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COMPARATIVE ECOLOGICAL STUDY OF PHYTOPLANKTON. *PART II*. BAKAR AND PHOOSNA LAKES - PAKISTAN

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A comparative ecological survey of phytoplankton part II of Lake Bakar, district Sanghar and Lake Phoosna, district Badin was carried out during August, 1993 to July, 1996. A total of 122 species belonging to 45 genera of 15 families of 5 orders of class Chlorophyceae were recorded. 11 species were common in both Lakes. 94 species were present in Lake Bakar and 17 in Lake Phoosna. The study showed that the aquatic environment of Lake Bakar is qualitatively much better as compared to Lake Phoosna.

Key words: Phytoplankton, Bakar lake, Phoosna lake.

Introduction

Phytoplankton is an important group of algal flora. These are the producers of food in the food cycle of aquatic ecosystems, fixing energy by the process of photosynthesis. The phytoplankton are widely distributed and are an important component of various ecosystems like marine, rivers, ponds and streams etc. Algal flora is a good indicator of pollution (Patrick and Reimer 1966) and in the water bodies receiving animal, poultry and household waste.

Qualitative and quantitative determinations of phytoplankton are essential for determing the aquatic productivity as they are the chief source of food for aquatic animals including fishes. Bakar lake is subtropical (Blatter *et al* 1929; Mitcheal 1967) and is situated in desert area of Sindh at an altitude of 50 m, latitude 26° 06′ North, longitude 68° 10′ East. Its width is 2.5 km and length is 45km. According to Prescott (1961) referring to older, shallow lakes, highly productive for the eutrophic lake so Phoosna is a shallow eutrophic lake, situated in between 68° 55′ longitude (East) and 24° 50′ latitude (North) at a distance of 20 km from Badin, 5 km, towards north of Hyderabad Badin Road. It is a private owned fishing lake, spread over an area of 500 acres. The lake is shallow, about 2-3 meters deep. Since it is surrounded by agriculture land, consequently also receives leached plant nutrients. The present study was carried out as very little work has been done on the phytoplankton of lakes from Sindh blooms is Kinjhar Lake in summer season (Nazneen 1974).

The present work will give the comparative results of phytoplankton distribution in the Phoosna and Bakar Lakes, where different physico-chemical properties and other parameters have been taken into consideration to study the phytoplankton flora.

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Materials and Methods

Phytoplankton were collected monthly from August, 1993 to July, 1996 between 11 a.m. to 3 p.m. with the help of boat using phytoplankton net of 5-10 mm mesh. Water samples were collected using water sampler (Nansen bottle) for studying physico-chemical features using standard methods (APHA 1985) and for quantitative studies of phytoplankton. Samples were preserved in 4% formalin. The species composition was determined by Utremohal method (Lund *et al* 1958). The micro algae (Ultra nannoplankton) were not counted as Gorham *et al* (1974), considered these algae comparatively unimportant in high productive lakes. The association of (Ultra nannoplankton) with phyto and tychoplankton so easily collected with the algal net and secondly in polythene bags crush the algal material easily found ultra nannoplankton. Phytoplankton identification and counts were done using inverted light microscope olymphus Japan (20X, 40X objective and eyepiece 10X) and identified with the help of available literature (Husted 1930; Majeed 1935; Smith 1950; Prescott 1961; Patrick and Reimer 1966; Tiffany and Briton 1971; Vinyard 1979; Akiyama and Yamagishi 1981; Leghari *et al* 1997).

Results and Discussion

According to the results of the comparative ecological studies of phytoplankton of Bakar and Phoosna Lakes, qualitative measurement done for the production of phytoplankton is shown in Table 1. Lake Bakar is clearly very productive as

compared to Lake Phoosna. Out of 122 species identified from these Lakes 94 were present in Bakar Lake, 17 in Phoosna Lake and 11 were common in both the Lakes. This clearly indicates 5.5 times richness of Bakar Lake in phytoplankton species. A look at the percentage reveals that 77% of the species are present in Lake Bakar and 13.93% in Lake Phoosna and 9% are common in both Lakes. This productivity of Lake Bakar can be attributed to the amount of dissolved oxygen which is an indicator that the phytoplanktons take in CO_2 for photosynthesis and give out O_2.

Total hardness was measured by the amount of $CaCO_3$ present in the Lake waters. The result reveals that Phoosna Lake has a minimum of 400 ppm hardness and Bakar Lake has 100 ppm while maximum was 516 ppm and 180 ppm present in Phoosna and Bakar Lakes, respectively (Table 2). Blue green algae was in high ratio in Phoosna Lake due to its hardness and the present studies indicate that phytoplankton is drastically low in this Lake.

It is also indicated in Table 2 that salinity level in Phoosna Lake is very high, maximum 3.8 ppt as compared to Lake Bakar which is 0.7 ppt. This is one of the reasons why the phytoplankton species are scanty in Phoosna Lake and flourish in Lake Bakar. Due to high salinity level, it was also observed that cells of the plants are damaged and deformed in Phoosna Lake. The T.D.S. ratio (330 ppm) is higher in Lake Bakar as compared to Phoosna Lake and this results in high productivity level of this Lake. Due to T.D.S. support the phytoplankton production increases and phytoplankton is the favourite food of fish which nourish on it. It has also been observed that the taste of the fish is very delicious, the reason being the ample and high quality of phytoplankton species present in Lake Bakar.

The orthophosphate content is very low (0.002 µg/l) in Lake Bakar due to which phytoplankton species flourish in this water. Moreover, due to greater depth of Lake Bakar (7.8 m) the temperature of its water does not rise as compared to Phoosna Lake which is shallow and therefore, the temperature rises more quickly in this Lake. Hence, the low temperature species also survive in the Bakar Lake.

It was observed during the studies conducted that there is proper inlet for water in the Lake Phoosna but there is no outlet. Due to stagnant water mostly the species recorded were the hard water ones. A perusal of Table 2 clearly indicates that variations in the physico-chemical properties of Lake have adverse effect on the fish of the Lake.

Lake Bakar on the other hand has proper inlet and outlet for water. The Nara Canal derived from this Lake serves to irrigate the agricultural lands. Due to this inlet and outlet

Table 1

The occurrence of various unicellular phytoplankton species during August, 1993 to July, 1996 in Bakar and Phoosna Lakes

Species	Baker lake	Phoosna lake
Division: Chlorophyta		
Class: Chlorophyceae		
Order: Chlorococcales		
Family: Oocystaceae		
1. *Ankistrodesmus convolutes* Corda	c	c
2. *A. falcatus* (Corda) Ralfs	c	c
3. *A. falcatus* var. *stipitatus* (Chod) Lemm	c	c
4. *Chlorella vulgaris* Beyerinck	p	a
5. *Chodatella baltonica* Scherefell	p	a
6. *C. chodatii* (Ber.) leg. var. *chodatii*	a	p
7. *Closteriopsis longissima* var. *tropical* W. & W.	p	a
8. *Excentrosphaera virdis* Moore	p	a
9. *Gloeotaenium loitelsbergerianum* Hansgirg	p	a
10. *Kirchneriella lunaris* (Kirch) Moebius	p	a
11. *Nephrocytium obesum* West & West	p	a
12. *Oocystis borgei* Snow	p	a
13. *O. crassa* (West & West) Nordstedt	p	a
14. *O. elliptica* W. West	p	a
15. *O. eremosphaeria* Smith	p	a
16. *O. gigas* Archer	p	a
17. *O. lacustris* Chodat	p	a
18. *O. marsonii* Lemm.	p	a
19. *O. parva* West & West	p	a
20. *O. pyriformis* Prescott	p	a
21. *O. solitaria* Wittrock & Nordstedt	p	a
22. *Planktosphaeria gelatinosa* Smith	p	a
23. *Scotiella antacotica* Fritsch	a	p
24. *Tetraedron asymmetricum* Prescott.	p	a
25. *T. caudatum* (Corda) Hansgirg	p	a
26. *T. muticum* (A. Broun) Hansgirg	c	c
27. *T. miticum* f. *punctulatum* Toni	a	p
28. *T. regulare* var. *incus forma* major Pres.	p	a
29. *T. regulare* var. *torsum* (Turner) Braun.	p	a
30. *T. trigonum* (Naegeli) Hansgirg	p	a
31. *T. tumidulum* (Reinsch) Hansgirg	p	a
32. *T. victoriae* Woloszynska	p	a
33. *Trochiscia hirta* West.	p	a
34. *T. granulata* (Reinsch) Hansgirg	c	c
35. *T. obtusa* (Reinsch) Hansgirg	p	a
36. *T. reticularis* (Reinsch) Hansgirg	p	a
37. *Westella botryoides* (West) Wildemann.	p	a
Family: Dictyosphaeriaceae		
38. *Dictyosphaerium pulchellum* Wood	p	a
39. *Dimorphococcus lunatus* A. Braun	p	a
Family: Characiaceae		
40. *Characium obtusum* A. Braun	c	c
41. *C. ambiguum* Hermann	a	p
42. *C. sphaericum* Naeg.	a	p
Family: Micractiniaceae		
43. *Golenkinia paucispina* West & West.	p	a

(Cont'd....)

(Table 1 Cont'd)

Species	Bakar lake	Phoosna lake
Family: Coelastraceae		
44. *Coelastrum astrodeum* var. *astrodeum*	a	p
45. *C. cambricum* Archer	p	a
46. *C. microporum* Naegeli A. Braun	p	a
47. *C. scarbrum* Reinsch	p	a
48. *C. sphaericum* Naegeli	p	a
Family: Hydrodictyaceae		
49. *Pediastrum boryanum* (Turp.) Men.	p	a
50. *P. tetras* (Ehr.) Ralfs	p	a
Family: Scenedesmaceae		
51. *Actinastrum hantzschii* var. *elongatum* Smith	a	p
52. *Crucigenia apiculata* (Lemm) Schmidle.	p	a
53. *C. irregularis* Wille	a	p
54. *C. quadrata* Morren	p	a
55. *C. rectangularis* (A. Broun) Gay	c	c
56. *C. tetrapedia* (Kirch) W & West	c	c
57. *Scenedesmus arcuatus* Lemm	c	c
58. *S. arcuatus* var. *arcuatus* K. Oshima	a	p
59. *S. arcuatus* var. *platidisca* Smith	p	a
60. *S. bijuga* (Turp.) Lagerheim	p	a
61. *S. ecornis* var. *deciformis* f. *obiciturus* Uherkovich	p	a
62. *S. hystrix* Legerheim	p	a
63. *S. quadricauda* (Turp.) Breb.	c	c
64. *S. quadricauda* var. *parvus* Smith	p	a
65. *Tetrallantos lagerheimii* Teiling	a	p
Order: Tetrasporales		
Family: Palmellaceae		
66. *Gloeocystis ampla* Kuetz. Legerheim	p	a
67. *G. major* Gerneck ex Lemm.	p	a
68. *G. vesiculosa* Naegeli	p	a
69. *Gloiococcus mucosus* West	p	a
70. *Palmella miniata* Naegeli	p	a
71. *Sphaerocystis schroeteri* Chodat	p	a
Family: Cocomaxaceae		
72. *Elakatothrix viridis* (Snow) Printz	a	p
Family: Tetrasporaceae		
73. *Schizochlamys compacta* Prescott	p	a
74. *S. gelatinosa* A. Braun	p	a
75. *Tetraspora cylindrical* (Wahl.) Agardh.	p	a
Order: Ulotrichales		
Family: Ulotrichaceae		
76. *Geminella crenulatocollis* Prescott	a	p
77. *G. ordinata* (W. & West) Heering	a	p
Order: Volvocales		
Family: Chlamydomonadaceae		
78. *Chlamydomonas ehrenbergii* Gorosh Pascher	p	a
79. *C. epiphytica* G. M. Smith	p	a
80. *C. polyperenoideum* Prescott	p	a
81. *C. pseudopertyi* Pascher	p	a
Family: Volvoaceae		
82. *Eudorina elegans* Ehr.	p	a

(Cont'd....)

(Table 1 Cont'd)

Species	Bakar lake	Phoosna lake
83. *Pandorina morum* Bory	p	a
84. *Volvox aureus* Ehr.	p	a
Order: Zygnematales		
Family: Desmidiaceae/Closterieae		
85. *Closterium acerosum* var. *elongatum* Breb.	a	p
86. *Cl. Dianae* Ehr.	p	a
87. *Cl. Leibleinii* Kuetz.	p	a
88. *Cl. Praelongum* var. *porosum* Kr.	p	a
89. *Cl. Ralfsii* var. *hybridium* Rabenk.	p	a
Sub-Family: Cosmarieae		
90. *Arthrodesmus incus* var. *extensus* Anderson	p	a
91. *Cosmarium contractum* Kirchner	c	c
92. *C. contractum* var. *ellipsoideum* W. & West	p	a
93. *C. crenatum* Ralfs	a	p
94. *C. excavatum* Nordstedt	p	a
95. *C. gibberulum* Lutkem.	p	a
96. *C. granatum* Breb	p	a
97. *C. margaritatum* (Lundell) Roy et Bisset	p	a
98. *C. maximum* (Borgesen) W. West	p	a
99. *C. moniliforme* f. *pandriforme* Heimerdl	p	a
100. *C. moniliforme* var. *limneticum* W. & West	p	a
101. *C. pachydermum* Lund	p	a
102. *C. subtumidum* Nordst.	p	a
103. *C. sulcatum* Nordstedt.	p	a
104. *C. tinctum* var. *tinctum* Ralfs.	p	a
105. *C. turpinii* Breb.	p	a
106. *C. turpinii* Breb var. *intermedium* n.v.	p	a
107. *Cosmocladium constrictum* Archer	p	a
108. *Euastrum binale* (Turpin) Her.	p	a
109. *E. dubium* var. *tropicum* (W. & West) Krieger	p	a
110. *E. pectinatum* Breb.	p	a
111. *Micrasterias pinnatifida* Ralfs	p	a
112. *Penium polymorphum* Perly	p	a
113. *P. simplex Nov.* sp.	p	a
114. *Pleurotaenium ehrenbergii* (Berb.) Bory	p	a
115. *Staurastrum brevispinum* Breb.	p	a
116. *S. gracile* Ralfs	a	p
117. *S. inflexum* Breb.	p	a
118. *S. hexacerum* (Ehr.) Wittr.	p	a
119. *S. hexacerum* (Ehr.) *forma pentagona*	p	a
120. *S. iotanum* var. *longatum* Hirano.	p	a
121. *S. orbiculare* var. *depressum* Roy it Bisset	a	p
122. *S. orbiculare* var. *ralfsii* West & West	p	a
a = absent	17 (13.93%)	94 (77.10%)
p = present	94 (77.10%)	17 (13.93%)
c = common/present	11 (9.02%)	11 (9.02%)
Total present	105	28

Division	Class	Order	Family	Genera	Species
1	1	5	15	45	122

a, Absent; p, Present; c, Common/present.

Table 2
Physico-chemical properties of Lakes Bakar and Phoosna

S. no.	Parameters	Bakar lake		Phoosna lake	
		Min	Max	Min	Max
1.	Soil temperature°C	11.000	26.000	12.0000	24.500
2.	Air temperature°C	17.000	39.000	18.0000	38.000
3.	Water surface temperature°C	15.000	31.300	20.0000	30.000
4.	Water bottom temperature°C	16.000	30.300	18.0000	30.000
5.	pH	7.700	8.900	8.2000	8.500
6.	Turbidity in NTU Range on 100	0.300	6.800	5.0000	45.000
7.	T.D.S (ppm)	220.000	330.000	160.0000	170.000
8.	Conductivity (m.Ohms x^{10})	40.000	103.000	40.0000	58.000
9.	Salinity (NaCl ppt)	0.100	0.700	3.0000	3.800
10.	Humidity (%)	33.000	77.000	31.0000	49.000
11.	Light transparency by Secchi disc (meter)	1.200	3.600	19.0000	43.000 (inch)
12.	Dissolved oxygen (mg/1)	5.000	11.500	5.0000	9.500
13.	Saturation (%)	40.500	91.000	40.5000	75.0000
14.	CO_2 (ppm)	15.000	77.000	(no free)	50.0000
15.	Ammonia nitrogen (NH_3 N_2 ppm)	0.020	0.110	0.0200	0.0400
16.	Density (30°Cg/v)	1.002	1.005	1.0044	1.0058
17.	Water color (Numbers)	12.000	17.000	14.0000	17.0000
18.	Orthophosphate (µg/1)	0.002	0.200	0.0300	0.2450
19.	Total hardness ($CaCO_3$ ppm)	100.000	180.000	400.0000	516.0000
20.	Ca^{++} Hardness (ppm)	60.000	120.000	200.0000	258.0000
21.	Mg Hardness (ppm)	40.000	80.000	200.0000	258.0000
22.	$CaCl_2$ Hardness (ppm)	66.600	109.900	222.0000	286.3800
23.	Mg Cl_2 (ppm)	57.000	109.300	190.0000	245.1000
24.	Grain Per Gallon (GPC)	6.400	10.440	23.2000	29.9300
25.	Refractive index (30°C)	1.330	1.330	1.3325	1.3328
26.	Total depth of lake (meter)	3.000	7.800	2.0000	3.0000
27.	Wave (inch)	2.000	18.000	2.0000	5.0000
28.	Taste	Tastless	Tastless	Tastless	Tastless
29.	Odour	Odourless	Fishy	Odourless	Fishy
30.	Wind	Cold	Dry hot	Cold	Dry hot
31.	Day	Cloudy	Clear	Cloudy	Clear
32.	Weather	Fogy	Dry clear	Fogy	Dry clear
33.	Wind in winter	North to South		North to South	
34.	Wind in summer	South to North		South to North	
35.	Water	Shallow near bank	Deep at centre	Shallow	Shallow
36.	Soil	Sandy on bank	Muddy in bottom	Muddy	Muddy
37.	Zone	Subtropical		Subtropical	

of water the species recorded are both soft and hard water species. The physico-chemical properties of the Lake clearly indicate that Lake Bakar is quite productive as compared to Lake Phoosna. The size and weight of the fish increases tremendously within one year which is more than 3 kgs. The fish species locally called Kurro and Dumbro attain the weight of 18 kgs which was recorded from this Lake. This clearly indicates that the ecological conditions of Bakar Lake are much better and suitable for the fish and other fauna.

The physico-chemical features of lake water are presented in Table 2. Dickman (1969) stated that lakes which act as temporary impoundments to the flow of water from inlet and outlet are unusual in species population because of the major role of flushing in regulating their primary productivity. Bakar Lake also act as a temporary impoundment and it appears that flushing may be a major cause of observed irregularities. Physical, chemical and biological features are strongly conditioned by surface level fluctuations, due to flooding and dewatering (Thornton *et al* 1990).

Table 3
Seasonal variation of unicellular phytoplankton of Lake Bakar

S.no	Species	Summer J-A	Autumn S-N	Winter D-F	Spring M-M
Division: Chlorophyta					
Class: Chlorophyceae					
Order: Chlorococcales					
Family: Oocystaceae					
1.	*Ankistrodesmus convolutes* Corda	c	c	c	c
2.	*A. falcatus* (Corda) Ralfs	c	c	c	c
3.	*A. falcatus* var. *stipitatus* (Chod) Lemm	c	c	c	c
4.	*Chlorella vulgaris* Beyerinck	a	r	c	c
5.	*Chodatella baltonica* Scherfell	a	vr	r	vr
6.	*C. chodatii* (Ber.) Leg. var. *chodatii*	a	a	a	a
7.	*Closteriopsis longissima* var. *tropical* W. & W.	a	a	vr	r
8.	*Excentrosphaera virdis* Moore	a	a	vr	vr
9.	*Gloeotaenium loitelsbergerianum* Hansgirg	a	a	vr	vr
10.	*Kirchneriella lunaris* (Kirch) Moebius	vc	c	c	c
11.	*Nephrocytium obesum* West & West	r	r	c	r
12.	*Oocystis borgei* Snow	c	c	c	c
13.	*O. crassa* (West & West) Nordstedt	r	r	c	r
14.	*O. elliptica* W. West	a	r	r	a
15.	*O. eremosphaeria* Smith	vr	vr	r	r
16.	*O. gigas* Archer	a	a	vr	vr
17.	*O. lacustris* Chodat	a	a	vr	a
18.	*O. marsonii* Lemm.	a	a	vr	a
19.	*O. parva* West & West	a	a	vr	r
20.	*O. pyriformis* Prescott	a	a	vr	vr
21.	*O. solitaria* Wittrock & Nordstedt	a	a	vr	a
22.	*Planktosphaeria gelatinosa* Smith	vr	r	r	r
23.	*Scotiella antacotica* Fritsch	a	a	a	a
24.	*Tetraedron asymmetricum* Prescott.	a	a	vr	vr
25.	*T. caudatum* (Corda) Hansgirg	a	a	vr	a
26.	*T. muticum* (A. Broun) Hansgirg	c	c	c	c
27.	*T. miticum* f. *punctulatum* Toni	a	a	a	a
28.	*T. regulare* var. *incus forma* major Pres.	a	a	vr	a
29.	*T. regulare* var. *torsum* (Turner) Braun.	vr	r	c	r
30.	*T. trigonum* (Naegeli) Hansgirg	c	c	c	c
31.	*T. tumidulum* (Reinsch) Hansgirg	a	a	a	vr
32.	*T. victroiae* Woloszynska	a	a	vr	r
33.	*Trochiscia hirta* West.	a	a	c	c
34.	*T. granulata* (Reinsch) Hansgirg	c	c	c	c
35.	*T. obtusa* (Reinsch) Hansgirg	a	a	vr	a
36.	*T. reticularis* (Reinsch) Hansgirg	a	a	vr	a
37.	*Westella botryoides* (West) Wildemann.	a	a	a	vr
Family: Dictyosphaeriaceae					
38.	*Dictyosphaerium pulchellum* Wood	a	vr	vr	r
39.	*Dimorphococcus lunatus* A. Braun	c	vr	c	vc
Family: Characiaceae					
40.	*Characium obtusum* A. Braun	c	c	c	c

(Cont'd....)

(Table 3 Cont'd....)

S.no	Species	Summer J-A	Autumn S-N	Winter D-F	Spring M-M
41.	*C. ambiguum* Hermann	a	a	a	a
42.	*C. sphaericum* Naeg.	a	a	a	a
Family: Micractiniaceae					
43.	*Golenkinia paucispina* West & West	a	a	vr	r
Family: Coelastraceae					
44.	*Coelastrum astrodeum* var. *astrodeum*	a	a	a	a
45.	*C. cambricum* Archer	a	vr	c	r
46.	*C. microporum* Naegeli A. Braun	vr	vr	c	r
47.	*C. scarbrum* Reinsch	a	a	vr	vr
48.	*C. sphaericum* Naegeli	a	a	vr	r
Family: Hydrodictyaceae					
49.	*Pediastrum boryanum* (Turp.) Men.	r	r	r	r
50.	*P. tetras* (Ehr.) Ralfs	vr	r	r	c
Family: Scenedesmaceae					
51.	*Actinastrum hantzschii* var. *elongatum* Smith	a	a	a	a
52.	*Crucigenia apiculata* (Lemm) Schmidle.	a	vr	vr	r
53.	*C. irregularis* Wille	a	a	a	a
54.	*C. quadrata* Morren	a	vr	r	a
55.	*C. rectangularis* (A. Braun) Gay	c	c	c	c
56.	*C. tetrapedia* (Kirch) W & West	c	c	c	c
57.	*Scenedesmus arcuatus* Lemm	c	c	c	c
58.	*S. arcuatus* var. *arcuatus* K. Oshima	a	a	a	a
59.	*S. arcuatus* var. *platidisca* Smith	r	r	r	r
60.	*S. bijuga* (Turp.) Lagerheim	r	r	r	r
61.	*S.ecronis* var. *deciformis* f. *obicitutus* Uherkovich	a	a	vr	a
62.	*S. hystrix* Legerheim	a	vr	vr	a
63.	*S. quadricauda* (Turp.) Breb.	c	c	c	c
64.	*S. quadricauda* var. *parvus* Smith	a	vr	vr	a
65.	*Tetrallantos lagerheimii* Teiling	a	a	a	a
Order: Tetrasporales					
Family: Palmellaceae					
66.	*Gloeocystis ampla* Kuetz. Legerheim	r	r	r	r
67.	*G. major gerneck* ex Lemm.	r	r	r	r
68.	*G. vesiculosa* Naegeli	r	r	r	r
69.	*Gloiococcus mucosus* West	a	vr	vr	a
70.	*Palmella miniata* Naegeli	vr	vr	r	r
71.	*Sphaerocystis schroeteri* Chodat	vr	r	r	r
Family: Cocomaxaceae					
72.	*Elakatothrix virdis* (Snow) Printz	a	a	a	a
Family: Tetrasporaceae					
73.	*Schizochlamys compacta* Prescott	a	a	vr	a
74.	*S. gelatinosa* A. Braun	a	vr	vr	a
75.	*Tetraspora cylindrical* (Wahl.) Agardh.	a	r	r	r
Order: Ulotrichales					
Family: Ulotrichaceae					
76.	*Geminella crenulatocollis* Prescott	a	a	a	a
77.	*G. ordinata* (W. & West) Heering	a	a	a	a
Order: Volvocales					
Family: Chlamydomonadaceae					
78.	*Chlamydomonas ehrenbergii* Gorosh Pascher	vr	vr	r	r

(Cont'd....)

(Table 3 Cont'd....)

S.no	Species	Summer J-A	Autumn S-N	Winter D-F	Spring M-M
79.	*C. epiphytica* G.M. Smith	r	r	r	r
80.	*C. polyperenoideum* Prescott	a	vr	vr	a
81.	*C. pseudopertyi* Pascher	a	vr	vr	vr
Family: Volvocaceae					
82.	*Eudorina elegans* Ehr.	a	vr	vr	vr
83.	*Pandorina morum* Bory	a	vr	vr	a
84.	*Volvox aureus* Ehr.	a	a	vr	a
Order: Zygnematales					
Family: Desmidiaceae/Closterieae					
85.	*Closterium acerosum* var. *elongatum* Breb.	a	a	a	a
86.	*Cl. dianae* Ehr.	r	r	r	r
87.	*Cl. leibleinii* Kuetz.	a	a	vr	vr
88.	*Cl. praelongum* var. *porosum* Kr.	r	a	vr	a
89.	*Cl. ralfsii* var. *hybridium* Rabenk.	vr	vr	r	r
Sub-family: Cosmarieae					
90.	*Arthrodesmus incus* var. *extensus* Anderson	vr	vr	vr	vr
91.	*Cosmarium contractum* Kirchner	c	c	c	c
92.	*C. contractum* var. *ellipsoideum* W. & West	r	r	r	r
93.	*C. crenatum* Ralfs	a	a	a	a
94.	*C. excavatum* Nordstedt	vr	vr	vr	vr
95.	*C. gibberulum* Lutkem.	r	vr	vr	r
96.	*C. granatum* Breb	r	r	r	r
97.	*C. margaritatum* (Lundell) Roy et Bisset	vr	vr	r	vr
98.	*C. maximum* (Borgesen) W. & West	vr	vr	r	r
99.	*C. moniliforme* f. *pandriforme* Heimerdl	a	vr	a	a
100.	*C. moniliforme* var. *limneticum* W. & West	a	vr	vr	a
101.	*C. pachydermum* Lund	a	vr	vr	a
102.	*C. subtumidum* Nordst.	a	vr	vr	a
103.	*C. sulcatum* Nordstedt.	a	vr	a	a
104.	*C. tinctum* var. *tinctum* Ralfs.	a	vr	vr	a
105.	*C. turpinii* Breb.	a	vr	vr	a
106.	*C. turpinii* Breb var. *intermedium* n.v.	a	vr	vr	a
107.	*Cosmocladium constrictum* Archer	a	vr	vr	a
108.	*Euastrum binale* (Turpin) Her.	a	vr	vr	a
109.	*E. dubium* var. *tropicum* (W. & West) Krieger	a	vr	vr	a
110.	*E. pectinatum* Breb.	a	vr	vr	a
111.	*Micrasterias pinnatifida* Ralfs	a	a	a	vr
112.	*Penium polymorphum* Perly	vr	vr	r	r
113.	*P. simplex Nov.*sp.	r	r	r	r
114.	*Pleurotaenium ehrenbergii* (Breb.) Bory	vr	r	r	vr
115.	*Staurastrum brevispinum* Breb.	a	vr	vr	a
116.	*S. gracile* Ralfs	a	a	a	a
117.	*S. inflexum* Breb.	a	vr	vr	a
118.	*S. hexacerum* (Ehr.) Wittr.	a	a	a	a
119.	*S. hexacerum* (Ehr.) *forma pentagona*	a	vr	vr	a
120.	*S. iotanum* var. *longatum* Hirano.	a	vr	vr	a
121.	*S. orbiculare* var. *depressum* Roy it Bisset	a	a	a	a
122.	*S. orbiculare* var. *ralfsii* West & West	a	vr	vr	a

a, Absent; r, Rare; Vr, Very rare; c, Common; J-A, June-August; S-N, Sep-Nov; D-F, Dec-Feb; M-M, March-May

Table 4

Seasonal variation of unicellular phytoplankton of Lake Phoosna

S.no	Species	SummerJ-A	Autumn S-N	Winter D-F	Spring M-M
Division: Chlorophyta					
Class: Chlorophyceae					
Order: Chlorococcales					
Family: Oocystaceae					
1.	*Ankistrodesmus convolutes* Corda	c	c	c	c
2.	*A. falcatus* (Corda) Ralfs	c	c	c	c
3.	*A. falcatus* var. *stipitatus* (Chod) Lemm	c	c	c	c
4.	*Chlorella vulgaris* Beyerinck	a	a	a	a
5.	*Chodatella baltonica* Scherfell	a	a	a	a
6.	*C. chodatti* (Ber.) Leg. var. *chodatii*	r	r	r	r
7.	*Closteriopsis longissima* var. *tropical* W. & W.	a	a	a	a
8.	*Excentrosphaera virdis* Moore	a	a	a	a
9.	*Gloeotaenium loitelsbergerianum* Hansgirg	a	a	a	a
10.	*Kirchneriella lunaris* (Kirch) Moebius	a	a	a	a
11.	*Nephrocytium obesum* West & West	a	a	a	a
12.	*Oocystis borgei* Snow	a	a	a	a
13.	*O. crassa* (West & West) Nordstedt	a	a	a	a
14.	*O. elliptica* W. & West	a	a	a	a
15.	*O. eremosphaeria* Smith	a	a	a	a
16.	*O. gigas* Archer	a	a	a	a
17.	*O. lacustris* Chodat	a	a	a	a
18.	*O. marsonii* Lemm.	a	a	a	a
19.	*O. parva* West & West	a	a	a	a
20.	*O. pyriformis* Prescott	a	a	a	a
21.	*O. solitaria* Wittrock & Nordstedt	a	a	a	a
22.	*Planktosphaeria gelatinosa* Smith	a	a	a	a
23.	*Scotiella antacotica* Fritsch	r	r	r	r
24.	*Tetraedron asymmetricum* Prescott.	a	a	a	a
25.	*T. caudatum* (Corda) Hansgirg	a	a	a	a
26.	*T. muticum* (A. Broun) Hansgirg	c	c	c	c
27.	*T. miticum* f. *punctulatum* Toni	r	r	r	r
28.	*T. regulare* var. *incus forma* major Pres.	a	a	a	a
29.	*T. regulare* var. *torsum* (Turner) Braun.	a	a	a	a
30.	*T. trigonum* (Naegeli) Hansgirg	a	a	a	a
31.	*T. tumidulum* (Reinsch) Hansgirg	a	a	a	a
32.	*T. victoriae* Woloszynska	a	a	a	a
33.	*Trochiscia hirta* West.	a	a	a	a
34.	*T. granulata* (Reinsch) Hansgirg	c	c	c	c
35.	*T. obtusa* (Reinsch) Hansgirg	a	a	a	a
36.	*T. reticularis* (Reinsch) Hansgirg	a	a	a	a
37.	*Westella botryoides* (West) Wildemann.	a	a	a	a
Family: Dictyosphaeriaceae					
38.	*Dictyosphaerium pulchellum* Wood	a	a	a	a
39.	*Dimorphococcus lunatus* A. Braun	a	a	a	a
Family: Characiaceae					
40.	*Characium obtusum* A. Braun	c	c	c	c
41.	*C. ambiguum* Hermann	r	r	r	r
42.	*C. spharicum* Naeg.	r	r	r	r

(Cont'd....)

(Table 4 Cont'd....)

S.no	Species	Summer J-A	Autumn S-N	Winter D-F	Spring M-M
Family: Micractiniaceae					
43.	*Golenkinia paucispina* West & West.	a	a	a	a
Family: Coelastraceae					
44.	*Coelastrum astrodeum* var. *astrodeum*	r	r	r	r
45.	*C. cambricum* Archer	a	a	a	a
46.	*C. microporum* Naegeli A. Braun	a	a	a	a
47.	*C. scarbrum* Reinsch	a	a	a	a
48.	*C. sphaericum* Naegeli	a	a	a	a
Family: Hydrodictyaceae					
49.	*Pediastrum boryanum* (Turp.) Men.	a	a	a	a
50.	*P. tetras* (Ehr.) Ralfs	a	a	a	a
Family: Scenedesmaceae					
51.	*Actinastrum hantzschii* var. *elongatum* Smith	vr	vr	vr	vr
52.	*Crucigenia apiculata* (Lemm) Schmidle.	a	a	a	a
53.	*C. irregularis* Wille	vr	vr	vr	vr
54.	*C. quadrata* Morren	a	a	a	a
55.	*C. rectangularis* (A. Broun) Gay	c	c	c	c
56.	*C. tetrapedia* (Kirch) W & West	c	c	c	c
57.	*Scenedesmus arcuatus* Lemm	c	c	c	c
58.	*S. arcuatus* var. *arcuatus* K. Oshima	r	r	r	r
59.	*S. arcuatus* var. *platidisca* Smith	a	a	a	a
60.	*S. bijuga* (Turp.) Lagerheim	a	a	a	a
61.	*S.ecornis* var. *deciformis* f. *obiciturus* Uherkovich	a	a	a	a
62.	*S. hystrix* Legerheim	a	a	a	a
63.	*S. quadricauda* (Turp.) Breb.	c	c	c	c
64.	*S. quadricauda* var. *parvus* Smith	a	a	a	a
65.	*Tetrallantos lagerheimii* Teiling	vr	vr	vr	vr
Order: Tetrasporales					
Family: Palmellaceae					
66.	*Gloeocystis ampla* Kuetz. Legerheim	a	a	a	a
67.	*G. major* Gerneck ex Lemm.	a	a	a	a
68.	*G. vesiculosa* Naegeli	a	a	a	a
69.	*Gloiococcus mucosus* West	a	a	a	a
70.	*Palmella miniata* Naegeli	a	a	a	a
71.	*Sphaerocystis schroeteri* Chodat	a	a	a	a
Family: Cocomaxaceae					
72.	*Elakatothrix viridis* (Snow) Printz	r	r	r	r
Family: Tetrasporaceae					
73.	*Schizochlamys compacta* Prescott	a	a	a	a
74.	*S. gelatinosa* A. Braun	a	a	a	a
75.	*Tetraspora cylindrical* (Wahl.) Agardh.	a	a	a	a
Order: Ulotrichales					
Family: Ulotrichaceae					
76.	*Geminella crenulatocollis* Prescott	vr	vr	vr	vr
77.	*G. ordinata* (W & West) Heering	vr	vr	vr	vr
Order: Volvocales					
Family: Chlamydomonadaceae					
78.	*Chlamydomonas ehrenbergii* Gorosh Pascher	a	a	a	a
79.	*C. epiphytica* G.M. Smith	a	a	a	a

(Cont'd....)

(Table 4 Cont'd....)

S.No	Species	Summer J-A	Autumn S-N	Winter D-F	Spring M-M
80.	*C. polyperenoideum* Prescott	a	a	a	a
81.	*C. pseudopertyi* Pascher	a	a	a	a
Family: Volvocaceae					
82.	*Eudorina elegans* Ehr.	a	a	a	a
83.	*Pandorina morum* Bory	a	a	a	a
84.	*Volvox aureus* Ehr.	a	a	a	a
Order: Zygnematales					
Family: Desmidiaceae/Closterieae					
85.	*Closterium acerosum* var. *elongatum* Breb.	r	r	r	r
86.	*Cl. Dianae* Ehr.	a	a	a	a
87.	*Cl. Leibleinii* Kuetz.	a	a	a	a
88.	*Cl. Praelongum* var. *porosum* Kr.	a	a	a	a
89.	*Cl. Ralfsii* var. *hybridium* Rabenk.	a	a	a	a
Sub-Family: Cosmarieae					
90.	*Arthrodesmus incus* var. *extensus* Anderson	a	a	a	a
91.	*Cosmarium contractum* Kirchner	c	c	c	c
92.	*C. contractum* var. *ellipsodieum* W. & West	a	a	a	a
93.	*C. crenatum* Ralfs	r	r	r	r
94.	*C. excavatum* Nordstedt	a	a	a	a
95.	*C. gibberulum* Lutkem.	a	a	a	a
96.	*C. granatum* Breb	a	a	a	a
97.	*C. margaritatum* (Lundell) Roy et Bisset	a	a	a	a
98.	*C. maximum* (Borgesen) W. West	a	a	a	a
99.	*C. moniliforme* f. *pandriforme* Heimerdl	a	a	a	a
100.	*C. moniliforme* var. *limneticum* W. & West	a	a	a	a
101.	*C. pachydermum* Lund	a	a	a	a
102.	*C. subtumidum* Nordst.	a	a	a	a
103.	*C. sulcatum* Nordstedt.	a	a	a	a
104.	*C. tinctum* var. *tinctum* Ralfs.	a	a	a	a
105.	*C. turpinii* Breb.	a	a	a	a
106.	*C. turpinii* Breb var. *intermedium* n.v.	a	a	a	a
107.	*Cosmocladium constrictum* Archer	a	a	a	a
108.	*Euastrum binale* (Turpin) Her.	a	a	a	a
109.	*E. dubium* var. *tropicum* (W. & West) Krieger	a	a	a	a
110.	*E. pectinatum* Breb.	a	a	a	a
111.	*Micrasterias pinnatifida* Ralfs	a	a	a	a
112.	*Penium polymorphum* Perly	a	a	a	a
113.	*P. simplex Nov.* sp.	a	a	a	a
114.	*Pleurotaenium ehrenbergii* (Breb.) Bory	a	a	a	a
115.	*Staurastrum brevispinum* Breb.	a	a	a	a
116.	*S. gracile* Ralfs	vr	vr	vr	vr
117.	*S. inflexum* Breb.	a	a	a	a
118.	*S. hexacerum* (Ehr.) Wittr.	a	a	a	a
119.	*S. hexacerum* (Ehr.) *forma pentagona*	a	a	a	a
120.	*S. iotanum* var. *longatum* Hirano.	a	a	a	a
121.	*S. orbiculare* var. depressum Roy it Bisset	vr	r	r	vr
122.	*S. orbiculare* var. *ralfsii* West & West	a	a	a	a

a, Absent; r, Rare; vr, Very rare; c, Common; vc, Very common.

J-A, June-August; S-N, Sept.-Nov.; D-F, Dec.-February; M-M, March-May

Generally inlet in Bakar Lake is from June to December and outlet from January to May every year. Water level fluctuation are particularly striking because of semi arid climate where evaporation rates are greater than precipitation and the irregular inflows generally are not balanced by out flow. As a whole, the phytoplankton seems to be strongly related to the water level fluctuation and the climatological features, and it seems reasonable to hypothesize that abiotic (e.g. flooding, dewatering, light, mixing, temprature, turbidity, rain, storm, wind, etc.) factors mainly affected the phytoplanktons in the study period also by inhibiting or delaying the development of that biotic relationship (i.e. fry predation efficiency) which commonly takes place in aquatic environments.

Phytoplankton are cosmopolitan species, found throughout the year. They are abundant in the inlet waters of the Lake, where grazing and other disturbances occur. Some of the phytoplankton species survive in cold waters and in low orthophosphate ratio containing waters. Their abundance can easily be judged by measuring the density of water samples. Normally water density is one (1) and any increase in the density is attributed to the ratio of phytoplanktons in the water samples.

An increase in the temperature of water help to dissolve the minerals resulting in pH increase which results in the increase of phytoplankton production.

Similarly the change in the colour of water from grey to greenish to dark green also results in the high production of phytoplankton. The reason may be that dark colour resists the light and ultimately temperature of water increases. The distribution of phytoplankton is also affected by the direction of the winds. In summers the winds blow from South to North and this drifts the concentration of phytoplankton in the northern banks of the Lakes and reverse happens in winters, when the winds blow from North to South concentrating the phytoplankton flora in the southern banks.

It has also been observed that floods cause increase in turbidity causing changes in the concentration of phytoplankton. They become rare with the storm and disturbed in turbidity. But as soon as the particles of clay, mud, sands etc. in water, settles down there is increased flora of the Lakes. The sampling were done throughout the year and effects of these factors on the distribution and concentration of phytoplankton were observed during the study and sampling period (Table 3 and 4). It is interesting to note that abundant species of the phytoplankton isolated from these studies were recorded from the gut content of the fish caught from these waters.

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