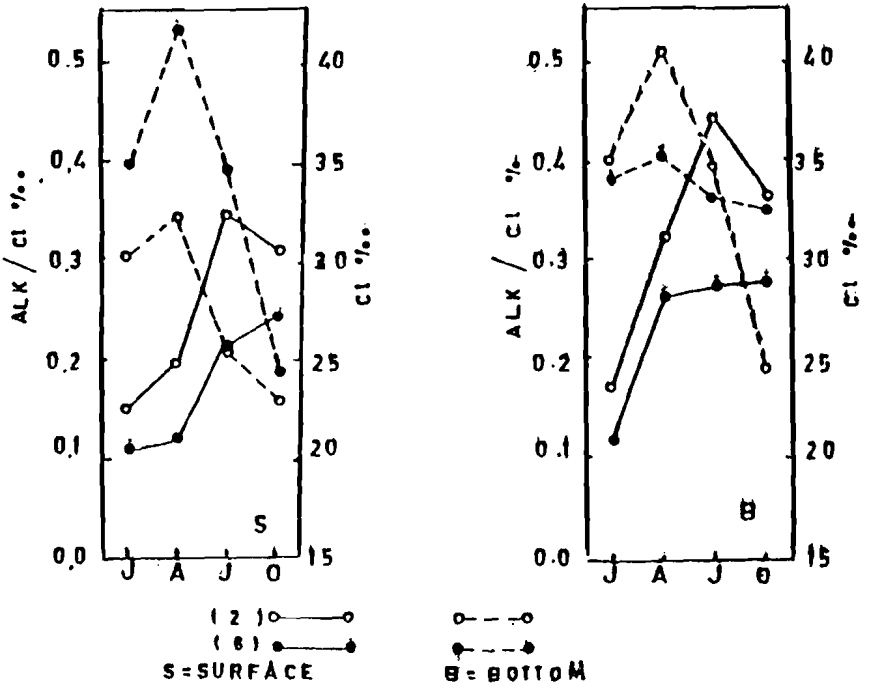

Fig. (4)
Seasonal variation of alkalinity to chlorinity ratio and chlorinity at station 2 & 6 in Bardawil Lagoon at surface and bottom waters.

The average specific alkalinity for the water of Bardawil is 0.29373 and 0.2613 at the surface and bottom water layers. It is noticeable that the Bardawil ratio is 7 times higher than that of sea water of 0.126 given by Koczy (1956).

SUMMARY AND CONCLUSION

Determination of sulphate and bromine contents and the alkalinity of the Bardawil Lagoon water was carried out at twelve stations during six seasons of mid 1985 and the year 1986. The sulphate/ chlorinity ratio increases with decrease of chlorinity. It has averages of 0.01013 at the surface and 0.1024 at the bottom waters which are less than the ratio of

0.1395 for sea water and lower than the ratio for rivers waters. Regional variations in the SO_4/Cl ratio are attributed to the effect of sea water of lower sulphate content than to the Lagoon, $CaSO_4$ of mineral deposits and may be to evaporation. The average bromine/ chlorinity ratios 0.003555 and 0.003556 were observed at the surface and bottom layers. Also, the seasonal variation of the Br/Cl ratio shows a regional variation. The specific alkalinity increases with the increase of chlorinity. The average specific alkalinity for the Bardawil Lagoon is 0.29373 and 0.2613 at the surface and bottom layers which is higher than sea water (0.126), and lower than that for river water. The high values of bicarbonate are index to the productively of the Lagoon water.

The change in alkalinity is analogous to variation in calcium content of the waters, (Siliem 1984).

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