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CHEMICAL CONDITIONS IN BARDAWIL LAGOON
III- SOME LIMNOLOGICAL STUDIES

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ABSTRACT

Some physical and chemical investigations of the Bardawil lagoon, an Egyptian Lagoon, were studied and discussed. variations of the secchi disc readings, hydrogen ion concentration, chlorisity and dissolved oxygen were correlated with the Mediterranean water introduced into the lagoon. The high rate of evaporation due to arid conditions.

INTRODUCTION

The Bardawil Lagoon, One of the largest salt water lagoons in the northern coast of Sinai province of Egypt, is an interesting ecosystem with an average water spread area of about 1440 km^2. Its average depth is 2.5 m. The Lagoon is connected to the Mediterranean Sea through Boughases I and II (Fig. 1). The Lagoon is subjected to tidal effect, arid conditions and high evaporation (Yitzhak, 1971; Siliem, in press). No stream flow into it. The mouth of the Lagoon gets silted up and closed, but since 1986 the digout of the two Boughases continue to prevent this silted up.

The importance of fisheries economy of Egypt depends mainly on the Egyptian lakes. So, it was necessary to make intensive studies on the environments and biology of these lakes in order to evaluate their productivity with regards to their fish production. Yitzhak (1971) studied the cations and anions of the waters collected from three parts of the lagoon, also sediment was identified by X-Rays.

In mid 1985 and through 1986, we have started a new program for studying the Bardawil Lagoon. This program coverd diffeent limnological aspects and was proceeded by a team of several workers. It is hoped that this new study will help to improve fisheries in such ecosystem. The first result of this program a Technical report (in Arabic 1986) was on the investigation of the hydrobiological studies on the hypersaline Bardawil lagoon.

The present work is caried out to study some limnological characteristics of the Lagoon and to compare the data obtained with those from other lakes and to improve its fisheries.

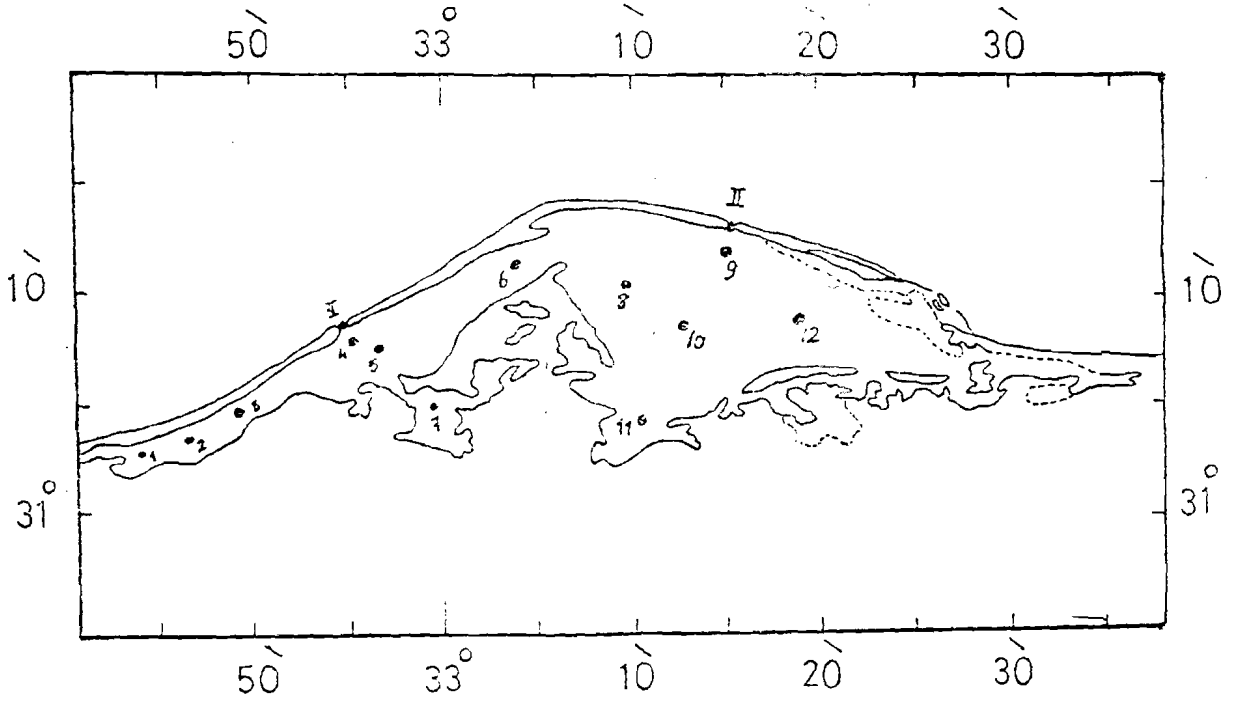

Fig. 1 - Map . Location of stations at Bardawil Lagoon.

MATERIALS AND METHODS

Sampling locations are indicated in Fig. 1. Water samples for physico-chemical studies were collected at 6 stations (1-6) in the western zone, one station (7) in the inner Lagoon and five stations (8-12) in the main Lagoon. The water samples were collected by Ruttner sampler and put in well stoppered polyethylene bottles of about one liter capacity.

Sampling was carried out during 1985-1986. The water temperature was measured with the thermometer in the sampler during sampling. Transparency measurements were made with a white enamilled secchi disc 25 cm in diameter. The pH of the water samples was determined using pH meter model 720. Total chloride and dissolved oxygen were carried out according to Anonymous (1965).

RESULTS

Transparency

Table 1 shows seasonal and regional variations of secchi disc readings in Bardawil Lagoon. Station 11 had lower values of secchi disc readings than the other stations followed by stations 10, 12 and 9 respectively. An average annual maximum and minimum values of secchi disc readings reached 183 and 107 cm at stations 3 and 11, respectively.

In addition, the seasonal average higher and lower values of secchi disc readings reached 156 and 132 cm in July and October respectively.

Temperature Measurements

The average air temperature, surface and bottom water temperatures in the Bardawil Lagoon during the study period are given in table 2. The air temperature recorded a maximum of 30.2°C in July 1986 and a minimum of 15.79° C in January.

The water temperature of the Lagoon obviously followed more or less that of the air. The average surface water temperature varied from a maximum of 30.27°C in July 1986 to a minimum of 16.17°C in January. The bottom water temperature varied slightly than that of the surface in summer, while in winter, it showed a uniformity in January (16.17° C). It recorded a higher value of 30.41° C in July to a lower of 16.17° C in winter.

Hydrogen Ion Concentration

The pH values obtained at all stations are given in table 3. The pH of the surface water ranged between 7.5 and 8.6 with an average value of 8.09 and the bottom water pH ranged between 7.2 and 8.76 with an average of 8.1. Local and seasonal variations of pH were recorded at different stations during the study period. The regional average pH values showed slight differences at all stations in the

TABLE 1
Seasonal and regional variations of Secchi disc readings (cm)
in the Bardawil Lagoon

		STATIONS												Seasonal average
		1	2	3	4	5	6	7	8	9	10	11	12	
Aug. 1985	S.D.	135	135	180	220	125	190	145	-	150	160	120	110	153
Nov.	S.D.	145	115	195	170	150	180	140	125	115	140	120	110	142
Jan. 1986	S.D.	175	175	160	135	190	135	130	150	80	85	85	125	135
Apr.	S.D.	160	140	17.0	140	100	200	200	160	120	150	100	150	149
Jul.	S.D.	200	160	195	-	200	140	215	150	140	90	100	130	156
Oct.	S.D.	175	165	200	100	100	160	120	130	140	60	120	115	132
Regional average value	S.D.	171	148	183+	196	144	167	158	143	124	114	107	123	144

TABLE 2
The average water temperature (C) for surface (S), bottom (b)
of the Bardawil Lagoon waters and air temperature (Ta)
at time of collection.

	Aug. 1985	Sept.	Nov.	Jan. 1986	Feb.	Apr.	May.	Jul.	Oct.	Nov.	Mean average value
Air temp.	29.65	28.75	20	15.79	19	23.82	26.0	30.2	26.2	16.94	23.64
Water temp. (S)	29.65	27.63	18.91	16.17	16.4	23.45	26.4	30.27	25	16.0	22.99
Water temp. (b)	29.65	28.38	19.0	16.17	16.5	23.45	26.7	30.41	25.7	16.56	23.25

Lagoon. A minimum and maximum value of 7.95 and 8.16 in the surface water were recorded at stations 11 and 12, respectively. For the bottom water, the maximum and minimum pH values were 8.21 and 7.92 at stations 1 and 11, respectiely. Generally, the bottom water had a slightly lower pH values than the surface one.

The seasonal average pH values gave aminimum of 7.78 for surface and bottom waters in January 1986 and a maximum of 8.3 for surface and bottom waters in November 1985.

Chlorosity Content

The chlorosity values expressed for the Bardawil Lagoon waters in the surface and bottom during the period of investigation are given in table 4. It is clear form the data obtained that chlorosity showed regional variations. The Mediterranean Sea water inrushing through Boughazes I and II gave exceedingly low chlorosity values. Stations 4, 5 and 9 taken in the vicinity of Boughazes I and II showed relatively lower chlorosity values than those in the other stations taken further away from these Boughazes. Exclusing the inner lagoon (station7), the regional average chlorosity values varied from a maximum of 31.5 and 37.01 g/l recorded for both surface and bottom water layers at station 2 and a minimum of 21.8 and 25.91 g/l for both surface and bottom waters, respectively at station 4.

The seasonal average chlorosity content ranged between a maximum of 33.06 and 36.15 g/l in Aug. 1985 before the digging processes of Boughazes I and II, to a minimum of 23.36 and 25.7 g/l in January during the continuous digging processes of Boughazes II. Generally, the chlorosity of the lagoon waters reached an annual average value of 27.75 g/l at the surface and 32.56 g/l near the bottom.

Dissolved Oxygen

Seasonal and regional variations of DO for the Bardawil Lagoon waters during the study period are given in table 5. Generally DO had normal concentration and distribution in the Bardawil Lagoon. Also, the bottom water, more or less, at all stations gave relatively higher values than the surface water at the same stations. The regional average surface values varied from a maximum of 5.38 ml/l at station 8 to a minimum of 4.05 ml/l at station 3. A maximum of 5.25 ml/l and a minimum of 3.94 ml/l at stations 8 and 1 for the bottom layer, respectively, were recorded.

The values of DO in summer 1985 and 1986 were lower than those found in the other season for both surface and bottom waters. The surface seasonal average maximum and minimum values of 5.8 and 3.99 ml/l were found in January and April respectively. The bottom seasonal average maximum and minimum DO values of 6.19 and 4.07 ml/l also were recorded in January and April.

TABLE 3
Seasonal and regional variations of pH in the Bardawil Lagoon water

		STATIONS												
		1	2	3	4	5	6	7	8	9	10	11	12	Seasonal Average
Aug.	S	-	7.9	7.8	7.95	8.15+	7.8	7.8	-	8.05	8.0	7.9	8.05	7.955
1985	B	-	7.95	7.85	8.00	8.2+	8.01	7.9	-	8.03	8.0	7.4	8.08	7.99
Nov.	S	8.2	8.3	8.4	8.3	8.3	8.3	8.2	8.3	8.25	8.6+	8.2	8.2	8.30+
	B	8.4	8.4	8.35	8.2	8.2	8.3	8.1	8.3	8.25	8.7+	8.4	8.3	8.33+
Jan	S	7.9	7.9	7.9	7.95+	7.8	7.7	7.85	7.9	7.8	7.6	7.5	7.7	7.78
1986	B	7.9	7.92	8.0+	7.78	7.7	7.85	7.85	7.9	7.85	7.5	7.4	7.75	7.78
Apr.	S	7.8	7.95	7.94	8.1	8.25+	8.03	7.88	8.07	8.00	7.6	8.13	8.12	7.99
	B	7.88	8.0	8.13	8.2	8.27	8.07	7.97	8.09	8.05	7.75	8.16+	8.12	8.06
Jul.	S	8.3	8.42	8.56+	-	8.23	8.13	7.97	8.18	8.2	8.1	8.35	8.41	8.26
	B	8.1	8.39	8.39	-	8.22	8.17	8.0	8.18	8.23	8.2	8.35	8.48+	8.25
Oct.	S	8.45	8.45	7.92	8.05	8.25	8.05	8.5+	8.25	8.3	8.5	7.6	8.45	8.23
	B	8.76+	8.4	8.0	7.97	8.25	8.2	8.4	8.2	8.2	8.47	7.3	8.15	8.19
Reg. av. value	S	8.13	5.15	8.095	8.04	8.15	8.04	8.03	8.14	8.11	8.07	7.95	8.16+	8.09
	B	8.21+	8.18	8.12	8.03	8.14	8.1	8.04	8.13	8.1	8.1	7.92	8.15	8.10

TABLE 4
Chloride content (g/l) in the Bardawil Lagoon

		STATION												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	38.15
Nov.	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
Jan.	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	25.70
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
Jul.	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
Oct.	S	36.17	31.99	29.91	20.86	20.87	28.52	25.73	27.82	23.65	27.12	31.3	27.82	27.56
	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
Regio. Aver. Value	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
	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

TABLE 5

Seasonal and regional variation of dissolved oxygen (DO) (ml/L) in the Bardawil Lagoon water

		STATION											Seasonal
		1	2	3	4	5	6	7	8	9	10	11	12 average
Aug. 1985	S	-	5.75	4.9	7.95	4.2	3.78	3.5	-	3.9	3.4	3.3	3.8 4.13
	B	-	6.56	5.6	8.00	4.5	3.66	3.6	-	4.9	3.55	3.64	4.22 4.42
Nov.	S	4.98	5.34	4.76	8.3	4.94	5.14	4.79	4.76	5.23	4.4	5.23	5.04 5.03
	B	5.37	5.52	6.71	8.2	5.32	5.49	3.29	4.79	5.86	4.6	4.66	5.72 5.28
Jan.	S	5.5	5.8	5.8	7.8	7.23	5.49	5.18	6.17	6.19	5.47	5.0	5.47 5.8
	B	5.8	6.0	5.9	7.78	6.63	6.25	6.6	6.86	5.14	5.9	5.5	6.47 6.19
Apr.	S	1.5	1.79	1.57	8.1	3.79	6.81	4.08	6.95	4.69	4.6	4.3	2.75 3.94
	B	1.66	1.56	1.57	8.2	3.53	7.47	3.58	6.68	4.77	4.77	4.4	2.08 4.07
Jul.	S	4.46	4.35	6.65	-	3.89	3.89	5.13	5.0	3.96	3.63	4.00	4.28 4.22
	B	3.37	3.51	4.29	-	3.89	3.79	3.24	5.14	4.28	3.37	4.41	3.67 3.87
Oct.	S	4.25	3.89	3.5	8.05	4.67	4.0	4.15	4.07	4.38	4.67	4.02	4.4 4.22
	B	3.5	3.5	3.3	7.97	4.54	4.15	3.88	3.76	4.28	4.54	4.02	4.15 4.01
Mean aver value	S	4.14	4.15	4.05	8.0	4.79	4.85	4.47	5.38	4.73	4.36	4.31	4.29 4.56
	B	3.94	4.46	4.67	8.0	4.74	5.13	4.14	5.25	4.87	4.46	4.41	4.39 4.64

S = Surface B = Bottom

DISCUSSION

According to Verhingtan (1930), the light intensity at the depth of disappearance is approximately one third of that at the surface. Verduin (1965) stated that such readings can be assumed to represent about one-fifth of the euophotic zone under normal conditions.

The turbidity of the Lagoon showed regional and seasonal variations. The highest turbidity of the Bardawil water observed in January and October 1986 is mainly due to the continuoud mixing of the Lagoon water and the sterring up of the Lagoon bottom water by the strong wind action which prevailed in January (Vatove, 1961) and the phytoplankton blooming in autumn. On the contrary, the highest transparency found in summer 1985 and 1986 is mainly more or less, due to the stability of the Lagoon water which resulted from the decrease of the wind speed. Generally, turbidity is primarily a function of the wind speed, since on windy days the turbidity was much higher than on calm days (White and Hartland Rowe, 1969). Siliem (1984) reported that the maximum transparency in the Damietta channel is related to the significantly higher O_2 resulting from dense blooms of phytoplankton.

The Bardawil Lagoon being shallow, its water temperature follows more or less that of the air. No clear thermal stratification could be observed in the Lagoon. This is due to the shallowness of its water and contenuous mixing by wind action and boat propellers (Elester and Jensen, 1960; Ganapati, 1965 and Siliem,1974). This is contrary to other tropical lakes studied by Boxter et al., (1965) and Beadle (1966). The monthly average temperature varied from a maximum of 30.27 and 30.41^{o}C for surface and bottom water in January. Aleem (1958) stated that, most of the dominant species of phytoplankton inhabiting the Egyptian lakes are eurythermic forms which tolerate wide ranges of temperature.

Hydrogen Ion Concentration

The hydrogen ion concentration of the surface water ranged between 7.5 and 8.6, and near bottom ranged between 7.2 and 8.76. Naguib (1958) recorded pH values ranging between 7.95 and 8.25 in Lake Quaron, an inclosed inland lake in Egypt. In most lakes a pH range from 6.5 to 8.5 is expected, although extreme values may be realised (Welch, 1935).

Generally, the average pH values recorded at different stations gave slight differences. This may be mainly attributed to boat propellers and the wind action on the lagoon water.

The increase in pH values in the Lagoon may be associated with dense phytoplankton blooms flourishing in spring and autumn and removing the dissolving CO_2 (Juday et al., 1924; Philip, 1927; Juday et al., 1943; John and Dodimead, 1957; Hutchinson, 1957; Aleem amd Samaan, 1969; El-Wakeel and Wahby, 1970 and Siliem. 1974 and 1984). Other factors, such as respiration are also responsible for the changes in pH values.

The lower pH values recorded in certain months can be related to the decrease in oxygen content which was observed at most stations (Wattenberg, 1933; Smith, 1952 and Siliem 1984). In addition, the decomposition of organic matter on the bottom can explain the lower pH values at the lower layer (Juday, 1924 and Naguib, 1958; Saad, 1973; Hannan and Young, 1974 and Siliem, 1974 and 1984).

Chlorosity Variation

The chlorosity of sabkhat El-Bardawil showed local variations. The distribution of chlorosity in the Lagoon is controlled mainly by the discharge of the Mediterranean Sea water through the feeding inlets (Boughaz), and the high rate of evaporation due to the arid conditions of the lagoon. Yitzhak (1971) recorded that chlorosity variations were high in the Lagoon due to the discharging the Mediterranean Sea water through Boughaz I. It ranged from 32.95 to 44.7 g/l in the surface of the inner Lagoon. At the western arm, the values ranged between 23.08 and 27.48 g/l

at the surface. The main Lagoon showed a slight variations relative to the inner Lagoon. It ranged between 33.95 and 42.25 g/l at the surface.

Recently, the discharge of the Mediterranean Sea water through two Boughazes (I and II) causes a exceedingly lower chlorosity values, as recorded at stations 4,5,6 and 9 being affecting directly by seawater. They gave a lower average chlorosity value than those at stations 1,2,3 7,8, and 11. These stations, selected further away from the two Boughazes, had higher chlorosity content.

Oxygen Variations

Dissolved oxygen is the most important factor affecting the survival and distribution of aquatic organisms. So, if the oxygen determinations are accompanied by observations on secchi disc transparenty, a very great deal is known about the Lake (Hutchinson, 1957) and hence its productivity (Ruttner, 1953).

The values of DO in summer were lower more or less than those in other seasons. This indicates an inverse correlation between DO and water temperature (Neel, 1951; Ruttner, 1953; Naguib, 1958 MacCrimmon and Kelso, 1970 and Siliem, 1974). In addition, the rate of oxygen consumption increases during the summer (Aleem and Samaan, 1969).

The DO for both summer and autumn was more or less similar. This mean that, the oxygen of the lagoon is affected more by physical (temperature) than by biological (aasimilation) factors (Elester and Jensen; 1960). The higher values recorded during the winter season are mainly attributed to low water temperature (Siliem, 1974) and to the continous mixing of the lagoon water by wind action (Aleem and Samaan, 1969). In addition, the motion of boat propellers must be also considered.

The increase in DO content recorded in autumn 1985 is mainly due to the phytoplankton crop. Several authors have reported that the phytoplankton growth is accompanied by an increase in DO (Harvey, 1928; Foyn, 1929; Braarud and Klem, 1931; Dakin and Colfax, 1935; Gran and Brearud, 1935; John and Dodimead, 1957; and Siliem, 1974).

The average surface values of DO gave regional differences. This may be due to continous stirring up of the Lagoon by wind action and boat propellers. The observed lower DO values near the bottom are mainly attributed to the decomposition of the descending plankton and organic matter (Heinrich, 1934; Welch, 1935; Siewell and Siewell, 1935, Naquib, 1958; El-Wakeel and Wahby, 1970; and Siliem, 1984).

Generally, the water of the Lagoon was well oxygenated and depletion of DO was never observed. For, the Nozha Hydrodrome, near Alexandria, Egypt (Saad, 1973) Manzalah Lake, and Egyptian coastal lake (El-Wakeel and Wahby, 1970) found the same conditions.

SUMMARY

Twelve stations, covering the whole Lagoon area, were selected. The period of investigation started in August 1985 and continued till October 1986. Air and water temperatures, transparency, pH, DO and chloride content were studied. The turbidity of the Lagoon showed regional and seasonal variations due to phytoplankton bloom, wind action and boat propellers. Due to the shallownens of the lagoon, obviously water temperature followed more its air temperature and no clear thermal stratification was observed. The average pH values gave slight differences at different stations and showed a slight decrease near the bottom. Chlorosity showed local variations according to the amount of Mediterranean Sea water discharged into the Lagoon through the feeding Boughazes (I and II) and to the high rate of evaporations. The Bardawil Lagoon was well oxygenated and depletion of DO was never observed.

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