Laboratory study on the effects of nutrient enrichment on a phytoplankton population in Sawa Lake, Iraq

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Abstract

Nutrient enrichment of Sawa lake water was made using different nitrogen and phosphorus concentrations during autumn and spring at three stations. Different concentrations of nitrogen, phosphorus and N: P ratios were used to test variations in phytoplankton population dynamics. Nitrogen at a concentration of 25 μmole.l^{-1} and N: P ratio of 10:1 gave highest phytoplankton cell number at all stations and seasons. A total of 64 algal taxa dominated by Bacillariophyceae followed by Cyanophyceae and Chlorophyceae were identified. The values of Shannon index of diversity were more than one in the studied stations.

Introduction

Plant nutrient (nitrogen and phosphorus), have important role in algal growth especially in aquatic ecosystem due to their scarcity (1). Several authors have shown that the response of phytoplankton to nutrient enrichment is a measure of their nutrients demand and an essential method for water management (2, 3). The limiting factor for phytoplankton growth in Soyany Lake, Korea was reported to be phosphorus (4). Whereas, the nutrient enrichment of the British lake, Kootenay, by nitrogen and phosphorous lead to significant increase in diatom density , species composition and diversity as well as some morphological changes in some species (5). Moreover, the phytoplankton community of the Sweden Lake, Njupfatet, and Canadian swamps showed clear responses to enrichment by phosphorus and nitrogen (6, 7). Indeed, the enrichment of Sager Lake in India by nitrogen and phosphorus individually or together lead to increase the productivity of the lake (8). D'Elia (9) revealed three levels of phytoplankton response for nutrient enrichment experiments, these are; 1. Immediate and strong: when the density of phytoplankton at nutrient treatment have double density of phytoplankton in contrast with control treatment, 2. Delayed and weak: when phytoplankton density less than double density of control treatment, 3. Slight or negligible: phytoplankton density equal or less than control treatment.

In Iraq, the enrichment experiments were recently started last two decades. The best algal growth in marshes, southern Iraq, was at N:P ratio of 10 :1 (10). The enrichment of Razzazah lake by N:P ratio of 10:1 during autumn lead to high diversity of phytoplankton species (11). In previous study (12), it has been found that, the optimum growth of the green algae species *Scenedesmas quadricauda* was reached at N: P ratio of 10:1, giving the highest chlorophyll – a concentration with least doubling time.

The present work was an attempt to study the phytoplankton population dynamics in Sawa Lake when subject to enrichment by nitrogen and phosphorus. The lake is located on the west-south of Samawa city about 30 km from center of

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the city, southern part of Iraq at 45° E and 31° 18¯ N (Fig. 1). The total surface area is about 10 Km2 with average length and width of 5 and 2 Km respectively. Its depth ranged between 3-5.5 m. This lake is of unique characters in comparison with other lakes in Iraq, it is a saline and has no in or out let and surrounded by gypsum plateau-like shores, which rise up six meters away from the surrounded area (13, 14). . It is brackish lake with salinity of 14-17.6 ppt, alkaline with pH 8- 8.4, very hard with total hardness of 9000 – 11090 mg CaCO3 .l-1 (15).

Materials and Methods

Water sub samples (30cm), were collected from three selected station in Sawa lake , southern part of Iraq (Fig.1), namely St. 1 (north) , St. 2 (middle) and St. 3 (south) during autumn, 2000 and spring seasons 2001. The phytoplankton composition and the environmental parameters were already given by Hassan et al. (14) and Al-Saadi et al. (16).

Nitrogen as NaNO3 was used at three concentrations (N1= 25 , N2 = 75 and N3 = 150 µmole. l^{-1}) , and phosphorus as K_2HPO_4 at concentration of 5 µmol . l^{-1}. These compounds were used to determine different N:P ratios (5:1 , 15:1 and 30:1).

Three liters conical flasks were used for the enrichment experiments with the above nutrients at triplicate and complete randomized design was used. A digital controlled Gallen incubator (Kamp) was used at temperature adjusted to the natural water temperature (during the sampling time) ± 3 °c and light intensity of 2925 µ Einstein m^{-2} sec^{-1} at 12:12 light : dark for 5 days in all experiments . pH value was maintained at alkaline value during the experiment period.

The total cell number of phytoplankton was calculated after the modified McNabb method (17). The identification of algal species followed several references (18, 19, 20, 21, 22). Complete Randomized Design (CRD) was used for enrichment experiments. Analysis of variance (ANOVA) was used to detect statistically significant interaction between different enrichment treatment and seasons.

Results and discussion

There are different responses of phytoplankton by means of total cell number to the different treatments of nutrient enrichments. The addition of nitrogen alone (N_1) or with phosphorus (N_2P) showed the highest cell number among the other treatments with significant differences (table 2) during all incubation day in both seasons. Enrichment by nitrogen alone (N_1) caused an increase in the phytoplankton density (16698 x 10^2 cell.l^{-1}) compared to the value of control treatment (7885 x 10^2 cell.l^{-1}) on day 4 of incubation during spring 2000, while, the N_2P treatment caused an increase in the phytoplankton density (19579 x 10^2 cell.l^{-1}) compared to control treatment (7837 x 10^2 cell.l^{-1}) on day 4 of incubation during spring 2001. Whereas, no responses to the phosphorus enrichment was obtained in all stations (Fig. 2). Such results may indicated that phytoplankton in the studied lake was subjected to nitrogen deficiency according to D'Elia scale (9). Similar results were obtained in Shatt al-Arab estuary (23), as well as in Jacaretinga Lake in Brazil (24) and Amazon Lake (25).

The interaction between seasons and different enrichment treatment, as well as stations showed that N_1 (25 µmol.l^{-1} N) and N_2P (15N:1P) recorded the highest cell number especially on days 2-5 (Fig.3&4). Meanwhile, in Razzazah Lake, the N: P ratio of 10:1 gave the highest response (11).

A total of 64 taxa of algae was identified during the enrichment experiments, whereas, only 51 algal taxa was identified in the field (16).

Meanwhile, the percentage of each class was almost similar (Table 1).

The variation in phytoplankton response to different treatment illustrates the result of phytoplankton population differences in size, composition and physiological status and metabolism (26, 27). Therefore, it may be not easy to follow such variations in the phytoplankton responses.

The dominance and algal succession of different species in enrichment experiments were affected by several factors, especially the major nutrient concentrations (28). The diatom growth is faster than other groups; therefore, its response to the nutrient enrichment will be higher. In the present study, the diatoms were dominant and growth as well as more species number in comparison with the field study (table 1). Such dominance was obtained by other workers (11, 29).

Shannon index of diversity was high (>5), during all enrichment treatments, which indicated that the addition of nitrogen and phosphorus alone or together gave high diversity of algal species. On other hand, no certain species was dominant. Also, diatoms, blue greens and green algae were the major algal group in all treatments, which was similar case in the field study (16). Such results were obtained also by workers (25, 30).

Our results generally supported the hypotheses, that nitrogen limitation phytoplankton growth in brackish water. The enrichment experiment will reflected an actual nutrient limitation for algae production.

Table(1) : Number of algal species identified in Sawa lake.

Class	Field		Enrichment	
	species	%	species	%
Cyanophyceae	12	23.5	15	23.4
Chlorophyceae	4	7.8	5	7.8
Euglenophyceae	2	3.9	2	3.1
Bacillariophyceae	33	64.7	42	65.6
Centrales	4	7.8	7	10.9
Penales	29	56.9	35	54.9
Total	51	100	64	100

Table 2: Analysis of variance for effect of stations , seasons, treatments and their interactions on phytoplankton density on incubation days.
(=High significant, N.D.=not significant)**

1st. day

Source of variation	D.F.	M.S.	Estimate F	Table F
Treatments	7	1976968.599	286.177**	2.104
Stations X treatments	14	3766.055	0.545 N.S.	1.796
Seasons X treatments	7	1237240.444	179.098**	2.104
Error	96	6908.194		
Total	143			

2nd. Day

Source of variation	D.F.	M.S.	Estimate F	Table F
treatments	7	234417.580	69259637.230**	2.104
Stations X treatments	14	62388404.634	74026.604**	1.796
Seasons X treatments	7	242674.563	19701601.463**	2.104
Error	96			
Total	143			

3rd

Source of variation	D.F.	M.S.	Estimate F	Table F
treatments	7	118679290.78	23156934.786**	2.104
Stations X treatments	14	311642.313	60808.256**	1.796
Seasons X treatments	7	23691076.991	4622649.169**	2.104
Error	96	125.5		
Total	143			

4th. day

Source of variation	D.F.	M.S.	Estimate F	Table F
treatments	7	234417.580	69259637.230**	2.104
Stations X treatments	14	62388404.634	74026.604**	1.796
Seasons X treatments	7	242674.563	19701601.463**	2.104
Error	96			
Total	143			

5th.day

Source of variation	D.F.	M.S.	Estimate F	Table F
Treatments	7	277023737.031	39846.511**	2.104
Stations X treatments	14	100145.781	14.405**	1.796
Seasons X treatments	7	25396408.507	3652.966**	2.104
Error	96	6952.271		
Total	143			

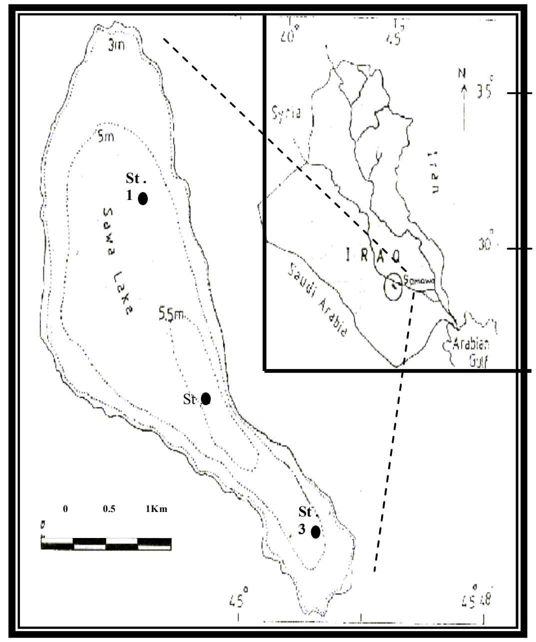

Fig 1: Map of the studied area.

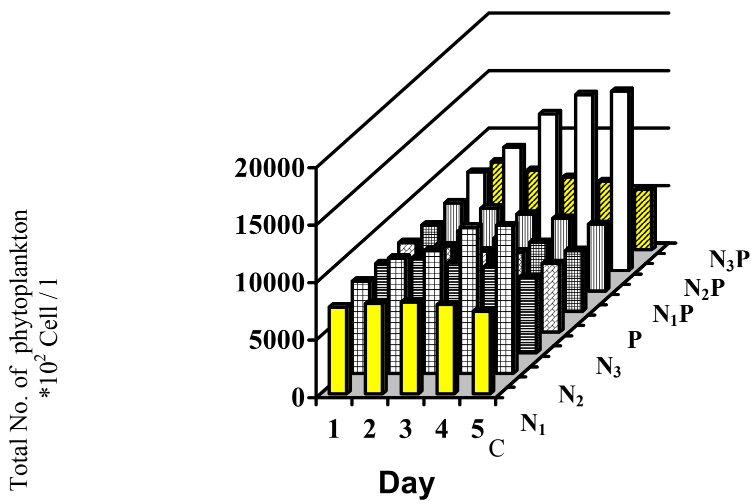

Fig. 2: Daily variations in phytoplankton density at different treatments.

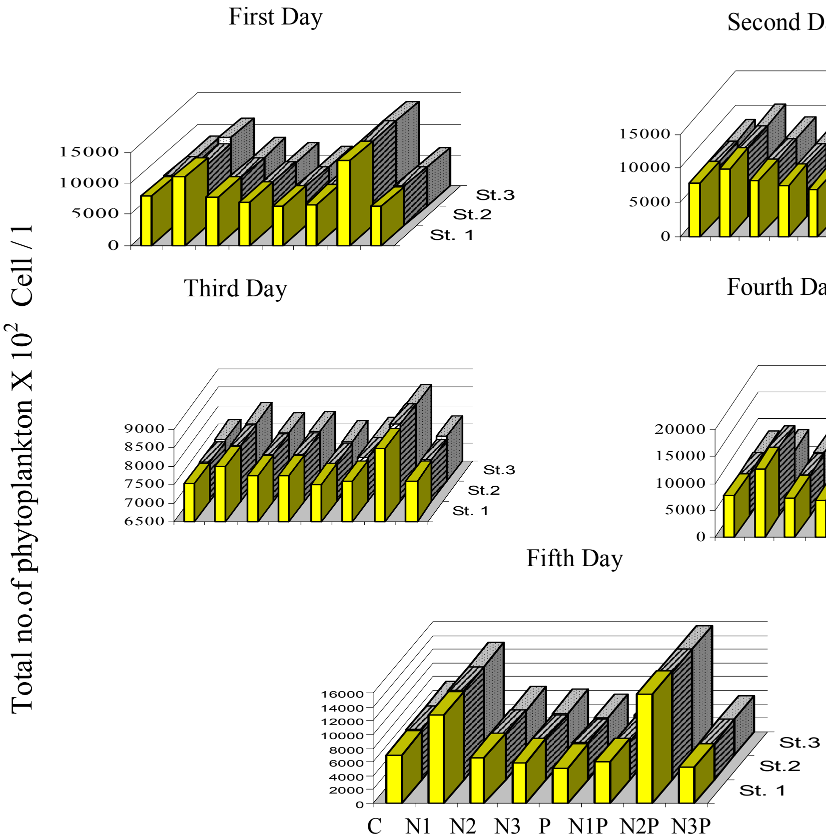

Fig.3: Interaction between the three studied stations and different nutrient treatment during the five days of incubations

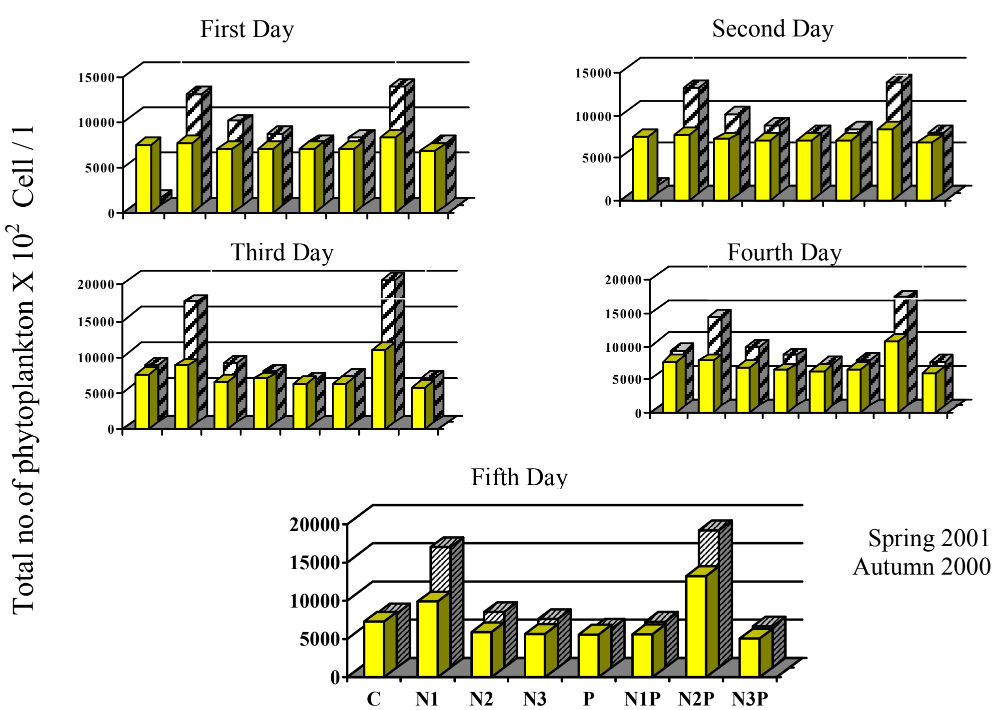

Fig 4: Interactions of studied seasons and different nutrient treatment during the five days of incubation

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دراسة مختبرية لتاثيرات الاغناء بالمغذيات على سكان الهائمات النباتية في بحيرة ساوة , العراق

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الخلاصة:

اجريت تجارب الاغناء بالمغذيات في بحيرة ساوة باستخدام تراكيز مختلفة من النتروجين والفسفور خلال فصلي الخريف والربيع في ثلاث محطات دراسية. استخدمت تراكيز مختلفة من النتروجين والفسفور وكذلك نسب مختلفة من النتروجين والفسفور لاختبار التغيرات في ديناميكية السكان للهائمات النباتية. سجلت أعلى عدد لخلايا الهائمات النباتية في جميع المحطات والمواسم عند استخدام النتروجين بتركيز 25 مايكرومول/لتر ونسبة نتروجين: فسفور1:10. وشخص 64 طحلب في هذه الدراسة وكانت الدايتومات هي السائدة وتلتها الطحالب الخضر المزرقة والطحالب الخضر. سجل مؤشر شانون للتنوع قيم اكثر من واحد في المحطات المدروسة في البحيرة.