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Studies on spatio-temporal dynamics of phytoplankton in El-Umum drain in west of Alexandria, Egypt

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Abstract

Phytoplankton was assessed quantitatively and qualitatively in regard to their abundance in the northern part of El-Umum drain, west of Alexandria at four stations to study the spatial, temporal, dominance and abundance of the phytoplankton community. The samples were collected monthly from April 2003 to April 2004. A total of 152 phytoplankton taxa were identified belonging to Bacillariophyceae (60), Chlorophyceae (46), Cyanophyceae (20), Euglenophyceae (17) and Dinophyceae (9). A limited number of these were recorded throughout the year, and showed an indication of organic pollution. The total densities (333.8×10^3 units l^{-1}) were mainly a reflection of the trends in counts of Bacillariophyceae and Chlorophyceae (138.1×10^3 and 131.6×10^3 units l^{-1}, respectively). Monthly differences in the quantitative (18×10^3 to 1645×10^3 units l^{-1}) and qualitative composition (41 to 113 taxa) of the phytoplankton communities in the different stations were marked, with recurrent high abundance in spring (910.4×10^3 units l^{-1}), whereas lowest densities occurred in autumn (99.7×10^3 units l^{-1}). Cyanophyceae was most abundant in July (67.5×10^3 units l^{-1}), whereas Euglenophyceae in December (32.0×10^3 units l^{-1}). Species diversity (H') gave a signal of the area is light to moderate polluted. The present study emphasized the need to use phytoplankton community as index of water quality.

Key words

El-Umum drain, Phytoplankton, Spatio-temporal dynamics, Diversity indices

Introduction

Generally, the water quality was detected and measured by chemical-physical analysis, but in dynamics environment the monitoring using phytoplankton needs to be done, because phytoplankton community analysis will describe clearer figurine the existence of the pollutant impact the community structure in the waters (Mathivanan, *et al*., 2007; Shashi Shekhar, *et al*., 2008).

In Egypt, after the construction of Aswan High dam and controlling of the Nile river water flow, El-Umum drain becomes one of the main land based sources regularly discharging its waters directly to the Mediterranean sea at El Mex bay, west of Alexandria. Due to the domestic and industrial waste effluents discharging, the drain water is slightly brackish, does not exceed 5 psu, with dissolved oxygen ranged between 0.5 and 3.48 ml l^{-1}, nutrient salts showed high levels up to 28, 346, 42 and 22 µM for phosphate, silicate, ammonia and nitrites, respectively, pH values fluctuated between 7.25 and 7.93 (Hossam and Petras, 1998; El-Rayis and Abdallah, 2005; Nessim *et al*., 2005; 2010). The water characteristics, phytoplankton and zooplankton population of El-Mex bay and El-Umum drain were previously studied (Soliman and Gharib, 1998; Gharib, 1998) and showed that, the continuous discharging polluted water into the bay caused massive development of algal blooms and a gradual deterioration of water quality created. In the present study, an attempt has been made to study the spatial and temporal distribution of phytoplankton and to find the indicator species in the northern part of El-Umum drain, before discharging to the Mediterranean sea.

Materials and Methods

El-Umum drain is located on latitude of 33°N and longitude of 33ºE with a length of 41 km (Nagy and Salem, 2003). At its downstream part, its water mixes with water effluent from neighboring sewage polluted lake called Lake Maruit (Fig. 1). The water temperature and salinity was estimated. During the period from April 2003 to April 2004, quantitative and qualitative phytoplankton samples

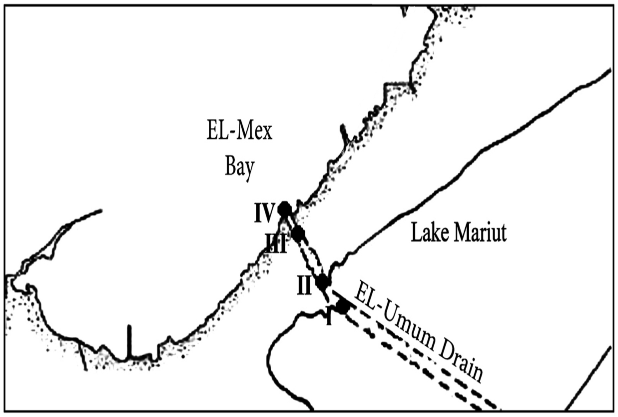

Fig. 1: Locations of the sampling (I to IV) of El-Umum drain, Western Alexandria, Egypt.

were collected monthly (13 cruises with 4 stations) using a Ruttiner bottle along the northern part (about one Km long) of El-Umum drain. Water samples were preserved with Lugol's solution and analyzed according to Utermöhl method (Utermöhl, 1958). Counting and identification were done as per APHA (2005), and the density was expressed as units l^{-1}.

Statistical analysis: Diversity (H') (Shannon and Wiener, 1963), Dominance (D) (Simpson, 1949), Evenness or equitability (J) (Pielou, 1966), Richness (R) (Margalef, 1951) indices were used to describe the numerical structure of the phytoplankton community. Simple correlation coefficient was used to examine the relationships among the different indices and phytoplankton density by using SPSS statistical software Program.

Results and Discussion

Water temperature did not deviate from the normal seasonal fluctuations on the southeastern coast of the Mediterranean sea (15-30°C). The lowest values were recorded during winter (15-18.4°C) and the highest in summer (27.0-30°C), with an average amplitude of 15°C. No significant differences were observed between sampling stations. Salinity varied from 3.0 to 5.0 psu, with an average of 3.53 psu. The average salinity values were 3.6 psu for stations I, II, III and was 3.4 psu for station IV. Water salinities did not differ significantly among stations throughout the study period. Mahmoud *et al.* (2005) found high (NH_4=227.35, NO_2=14.32, NO_3=82.75, PO_4=19.69 and SiO_4=140.69 µmol l^{-1}) nutrient salt concentrations in samples which were parallel to present study.

From the analyzed data, a visible change in phytoplankton community with regard to the numerical abundance and species composition was noticed among stations and seasonal cycle. A total of 152 phytoplankton taxa were identified. Bacillariophyceae comprised the highest number of taxa (25 genera, 60 species), but Dinophyceae showed remarkably low number (4 genera, 9 species). The freshwater Chlorophyceae, Cyanophyceae and Euglenophyceae were represented by 46, 20 and 17 taxa, respectively. Bacillariophyceae and Chlorophyceae were more abundant both qualitatively (69.7%) and quantitatively (80.6%) than the other taxonomic groups. They were conspicuous as the two most diverse groups with 39.5 and 30.2% in the total species number, respectively, although diatoms and green algae were almost equally in quantitative proportion (41.3 and 39.3%, respectively). The dominance of Bacillariophyceae and Chlorophyceae amongst phytoplankton was in accordance with Gharib (1998) at the same region; Gharib and Dorgham (2000) at the connection canal between Lake Edku and Mediterranean sea and Gharib (2006) at Rosetta estuary between River Nile and Mediterranean sea. Dinoflagellates were the least abundant and absent in station I; this might be attributed to their inefficiency to compete for nutrients (Reynolds, 2006). The total number of species at the sampled stations demonstrated more pronounced variations on the temporal scale more than the spatial one. High diversity (111 species) was recorded at station II, and

Table - 1: Mean values and standard deviation (SD) of phytoplankton species richness (R), diversity (H'), dominancy (D) and evenness (J) of the four stations of El-Umum drain in Western Alexandria, Egypt

Station	I		II		III		IV	
	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD	Range	Mean ± SD
Diversity	1.63-3.13	2.64 ±0.48	1.96-3.32	2.74±0.40	1.23-2.74	2.41±0.42	0.69-3.20	2.60±0.67
Evenness	0.08-0.40	0.26 ±0.11	0.13-0.43	0.27 ±0.09	0.09-0.40	0.24 ±0.11	0.15-0.41	0.26 ±0.11
Richness	1.32-3.50	2.43±0.61	1.03-5.09	2.76±1.25	1.28-4.44	2.31±0.94	1.44-3.51	2.42±0.69
Dominance	0.06-0.35	0.12±0.09	0.06-0.24	0.10±0.05	0.07-0.46	0.16±0.10	0.54-0.78	0.17±0.20

Table - 2: Monthly variation in phytoplankton abundance (10^3 unit l^{-1}) at the sampling stations (I to IV) of El-Umum drain from April 03 to April 04

St./ Month	April 03	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.04	Feb.	March	April	Average
I	616	689	602	381	1123	153	142	272	95	173	55	19	76	338
II	931	640	167	210	93	51	156	44	65	90	82	18	354	223
III	341	1470	208	40	35	176	128	79	51	81	250	1268	308	364
IV	1151	1145	144	85	108	50	33	53	78	145	1645	579	116	410
Average	**834.8**	**986**	**280**	**179**	**339.8**	**107.5**	**114.8**	**112**	**72.25**	**122.3**	**508**	**471**	**213.5**	**333.8**

Table - 3: Dominant and subdominant phytoplankton species at the successive months and their percentage to the total abundance at the sampled stations

Month	St.	Abundance X10^3 unit l^{-1}	Dominant and subdominant species
April 2003	I	616	*Melosira varians* C.Agardh (23.1%)*Chlorella vulgaris* Beijerinck (16.0%).
	II	931	*Cylindrotheca closterium* (Ehrenberg) Reimann & J.C.Lewin, (15.2%), *Chlorella vulgaris* (9.9%), C*yclotella glomerata* Bachmann (9.6%), *Ankistrodesmus falcatus* (Corda) Ralfs (9.2%).
	III	641	(19.5%), *Skeletonema costatum* (Greville) Cleve C. *glomerata* (19.0%), *M.variance* (14.5%).
	IV	1151	*Skeletonema costatum* (34.3%), *M. variance* (7.9%), *Carteria globosa* Schiller (7.1%).
May	I	689	C. *glomerata* (23.4%), *C. meneghiniana* Kutz (18.0%), *Cyclotella kuetzingiana* Thwaites (15.5%).
	II	640	*Scenedesmus bijugus* (Turpin) Lagerheim (13.2%), C. *glomerata*(10.6%),*C. meneghiniana*(9.5%).
	III	1470	*C. meneghiniana* (35.0%), C.*glomerata* (5.5%).
	IV	1145	*C .kutzingiana* (18.0%), C. *glomerata* (16.6%).
June	I	602	*Chlorella vulgaris* (35.9%), C. *glomerata* (26.9%).
	II	167	*C. glomerata* (38.4%), *C. meneghiniana* (28.8%).
	III	208	C. *glomerata* (29.3%), *Chlorella vulgaris* (22.5%), *C. meneghiniana* (22.4%).
	IV	144	C. *glomerata* (11.0%), *Chlorella vulgaris* (9.0%), *Aulacoseira distans* (Ehrenberg) Simonsen (8.8%), *Acutodesmus acuminatus* (Lagerheim) Tsarenko (8.7%).
July	I	381	*Planktolyngbya limnetica* (Lemm.), J. Komárková-Legnerová and G.Cronberg (32.0%), *M. variance* (32.0%).
	II	210	*Chlorella vulgaris* (24.6%), *Pseudanabaena limnetica* (Lemmermann) Komárek (20.0).
	III	40	*Lyngbya contorta Lemm.* (21.5%), *Ankistrodesmus falcatus* (14.0%), *Chlorella vulgaris* (12.8%).
	IV	85	*Merismopedia punctata* Meyen (16.9%), *Thalassiosira subtilis* (Osten.) Grun (11.5%), *Actinastrum hantzschia* Lagerh (10.8%).
August	I	1123	*M. variance* (55.3%), *Planktolyngbya limnetica* (19.1%).
	II	93	*Planktolyngbya limnetica* (21.1%), *Euglena caudata* Hübner (9.0%).
	III	35	*Chlorella vulgaris* (24.0%), *Planktolyngbya contorta* (Lemmermann) Anagnostidis & Komárek (18.3%).
	IV	108	*M. variance* (10.6%), *Gonyaulax polygramma* Stein (10.4%), *Planktolyngbya limnetica* (10.3%).
September	I	153	*Scenedesmus quadricauda* (Turpin) Brébisson (13.0%), *Ankistrodesmus falcatus* (11.6%)
	II	51	*Gloeocapsa minima* f. *smithii* (15.9%), *Microcystis aeruginosa* Kg. (14.1%), *Pseudanabaena limnetica* (12.4%).
	III	176	*C. meneghiniana* (24.0%), C. *glomerata* (22.5%).
	IV	50	*C. meneghiniana* (15.1%), *Scened. bijugatus* (9.6%), *Thalassiosira subtilis* (9.6%), (9.6%). *Kirchneriella lunaris* (Kirchner) K.Möbius.
October	I	142	*Merismopedia punctata* (10.4%), *Scened. quadricauda* (10.1%), *C. meneghiniana* (7.9%).
	II	156	*Scened. quadricauda* (19.0%), *E. caudata* (13.9%), *Chlorella vulgaris* (13.8%).
	III	128	*Merismopedia punctata* (40.0%), *Scened. quadricauda* (7.5%).
	IV	33	C. *glomerata* (17.0%), *Scened. quadricauda* (14.5%).
November	I	272	*Ankistrodesmus falcatus* (26.5%), *Chlorella vulgaris* (22.6%).
	II	44	*Phacus longicauda* (Ehrenberg) Dujardin (22.9%) (13.1%), *Euglena viridis* (O.F. Müller) Ehrenberg (14.1%), *Planktolyngbya contorta Chlorella vulgaris* (12.7%).
	III	79	*Ankistrodesmus falcatus* (20.5%), *Chlorella vulgaris* (14.2%), *Microcystis aeruginosa* (11.9%) .
	IV	53	*Thalassiosira subtilis* (35.0%), C. *glomerata* (16.1%).
December	I	95	*Euglena caudate* (12.6%), *Euglena granulata (Klebs.) Lemm* (12.3%).
	II	65	*Phacus logicauda*(11.4%), *E. viridis* (9.5%), *E. caudate* (9.4%).
	III	51	*E. granulata* (16.1%), *Chlorella vulgaris* (11.6%), *Scened. quadricauda*(11.0%).
	IV	78	*Thalassiosira subtilis* (16.2%), *Skeletonema costatum* (14.2%).
January 2004	I	173	*Phacus triqueter* Ehr. (12.4%), *Ph. curvicauda* Swirenko(9.0%).
	II	90	*E. granulata* (12.4%), *Chlorella vulgaris* (12.4%), *Ankistrodesmus falcatus* (12.2).
	III	81	*Scened. quadricauda*(24.2%), *E. granulata* (9.1%).
	IV	145	*Carteria globosa* (10.8%), *Scened. quadricauda* (10.2%).
February	I	55	C. *glomerata* (11.6%), *Merismopedia punctata* (8.7%), *E. caudate* (7.6%).
	II	82	*Scened. quadricauda* (11.7%), *Chlorella vulgaris* (11.2%).
	III	250	*Acutodesmus obliquus* (Turpin) Hegewald and Hanagata (21.1%), *Scened. quadricauda* (9.9%), *E. granulata* (8.6%).
	IV	1645	*Crucigenia quadrata* Morren (88.5%).

March	I	19	*Merismopedia punctata* (32.0%), *Ankistrodesmus falcatus* (8.0%).
	II	18	*Kirchneriella lunaris* (36.7%), *Pseudanabaena limnetica* (8.4%).
	III	1268	*Scened. quadricauda (*65.9%), *Pseudanabaena limnetica* (9.3%).
	IV	579	*Pseudanabaena limnetica* (39.4%), *Anabaena circularis* Rab (24.8%).
April	I	76	*Chlorella vulgaris* (12.6%), *Cylindrotheca closterium* (12.6%).
	II	76	*C. meneghiniana* (19.7%), *Chlorella vulgaris* (11.6%).
	III	308	*Skeletonema costatum* (42.0%).
	IV	116	*Ankistrodesmus falcatus* (15.7%), (12.4%). *Acutodesmus obliquus*.

approximately similar number of species (94-95 species) were recorded at stations III and IV, while markedly lower one (69 species) was found at station I which lies near El-Mex pumping station, this may be due to either the disturbance of the water resulting from discharged water from the pump, or the direct effect of pollutant coming from the pumping station. Monthly differences in the qualitative composition showed that, November harboured lowest diversity (41), while highest diversity (113) was observed in May. From a recorded species throughout the study period; *Cyclotella meneghiniana*, *Ankistrodesmus falcatus, Chlorella vulgaris, Planktolyngbya contorta , Microcystis aeruginosa, Pseudanabaena limnetica, Euglena caudate, E. granulate, Phacus curvicauda* and *Phacus triqueter.* All the last mentioned species could be considered as pollution tolerant species (Kaur *et al*., 2001).

Species diversity is a reliable parameter in biology to determine how healthy an environment is (Ogbeibu and Edutie, 2002). In the present study, the diversity index was relatively high most of the time, fluctuating between 0.69 and 3.32 (Table 1), accompanied by high species richness (1.03-5.09). There was a good coincidence in the temporal variation of species number, diversity index, evenness and species richness (Table 1), but each station sustained a characteristic temporal pattern which was different from the other station. The statistical analysis indicated significant correlation between the species number and both the diversity index and species richness ($r = 0.325$ and 0.979, respectively, at $n = 52$, $p<0.05$). Species diversity (H') and dominance are generally inversely related ($r = -0.905$, $p<0.001$). There are several numerical attempts (Sabae and Rabeh, 2000) to express degrees of oligotrophy and eutrophy from a consideration of species complements rather than from nutrient levels. As previously mentioned, the biological estimation of the degree of eutrophication and pollution of aquatic ecosystem is probably more informative than chemical determinations, and so, the investigated area is light to moderate polluted.

The abundance and species composition of phytoplankton varied strongly at the successive months and between stations in the study area. They varied widely from $18x10^3$ (March 04, St. II) to $1645x10^3$ units l^{-1} (Feb., St. IV), with an average of 333.8 $x10^3$ units l^{-1} among the four stations during the study period (Table 2). This value found to be less than previously recorded in the same region (Gharib, 1998). The natural unpolluted environments are characterized by balanced biological conditions and contains a great diversity of plants and animals life's with no one species dominating. The total densities were mainly a reflection of the trends in counts of Bacillariophyceae and Chlorophyceae (138.1 x 10^3 and 131.6 x 10^3 units l^{-1}, respectively). High abundance was observed in spring ($910.4x10^3$ units.l^{-1}), whereas lowest densities occurred in autumn ($99.7x10^3$ units l^{-1}). Cyanophyceae was most abundance in July ($67.5x10^3$ units l^{-1}), whereas Euglenophyceae in December ($32.0x10^3$ units l^{-1}). The dominant and subdominant species at the different months and their percentage to the total abundance at the sampled stations were summarized in Table 3. Whatever, the dominance of any species in the polluted water for one season or more may be considered as indicator species.

Not only the dominant species differed between stations but also differed between months. With regards to the average of the study period, *Melosira varians* (21.79%) was the most conspicuous species throughout the year at station I. *Cyclotella glomerata* (9.67%) and *Chlorella vulgaris* (9.51%) at station II, while *Scenedesmus quadricauda* (19.84%), and *Cyclotella meneghiniana* (13.95%) at station III, and *Crucigenia quadrata* (27.35%) at station IV.

Generally, the lowest abundance occurred in autumn (September- December) and the highest was observed in spring (April- May). At station I, a distinguished peak appeared in August and other less ones were recorded during April, May and June. The August peak was composed mainly of *Melosira varians*, followed by *Planktolyngbya limnetica.* In April, *Melosira varians* and *Chlorella vulgaris* were the leaders. The two later species formed the June peak, besides *Cyclotella glomerata.* The genus *Cyclotella* was responsible to May peak. At station II, two unequal peaks occurred in April and May. The first one resulting from *Cylindrotheca closterium, Cyclotella glomerata*, *Chlorella vulgaris*, *Ankistrodismus falcatus* var. *acicularis* and *Ankistrodismus spiralis*. While in May, *Cyclotella* spp. and *Scenedesmus bijugus* were the dominant forms. On the other hand, two high peaks were recorded at station III in May and March and less one in April 2003. In May, *Cyclotella* spp. and *Scenedesmus quadricauda* appeared as the dominant forms. The April peak consisted mainly from *Skeletonema costatum*, *Cyclotella glomerata, Melosira varians* and *Chlorella vulgaris*. At station IV, the blooms were recorded during April-May and February-March. The April peak was composed mainly of *Skeletonema costatum*, *Melosira varians*, *Acutodesmus obliquus* and *Carteria globosa*, and the May peak consisted mainly due to the absolute dominance of the genus *Cyclotella* and *Navicula cryptocephala*. The highest peak in February was caused mainly by predominating *Crucigenia quadrata*, but in March the blue-green algae appeared as *Planktolyngbya limnetica* and *Anabaena circularis*. The genus *Cyclotella* was represented as indicator for oligotrophic environments (Tas *et al*., 2002; Stoermer and Julius, 2003). It was also recorded as the dominant species in Egyptian waters in other studies (Okbah and Hussein, 2006; Abdel Aziz *et al.,* 2006; Ismael and Dorgham, 2003; El-Sherif and Mikhail, 2003).

The irregular appearance of blooms and the variations in the dominance of species in the different stations were related to the prevailing ecological conditions. Low salinity (<5 psu), high water temperature, a steady increase in the concentration of oxidizable organic matter and adequate nutrient availability were likely contributed to the increase in abundance (Soliman and Gharib, 1998). Gharib (1998) observed that the phytoplankton abundance and the number of species increased consistently towards the outer region of El-Mex bay, where the salinity was high. The great fluctuations in the quantitative and qualitative composition of the phytoplankton in the different stations over the months were mainly due to several environmental factors, which are variable in different seasons and regions; this is further supported by El-Gindy and Dorgham (1992). This kind of cyclic change in the species composition of phytoplankton was a characteristic feature of the Alexandria coastal area (Gharib and Dorgham, 2000, Gharib and Dorgham, 2006, Gharib, 2006).

In conclusion, the continuous land run off into the Mediterranean coast caused massive development of algal blooms and the coastal current allows such blooms to extend along the shore line, and so water quality creates on the long run nuisance and aesthetic problems in the recreational beaches. The results gave a signal of the area is light to moderate polluted and emphasized the need of use phytoplankton community as index of water quality. Accordingly, it is recommended that the waste water should be treated and/ or recycled before discharge into this natural aquatic body.

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