EFFECT OF DISSOLVED NUTRIENTS ON THE DISTRIBUTION OF ALGAL FLORA IN SELECTED LAKES OF U.R.A.

1 — QARUN LAKE

By

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INTRODUCTION

In U.A.R. we have so many lakes the water of which varies mainly in the kind and concentration of the dissolved nutrients. Subsequently, the algal flora varies in kind and density. Lake Qarun is one of these lakes which is so interesting to be studied since our knowledge about its algal flora is still very scanty.

Lake Qarun lies in the North West of El-Faiyum Depression which is situated on the left bank of the Nile, about 90 kilometer to the South West of Cairo. The lake has a rectangular irregular shape and its area is about 200 km^2. Its surface is about 45.5 m. below sea level. Also it is bounded by cultivated lands in the South and by desert lands in the North.

The cultivated lands are naturally irrigated by a number of canals derived from Bahr-Yossef River, which received its water from the Nile. The irrigation-water drains off into the lake by two main drains (see figure 1). The drainage of water starts at the beginning of February every year when the water level reaches its climax. At that time of the year the sun is not perpendicular, the temperature is low (10 — 18°C), and the water evaporation is very little. There is a seasonal variation of the salt content of the lake. The climax of salinity period is reached in June when the water starts to evaporate.

The importance of dissolved nutrients to alge has been the subject of a great many investigators. Chu (1942, 1943) stated that as long as both N and P concentration are within the optimum range for growth, no change in their ratio will markedly affect the growth of the algae concerned. The same author (1942) found that the most favorable concentration of Ca, Mg, K, Na and silicate differ considerably for different algae. She also found that an appreciable amount of silica is necessary for diatoms. Pearsall (1921, 1923, 1930, 1932) noted that diatom population occur in abundance in waters where large amounts of silica, phosphate and nitrate, and low monovalent / divalent ratios are present. Atkins (1923) and Atkins and Harris (1924) found a direct correlation between the amount of phosphate and the growth of fresh-water plankton, and they suggested that the lack of phosphate rather than the lack of nitrate or ammonium salts limits the plankton as a general rule in fresh water. Patrick (1945) observed that the chemical elements, radicals or compounds, are important in diatom nutrition and growth (e.g. Na, Ca, Fe, silica, nitrate, phosphate, sulphate, O_2 and humic acid). Gran (1929) noted that the abundance of the plankton is dependent on the nutrients present.

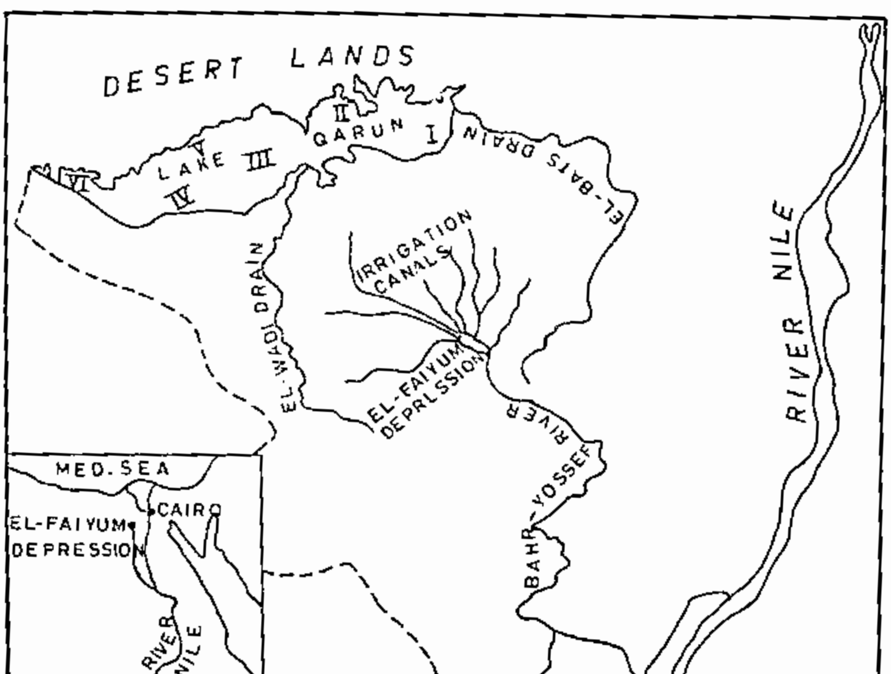

Fig. 1 -- Lake Qarun. The figures indicate the sites selected.

As regards salinity, Kolbe (1927), salinity and temperature (Gran, 1929 and Patrick, 1948) were also found to affect algal distribution. Braarud (1935) stated that salinity, pH and Ca content affect the kind of species that may be abundant rather than the total amount of the plankton. More recently, Nasr et al. (1961) studied the flora of Lake Edku, the smallest of the three Delta lakes (U.A.R.) which possesses a free communication with the Mediterranean Sea. They could identify 52 spp. of benthic diatoms together with very few species of Chlorophyceae and Cyanophyceae, and classified the diatoms present according to their degree of tolerance to NaCl concentration.

Concerning, the pH, Durrell (1964) observed that Bacillariophyceae and Cyanophyceae are more characteristic of alkaline environment. The same author noted that a marked gradual increase in growth of several soil alage was accompanied by elevation of the surface pH from 4.2 — 7.6. Patrick (1948) explained that waters of different pH have different floras, and very few species can live in a water with pH below 3.5, though the flora may be rich quantitatively it is poor qualitatively.

The aim of the present study is to investigate the effect of dissolved nutrients, namely O_2, Ca, Mg, K, Cl, PO_4, NO_3 ; together with pH on the distribution of Algal Flora, especially diatoms, in Lake Qarun.

MATERIAL AND METHODS

The samples used in this study were taken from 6 sites in Lake Qarun and were chosen at random in snch a way to cover the whole lake-water. The samples were taken at different levels, i.e. surface and bottom (three from each). The bottom samples were taken from depths ranging from 4 to 10 meters. The collection was done at the end of February, 1969 (winter time) after the drainage of irrigation water in the lake.

Microscopic examination of the samples revealed the presence of fresh, branckish and marine water-algae. The main algal groups found are Bacillariophyceae, Cyanophyceae and Chlorophyceae. The Bacillariophyceae was found to be the dominant group. The available texts which were used to get the right identity for each taxon are Fritsch (1961), Van-Heurck (1896) and Nasr et al. (1961). A full list of all algae identified in all the sites is compiled at the end of this paper.

The samples were treated by a mixture of concentrated nitric and sulphuric acids for clearing the diatoms and an intensive microscopic identification of all diatom species were done. Further fresh samples were examined microscopically for identification of the algae other than the diatoms.

The pH of all the sites was determined, directly after sampling, by using the pH meter. However, the determination of dissolved O_2 and the dissolved nutrients such as Ca, Mg, K, NO_3, PO_4 and Cl were done by using different methods (Nosseir, 1967). Ca & Mg were determined by titration against standard trilon solution using murexide and eriochrome black indicators respectively. Phosphate and nitrate determinations were accomplished colorimetrically using molybdinum reagent with stannous chloride for phosphate and disulphophenolic acid for nitrate. K was determined by the flame photometer (Eel type), chlorides by means of titration against standard silver nitrate solution using dichlorofluorescin indicator while dissolved O_2 was estimated iodimetrically by titration against standard thiouslphate solution using starch indicator.

The data depicted in table (1) represent the mean values of three samples taken from the surface or from the bottom while the mean value of the six samples taken from each site was considered as a measure for the magnitude of the dissolved nutrient in each site and are represented by figure (2). All data are expressed in mgms./liter.

RESULTS AND DISCUSSION

It is clear from the taxonomic account of algae that the three groups. Bacillariophyceae, Cyanophyceae and Chlorophyceae were found in all the samples. Also a glimpse to table (1) shows that the concentration of every nutrient in the surface water was lower than that of the bottom water. Oxygen concentration on the other hand was the reverse. This is obviously due to the continuous accessibility of O_2 from the atmosphere and due to decomposing plant material and sedimentation of salts at the bottom. The importance of aerobic metabolism for the maintenance of the integrity of aerobic cells is now recognised. Also it is now established that Chlorophyta and Euglenophyta have a respiratory chain essentially identical to that of higher plants (Webster and Hachett, 1965) and possess a classical citric acid cycle (Marsh et al., 1965).

The Bacillariophyceae formed more than 90% of the algal population concerning the number of species, 77 sp. belonging to 26 genera appeared in the material. Also it has been noticed that the species which are numerous and tolerant were of the marine, (28 sp.), and brackish, (23 sp.) types (saline condition) while the fresh water type was only 33 species. Willans (1964) stated that the species mixture varies with the proportions of the mixing water. Also Kolbe (1927) found that Na chloride was the first salt that should be recognised as important in determining diatom distribution, as the water was classified as marine, brackish or fresh. This explains the abundance and the dominance of the brackish and marine forms in Lake-Qarun. Since it lies below the sea-level, it receives mixing water (irrigation water from the Nile + salty water from the soil) with chloride content varing from 9500 — 15625 mg./liter, and it seems to be the highst nutrient present.

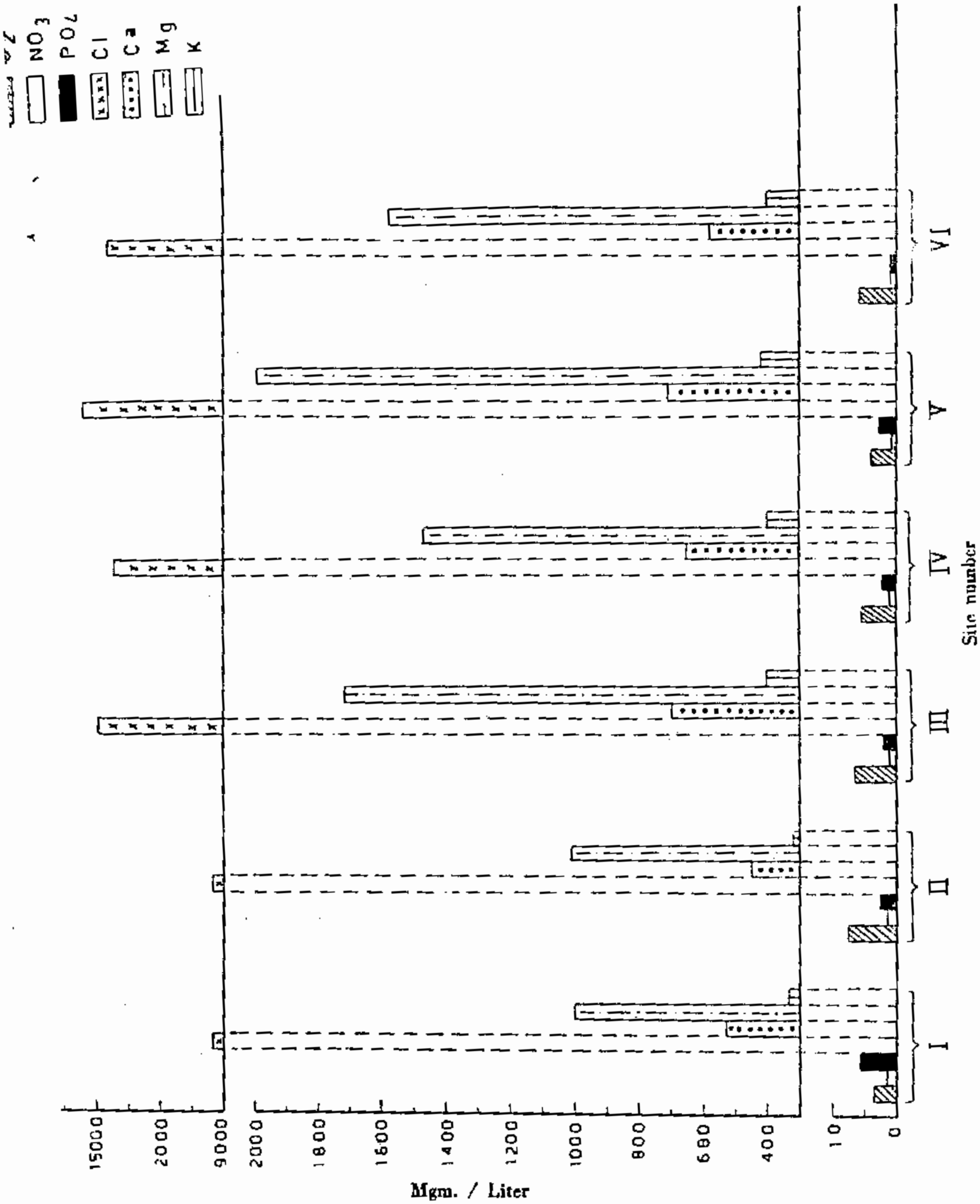

Fig. 2 — Dissolved nutrients of Lake Qarun water (means of 6 samples taken from every site, Mgm./L.).

TABLE 1

pH and dissolved nutrients of Lake Qarun-water
(means of triplicate samples, Mgm./L.)
(S = surface B = bottom)

Site Number	Nurtients														pH	
	O_2		NO_3		PO_4		Cl		Ca		Mg		K			
	S	B	S	B	S	B	S	B	S	B	S	B	S	B	S	B
I	4.80	2.20	1.6	0.80	1.70	8.60	9500	9500	500	550	990	1009	252	400	6.70	6.10
II	9.0	5.60	0.80	0.80	1.0	1.0	9500	9500	450	450	1032	978	300	320	6.80	6.40
III	8.0	4.0	0.80	0.40	1.0	1.20	15,000	15,050	650	750	1470	1980	320	480	7.00	6.80
IV	7.40	4.0	0.80	0.40	1.20	2.70	14,000	14,250	650	650	1410	1500	390	420	7.20	7.10
V	5.20	3.4	0.40	0.40	1.70	3.40	17,000	14,250	670	750	1078	2112	400	450	7.30	7.10
VI	8.20	3.60	1.0	0.40	0.70	0.60	9750	19,500	500	650	978	2178	320	490	7.00	6.80

The largest number of diatom species was found in site No. 2 and No. 1 respectively. and the leading and more distributed genus was found to be *Nitzschia, Grammatophora,* and *Biddulphia.* Patrick (1948) stated that there are a great many chemical and physical factors which may limit diatom growth, and it is a balance between these factors which determine whether conditions are suitable for diatom growth and the type of the diatom flora present. It seems to be the case in site 2 and 1. Although they have the largest number of diatom species, yet they contain relatively low contents of dissolved nutrients. This explains that, this may be due to the effect of some other factors together with the dissolved nutrients.

The most widely distributed forms were found to be *Pleurosigma acuminatum,* and *Gramatophora maxima* in site No. (1), *Licmophora Dalmatica* and *Biddulphia sp.* in site No. (2), *Amphiprora alata* in site No. (3), *Epithemia gibba* and *Navicula appendiculata* in site No. (5). Braarud (1938) stated that salinity, pH and Ca content affect the kind of species that may be abundant, rather than the total amount of the plankton. Patrick (1945) found that, it was the chemical content of the water together with light and temperature which determined the species to be found. Pearsall (1924) stated that certain species attain dominance when the concentration of nutrients like silica. nitrate and phosphate are in the higher ranks.

The kind of the dominant species in site No. (1) was found to be fresh and site No. (2) was marine, although they have the same and lowest chloride contents. Also site No. (3) was found to be marine and No. (5) was fresh although they have nearly the same and highest chloride content. This indicates that other factors together with or rather than the salinity affect the kind of diatom species present in lake Qarun.

Cyanophyceae and Chlorophyceae has been found but not so much in the number of their species. Although Cyanophyceae are the next to Bacillariophyceae in abundance, they account for only approximately 2.4% of the algal population while the Chlorophyceae forms only 4%.

The leading taxa representing the Cyanophyceae are *Oscillatoria* and those representing Chlorophyceae are *Chlamydomonas* and *Euglena.* Also blue-green and green algae showed better development in certain sites (2,4) but still dominated by diatoms.

The following table shows the % of each group for every site concerning the number of species.

Site No.	Bacillariophyceae	Cyanophyceae	Chlorophyceae
1	36.3	2.3	2.3
2	58.0	2.3	2.3
3	4.5	—	—
4	17.0	—	—
5	19.0	1.10	2.3
6	4.5	—	—

Here in lake-Qarun, the great bulk of algal flora is neither green nor blue-green but diatoms. Neverthless, blue-green and green algae showed better development in certain sites, but still dominated by diatoms. Tiffany, (1951) stated that the ecological factors which determine the distribution of algae are similar to those affecting the distribution of seed plants.

Rich (1933) noticed that blue-green algae were plantiful where the salinity was high as well as where it is low. This observation of Rich seems not to be the case in the present investigation, since the blue-green algae were found to be rare in all the sites where the salinity ranges from 9.50 - 15.625 gm./L.

Okuda and Yamaguche (1952) stated that the pH limits tolerated by algae on paddy soils (India) are between 4.0 - 5.0. Acidic pH favours the development of the algae especially the diatoms. This was found in agreement with Jorgensen (1957), Kolbe (1932) and Lund (1945). In the present investigation the pH in the six sites studied varied from 6.4 to 7.2. Durrell (1964) observed that the Bacillariophyceae and Cyanophyceae are more characteristic of alkaline environment. The same author noted that a marked gradual increase in growth of several soil algae was accompanied by clavation of the surface pH from 4.2 - 7.6. Kundson (1954) noted the importance of the alkalinity of water to certain diatoms. The results in hand were found in agreement with the findings of Durrell (1964) and Kundson (1954).

Generally speaking, the abundance of the planktons found in Lake-Qarun seems to depend on the nutrients as well as the factors already mentioned. The proportional amounts of certain dissolved nutrients such as Ca, Mg, K, PO_4, NO_3, Cl are 450 — 710, 1000 — 1995, 310 — 425, 0.65 — 5.15, 0.4 — 1.2, 9500 — 15625 p.p.m. respectively (Fig. 2).

Partick (1945) observed that Na, Ca, Fe, silicate, NO_3, PO_4, SO_4, O_2 and humic compounds ar important in diatom nutrition and growth.

Pearsall (1921, 1923, 1930 and 1932) noted that diatom population occurs in abundance in water where large amounts of silica, phosphate, nitrate and low monovalent / divalent ratios are present. The low monovalent / divalent ratio seems to be the dominant factor affecting the diatom abundance in Lake Qarun under the present investigation since the water contains low phosphate and nitrate contents.

Atkins (1923) and Atkins and Harris (1924) found a direct correlation between the amount of phosphate and the growth of fresh-water plankton, and they suggested that the lack of phosphate rather the lack of nitrate or ammonium salts limits the plankton as a general rule. The poor population of Cyanophyceae and Chlorophyceae found in Lake Qarum might be due to the very low level of phosphate and intrate in the water.

SUMMARY

The effect of dissolved nutrients on the distribution of the Algal Flora, especially diatoms, in Lake Qarun is given. 85 species of the algae (Bacillariophyceae, Cyanophyceae, and Chlorphyceae) are identified. The Bacillariophyceae form more than 90% of the algal poulation concerning the number of species. 77 spp. belong to 26 generdl. The diatom species which are numerous and tolerant are the marine (28 sp.) and brackish (23 spp.) types while the fresh type is only 33 spp.

Factors rather than salinity or together with salinity such as pH, nutrients (O_2, Ca, Mg, K, NO_3, PO_4) in some sites and low monovalent / divalent ratio in other sites seem to be responsible for the abundance of diatom population. The poor population of Cyanophyceae and Chloroplyceae appears mainly to be due to the very low phosphate and nitrate level in the water.

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SYSTEMATIC LIST OF THE ALGAE FOUND IN LAKE-QARUN

Bacillariophyceae

1.	Actinoptychus undulatus Ehr.	M.
2.	Amphiprora alata Kütz.	M. & B.
3.	Amphora robusta Greg.	M.
4.	Asterionella formosa Hassall	F.
5.	Biddulphia Sp.	M.

6.	Biddulphia laevis (Ehr.) f. minor H.V.H.	M.
7.	Biddulphia pulchella Grey	M.
8.	Biddulphia Eurgida W.Sm.	M.
9.	Campylodiscus Echeneis Ehr.	F. & B.
10.	Calloneis placentula Ehr.	F. & B.
11.	Cyclotella comta (Ehr.) v. radiosa Grun.	F.
12.	Cymbella Cymbiformis Ehr.	F.
13.	Cymbella obtusa Greg.	F.
14.	Denticula tenuis Kutz.	F.
15.	Ditylum sp. Bailey	M.
16.	Epithemia sp.	F.
17.	Epithemia gibba Kutz.	F.
18.	Epithemia Sorex Kutz.	F.
19.	Fragilaria construens (Ehr.) Grun.	F.
20.	Grammatophora marina (Lyngb) Kutz.	M.
21.	Grammatophora maxima Grun.	M.
22.	Grammatophora serpentina (Ralfs) Ehr.	M.
23.	Hantzschia amphioxys (Ehr.) Grun.	F. & B.
24.	Liemophora Dalmatica (Kutz) Grun.	M.
25.	Licmophora Ehrenbergii (Kutz) Grun.	M.
26.	Licmophora tincta (Ag) Grun.	M.
27.	Mastogloia Sp.	B.
28.	Mastogloia exigua Lewis	B.
29.	Melosira crenulata Kutz.	F.
30.	Melosira Roeseana Rabh.	on moss.
31.	Melosira Westii W.Sm.	M.
32.	Navicula appendiculata Kutz.	F.
33.	Navicula Cryptocephala Kutz.	F. & B.
34.	Navicula Cryptocephala v. veneta. H.V.H.	F.

35.	Navicula digito-radiata Greg.	B.
36.	Navicula Johnsonii W.Sm.	B.
37.	Navicula viridula (Kutz) F. minor H.V.H.	F.
38.	Nitzschia Sp.	
39.	Nitzschia fasciculata Grun.	M.
40.	Nitzschia linearis (Ag.) W.Sm.	F.
41.	Nitzschia lorenziana Grun.	B.
42.	Nitzschia obtusa W.Sm.	B.
43.	Nitzschia obtusa v. brevissima Grun.	B.
44.	Nitzschia obtusa v. nana Grun.	B.
45.	Nitzschia palea (Kutz.) W.Sm.	F.
46.	Nitzschia palea v. Fonticola Grun.	F.
47.	Nitzschia palea v. tenuirostris H.V.H.	F.
48.	Nitzschia panduriformis Grun.	M.
49.	Nitzschia punctata (Sm.) Grun.	B.
50.	Nitzschia Sigma W.Sm.	B.
51.	Nitzschia Sigma v. Sigmatella Grun.	B.
52.	Nitzschia Subtilis Grun.	F.
53.	Nitzschia thermalis (Kutz) Grun.	F.
54.	Nitzschia thermalis v. intermedia Grun.	F.
55.	Nitzschia tryblionella Hatz.	F. & B.
56.	Nitzschia vermicularis (Kutz) Grun.	F.
57.	Nitzschia vitrea (Norman) v. recta Hatz.	F. & B.
58.	Nitzschia vitrea v. Salinarum Grun.	B.
59.	Pleurosigma acuminatum (Kutz) Grun.	F.
60.	Pleurosigma attenuatum W.Sm.	F.
61.	Pleurosigma Balticum W.Sm.	M.
62.	Pleurosigma elongatum W.Sm.	M.
63.	Pleurosigma obscurum W.Sm.	M.

64.	Pleurosigma Spencerii W.Sm.	F.
65.	Pinnularia Tabellaria	F.
66.	Rhabdonema adriaticum Kutz.	M.
67.	Rhabdonema arcuatum (Ag) Kutz.	M.
68.	Synedra Sp.	
69.	Synedra acus (Kutz) Grun v ; delicatissima Grun.	F.
70.	Synedra affinis Kutz.	M. & B.
71.	Synedra affinis v. parva kutz.	M. & B.
72.	Synedra affinis v. tabulata kutz.	M. & B.
73.	Synedra Crystallina (Lyng) kutz.	M.
74.	Synedra nitzschioides Grun.	M.
75.	Synedra superba kutz.	M.
76.	Synedra ulna (Nitz.) Grun. v. longissima W.Sm.	B.
77.	Tetracyclus rupestris (A. Braun) Grun.	F.

Cyanophyceae

78. Oscillatoria sp.
79. Stigonema informe Kutz.
80. Anabaena sp.

Chlorophyceae

81. Chlamydomonas sp.
82. Chlorococcum sp.
83. Euglena sp.
84. Scendesmus sp.
85. Selenastrum sp.

N.B. F = Fresh, B = Brackish, M = Marine