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Cyanophyceae of Two Freshwater Lakes of Hyderabad

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Cynaophyceae were the dominant group (65–90% of total and 19% of the total algal species recorded) of phytoplanktons in the Osman Sagar and Mir Alam lakes. Oxidisable organic matter and cations seem to have played an important role in the spatio-temporal distribution of the blue-greens. The blue-green biomass was more significant in Mir Alam, which was possibly inhibited by the diatoms in the Osman Sagar lake. *Anabaenopsis raciborskii* Wolosz., *Raphidiopsis mediterranea* Skuja, *Merismopedia punctata* Meyen, *Phormidium foveolarum* (Mont.) Gomont. and *Chroococcus minutus* (Kuetz.) Naeg. were the dominant blue-green algae which appeared throughout the period of study (in that decreasing order).

Key Words: Osman Sagar, Mir Alam, Cyanophyceae, Distribution, Periodcity

Introduction

Blue-green algae are reported to be dominant in the phytoplanktons of tropical freshwaters (Singh 1955). Nutrient enrichment and eutrophication processes are said to cause proliferation of these algae. The plasticity of their photosynthetic apparatus (Krogmann 1973) and their ability to assimilate a variety of biogenic organic compounds (Smith 1973) are also suspected to be responsible for their qualitative and quantitative preponderance. Their spatio-temporal distribution in Indian waters has been recorded by Gonzalves and Joshi (1946). Chakrabarty et al. (1959), Ganapati (1960), Singh (1960), Zafar (1967), Seenayya (1971), Jana (1973), Rao (1975), Cynthia (1980), Khanum (1980) and Reddy (1984). This paper attempts to examine the parameters that determine the periodicity and distribution of the blue-green algae in two man-made lakes, viz. Osman Sagar and Mir Alam, lying in the vicinity of Hyderabad metropolis.

The Lakes

Hyderabad is situated at 17°22'N and 78°27'E at an elevation of 540 meters above the mean sea level. Climatically it is in the tropical region with cyclic rains. The air temperature rises to a maximum 43°C in summer and falls to 12°C in winter. The average annual rainfall is 65 cm.

Osman Sagar built across River Musi, is the main source of drinking water lake for Hyderabad metropolis. Mir Alam, a closed lake, which presently caters to the needs of the zoo situated along its bank, was till recently used for public consumption. The physiographical features of these lakes are given in table 1.

Methods

Surfacial water from Osman Sagar and Mir Alam lakes was studied at monthly intervals for two consecutive years (1977–78). Three sampling stations on each lake were earmarked—two from offshore (Stations designated as 1 and 2 in the text) and one onshore or nearshore (Station 3 in the text) regions. Standard methods prescribed by APHA (1971) were followed for chemical analysis of water. Samples for phytoplankton were sedimented in 1 litre measuring cylinders for a fortnight after fixation with Lugol's solution (Vollenweider 1969). Enumeration of phytoplankton

was done using a Sedwigrafter Counting Cell and the results are reported as 'organisms per litre of lake water'. Phytoplankton biomass was studied only in the second year. For this 1 litre of the water sample was passed through ash-less, pre-dried and pre-weighed Whatman filter disc (No. 42) under indirect suction. The filter was dried at room temperature for an hour and weighed again. The difference is referred to as 'air-dry' or 'fresh weight'. The filter paper was dried further in an oven at 105°C for 1 hr, cooled in a desiccator and weighed. The difference of air-dry and oven-dry material represented 'oven-dry biomass'. The filter paper was then ignited in a muffle furnace at 800°C for 2 hr and the weight of the 'residual ash' was determined. The difference of oven-dry weight and ash is referred to as the 'loss on ignition'. Pigments were extracted following the procedures of Richards and Thompson (1952) as modified by Parsons and Strickland (1963). Statistical calculations were made as per the formulae of Panse and Sukhatme revised by Sukhatme and Amble (1978).

Table 1 *Physiographical features of Osman Sagar and Mir Alam*

	Osman Sagar	Mir Alam
Catchment area (km^2)	740.74	16.50
Capacity at storage level (Mm^3)	136.41	8.12
Maximum water spread (km^2)	22.12	1.69
Maximum depth (m)	31.70	13.41
Maximum length (km)	11.28	2.54
Mean width (km)	1.96	0.67
Volume development	0.58	1.07

Table 2 *Phytoplankton distribution in Osman Sagar and Mir Alam lakes (Values in org/l)*

	Osman Sagar			Mir Alam		
Station	1	2	3	1	2	3
Chloro-phyceae	541	515	333	6572	6018	3090
Eugleno-phyceae	144	84	76	296	220	1783
Bacillario-phyceae	3145	3052	3866	8237	8981	17528
Dinophyceae	331	241	224	3225	3341	620
Cyano-phyceae	11404	10838	5994	339731	351735	56185
Total algae	15565	14730	10493	358061	370295	79206

Results and Discussion

Blue-greens formed the largest group of phytoplanktons in these lakes (table 2). Quantitatively they constituted about 65% of the phytoplanktons in Osman Sagar lake and around 93% in Mir Alam lake. Diatoms formed the second largest group. Green algae and the phyto-flagellates were fewer in these lakes. Qualitatively and quantitatively blue-greens were more abundant in the offshore regions and much less in the nearshore stations (table 3). Thirty species of blue-greens were recorded in the present study, which formed 19% of the total number of algal species encountered. The species in the decreasing order of dominance were *Anabaenopsis raciborskii* Wolosz., *Raphidiopsis mediterranea* Skuja, *Merismopedia punctata* Meyen, *Phormidium foveolarum* (Mont.) Gomont. and *Chroococcus minutus* (Kuetz.) Naeg.

While *Aphanothece* sp. and *Oscillatoria geminata* Menegh. were confined to the Osman Sagar lake only, *Microcystis* sp., *Synechocystis aquatilis* Sauv., *Merismopedia minima* Beck., *O. amphigranulata* Van Goor, *Anabaenopsis circularis* var. *javanica* Wolosz., and *Nostoc* sp. were recorded only from the Mir Alam lake (table 4). *Chroococcus minor* (Kuetz.) Naeg., *C. turgidus* (Kuetz.) Naeg., *Synechocystis aquatilis*, *Merismopedia minima*, *Aphanothece* sp., *O. angusta* Koppe, *Phormidium laminosum* Gomont. and *Lyngbya limnetica* Lemm. were recorded from the offshore zones while *Nostoc* sp. confined itself to the shallower regions of these lakes. *Aphanocapsa* sp., *Synechococcus* sp., *Merismopedia punctata*, *Gomphosphaeria aponina* Kuetz., *Phormidium foveolarum*, *Lyngbya perelegans* Lemm., *Anabaena* sp. and *Anabaenopsis raciborskii* were present in both the lakes. The difference in chemistry of the lakes was possibly responsible for such a distribution pattern (table 5). Both the lakes are of alkaline-bicarbonate type with *p*H never recording below 7.6. The study shows no conspicuous variation of *p*H—spatially or temporally—to have any influence on the blue-greens.

Table 3 *Station-wise distribution of blue-green algae in Osman Sagar and Mir Alam lakes*

	Osman Sagar			Mir Alam		
Station	1	2	3	1	2	3
No. of species	16	17	13	20	27	18
Org/l($\times 10^3$)	11.40	10.83	5.99	339.73	351.73	56.19
% composition of total plankton	66.69	66.13	59.33	94.01	93.77	52.29

Mir Alam lake, in general, had more concentrations of inorganic carbon, chloride, organic matter, phosphate, cations and total solids. Osman Sagar lake had more nitrogen and showed cationic composition as Ca > Mg > Na > K. Mir Alam lake was poor in nitrogen with cations as Ca > Na > Mg > K. This is in contrast to the findings of Rao (1980) indicating the influence of nitrate-nitrogen on the growth of blue-green algae in a sewage stabilisation model pond. With age, both the lakes are getting enriched chemically, particularly in chloride, organic matter and solids (both total and suspended), and blue-greens, which indicates deterioration in their water quality (table 6).

Table 4 *Qualitative distribution of blue-green species in the Osman Sagar and Mir Alam lakes*

	Osman Sagar			Mir Alam		
Station	1	2	3	1	2	3
Chroococcus minor (Kuetz.) Naeg.					+	
C. minutus (Kuetz.) Naeg.	+		+ +	+ + +	+ + +	+ + +
C. turgidus (Kuetz.) Naeg.		+			+	
Gloeocapsa sp.	+	+		+	+ +	+
Synechocystis aquatilis Sauv.				+ +	+ +	
S. pevalekii Erceg.	+	+		+ +	+ +	+ +
Aphanocapsa sp.	+	+	+	+	+ +	+
Microcystis sp.				+	+	+
Synechococcus sp.	+	+	+	+	+ +	+
Aphanothece sp.	+	+				
Merismopedia minima Beck.					+ +	
M. punctata Meyen	+ + +	+ + +	+ +	+ + +	+ + +	+ + +
Coelosphaerium kutzingianum Naeg.	+	+		+	+ +	+
Gomphosphaeria aponina Kuetz.	+	+	+ +	+	+ +	+
Spirulina sp.	+			+ +	+ + +	+ +
Oscillatoria amphigranulata Van Goor				+ +	+ +	+ +
O. angusta Koppe		+			+	
O. chalybea (Mertens) Gomont.				+	+	
O. geminata Menegh.	+		+			
O. limnetica Lemm.		+	+		+	
O. princeps Vaucher ex Gomont.			+		+	
Phormidium laminosum Gomont.		+			+	
P. foveolarum (Mont.) Gomont.	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +
Lyngbya limnetica Lemm.	+	+		+	+	
L. perelegans Lemm.	+ +	+ +	+ +	+ + +	+ + +	+ + +
Anabaena sp.	+ +	+ +	+	+	+ +	+
Anabaenopsis circularis var. *javanica* Wolosz.				+	+ +	+
A. raciborskii Wolosz.	+ + +	+ + +	+ + +	+ + +	+ + +	+ + +
Nostoc sp.						+
Raphidiopsis mediterranea Skuja			+ +	+ + +	+ + +	+ + +

\+ Present + + Common + + + Dominant

A number of researchers have given prime importance to oxidisable organic matter in the ecology of blue-greens. These include Pearsall (1923, 1932), Yeshimura (1932), Gonzalves and Joshi (1946), Komarovsky (1953), Rao (1955) and Zafar (1967). This was true to a great extent in the lake-wise distribution (table 7), but Station 3 of Mir Alam lake with high averages of organic matter harboured unexpectedly less number. Interestingly, the relative proportions of carbonaceous (C) and nitrogenous (N) organic matter were more closely associated with the distribution of blue-greens (table 8). Another chemical parameter that apparently influenced the distribution of these algae was sodium. The average concentration of sodium was 57 mg/l for Mir Alam lake and 49 mg/l for the Osman Sagar lake. This difference reflected in harbouring of denser populations of blue-greens in Mir Alam lake. The work of Provasoli (1969) also suggests the link of sodium with the growth pattern of blue-greens.

Table 5 *Averages of certain chemical parameters recorded from various stations of the Osman Sagar and Mir Alam lakes (Values except pH in mg/l)*

	Osman Sagar			Mir Alam		
Station	1	2	3	1	2	3
*p*H	8.07	8.06	8.1	8.2	8.2	8.1
Inorganic carbon	40.7	39.8	38.1	61.9	62.7	65.5
Chloride	28.9	30.9	32.4	50.8	52.0	49.9
Oxidizable-organic matter	1.8	1.6	1.7	5.7	6.1	5.3
Nitrate	0.73	0.74	0.65	0.6	0.61	0.66
Nitrite	0.008	0.007	0.006	0.003	0.003	0.015
Free ammonia	2.27	2.28	2.36	1.25	1.73	1.86
Albuminoid ammonia	2.17	2.47	1.81	0.81	1.24	1.30
Total phosphorus	0.24	0.24	0.26	0.49	0.49	0.41
Total cations	187.8	186.6	186.3	194.8	198.2	209.6
Total solids	500.9	468.5	476.5	671.2	675.7	772.5

Periodicity

Blue-greens developed more profusely in the first year of observation in both the lakes. That year was characterised by less of rainfall and higher air temperature. Blue-greens multiplied profusely when the water temperature was between 26–29°C. At Station 1 of Osman Sagar they reached their optimum when it was as high as 32°C. Broadly they showed two annual peaks of growth—one in early summer and the other at the end of monsoon season. The early summer peaks in Osman Sagar were dominated by *Merismopedia punctata* and *Anabaenopsis raciborskii* and the late monsoon peak by *A. raciborskii* alone. *Raphidiopsis mediterranea*, *Chroococcus minutus*, *Merismopedia punctata*, *Anabaenopsis raciborskii* and *Phormidium foveolarum* were the late monsoon forms which contributed to the growth peak in Mir Alam. Very heavy rainfall as was witnessed in the second year, reduced their number considerably.

Table 9 enlists the seasonal distribution of blue-greens in these lakes. It is obvious that only a few of the species showed seasonal specificity, while many of them occurred perennially throughout the period of study.

The seasonal fluctuation of individual cation concentration showed little correlation with the periodicity of blue-greens in these lakes. However, at Station 1 of Mir Alam lake calcium reached a maximum of 256.1 mg/l only once and the optimum development of *Raphidiopsis mediterranea* coincided

Table 6 *Rate (mg/l/yr) and per cent accumulation of certain parameters in Osman Sagar and Mir Alam lakes*

	Osman Sagar				Mir Alam			
	Past* average	Present (@ average	Rate of accum.	% acc. year	Past* average	Present (@ average	Rate of accum.	% acc/ year
Chloride	17.75	29.92	+0.87	+4.90	30.92	51.39	+1.46	+4.72
Oxidizable organic matter	2.22	1.66	−0.04	−1.80	3.51	5.87	+0.17	+4.80
Total solids	261.9	484.7	+15.91	+6.07	402.67	673.46	+19.34	+4.80
Susp. solids	37.08	69.39	+2.31	+6.23	37.58	121.94	+6.03	+16.05

* Srinivasan et al. (1965)

(@ Average concentrations of main basin stations (1 and 2)

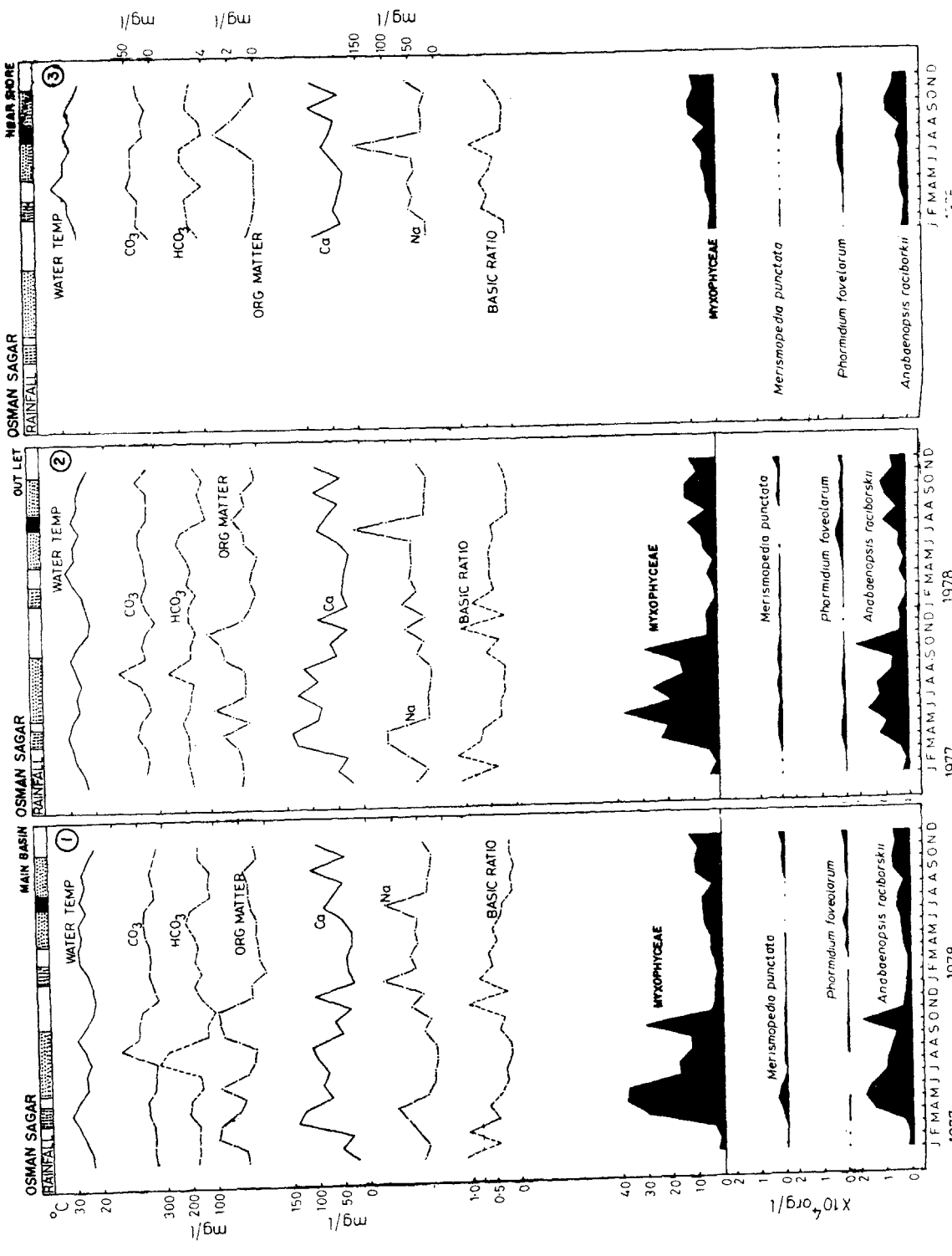

Figure 1 Periodicity of Cyanophyceae and the dominant taxa in the Osman Sagar lake

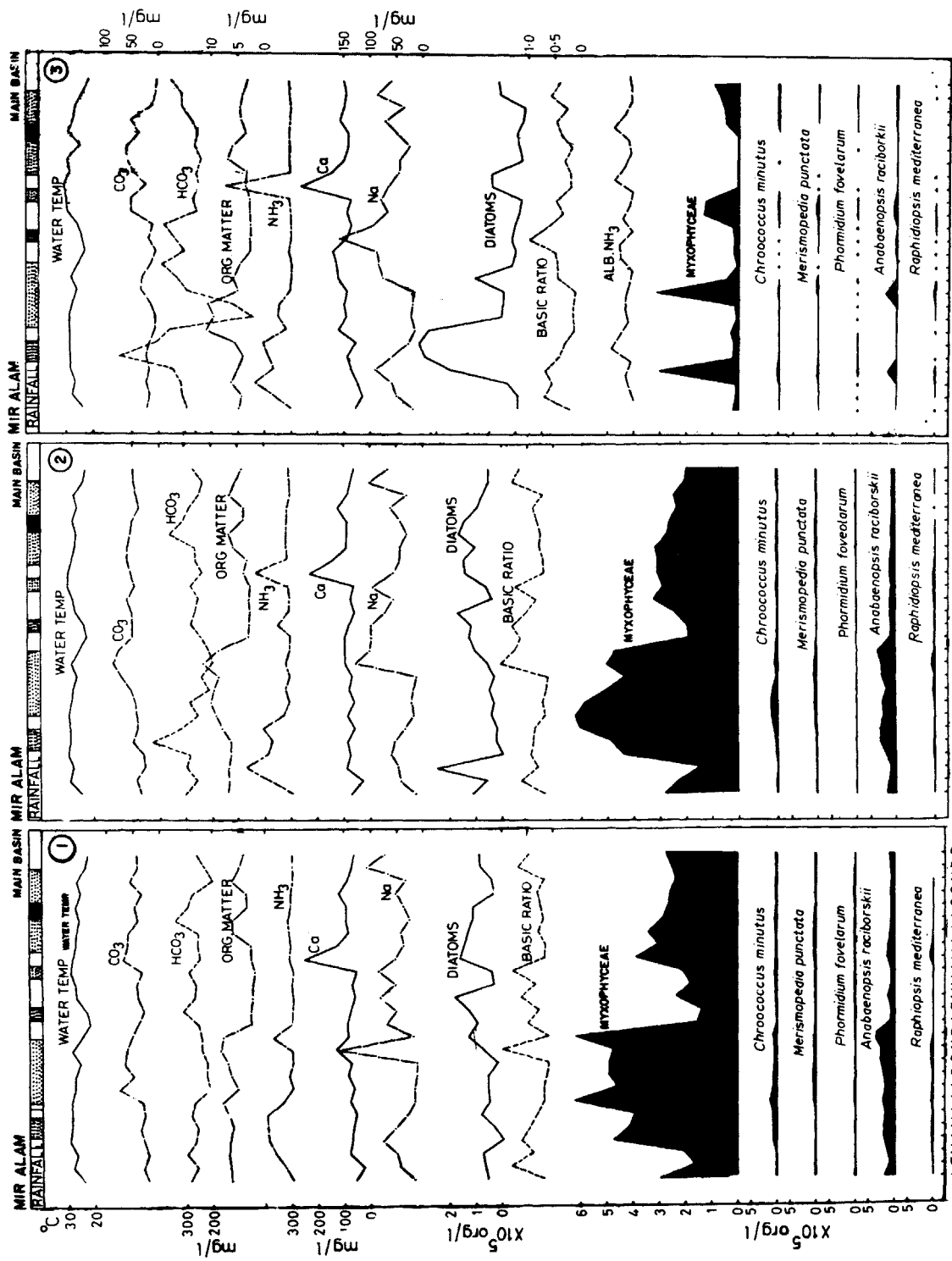

Figure 2 Periodicity of Cyanophyceae and the dominant taxa in the Mir Alam lake

Table 7 *Lakewise averages of blue-green algae in relation to the organic matter content in the two lakes*

	Osman Sagar	Mir Alam
Bluegreen algae ($\times 10^3$ org/l)	9.40	249.2
Oxidizable organic matter (mg/l)	1.65	5.67

Table 8 *Stationwise averages of blue-greens (org/l) shown in relation to C/N and C+N in the two lakes*

	Osman Sagar			Mir Alam		
Station	1	2	3	1	2	3
Bluegreens ($\times 10^3$)	11.4	10.8	5.9	339.7	351.7	56.2
C/N	0.81	0.63	0.91	6.98	4.90	4.07
C+N	3.92	4.02	3.47	6.46	7.32	6.59

Table 9 *Seasonal distribution of blue-green species in the Osman Sagar and Mir Alam lakes*

	Osman Sagar	Mir Alam
Summer forms	*Gloeocapse* sp.	*Coelosphaerium kutzingianum* *Lyngbya perelegans* *Anabaena* sp. *Nostoc* sp.
Monsoon forms	*Chroococcus minutus* *Gomphosphaeria aponina* *Oscillatoria princeps*	
Winter forms	*Chroococcus minor* *Synechococcus* sp. *Aphanocapsa* sp. *Coelosphaerium kutzingianum* *Gomphosphaeria aponina*	*Microcystis* sp. *Oscillatoria princeps* *Lyngbya perelegans*
Perennials	*Merismopedia punctata* *Oscillatoria limnetica* *Phormidium foveolarum* *Lyngbya perelegans* *Anabaena* sp. *Anabaenopsis raciborskii*	*Chroococcus minutus* *Synechocystis pevalekii* *Synechococcus* sp. *Merismopedia punctata* *Spirulina* sp. *Oscillatoria amphigranulata* *O. geminata* *Phormidium foveolarum* *Anabaenopsis raciborskii* *Raphidiopsis mediterranea*

with that. On other occasions the rise in concentrations of sodium (130–160 mg/l) synchronised with the profuse multiplication of that species. May be the waters of high osmotic concentrations favoured its growth. The relative proportions of cations—Na + K/Ca + Mg (expressed as basic ratio) in the range of 0.1–1.0 was helpful in the growth of certain blue-green species. For example, *Merismopedia punctata* was prolific at 0.63 and *Chroococcus minutus* and *Phormidium foveolarum* at 0.71. Apparently *Raphidiopsis mediterranea* and *Anabaenopsis raciborskii* were favoured by a much wider basic ratio 0.12–1.0 (figures 1 and 2).

The periodicity of the nitrogen- and non-nitrogen-fixing Cyanophyceae was almost identical. The former were represented mainly by *Anabaenopsis raciborskii* in both the lakes. From the present data it was not possible to assess if it fixed atmospheric nitrogen in spite of availability of ammonia and nitrate in the medium. However, it did produce heterocysts quite frequently and on that basis one may suspect that it did fix nitrogen. This was further indicated by the fact that waters were enriched by inorganic and organic nitrogen following its optimum development.

Bluegreen-Biomass Relationship

Blue-greens as already mentioned was the most dominant group of phytoplankton in these lakes. The fact that they also contributed enormously to the phytoplankton biomass is also obvious in table 10.

Table 11 *Correlation matrix showing correlation (r) of bluegreen populations with biomass parameters in Osman Sagar and Mir Alam lakes*

	Osman Sagar	Mir Alam
Blue-greens vs chlorophyll-a	0.5833	0.6061
Blue-greens vs oven dry biomass	−0.1669	0.7085**
Blue-greens vs residual ash	−0.2521	0.7165**
Blue-greens vs primary production	0.5813*	0.7009

*Significant at 5% level, **Significant at 1% level

Table 10 *Blue-green populations (org/l) related to biomass (g/m³) parameters in Osman Sagar and Mir Alam lakes*

	Osman Sagar			Mir Alam		
Station	1	2	3	1	2	3
Bluegreens ($\times 10^3$)	11.4	10.8	5.9	339.7	351.7	56.2
Oven dry biomass	5.7	6.6	5.2	17.0	20.2	6.7
Chlorophyll-a	0.15	0.14	0.12	1.78	1.92	0.86

However, statistical approach to the data (table 11) revealed that their population density showed a better correlation with biomass in Mir Alam than in 'Osman Sagar' lake. The relationship deteriorated in the latter lake as it contained considerably thicker populations of diatoms which are by nature heavier than blue-greens. The correlation between diatom populations and phytoplankton biomass in Osman Sagar lake ($r = 0.6501$) was significant at 1% level of confidence. It was, therefore, concluded that the blue-greens contributed more to the biomass in Mir Alam than in Osman Sagar lake.

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References

APHA 1971 *Standard Methods for the Examination of Water and Wastewater* 13th edn (Washington: American Public Health Association) 874 pp.

Chakrabarty R D, Roy P and Singh S B 1959 A quantitative study of the plankton and the physicochemical conditions of the river Jumna at Allahabad in 1954–55; *Indian J.Fish.* **6** 186–203

Cynthia M E 1980 Ecological Investigations on Phytoplankton of Two Small Lakes situated in Hyderabad Development Area; Ph.D. Thesis, Osmania University

Ganapati S V 1960 Ecology of tropical waters; *Proc. Symp. Algology* pp 214–218 (New Delhi: ICAR)

Gonzalves E A and Joshi D B 1946 Freshwater algae near Bombay. I. The seasonal succession of the algae in a tank at Bandra; *J. Bombay Nat. Hist. Soc.* **46** 154–176

Jana B B 1973 Seasonal periodicity of plankton in a freshwater pond in West Bengal, India; *Int. Rev. ges. Hydrobiol.* **58** 127–143

Khanum A 1980 Ecological Studies of the Husain Sagar and Saroor Nagar Lakes with reference to the Planktonic and Mat-forming Algal Communities; Ph.D. Thesis, Osmania University

Komarovsky B 1953 A comparative study of the phytoplankton of several fish ponds in relation to some of the essential chemical constituents of the water; *Bull. Res. Coun. Israel* **II** 379–410

Krogmann D W 1973 Plasticity of the photosynthetic apparatus in blue-green algae, in *Biology of the Blue-green Algae* pp 80–98 (Oxford: Blackwell Sci. Publ. Ltd.)

Parsons T R and Strickland J D H 1963 Discussion of spectrophotometric determination of marine plant pigments, with revised equations for ascertaining chlorophylls and carotenoids; *J. mar. Res.* **21** 155–163

Pearsall W H 1923 A theory of diatom periodicty; *J. Ecol.* **11–12** 165–183

—— 1932 Phytoplankton in the English lakes. II. The composition of the phytoplankton in relation to dissolved substances; *J. Ecol.* **20** 241–262

Provasoli L 1969 Algal nutrition and eutrophication; in *Eutrophication: Causes, Consequences, Correctives* pp. 574–593 (Washington: National Academy of Sciences)

Rao C B 1955 On the distribution of algae in a group of six small ponds. II. Algal periodicity; *J. Ecol.* **43** 291–308

Rao M V 1980 Algal succession during sewage stabilisation; *Indian J. Environ. Hlth.* **22** 20–29

Rao V S 1975 An ecological study of three freshwater ponds of Hyderabad, India. III. The Phytoplankton (Volvocales, Chlorococcales and Desmids); *Hydrobiol.* **47** 319–337

Reddy N S N 1984 A Limnological Study of the Himayat Sagar and Husain Sagar Lakes; Ph.D. Thesis, Osmania University, Hyderabad

Richards F A and Thompson T G 1952 The estimation and characterisation of plankton populations by pigment analysis. II. A spectrophotometric method for the estimation of plankton pigments; *J. mar. Res.* **11** 156–172

Seenayya G 1971 Ecological studies in the plankton of certain freshwater ponds on Hyderabad, India. II. Phytoplankton; *Hydrobiology* **37** 55–58

Singh R N 1955 Limnological relations of Indian inland waters with special reference to waterblooms; *Verh. int. Verein. theor. angew. Limnol.* **12** 831–836

Singh V P 1960 Phytoplankton ecology of the inland waters of Uttar Pradesh; *Proc. Symp. Algology* pp 243–271 (New Delhi: ICAR)

Smith A J 1973 Synthesis of metabolic intermediates; in *Biology of the Blue-green Algae* pp 1–38 (Oxford: Blackwell Sci. Publ., Ltd.)

Srinivasan T K, Srinivasan K, Seth G K, Rao P M and Rao D V 1965 Studies on raw water characteristics of the lakes in and around Hyderabad; *Indian J. Environ. Hlth.* **8** 177–187

Sukhatme P V and Amble V N 1978 *Statistical Methods for Agricultural Workers* (New Delhi: ICAR) 347 pp

Vollenweider R A 1969 *A Manual on Methods for Measuring Primary Production in Aquatic Environments*; IBP Handbook 12 (Oxford: Blackwell Sci. Publ. Ltd.) 213 pp

Yoshimura S 1932 Seasonal variation in the content of nitrogenous compounds and phosphate in the water of Takasuka pond, Saitama, Japan; *Arch. Hydrobiol.* **24** 155–176

Zafar A R 1967 On the ecology of algae in certain fish ponds of Hyderabad, India. III. The Periodicity; *Hydrobiology* **30** 96–112