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PHYTOPLANKTON DIVERSITY IN SOME PONDS AT NEW DAMIETTA -EGYPT.

Mohamed A. Deyab, Mamdouh M. Nemat Alla, and Magda F. El Adl
Botany Department, Faculty of Science at Damietta, Mansoura University, Egypt (Fax 057.403868) E-mail: maideyab@ yahoo.com

Abstract

Phytoplankton diversity and biomass in five ponds at New Damietta (El-Ladamin; Western New Damietta 1, W1; Western New Damietta 2, W2; Eastern New Damietta 1, E1; and Eastern New Damietta 2, E2) differed in salinity and pollution level were studied over a full year (from January to December 1998) relative to irrigation water (Halawa canal). Salinity was low at Halawa canal and El-Ladamin pond but high at Western and Eastern New Damietta ponds. These results were in agreement to great extent with hardness, alkalinity and contents of nitrate, phosphate, sulphate, sodium, potassium, copper and zinc but inversely proportional with dissolved oxygen. However, 136 of algal taxa were identified at the irrigation canal, 120 at El-Ladamin pond, 107 at W1, 64 at W2, 13 at E1 and only 12 at E2. Phytoplankton standing crop of Halawa canal and El-Ladamin pond was mainly due to Euglenophyta and Bacillariophyta but due to Dinophyta and Cyanophyta at W1, to Cyanophyta, Dinophyta and Bacillariophyta at W2 and exclusively to Chlorophyta or Cyanophyta blooming at E1 or E2, respectively. Diversity index indicated that Halawa and El-Ladamin water was slightly polluted while the Western ponds (W1 and W2) were moderately polluted but the Eastern ponds (E1 and E2) were heavily polluted. Saprobic situation revealed that irrigation water located in α–oligosaprobic zone, El-Ladamin in β``-mesosaprobic, the Western ponds in α–mesosaprobic and the Eastern ponds in α-polysaprobic. Compound eutrophication indicated that nature of water was eutrophic at Western and Eastern ponds but mesotrophic at Halawa bay and El-Ladamin pond.

Introduction

Microalgae can grow in mass culture in outdoor solar bioreactors and are used as the whole biomass for the most part in large scale commercial, because they have a high capacity for inorganic nutrient uptake (Blier *et al.*, 1995). Some methods have been developed for the biological monitoring of rivers using algae in addition to several indices that have been adopted to estimate water quality in terms of its organic pollution, eutrophication, acidification and other types of pollution (Kelly *et al.*, 1998; Kwandrans *et al.*, 1998). *Spirulina platensis* blooms is characteristic for organic polluted water (El-Awamri *et al.*, 2000). Mortality of aquatic organisms, have alarmed the public to emerge from the enhanced oxygen consumption. Eutrophication, however, would result in an oxygen deficiency and consequently mass required to mineralize the increasing amounts of organic matter produced within the ecosystem (Borum and Sand- Jensen, 1996). Bu-Olayan *et al.*,(2001) found that increasing in concentrations of trace metal pollution decreased the rate of oxygen. Wastewater often contains mixed contaminants, which are less toxic when complexed (Wong *et al.*, 1994). Moreover, the number of phytoplankton species decreases with the increase in salinity levels; some of them show a reduction in size (Remane and Schlieper, 1971). Nevertheless salinity may be an important factor in increasing the tolerance of algae to toxicants, e.g. heavy metals. This may be caused by a decrease in the activity of toxic species due to the increased ionic strength or to complexation reactions or by biochemical interference with some common ions in water

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(Haglund *et al.*, 1996). Temperature and pH play an important role in determining the density and biovolume of the minor algal groups (Yung *et al.*, 2001). Moreover, Shaaban–Dessouki *et al.* (1994) found that phytoplankton standing crop fluctuation was due to the irregular influx of different pollutants (mainly domestic and agricultural wastes) and / or the consumption of nutrients by the phytoplankton populations in Damietta estuary. Such fluctuations have been expected to extend to some ponds located in the vicinity of Damietta Dam. So, the present study was conducted to investigate the monthly variations of phytoplankton composition, biomass, succession and diversity in some of New Damietta ponds in response to levels of pollution and salinity, relative to irrigation water.

Material and methods

Study area

Six water resources at New Damietta city were chosen (Fig. 1). These stations are:

1- Halawa station, a standard fresh water irrigation canal,
2- El -Ladamin pond, a stagnant fresh water pond,
3- Eastern New Damietta Pond 1 (E1), a saline water pond receiving sewage pollution,
4- Eastern New Damietta Pond 2 (E2), a high saline water pond, receiving industrial discharges,
5- Western New Damietta Pond 1 (W1), a brackish water pond receiving sewage pollution, and
6- Western New Damietta Pond 2 (W2), a saline water pond receiving sewage pollution.

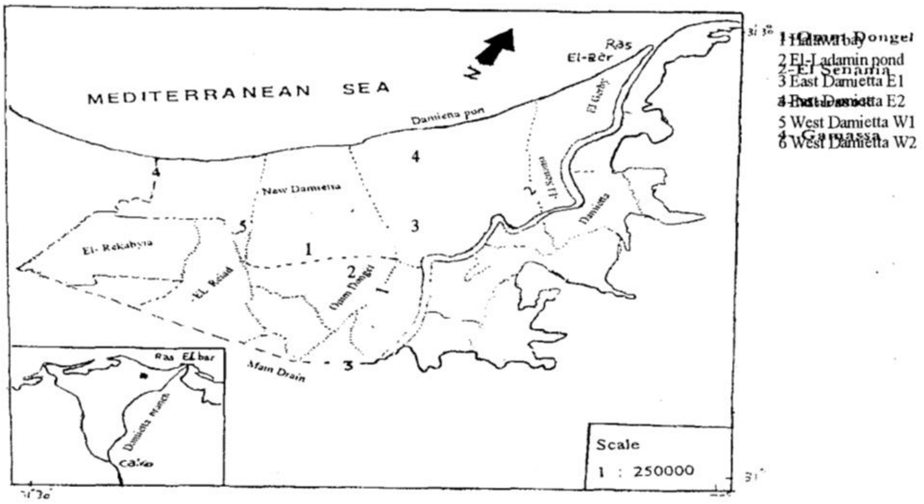

Fig. (1): A map showing the sampling stations.

Sampling and chemical analyses

The monthly collected surface water samples of the six stations all over the year 1998 were physico-chemically and biologically analyzed as soon as possible. Temperature and pH were recorded at each sampling site. The methods of Golterman (1969) were performed for the determination of Cl^- salinity, ph.ph alkalinity, total alkalinity, total hardness, turbidity, dissolved oxygen, ammonia, NO_2^-, NO_3^-, PO_4^{--}, total P, SO_4^{--}, silica, Na, K, Fe, Cu, Mn and Zn. The algal species were identified and counted using an inverted microscope, following sedimentation according to Utermohl (1958). The diversity index, saprobic index and compound eutrophication were performed according to Shannon and Weaver (1963), Sladecek (1973) and Round (1981), respectively.

Results

Physico-chemical characteristics of water

As depicted in Table 1, changes in temperature were more or less similar at the different stations. The pH values of the different stations fall in the alkaline side. The pattern of change in salinity, chloride, total hardness, total alkalinity, ph.ph alkalinity and turbidity appeared alike; high levels appeared at eastern and western ponds with particular magnitudes at W2 and E2. On the contrary, irrigation water and El-Ladamin pond had higher concentrations of dissolved oxygen respecting the low concentrations of other ponds. High concentrations of ammonia were detected at Western and Eastern ponds while nitrite mostly undetectable at the different stations. Nitrate and total phosphorus were higher at different ponds in particular W2 and E1. Orthophosphate values were higher especially at eastern and western ponds.

Table 1: Mean values of monthly changes in some physico-chemical parameters of the five ponds (El-ladamin, W1, W2, E1 and E2) during the year 1998 relative to a reference irrigation canal (Halawa).

	Halawa	El-Ladamin	W1	W2	E1	E2
Temperature (C)	22.40	21.70	23.96	23.96	22.58	23.88
PH	7.50	7.96	8.90	8.69	8.52	8.64
Total soluble salts (g/L)	0.83	2.28	26.76	43.33	34.75	51.18
Chloride (mg/L)	199.8	546.0	6429	10500.0	8337.33	12851.9
Total hardness (meq/L)	7.6	15.9	187.3	443.2	328.6	566.8
Total alkalinity (meq/L)	4.83	6.96	14.00	19.24	17.66	20.90
Ph alkalinity (meq/L)	0.40	0.43	2.36	3.95	3.30	4.15
Turbidity (NTU)	3.1	2.8	140.1	138.1	134.4	152.9
Dissolved Oxygen (mg/L)	9.90	8.16	6.36	7.43	1.20	1.43
Ammonia (mg/L)	0.03	0.01	0.17	0.12	0.16	0.10
Nitrite (mg/L)	0.02	0.01	0.05	0.08	0.09	0.06
Nitrate (mg/L)	0.09	0.02	0.23	0.34	0.88	0.16
Orthophosphate (mg/L)	0.23	0.22	0.92	0.69	0.78	1.07
Total phosphorus (mg/L)	11.82	8.10	18.24	36.06	36.06	18.65
Sulphate (mg/L)	74.3	204.7	2158	5700.0	3841.5	6627.8
Silica (mg/L)	2.30	2.30	2.96	2.99	2.53	2.75
Sodium (mg/L)	185	455	5352	12666	7592	15093
Potassium (mg/L)	25.0	59.4	317.1	758.5	523.7	941.1
Iron (ppm)	0.93	1.10	1.33	1.09	1.29	1.08
Copper (ppm)	0.11	0.13	0.20	0.16	0.21	0.17
Manganse (ppm)	0.09	0.24	0.17	0.18	0.18	0.17
Zinc (ppm)	0.85	4.54	21.38	23.34	20.33	24.20

Sulphate concentrations were very low at irrigation bay and very high at the other stations particularly W2 and E2. There were no great differences in silica concentration between the six water stations. Sodium and potassium contents were very low at irrigation water and El-Ladamin pond whilst at western and eastern ponds especially W2 and E2 have very high content of sodium. Iron and copper concentrations were most likely in irrigation water as in the different ponds while zinc concentration was very high at W1, W2, E1 and E2. A similar pattern, but to a lesser extent, was also detected for manganese; irrigation water contained the least content of Zn and Mn.

Species composition and diversity

There was a gradual increase in total phytoplankton growth at irrigation bay from January to March. The minimum growth was recorded in April and a high rate was detected in August. Cyanophyta was predominated in most months especially June and August constituting 90% and 91% of total phytoplankton number, respectively (Table 2). This was mainly due to the high growth of *Spirulina laxa, S. massartii* and *Microcystis pulverea*. Bacillariophyta predominated in October and December forming respectively 71% and 51% of total phytoplankton number mainly as *Navicula cincta* and *Nitzschia sublinearis*. Chlorophyta predominance in February and March forming 88% and 99% of total phytoplankton number respectively was mainly due to the growth of *Chlorella vulgaris*. The table shows also that total phytoplanktonic biomass detected at Halawa canal was being mostly due to Euglenophyta, Bacillariophyta and to some extent Chlorophyta constituting most of phytoplankton biomass.

Table 2: Most abundant phytoplankton species and values of total number and biomass of the different groups at the irrigation canal (Halawa) during the year 1998.

	Month	Number (x1000 cell/L)	Biomass (mg/L)
Cyanophyta total number and biomass		4166	0.52
Merismopedia punctata Meyen	Jan.	632	0.063
Microsystis pulverea (wood) Forti emend. Elenk	Jun.	9417	0.94
Oscillatoria rupicola (Hansg.)	Aug.	1667	0.167
Spirulina laxa Smith	Jun.	15000	1.05
Spirulina massartii (Kuff.)	Aug.	10667	1.00
Chlorophyta total number and biomass		13199	1.404
Chlorella vulgaris Beiyer	Mar.	138129	2.84
Ch.vulgaris Beiyer	Feb.	13135	3.95
Euglenophyta total number and biomass		95	3.385
Euglena acus Ehr.	Feb. and Mar.	25	0.62
Euglena caudata var. minor Drez.	Aug.	833	4.45
Dinophyta total number and biomass		25	0.05
Glenodinium pulvisculus (Ehrenb.)	Sep. and Dec.	21	0.00
Gymnodinium eurytopum	Feb. and May	21	0.05
Gymnodinium lantzschii var. rhinophoron	Jun. and Oct.	33	0.04
Peridinium orbiculare Paulsen	Mar.	29	0.01
Cryptophyta total number and biomass		0.3	0.0006
Cryptomonas marssonii Skuja	Mar.	1	0.0006
Bacillariophyta total number and biomass		454	2.644
Amphora coffeaeformis var. angularis V. H.	Mar.	410	0.09
Cyclotella meneghiniana Kutz.	Feb.	150	0.08
Cymbella aspera (Her.) Cl.	Jan. and Feb.	125	1.76
Navicula cincta (Ehr.) Kutz.	Oct. and Nov.	219	0.31
Nitzschia sublinearis Hust.	Dec.	183	0.50
Pinnularia microstauron (Ehr.) Cl.	Feb. and Mar.	566	1.71

Total number of phytoplankton at El-Ladamin pond was maximum in March and May mainly due to the dominance of Cyanophyta as *Anabaena constricta* and *Oscillatoria planctonica*, respectively (Table 3). Chlorophyta was the predominant group in four months especially in July forming 72 % of total phytoplankton number. This was mainly due to the growth of *Pediastrum tetras*. Bacillariophyta predominated in most months especially in March and November due to the growth of *Cyclotella meneghiniana*. However, Bacillariophyta showed the highest number of phytoplankton species. On the other hand, total phytoplanktonic biomass detected at El-Ladamin pond was most likely due to Euglenophyta and Bacillariophyta.

Table 3: Most abundant phytoplankton species and values of total number and biomass of the different groups at El-Ladamin during the year 1998.

	Month	Number (x1000 cell/L)	Biomass (mg/L)
Cyanophyta total number and biomass		234	0.15
Anabaena constricta (Szaf.) Geitl	Mar.	333	0.651
Oscillatoria putrida Schmidle	May and Jun.	279	0.012
Oscillatoria planctonica Woloez.	May	1250	0.015
Chlorophyta total number and biomass		353	0.147
Chlorella vulgaris Beiyer.	Apr.	383	0.003
Pandorina morum (O. Mul.)(Bory)	Jan.	600	0.039
Pediastrum tetras (Ehr.) Ralfs	Jul.	800	0.523
Scenedesmus dimorphus	Jul.	400	0.040
Scenedesmus quadricauda var. quadrispina	Sep.	400	0.010
Euglenophyta total number and biomass		48	0.845
Astasia inflata	Apr.	60	0.650
Euglena variabilis Klebs	Mar.	154	3.441
Phacus longicauda	Feb.	104	3.507
Dinophyta total number and biomass		72	0.14
Gymnodinium eurytopum	Jun.	38	0.090
Gymnodinium mitratum	Mar., Jul. and Sep.	38	0.199
Peridinium volzii	Feb.	121	0.063
Cryptophyta total number and biomass		19	0.002
Cryptomonas marssonii Skuja	Jan. and Oct.	92	0.014
Bacillariophyta total number and biomass		380	0.678
Achnanthes atacamae Hust	May	96	0.010
Achnanthes lanceolata var. minuta	Jul.	192	0.006
Cyclotella meneghiniana Kutz.	Mar.	554	0.277
Navicula gregaria	Jul.	125	0.080
Navicula subculta	May	138	0.070
Nitzschia holsatica Hust.	Aug.	300	0.010

At western New Damietta pond (W1), there was a successive increase in phytoplankton growth may be attributed to the high number of Cyanophyta and Chlorophyta as well as Bacillariophyta through the investigated period (Table 4). Cyanophyta predominated at W1 in some months especially in May forming 99 % of total phytoplankton number mainly due to the growth of *Oscillatoria putrida*. Chlorophyta especially as *Tetraspora cylindrica* predominated in June and as *Eudorina illinoisensis* in March. Bacillariophyta dominated in few months especially April and October mainly due to the growth of *Nitzschia closterium* and *Cyclotella meneghiniana*, respectively. Total phytoplanktonic biomass of W1 was mainly due to Dinophyta, Cyanophyta and to some extent Bacillariophyta.

Table 4: Most abundant phytoplankton species and values of total number and biomass of the different groups at Western New Damietta pond1 (W1) and Western New Damietta pond2 (W2) during the year 1998.

	Month	Number (x1000 cell/L)	Biomass (mg/L)
(A) Western New Damietta pond1 (W1)			
Cyanophyta total number and biomass		52916.7	1.48
Anabaenopsis Elenkinii V. Miller	Apr.	83334	0.400
Microcystis pulverea f. racemiforms (Nyg.) bHollerb	May	14414	0.723
Oscillatoria putrida Schimdle	May	188087	2.469
Spirulina massartii (Kuff.) Geitl.	Aug.	61333	6.700
Chlorophyta total number and biomass		25317.3	0.358
Eudorina illinoisensis	Mar.	9600	1.600
Pandorina morum (O. Mul.) (Bory)	Mar.	1600	0.072
Tetraspora cylindrica (Wahl.) Ag.	Jun.	187500	0.760
Euglenophyta total number and biomass		99.8	0.372
Euglena viridis Ehr.	Apr.	467	0.330
Exuviaella comperssa Ostenfeld	Nov.	300	0.470
Dinophyta total number and biomass		445.9	2.08
Peridinium pusillum	Apr.	3250	0.420
Bacillariophyta total number and biomass		1529	1.12
Achnanthes lanceolata var. rostrata (Ostr.) Hust	Apr.	417	0.042
Amphora coffeaeformis Ag.	Feb.	125	0.06
Chaetoceros Wighamii Bright	Jun.	2250	1.670
Cyclotella meneghiniana Kutz.	Oct.	3400	1.780
Fragilaria construens var. subsalina Hust.	Mar.	2000	2.000
Nitzschia closterium (Ehr.) W. Sm.	Apr.	4783	2.095
(B) Western New Damietta pond2 (W2)			
yanophyta total number and biomass		639.8	0.22
Anabaenopsis kulundineusis Woronich.	Jun.	10000	0.14
Oscillatoria rupicola	Feb.	833	0.089
Spirulina massartii (Kuff.) Geitl.	Mar.	2000	0.20
S. flavovirens Wist	Jul.	325	0.014
Chlorophyta total number and biomass		5597.3	0.023
Chlorella vulgaris Beiyer.	Apr.	31250	0.020
Pandorina morum (O. Mul.) (Bory)	May	1300	0. 058
Euglenophyta total number and biomass		35.8	0.208
Phacus brevicaudatus (Klebs) Lemm.	Sept.	226	0.652
Dinophyta total number and biomass		71.0	0.42
Gymnodinium ochraceum	Mar.	192	2.199
Bacillariophyta total number and biomass		173.2	0.321
Achnanthes lanceolata var. rostrata (Ostr.) Hust	Jan.	483	0. 062
Navicula perpusilla Grun.	Jan.	273	0.271
Nitzschia acicularis W.Sm.	Mar.	129	0.028
Nitzschia paleacea Grun	Nov.	33	0.076
Nitzschia sublinearis Hust.	Mar.	154	0.097

The table shows also that phytoplanktonic growth at Western New Damietta pond (W2) appeared moderate in winter. In despite of the maximum growth recorded during April, this mainly due to the dominance of Chlorophyta particularly *Chlorella vulgaris;* there was a gradual decrease thereafter up to June. During summer there was a gradual increase in phytoplanktonic growth from July to August whereas the minimum growth during the entire period of investigation was recorded during autumn especially in November. Cyanophyta predominated in six months especially June and March as *Anabaenopsis kulundineusis* and *Spirulina massartii,* respectively. Bacillariophyta dominated in November as *Nitzschia paleacea* and January as *Achnanthes lanceolata var. rostrata* and *Navicula perpusilla.* Total biomass phytoplankton at W2 was restricted to the growth of Dinophyta, Bacillariophyta, and Cyanophyta.

As depicted in Table 5, there was a blooming formation Chlorophyta at Eastern new Damietta pond1 (E1) during entire period of investigation, the maximum value was recorded in April and July. *Chlorella vulgaris* was the most predominant species from January to May in addition to *Didmochrysis paradoxa* from June to December. There was a very low growth of the other phytoplanktonic groups.

Table 5: Most abundant phytoplankton species and values of total number and biomass of the different groups at Eastern New Damietta pond1 (E1) and Eastern Western New Damietta pond2 (E2) during the year 1998.

	Month	Number (x1000 cell/L)	Biomass (mg/L)
A- Eastern New Damietta pond 1 (E1)			
Cyanophyta total number and biomass		7833.7	0.52
Spirulina laxissima G.S.West	Jan.	93333	6.060
Chlorophyta total number and biomass		301053230.6	2448.374
Chlorella vulgaris Beiyer	Apr.	$17.5x10^8$	13233.000
Didymochrysis paradoxa	Jul.	$183 x10^4$	244.000
Euglenophyta total number and biomass		1.4	0053
Phacus brevicaudatus (Klebs) Lemm.	Feb.	13	0.615
Dinophyta total number and biomass		16.0	0.18
Gymnodinium ochraceum	Apr.	113	1.295
Bacillariophyta total number and biomass		9.6	0.0001
Achnanthes Hauckiana var. elliptica Schulz	Feb.	25	0.028
Cyclotella meneghiniana Kutz.	Feb.	42	0.023
B- Eastern New Damietta pond 2 (E2)			
Cyanophyta total number and biomass		943500834.9	44306.55
Spirulina platensis (Nordst.)	Jul.	$57x10^8$	281900.000
Chlorophyta total number and biomass		1.4	0.0001
Dictyocha navicula Ehr.	Apr.	17	0.003
Euglenophyta total number and biomass		40.3	0.029
Euglena viridis Ehr.	Apr.	467	0.330
Dinophyta total number and biomass		277.8	0.03
Peridinium pusillum	Apr.	3250	0.419
Bacillariophyta total number and biomass		491.0	144.0
Achnanthes profunda Skv.	Apr.	417	0.042
Amphora coffeaeformis var. angularis f. curta Poretzky	Feb.	125	0.060
Nitzschia longissima (Breb.)	Apr.	4783	2.095
Surirella ovata Kutz.	Apr.	250	0.093

A similar high blooming formation was found also at Eastern New Damietta ponds (E2) but limited to the Cyanophyta organism *Spirulina platensis* throughout the entire period of investigation. Other phytoplanktonic groups had, if any, a little growth during the entire period of investigation. Consequently, total phytoplanktonic biomass detected at both E1 and E2 was being restricted to the blooming of Chlorophyta and Cyanophyta, respectively.

Discussion

Temperature is considered as a key in the optimization of solar bioreactors (Tang *et al.*, 1997). Water temperature of the present investigation seemed suitable for algal growth. However, Kebede and Ahlgren (1996) reported that the optimum temperature for phytoplankton is 30 °C. Nevertheless, the increase in water temperature often accompanied with algal blooms especially Cyanophyta species has been confirmed (Reynolds, 1984; Kebede and Ahlgren, 1996). In addition, water of the investigated ponds had a general tendency to alkaline side which is probably suitable for phytoplankton growth. In fact, Qijun *et al.* (1994) found that the maximum growth of phytoplankton was observed at pH 7.5 – 8.5. The relative higher pH values at Eastern and Western New Damietta ponds may be attributed to the massive phytoplankton growth.

The increase in pH values could occur naturally as a result of photosynthetic activity of the chlorophyll-bearing vegetation (Heath *et al.*, 1995). Moreover, New Damietta ponds were more turbid might be because of its receiving large amounts of sewage, industrial and agriculture discharges. However, this high turbidity may control the species composition and provides a good defense against photoinhibition of the population as a whole (Reynolds *et al.*, 1984). On the other hand, water at El-ladamin station is relatively stagnant and low polluted which could explain the low values of turbidity.

The very high salinity levels of water at Eastern and Western New Damietta ponds may be attributed to saline soil in addition to the nature of shallow water of these ponds. Nevertheless salinity may be an important factor in increasing the tolerance of algae to toxicants, e.g. heavy metals (Haglund *et al.*, 1996). In accordance, chloride concentration increased in these stations. In this account, Kebede *et al.* (1994) indicated that chloride concentrations increased with increasing salinity and alkalinity. Total hardness exhibited a similar pattern of response as shown in salinity and chlorisity. Water hardness is caused mainly by the polyvalent metallic ions dissolved in water especially Ca^{+2}, Mg^{+2} , Fe^{+2}, Sr^{+2}. The ph.ph and total alkalinity were high at Western and Eastern New Damietta ponds particularly at E1. These increased values might arise from the high phytoplankton growth.

In flood water containing algae, ammonia could be increased because CO_2 can be depleted during photosynthesis, thereby, increasing pH, and enhancing NH_3 volatilization (Bartlett and Harris, 1993). Ammonia–N was low in irrigation water and El-Ladamin pond but high in western and eastern New Damietta ponds probably because of relative high pH and pollution at these ponds. Algae generally prefer ammonia-N as a nitrogen source because its uptake is less expensive than the uptake of nitrate or urea (Leskinen, 1996). There was low concentrations of nitrite in the present study whereas the values of nitrate and phosphorus were most likely higher at Western and Eastern New Damietta ponds because of receiving sewage and/or agriculture discharges. Moreover, shallow water in ponds could enhance the erosion of phosphorus from bottom sediments. In this respect, Bailey-watts *et al.* (1990) reported that in eutrophic unstratified lakes and ponds, there may be a rapid and massive release of phosphorus from the sediment, which is distributed throughout the water column. Moreover, phosphorus content in water could increases by using fertilizer (Carpenter *et al.*, 1998). Phytoplankton prefer essentially to utilize phosphorus as inorganic forms. In support, under phosphorus deficiency conditions, some phytoplankton has the ability to produce alkaline phosphatase for enzymatic hydrolysis of ambient organically bound phosphates to inorganic phosphorus (Vrba *et al.*, 1995). The high phosphorus concentrations generally corresponded with increasing salinity (Kebede *et al.*, 1994).

Sulphate concentration seemed to correlate with salinity. In this connection, Kebede *et al.* (1994) concluded that $SO_4^{=}$ concentration increased with increasing salinity and alkalinity. The reactive silica was alike for all stations confirming that it might not be considered a critical element for phytoplankton growth in the present study. Dissolved oxygen sharply variated among the different stations depending upon the degree of salinity and pollution. The variations of Na^+ and K^+ concentrations in water were linked to the variations of salinity and chlorisity. In this respect, there are strong positive correlation between increasing salinity and the concentrations of Na^+, K^+, alkalinity and Cl^- (Kebede *et al.*, 1994). Iron, copper, zinc and manganese are essential micronutrients for metalloprotein enzymes. Nevertheless, zinc is considered as the first heavy metal pollutant. Copper, even though is an essential micronutrient, it is very toxic to algae. Copper sulphate and other copper–containing compounds have been used to control algal blooms in freshwaters (Fitzgerald, 1979). Copper inhibits growth as well as photosynthesis of algae (Fujita *et al.*, 1977). Manganese in excess amounts may be inhibitory or toxic as it behaves as an antimetabolite. However, there were no great changes in iron concentration neither regarding the different stations nor the different seasons. Whilst the highest concentration of Zn was recorded at Western pond 2, a station that receives greater amounts of the sewage pollution in addition to industrial wastes. Also manganese concentration was high at the ponds while copper at all stations appeared much more concentrated during summer; a phenomenon that was reversed during winter. However, the concentration of copper in the present study was relatively alike in most stations.

Regarding biological analysis, there was a gradual increase in total phytoplankton growth in irrigation water by increasing temperature. Temperature has a role in controlling production, distribution and seasonal succession of phytoplankton in natural waters (Turner *et al.*, 1983). Meanwhile there was a drop of total phytoplankton in April may be due to the consumption of the nutrient content in previous months. With increasing nutrient content and temperature, total phytoplankton increased again from May to August. By decreasing temperature and nutrients, a decrease in total phytoplankton was detected in September and October followed by an increase during November and December because of an increase in nutrient content. Stoyneva (1998) reported that the values of structural parameters were related to nutrient input and changed after restoration. Cyanophyta was the predominant group in most months might be because of the considerable content of phosphorus in water.

These results are in agreement with those of Yurkovskis *et al.* (1999), who reported that the vigorous growth of Cyanophyta is correlated with the increase of phosphorus surface values. Chlorophyta predominant in February and March because of the presence of considerable nitrogen content. Moreover, Bacillariophyta showed some predominance in most months due to the considerable content of silicate. Moreover, Bacillariophyta constituted most of total phytoplanktonic biomass because of the relative high size of fresh water Diatom cells. Euglenophyta alternated Chlorophyta and

Cyanophyta because of the relative large size of Euglenoid forms and the low size of cyanophyten cells.

At El-Ladamin pond, the maximum growth was recorded in spring and the minimum in autumn. Bacillariophyta mostly predominated followed by Chlorophyta, Cyanophyta and Dinophyta. The increased number of Bacillariophyta in addition to the relative size of diatoms could explain its great participation in the total phytoplankton biomass. These changes certainly depend on the composition of nutrient content. However, Cyanophyta predominated with high phosphorus content and Chlorophyta with high N content while Diatoms predominated where content of N, P and Si were considerable.

By increasing temperature, phytoplankton growth at western ponds successively increased from January to June mainly as Cyanophyta in pond 1 and as Chlorophyta in pond 2 depending upon nutrients. Kopczynska (1980) reported that seasonal variations of phytoplankton may be due to the variations of both temperature and light, if nutrients were present in excess. Bacillariophyta predominated in some months depending upon the abundance of Si. In fact, Sommer (1995) reported that when Si is abundant, diatoms are often strong competitors for other nutrients. Phytoplankton succession at the Western ponds appeared stable. Bacillariophyta dominated during cold months (January, February, November and December) but as temperature increased, Cyanophyta predominated. In this context, El–Sheekh *et al.* (2000) found that Bacillariophyta is the most dominant group in winter. In support also, Guasch *et al.* (1998) stated that Cyanophyta and Chlorophyta were shown to dominate in sites with higher water temperature. Moreover, total number and biomass was higher at pond 1 than pond 2 may be because of the higher salinity of the latter. Confirming these findings, Colburn (1988) found that species number decreased by increasing salinity.

Blooming of *Chlorella vulgaris* at Eastern pond 1 throughout the entire period of investigation may be attributed to the considerable salinity, alkalinity and sewage pollution. Supporting these findings, Guasch *et al.* (1998) found that Chlorophyta dominated in sites with higher water temperature and alkalinity. The massive growth of *Spirulina platensis* at Eastern pond 2 could be explained on the basis of the presence of organic and industrial pollution and high range of salinity at this pond. *Spirulina platensis* blooms is characteristic for organic polluted water (El-Awamri *et al.*, 2000). In support, Vonshak *et al.*, (1996) reported that *Spirulina* culture was grown at high salinity. Moreover, Cyanophyta was the most common in industrial areas (Guasch *et al.*, 1998). The blooming of Cyanophyta was shown to be a prominent symptom of eutrophication (Smith, 1998).

These findings as supported by diversity index .claimed to indicate that a slight level of pollution occurred in water of either irrigation canal or El-Ladamin pond (Table 6). In contrast, saprobic index was 2.1 and 2.3 for Halawa canal and El-Ladamin pond, respectively indicating that water could be considered to be located in α -oligosaprobic or β``-mesosaprobic zone, respectively with a consequent low level of contamination at both stations. Saprobic index of Western ponds 1 and 2 was about 2.6 indicating that water was moderately contaminated and could be located in α`-mesosaprobic zone. The two Eastern ponds 1 and 2 might be considered extremely contaminated and water could be located in α–polysaprobic zone since saprobic index was 4.2 and 4, respectively. Moreover, compound eutrophication indicated that water of Halawa canal and El-Ladamin pond was mesotrophic while the nature of water of Western and Eastern ponds was eutrophic.

Table 6: Mean values of monthly calculated diversity index, saprobic index and compound eutrophication of the five ponds (El-Ladamin, W1, W2, E1 and E2) during the year 1998 relative to a reference irrigation canal (Halawa).

	Diversity index	Saprobic index	Compound Eutrophication
Halawa	2.1	2.1	1.7
El-Ladamin	2.2	2.3	1.4
W1	1.0	2.6	3.0
W2	1.0	2.6	3.1
E1	0.4	4.2	3.1
E2	0.3	4.0	3.4

It could be concluded thus that phytoplankton diversity and composition significantly correlated with several parameters. Inspection of Table 7 reveal that there was a positive correlation between salinity, hardness, phosphorus, sulphate, silica, sodium and potassium. Total number also correlated with total biomass as well as number and biomass of Cyanophyta. Similarly, total biomass positively correlated with Cyanophyta biomass. However, there was a general positive correlation between biomass of a phytoplanktonic group with its total number.

Table 7: Person moment correlation (r) between the studied parameters of Halawa canal and five ponds at Damietta (El-ladamin, W1, W2, E1 and E2).

	Div in.	Sap ind	T.S.S	Cl-	SO_4^{--}	Na^+	Tot num	Cya num	Chl num	Eug num	Din num	Cry num	Chr num	Tot biom
Saprobic index	-0.88													
Eutrophication index	-0.96	0.71												
Cl^-			0.90											
Total hardness			0.85	0.73										
Total alkalinity			0.89	0.87										
ph.ph alkalinity			0.89	0.89										
Turbidity.			0.90	0.90										
Dissolved O_2		-0.99												
Ammonia			0.93											
Nitrite			0.85											
Nitrate			0.81											
Orthophosphate			0.69											
Total Phosphorus			0.81											
Si			0.82											
SO_4^{--}			0.89											
Na^+			0.88	1.0	1.0									
K^+			0.84	0.98	0.97	0.99								
Total Number	-0.68	0.80												
Cyanophyta number							0.95							
Total Biomass							0.96	1.0						
Cyanophyta Biomass							0.95	1.0						1.0
Chlorophyta Biomass									1.0					
Euglenophyta Biomass										0.60				
Dinophyta Biomass											0.79			
Cryptophyta Biomass												0.55	0.99	
Chrysophyta Biomass													1.0	
Bacillariophyta Biomass														

In addition, diversity index gave a positive correlation with dissolved oxygen but negatively correlated with saprobic index, eutrophication index and total biomass as well as many other physico-chemical parameters. Whereas saprobic index positively correlated with eutrophication index, total alkalinity and total number of phytoplankton but negatively correlated with dissolved oxygen. Similarly, eutrophication index gave a positive correlation with most parameters but negatively correlated with dissolved oxygen.

From another side, a total of 253 algal taxa, comprising 76 genera, were identified in the present study area. Of these taxa, 25 were recorded to belong to Cyanophyta, 32 to Chlorophyta, 38 to Euglenophyta, 12 to Dinophyta, 3 to Cryptophyta and 143 to Bacillariophyta. The species diversity of phytoplankton indicates that irrigation water attained the highest number of species (136 species) while El-Ladamin pond attained 120 species. The two Western ponds of New Damietta have a considerable species number (49 at W 1 and 42 at W2) while the two Eastern ponds have low species number (13 and 12 at E1 and E2, respectively). Anyhow, diatom taxa contributed in total phytoplankton with the great number in comparison with the other algal groups. On the other hand, the Cyanophyta species constituted the main bulk of algal standing crops in most study sites. The very high Blooming of phytoplankton at Eastern New Damietta ponds (E1and E2) could point to an economic importance of these ponds in case of using them as natural source for microalgal biomass in large commercial scales. However, to verify or realize this aim further scientific studies and remanagement for this ponds are required.

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التنوع فى الهائمات الطحلبية فى بعض البرك بدمياط الجديدة

محمد على دياب - ممدوح محمد نعمة الله - ماجدة فايز العدل

قسم النبات - كلية العلوم بدمياط - جامعة المنصورة - دمياط – مصر.

تم دراسة تنوع الهائمات الطحلبية وكتلتها الحية فى خمس برك مختلفة الخواص بدمياط الجديدة، وهى بركة اللضامين، وبركتين بغرب دمياط الجديدة (W1 and W2) ، وبركتين شرقها (E1 and E2) على مدار عام ١٩٩٨، مقارنة بترعة الرى (حلاوة). وكانت مستويات الملوحة منخفضة بترعة حلاوة وبركة اللضامين وعالية بباقى المواقع خاصة البركة الثانية شرق دمياط الجديدة (E). واتفقت هذه النتائج إيجابيا مع عسر الماء وقلويته ومحتواه من الكلوريدات والفوسفات والكبريتات والبوتاسيوم والصوديوم والنحاس والزنك، وعكسيا مع الأكسجين الذائب. وتم تسجيل ٢٥٣ نوع من الهائمات الطحلبية تمثل ٧٦ جنسا في المنطقة قيد البحث منها ٢٥ نوع من الطحالب الخضراء المزرقة، ٣٢ من الطحالب الخضراء، ٣٨ من اليوجلنية، ١٢ من الدينوفيتية،٣ من الكريبتوفيتية و١٤٣ من الدياتومات. هذا و سجلت ترعة حلاوة ١٣٦نوعاً من الطحالب معظمها من الطحالب الدياتومية واليوجلينية و الخضراء، ١٢٠ باللضامين معظمها من الدياتومات والطحالب الخضراء واليوجلينية ، ٤٩ بالبركة الأولى غرب دمياط الجديدة (W1) معظمها من الطحالب الدياتومية والخضراء المزرقة واليوجلينية، ٤٢ بالبركة الثانية غربها (W2) معظمها من الطحالب الدياتومية والخضراء السيانوفيتا ، وأما بركتى شرق المدينة فكانت أقل المحطات تنوعاً للهائمات الطحلبية حيث سجلت الأولى ١٣ نوعا معظمها من الطحالب الخضراء وبخاصة طحلب *Chlorella vulgaris* الذي أعطي نموات كثيفة جداً معظم شهور السنة بالإضافة إلى طحلب *Didmochrysis paradoxa* فى بعض الشهور، بينما سجلت الثانية ١٢ نوعا معظمها من الطحالب الخضراء المزرقة وبخاصة طحلب *Spirulina platensis* الذي أعطي نموات عالية جداً معظم شهور السنة. ووضح من دليل التنوع ودليل التلوث أن مستوي التلوث طفيف بترعة حلاوة وبركة اللضامين ومتوسط ببركتى غرب مدينة دمياط الجديدة ومرتفع ببركتى شرق المدينة. بالرغم من أن الدياتومات سجلت أكبر عدد من الأنواع الطحلبية إلا أن الطحالب الخضراء المزرقة والخضراء أعطت أكبر القيم من الأفراد والكتلة الحية في البركتين الشرقيتين. ولذا فمن الممكن استخدام هاتين البركتين كمصدر طبيعي للحصول علي الكتلة الحية من الطحالب الميكروسكوبية والتي تساهم في مجالات تجارية كبيرة. ولتحقيق هذا الهدف مطلوب مزيد من الدراسة العلمية وإعادة تخطيط هذه البرك.