

## 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  $\mu\text{mole.l}^{-1}$  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 Km<sup>2</sup> 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 CaCO<sub>3</sub> .l<sup>-1</sup> (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 NaNO<sub>3</sub> was used at three concentrations ( N<sub>1</sub>= 25 , N<sub>2</sub> = 75 and N<sub>3</sub> = 150 μmole. l<sup>-1</sup> ), and phosphorus as K<sub>2</sub>HPO<sub>4</sub> at concentration of 5 μmol . l<sup>-1</sup>. 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<sup>-2</sup> sec<sup>-1</sup> 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<sub>1</sub> ) or with phosphorus ( N<sub>2</sub>P ) 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<sub>1</sub> ) caused an increase in the phytoplankton density (16698 x 10<sup>2</sup> cell.l<sup>-1</sup>) compared to the value of control treatment (7885 x 10<sup>2</sup> cell.l<sup>-1</sup>) on day 4 of incubation during spring 2000, while, the N<sub>2</sub>P treatment caused an increase in the phytoplankton density (19579 x 10<sup>2</sup> cell.l<sup>-1</sup>) compared to control treatment (7837 x 10<sup>2</sup> cell.l<sup>-1</sup>) 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<sub>1</sub> (25 μmol.l<sup>-1</sup> N) and N<sub>2</sub>P (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)

1<sup>st</sup>. 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 <sup>N.S.</sup>	1.796
Seasons X treatments	7	1237240.444	179.098**	2.104
Error	96	6908.194		
Total	143			

2<sup>nd</sup>. 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			

3<sup>rd</sup>

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			

4<sup>th</sup>. 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			

5<sup>th</sup>. 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			

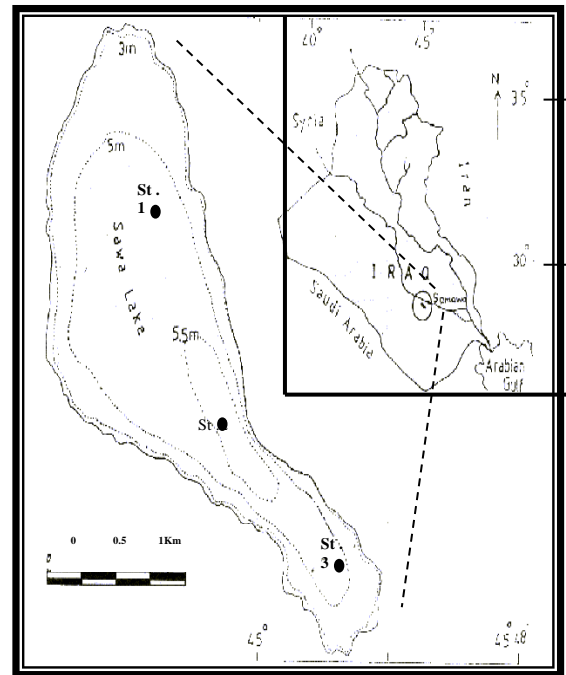


Fig 1: Map of the studied area.

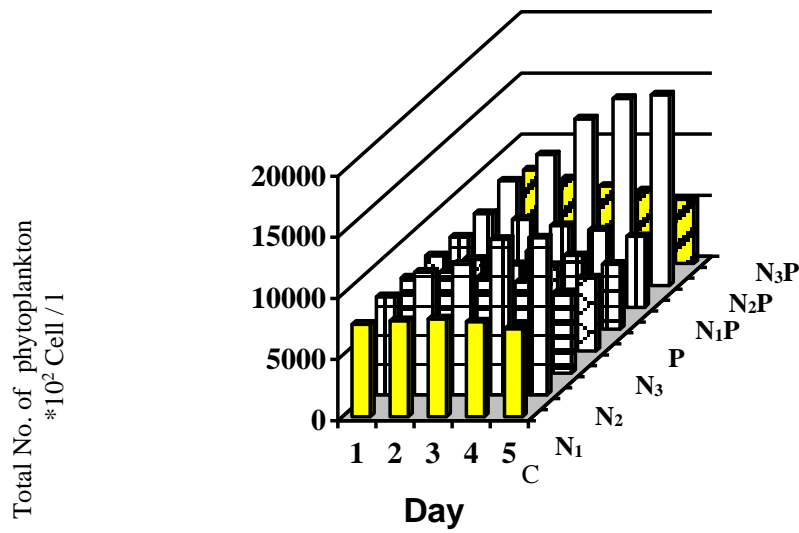


Fig. 2: Daily variations in phytoplankton density at different treatments.

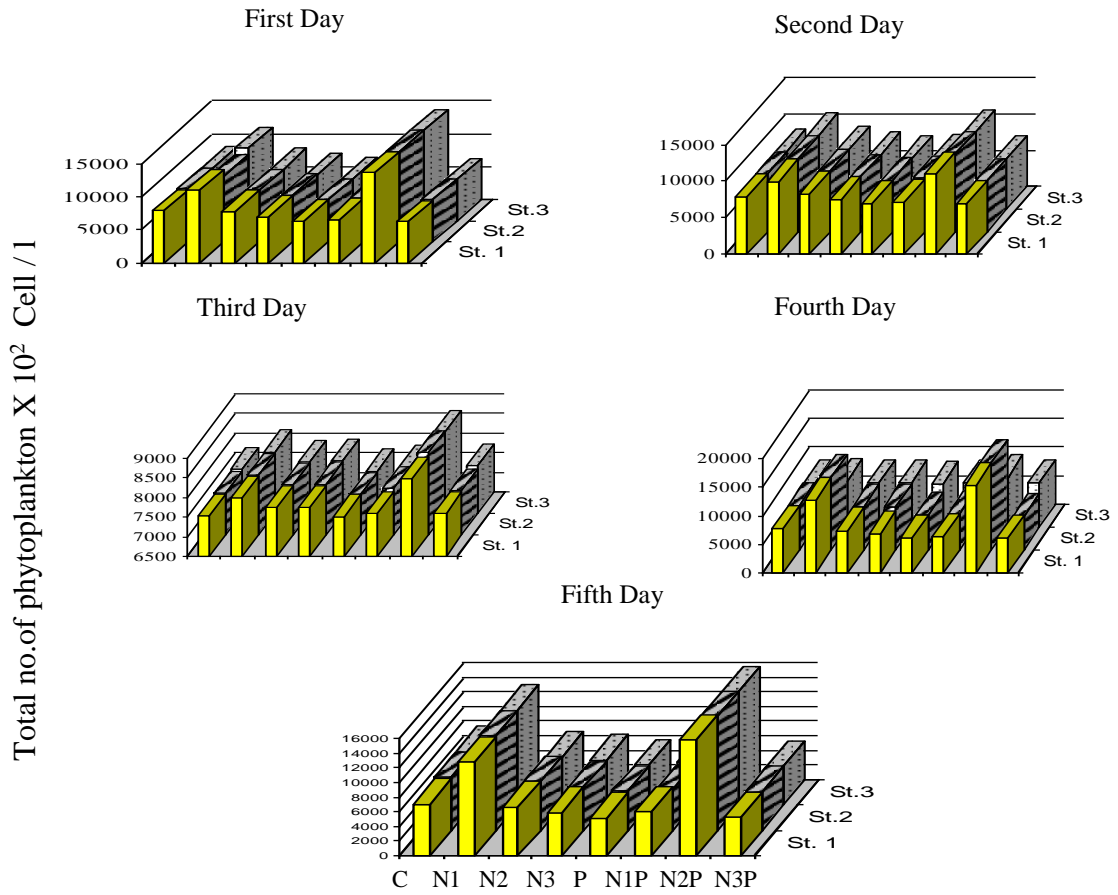


Fig.3: Interaction between the three studied stations and different nutrient treatment during the five days of incubations

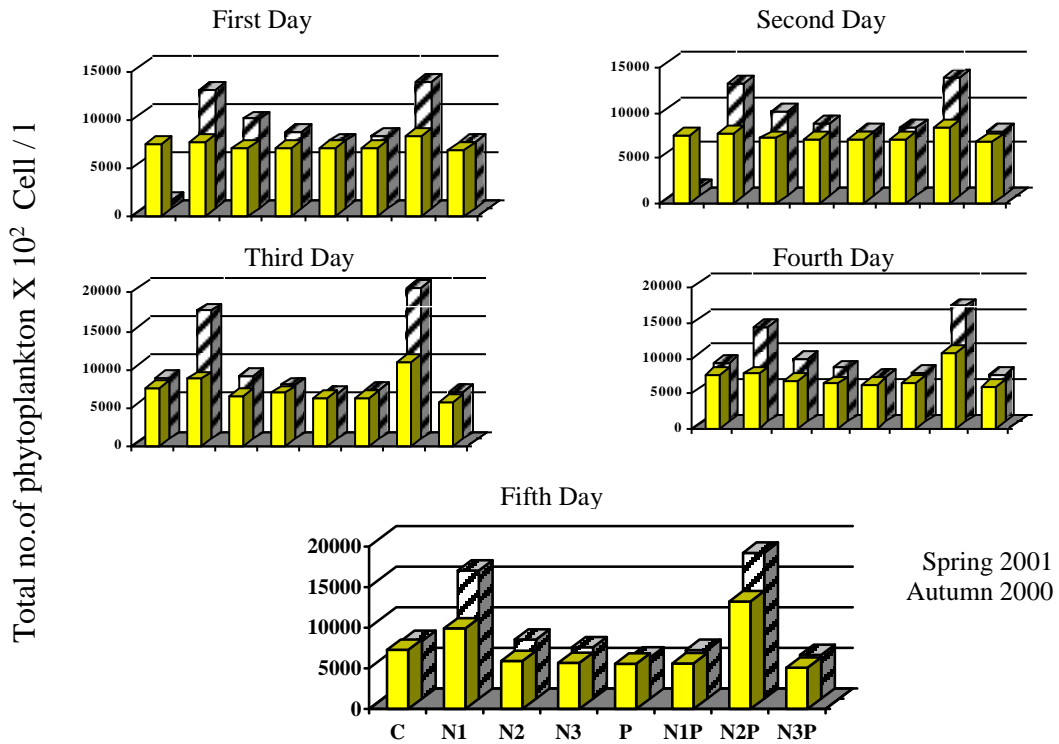


Fig 4: Interactions of studied seasons and different nutrient treatment during the five days of incubation

## References

1. Lee, J.A., A.R. Choi and I.K. Chung. 1995 .Phytoplankton stoichiometry and nutrient status of Sonaktong river . The Kor. J. Phycol. 10(1): 37-44.
2. Viner, A. B. (1973). Responses of a mixed phytoplankton population to nutrient enrichments of ammonia and phosphate, and some associated ecological implications. Proc. R. SOC. Lond. B. 183: 351-370.
3. Al-Saadi, H. A.; R. A. M. Hadi; U. Schiewer and A. H. Al-Mousawi (1989). On the influence of the sewage drainage from Basrah city on the phytoplankton and related nutrient in the Shatt Al-Arab estuary, Iraq. Archiv. Fur. Hydrobiol. 114(3): 443-452.
4. Kim, B.C.(1987). An ecological study of phytoplankton in lake Soyang. Ph.D. Thesis , Univ. Seoul.
5. Yang, J.R., F.R. Pick, P.B. Hamilton (1996). Changes in the planktonic diatom flora of a large mountain lake in response to fertilization. J. of Phycology. 32(2): 232-243.
6. Blomquist, P.(1996). Late summer phytoplankton responses to experimental manipulations of nutrients and grazing in unlimed and limed lake Njupfätel, Central Sweden. Archiv. Fur. Hydrobiol. 137(4): 425-455.
7. McDougal, R.L., L.G. Goldsborough and B.J. Hann (1997). Responses of a prairie wetland to press and pulse addition of inorganic nitrogen and phosphorus-production by planktonic and benthic algae. Archiv. Fur. Hydrobiol. 140(2): 145-167.
8. Bais, V.S., N.C. Agrawal, and T. Arasta (1997). Seasonal changes in phytoplankton productivity due to artificial enrichment of nutrient Asitu experiment. J. of Environmental Biology, 18(3): 249-255.
9. D'Elia, C.F., J.G. Sanders and W.R. Boynton (1986). Nutrient enrichment studies in a coastal plain estuary phytoplankton growth in large scale, continuous cultures. Can. J. Fish. Aquat. Sci. 43 : 397-406.
10. Al-Araji, M.J.(1988). An Ecological study on phytoplankton and nutrients in Al- Hammar marsh, Iraq. M.Sc. Thesis, Basra University ( in Arabic).
11. Hassan, F. M.; H A. Al- Saadi and A.A. K. Mohamed (2007). Effects of nitrogen and phosphorus enrichment on the phytoplankton in Razazzah Lake, Iraq. Environmental Research and Sustainable Development, 10 (1):27-44 (in Arabic).
12. Al-Saadi, H.A.; T. I. Kassim; A. A. Al-Rawi and M. T. Al-Kasisi (2001). The role of main nutrients in the growth and productivity of *Scenedesmas quadricauda*. J. Qadisiya, 6(3):126-140.
13. Jamil, A. K. (1977). Geological and Hydrogeochemical aspects of Sawa Lake, S. Iraq. Bull. Coll. Sci., 18(1): 221-253.
14. Hassan, Fikrat M., Al-Saadi, H.A., and Alkam, F.M. (2006). Phytoplankton composition of Sawa Lake, Iraq. Iraq J. Aqua., 3(2): 89-97.
15. Alkam, F.M.; F.M. Hassan and H.A. Al-Saadi (2002). Seasonal variations of the physico- chemical characters of Sawa lake, Iraq. Environmental Research and Sustainable Development 5(2):55-65.
16. Al-Saadi, H.A., F.M. Hassan, F.M. Alkam ( 2007). Seasonal variations of phytoplankton and related nutrients in Sawa lake, Iraq. ( in press; J. Dohuk university).
17. Hinton, G.C.F. and B.K. Mouloud (1980). Some diatoms from brackish

- water habitat in southern Iraq. Nova Hedwigia, 33: 475-486.
18. Desikachary, T.V. (1959). Cyanophyta, Indian Council of Agricultural research. New Delhi.
19. Patrick, R., C.W. Reimer (1966). The diatoms of the untied states exclusive of Alaska Hawaii. Monogr. Acad. Nat. Sci. Philadelphia No.13.
20. Prescott, G.W. (1973). Algae of the Western Great Lakes Area. William C. Brown Co. Publ. Dubuque, Iowa.
21. Hadi, R.A.M., A.A. Al-Saboonchi, and A.k.Y. Haroon (1984). Diatoms of the shatt al Arab river, Iraq. Nova Hedwigia 39: 513-557.
22. Al-Handal, A.Y. (1994). Contribution to the Knowledge of diatoms of Sawa lake, Iraq. Nova Hedwigia. 59(1-2): 225-254.
23. Al-Mousawi, N.J.M. (1992). Ecological study of the Shatt al-Arab estuary at Basrah city, Iraq. M.Sc. Thesis, Basra University (in Arabic).
24. Henry, R., K.Hino, J.G. Tundisi and J.S.B. Riberio (1984). Responses of phytoplankton in lake Jacaretinga to enrichment with nitrogen and phosphorus in concentration similar to those of the river Solimoes (Amazon, Brazil) Arch. Hydrobiol. 103(4): 453-477.
25. Setaro, F.C. and J.M. Melack (1984). Responses of phytoplankton to experimental nutrient enrichment in an Amazon flood plain lake. Oceanogr. 29(5):972-984.
26. Dorely, W.M. (1982). Algal biology phycological approach. Black Well Sci., Publ. Oxford, London.
27. Reynolds, C.S. (1984). The ecology of freshwater phytoplankton. Cambridge Univ. Press. Cambridge.
28. Sanders, J.G., S.J. Gibik, C.F.D'Elia, and W.R. Boynton (1987). Nutrient enrichment studies in a coastal plain Estuary: changes in phytoplankton species composition. Can. J. Fish Aquat. Sci., 44: 83-90.
29. Thomas, W.H., A.N. Dodsom and F.M.H. Reid (1978). Diatom productivity compared to other algae in natural marine phytoplankton assemblages. J. Phycol. 14: 250-253.
30. Agius, C. and V. Jaccarina, (1982). The effects of nitrates and phosphate enrichments on the phytoplankton from marsaxlokk Bay, Malta (Central Mediterranean Hydrobiol. 87:89-96.

## دراسة مختبرية لتأثيرات 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: فسفور 1:10. وشخص 64 طحلب في هذه الدراسة وكانت الدايتومات هي السائدة وتلتها الطحالب الخضر المزرقه والطحالب الخضر. سجل مؤشر شانون للتنوع قيم أكثر من واحد في المحطات المدروسة في البحيرة.