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IMPACT OF DRAINAGE WATER INFLOW ON THE ENVIRONMENTAL CONDITIONS AND FISHERY RESOURCES OF LAKE BOROLLUS

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ABSTRACT

The brackish water lake Borollus occupies a central position at the north between the two branches of the Nile delta. This lake has a particular importance in the fish economy of Egypt. Therefore environmental and fisheries investigation was carried out at the lake during 2000 – 2002, where 15 stations covering the whole area of the lake were sampled. The present study points out that:

1. The water transparency of the lake is low where the average Secchi disc depth ranged between 21.14 cm and 43.89 cm.
2. The average water temperature attained its minimum in winter and ranged between 16.20 °C and 17.80 °C. The highest temperature was in summer where it ranged between 28.33 °C and 28.52 °C.
3. The recorded pH values indicate that the lake water was generally in the slightly alkaline side and optimum for fish to live in.
4. The eastern part of the lake exhibited higher chlorosity values comparing with the middle or western areas as a result of mixing with the penetrated sea water.
5. The whole water body of the lake is well oxygenated where the average values of dissolved oxygen ranged between 6.6 mg/L and 11.1 mg/L.
6. The most abundant species among the inorganic nitrogen compounds was the nitrates. The average concentrations of nitrates in the water of the lake ranged between 1.23 μ gat/L and 7.165 μ gat/L.
7. The isolines distribution of phosphates concentrations indicate that such concentrations were high at the south decreasing northwards.
8. The drainage water contributes in increasing silicates concentrations in the lake water.
9. The sharp decrease in chlorosity of the lake water during the last 30 years greatly contributed in changing the species composition of fish population in the lake.
10. The percentage weight of marine fish species in the experimental catch decreased from 15.99% in 1973 to 1.81% in 2002, where the most of marine fish species did not exist in the catch.
11. The percentage weight of ***Oreochromis niloticus*** increased from 19.70% in 1973 to 39.43% in 2002.

1. INTRODUCTION

The Nile delta lagoons situated south to the Mediterranean Sea mainly get their water supply from the drainage water through several drains connected to these lakes at their southern parts.

Montasir (1937) pointed out that these lakes are not of marine origin, and supposed to be formed as a result of Nile water accumulation.

At Lake Borollus the drainage water mixes with sea water which invades the lake through lake – sea connection located at the north eastern part of this lake. Therefore the lake water is given brackish character.

Associated with the errection of Aswan high dam, the last normal discharge of the Nile flood water into the Mediterranean and north delta lakes took place during 1964. Since 1967 the total surplus of flood water has been planned to use for agriculture purposes.

To compensate for the decreased Nile water discharge to the lake it was planned to pour the drainage water of the surrounding agricultural lands and other human activities into the lake before reaching the sea. About 3904 million m^3 of drainage water reached the lake during the year 2000. On the other hand the ground water inflow to Lake Borollus during the same year was estimated as 266.7 thousand m^3/month.

The fish fauna of Lake Borollus is usually composed from both fresh water fish species; mainly tilapia and some species of marine origin which enter the lake for feeding. Such marine fish live in the lake until reaching sexual maturity it migrates for spawning into the sea.

The increased rate of drainage water discharge to the lake during the last years influenced the abundance and distribution of fish populations in such important fishing area.

The present study deals with:

1. Investigating the important chemical features of both the lake and drainage water.

2. Identifying the impacts of drainage water on the environmental conditions at the lake.

3. Assessment the impact of drainage water discharge on the abundance and distribution of fish resources at Lake Borollus.

This study is a part of the research program of fisheries division (NIOF) during 2000 – 2003.

1.2. Area of study:

Lake Borollus occupies a central position among the north delta lakes of Egypt. It locates between Rosetta branch of the Nile delta in the west and Damiatta branch at the east. It is the second largest lake. It occupies at present about 100,000 feddans. It is roughly of rectangular in shape extending from the west to the east for 60 km with surface water width ranging between 6 and 18 km as shown in the map (Fig. 1). This lake is separated from the Mediterranean by a sandy belt which becomes wider in the western part of the lake.

While the Northern shore of the lake is sandy, the southern one is largely muddy with large areas overgrown by reed. Along the southern shore, several drains discharge drainage water.

Like other delta lagoons; Lake Borollus is shallow; almost everywhere the depth of water is less than one meter. This depth slightly increases westward. Because of such shallow depth the fishermen can easily work out of their boats walking in the water.

The bottom of the lake consists of sands, calcarious material of sea origins (shells of Cardium and other Mollusks) and silt. There is a number of islands on the lake, some of them is large in size. These islands are not populated except for some fishermen.

Beyond the short-term variations of water level caused by wind the depths fluctuate slightly in the various seasons of the year. In general a drop is evidenced in summer due to the increased evaporation. The other drop of water level of the lake occurs in winter in consequence of the decreased amount of water discharge by the drains.

The transparency of the lake water is generally very low due to the action of wind in mixing the water with the fine bottom sand. Only small areas located at the south of the lake where reed and other emergent aquatic macrophytes shelter the surface water therefore these areas exhibit relatively clear water.

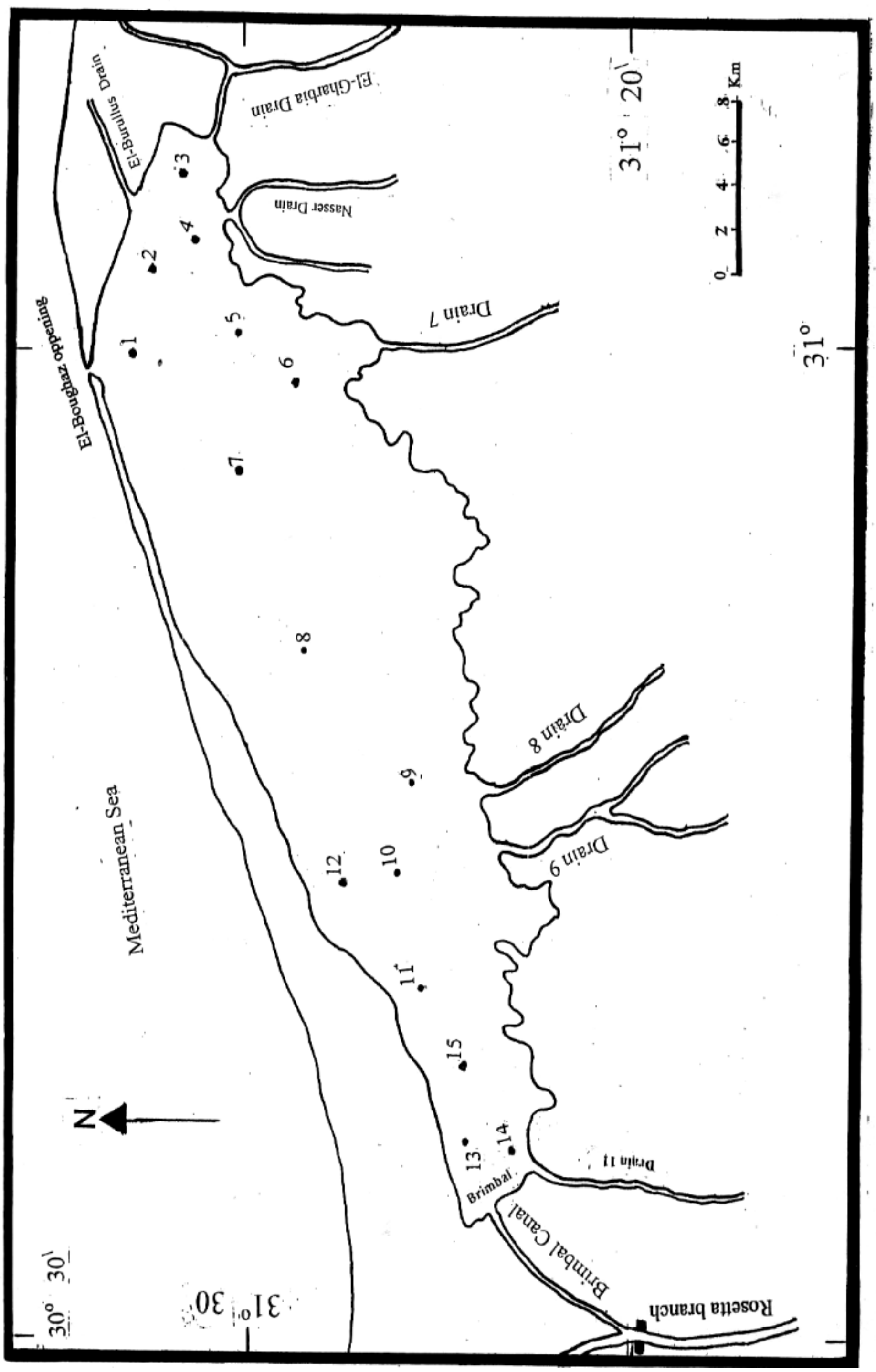


Fig. (1): Sampling stations at Lake Borollus

High human population inhabits the lake shores. People earn their livings through exploiting the fishery resources and agriculture. There are two main concentrations of villages at the lake, one at the south east and the other at the north east.

According to environmental conditions the lake can be roughly subdivided into three parts namely Eastern, Middle and Western parts.

1.3. Water resources of Lake Borollus:

Lake Borollus water is of brackish nature. A mixture of drain and sea water is the two main sources to the lake. Seepage from the cultivated lands and rain fall in winter are secondary sources. Human activities wastes are discharged to the lake. Generally the Southern part of the lake and its Southern basin are more affected by the drainage. water Northern parts and the Eastern basin are more affected by the sea water.

Rainfall water:

The average rainfall water given by El-Shinnawy (2003) Table(1), is 187.33 mm. This depth of water provides the lake with mean annual volume of about 77.35 million m^3.

Drainage water :

The drainage system provides the lake with about four million cubic meters annually of agricultural drainage water. El-Shinnawy (2003), Table (2) shows the monthly inflow of the drainage water through each of the drains joining the lake at its southern margin.
Tidal water inflow:

Tidal water inflow:

Fanos (1990) found that the tide at Lake Borollus can be estimated as the difference between the mean high water level (33-cm) and the mean low water level (18-cm) of a difference 15.0 cm. Accordingly the tide effect is too small and may be neglected during spring, summer and autumn and considered in winter where the action of wind contributes in the invasion of sea water to the lake.

Domestic discharge:

The social studies in the area surrounding Lake Borollus indicated that about 185 thousand people live in such area. Water consumption of that population can be estimated as 27,750 m^3/day. This volume of water is discharged to the lake.

Ground water:

The ground water inflow to Lake Borollus was estimated by El-Shinnawy (2003) as flows:

Interface	Ground water inflow (m^3 / day)
Bottom	63141
Boundaries	25761
Total	88902

Table (1) : Statistical analysis of monthly rainfall over Lake Borollus (El-Shinnawy 2003).

Month	Jan	Feb	M.	Ap	May	Jun	Jul	Aug	Sep.	Oct	Nov	Dec.	total
Mean	44.66	32.70	14.72	4.58	1.45	0.0	0.0	0.0	0.61	7.80	27.95	48.78	187.33
S.D.	+33.89	+32.52	+25.39	+7.00	+8.88	0.0	0.0	0.0	0.0	+15.78	+26.53	+41.79	+82.59

Table (2): Monthly drainage inflow to Lake Borollus (1997 – 2000) in million m^3 (After El-Shinnawy 2003).

Month	Terah	Borollus	D.7	D.11	D.8	Bur.??.	D.9	Ghar.	Bremb.	Total	%
Jan	32.93	4.89	27.77	45.08	29.75	7.44	65.00	32.22	13.70	258.78	6.63
Feb.	36.83	4.56	31.75	39.91	28.58	7.37	65.00	21.37	5.70	241.07	6.17
Mar	40.11	5.74	32.23	56.71	29.64	10.45	65.00	36.41	16.75	293.04	7.50
Apr.	41.83	4.86	39.07	51.20	28.55	9.01	65.00	33.13	14.42	287.07	7.35
May	55.64	5.03	36.64	65.52	32.68	12.66	65.00	31.50	16.35	321.02	8.22
June	60.64	4.40	44.53	78.16	37.29	16.62	65.00	48.52	15.46	370.63	9.49
July	72.59	5.87	51.32	85.00	48.46	18.19	65.00	60.21	16.99	423.63	10.85
Aug.	72.34	6.30	52.00	77.62	49.55	17.35	65.00	52.37	18.02	410.55	10.51
Sep.	64.14	6.79	48.18	71.87	41.90	14.14	65.00	60.01	23.32	395.35	10.13
Oct.	46.65	5.80	39.48	56.67	33.42	9.83	65.00	44.02	19.12	319.69	8.19
Nov.	42.89	5.55	36.60	53.75	33.18	9.86	65.00	32.36	20.30	299.49	7.67
Dec.	43.08	5.96	36.53	41.49	33.97	6.83	65.00	33.63	18.80	284.29	7.28
Total	609.67	65.75	476.10	722.52	425.67	139.75	780.00	485.76	198.93	304.6	100
%	15.61	1.68	12.19	18.52	10.90	3.58	19.98	12.44	5.09	100.0	

2. MATERIAL AND METHODS:

A total number of 15 sampling stations were selected at Lake Borollus to cover the eastern, middle and western parts of the lakes as indicated in Fig. (1).

Extra seven stations were chosen at the seven drains discharging to the lake.

Monthly water samples were collected during the period from June 2000 to December 2002. Ruttener water sampler of 2 liters capacity was used for sampling.

Water temperature was measured using 0.1°C graduated thermometer. That was protected in a metallic case in which the water enters through holes in such case to keep on constancy of water temperature for a while.

Circular white Secchi disk 25 cm in diameter was used to determine the water turbidity at the sampling stations.

The pH of water was measured using portable glass electrode pH meter (Larton Research model 206).

Dissolved Oxygen was determined by the modification of Winkler method according to APHA (1985).

Chlorosity was determined according to Mohr's method (Vogel, 1953).

Nutrient salts, nitrates, nitrites and dissolved inorganic phosphorus were determined spectrophotometrically Grashof (1976) A Shimadzue double beam spectrophotometer UV-150-02.

For fisheries resources assessment at Lake Borollus, experimental fishing operations were carried out at various localities of the open water of the lake during the period from January 2000 to December 2002. These fishing stations were distributed at the whole area of the lake. Monofilament nylon trammel nets with various mesh sizes, seine net, and wire basket traps were used for collecting fish samples.

Length of fish from the tip of snout to end of the tail was measured to the nearest mm. Total weight of each fish was determined to the nearest gm.

Statistical data concerning the annual landed catch from Lake Borollus are given. (The year book of fisheries statistics in Egypt, GFARD).

2.1. Water depth of the lake water:

Lake Borollus is characterized by its low water depths (Table 3), where it can be observed that:

(1) The lowest depths were found at the various sampling stations of the eastern area of the lake. These depths ranged between 94.75 cm and 123.19 cm. The highest depths occurred at the western area and ranged between 120.00 cm and 142.22 cm.

(2) Beyond the short-term variations in the water level caused by wind, the depths fluctuate slightly in the different seasons of the year.

Table (3): Water depth (Cm) at Lake Borollus during the years 2000 to 2003.

Area	Eastern area									Middle area							Western area					Total Av.
Season	1	2	3	4	5	6	7	Av.	S.D	8	9	10	11	12	Av.	S.D	13	14	15	Av.	S.D	
Summer 2000	105.00	70.00	116.67	170.00	73.33	78.33	110.00	**103.33**	**34.89**	116.67	110.00	123.33	143.33	146.67	**128.00**	**16.26**	166.67	116.67	143.33	**142.22**	**25.02**	**119.33**
Autumn 2000	81.67	67.33	236.67	196.67	83.33	90.00	106.67	**123.19**	**65.93**	110.00	101.67	105.00	126.67	130.00	**114.67**	**12.88**	150.00	105.00	140.00	**131.67**	**23.63**	**122.04**
Average 2000	**93.33**	**68.67**	**176.67**	**183.33**	**78.33**	**84.17**	**108.33**	**113.26**		**113.33**	**105.83**	**114.17**	**135.00**	**138.33**	**121.33**		**158.33**	**110.83**	**141.67**	**136.94**		**120.69**
Winter 2001	80.00	75.00	236.67	146.67	83.33	78.33	96.67	**113.81**	**59.59**	105.00	80.00	103.33	116.67	135.00	**108.00**	**20.12**	135.00	100.00	130.00	**121.67**	**18.93**	**113.44**
Spring 2001	71.67	55.00	191.67	121.67	83.33	93.33	83.33	**100.00**	**45.28**	111.67	100.00	116.67	146.67	125.00	**120.00**	**17.44**	146.67	76.67	136.67	**120.00**	**37.86**	**110.67**
Summer 2001	96.67	63.33	176.67	186.67	85.00	60.00	100.00	**109.76**	**51.48**	113.33	103.33	143.33	146.67	133.33	**128.00**	**18.94**	160.00	100.00	143.33	**134.44**	**30.97**	**120.78**
Autumn 2001	88.33	75.00	176.67	145.00	88.33	68.33	91.67	**104.76**	**40.24**	126.67	103.33	140.00	136.67	123.33	**126.00**	**14.41**	163.33	91.67	151.67	**135.56**	**38.45**	**118.00**
Average 2001	**84.17**	**67.08**	**195.42**	**150.00**	**85.00**	**75.00**	**92.92**	**107.08**		**114.17**	**96.67**	**125.83**	**136.67**	**129.17**	**120.50**		**151.25**	**92.08**	**140.42**	**127.92**		**115.72**
Winter 2002	90.00	81.67	166.67	86.67	76.67	76.67	85.00	**94.76**	**32.09**	128.33	90.00	135.00	131.67	135.00	**124.00**	**19.21**	155.00	90.00	148.33	**131.11**	**35.76**	**111.78**
Spring 2002	83.33	68.33	173.33	115.00	76.67	71.67	83.33	**95.95**	**37.40**	135.00	90.00	146.67	141.67	140.00	**130.67**	**23.11**	136.67	116.67	148.33	**133.89**	**16.02**	**115.11**
Summer 2002	85.00	63.33	173.33	166.67	76.67	66.67	100.00	**104.52**	**46.38**	110.00	95.00	143.33	143.33	126.67	**123.67**	**21.16**	156.67	83.33	133.33	**124.44**	**37.47**	**114.89**
Autumn 2002	96.67	73.33	183.33	140.00	73.33	80.00	130.00	**110.95**	**41.71**	126.67	96.67	123.33	140.00	140.00	**125.33**	**17.73**	136.67	95.00	138.33	**123.33**	**24.55**	**118.22**
Average 2002	**88.75**	**71.67**	**174.17**	**127.08**	**75.83**	**73.75**	**99.58**	**101.55**		**125.00**	**92.92**	**137.08**	**139.17**	**135.42**	**125.92**		**146.25**	**96.25**	**142.08**	**128.19**		**115.00**

3. RESULTS AND DISCUSSIONS

3.1. Environmental conditions

3.1.1. Transparency:

Suspension of the particles of silt and clay increases the turbidity of water; this reduces both the penetration of light and photosynthesis activity and reducing waste assimilations. Capacities and may impair or curtail fish spawning.

Table (4) gives the average seasonal secchi depths recorded during 2000, 2001 and 2002. The data given indicate that:

(1) The lowest transparency was recorded at the eastern part of the lake increasing westwards to reach the highest values at the western part of such lake. Stagnancy of water at the western part due to sheltering by reed and other emergent aquatic plants is an important factor in increasing water transparency in such area.

(2) The transparency of the lake water is generally very low. Secchi – disc disappeared at depths varying between 21and 44 cm.

(3) The seasonal variations of wind speed and direction affects to great extent the water transparency at the lake.

Transparency of lake water mostly attained its highest values during autumn. The phytoplankton bloom exists at the lake during spring may contribute in decreasing water transparency in some areas of such lake.

3.1.2. Water temperature:

As a result of the shallowness of Lake Borollus, and the action of winds, the water body of this lake is subjected to mixing. The direction of wind has a great effect on the movement of water inside the lake. Therefore the thermal stratification is difficult to exist in the water body of the lake.

The average recorded surface water temperature at the various sampling stations of Lake Borollus during the period of study are shown in table (5). Such data show that:

(1) The lowest water temperature was found in winter where it ranged between 16.20 °C to 17.50 °C at the eastern and western areas respectively during 2001 and from 17.0 °C to 17.80°C in 2002.

(2) The highest water temperature in summer was 28.52°C and 28.33°C at the eastern area of the lake during 2001 and 2002 respectively. On the other hand these average values were 26.89°C and 26.89°C at the western area during 2001 and 2002, respectively.

(3) The surface water temperature variations followed the variations of air temperature. In this concern Welch (1952) indicated that in case of shallow water body it more quickly attains the changes in atmospheric temperature.

(4) The recorded water temperature did not exhibit significant differences from one station to another.

(5) In general, the water temperature starts to increase in spring reaching its maximum in summer.

Saad (1987) pointed out that water temperature influences the total standing crop of phytoplankton where it decreases during winter and regains its maximum during spring and summer. Dissolved oxygen which is an important environmental parameter for marine organisms is also influenced by water temperature. Reverse correlation can mostly be observed between temperature and dissolved oxygen.

Temperature influences the phosphorus release where it increases in summer. (Prepas and Trew, 1983) and fish is sensitive to temperature variations.

Table (4): Sechi disc depth (Cm) at Lake Borollus during the years 2000 to 2003

Area	Eastern area									Middle area							Western area					Total Av.
Season	1	2	3	4	5	6	7	Av.	S.D	8	9	10	11	12	Av.	S.D	13	14	15	Av.	S.D	
Summer 2000	35.00	31.67	28.33	19.00	28.33	25.00	28.33	**27.95**	**5.05**	31.67	26.67	32.67	46.67	31.67	**33.87**	**7.53**	40.00	25.00	48.33	**37.78**	**11.82**	**31.89**
Autumn 2000	36.67	28.33	23.33	23.33	23.33	24.33	36.67	**28.00**	**6.18**	30.00	29.00	28.33	48.33	33.33	**33.80**	**8.35**	48.33	35.00	48.33	**43.89**	**7.70**	**33.11**
Average 2000	**35.83**	**30.00**	**25.83**	**21.17**	**25.83**	**24.67**	**32.50**	**27.98**		**30.83**	**27.83**	**30.50**	**47.50**	**32.50**	**33.83**		**44.17**	**30.00**	**48.33**	**40.83**		**32.50**
Winter 2001	30.00	25.00	23.33	23.33	23.33	20.00	26.67	**24.52**	**3.15**	21.67	21.67	21.67	36.67	25.00	**25.33**	**6.50**	40.00	31.67	53.33	**41.67**	**10.93**	**28.22**
Spring 2001	28.33	21.33	17.33	21.67	28.33	20.00	20.00	**22.43**	**4.27**	35.00	20.00	28.33	41.67	35.00	**32.00**	**8.20**	41.67	30.00	48.33	**40.00**	**9.28**	**29.13**
Summer 2001	25.00	24.67	21.67	18.33	30.00	11.67	25.00	**22.33**	**5.90**	35.00	23.33	30.00	31.67	30.00	**30.00**	**4.25**	24.33	22.67	26.67	**24.56**	**2.01**	**25.33**
Autumn 2001	23.33	18.33	23.33	20.00	28.33	16.67	31.67	**23.10**	**5.39**	28.33	26.67	26.67	33.33	27.33	**28.47**	**2.80**	23.33	20.00	25.00	**22.78**	**2.55**	**24.82**
Average 2001	**26.67**	**22.33**	**21.42**	**20.83**	**27.50**	**17.08**	**25.83**	**23.10**		**30.00**	**22.92**	**26.67**	**35.83**	**29.33**	**28.95**		**32.33**	**26.08**	**38.33**	**32.25**		**26.88**
Winter 2002	26.67	21.67	20.00	17.33	20.33	17.67	24.33	**21.14**	**3.40**	23.33	20.00	26.67	35.00	33.33	**27.67**	**6.41**	28.33	20.00	33.33	**27.22**	**6.74**	**24.53**
Spring 2002	28.33	21.67	19.67	19.67	20.00	18.33	21.67	**21.33**	**3.31**	28.33	26.33	23.33	36.67	30.00	**28.93**	**4.99**	26.67	25.00	35.00	**28.89**	**5.36**	**25.38**
Summer 2002	23.33	23.33	20.00	20.00	28.33	13.33	23.33	**21.67**	**4.61**	30.00	20.00	30.00	36.00	33.33	**29.87**	**6.06**	28.33	21.67	40.00	**30.00**	**9.28**	**26.07**
Autumn 2002	23.33	26.67	21.67	22.33	21.67	15.00	23.33	**22.00**	**3.53**	28.33	19.33	24.33	50.00	30.00	**30.40**	**11.70**	33.33	26.67	53.33	**37.78**	**13.88**	**27.96**
Average 2002	**25.42**	**23.33**	**20.33**	**19.83**	**22.58**	**16.08**	**23.17**	**21.54**		**27.50**	**21.42**	**26.08**	**39.42**	**31.67**	**29.22**		**29.17**	**23.33**	**40.42**	**30.97**		**25.98**

Table (5): Surface water temperature (^{O}C) at Lake Burollus during the years 2000 to 2003.

Area / Season	Eastern area									Middle area							Western area					Total Av.
	1	2	3	4	5	6	7	Av.	S.D	8	9	10	11	12	Av.	S.D	13	14	15	Av.	S.D	
Summer 2000	27.00	27.33	27.50	27.67	28.67	29.00	29.33	**28.07**	**0.91**	29.00	29.00	28.67	28.33	28.67	**28.73**	**0.28**	28.67	27.67	28.67	**28.33**	**0.58**	**28.34**
Autumn 2000	21.33	21.00	19.33	19.33	20.33	21.00	21.33	**20.52**	**0.88**	20.33	20.00	19.33	19.33	19.83	**19.77**	**0.43**	19.33	20.67	20.00	**20.00**	**0.67**	**20.17**
Average 2000	**24.17**	**24.17**	**23.42**	**23.50**	**24.50**	**25.00**	**25.33**	**24.30**		**24.67**	**24.50**	**24.00**	**23.83**	**24.25**	**24.25**		**24.00**	**24.17**	**24.33**	**24.17**		**24.26**
Winter 2001	16.83	17.33	16.33	16.33	16.83	17.67	16.33	**16.81**	**0.53**	16.33	17.33	16.33	15.33	15.67	**16.20**	**0.77**	16.83	18.33	17.33	**17.50**	**0.76**	**16.74**
Spring 2001	24.67	25.67	25.67	24.33	23.67	24.00	24.67	**24.67**	**0.77**	24.00	24.67	24.33	24.67	23.67	**24.27**	**0.43**	25.67	26.33	26.00	**26.00**	**0.33**	**24.80**
Summer 2001	28.00	28.67	28.33	28.00	28.00	30.00	28.67	**28.52**	**0.72**	28.00	28.00	28.00	27.67	27.33	**27.80**	**0.30**	26.67	27.67	26.33	**26.89**	**0.69**	**27.96**
Autumn 2001	20.00	19.67	20.33	20.33	22.00	20.83	21.00	**20.60**	**0.77**	21.00	20.67	20.67	21.33	20.50	**20.83**	**0.33**	21.00	21.00	20.67	**20.89**	**0.19**	**20.73**
Average 2001	**22.38**	**22.83**	**22.67**	**22.25**	**22.63**	**23.13**	**22.67**	**22.65**		**22.33**	**22.67**	**22.33**	**22.25**	**21.79**	**22.28**		**22.54**	**23.33**	**22.58**	**22.82**		**22.56**
Winter 2002	16.67	18.00	17.67	18.00	17.00	17.67	17.00	**17.43**	**0.53**	17.33	18.00	18.00	18.00	17.67	**17.80**	**0.30**	17.00	18.67	17.33	**17.67**	**0.88**	**17.60**
Spring 2002	24.67	25.33	24.33	24.83	24.67	26.00	25.00	**24.98**	**0.55**	24.33	24.17	23.00	23.67	24.00	**23.83**	**0.53**	24.33	25.33	24.67	**24.78**	**0.51**	**24.56**
Summer 2002	28.00	28.33	28.67	28.33	28.00	28.33	28.67	**28.33**	**0.27**	27.67	28.00	27.67	27.67	28.00	**27.80**	**0.18**	26.67	26.67	27.33	**26.89**	**0.38**	**27.87**
Autumn 2002	21.33	21.33	21.33	22.00	22.33	22.17	21.33	**21.69**	**0.46**	22.67	23.33	23.00	22.33	22.00	**22.67**	**0.53**	22.00	22.67	22.33	**22.33**	**0.33**	**22.14**
Average 2002	**22.67**	**23.25**	**23.00**	**23.29**	**23.00**	**23.54**	**23.00**	**23.11**		**23.00**	**23.38**	**22.92**	**22.92**	**22.92**	**23.03**		**22.50**	**23.33**	**22.92**	**22.92**		**23.04**

3.1.3. Hydrogen ion concentration:

Ness (1949) pointed out that fish are able to live in water having a pH range from 5 to 10, where at pH 5.5 fish develop hypersensitivity to bacterial parasites and usually die within a short time if the pH is lower than 4.5. Moreover very hard waters are sometimes toxic to fish.

Shakweer (2003) pointed out that the optimum \environmental pH for nitrification lies between 6.5 and 8.0.

The recorded values are given in Table (6). The data given point out that:

(1) The average values of pH ranged between 7.41 at the eastern part of the lake during autumn (2002) and 9.14 at the same part of the lake during summer (2000). i.e. of alkaline behavior. Such data are of similar trend that reported by Darage (1983).

(2) The pH values recorded at the various sampling stations throughout the period of study lied in the optimum range for fish living. Huet (1972) recommended optimum pH 7.0 to 8.0 for fish ponds of similar situation to the present study.

(3) It was difficult to observe significant differences in the pH values from one station to another in the three parts of the lake. Shallowness of the lake and action of winds played an important role in mixing the water of each part.

3.1.4. Chlorosity:

Chloride content of Lake Borollus is mainly affected by two processes, i) the discharge of drainage water into the lake, ii) The invasion of sea water through the lake sea connection. The higher rates of evaporation due to elevate high temperature and the rain water during winter are other factors than can affect the chlorsity of lake water.

The chlorosity values of drainage water are given in table (7). On the other hand, the horizontal distribution of chlorosity in the whole area of the lake is indicated in Figures (2,3,4) in respective where it can be pointed out that:

(1) Higher chlorosity values were found in the water of the drains discharging at the eastern part of the lake in comparison with the other drains discharging at either the middles or western parts. These average values were 2.58%o 1.68%o and 1.94%. in the drain water discharging at the eastern, middle and western areas respectively during 2003.

(2) The average chlorosity of the drainage water attained the highest values in summer in most of the draims discharging to the lake. On the other hand the lowest values were recorded in winter.

(3) The invasion of sea water into the lake in winter as a result of rough weather contributes significantly in increasing the chlorosity of lake water at the eastern area in comparison with the middle or western areas of the lake. The impact of sea water movement to the lake in increasing the chlorosity of the water in this part is greater than that of the decreased chlorosity of drainage water during winter.

(4) The eastern part of the lake exhibited mostly higher chilorosity values compared to either middle or western areas as deduced from the spatial distribution of chlorosity (Figs. 2, 3 and 5).

(5) The chlorosity values of lake water were in most cases higher than that of drain water. Mixing with the penetrated sea water and evaporation are probably increasing the lake water Cl‰.

Table (6): pH values at Lake Borollus during the years 2000 to 2003.

Area / Season	Eastern area									Middle area							Western area					Total Av.
	1	2	3	4	5	6	7	Av.	S.D	8	9	10	11	12	Av.	S.D	13	14	15	Av.	S.D	
Summer 2000	9.10	9.03	8.87	8.57	9.43	9.47	9.50	9.14	0.35	9.10	8.60	9.03	9.00	8.73	8.89	0.22	8.30	8.57	8.77	8.54	0.23	8.94
Autumn 2000	9.10	8.83	9.07	8.80	8.90	8.97	9.10	8.97	0.13	9.00	8.80	8.73	9.43	8.93	8.98	0.27	9.03	8.43	8.90	8.79	0.32	8.94
Average 2000	9.10	8.93	8.97	8.68	9.17	9.22	9.30	9.05		9.05	8.70	8.88	9.22	8.83	8.94		8.67	8.50	8.83	8.67		8.94
Winter 2001	8.73	8.30	8.27	8.23	8.33	8.40	9.00	8.47	0.29	8.40	9.10	8.63	8.07	8.87	8.61	0.40	8.47	8.07	8.90	8.48	0.42	8.52
Spring 2001	8.03	7.73	8.07	7.93	8.40	8.53	8.07	8.11	0.27	8.30	8.07	8.00	8.10	8.33	8.16	0.15	8.20	8.43	8.07	8.23	0.19	8.15
Summer 2001	8.77	8.73	8.43	8.27	8.97	8.67	8.77	8.66	0.23	9.13	8.23	8.70	8.47	8.60	8.63	0.33	8.10	8.13	8.37	8.20	0.15	8.56
Autumn 2001	8.17	8.67	8.17	8.33	9.00	9.10	8.63	8.58	0.38	8.73	8.23	8.43	8.30	8.47	8.43	0.19	7.80	7.70	8.27	7.92	0.30	8.40
Average 2001	8.43	8.36	8.23	8.19	8.68	8.68	8.62	8.45		8.64	8.41	8.44	8.23	8.57	8.46		8.14	8.08	8.40	8.21		8.41
Winter 2002	8.07	8.00	8.10	8.30	8.13	7.60	8.13	8.05	0.22	8.50	8.27	8.17	8.00	8.23	8.23	0.18	7.73	7.50	7.63	7.62	0.12	8.02
Spring 2002	8.23	7.90	7.93	8.23	8.53	8.37	8.23	8.20	0.22	8.40	8.00	8.00	8.20	8.33	8.19	0.18	8.23	7.90	8.33	8.16	0.23	8.19
Summer 2002	7.33	7.40	7.63	7.67	7.67	7.67	7.27	7.52	0.18	7.67	7.70	7.77	7.73	7.50	7.67	0.10	7.83	8.07	7.80	7.90	0.15	7.65
Autumn 2002	7.27	7.37	7.33	7.37	7.73	7.63	7.20	7.41	0.20	7.73	7.53	7.83	7.80	7.90	7.76	0.14	7.87	7.57	7.87	7.77	0.17	7.60
Average 2002	7.73	7.67	7.75	7.89	8.02	7.82	7.71	7.80		8.08	7.88	7.94	7.93	7.99	7.96		7.92	7.76	7.91	7.86		7.87

Table (7): Chlorosity (‰) values in the water of drains discharging to Lake Borollus in (2003)

Month	Eastern area					Middle area			West area
	Bur.	Ghar	Tera	No.7	Av.	No.8	No.9	Av.	No. 11
Jan.	2.0	2.0	3.0	1.9	2.23	1.1	1.0	1.0	1.0
Feb.	1.8	2.4	2.8	2.1	2.28	1.0	0.9	0.95	0.9
March	1.5	2.6	2.7	2.1	2.23	1.6	1.3	1.45	1.3
Winter	1.77	2.33	2.83	2.03	2.24	1.23	1.07	1.15	1.57
April	1.7	1.9	3.4	2.8	2.45	1.9	1.2	1.35	1.2
May	1.5	2.4	3.0	2.6	2.38	1.4	1.54	1.45	1.5
June	1.6	2.7	2.9	3.0	2.55	1.6	1.8	1.70	1.8
Spring	1.60	2.33	3.10	2.80	2.46	1.63	1.50	1.57	1.50
July	2.1	1.8	3.4	2.9	2.55	1.9	1.9	1.9	1.9
Aug.	2.5	2.4	3.2	3.3	2.85	2.0	2.9	2.45	2.9
Sept.	2.8	1.7	2.7	3.5	2.68	1.7	3.0	2.35	3.0
Summer	2.47	1.97	3.10	3.23	2.69	1.75	2.60	2.18	2.60
Oct.	2.7	2.9	2.6	2.7	2.73	1.6	2.4	2.00	2.4
Nov.	3.1	3.4	2.9	2.3	2.93	1.8	2.1	1.95	2.1
Dec.	3.6	3.0	2.7	1.8	2.78	1.3	1.7	1.50	1.7
Autumn	3.13	3.10	2.73	2.27	2.81	1.57	2.07	1.82	2.07
Average	2.24	2.43	2.94	2.58	2.55	1.55	1.81	1.68	1.94

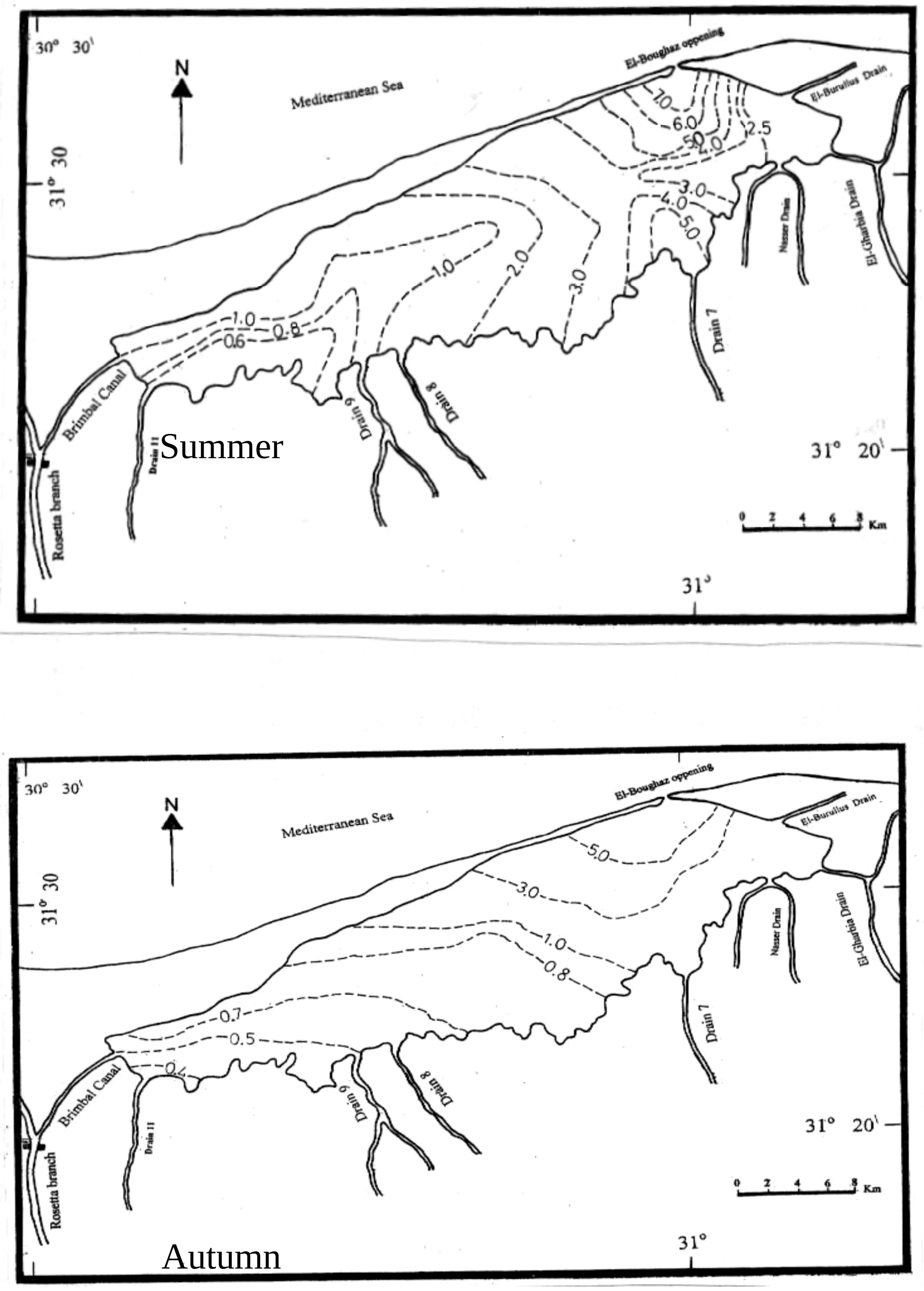


Fig. (2): Spatial distribution of cholorosity at Lake Borollus during 2000

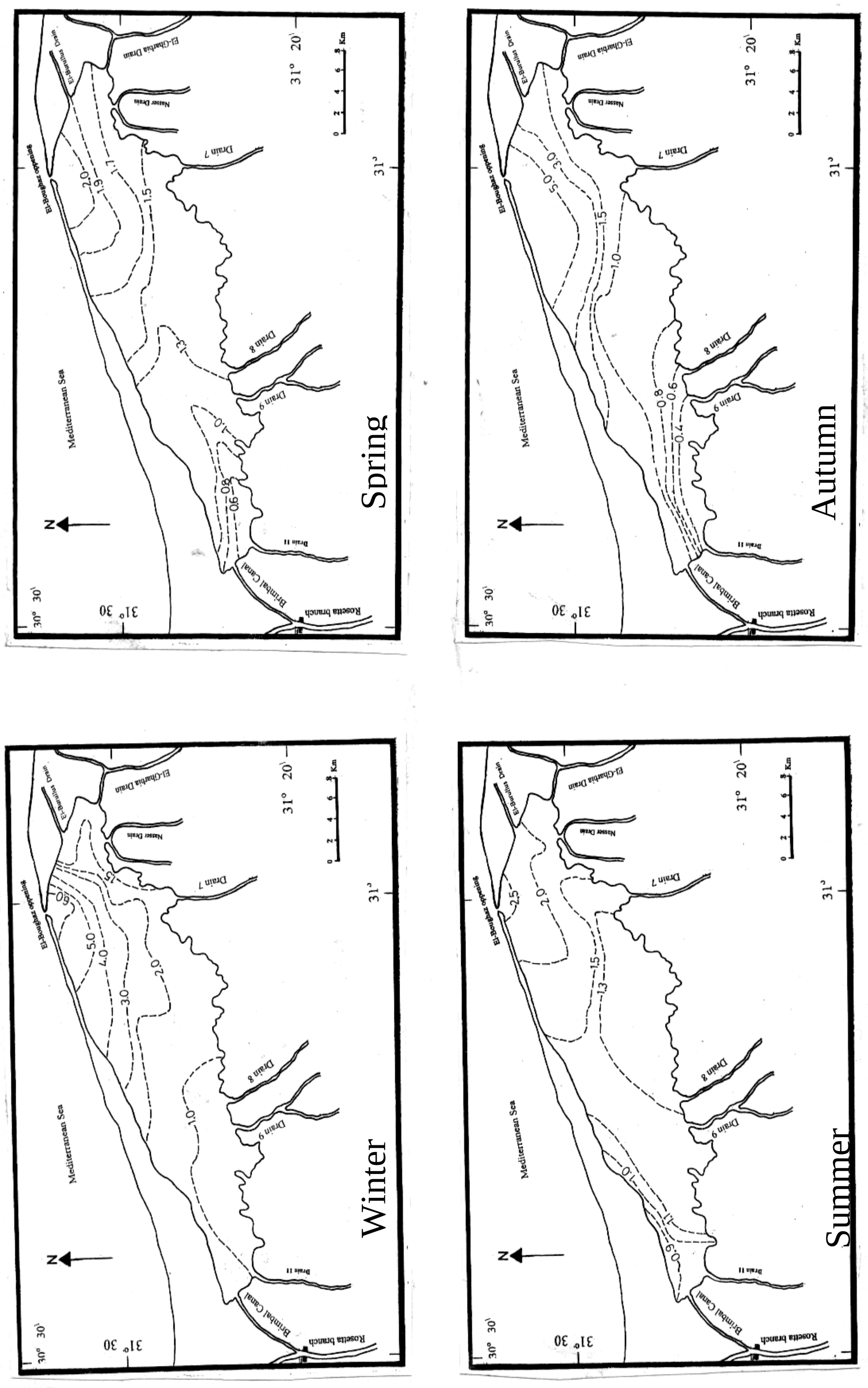


Fig. (3): Spatial distribution of cholorosity at Lake Borollus during 2001

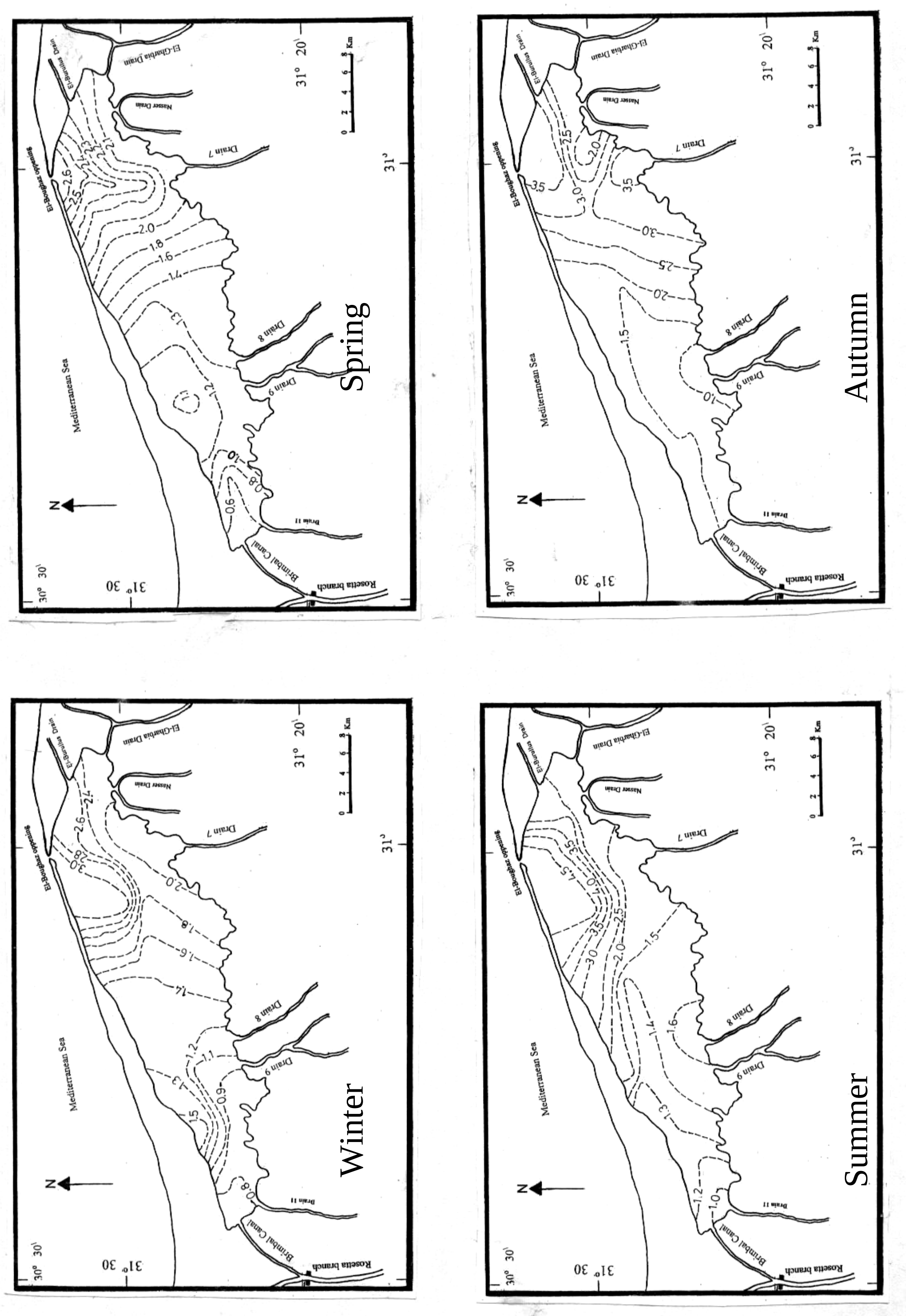
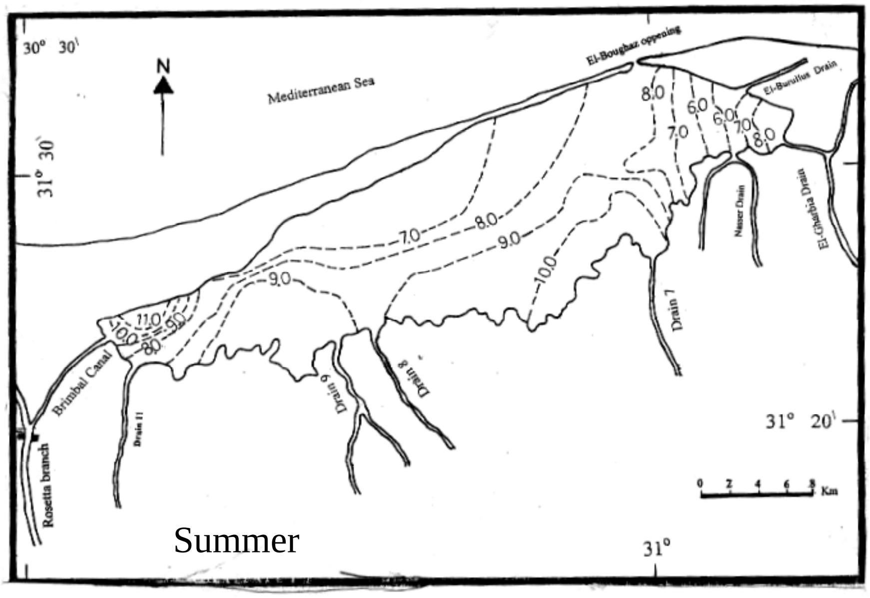


Fig. (4): Spatial distribution of cholorosity at Lake Borollus during 2002



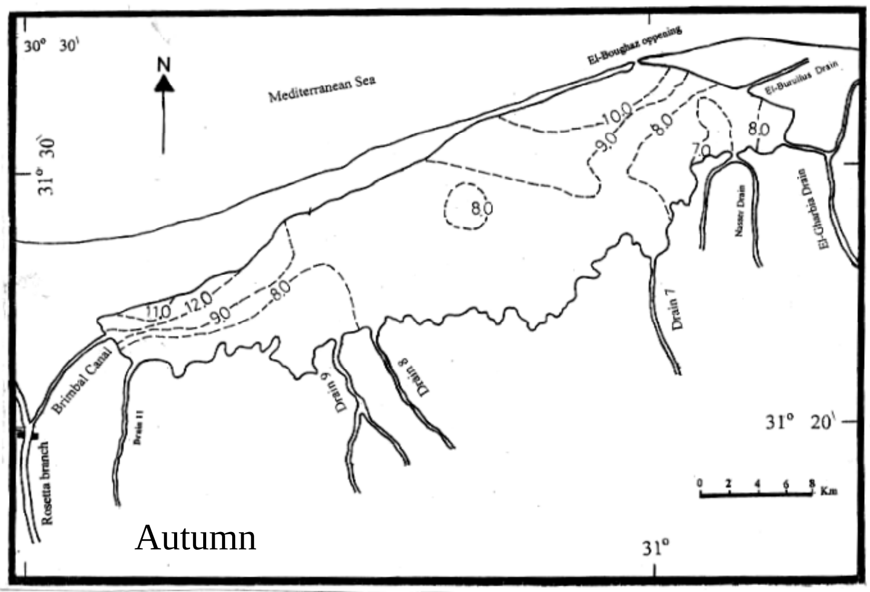


Fig. (5): Spatial distribution of dissolved Oxygen at Lake Borollus during 2000

3.1.5. Dissolved Oxygen:

In shallow water bodies e.g. Lake Edku, dissolved oxygen is affected by air and water temperatures, wind mixing and photosynthetic activity. Oxidation process in water and sediments of the lake is also an important factor.

The horizontal distribution of dissolved oxygen in the lake water as shown in Figures (5, 6 and 7) indicated that:

(1) The whole water body of Lake Borollus is well aireated and oxygenated during the period of investigation. These values ranged between a minimum one of 6.6 mg/L and a maximum of 11.1 mg/L.

(2) Higher values of dissolved oxygen were reported in winter while the least concentrations were existing during summer season of the years 2001 and 2002.

It appears therefore that the water temperature can be considered as an important factor controlling the concentration of dissolved oxygen in the lake water. Rough weather and strong winds that occur during winter play an important role in aeriating the water of the lake. The decreasing rates of oxygen consumption by the living organisms especially zooplankton and aerobic bacteria due to its less activity during the lowest water temperature of winter contributes in increasing concentration of dissolved oxygen during such cold season.

Ruttener (1968) and Kenawy (1974) found that there was an inverse relationship between dissolved oxygen and water temperature. Welch (1952) pointed out that the increase of water temperature diminishes the solubility of oxygen.

(3) The increasing rates of drainage water discharge rich with organic matter at the southern area of the lake adjacent to the outlets of the drains contribute in decreasing the concentration of dissolved oxygen in these areas. Oxidation of such organic matter consumes the dissolved oxygen.

In this concern El-Hehyawi (1977) and El-Ghobashy (1990) indicated that the lower values of dissolved oxygen in the southern areas of Lake Manzalah were due to the consumption of high rates of oxygen in the decomposition of organic matter discharged in this area.

3.1.6. Nutrients:

a. Inorganic nitrogen:

a-1: Ammonia:

The average concentrations of ammonia (μ gat/l) at the various sampling stations at Lake Borollus during 2002 are given in Table (8), was found that:

(1) The highest concentrations of ammonia in the lake water were found during winter at the eastern, middle and western areas of the lake.

(2) The water of the western area exhibited higher concentrations of ammonia in compared with the other areas.

(3) The average concentrations of ammonia ranged between a minimum of 5.82 μ gat/L and a maximum of 21.33 μ gat/l.

a-2: Nitrites:

Nitrite appears in the water mainly as a result of biochemical oxidation of ammonia (nitrification) or the reduction of nitrate (denitrification) (Abdel – Moneim, 1977). Nitrites can therefore be considered as an intermediate oxidation state between the low oxidant state (ammonia) and the higher oxidant state (nitrate).

In their study on the hydrochemical characters of Lake Edku, Abbas *et al*. (2001), pointed out that about 58% of the water samples collected from the lake, nitrites exhibited the lowest percentages of the total inorganic nitrogen species.

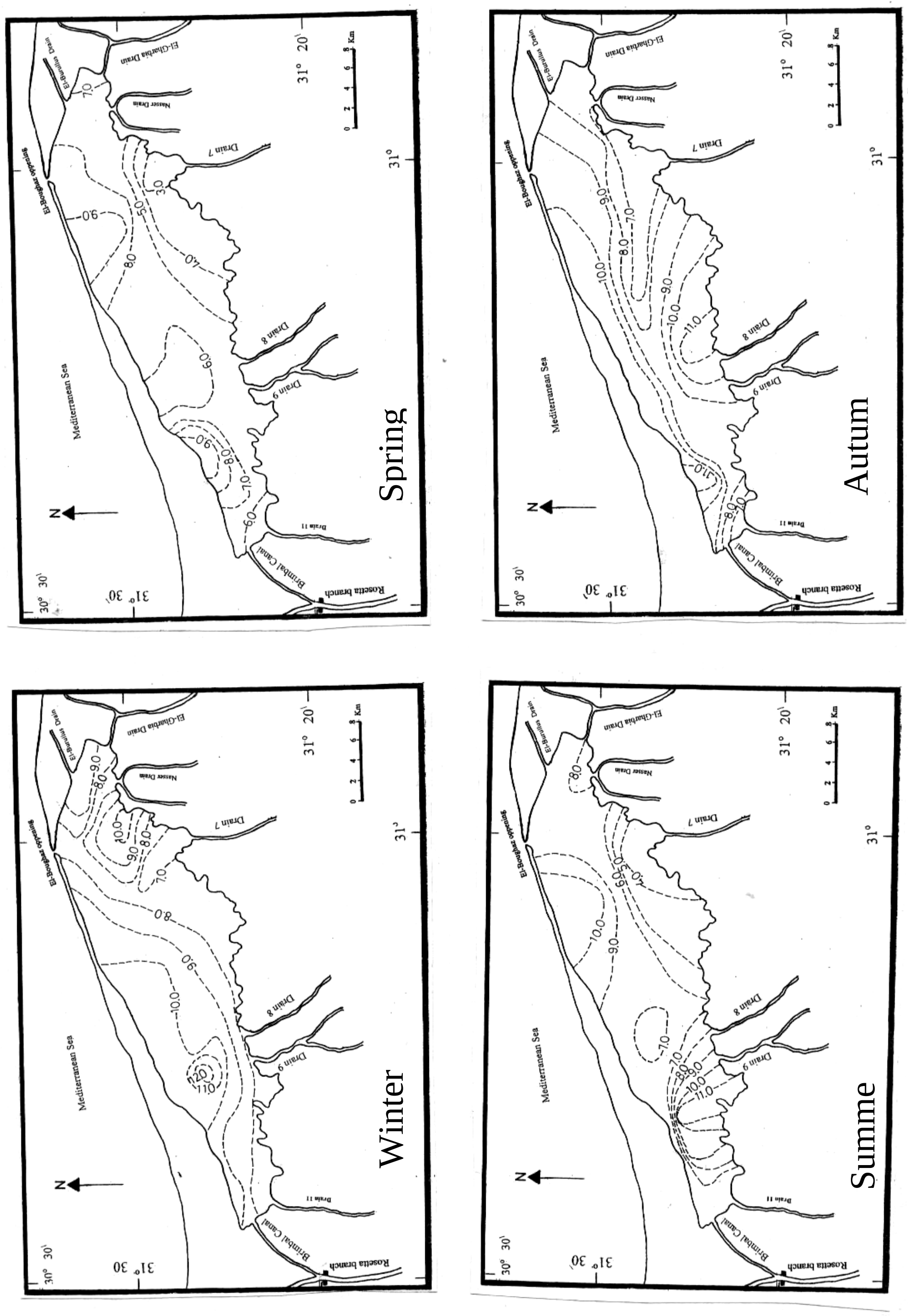


Fig. (6): Spatial distribution of Oxygen at lake dissolved Borollus during 2001

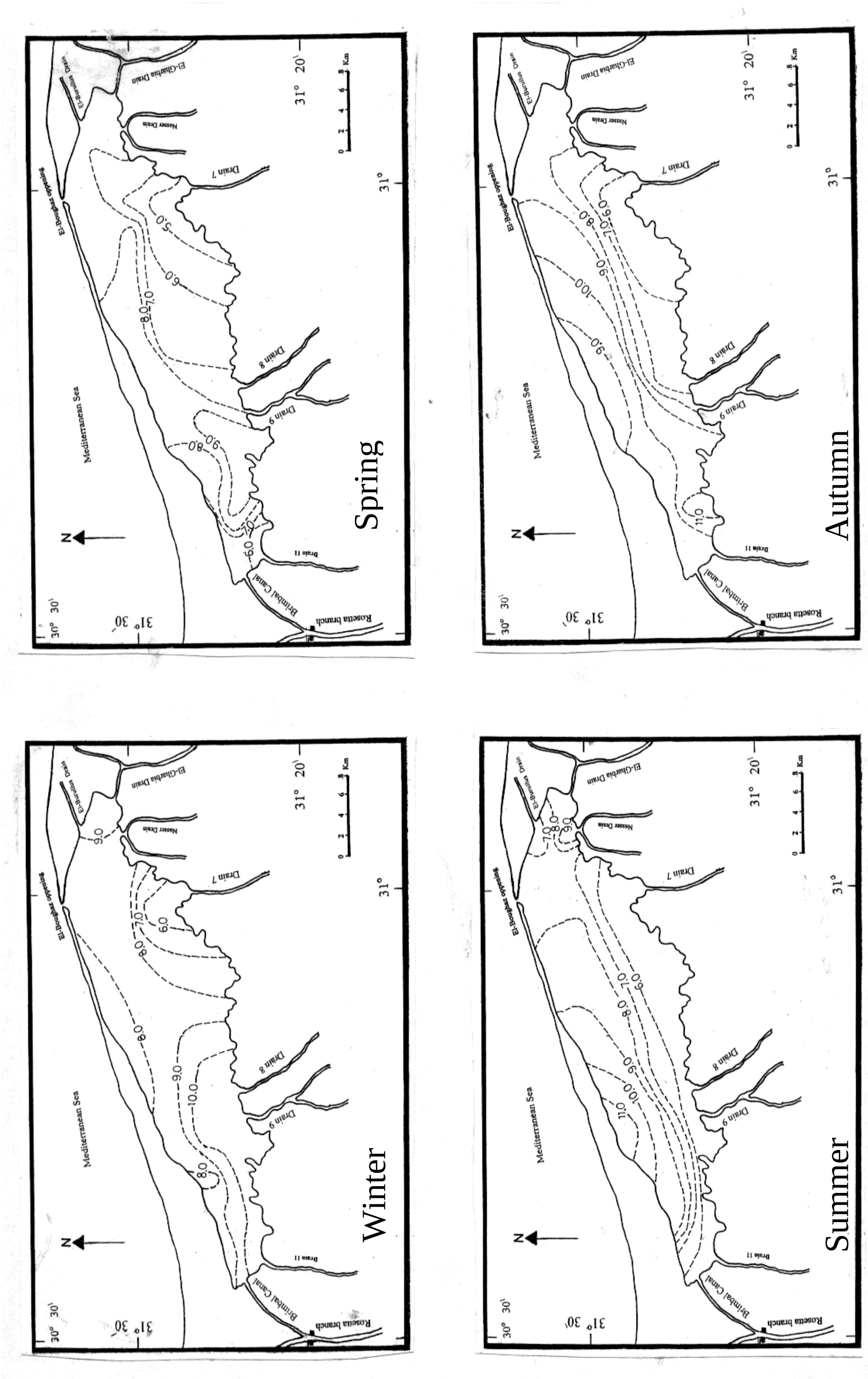


Fig. (7): Spatial distribution of dissolved Oxygen at lake Borollus during 2002

Table (8): Ammonia Concentrations μ gat/L at various areas of lake Borollus during 2002.

Area / Season	Eastern area								Middle area						Western area			
	1	2	3	4	5	6	7	Av.	8	9	10	11	12	Av.	13	14	15	Av.
Winter	0.55	16.81	29.09	24.39	17.27	14.72	11.34	17.06	4.10	23.27	8.78	2.76	6.24	9.03	10.37	43.25	10.38	21.33
Spring	0.47	9.86	17.15	17.04	1.05	7.90	9.24	8.96	2.29	12.68	4.14	3.49	1.93	4.91	5.02	16.62	4.44	8.69
Summer	0.93	5.09	7.92	5.75	6.15	13.38	1.73	5.85	3.10	18.00	2.06	4.10	1.83	5.82	7.40	9.93	6.11	7.81
Aut.	1.77	11.38	8.75	7.69	7.42	12.55	2.82	7.48	2.18	19.74	1.82	2.42	2.31	5.69	6.82	21.46	4.54	10.94

The average concentrations of nitrites at the various sampling stations of Lake Borollus are given in Table (9). It can be indicated from the data given that

(1) The average concentrations of nitrites ranged between a minimum of 0.689 μ gat/L at the western area of the lake during spring 2001 and a maximum of 2.826 μ gat/L at the same area during autumn 2001.

(2) The middle area of the lake exhibited mostly the lowest concentrations of nitrites during the period of study.

(3) The average concentrations of nitrites were found to increase from 2001 to 2002 in the whole area of the lake.

a-3: Nitrates:

Nitrate is the most stable form of inorganic nitrogen in oxygenated water. Sillen (1961) denoted that nitrate is considered to be the only stable oxidation level in the presence of oxygen in water.

The Egyptian delta lakes are characterized by the rapid regeneration of nutrient salts and specially nitrates. The increased discharge of drainage water enriches Lake Borollus with nitrites. The use of ammonia containing fertilizers (ammonium sulphate, ammonium nitrates, and urea) is a good source of ammonium ion in water. In an aerobic condition in the aquatic environment nitrification takes place converting ammonia and nitrite to nitrate.

The spatial distribution of nitrates is represented by Figures (8, 9 and 10). The data given indicate that:

(1) The lowest concentration of nitrate was found to be 1.230 μ gat/L at the middle area of the lake during autumn 2000 and the highest concentration was 7.165 μ gat/L at the western area in summer 2002.

(2) Similar to that of nitrite concentrations at the lake, an increase in the average concentrations of nitrates was observed from one year to the next during the years 2000 to 2002.

(3) Comparing the average concentrations of nitrates at the various sampling stations of the lake with its average concentrations in the drainage water discharging from various drains (Table 10). These concentrations were significantly higher in the drainage water. Consumption of nitrate compounds by the aquatic vegetations in the lake can be considered as the main reason for decreasing nitrate concentrations in the lake water if compared with its concentrations in the drains water.

(4) Lower concentrations of nitrates were observed in both the eastern and western areas compared with the middle area of the lake.

(5) Higher concentrations of nitrates existed in the drainage water during summer while the lowest ones were in autumn.

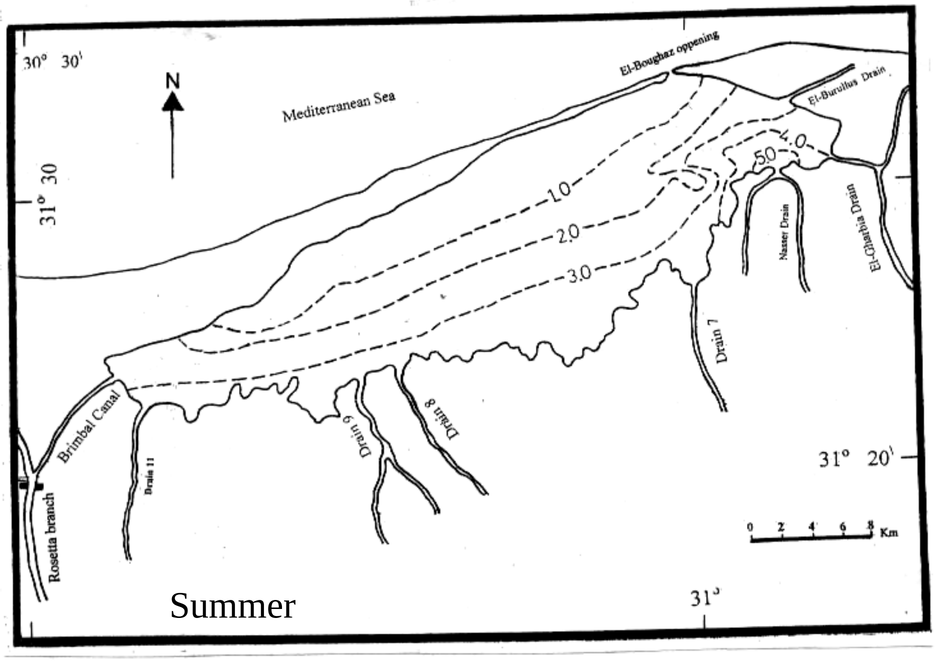
(6) The spatial distribution of nitrates in the lake water during the period of study as shown in Fig. 8, 9 and 10 pointed to higher concentrations occurred at the southern parts of the lake decreasing northwards. Such higher concentrations at the southern parts are due to the direct discharge of the drainage water in these areas.

The data given in the present study are in harmony to that reported by Darrag (1983) where the average concentrations of nitrogen compounds in the drain water were higher than those in the lake water. The concentrations of these compounds decreased gradually at the sampling stations from the south to the north.

Shakweer, (2005) found that the higher concentration of inorganic compounds in Lake Edku water can be attributed to the increased concentrations of these compounds in the drainage water discharging to the lake.

Table (9): Nitrites concentrations (μ gat/L) in the water of Lake Borollus during the years 2000 to 2002.

Area	Eastern area									Middle area							Western area					Total Av.
Season	1	2	3	4	5	6	7	Av.	S.D	8	9	10	11	12	Av.	S.D	13	14	15	Av.	S.D	
Summer 2000	0.444	0.817	2.433	1.793	0.513	0.762	0.625	**1.055**	**0.757**	1.143	1.497	1.263	1.062	1.573	**1.308**	**0.221**	1.333	3.123	1.937	**2.131**	**0.911**	**1.355**
Autumn 2000	0.397	1.011	1.647	2.192	0.925	0.722	0.276	**1.024**	**0.684**	0.258	0.974	0.844	0.669	0.219	**0.593**	**0.341**	1.264	1.207	1.014	**1.162**	**0.131**	**0.908**
Average 2000	**0.421**	**0.914**	**2.040**	**1.993**	**0.719**	**0.742**	**0.451**	**1.040**		**0.701**	**1.235**	**1.054**	**0.865**	**0.896**	**0.950**		**1.299**	**2.165**	**1.476**	**1.646**		**1.131**
Winter 2001	0.174	1.461	1.266	2.681	1.186	1.385	0.289	**1.206**	**0.835**	0.154	1.096	1.422	0.985	0.622	**0.856**	**0.485**	2.131	0.893	1.220	**1.415**	**0.641**	**1.131**
Spring 2001	0.259	0.964	0.819	1.377	0.708	2.124	0.247	**0.928**	**0.659**	0.608	1.892	0.456	0.524	0.142	**0.724**	**0.676**	0.772	0.788	0.506	**0.689**	**0.158**	**0.812**
Summer 2001	0.408	1.011	2.111	2.435	0.962	2.167	0.472	**1.367**	**0.851**	1.018	1.767	1.002	0.832	0.565	**1.037**	**0.447**	1.647	3.239	1.151	**2.012**	**1.091**	**1.386**
Autumn 2001	0.411	1.236	1.595	3.679	1.242	2.406	1.146	**1.674**	**1.066**	1.426	2.343	1.107	0.630	0.940	**1.289**	**0.655**	2.317	5.043	1.119	**2.826**	**2.011**	**1.776**
Average 2001	**0.313**	**1.168**	**1.448**	**2.543**	**1.025**	**2.021**	**0.538**	**1.294**		**0.801**	**1.774**	**0.996**	**0.743**	**0.567**	**0.976**		**1.717**	**2.491**	**0.999**	**1.735**		**1.276**
Winter 2002	0.646	2.591	3.315	3.742	1.400	2.660	2.421	**2.397**	**1.066**	0.720	2.969	1.702	1.165	1.116	**1.534**	**0.875**	1.524	4.691	1.460	**2.558**	**1.848**	**2.141**
Spring 2002	0.454	1.974	2.417	2.751	1.745	2.697	0.713	**1.822**	**0.923**	0.642	1.963	0.834	1.581	0.428	**1.090**	**0.654**	0.644	2.862	1.056	**1.521**	**1.180**	**1.517**
Summer 2002	0.749	1.908	2.236	3.181	4.648	3.293	0.856	**2.410**	**1.405**	0.404	3.075	1.521	1.834	0.969	**1.561**	**1.007**	1.897	3.855	1.715	**2.489**	**1.187**	**2.143**
Autumn 2002	0.235	1.289	1.855	2.902	0.941	2.828	0.520	**1.510**	**1.062**	1.955	3.748	1.103	1.060	0.513	**1.676**	**1.268**	1.142	2.284	1.380	**1.602**	**0.603**	**1.584**
Average 2002	**0.521**	**1.941**	**2.456**	**3.144**	**2.184**	**2.870**	**1.128**	**2.035**		**0.930**	**2.939**	**1.290**	**1.410**	**0.757**	**1.465**		**1.302**	**3.423**	**1.403**	**2.043**		**1.846**



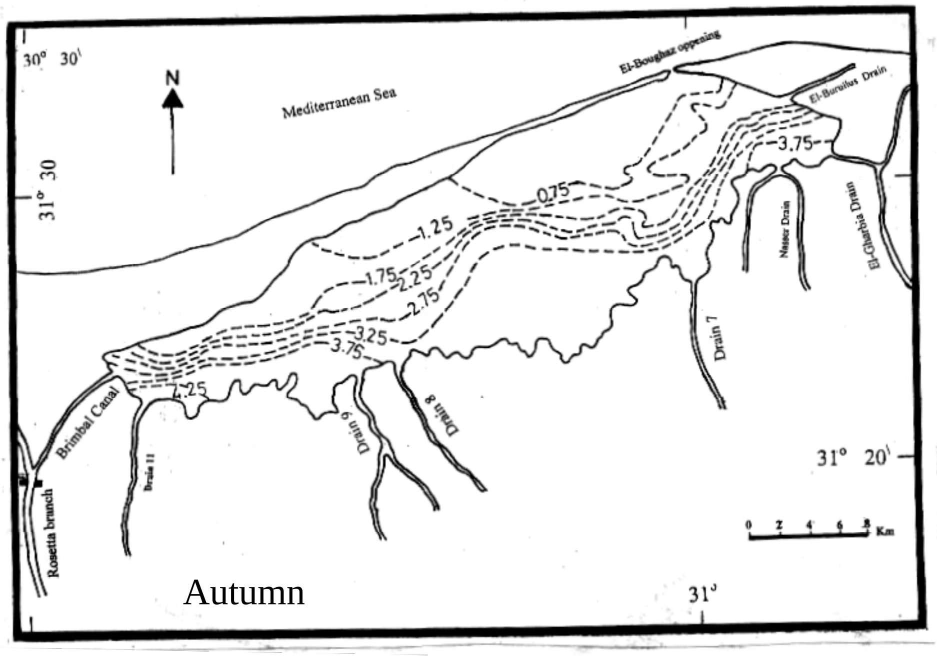


Fig. (8): Spatial distribution of Nitrates at Lake Borollus during 2000

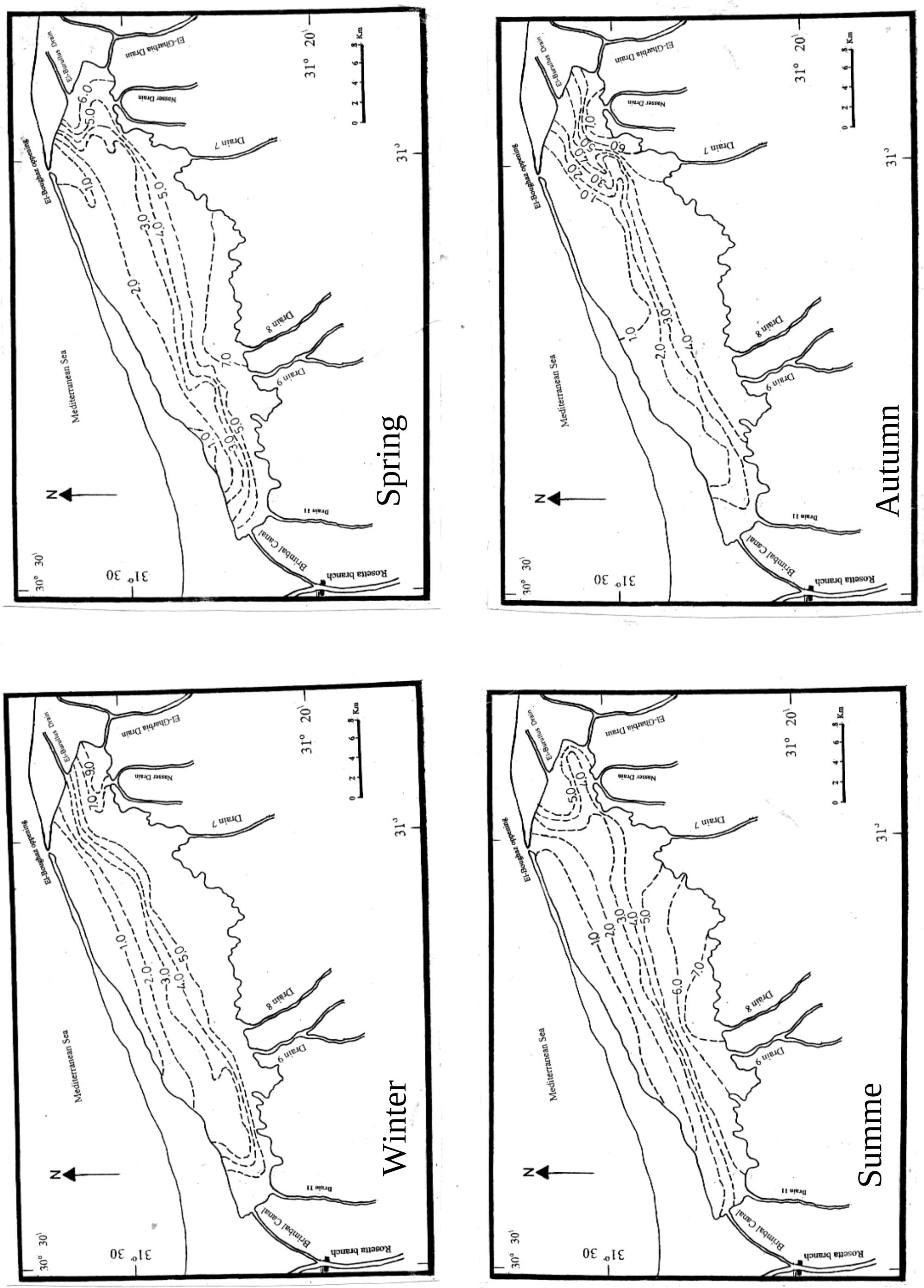


Fig. (9): Spatial distribution of Nitrates at Lake Borollus during 2001

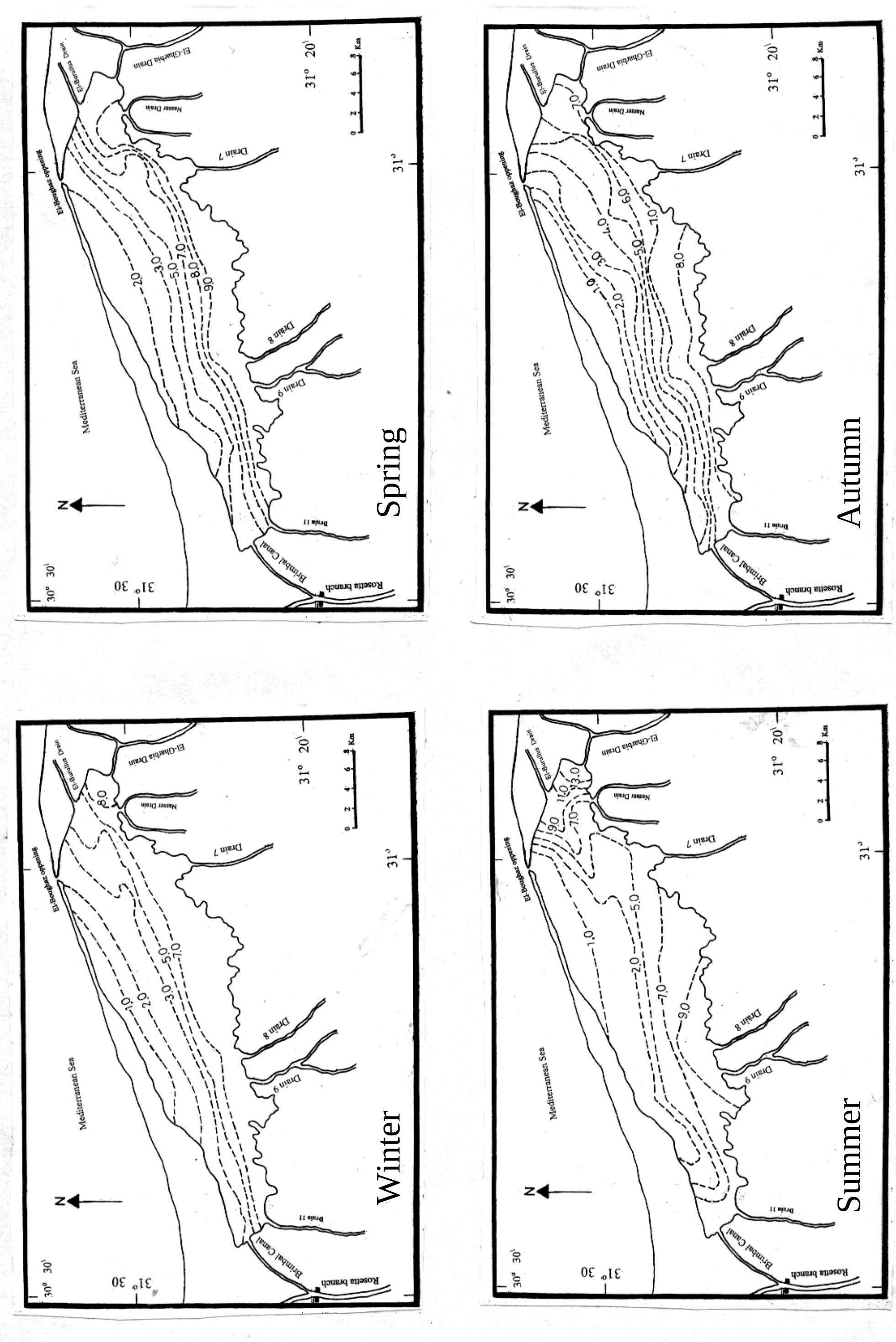


Fig. (10): Spatial distribution of Nitrates at Lake Borollus during 2002

Table (10): Concentrations of nitrates (μ gat/L) in the water of drains discharging to Lake Borollus.

Month	Eastern area					Middle area			West area
	Bur.	Ghar	Tera	No.7	Av.	No.8	No.9	Av.	No. 11
Jan.	14.3	15.7	17.3	16.4	15.93	11.8	13.7	25.50	11.7
Feb.	10.7	16.4	16.8	15.4	14.83	12.4	14.0	13.20	12.4
March	9.4	13.4	21.4	15.9	15.03	16.7	12.8	14.75	13.9
Winter	11.47	15.17	18.50	15.90	15.26	13.63	13.50	13.57	12.67
April	8.1	10.8	18.4	17.8	13.78	12.9	11.7	12.30	10.4
May	7.4	11.2	15.8	19.1	13.38	10.9	13.0	11.95	10.8
June	11.1	16.8	17.2	21.8	16.73	14.3	15.4	14.85	12.7
Spring	8.87	12.93	17.13	19.57	14.63	12.70	13.37	13.04	11.30
July	13.4	18.9	19.7	19.4	17.60	16.9	15.8	16.35	15.5
Aug.	10.3	18.4	21.8	16.9	16.85	15.7	18.7	17.20	16.8
Sept.	8.7	13.8	18.1	14.1	13.68	18.4	16.2	17.30	21.4
Summer	10.80	17.03	19.87	16.80	16.13	17.00	16.90	16.95	18.03
Oct.	9.4	15.1	11.8	14.8	12.78	14.7	16.8	15.75	17.4
Nov.	11.2	11.8	10.1	16.3	12.35	12.4	14.9	13.65	17.9
Dec.	10.4	14.1	13.8	11.1	12.35	11.9	17.1	14.50	13.8
Autumn	10.33	13.67	11.90	14.07	12.51	13.00	12.27	12.64	16.37
Average	10.36	14.70	16.85	16.86	14.63	14.08	14.01	14.05	14.59

b. Phosphates:

The environmental significance of phosphorous arises out of its role as a major nutrient for both plants and microorganisms (Vanaloon and Duffy, 2000). The nutrients salts that contribute to eutrophication most commonly the limiting one is phosphorous.

The whole PO_4 concentration in the lake water is mostly affected by the following factors:

I- Increase caused by:

1. Introduction of P through drainage water.
2. Phosphorous regeneration by mineralization of organic matter by bacterial activity.
3. Release of chemically combined or physically absorbed phosphorous by reduction process and by pH changes.

II- Decrease caused by:

1. Consumption of P by plants.
2. Chemical combination of P with manganese and iron dependant on oxidation and pH conditions.
3. Absorption of phosphorous by the particles and on organic material and sediments together with those colloids.

The spatial distribution of phosphates concentrations at the lake is shown in Figures (11 and 12). The concentrations of phosphates in the drainage water during 2002 are given in Table (11).

The data given indicate that:

(1) The average concentration of phosphates in the lake water during the period of study ranged between 0.840 μgat/L at the middle area during winter 2001 and 6.205 μgate/L at the western area during the same season of 2002.

On the other hand the average concentrations of PO_4 in the drainage water attained higher values during summer where it was found to be 10.77 μgate/L, 14.38 μgat/L and 12.20 μgat/L in the drains discharging at the eastern, middle and western areas of the lake. These concentrations were low during winter and been 9.48 μgat/L, 10.49 μgat/L and 8.93 μgat/L at these drains respectively.

It appears therefore that the concentrations of phosphates in the drainage water were significantly higher than those in lake water.

Said *et al*. (2005) indicated that the phosphorus compounds load from drainage water was found to be about 1298 tons per year and that from rain about 25 tons per year.

(2) The main source for phosphorous compounds to the lake is the drainage water discharging to the south of the lake.

(3) The isoclines distribution of PO_4 concentrations in the lake water indicates that these concentrations are high at the southern area of the lake and trends to decrease northwards.

(4) The water in the middle part of the lake exhibited comparatively lower concentrations of PO_4.

c. Reactive Silicates:

Silicon occurs in sea water as silicate. It is utilized by diatoms. When diatoms are eaten the remains sinks, then the silica dissolves slowly in the water. In addition to the dissolved silica, the water even from land contains silicon in suspended particulate form, in clay and presumably in undissolved diatom frustules (Harvey, 1974). Various analysis of diatoms quoted by vinogradov (1953), showed a Si/P ratio of 16 to 50 varying greatly with the species. It appears therefore that the diatoms play an important role that influences the concentration of silica in the seawater.

The average concentrations of silica in the drainage water of deferent drains during 2002 of the present investigation are given in table (12). On the other hand, silicates concentrations in lake water during 2002 are indicated in table (13). The date given indicates that:

(1) The average concentrations of silicates ranged between 27.01 μgat/L and 77.68 μgat/L in the lake water. These

concentrations ranged from 47.20 μ gat/L and 112.4 μ gat/L in the drainage water. This indicates that the drainage water contains comparatively higher concentrations of silicates in comparison with lake water.

(2) Higher concentration of silicates were found in the western part of the lake rather either. The middle or eastern areas. It was observed also that silicates concentrations in the water of drains discharging at the western area were comparatively higher than those discharging at the middle or eastern areas.

This may mean that the drainage water discharging to the lake contributes in increasing silicates concentrations in the lake water.

(3) Higher concentrations of silicates were found during summer in both the lake or drainage water.

II- Abundance and distribution of fish resources in the lake in relation to the environmental conditions:

It is a matter of fact that the environmental conditions especially the chemical composition of the lake water plays a very important role in distributing the various fish species through the whole area of the lake.

Shaheen and Yosef (1979), in their study on fish distribution at Lake Manzalah pointed out that, since the different areas of the lake show various physico – chemical characters where chlorosity is the most potent factor in the life of the living organisms, changes of fish populations composition are related to variations in chlorosity. Tilapia and the fresh water fish could be found with high abundance in areas of low chlorosity while mullets and other marine fish were found with low percentages in these areas. In the areas characterized by high chlorosity tilapies and the other fresh water fish species occur with low percentages while mullets and other marine species more abundant.

Alsayes and Soliman (1993) studied the species composition of fish population at Edku Lake where they indicated that the favorable environmental conditions for *Tilapia Zillii* are not the optimum for Sarotherodon galilaeus. Lake water of higher salinities is preferable for *T. Zillii* while *S. galilaeus* prefers to live at lower salinity water.

In agreement with the above idea El-Shazly (1993) in his study on the biological characters of the four cichlid fish species at Mariut Lake, showed that *Oreochremis niloticus* is the most common fish species in the areas of low salinities while *Tilapia Zillii* is frequently common in the more saline areas. He indicated also that *T. Zillii* is sometimes found with *O. aureus* near the lake-sea connections, while *S.galilaeus and O. niloticus* are commonly foundat the areas adjacent to drains outlets to the lake.

It is attempted in the following part of the present study to compare between the species composition of fish population in Lake Borollus during 2002 and 1973 in relation to the variations in water chlorosity of the lake water during these years.

The minimum and maximum values of water chlorosity at various areas of Lake Borollus during 1973 as given by Alsayes, (1976) and those recorded in 2002 are given in table (14).

On the other hand the species composition of fish population at the lake during 1973 according to Alsayes (1976) and the composition of such population at the lake during 2002 are given in table (15). It may be worth to indicate that experimental fishing was undertaken during both years covering the whole area of the lake to describe the variations occurred in the species composition of fish population at the lake.

The data given in the tables indicate that:

(1) The minimum and maximum values of chlorosity sharply decreased during 2002 in comparison with its values during 1973.

The sharp decrease in water chlorosity of the lake can be attributed to the following:

a- The higher water level in the lake than that in the sea in most time of the year. This allaws continuous outflow of lake water to the sea without giving chance to the invasion of sea water into the lake.

b- Unfavorable conditions of the unexcavated lake – sea connection where sea water may hardly inflow to the lake through few days of the year. This can be obviously detected from the low chlorosity values recorded at the eastern area near the lake-sea connection as shown in table (14).

c- Spreading of aquatic vegetation in wide areas of the lake which prevents the movement of higher chlorosity water from the Eastern area to the western one.

(2) The percentage weight of marine fish species decreased in the experimental catch from 15.99% in 1973 to 1.81% during 2002, where it can be observed that:

a. The percentage weight of *Liza ramada* decreased from 8.76% in 1973 to 1.81% in 2002.

b. The other marine fish species namely *Morone Labrx, Morone punctata, Mugil Cephalus* and *Anguilla Vulgaris* were not existing in the experimental catch.

The absence of marine fish species in the lake is mostly due to the unfavorable environmental conditions of the lake water specially, it low salinity where such marine species are able to live.

In agreement with that Shaheen and Yosef (1979) indicated that most of the marine fish species can be found in high percentage at the high saline areas of lake Manzalah.

(3) The percentage weight of *O:niloticus* increased from 19.70% in 1973 to 39.43% in 2002. On the other hand this percentage decreased form 47.39% during 1973 to 12.51% in 2002 for Tilapia Zillii.

The decrease of water chlorosity from 1973 to 2002 is the main factor that changed the abundance of various cichlid fish species in the lake.

It is obvious also that the decreased values of water chlorosity favored the increased abundance of *S. galilaeus* where its percentage weight increased from 0.97% in 1973 to 13.72% in 2002.

In agreement with that El-Shazly (1993) attributed the variations in the abundance of the four species of Tilapia in lake Mariut to the differences in water salinity where he pointed out that *O. niloticus* and *S.galilacus* are common in the areas of the lake adjacent to outlets of drains while *T. Zillii* and *O. aureus* are mostly found in the higher Salinity areas of the lake.

(4) The percentage weights of the two fresh water species *Clarias Lazera* and *Bagrus bayad* decreased from 11.50 % to 3.42% for the first species and from 2.08% to 0.90% during 1973 and 2002 respectively.

The decrease of water chlorosity in the lake from 1973 to 2002 is believed to be less effective in the abundance of these two species in the lake. Fishing activity and met selection may be considered as factors affecting the existence of these two species in the experimental catch.

4. SUMMARY AND CONCLUSIONS

The fish fauna of Lake Borollus is composed from fresh water fish species as well as other species of marine origin.

The abundance and distribution of either the marine or fresh water fish species is greatly affected by the environmental conditions prevailing at the lake.

It is attempted in the present study to investigate the chemical composition of the lake water as an important environmental factor affecting the marine life in the lake.

It can be concluded from the present study that:

(1)The transparency of the lake water is generally very low. The seasonal variations in wind speed and direction are main factors affecting the Secchi depth. The phytoplankton enhancement during spring is another factor in decreasing the transparency.

(2) The average water temperature of the lake water ranged between 16.20^{o}C in summer. The recorded water temperature did not exhibit significant variations from one station to another in the lake.

(3) The recorded pH values lied in the range from 7.41 to 9.14 indicating that the lake water was in general in the alkaline side.

The values were mostly in an optimum range for fish living in the lake.

(4) The average chlorosity of the drainage water attained the highest values in summer while the lowest values were recorded in winter.

(5) The chlorosity values of the lake water were in most cases slightly higher than those of drainage water. Mixing with the penetrated sea water as well as evaporation are believed to be important factors in increasing the chlorosity of lake water.

(6) The Eastern part of the lake adjacent to lake sea connection exhibited mostly higher chlorosity values in comparison to either the middle or western areas.

(7) The whole water body of the lake is considered to be well oxygenated. These values ranged between 6.6 mg/L and 11.1 mg/L. Higher values were found in winter while the least values were recorded in summer.

(8) The increased rates of drainage water discharge rich with organic matter at the southern area of the lake decreased the concentrations of dissolved oxygen at these areas due to consumption of Oxygen in the oxidation of such organic matter.

(9) The average concentrations of ammonia in the lake water ranged between 5.82 μ gat/L and 21.33 μ gat/L.

(10) The middle area of the lake exhibited mostly the lowest concentrations of ammonia.

(11) The average concentrations of nitrates were significantly higher in the drainage water than that in the lake water. Consumption of nitrates by the aquatic vegetations is the main reason for such difference in nitrates concentrations.

(12) Higher concentrations of nitrates were observed at the Southern part of the lake decreasing northwards.

(13) The average concentrations of phosphates in the lake water attained higher values during summer. These values were low during winter.

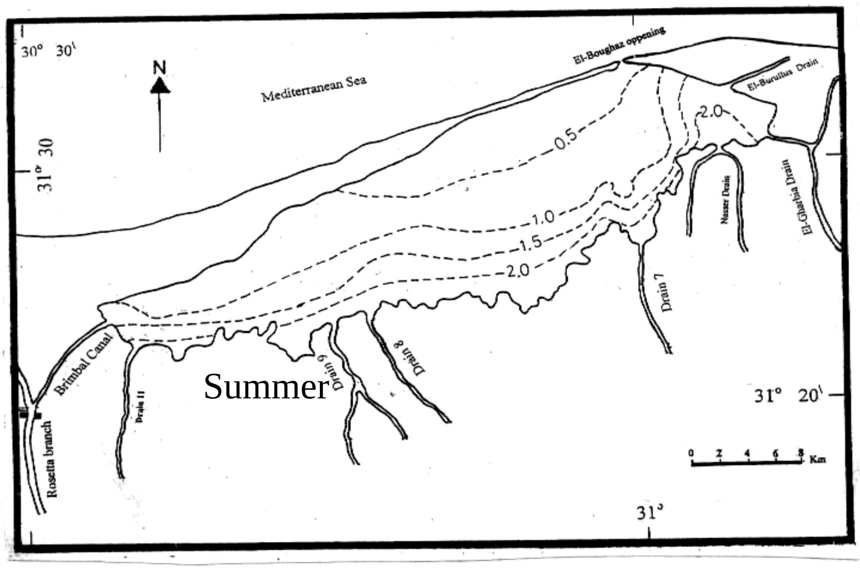
(14) The average concentrations of silicates ranged between 27.01 μ gat/L and 77.68 μ gat/L. These values lied between 47.20 μ gat/L and 112.4 μ gat/L in the drainage water discharging to the lake.

(15) The average values of chlorosity of the lake water sharply decreased in the last years in comparison with its values since 30 years. Such decrease in water chlorosity changed the species composition of fish populations in the lake where the abundance of the marine species drastically decreased.

a. The percentage weight of the marine fish species decrease in the experimental catch taken at the lake from 15.99% in 1973 to 1.81% in 2002.

b. The percentage weight of Liza ramada decreased from 8.76% in 1973 to 1.21% in 2002.

c. On the other hand the percentage weight of *O. niloticus* increased from 19.70% in 1973 to 39.43% in 2002, while such percentage decreased from 47.39% during 1973 to 12.51% in 2002 for T. Zillii.



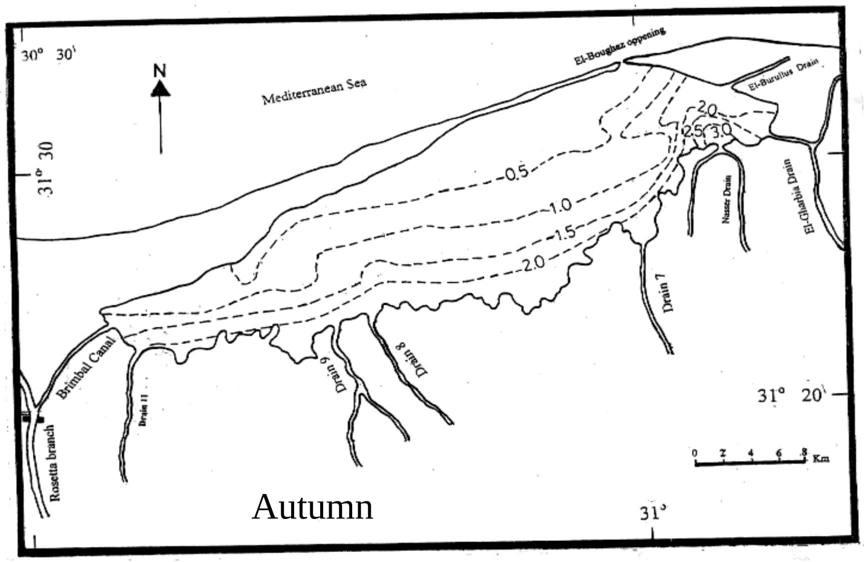


Fig. (11): Spatial distribution of Phosphates at Lake Borollus during 2000

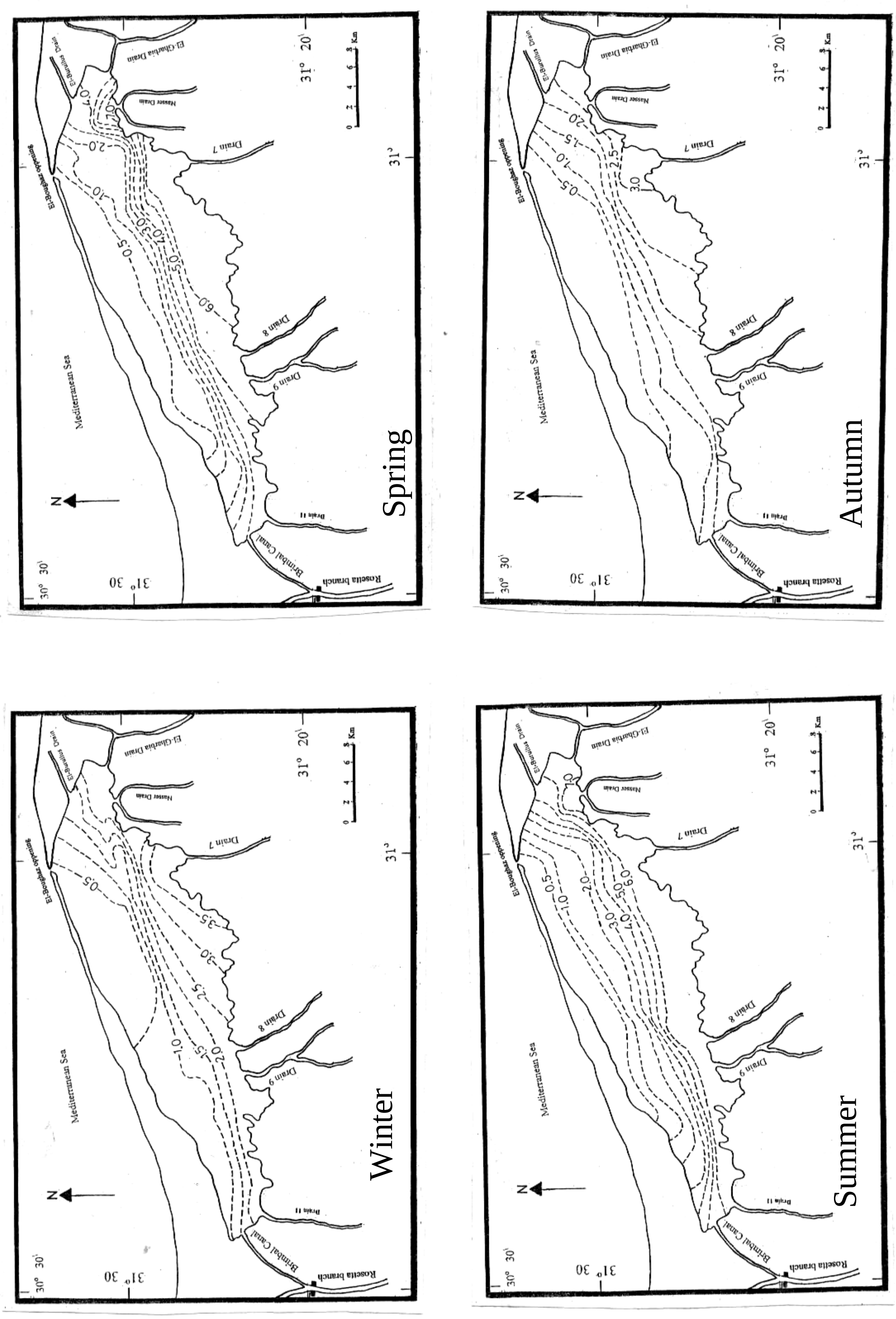


Fig. (12): Spatial distribution of Phosphates at lake Borollus during 2001

Table (11): Concentrations of PO_4 (μ gat/L) in the drainage water discharging to Lake Borollus during 2002.

Month	Eastern area					Middle area			West area
	Bur.	Ghar	Tera	No.7	Av.	No.8	No.9	Av.	No. 11
Jan.	9.8	8.1	10.8	8.3	9.25	10.4	9.1	9.75	8.7
Feb.	10.1	8.8	11.0	9.8	9.93	9.5	9.7	9.60	9.4
March	6.8	10.7	12.8	6.8	9.28	12.8	11.4	12.10	8.7
Winter	8.9	9.2	11.53	8.30	9.48	10.90	10.07	10.49	8.93
April	8.1	9.1	11.4	10.3	9.73	14.6	13.0	13.80	6.9
May	7.1	7.7	10.8	6.1	7.94	14.8	11.7	13.25	8.8
June	11.7	10.4	13.0	8.4	10.88	16.1	12.4	4.25	10.7
Spring	8.97	9.07	11.73	8.27	9.52	15.17	12.37	13.77	8.80
July	9.8	12.4	12.8	10.3	11.3	13.7	14.7	14.20	11.0
Aug.	10.1	14.7	9.0	8.7	10.63	11.9	16.8	14.35	13.2
Sept.	8.0	11.3	10.4	11.7	10.35	14.1	15.1	14.60	12.4
Summer	9.30	12.80	10.73	10.23	10.77	13.23	15.53	14.38	12.20
Oct.	6.9	9.8	9.9	11.3	9.48	11.4	12.3	11.85	8.9
Nov.	7.4	9.1	11.8	9.7	9.50	11.8	10.0	10.90	9.7
Dec.	7.9	8.9	12.1	8.9	9.45	10.9	10.9	10.90	8.1
Autumn	7.40	9.27	11.27	9.97	9.48	11.37	11.07	11.22	8.90
Average	8.64	10.09	11.32	9.19	9.81	12.67	12.26	12.47	9.71

Table (12): Concentrations of Silicates (μ gat/L) in the drainage water discharging to Lake Borollus.

Month	Eastern area					Middle area			West area
	Bur.	Ghar	Tera	No.7	Av.	No.8	No.9	Av.	No. 11
Jan.	66.3	39.8	62.8	49.3	54.55	78.4	83.4	80.90	91.8
Feb.	63.8	46.8	66.9	52.7	57.55	83.4	81.7	82.55	97.4
March	54.9	55.4	73.5	47.8	57.90	68.9	78.9	73.90	88.9
Winter	61.67	43.33	67.73	49.93	55.67	76.90	81.33	79.12	92.70
April	49.6	51.9	63.2	33.9	49.65	72.5	77.7	75.10	86.4
May	38.4	52.9	58.8	38.7	47.20	86.1	63.8	74.95	81.6
June	51.9	61.8	57.9	31.1	50.68	85.8	78.5	82.15	98.4
Spring	46.63	55.53	59.97	34.57	48.18	81.47	73.33	77.40	88.80
July	53.8	67.1	62.8	49.2	58.23	85.4	88.7	87.05	103.7
Aug.	42.4	57.8	57.9	43.8	50.48	76.1	76.5	76.30	106.4
Sept.	39.8	51.7	53.1	55.7	48.20	81.4	68.7	75.05	112.4
Summer	45.33	58.87	57.93	49.57	52.93	80.97	77.97	79.47	107.50
Oct.	44.4	45.8	48.8	47.4	46.6	66.8	66.4	66.60	99.7
Nov.	58.1	41.9	51.8	46.8	49.65	68.9	74.5	71.70	96.8
Dec.	55.9	35.4	59.1	41.6	48.0	74.2	78.8	76.50	96.1
Autumn	52.80	41.03	53.23	45.22	48.08	69.97	73.27	71.60	97.53
Average	51.61	49.69	59.72	44.84	51.20	77.33	76.47	76.90	96.63

Table (13): Silicates Concentrations μ gat/L in the water at various sampling stations of lake Borollus during 2002.

Area / Season	Eastern area								Middle area						Western area			
	1	2	3	4	5	6	7	Av.	8	9	10	11	12	Av.	13	14	15	Av.
Winter	19.34	30.10	30.69	40.89	22.90	19.89	25.27	27.01	35.27	46.92	29.98	37.94	44.12	38.85	58.62	55.30	51.95	55.29
Spring	40.50	53.08	60.67	53.54	48.84	59.67	42.35	51.24	71.31	60.79	39.54	70.02	62.84	60.90	80.32	76.08	76.63	77.68
Summer	38.90	51.50	49.37	40.67	36.83	47.13	33.03	42.49	52.07	57.70	36.88	52.70	46.97	49.26	75.43	57.53	67.43	66.80
Aut.	30.00	46.00	34.63	41.63	26.09	35.33	27.18	34.41	35.02	50.13	34.20	62.17	43.67	45.03	64.67	42.43	55.90	54.33

Table (14): Minimum and maximum Cl ‰ values recorded at Lake Borollus (1973) and (2002).

Month	East. area				Middle area				West area			
	1973		2002		1973		2002		1973		2002	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Jan.	8.0	20.4	1.6	3.6	2.5	4.1	1.11	2.6	0.6	3.1	1.2	1.3
Feb.	8.8	20.5	1.4	6.5	2.5	4.5	1.13	2.7	0.9	2.7	1.1	1.4
March	9.4	20.0	1.7	6.6	2.5	4.5	1.0	2.0	1.0	3.8	1.8	1.9
Winter	8.7	20.3	1.6	5.6	2.5	4.4	1.1	2.4	0.8	3.2	1.4	1.6
April	9.3	20.8	1.9	5.9	3.9	6.5	1.0	2.2	1.0	3.9	1.6	1.8
May	9.3	20.8	1.6	2.4	3.3	5.6	0.8	1.4	1.0	2.8	0.2	0.5
June	9.6	20.9	1.7	2.4	3.5	4.1	1.0	1.5	1.0	2.8	0.3	0.5
Spring	9.4	20.8	1.7	3.6	3.2	5.4	0.9	1.7	1.0	3.2	0.7	0.9
July	10.1	20.9	2.0	2.7	3.3	4.5	1.0	1.1	1.0	3.4	0.4	0.5
Aug.	9.2	20.8	1.9	2.5	2.8	4.7	1.0	1.5	0.5	3.9	0.4	0.5
Sept.	8.0	20.8	1.9	2.5	2.6	3.7	1.0	1.5	0.4	3.1	0.6	0.7
Summer	9.1	20.8	1.9	2.6	2.9	4.3	1.0	1.4	0.6	3.5	0.5	0.6
Oct.	6.5	20.6	1.9	2.5	1.3	3.6	1.0	1.6	0.2	2.3	0.7	0.9
Nov.	7.4	20.3	2.2	3.2	0.7	3.2	1.0	1.5	0.3	2.1	0.4	0.8
Dec.	7.1	19.8	1.2	2.6	0.8	2.7	1.1	1.5	0.4	3.2	0.6	0.9
Autumn	7.0	20.2	1.8	2.8	0.9	3.2	1.0	1.5	0.3	2.5	0.6	0.9

Table (15): % weight of marine and freshwater fish species in experimental fishing at Lake Borollus (1973) and (2002).

Fish species	% Weight	
	1973	**2003**
Oreochromis niloticus	**19.70**	**39.43**
Oreochromis aureus	**-**	**28.21**
Tilapia Zillii	**47.39**	**12.51**
Sarotherodon galilaeus	**0.97**	**13.72**
Total tilapia	**68.06**	**93.87**
Clariaus lazera	**11.58**	**3.42**
Bagrus bayad	**2.08**	**0.90**
Total fresh water	**81.72**	**98.18**
Liza ramada	**8.76**	**1.81**
Mprpome Lanrax	**1.54**	**-**
Morone punctata	**3.61**	**-**
Mugil cephalus	**1.54**	**-**
Anguila Sp.	**0.54**	**-**
Total marine fish	**15.99**	**1.81**

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