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PHYTOPLANKTON STANDING CROP OF EL-MAX FISH FARM IN RELATION TO THE ENVIRONMENTAL CONDITIONS

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Key wards: Fish Farm, Physico-chemical parameters, Phytoplankton, Diversity index.

ABSTRACT

EL-Max Fish Farm Station is located at 15 km. westward of Alexandria City. It receives the feeding waters from Ummoum drain.

The aim of this work is to estimate the physico-chemical parameters and their impacts on phytoplankton standing crop as well as diversity index.

The data of the physico-chemical parameters of the investigated area revealed greater amount of nutrient salts at the water sources. The average values of nutrient salts were in the range from 1.56 to 58.7 µmole l^{-1} for nitrate; from 1.0 to 202.1µmole l^{-1} for ammonia; from 0.19 to 31.25 µmole l^{-1} for reactive phosphate and from 1.58 to 161.76 µmole l^{-1} for silicate

Higher counts of phytoplankton standing crop were observed in the basins farm comparing with those recorded in the water sources. Although, water source is rich in nutrient salts, yet it attained higher counts of bacteria. Moreover, low values of pH (7.1-7.8), dissolved oxygen (3.96-4.32 ml $O_2.l^{-1}$) and water salinity (5.28-6.79‰).

Phytoplankton community structure is differing from basin to another and from one month to the other at the same basin. Diatoms, *Cyclotella* and *Nitzchia spp.,* dominated during July (B9), blue green alga, *Microcystis spp.,* constitute 98.2% during March (B10). However, green alga, *Chlorella vulgaris*, ranked the main component during December. This is attributed to higher values of water alkalinity and reactive silicate, low values of dissolved oxygen and water salinity.

Phytoplankton diversity varied from 0.61 to 1.87 nats in the water sources (average 1.4 nats). However, it ranged from 0.1 to 1.22 nats at farm basins (average 0.6 nats).

Correlation coefficient of biological factors with some physico-chemical parameters, a series of stepwise regression equations describing the dependence of standing crop and diversity index on the changes of most abiotic prevailing conditions are given and discussed.

INTRODUCTION

El-Max Fish Farm was established in 1931, at about 15 km. westward of Alexandria City, in the vicinity of Lake Mariout and at about one kilometer south of the Mediterranean Sea Coast. To the north of this farm lies El-Max Pumping Station. It serves to pump out the water from Ummoum drain which connects the lake to the Mediterranean Sea through a channel of about 800 meters long, so that the level of water in the lake is kept at about 2.8-3.0 meters below sea level. Taking advantage of the difference in level between water in this channel and the low water in basins farm, a line of pipes was constructed to permit the water to flow into the feeding canal which supplies the fish basins. The total area of this fish farm is about 37 Feddan. This aquatic farm is divided into 14 basins (Fig.1). The largest one is the basin number 14 with an area about 14 Feddan and the rest basins

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areas are ranged from 0.14 to 1.25 Feddan. The water depth of basins is varied from 0.5 to 1.8 m. These aquatic fish farm basins receive the feeding waters coming from El-Nubaria fresh water mixed with the water drained through different waste production such as the irrigation water, industrial products and others which discharged into Ummoum drainage.

The available data concerning water quality and biological characters of El-Max Fish are scarce. Wahby (1974) studied the effect of inorganic and organic fertilizers on the water quality. El-Zarka and Fahmy (1968) conducted several fertilization experiments to study the effect of organic and inorganic fertilizers on water quality and biological characteristics of the pond waters. Bishara (1978) reported the effect of different fertilizers and supplemental feeds on growth rate of *Mugil cephalus* in seven ponds of El-Max Fish Farm. Bishara (1979) studied the possibility of increasing growth rate of *Mugil capito* in El-Max Fish Farm. El Banna (1993) studied physico-chemical characteristics and primary production of five basins(5, 6, 7, 9 and 14) in El-Max Farm. Abdel-Alatif (1996) studied on some micro organisms and their relationships with *Mullets* and *Tilapia* fishes reared in El-Max ponds.

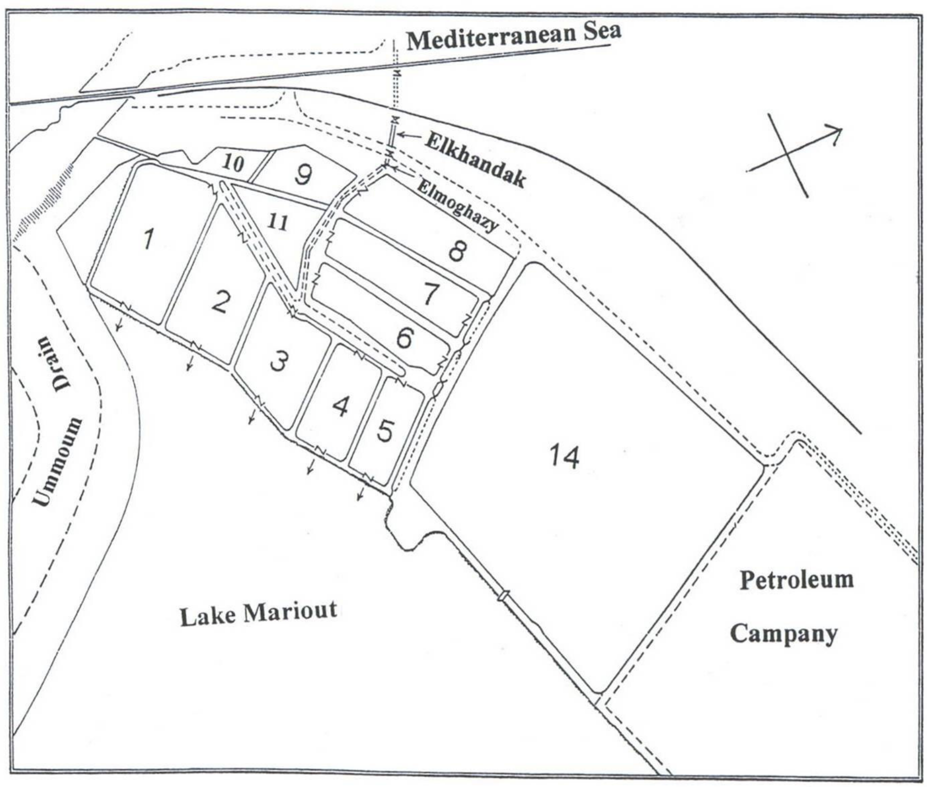


Figure (1): El-Max Fish Farm.

There is no available data concerning the phytoplankton community composition of El-Max Fish Farm and its relation to the environmental conditions the water basins over the last ten years. Although basins situated side by side and subjected to the same management procedures, they have different physico-chemical characteristics than the water sources of the farm and consequently develop widely different algal floras.

The present contribution is a part of research plan, Ecological and Economic Evaluation of El-Max Fish Farm, Marine Environmental Division (National Institute of Oceanography and Fisheries, Anon, 2004).

This work is aiming to study the change of the physico-chemical parameters in each of the water basins as well as in the water source of the fish farm (Elmoghazy and Elkhandak) and its effect on phytoplankton community structure in El-Max Fish Farm. Although these information are basically descriptive, they allow insight into the chemical characters, types of phytoplankton communities and species diversity. These findings give a clear picture about the availability of natural feeding for the fish farm.

MATERIAL AND METHODS

Monthly water samples (March-December 2003) were collected from eight basins; representing different habitats in the farm; (1, 2, 3, 7, 9, 10, 11 and 14), beside two water samples from Elmoghazy and Elkhandak areas (Water sources of the fish farm). These water samples were analyzed chemically and for phytoplankton community composition at the same time as follows:

Chemical analysis:

The water samples have been analyzed for the following chemical parameters; nutrient salts, oxidizable organic matter, dissolved oxygen, total alkalinity, besides pH, temperature and salinity of the water samples as follows:

The temperature and the pH values of the water samples measured in the field, immediately after the water sampling using graduating thermometer and portable digital pH meter(Model 201/ digital). Water salinity was measured using Salinometer (Bekman, Model RS-10).Total Alkalinity was determined by the titration using 0.01N hydrochloric acid and methyl orange as indicator (Grasshoff, 1976). Dissolved oxygen was determined according to Winkler's method (Strickland and Parson, 1968). Oxidizable organic matter was determined by boiling a known volume of water samples in presence of alkaline potassium permanganate and the titration is performed as for oxygen with sodium thiosulphate, (Ellis *et al*. 1946). Nutrient salts (nitrate, phosphate, ammonia, and silicate) were determined spectrophotometer according to the methods of Grasshoff, 1976; Strickland and Parsons, 1968.

Biological analysis:

The phytoplankton standing crop at different sites were carried out using sedimentation technique as reported in the standard methods (A.P.H.A. 1985), and expressed in unit per liter. For the identification of the phytoplankton species the following works were consulted: Van Heurck (1896); Huber-pestulozzi (1938); El-Nayal (1935&1936); Smith (1950) and Hustedt (1930). Species diversity index was estimated according to Shannon and Weaver (1963). The results were expressed as "nats".

Correlation coefficient as well as stepwise multiple regression equations at a confidence limit 95% were evaluated for both water sources and farm basins separately to quantize the phytoplankton standing crops and diversity index in relation to the most correlative environmental factors. In addition to factor loadings extracted from the principal component analysis were computed and plotted to confirm the relation between biological and environmental factors.

RESULTS AND DISCUSSION

I. Physico-chemical characteristics.

Hydrogen ion concentration (pH):

Most of the water basins are on the alkaline side, pH > 8; water sources (Elkhandak and Elmoghazy) are always lower in their pH values than the other basins and ranged between 7.1-7.9 during the period of study. The highest pH value was recorded in December in basin 7 (8.9) followed by basin 1(8.8). The highest pH values in most months were noticed in both basins 14 and 1 in comparison to the other basins of El-Max Fish Farm (Fig.2).

Water temperature:

The temperature of the water basins varied between maximum 31 ^{o}C in summer months to a minimum of 18.5 ^{o}C in December. The highest temperature was recorded in basins 7 and 14 in most months (Fig.3). No significance difference in averages temperature among the different basins (23.9-26.6 ^{o}C).

Total alkalinity:

The total alkalinity was measured in water basins. The lowest average was determined in basin 1(4.41 ml. eq.l^{-1}), while the highest in both basin 10 and Elkhandak (5.9 and 5.85 ml. eq. l^{-1} respectively; Fig. 2). The high value of alkalinity at most the water basins reflect the high productivity of the fish farm. Total alkalinity was a negatively correlated with water temperature (r = -0.3). It is noteworthy that alkalinity of the water is positively correlated with fish production i.e hard waters are more productive than soft waters. The high productivity of the fish farm water basins is also due to their high phosphorous concentration and other essential elements which increase along with alkalinity (Boyd, 1984).

Salinity:

Salinity was measured in most of the water basins. The highest salinity is always recorded in the water of basin 11 with an average of 6.79 ‰ followed by basins 7 and 1 with average of 5.66 ‰ and 5.28 ‰ respectively. On the other hand, their average values are ranged between 3.87-4.88 ‰ (Fig. 2). It is noticed that there is no significance difference in water salinity of other water basins of the fish farm.

Dissolved oxygen (DO):

Present study showed that, the level of dissolved oxygen in the farm is influenced by several factors such as temperature, wind, photosynthetic activity of phytoplankton communities, respiration of heterotrophic, autotrophic organisms and decomposition of organic matter.

Dissolved oxygen concentration are always low in water sources (Elmoghazy and Elkhandak.). Their average values are 3.96 and 4.32 mlO_2l^{-1} respectively. The highest DO value was measured in water of basin 9 in June (17.78 mlO_2l^{-1}) followed by basins 2, 3 and 14 (Fig. 2). The maximum dissolved oxygen values for most of water basins were obtained in June. It ranged from 6.8 mlO_2l^{-1} to 17. 8 mlO_2l^{-1} for basin 1 and 9 respectively. On the other hand, the lowest oxygen reading were recorded in December and varied from 3.4 mlO_2l^{-1} to 5.4 mlO_2l^{-1} for basins 10 and 11 respectively. Dissolved oxygen showed a negative correlation with water alkalinity (r = -0.3) and positively one with water temperature (r = 0.36).

Oxidizable organic matter (OOM):

The average value of OOM was comparatively low in basin 9 (1.395 mg $O_{2.}l^{-1}$). The highest mean value is always measured in basin 7 and Elmoghazy. The maximum value of OOM content in the water basins in May and ranged from 2.2-4.3 mg $O_{2.}l^{-1}$ for basins 1, 11 respectively. The minimum value was measured in December 1.05-1.74 mg $O_{2.}l^{-1}$ for basins 3, 7 respectively.

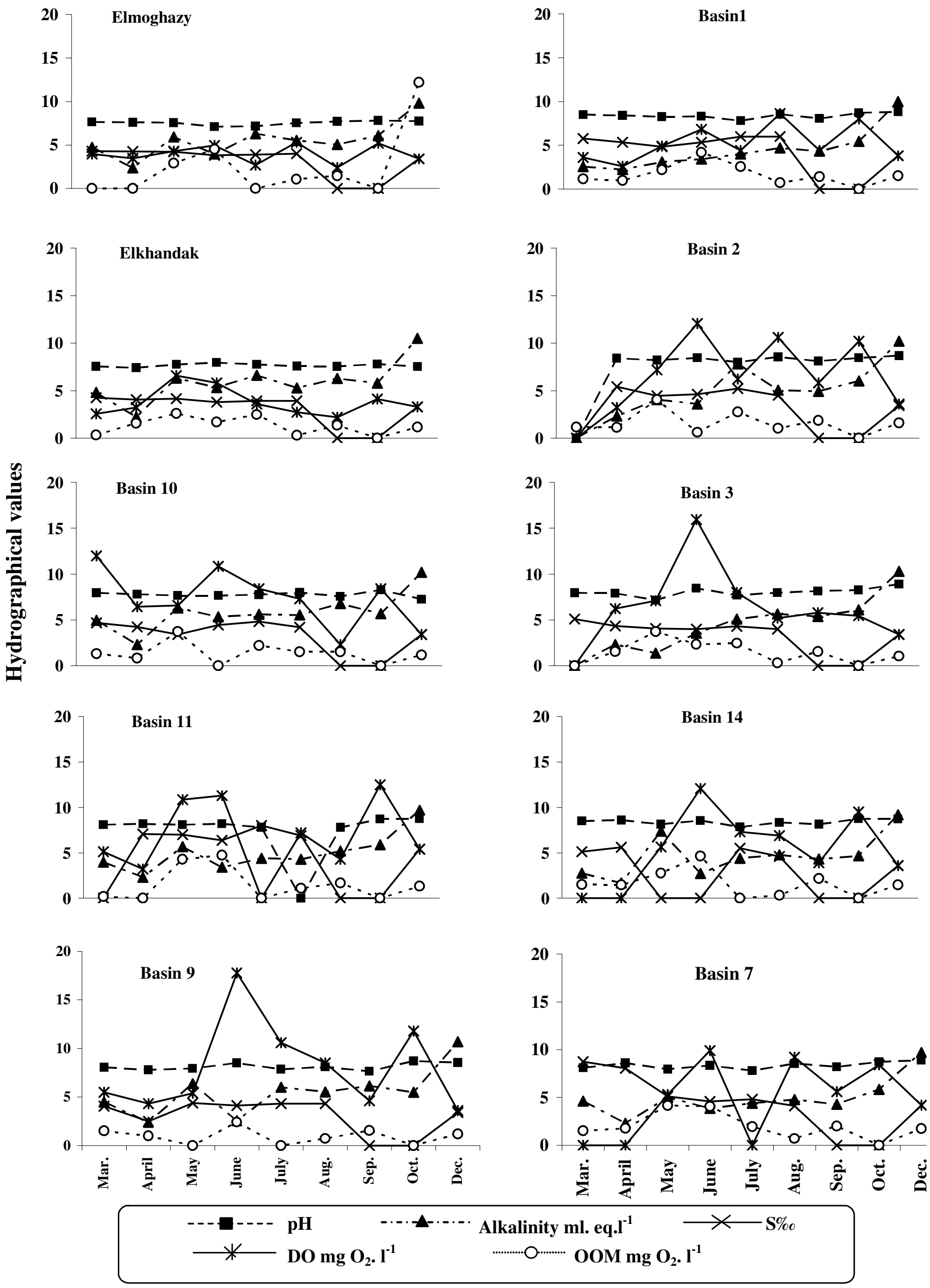


Fig. (2): Monthly and Regional variaitons of pH, alkalinity, S‰, DO, OOM in El- Max Ffish Farm during the period March - December 2003

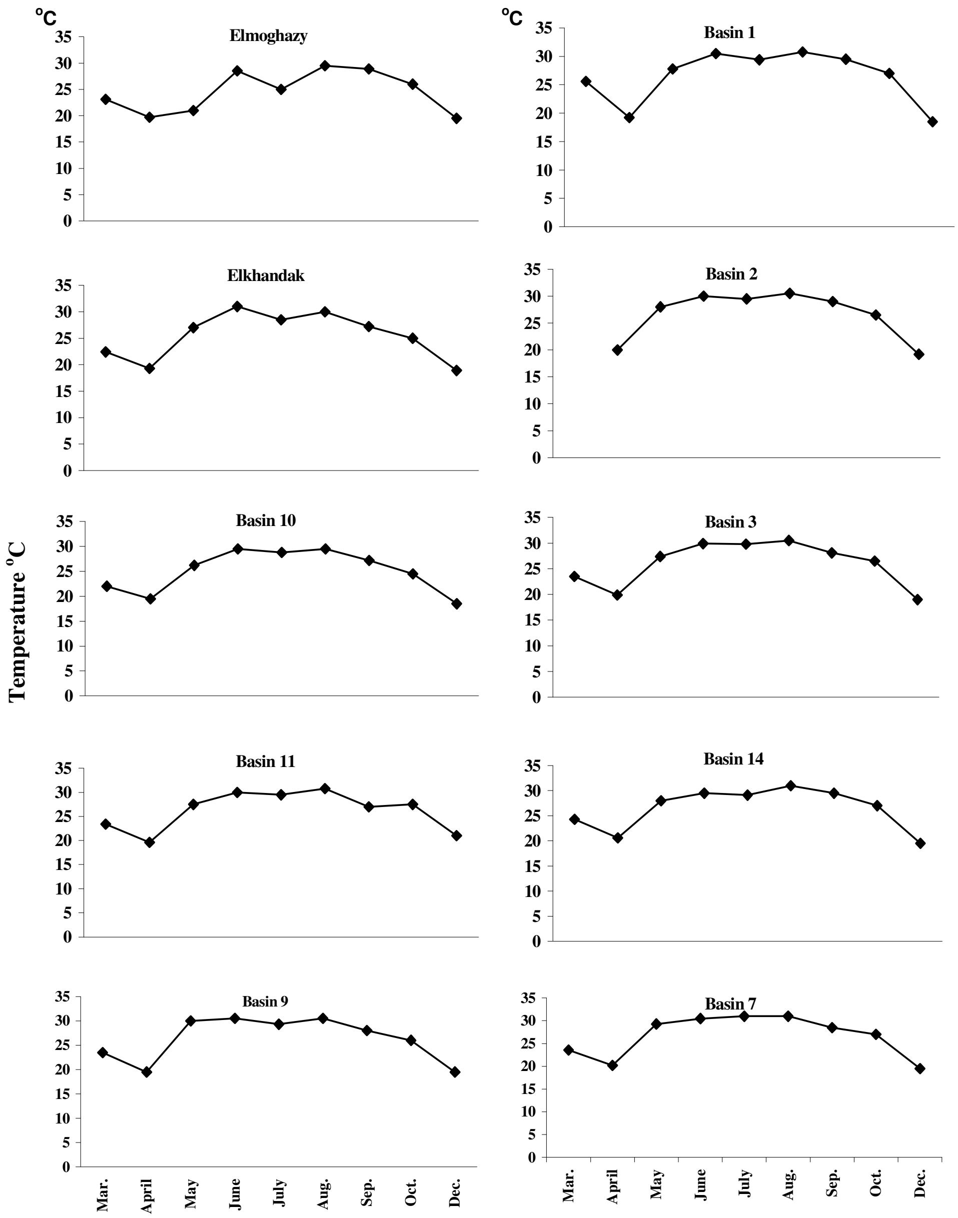


Fig. (3): Monthly and Regional variaitons of Temperature (°C) in El- Max Fish Farm during the period March - December 2003

Reactive Phosphate (PO_4-P):

The regional and monthly variations of reactive phosphate during the period of study are reported (Fig 4). Reactive phosphate concentration was fluctuated from the minimum of 0.19 µmole l^{-1} at basin 1 during August to the maximum content of 31.25 µmole l^{-1} at basin 9 during March. The average value revealed greater amount of PO_4, ranged from 8 to 14.5 µmole. l^{-1} at five basins; Elmoghazy, Elkhandak, B3, B9 and B10. The high level of PO_4 may be attributed to the wastewater, which discharged from the domestic, agricultural and industrial waste from Lake Mariout. This untreated wastewater discharged directly and indirectly into the study area. Another source of PO_4 is the release of phosphate from the bottom sediments under the variation of geochemical conditions such as pH, temperature, clay mineral, organic matter content. On the other hand, the basins 11, 1, 2, 7and 14 showed relatively low level of PO_4, its content ranged from 2.81 at B1 to 4.44 at both B7 and B 14.

The relative decrease of PO_4 content may be attributed to several factors lead to removal of phosphorus from the water, the consumption of PO_4 by algae and aquatic plant, phosphate adsorption on the clay mineral and suspended matter or precipitation by iron, calcium and aluminum.

There is a negative correlation between phosphate content and water temperature ($r = -0.50$).

Ammonia (NH_4):

Figure (4) showed the regional and monthly distribution of ammonia concentration in El-Max Fish Farm. The minimum value was recorded at basin 14 (1.0 µmole l^{-1}) in December, while the maximum content was found at the Elmoghazy (202.1 µmole l^{-1}) in March. The average value of ammonia concentration showed wide variations; it ranged between 4.1 µmole l^{-1} (Basin 7) and 53.16 µmole l^{-1} (Basin 3).

The highest average content was reported at water sources, Elmoghazy (91.34 µmole l^{-1}) and Elkhandak (88.84 µmole l^{-1}). This may be attributed to the low oxygen content (3.96 and 4.32 $mlO_2.l^{-1}$, respectively), which lead to reduction of nitrate to the other form in the reduced form of nitrogen as well as the high rate of organic matter degradation, as shown in Figs. (3&4). These conditions cause the increasing of ammonia content in the aquatic environment. Grasshoff (1976). With some exception, the minimum values of ammonia content were recorded during the summer season at B11, B1, B2, B14 and B7. This is probably due to the consumption and assimilation by phytoplankton. Ammonia concentration showed a negative correlation with both water Temperature ($r = - 0.40$) and dissolved oxygen ($r = -0.30$).

Silicate (SiO_4):

Figure (5) revealed the monthly and regional distribution of silicate content of El-Max Fish Farm during the period of investigation. The values of silicate content showed wide variation, it ranged from 1.58 µmole l^{-1} at basin 3 in June to161.76 µmole l^{-1} at basin 14 in April. The data of reactive silicate (Fig. 5) can be concluded as the following:

1. The results of reactive silicate showed regular variations in the level of silicate content during the investigated period at three basins, Elmoghazy, Elkhandak and basin 14, It's concentrations were more than 90 µmole l^{-1}, but in basin 14 silicate content was decreased to 16.37 µmole l^{-1} in September and 54 µmole l^{-1} in December.
2. A gradual increase in the concentrations of silicate through the period from June to December 2003, was observed at the seven basins 1, 2, 3, 7, 9, 10 and 11. On the other hand, during the period from March to May, the silicate concentration droped sharply (Fig.5). Very low concentration of silicate was observed in June 2003 at basin 2 (1.91 µmole l^{-1}). In general, the lowest concentrations of silicate were found in May and June for basins 1, 2, 9, 10 and 11, while

basins 2 and 7 revealed the lowest level in September.

3. The highest average values of silicate was recorded at water sources, Elmoghazy (121.2 µmole l^{-1}); Elkhandak (121.4 µmole l^{-1}) and basin 14 (103.6 µmole l^{-1}), while the all other basins revealed decreasing in the content of silicate, reached to the half levels. This may be attributed to several factors, the wastewater discharged indirectly to the basin. Also, the basins are different in its characteristics such as the water depth, the area and the shape of basins. The irrgulation of the basins may be lead to variations in the hydrographic and chemical conditions. There is a negative correlation of silicate content with both water temperature (r = -0.47) and dissolved oxygen (r = -0.30)

Nitrate (NO_3):

Nitrate is the final oxidation product of nitrogen compounds in the aquatic system. It is essential for most of biochemical reactions.

The regional and monthly variations of nitrate concentrations in El-Max Fish Farm basins are shown in Figure (4). The minimum concentration of 1.56 µmole l^{-1} was recorded at basin 10 during July, while the maximum value of 58.7 µmole l^{-1} recorded at basin 9 during December.

The low average value of NO_3 observed at basin 14 (6.25 µmole l^{-1}) which characterized by relatively high depth of water comparing with the other basins. The highest average concentration of NO_3 was detected at water sources; Elmoghazy (27.7 µmole l^{-1}) and Elkhandak (34.35 µmole l^{-1}). The average concentration of NO_3 around 20 µmole l^{-1} was recorded at basins 1, 9, 10 and 11, while the content around 15 µmole l^{-1} at basins 2 and 7.

There are several factors which may be affected on the distribution of nitrate content in the study area, the drainage water, organic matter decomposition, regeneration from suspended matter and bottom sediments as well as phytoplankton assimilation.

Generally the investigated area, affected by wastewater from the neighboring cultivated land and Lake Mariout, rich in nitrate content.

II. Phytoplankton Standing Crop.

Community Composition and distribution:

The average counts of phytoplankton standing crop in El-Max basins farm are higher than that determined in water source (4.0×10^6 and 0.69×10^6 unit.l^{-1} respectively). Bacillariophyceae are predominant at both water source and basins, contributing respectively about 78.5% and 61.4% by number to the total phytoplankton, while Chlorophyceae shared by 7.2% and 29.4% respectively. Cyanophyceae are frequently recorded (12.6% and 7.7% respectively), while, Euglenophyceae and Dinophyceae are rarely recorded (Table 1).

Regarding to the phytoplankton distribution, Elmoghazy and Elkhandak attained low average counts (0.72×10^6 & 0.66×10^6 unit.l^{-1} respectively). It dominated by Bacillariophyceae (78.5% at each region). In spite of the distance between the two localities about 20m, Cyanophyceae is more frequently in Elmoghazy (15.4%) than Elkhandak (9.7%). Chlorophyceae showed high percentage frequency (11.04%) in Elkhandak than that recorded at Elmoghazy (3.9%). This simaller to high average counts of bacteria at Elmoghazy and Elkhandak; *Vibrio* sp. (71800 & 4700 /100ml) and *E. coli* (56100 & 70800/ 100ml Abo-Elela *et al*, 2005), higher average values of ammonia concentration (91.3 & 88.8 µ mole.l^{-1} respectively), lower values of dissolved oxygen (3.96 & 4.32 mlO_2.l^{-1} respectively), and the lowest pH values.

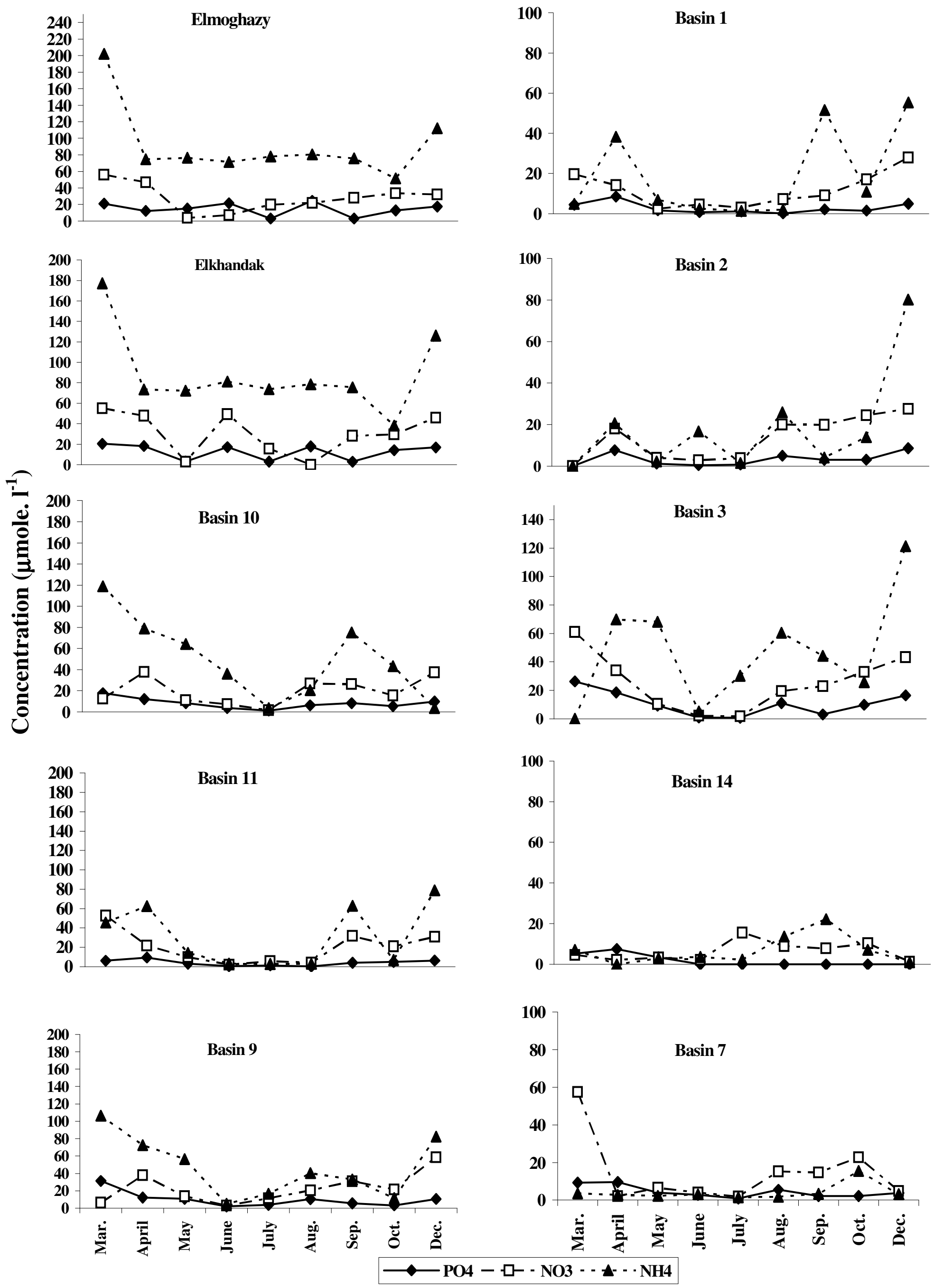


Fig. (4): Monthly and Regional variaitons of PO_4, NO_3 and NH_4 in El- Max fish farm during the period March - December 2003

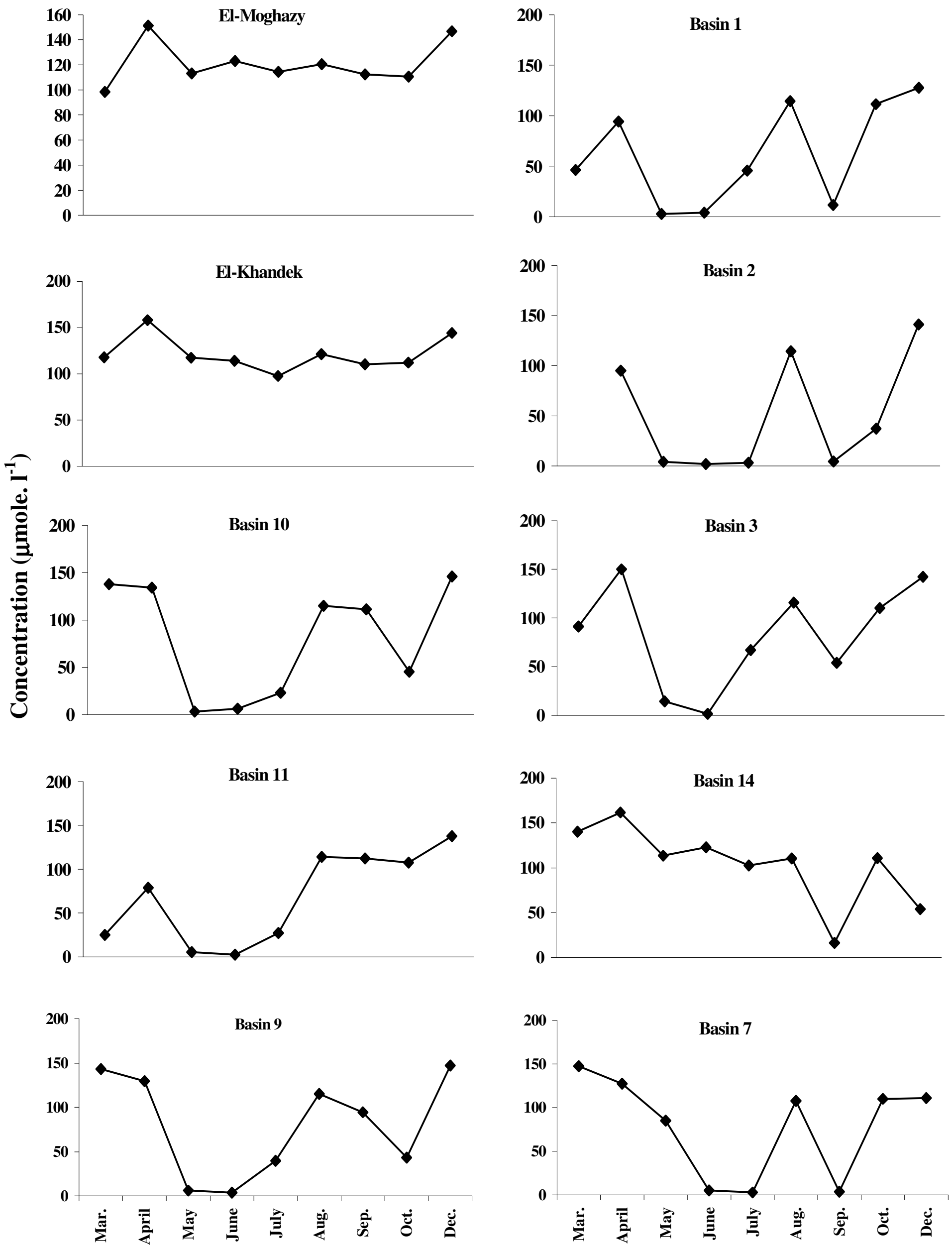


Fig. (5): Monthly and Regional variaitons of S_iO_4 in El- Max Fish Farm during the period March - December 2003

Table (1): The average number of different phytoplankton groups and their percentage frequencies in El-Max Fish Farm during March – December 2003.

Groups	Water sources		Basins	
	Average no.	%	Average no.	%
Bacillariophyceae	539722	78.53	2453094	61.47
Dinophyceae	238	0.03	26076	0.65
Cyanophyceae	87180	12.69	309140	7.75
Chlorophyceae	50100	7.29	1174918	29.44
Euglenophyceae	10007	1.46	27245	0.69
Total phytoplankton	687247	100	3990473	100

Basins farm are highly eutrophic, the standing crop ranged from 2.7 x 10^6 unit.l^{-1} at Basin 14 to 4.9 x 10^6 unit.l^{-1} at both Basin 9 and 10. It dominated with Bacillariophyceae (68.0%, 64.3% & 62.0% at B14, B9 & B10 respectively) and less so of Chlorophyceae (24.0%, 27.8% & 18.3% respectively). But if zooplankton grazing is taken in consideration it becomes obvious that the lowest numbers of zooplankton are recorded at both Basin 10 and 9 (1.2 x 10^6 & 1.5 x 10^6 organisms/m^3 respectively, Anon. 2004). While the highest counts is recorded at Basin 1 (5.7 x 10^6 organism/m^3) and constituted mainly of Rotifera (91.0%). It feeds mainly on Bacillariophyceae which represent 36.8% only i.e. high grazing rate at this basin.

Basin 14 attained to the lowest standing crop counts. This attributed to high average number of bacteria; *Streptococcus fecalis* (7 x10^6 /100ml, Abo-Elela *et al*, 2005). Other basins; 11, 2, 3, and 7 attained high phytoplankton standing crop as shown in Figure (6).

Monthly variations of phytoplankton standing crop:

Water sources of El-Max Fish Farm (Elkandak and Elmoghazy) showed more or less the same monthly variations. Since the lowest counts attained during March and April. This attributed to low values of dissolved oxygen (2.56 & 3.44 ml O_2.l^{-1} respectively), pH value (7.6) and high values of ammonia concentration (177.1 & 74.67 µmole.l^{-1}) as well as highest counts of bacteria; *E. coli* (420000 & 130000/100ml, Abo-Elela *et al,* 2005) which is considered as indicator for pollution with sewage outfalls; This confirmed with high percentage frequency of *Euglena* spp., since it formed 24.6% at both region. Moreover, *Vibrio* sp. (1800 & 600000/100ml) and *Streptococcus fecalis* (82000 & 50000/100ml).

The highest phytoplankton counts recorded during October (1.4 x 10^6 & 2.7 x 10^6 unit.l^{-1} at Elkhandak and Elmoghazy respectively). This accompanied with 4.1 and 5.2 ml O_2.l^{-1}, values of dissolved oxygen; 38.77 and 51.33 and µmole.l^{-1} of ammonia concentration, high values of reactive silicate (112.2 & 110.5µmole.l^{-1}) and low counts of bacteria; *Vibiro* sp. (5200 & 8900/100ml) and *Streptococcus fecalis* not detected (Abo-Elela *et al,* 2005). Bacillariophyceae particularly *Nitzschia spp.* (53.1% & 53.3% at Elkhandak and Elmoghazy respectively) and *Cyclotella* (3.5% & 38.4% respectively). Chlorophyceae; *Crucigenia spp.* and *Actinastrum spp.* shared by 34.3% and 5.8% at Elkhandak and Elmoghazy respectively, while *Euglena* spp. are rarely recorded as shown in Figure (7).

The number of phytoplankton species at water sources are much higher than that farm basins as well as some species are considered as a dominant form in water sources such as; *Anabaena* spp. (54% and 83% at Elmoghazy and Elkhandak) during August, *Nitzschia* spp. (53% at both sits) during October *Navicula* spp. (57%) during June at Elkhandak and *Cyclotalla meneghiniana* which recorded as a main component during most of the year particularly during April (67% & 72% at Elmoghazy and Elkhandak) and September

(40% & 38% respectively). In addition to *Actinastrum* spp., *Scenedesmus* spp., *Merismopedia punctata* and *Crucigenia* spp. during June.

Basins 9 and 10 showed minimum phytoplankton counts during April (Fig.7). This attributed to highest counts of bacteria; *Vibrio sp.* (220000 & 13000/100ml respectively); *E. coli* (20000 & 31200/100ml Abo-Elela *et al,* 2005), the highest counts are recorded during March and December at Basin 10 as well as during July and December at Basin 9 (Fig.7).

Community compositions are differ from one basin to another and from month to the other at the same basin. At Basin 10, the Cyanophyceae species *Microcystis*; attained to the highest counts during March (98.2%). While the Chlorophyceae *Chlorella vulgaris*; dominated during December (95.5%). At Basin 9, high phytoplankton counts attained during both July and December. Bacillariophyceae particularly *Nitzschia spp.* and *Cyclotella* shared with 66.5% and 33.3% during July. Chlorophyceae; *Chlorella vulgaris* contributed 97.1% during December. This attributed to low counts of bacteria; *Vibrio sp.* (300/100ml) and *E. coli* not detected (Abo-Elela *et al,* 2005); and high concentration of dissolved oxygen (11.96 ml O_2 l^{-1} at B10 during March & 10.6ml O_2 l^{-1} at B9 during July).

Basin 11 (lower area; 550m^2) attained high phytoplankton counts during most of the year except the period from July-October (Fig. 7). This is mainly due to higher counts of bacteria particularly during July (*Vibrio sp.* in 10 100/100ml; *E. coli* in 1000/100ml, Abo-Elela *et al,* 2005), August (*Streptococcus fecalis* in 1000/100ml and *E. coli* in 25000/100ml), September (*E. coli* in 43000/100ml) and October (*Vibrio sp.* 8000/100ml and *E. coli* in 1000/100ml) besides to lower pH values (7.8) and high values of water salinity (8%$_o$ & 6.9%$_o$ during July and August). Standing crop ranged from 0.2 x 10^6 unit.l^{-1} (August) to 10 x 10^6 unit.l^{-1} (June) with an average of 3.8 x 10^6 unit.l^{-1}. During June Bacillariophyceae; *Cyclotella*, contributed 80% and Chlorophyceae; *Carteria*, formed 20%. This accompanied with lower counts of bacteria; *Streptococcus fecalis* (20/100ml), *E. coli* (1000/100ml) and high values of dissolved oxygen (11.29 ml O_2 l^{-1}). In December, high phytoplankton counts are recorded (8.3 x 10^{6}unit.l^{-1}). This is attributed with increase numbers of green alga; *Chlorella vulgaris*; which contributed 98.2% by number to the total standing crop. This met with higher values of water alkalinity (9.7ml.eq.l^{-1}), pH values (8.76), dissolved oxygen (7.5 ml O_2.l^{-1}) and water salinity (5.4‰). In addition to lower counts of bacteria.

Although the average number of Basins 1 and 2 is comparable (3.9 x 10^6 & 3.7 x 10^6 unit.l^{-1} respectively) and the two basins are side by side, yet Basin 1 attained higher phytoplankton counts than basin 2 during most of the year (Fig. 7). At Basin 1, standing crop ranged from 0.7 x 10^6 unit^{-1} (July & August) to 16.4 x 10^6 unit^{-1} (December). At Basin 2, it ranged from 1.0 x 10^6 unit^{-1} (July) to 11 x 10^6 unit^{-1} (December).

Basin 1 attained lower phytoplankton counts during July, August and October (0.74 x 10^6, 0.72 x 10^6 & 0.70 x 10^6 unit. l^{-1} respectively). This may be attributed to higher counts of bacteria; *Vibrio sp.* (9600, 10600/100ml during July and October), *E. coli* (45000/100ml during August). Phytoplankton blooms during December is met with low zooplankton counts (1.1 x 10^6 organisms. m^{-3}) and mainly constituted of Chlorophyceae particularly *Chlorella vulgaris* (92%). This is attributed to lower counts of bacteria and higher values of water alkalinity (10 ml.eq.l^{-1}), pH values (8.83) and nutrient salts; phosphate (4.95 µmole.l^{-1}),, ammonia (55.4 µmole.l^{-1}) and silicate (127.65 µmole.l^{-1}).

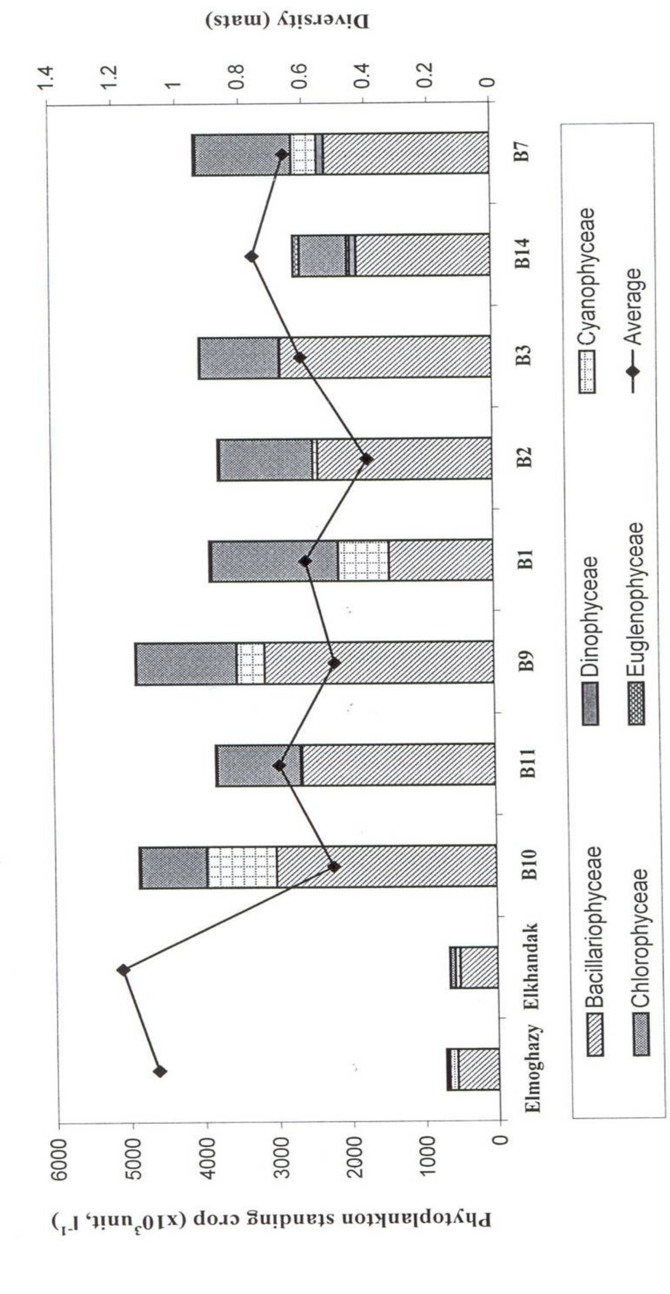


Figure (6): Distribution of phytoplankton standing crop (average number in unit 1-1) and diversity values in El-Mex Fish Farm during the period March-December 2003.

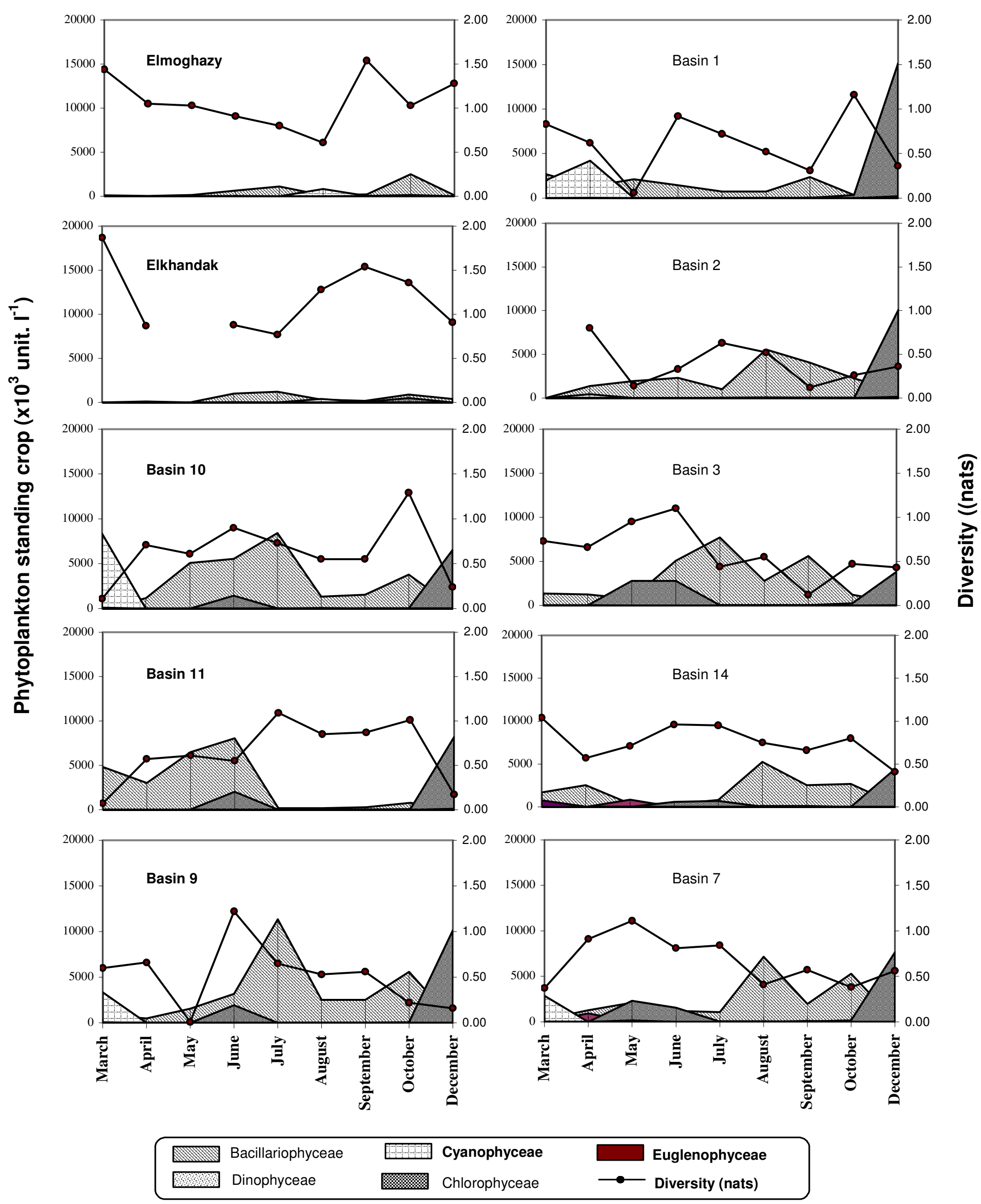


Figure (7): Monthly variations of phytoplankton standing crop and diversity values at water sources and different Basins of El-Mex Farm during the period March - December 2003.

Basin 2 attained to the lowest phytoplankton counts during July. This may be attributed to lower concentration of nutrient salts; phosphate (0.76 µmole.l^{-1}), ammonia (1.5 µmole.l^{-1}) and reactive silicate (3.2 µmole.l^{-1}) in addition to higher density of zooplankton population (4.1 x 10^6 organisms. m^{-3}, Anon., 2004). The highest standing crop are recorded during December. The green alga *Chlorella vulgaris*; ranked the main componant, since it shared with 92% by number to the total phytoplantkton there. This attributed to high concentration of nutrient salts; phosphate (8.6 µmole.l^{-1}) ammonia (80.2 µmole.l^{-1}) and reactive silicate 141.15 µmole.l^{-1}).

Standing crop at Basin 3 is high most of the year (Fig. 7). It ranged from 1.3 x 10^6 unit.l^{-1} (April) to 7.9 x 10^6 unit l^{-1} (June) with an average of 4 x 10^6 unit.l^{-1}. The lowest counts is accompanied with higher numbers of bacteria, as recorded by Abo-Elela *et al*, 2005; *Vibrio* sp. (88000/100ml. Anon., 2004), *E. coli* (66000/100ml) and high zooplankton population (2.9 x 10^6 organism.m^{-3}). The highest phytoplankton counts recorded during June. This is attributed to higher dissolved oxygen (15.93 ml O_2 l^{-1}) and lower counts of bacteria; *E. coli* (350/100 ml) and *Vibrio sp.* (3000/100ml). Moreover, to lower zooplankton counts (0.2 x 10^6 organism/m^3). Phytoplankton blooms are mainly constituted of Bacillariophyceae *Nitzschia* spp. (35.2%) and *Cyclotella* (29.4%), besides to *green alga*; *Carteria* (35.2%).

Basin 14 is the largest one, it has an area of 58800 m^2. It is considered as an eutrophic basin during the period of study except May and June (1.3 x 10^6 & 0.93 x 10^6 unit.l^{-1} respectively). This is attributed to higher zooplankton population particularly during May (5.6 x 10^6 organism. m^{-3}, Anon., 2004), it dominated with Rotifera which feeds mainly on diatoms. This met with low percentage frequency of diatoms 31.0% during May. The highest standing crop attained during August (5.4 x 10^6 unit.l^{-1}) and December (4.8 x 10^6 unit.l^{-1}). This attributed to lower counts of bacteria; *Vibrio* sp. (0 & 100/100ml respectively), *E. coli* not detected in addition to lower counts of zooplankton (0.8 x 10^6 & 0.17 x 10^6 organism.m^{-3} respectively). August blooms consisted mainly of *Cyclotella* (73.5%) and *Nitzschia* spp. (22.0%). Standing crop in December are mainly due to green alga; *Chlorella vulgaris* (90.4%).

Basin 7 has an area of 4800m^2, it is considered as a highly eutrophic one during most of the year except in June (2.7 x 10^6 unit.l^{-1}) and July (1.1 x 10^6 unit.l^{-1}). This is attributed to higher zooplankton population particularly during June (11.5 x 10^6 organism.m^{-3}, Anon., 2004) and higher counts of bacteria; *Vibrio* sp. (6500 & 9000/100ml during June and July respectively). Moreover, lower concentration of nutrient salts; phosphate (2.81 & 0.84 µmole.l^{-1} respectively), ammonia (3.04 & 1.5 µmole.l^{-1}) and silicate (4.93 & 2.6µmole.l^{-1}). The highest phytoplankton density are recorded during both August (7.2 x 10^6 unit.l^{-1}) and December (7.8 x 10^6 unit.l^{-1}). This met with lower counts of bacteria; *Vibrio* sp. (0 & 500/100ml during August and December respectively) and *E. coli* not detected. In addition to lower zooplankton counts (0.6 x 10^6 & 1.3 x 10^6 organism.m^{-3} respectively, Anon., 2004). Community composition of standing crop are completely, differ; in August, *Cyclotella* shared with 87.7 and *Nitzschia* spp, in 11.7%. While during December, green alga, *Chlorella vulgaris* ranked the main constituent (97.9%).

Phytoplankton structure and environmental conditions.

At water sources, phytoplankton standing crop are positively correlated with dissolved oxygen and negatively with ammonia concentration (Table 2). This explained lower counts of standing crop and dissolved oxygen (average of 0.7 x10^6 units. l^{-1} & 4.1 ml O_2 l^{-1}). As well as higher concentration of ammonia (average 90.0 µ mole. l^{-1}). Euglenophyceae showed positively correlated with ammonia concentration. This confirmed that it is considered as indicator for pollution. This agree with the result of Mihnea (1978).

Stepwise multiple regression model showed the dependence of phytoplankton standing crop (St. crop) on the most correlative environmental factors is as follows.

St. crop = 297520 + 0.46 **DO** – 0.43 **NH_4** (Multiple R = 0.7)

This confirmed in figure (8A). Regarding the correlation in the farm basins, it showed that phytoplankton standing crop and Chlorophyceae are positively correlated with total alkalinity. This explained higer standing crop during December and dominated with Chlorophyceae. This met with highest values of total alkalinity (an average of 10 ml eq.l^{-1}). This confirmed with negative correlation between Chlorophyceae and water temperature (Table 2, Fig. 8B). On the other hand, Bacillariophyceae showed a positive correlation with both water temperature and dissolved oxygen (Table 2). It confirmed with the dominance of this group most of the year round (Table 1, Figs. 6, 7, 8A). Bacillariophyceae are negatively correlated with both phosphate and silicate concentration (Fig. 8B). This indicate that eutrophication phenomena in farm basins.

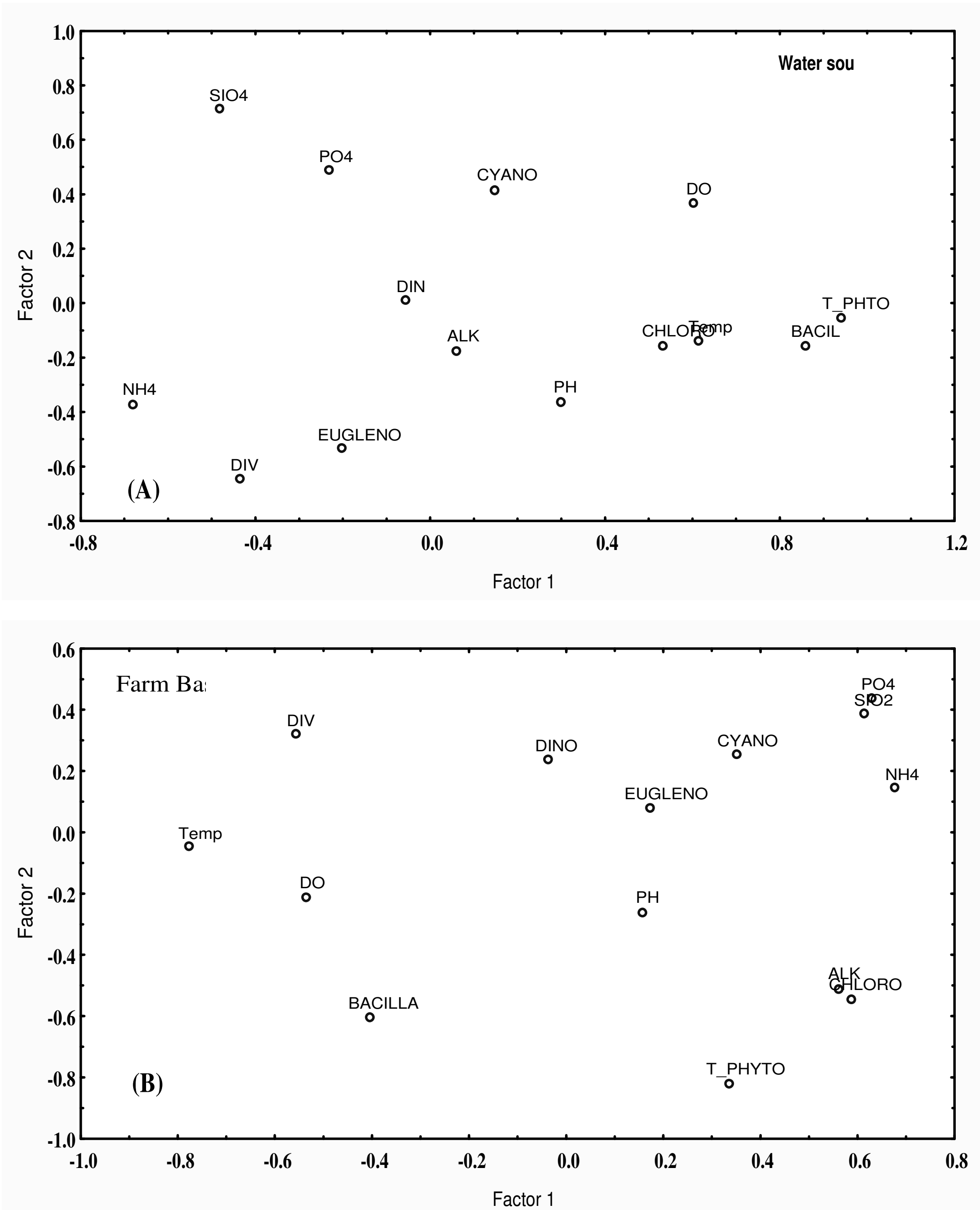
Stepwise multiple regression models showed the dependence of phytoplankton standing crop (St. crop) and Bacillariophyceae on the most correlative environmenral factors are as followes.

St. crop = 5907306 + 0.5 **Alk** + 0.33 **DO** – 0.35 **Temp**. – 0.25 **SiO_4** (Multiple R = 0.6)

Bacillariophyceae = 2039485 + 0.28 **DO** – 0.04 **PO_4** – 0.34 **SiO_4** + 0.02 **Temp**. (Multiple R= 0.52).

Table (2): Significant correlation coefficient at $P \leq 0.05$ of biological factors with some physico-chemical environmental factors at both water sources and farm basins of El-Max Fish Farm during the period March – Desember,2003.

Parameters Groups	Water sources		Farm basins						
	DO	NH4	Temp.	DO	Alk.	NH4	PO4	SiO4	Div.
Standing crop	0.55	-0.53			0.44				-0.33
Bacillariophyceae			0.29	0.39			-0.27	-0.44	
Chlorophyceae			-0.43		0.66				
Cyanophyceae						0.35	0.40		
Euglenophyceae		0.66							
Diversity index	0.55		0.35	0.35	-0.43	-0.39			


Water sou
SIO4
PO4
CYANO
DO
DIN
T_PHTO
ALK
CHLORO
Temp
BACIL
NH4
PH
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DIV
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Factor 2
Factor 1
Farm Ba
PO4
SIO2
DIV
DINO
CYANO
NH4
EUGLENO
Temp
DO
PH
ALK
CHLORO
BACILLA
T_PHYTO
(B)
Factor 2
Factor 1

Diversity Index:

The average values of phytoplankton diversity is higher at water sources (Elmoghazy and Elkhandak, 1.4 nats) than that recorded at farm basins (0.6 nats).

Regarding the regional variations of diversity index (Fig. 6), it showed that higher values are recorded at water sources (1.08 & 1.19 nats at Elmoghazy and Elkhandak respectively). The values for farm basins ranged from 0.4 nats (basin 2) to 0.76 nats (basin 14). The lowest diversity value coincided with high phytoplankton standing crop at basin 2 (Fig. 6) than that recorded at basin 14. A condition which may confirm the inverse relationship between diversity index and phytoplankton standing crop (Fig. 8A). This agree with the result of. Zaghloul and Heussin (2000) in Lake Edku.

Monthly variations of diversity index are shown in Figure (7). The absolute values of diversity ranged from 0.61 nats at Elmoghazy during August to 1.87 nats at Elkhandak in March. Although the phytoplankton density in August ($1x10^6$ unit. l^{-1}) was much higher than that recorded during March ($0.03x10^6$ unit. l^{-1}) and species richness were similar. Such high diversity values are attributed to the dominance of several species, namely; *Euglena granulata* (25% by number to the total phytoplankton counts), *Nitzschia* spp. (23%), *Cyclotella meneghiniana* (16%), *Navicula* spp. (13%) and *Anabaena* (12%). On the other hand, the lowest diversity value is attributed to dominance of only one species; *Anabaena* (83%), this is confirmed with the significant inverse relation between diversity values and the degree of dominance.

The absolute values of species diversity at farm basins (Fig. 7) ranged from 0.01 nats at basin 9 during May and 1.22 nats at the same basin in June. The lowest value was attributed to the dominance of only one species; *Cyclotella meneghiniana* contiuting about 99% as well as lowest counts of phytoplankton ($1.5 \ x10^6$ units. l^{-1}). While the highest value was accompanied with high numbers of species and the dominance were shared by more than one species namely; *Cyclotella meneghiniana* (46.5%), *Carteria vulgaris* (31.0%), *Nitzschia* spp. (15.5%) and *Pediastrum* spp. (6.2%). Generally, 92% of calculated diversity values in farm basin are less than one nats.

Diversity and habitat structure relationship:

The number of species occurring in a particular phytoplankton community depends on the interaction between several ecological factors (Hallegraeff & Reid, 1986; and Zaghloul, 1995). The availability of resources is one of the most important ecological factors affecting species diversity. This effect was emphasized by numerous workers who have reported correlation between species diversity and some aspects of habitat structure (Borowitzka, 1972 and Samaan *et al.*, 1996).

Water sources of El-Max Fish Farm in characterized by high nutrient concentrations (Figs. 4&5) with annual average of 13.6 µmole l^{-1} of PO_4 – P.l^{-1}, 121.3 µmole SiO_2 – Si. l^{-1}, 90.0 µmole NH_4 – N.l^{-1} and 31.0 µmole NO_3. N. l^{-1} as well as lower dissolved oxygen (4.1ml O_2 l^{-1}). Diversity showed a negative correlation with dissolved oxygen (r = 0.55).

A full model showing the dependence of diversity on the most correlative environmental factors was developed. The equation being:

Diversity = 2.84-0.57**DO** + 0.37 **pH** + 0.33 $\mathbf{NH_4}$ (Multiple R = 0.73)

Regarding the diversity of farm basins, it showed a positive correlation with temperature and dissolved oxygen (Table 2) while it negatively one with total alkalinity and ammonia concentration (Fig. 8B). The average values of nutrient concentration are 5.9 µmole PO_4 – P. l^{-1}, 66.6 µ mole SiO_2 – Si. l^{-1}, 29.4 µ mole NH_4 – N. and 16.3 µ mole NO_3 –N. l^{-1}, such values are lower than that previously recoded at same region during last years (El-Banna, 1993).

A full model showing the dependence of diversity on the most correlative environmental factors were developed. The equation being:

Diversity = 0.79 – 0.33 **Alk** – 0.27 **NH_4** + 0.18 **DO** (Multiple R = 0.56)

From this model, it is clear that diversity reflects the eutrophication phenomena in El-Max Fish Farm. Logically, eutrophication reflects the excess of ammonia and water alkalinity, which are introduced by the huge amounts of drainage water from Ummoum drain, characterized by higher values of total alkalinity and nutrient salts, which in turn stimulate photosynthesis of phytoplankton.

CONCLUSION

Basins farm attained higher counts of phytoplankton standing crop than that recorded in water input. Although, water source is rich in nutrient salts, yet it attained higher counts of bacteria. Moreover, low values of pH, dissolved oxygen and water salinity.

Phytoplankton community composition is differing from basin to another and from one month to the other at the same basin. Diatoms, *Cyclotella* and *Nitzchia* spp., dominated during July (B9), blue green algae, *Microcystis* spp., constitute 98.2% during March (B10). However, green algae, *Chlorella vulgaris*, ranked the main component during December. This is attributed to higher values of water alkalinity, reactive silicate and low values of dissolved oxygen and water salinity.

Generally, it appears that El-Max Fish Farm is a very fertile area, considerably more productive in phytoplankton standing crop than water source. This would account for its importance as a nursery ground for fish fry.

REFERENCES

Anon. 2004. Ecological and Economic Evaluation of El-Max Fish Farm, Final report of Marine Environmental Division, Nat. Inst. Oceanogr. & Fisheries, Alex., 68pp.

Abdel-Alatif. H.H, 1996. Studies on some microorganisms and their relationships with Mullets and Tilapia fishes reared in El-Max Farm Ponds. Master's thesis. Faculty of Science, Alexandria University 135pp".

Abo-Elela, G.M., Elsersy N.A, Elshenawy M. and Adel Mawlde, 2005. Microbial Assessment of El-Max Fish Farm, Egyptian Journal of Aquatic Reseach. Vol. 31 (1): P. 171-185.

American Public Health Association (A.P.H.A.), 1985. Standard methods for the examination of water and wastewater 16th edition, APHA, AWWA and WPCF,1268 pp.

Bishara, N.F. 1978. Fertilizing fish ponds. II. Growth of *Mugil cephalus* in Egypt by pond fertilization and feeding. Aquaculture, 13: 361-367.

Bishara, N.F.1979. Fertilizing fish ponds. III. Growth of *Mugil capito* in Egypt by pond fertilization and feeding. Aquaculture, 16: 47-55.

Borowitzka, M.A., 1972. Intertidal algal species diversity and effect of Pollution. Australian Journal of Marine and Fresh Water Research 23, 73-84.

Boyd, C.E. 1984. Water quality in warm water Fish Ponds. Anburn University 3rd edition 359 pp.

El-Banna, M.M.H. 1993. A study of phytophlankton and primary productivity in El-Max Fish Farm, Master's thesis. Faculty of Science, Alexandria University 190pp.

El-Nayal, A.A., 1935. Egyptian fresh water algae. Bull. Fac. Sci., Cairo University, No. 4, 31 pp.

El-Nayal, A.A. 1936. Contribution to our knowledge of the fresh water algae of Egypt. Bull. Fac. Sci. Cairo University, Part. I, No. 9: 105 pp.

El-zarka, S.E. and Fahmy, F.K. 1968. Experiments in the culture of the grey Muliet, *Mugil cephalus* in brackish water ponds in the U.A.R.,F.A.O, Fish Rep. (44). Vol (5): 255-266. F.A.O. world symposium on water pond fish culture.

Ellis, M.M; B.A. Westfall, and M.D. Ellis 1946. Determination of water quality U.S. Dept. Inst. Fish. Wildl. Serv., Research Report. No 9: 122p.

Grasshoff, K. 1976. Methods of Sea Water Analysis VCH. Weinheim, New York, pp. 59,97 and 117.

Hallergraeff, G.M. and D.D. Reid, 1986. Phytoplankton species succession and their hydrological environments at a coastal off Sydney Australian Journal of Marine and Fresh Water Research, 37, 361-377.

Huber- Pestulozz, G., 1938. Das phytoplankton des susswassers. I- Teile, Die Binnerge wasser. Stuttgart, 342 pp.

Hustedt, F., 1930. Die Kieselalgen Deutschlands Osterreichs und Schwiez. In: Rabenhorst Kryptogamen Flora, 7 (1-920).

Mihnea, P.E., 1978. Euglenacees at chrysophycees en tant qu'orgamisnes entraines dans la pollutions marine littorale. IV Journees Etud. Pollution, 471-475.

Samaan, A.A; Zaghloul, F.A. and Soliman, A.M, 1996. Phytoplankton diversity index in Rosetta Nile Branch, Egypt, Bulletin of the Faculty of Science, University of Alexandria, 36(1):265-279.

Shannon, G.E. and Weaver, W. 1963. The mathematical theory of communication. Urban, University of Gellionis Press, 125pp.

Smith, G.M., 1950. The fresh water algae of the United States, 2nd ed. New York, Mc Graw- Hill. Co. vii, 719 pp.

Strickland, J.D.H. and Parsons, L.R. 1968. A practical hand book of seawater analysis. Fish. Res. Bd. Canada Bull. 311pp.

Van Heurck, V.H., 1896. A Treatise on the Diatomaceae. William Westey and Son, Essex, Strand, W.C., 559 pp.

Wahby, S.D, 1974. Fertilizing Fish Ponds .I. Chemistry of the waters. Aquaculture, 3: 245-259.

Zaghloul, F.A. 1995. Comparative studies of phytoplankton diversity index in the eutrophic bay, the Eastern Harbour of Alexandria, Egypt. Bulletin of the High Institute of Public Health, Vol. 25(3): 665-678.

Zaghloul, F.A. and Hussein, N.R. 2000. Impact of pollution on phytoplankton community structure in Lake Edku, Egypt. Bulletin of National Institute of Oceanography and Fisheries, A.R.E., Vol. (26): 297-318.