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Assessing the Water Fertility and Toxicity of North-West Part of Lake Manzala (Egypt) by an Algal Growth Potential Test

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ABSTRACT. Water fertility and toxicity of north-west part of Lake Manzala in Egypt were investigated bimonthly from May, 1991 to March, 1992. Nutrient enrichment biotests to define algal growth limiting nutrients, their bioavailability and the heavy metal toxicity of the sampled water were achieved using *Selenastrum capricornutum* Strain NIVA-CHL 1.

Maximum algal growth of the test alga was usually much higher than 10 mg dry wt L^{-1} indicating the hypereutrophic conditions of the investigated water and its undesirable quality. Algal growth potential test (AGPT) exhibited results ranging from 30.60 mg L^{-1}, to 1228.78 mg L^{-1} algal dry weight. The algal growth was mainly limited by N, heavy metal toxicity and in few cases by P. The observed Chl. a (phytoplankton chlorophyll a) was significantly lower than the expected Chl. a. No consistent interrelationship was found between the observed and the expected Chl. a values. The N:P weight ratio is a pertinent parameter for determining growth limiting nutrient. The relationships between the chemically analyzed nutrients (P and N) and their bioavailable concentrations were greatly affected by the N:P ratio and heavy metal toxicity. Generally, the results of AGPT revealed that this technique is good, effective and sensitive tool to assess the fertility, nutrient bioavailability and toxicity of the lake Manzala waters.

Introduction

Since standard bioassay procedures were recommended by Hart *et al.* (1945), Doudoroff *et al.* (1951) and Sprague (1969, 1973), there have been a multitude of tests developed by researchers for evaluating or measuring toxicity by means of various organisms living in different levels of the food chain (APHA, 1975). The concept of algal bioassays provides a method for determining and assessing the toxic effect on algal growth and productivity as well as the biological availability of metals in waters (Shu-

bert, 1984). The algal growth potential test (AGPT) has been found to be accurate, consistent, economical and always useful for evaluating the bioactivity and nutrient load in freshwater systems (Raschke and Schultz, 1978, 1987; Abdel-Hamid *et al.*, 1992).

Lake Manzala is the largest Egyptian, coastal deltaic lake. It is considered to be the most productive fishery ground in Egypt (Ibrahim, 1989; El-Sabrouti, 1990). For many years Lake Manzala has been the ultimate site for the disposal of huge amounts of drainage water. The mean annual input of drainage water is approximately 5.4×10^9 m^3/year (Hamza, 1985). Generally, the drainage water is composed mainly of agricultural, industrial and sewage effluents (El-Sabrouti, 1990).

In the present study, an investigation was undertaken to evaluate the fertility and toxicity of water samples collected from the north-west part of Lake Manzala in 1991-1992. This study may be helpful for further limnological studies aiming to the protection of this lake and management of its restoration.

Materials and Methods

Study Area

Lake Manzala is located in the northern quadrant of the Nile delta, along the Mediterranean Sea to the east of the Damietta branch of the River Nile in Egypt. Lake Manzala is about 47 km long and 30 km wide but narrows in the middle to only 17 km (Zahran and Wills, 1992). Recently, the north-west part of the lake has been the ultimate site for disposal of secondary sewage effluents from the El-Inanyia sewage treatment plant (15 km NE of Damietta City). The treated sewage (90,000 m^3 day^{-1}, Aly, 1993) discharges into this part of the lake through a narrow drain of approximately 2 km long. The sampling site (about 1 km in the pelagial zone of the lake) was located near the site of disposal of the treated sewage (Fig. 1). This part of the lake is very important since it serves as a source of water and fish fry that feed a number of surrounding fish farms.

Sampling

Samples of water were collected bi-monthly from May, 1991 to March, 1992 and were taken from the surface using non-metallic samplers. The containers were kept in the dark, packed on ice and carried to the laboratory as soon as possible. Upon arrival water samples were thoroughly mixed and five liters were filtered through GF/C Whatman glass fiber filters. The first one liter of filtrate was discarded and the remaining four liters were stored at 4°C in the dark until used. The analyses were carried out as soon as possible (1-2 days).

Laboratory Analyses

Chemical analyses were carried out on GF/C filtered waters. Analyses of total dissolved phosphorus (TDP) and dissolved reactive phosphorus (DRP) were carried out according to APHA (1985). The methods described by Barnes and Folkard (1951), Golterman (1969) and APHA (1985) were followed to analyze nitrite-N, Nitrate-N and ammonia-N, respectively. The heavy metals: Cd, Cu, Fe, Pb and Zn were measured us-

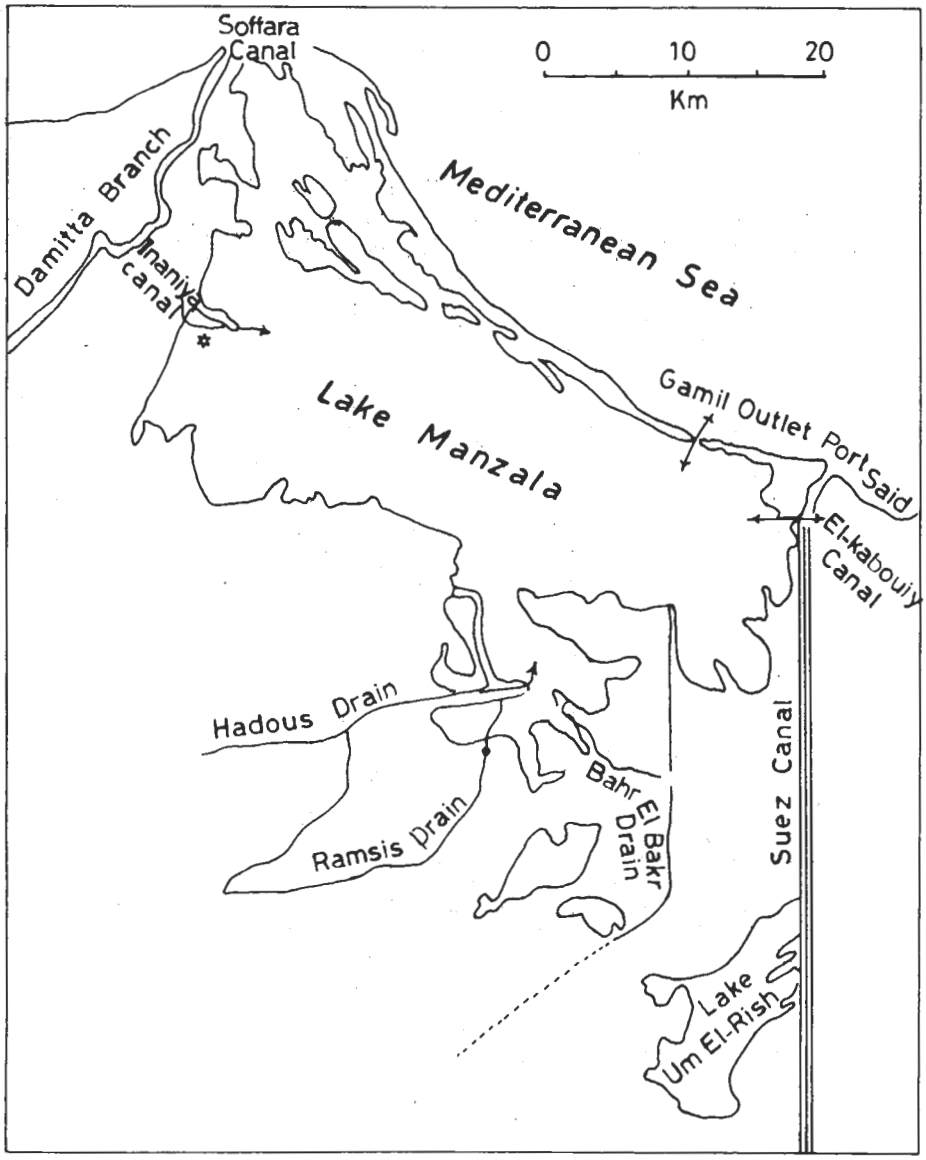

FIG. 1. Sketch map to show the locality of the study area (*) in Lake Manzala in Egypt.

ing an Atomic Absorption Spectrophotometer (Perkin-Elmer 2380), following the direct aspiration method (APHA, 1985).

The algal growth potential test (AGPT) was carried out according to Miller *et al.* (1978). According to the scheme shown in Table 1, the GF/C filtered water was spiked with phosphorus, nitrogen and Na_2EDTA to define nutrient limitation and heavy metal toxicity. The test alga *Selenastrum capricornutum* Strain NIVA-*Chl* (now, *Rhaphidocelis subcapitata,* Nygaard *et al.,* 1986) was obtained from the culture collection of

the Norwegian Institute for Water Research (NIVA), Oslo, Norway. The test alga was grown for five days in AAM medium (Miller *et al.*, 1978). Algal inoculum was prepared by centrifuging 100 ml of the stock culture at 1000 rpm for 5 minutes. Triplicate culture flasks were used for each treatment listed in Table 1. The flasks were inoculated with the test alga to obtain 5000 cells/ml as initial algal density. To avoid CO_2 limitation the sample volume to flask volume was adjusted to a 1:5 ratio. Flasks were incubated at 24 ±2°C for 14 days under continuous illumination of cool white fluorescent tubes providing 4304 lumens (400±10% ft-c). The light intensity was measured adjacent to the culture flasks at the liquid level. To ensure free gas exchange, the culture flasks were plugged with cotton stoppers and shaken by hand once every day during the incubation period.

TABLE 1. Basic experimental design of the algal growth potential test (AGPT).

Treatments	Symbol
Control (Gf/C filtered water sample	C
Control + 0.05 mg P/l (as K_2HPO_4)	C + P
Control + 1.0 mg N/l (as $NaNO_3$)	C + N
Control + 1.0 mg Na_2EDTA/l	C + E
Control + 0.05 mg P/l + 1.0 mg N/l	C + P + N
Control + 0.05 mg P/l + 1.0 mg Na_2EDTA/l	C + P + E
Control + 1.0 mg N/l + 1.0 mg Na_2EDTA/l	C + N + E
Control + 0.05 mg P/l + 1.0 mg N/l + 1.0 mg Na_2EDTA/l	C + P + N + E

Determination of algal dry weight (growth parameter) was carried out by centrifuging a suitable volume of algal culture. The sedimented algal cells, after washing with distilled water, were dried to constant weight in a hot air oven at 70-75°C. In cultures which did not show detectable growth by naked eye, the approximate algal dry weight was obtained by multiplying the cell number by a factor 2.5×10^{-8} which represents the average specific dry weight of the algal strain used in this study (Kallqvist, 1984).

The bioavailable phosphorus (BAP mg L^{-1}) for the growth of *Selenastrum* was derived by dividing the growth yield, maximum standing crop (MSC), obtained with 1.00 mg N L^{-1} by the phosphorus yield coefficient (430), whereas bioavailable nitrogen (BAN mg L^{-1}) was determined by dividing the growth yield obtained with 0.05 mg P L^{-1} by the nitrogen yield coefficient (38). The yield coefficients (Miller *et al.*, 1978) were calculated for the test alga.

The expected chlorophyll a (the maximum chlorophyll a biomass that the sampled water could support under optimum growth conditions) was calculated according to the equation, (Log_{10} Chl.a = 1.15 log_{10} (dry weight) + 0.95), proposed by Raschke and Schultz (1987).

For the determination of the observed or actual Chlorophyll a (the algal standing crop biomass at the time of sampling) one liter was filtered onto GF/C filters. The filters were ground using a tissue grinder in the presence of cooled 90% acetone and kept in

dark for 12 hours at 4°C for extraction. Spectrophotometric determinations of chlorophyll a were carried out according to the trichromatic method (APHA, 1985).

The heavy metal toxicity was reported as the % of inhibition at day 14 (% I_{14}) based on the difference in mg algal dry weight L^{-1} obtained in EDTA treated and control cultures. It is calculated from the formula:

$$\% I_{14} = \frac{\text{MAG (control + EDTA)} - \text{MAG (control)}}{\text{MAG (control + EDTA)}} \times 100$$

MAG = Maximum algal growth (dry weight) of the test alga after 14 days.

Miller *et al.* (1978) proposed a guideline of the percent coefficient of variance (% CV = sample standard deviation/mean × 100) to ascertain weather or not the differences obtained in algal maximum standing crop (MSC) between replicate flasks of a single treatment and/or different treatments and control are statistically significant. Abdel-Hamid (1991) made a minor modification of the % CV model of Miller *et al.* (1978). The adopted % CV is shown in Table 2.

TABLE 2. A proposed % coefficient of variance (% CV) guideline adopted by Abdel-Hamid (1991) from Miller *et al.* (1978).

Maximum algal growth	% C.V.	Statistical difference	Designation in the text
< 1.0 mg dry wt/l	±50 - ±75	Significant	*
	±75 - ±100	Highly significant	**
	> ±100	Very high significant	***
> 1.0 mg dry wt/l	±30 - ±45	Significant	*
	±45 - ±60	Highly significant	**
	> ±60	Very high significant	***
> 10 mg dry wt/l	±10 - ±15	Significant	*
	±15 - ±20	Highly significant	**
	> ±20	Very high significant	***

% C.V. = Sample standard deviation/mean × 100. * $P < 0.05$. ** < 0.01 *** < 0.001.

Statistical Analysis

Statistical analyses of data obtained, linear regression and correlations (Predictive statistics) were carried out using STATGRAPHICS (STSC, Ver. 4.2) programme. The correction coefficients are considered significant at the 95% confidence ($P \leq 0.05$).

Results

Assessment of Toxicity, Fertility and Nutrient Limitation

The results of algal growth potential (AGP) are shown in Fig. 2. These results are reported as the mean maximum standing crop (mg dry wt L^{-1}) of the test alga grown for 14 days at different treatments (Table 1), under optimum growth conditions. The results of a proposed percent coefficient of variance (% CV) are summarized in Table 3. These data indicate that AGP showed remarkable periodic variations. The results ranged between 30.60 mg L^{-1} and 1228.75 mg L^{-1} algal dry weight. From Fig. 2 one can notice obvious responses of the test alga towards different water qualities and treat-

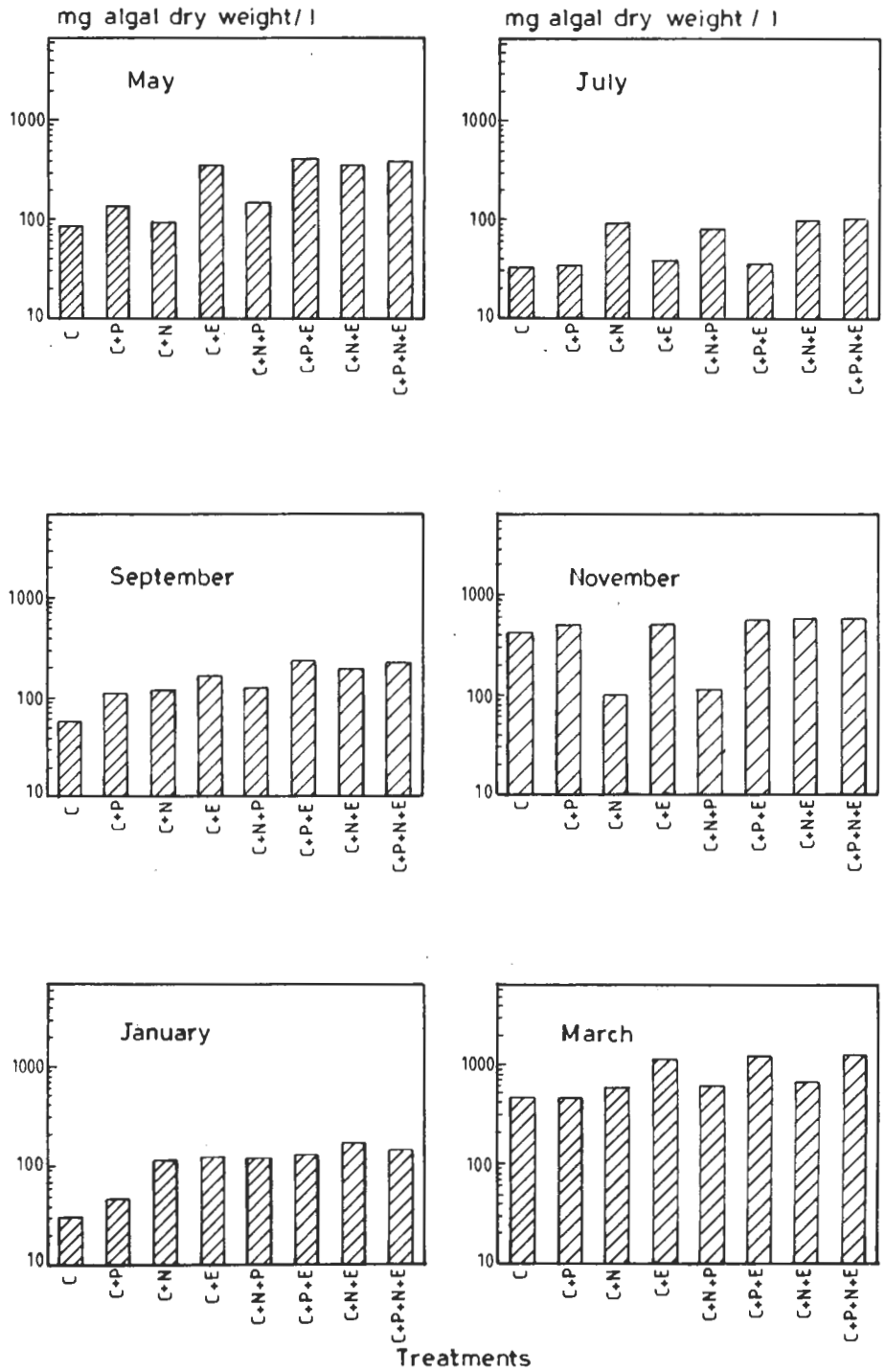

FIG. 2. Algal growth potential of Lake Manzala at different months in 1991/1992.

ments as well. Maximum algal growth of control cultures showed marked periodic variations with highest values in November (410.63 mg dry wt L^{-1}) and March (455.08 mg dry wt L^{-1}) (Fig. 2). Compared to the control cultures the EDTA treated cultures showed a pronounced increase in algal dry weight, suggesting the role of heavy metal toxicity as a growth limiting factor. Moreover, the combined P and N addition, with or without EDTA caused a significant increase in the algal biomass. Generally, it is convenient to discuss the results on a seasonal base.

TABLE 3. Results of the algal growth potential test.

Treatments	Month					
	May	July	Sept.	Nov.	Jan.	March
C + P	***	N	***	*	***	N
C + N	N	***	***	D	***	*
C + E	***	N	***	*	***	***
C + P + N	***	***	***	***	***	**
C + P + E	***	N	***	**	***	***
C + N + E	***	***	***	***	***	***
C + P + N + E	***	***	***	***	***	***

N = Non-significant
* = Significant increase.
** = High significant increase.
*** = Very high significant increase
D = Very high significant decrease.

In May, the addition of P caused a significant increase in algal growth, indicating P-limitation conditions in the sampled water. The increase in algal biomass due to the combined addition of P and EDTA, was significantly higher (417.75 mg dry wt L^{-1}) than in the case of P addition only (136.63 mg dry wt L^{-1}). The same was true for EDTA treatment (360.63 mg dry wt L^{-1}). Nitrogen addition caused a non-significant increase in the algal growth (92.38 mg dry wt L^{-1}) while its combined addition with EDTA revealed a highly significant increase (359.5 mg dry wt L^{-1}). These findings indicate that the growth of the test alga was primarily limited by heavy metal toxicity and secondarily by phosphorus (Fig. 2).

In July the addition of N, singly or in combination with EDTA, to water samples resulted in a significant increase in algal biomass (Fig. 2). It is also obvious from Fig. 2 that the addition of P singly or even in combination with EDTA resulted in a non-significant increase in the algal biomass. This indicates that the AGP was primarily limited by N and secondarily by heavy metal toxicity.

In September, the addition of either P or N to the sampled water caused a significant increase in the algal biomass (Fig. 2). However, the combination of any of them or both with EDTA resulted in a higher increase in biomass. From these results, one may conclude that the algal growth potential was mainly limited by the toxicity of heavy metals followed by phosphorus and to some extent by nitrogen.

In November the cultures treated with either P and/or EDTA showed an increase in APG compared to the control cultures. Addition of N, alone or in combination with P, caused unexpected decrease in algal biomass. Compared to the control cultures, the

combined addition of N and EDTA gave a highly significant increase in biomass production, comparable to that produced with EDTA alone (Fig. 2). Thus the enhancement of AGP seemed to be mainly due to the detoxification effect of EDTA.

In January the addition of N caused a highly significant increase in algal growth (Fig. 2). On the other hand, the addition of P singly was accompanied by a significant increase in growth of the test alga. Also the algal biomass increased significantly with EDTA addition singly or in combination with P and/or N (Fig. 2). However, the other all additions revealed that the AGP was mainly controlled by the additions of EDTA and N.

In March the addition of P did not enhance the growth of the test alga while its combined addition with EDTA showed a significant increase in AGP, suggesting heavy metal toxicity was acting as a growth limiting factor. However, the N-treated cultures singly or in combination with phosphorus resulted in an increase in algal biomass (Fig. 2).

It is perhaps relevant to mention that the AFP was mainly limited by heavy metal toxicity and to some extent by nitrogen.

The Relationship between Chemically Analyzed Nutrients (P & N) and their Bioavailable Concentrations

The periodic variations of the chemically analyzed and bioavailable concentrations of P and N are illustrated in Fig. 3 and 4, respectively. These data indicate that the total dissolved phosphorus (TDP) (1.08-6.39 mg P L^{-1}) differed from orthosphosphates (OP) (0.267-4.22 mg P L^{-1}). However, the total nitrogen (2.096-46.592 mg N L^{-1}) varied significantly ($P < 0.01$) from total soluble inorganic nitrogen (TSIN) (0.114-15.272 mg N L^{-1}). Quantitative information about the relationship between the nutrients and their bioavailable concentrations, shown in Table 4, indicated that the highest concentrations of bioavailable phosphorus (BAP) and bioavailable nitrogen (BAN) were recorded when N was the limiting nutrient.

TABLE 4. Quantitative relationship between chemically analyzed nutrients (N & P) and their bioavailable concentrations.

	Month					
	May	July	Sept.	Nov.	Jan.	March
% BAP / OP	82.0	31.7	48.1	6.01	26.1	31.45
% BAP.EDTA / OP	319.1	34.5	77.1	34.5	38.5	34.8
% BAP / TDP	19.9	15.0	24.7	5.7	4.2	20.8
% BAP.EDTA / TDP	77.4	17.4	39.6	32.8	6.13	23.0
% BAN / TSIN	43.5	79.4	193.9	177.8	75.3	77.6
% BAN.EDTA / TSIN	133.4	825.4	394.2	189.5	192.5	203.8
% BAN / TN	42.6	25.7	142.1	69.3	13.8	25.4
% BAN.EDTA / TN	130.6	26.7	288.9	73.9	35.2	67.4

BAP = Bioavailable phosphorus.
RAP.EDTA = Bioavailable phosphorus in case of EDTA treatment
TSIN = Total soluble inorganic nitrogen
BAN = Bioavailable nitrogen
BAN.EDTA = Bioavailable nitrogen in case of EDTA treatment.

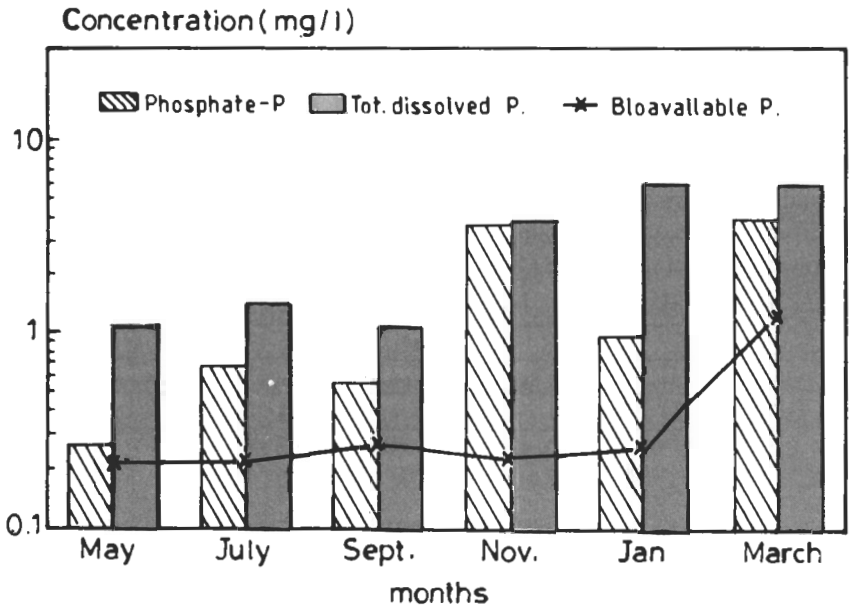

FIG. 3. Relationship between chemically analyzed phosphorus and bioavailable concentration.

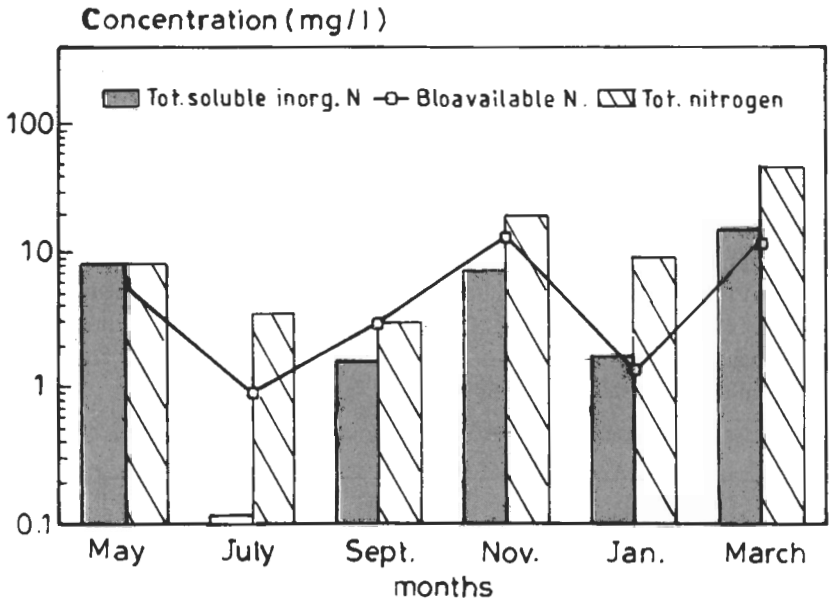

FIG. 4. Relationship between chemically analyzed nitrogen and bioavailable concentration.

Evaluation of Limiting Nutrients

Based on the calculated N:P weight ratio (TSIN:OP) (Table 5) and the results of AGPT (Table 3), the evaluation of nutrient limitation is illustrated in Table 6. Identical similarities were found between the N:P ratios of water samples and the corresponding AGP as two different parameters evaluating the concept of limiting nutrients (Table 6). However, the AGPT gave detailed information about the toxic effect of heavy metal on growth, and which nutrient was primarily or secondarily limiting for algal growth. It is obvious from Table 6, that the main limiting nutrient was N and in a few case P. One cannot however cancel the effect of heavy metal toxicity on the AGP.

TABLE 5. Bi-monthly variations in N:P weight ratio (TSIN:OP).

Months					
May	July	September	November	January	March
30.87	0.17	2.72	1.95	1.68	3.62

TSIN = Total soluble inorganic nitrogen (Nitrate-N + Nitrite-N + Ammonia-N)
OP = Orthophosphates.

TABLE 6. Evaluation of limiting nutrient(s) according to the calculated N:P weight ratio (TSIN:OP) and the results of the algal growth potential (AGPT).

	Month					
	May	July	Sept.	Nov.	Jan.	March
N:P	P	N	N	N	N	N
AGPT	H.P	N.H.	H.P.N.	H	H.N	H.N

P = Phosphorus limitation N = Nitrogen limitation H = Heavy metal, toxicity.

The Relationship between Observed and Expected Chlorophyll a

The two parameters did not show any consistent interrelationship (Fig. 5). However, the observed Chl a was significantly lower ($P < 0.01$) than the expected Chl a.

Assessment of Heavy Metal Toxicity

The effect of heavy metal toxicity on algal growth (Fig. 6) was represented as % growth inhibition at day 14 (% I_{14}) based on the difference in mg dry weight L^{-1} obtained in EDTA treated and control cultures (see Material & Methods). The highest value (76.66%) was recorded in May (Fig. 6), while the lowest (14.94%) occurred in July. It perhaps relevant that concentrations of heavy metals, mainly Zn and Cd attained their highest levels in the same sampling months (Table 7).

TABLE 7. Bi-monthly variations in heavy metals concentrations (mg/l) at Lake.

Metal	Month					
	May	July	Sept.	Nov.	Jan.	March
Pb	0.32	0.35	0.30	0.35	0.34	0.32
Zn	0.07	0.06	0.03	0.02	0.01	0.02
Fe	0.64	0.75	0.50	0.54	0.68	0.46
Cd	0.26	0.20	0.24	0.16	0.10	0.17

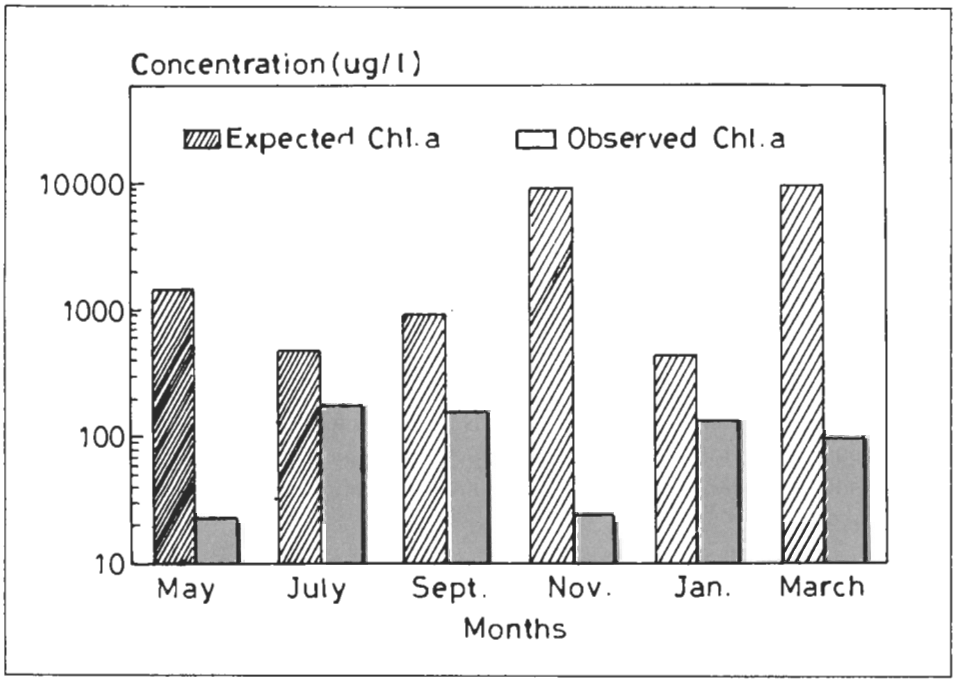

FIG. 5. Relationship between observed (phytoplankton) chlorophyll a and expected (AGP) chlorophyll a.

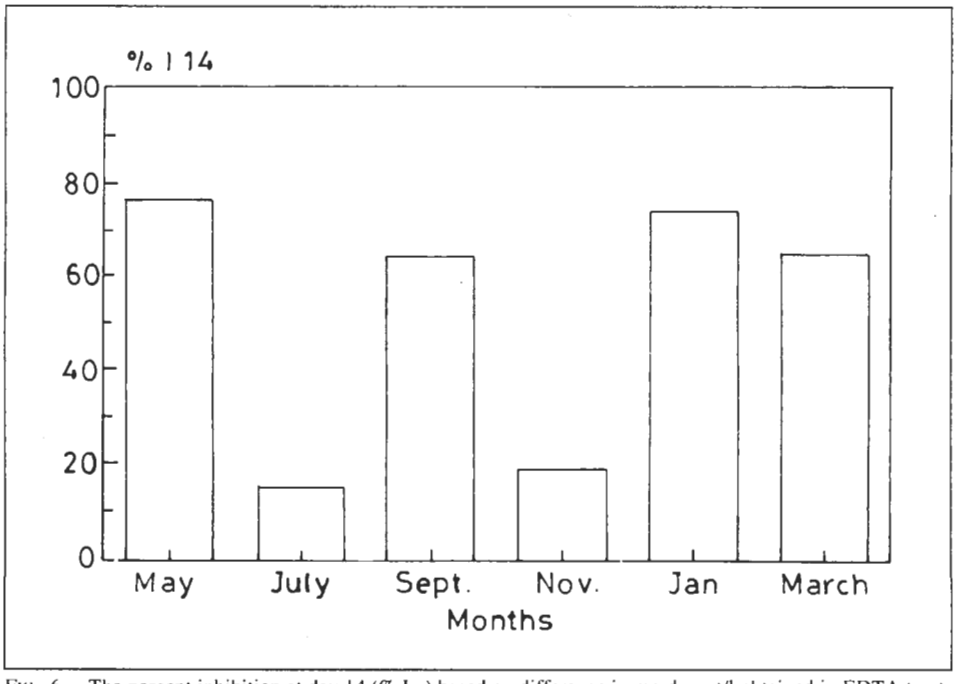

FIG. 6. The percent inhibition at day 14 (% I_{14}) based on difference in mg dry wt/l obtained in EDTA treated and control cultures.

Discussion

The present study showed that maximum algal growth (MAG) of the test alga was usually much higher than 10 mg dry wt L^{-1}, indicating the hypereutrophic conditions (Paerl and Bowles, 1987) of the used water, and its undesirable quality (Vollenweider, 1971; Raschke and Schultz, 1978). The high fertility of Lake water may be attributed to a high nutrient budget reaching it from El-Inanyia sewage treatment plant.

Generally, the addition of EDTA was accompanied by a highly significant increase ($P < 0.01$) in the AGP. This may indicate the presence of heavy metals with toxic concentrations in the used Lake water. However, other beneficial effects of EDTA due to its binding capacity as a chelating agent (Gachter *et al.*, 1974) should not be ruled out. The beneficial effects of a chelating agent are more obvious in a medium containing either inhibiting concentrations of some cations or cations tending to precipitate. Spencer (1957) found Cu^{++} toxic to *Phaeodactylum tricornutum* at a concentration of about 2×10^{-6} mol, but with the addition of EDTA it was nontoxic until the concentration reached about 2×10^{-3} mol.

Steemann Nielsen and Wium-Anderson (1970) presume that copper in natural water is not ordinarily present in ionic form but is complexed by organic matter such as polypeptides. On the other hand, chelators can help to keep certain ions in solution where they gradually become available to algae (Schelske, 1962; Dufkova, 1984). A chelating agent may also maintain a more favourable ratio between different cations in the medium. An improvement of growth similar to that produced by chelators can be evoked by increasing the amount of magnesium in calcium-rich media (Javornicky and Shaaban-Dessouki, 1975). Moreover, addition of EDTA was found to facilitate the uptake of phosphorus (Wetzel, 1975).

The results revealed that beside the positive effect of EDTA upon the algal growth potential, nitrogen as well as phosphorus may be limiting. This was more obvious during July, January and to some extent, March regarding nitrogen. However, phosphorus followed EDTA during May and September. In some cases, the addition of phosphorus showed a tendency to stimulate the AGP. However, in combination with EDTA algal biomass produced was about the same as that produced with EDTA alone. This result may be attributed to a detoxifying effect of phosphorus and/or the addition of EDTA facilitating uptake of phosphorus (Wetzel, 1975), which is already present in the water samples. Thus, the role of the added phosphorus in combination with EDTA was abolished.

Changes in the N:P ratio due to the addition of either P or N should be taken into consideration. Rest and Lee (1978) mentioned that N:P ratios below 10 exerts nitrogen limitating condition while above 20 phosphorus is the growth limiting nutrient. In accord with this observation the results of AGPT correspond with the findings of the calculated N:P weight ratio, since, the used water samples were characterized by a very low ratio (0.17, 2.72, 1.95, 1.68, and 3.62) during July, September, November, January and March, respectively, where nitrogen was found to be a limiting nutrient. Phosphorus, however, played that role during May, where the N:P weight ratio was 30.87.

In many waste-affected waters, nitrogen is usually the algal growth-limiting nutrient, especially when the degree of pollution is very high (Forsberg, 1976). In less polluted waters, phosphorus plays the reciprocal role. The first finding agrees well with our results as nitrogen was almost always the limiting nutrient in our study area. This was revealed by both the calculated N:P weight ratio and the algal growth potential test which indicated the high degree of phosphorus pollution in lake Manzala. From that one can conclude that excessive loading of P- rich effluents from El-Inanyia treatment plant is the main cause of raising the Lake waters into a high level of phosphorus pollution and hence into the critical N-limitation condition.

The role of the nutrient bioavailability should nevertheless be taken into consideration. The relationships between the chemically analyzed P and N and their bioavailable concentrations were greatly affected by the N:P ratio heavy metal toxicity. Similar observations were reported by Greene *et al.* (1975), Miller *et al.* (1976, 1978), Fayed (1981), Van Donk *et al.* (1988) and Abdel-Hamid *et al.* (1992).

The calculated bioavailable nitrogen indicates that the test alga was able to utilize organic nitrogen under strong N-limitation. This finding was recorded in July, September and November. Similar results were reported by Miller *et al.* (1978) and Abdel-Hamid *et al.* (1992). In addition, there is evidence for the utilization of organic nitrogen by *Chlorella* (Samejima and Myers, 1958; Javornicky and Shaaban-Dessouki, 1975) as well as by *Chlamydomonas* sp. (Rodhe *et al.*, 1966).

Generally the results, especially that of $\%I_{14}$, indicate that the AGP was mainly inhibited by heavy metal toxicity, followed by limitation of nitrogen and phosphorus. In addition, the chemical analyses and AGPT revealed that Cd and/or Zn were the most effective heavy metals especially during May.

The establishment of a fixed relationship between the observed phytoplankton chlorophyll a and the expected chlorophyll a biomass have seriously questioned. Similar to what was observed by Claesson (1978), and Abdel-Hamid *et al.* (1992) the observed Chl.a showed no direct relationship with the expected Chl.a. This discrepancy between the observed and the expected chlorophyll a biomass, may be due to the role of the manifold factors governing the growth of natural phytoplankton populations such as temperature (Kopczynska, 1981), light (Van Donk, 1983), water turbidity (Smith, 1982), sediment nutrients and external loadings (Golterman, 1983), morphometry, depth and relative proportion of eutrophic to mixed depth (Talling, 1971; Fee, 1979; Forsberg, 1980), grazing (Smeltzer, 1980); inter- and intraspecific interactions within natural communities (Lovstad, 1986), fungal parasitism (Van Donk and Ringerberg, 1983) and differences in nutrient physiology of different algal species (Sakamoto, 1966). However, the data obtained by Raschke (1987) showed a strong positive correlation ($r = 0.96$) between the observed and the expected chlorophyll a. This difference may be attributed to the preparation of water samples for the algal bioassay. Raschke (1987) used autoclaved filtered samples which presumably contain all nutrients in solution (Miller *et al.*, 1978). In our AGP test, a GF/C filtered water was used because the total hardness was always greater than 100 mg $CaCO_3$ L^{-1}, a condition which result in precipitation of the

essential nutrients like Ca, N, and P upon autoclaving (Miller *et al.*, 1978).

The above mentioned survey of results indicate that Lake Manzala is actually injured and deteriorated heavily by various man related activities.

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تقـــدير مـدى خصوبـة وسميـة ميـاه الجـزء الشمالي الغـربي لبحـيرة المنزلة بمصر باستخدام اختبار النمو الطحلبي المحتمل

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المستخلص . تم إجراء هذا البحث لدراسة مدى تأثير مياه الصرف على نوعية مياه هذه البحيرة من خلال تبيان خصوبة وسمية مياه الجزء الشمالي الغربي للبحيرة في الفترة مابين مايو ١٩٩١ ومارس ١٩٩٢ . في هذا البحث استخدمت اختبارات الغذاء المخصب الحيوية لتقدير المغذيات المحددة للنمو الطحلبي وتواجدها الحيوي ومدى سمية المعادن الثقيلة المتواجدة في الماء ولإجراء هذه الاختبارات استخدم الطحلب *سيلينا سترم كابريكورناتم* سلالة نيفا كلوروفيل١ كطحلب قياس . وخلال هذه الفترة جمعت عينات مياه البحيرة مرة كل شهرين .

أظهرت هذه الدراسة أن الحد الأقصى لنمو طحلب القياس كان عادة أكثر من ١٠ مجم وزن جاف/ لتر مما يدل على أن مياه منطقة البحث تحتوى على كميات عالية من المغذيات (Hypereutrophic) وأن هذه المياه ذات نوعية غير مرغوبة . هذا وقد وجد أن نتائج اختبار النمو الطحلبي المحتمل (AGPT) قد تراوحت بين ٦٠ و ٣٠ مجم وزن جاف/ لتر و ٧٨ و ١٢٢٨ مجم وزن جاف/ لتر. ووجد أن النيتروجين والعناصر الثقيلة كانت مقيدة للنمو الطحلبي وفي بعض الحالات كان النمو مقيداً بتواجد الفوسفور .

دلت النتائج أن كلوروفيل أ : المقدر (كلوروفيل (أ) المستخلص من العوالق النباتية) كان أعلى بكثير من كلوروفيل (أ) المتوقع تواجده ، ولم توجد علاقة ثابتة بين قيم كل منهما . ويمكن القول أن النسبة بين النيتروجين والفوسفور تعتبر دليل مناسب لتقدير أكثر المغذيات المحددة للنمو الطحلبي . وأن العلاقات بين المغذيات (الفوسفور والنيتروجين) المعينة كيميائيًا وتركيزها الحيوي المتاح يعتمد بصفة أساسية على كل من نسبة النيتروجين إلى الفوسفور وسمية المعادن الثقيلة .

من خلال هذه الدراسة يمكننا بصفة عامة أن نقول أن نتائج اختبار النمو الطحلبي المحتمل (AGPT) تؤكد أن هذا الاختبار يعتبر وسيلة جيدة ومؤثرة وأيضًا حساسة لتقدير مدى خصوبة وسمية المياه وكذلك مقدار المغذيات المتاحة بيولوجيا في مياه بحيرة المنزلة .