

Physico-chemical and Cyanophytic variation of Shahpura Lake, Bhopal

Bharti Khare and Pramod Patil

M.L.B. Gov't Girsl P.G. College, Bhopal (India)

E-mail-kharebt@gmail.com

ABSTRACT

The present studies focused on Physico-chemical aspects and Cyanophitic diversity of Shahpura Lake. The physico-chemical parameters like temperature, water temperature, D.O., pH, free CO₂, Total alkalinity, total hardness, calcium hardness, chloride, phosphate and nitrate were studied to analyze the Shahpura Lake. The study area selected was Cyanophitic diversity has been done with scientific name in this Lake. These studies an attempt has been made to identify the taxa of Cyanophyta in Pre monsoon, monsoon, summer and Post monsoon from July, 2007 to June, 2009.

Key words-Cyanophyta, Bhopal, Shahpura Lake, Physico-chemical.

Among the Bhopal Lakes, the Shahpura Lake is one of the important Lakes, which is known as the third Lake of Bhopal. The Lake has a catchments area of 8.29 km² and a submergence area of 0.96 km². This Lake is surrounded by human habitation and receives untreated sewage from various point and non-point pollution sources. The man made water impoundment was constructed in the southern part of city near Chuna Bhatti village in 1974 - 75 under the Betwa irrigation scheme. Although irrigational use of reservoir water becomes secondary but 1975 onwards fisheries and recreational activities have been promoted. This Lake is constructed on a small stream, which used to bring the overflow of the oxidation

Ponds, situated near Mata Mandir, which is about 3 km in the upstream of the Lake. After the closing down of the oxidation Ponds, in the year 1977-78 the Nullah carry only the storm water and sewage and draining in the Lake. Besides this Lake also receives sewage and wastewater through unlined number of drains The water quality of the Lake is deteriorating on account of Untreated sewage inflow, siltation, encroachments, excessive growth of aquatic weeds, deforestation in catchments area, cattle population pressure, washing of clothes, unmanaged fisheries, and outflow through spillway.

The other part of the Lake is also receiving untreated sewage and wastewater

from the eastern, northern and southeastern part of the Lake. The other main stream, which joins the Lake on the eastern side, comes from the Shahpura hillocks and Shahpura residential colony. The western part of the Lake is covered by MACT hill while Southeastern part is occupied by Shahpura hillock.

Cyanophyta are a very old group of organisms and represent relics of the oldest photoautotrophic vegetation in the world that occur in freshwater, marine and terrestrial habitats. They were the first organisms to evolve oxygenic photosynthesis, and so changed the Earth's atmosphere from anoxic to toxic. Ponds are critical "storage tanks" for freshwater. More than 90% of all available liquid surfaces freshwater are contained in lakes and reservoirs. Despite their importance, many of the world's lakes are in crisis.

Fortnightly collections of water samples were collected from all the stations *i.e.* from four sampling stations of Shahpura Lake. Parameters such as atmospheric temperature, water temperature, D.O., pH and CO₂ were studied at the sampling stations as they are liable to change soon. Total alkalinity, total hardness, calcium hardness, chloride, phosphate, and nitrate parameters were analyzed in the laboratory on the same day of collection. The all physico-chemical parameters were determined adopting methods given by APHA⁴, NEERI¹⁸, Trivedi and Goyal²² and Adoni¹.

The algal sample collection carried out with the help of truncated cone shape plankton net. The plankton net is made of bolting silk No.25 standard grade. This has an aperture size of 0.064mm. The concentrate was preserved in 4% formalin for study^{15,23}.

Detail of the physico-chemical characteristics of water of ponds the present study from July, 2007 to June, 2009 are given below. The data have been collected by the middle of the month when there was particularly no rain fall. The changes in physico-chemical parameters are the direct and indirect indices of quality of ponds water. The proper analysis of these factors enables to characterize the degree of water pollution.

Physico-chemical observations :

The water temperature ranged between 15.3°C to 30.6°C. The maximum temperature was recorded in the month of May, 2008 and minimum temperature value was recorded in the month of January, 2008 during 2007-08 and second year maximum temperature was recorded in the month of May 2009 and minimum temperature was recorded in the month of January, 2009 (Fig. 1). The pH range from 7.3 mg/l to 8.8 mg/l (Fig. 2) and the maximum D.O. value were 12.0 mg/litre in the month of October, 2008 and minimum were 4.5 mg/litre in the month of April, 2008 (Fig. 3) but the free carbon dioxide varied between 0.0 mg/litre to 1.6 mg/litre (Fig. 4). The total hardness varied from 145 mg/litre to 295 mg/litre. During 2007-08 the maximum total hardness value was 280 mg/litre in the month of May, 2008 and minimum was 145 mg/litre in the month of September, 2007. During 2008-09 the maximum value in the month of January, 2009 and minimum value in the month of August, 2008 and September, 2009 (Fig. 5). Calcium hardness varied from 42.0 mg/litre to 83.5 mg/litre (Fig. 6). The chloride content showed the highest value of 55.6 mg /litre in the month of February, 2008 and lowest value of 33.5 mg/litre in the month of August, 2008 (Fig. 7). Maximum alkalinity value was recorded

was 280 mg /l in the month of October, 2008 and minimum alkalinity was recorded 70.0 mg/ l in the month of July, 2008 (Fig. 8). Phosphate contents in Shahpura Lake range from 7.56 mg/litre to 9.56 mg/litre. In the month of November, 2008 the phosphate contents was maximum and in the month of January, 2008 the phosphate contents minimum (Fig. 9). Nitrate content range from 0.29 mg/litre to 3.51 mg/litre. In the month of July, 2007 the nitrate contents was minimum and in the month of March, 2008 the nitrate contents maximum (Fig. 10).

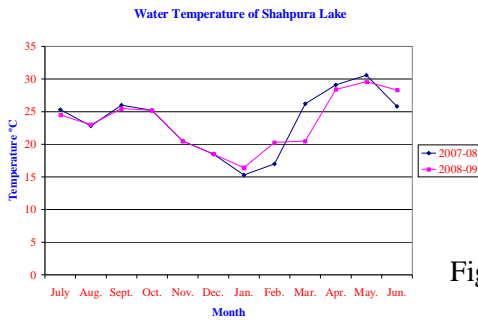


Fig. 1

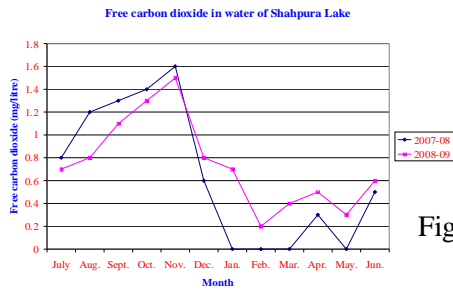


Fig. 2

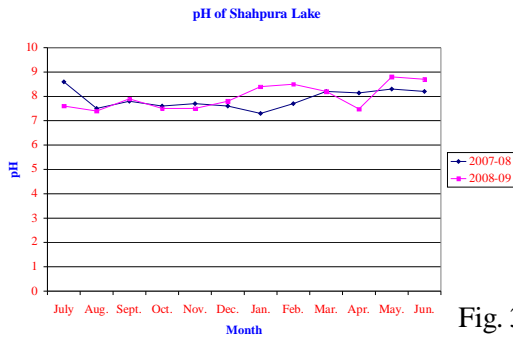


Fig. 3

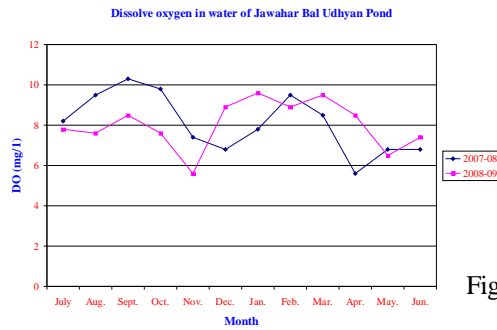


Fig. 4

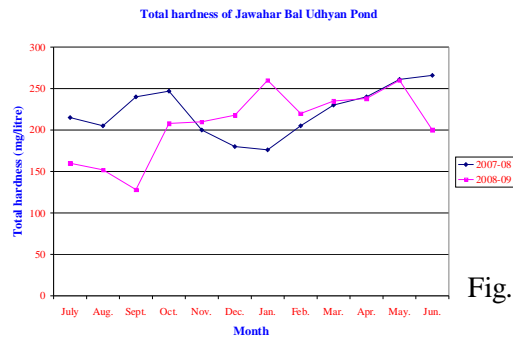


Fig. 5

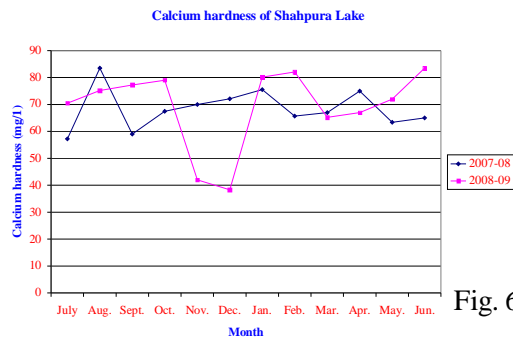


Fig. 6

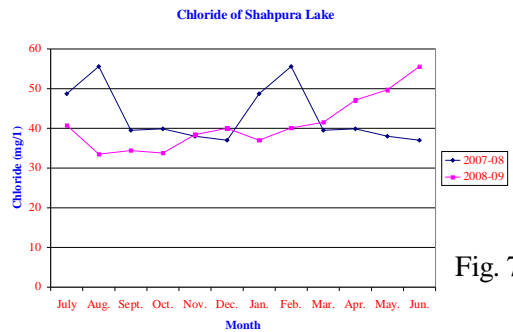


Fig. 7

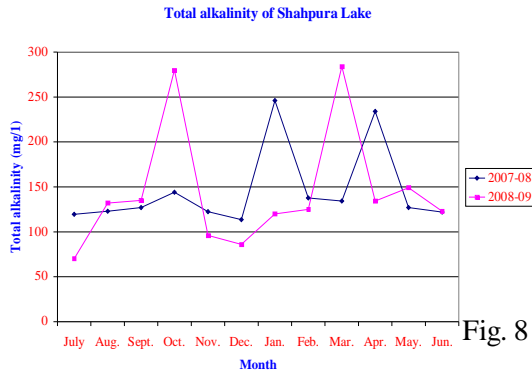


Fig. 8

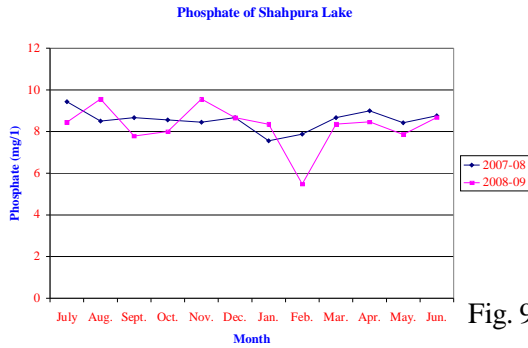


Fig. 9

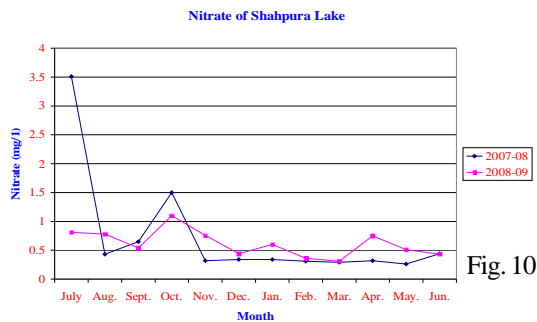


Fig. 10

1. *Microcystis aeruginosa* Kutz.

Desikachary⁸, p. 93 Pl.17, Fig. 10

Colonies, clathrate with hyaline colonial mucilage; cell spherical with gas vacuoles, d - of cell 5.5-7.5 μ ; Occurrence – Planktonic

2. *Microcystis elongata* sp. nov.

Desikachary⁸, p. 89 Pl.18, figs. 7, 8

Colonies elongate, unstricted; cells closely

arranged, olive green in colour with gas vacuoles, spherical, d - of cell 6.5-7.5 μ , l x b of colony 1066 x 66 – 93 μ ; Occurrence – Planktonic

3. *Microcystis flos-aquae* (wittr.) Kirchner.

Desikachary⁸, p. 94, Pl.18, fig. 11

Colonies roughly spherical or ellipsoidal, with indistinct colonial mucilage; cells 3.5-6.5 μ in diameter; gas vacuoles present, Occurrence – Planktonic

4. *Microcystis protocystis* Crow.

Desikachary⁸, p. 91, Pl.20, fig. 4

Colonies irregular diffuse; colonial mucilage not clears; cell very much closely packed, spherical; with gas vacuoles. l x b of colony 666 x 599 μ , d – of cells 5.5 – 7.5 μ , Occurrence – Planktonic;

5. *Microcystis pseudofilamentosa* Crow.

Desikachary⁸, p. 94. Pl.18, fig.9 and Pl.20, fig.1

Long colony, constricted, cells spherical, closely arranged with gas vacuoles, d-of cell 3.5–5.5 μ , Occurrence – Planktonic;

6. *Microcystis viridis* (A. Br.) Lemm.

Desikachary⁸, p. 87, Pl.18 figs. 1-6

Colonies rounded, elongate to irregular, cells spherical with gas vacuoles, sheath-definite; cells loosely arranged, d - of cells 4-5.5 μ ; Occurrence – Planktonic

7. *Chroococcus limneticus* Lemm.

Desikachary⁸, p. 107, Pl.26, fig. 2

Colony ovate– spherical; cells evenly arranged, cell sheath is distinct, colourless, cells blue-green in color, d- of cells 7.5 – 14.5 μ , d – of colony 426 μ ; Occurrence – Plank tonic

8. *Chroococcus macrococcus* (Kutz.) Rabenh.

Desikachary⁸, p.101, Pl. 27, fig. 10

Thallus somewhat broad, yellowish brown; 2-4 cells together; cells 30-40 μ in diameter with sheath; sheath lamellated, thick, hyaline; Occurrence – Plank tonic.

9. *Chroococcus minor* (Kutz.) Naegeli.

Desikachary⁸, p.105, Pl. 24, Fig. 1

Cells spherical in group of 4, dirty blue-green in colour; sheath thin and colourless, d – of cells 3 – 4.5 μ , l x b of colony 10 x 7.5 μ , Occurrence-Plank tonic.

10. *Chroococcus minutus* (Kutz.) Nag.

Desikachary⁸, p. 103, Pl. 24, figs. 4, 15

Cells spherical or hemispherical in groups of 2-4 with sheath 6.5-9.5 μ in diameter, without sheath 4 - 6.5 μ .; Plank tonic.

11. *Chroococcus turgidus* (Kutz) Nag.

Desikachary⁸, p. 101, Pl. 26, fig. 6.

Cells ellipsoidal; sheath hyaline, feebly lamellated; cells 20-40 μ in diameter with sheath, 10-20 μ without sheath; sheath colourless Plank tonic.

12. *Chroococcus turgidus* var. *maxius* Nygaard.

Desikachary⁸, p. 102, Pl. 24, fig. 2 and Pl.26, fig. 8

Cells in groups of 2-4 or 8; 25-45 μ in diameter, blue-green; sheath colorless, without sheath 8-32 μ , with sheath 13-25 μ diameters; Plank tonic

13. *Gleocapsa stegophila* Var. *crassa*, Rao, C. B

Desikachary⁸, p. 119, Pl. 25, fig. 3

Cells with sheath, 4.5 to 8 μ diameter, cells spherical, Sheath golden-yellow; colony with sheath 8-15 μ broad and 9.6- 19.2 μ long; Plank tonic.

14. *Gloeothece rupestris* (Lyngb.) Bornet

Desikachary⁸, p. 127, Pl. 25, fig. 4

Cells ellipsoidal; without sheath 6-7.5 μ broad, 1.5 to 3 times longer; colonies oval to subglobose up to 55 μ in diameter, Cells and colonies are slightly bigger than the type; Epiphytic.

15. *Gloeothece samoensis* Wille

Desikachary⁸, p. 128, pl.23, Fig. 3

Cells ellipsoidal, without sheath 4-5 μ broad, 8 μ long, cells yellowish or blue-green, in round colonies, often many uniting, mostly 2-4 in a common envelope; Occurrence Plank tonic;

16. *Aphanocapsa koordersi* Strom

Desikachary⁸, p. 132, Pl. 23, fig. 1

Colony spherical dull green to blue-green 2-3 mm in diameter; cells loosely arranged, spherical, 2.2-2.8 μ in diameter; Plank tonic

17. *Aphanocapsa bififormis* A. Br.

Desikachary⁸, p. 134, Pl. 21, figs. 3, 4

Thallus olive green, gelatinous, Cells 2-4, spherical, arranged loosely in a common envelope .Cells 6-8 μ in diameter. Plank tonic

18. *Aphanocapsa grevillei* (Hass.) Rabenh

Desikachary⁸, p. 134, Pl. 21, fig. 9

Thallus gelatinous, spherical, cells 4.5-5.5 μ in diameter, arranged in homogenous mucilage, colonies light blue-green; Plank tonic

19. *Aphanocapsa pulchra* (Kutz.) Rabenh

Desikachary⁸, p. 132, Pl. 21, fig. 2

Thallus gelatinous, homogeneous, blue-green tuberculate; cells loosely arranged in twos, 3.5-4.5 μ in diameter. Plank tonic

20. *Aphanothece nidulans* Richter, P.

Desikachary⁸, p. 138, Pl. 22, fig. 1

Thallus irregularly expanded more or fewer rounds; cells 1.66-3.3 μ in diameter, cells pale blue-green. Plank tonic

21. *Aphanothece pallida* (Kutz.) Rabenh.

Desikachary⁸, p. 140, Pl. 22, fig. 3

Cells oblong, elliptical to cylindrical, loosely arranged in gelatinous sheath, olive green in colour, l x b of cell 8 - 10 x 5 – 7 μ ; occurrence Plank tonic.

22. *Aphanothece stagnina* (Spreng.) A. Br.

Desikachary⁸, p. 137, Pl. 21, fig. 10

Thallus gelatinous, spherical; ellipsoidal, pale blue-green, dull brown, cells ovoid to cylindrical, 4-5 μ broad, 5-7 μ long, Homogeneous

mucilage, occurrence Plank tonic

23. *Synechococcus elongates* Nag.

Desikachary⁸, p. 143, Pl.25, fig. 7,8

Cells cylindrical, 1.4 - μ board, 1.5-3 times as long as broad, single or 2-4 cells together; contents homogeneous and light blue-green, Plank tonic; Coll. No. SL 413, 15/1/08.

24. *Dactylococcopsis fascicularis* Lemm. f. *indica*

Desikachary⁸, p. 158, Pl. 29, fig. 16

Cells spindle-shaped with a long narrow pointed apex many together in free swimming bundles; ends tapering; cells 24-32.5 μ long, 2.3 μ broad. Plank tonic

25. *Dactylococcopsis raphidiodes* Hansg.

Desikachary⁸, p. 158, Pl. 29, figs. 1, 2

Cells spindle-shaped, sigmoid, long, solitary, spindle shaped cells, 2-3 μ broad, 20-34 μ long, Little mucilage. Plank tonic.

26. *Coelosphaerium kuetzingianum* Nag.

Desikachary⁸, p. 148, Pl. 28, fig. 8

Colony spherical with a thin colonial mucilage envelope, 35-45 μ Broad; Cells spherical, 2.5-4 μ in diameter; Plank tonic; Plank tonic;

27. *Merismopedia glauca* (Ehrenb.) Nag.

Desikachary⁸, p. 155, Pl. 29, fig. 5

Colony 16-64 celled; mostly small, cells 3.5-5 μ broad. Oval or spherical shape, closely arranged, 3-6 μ broad; pale blue blue-green, Plank tonic;

28. *Merismopedia minima* Beck.

Desikachary⁸, p. 154, Pl. 29, fig. 11

Cells pale blue-green 4 to many in small colonies, 0.5 μ broad, and groups of four cells 2-3 x 3 μ . Plank tonic.

29. *Merismopedia punctata* Meyen

Desikachary⁸, p. 155, Pl. 29, fig. 6

16 - 32 celled colony, small; cells not compactly arranged, spherical to ovoid, l x b of cells 4.5 x 3 μ , l x b of colony 33 x 22 μ ;

Plank tonic

30. *Merismopedia tenuissima* Lemm.

Desikachary⁸, p. 154, Pl. 29, fig. 7

64 celled colony, cells subspherical closely packed with gelatinous envelope; l x b of cells 3.5-4.5 x 2 μ . Cells grouped into dark blue-green colonies; l x b of colony 29 x 25 μ . Plank tonic

31. *Stichosiphon sansibaricus* (Hieron.) Drouret Daily.

Desikachary⁸, p. 176, Pl.32, figs. 9-13

Plants solitary or in a group erect or curved; content divided in to a series of spherical ovoid or cylindrical endospores; sheath hyaline, l x b of cells 7.5 - 8.5 x 6.5 μ . Epiphytic

32. *Arthospira massartii* Kuffaregh var. *indica*

Desikachary⁸, p. 191, Pl. 35, figs. 7, 8

Trichomes 4-5 μ broad, with loose spirals, distance between two spirals 40-48 μ . Plank tonic.

33. *Spirulina major* Kutz. ex Gomont.

Desikachary⁸, p. 196, Pl.36, fig. 13

Trichome 1.6-2 μ broad, blue-green spirals 2.5 μ broad, distances between two spirals 5 μ . Plank tonic;

34. *Oscillatoria acuta* Bruhl et Biswas, orth. mut. Geitler

Geitler, Kryptogamenflora, 978, 1932.

Desikachary⁸, p. 240, Pl39, Figs 5, 8

Trichomes either solitary, hardy, brittle, not constricted at the cross-walls, 4-6 μ thick, broad, 70-400 μ long, usually quite straight, cells 3-4 μ long. Plank tonic.

35. *Oscillatoria amphigranulata* van Goor

Desikachary⁸, p. 226, Pl.37, fig. 4

Trichome straight, 1.75-2.5 μ broad; cells 2.5-5 μ long, as long as broad with two gas-vacuoles at the septa, pale blue-green; end cell rounded, Plank tonic.

36. *Oscillatoria chalybea* (Mertens) Gomont

Desikachary⁸, p. 218, Pl.38, fig. 3

Thallus dark blue-green; trichome straight, cells 6-8 μ broad, 3.5-5 μ long; septa not granulated, end cell obtuse, Plank tonic.

37. *Oscillatoria curviceps* Ag. ex Gomont
Desikachary⁸, p. 209, Pl.38, fig. 2

Thallus dark blue-green; 10-12 μ broad, cells 3.5-5 μ long; cross walls granulated; end cell round and flat. Planktonic.

38. *Oscillatoria foreau* Frey

Desikachary⁸, p. 219, Pl. 40, fig. 18

Trichomes elongate, suberect, apex gently curved, cells torulose, 2-3 μ broad, septa inconspicuous. Plank tonic.

39. *Oscillatoria formosa* Bory ex Gomont
Desikachary⁸, p. 232, Pl. 40, fig. 15

Trichome straight, gently attenuated at the ends, 5.5-6 μ broad; cells 2.5-4.5 μ long. Tychoplanktonic.

40. *Oscillatoria grunowiana* Gomont

Geitler, Kryptogamenflora, 953, 1932

Desikachary⁸, p. 216,

Trichome straight, slightly attenuated, capitates; cross walls granulated; end cell rounded without a calyptra, 1 x b of cells 2 – 3 x 8.5 μ . Plank tonic.

41. *Oscillatoria laete-virens* Gomont.

Geitler, Kryptogamenflora, 949, fig. 603c, 1932

Desikachary⁸, p. 213

Trichome straight, constricted; anices slightly attenuated and bent; septa granulated end cell not capitate, conical, 1 x b of cells 2-4.5x4.5 μ , 1 x b of end cell 5.5 x 2.5 μ . Plank tonic

42. *Oscillatoria laete-virens* Gomont var. *minimus* Biswas.

Desikachary⁸, p. 213, Pl.39, figs 2, 3

Trichome unstricted; apex tapering very little curved; apical cell pointed, not capitate, not granulated at the cross walls, 1 x b of cells 3 x 3 μ . Plank tonic

43. *Oscillatoria limosa* Ag. ex Gomont

Desikachary⁸, p. 206, Pl. 42, fig. 11

Trichomes forming blackish blue-green mats, trichome more or less straight; cells 11-13 μ broad, 2.5-3.5 μ long; tip 5 μ broad, flatly rounded with slightly thickened membrane. Plank tonic.

44. *Oscillatoria nigra* Vancher

Prescott, 1951, p. 489, Pl.100, fig.18

Desikachary⁸, p. 223

Trichome straight, slightly tapering toward the apex and curved; apical cell rounded; not capitate; 2.5-6 μ long, granulated at the cross walls. Occurrence – Plank tonic.

45. *Oscillatoria princeps* Vaucher ex Gomont.

Desikachary⁸, p. 210, Pl. 37, figs. 1, 10,11,13,14

Thallus blue- green in colour, not constricted, slightly attenuated at the apices and bent; end cell flatly round or slightly capitates, trichome 27-32.5 μ broad, tip 20-75 μ broad; Plank tonic.

46. *Oscillatoria proboscidea* Gomont.

Desikachary⁸, p. 211, Pl.38, fig. 9

Trichome more or less straight, 12-15 μ broad, at the ends distinctly attenuated, slightly curved; cells 4.5 μ long and 15 μ broad end cell flatly rounded, or capitates with slightly thickened membrane; Plank tonic.

47. *Oscillatoria subbrevis* Schmidle.

Desikachary⁸, p. 207, Pl. 37, fig. 2

Trichome single straight, 5-6 μ broad; cells 1-2.5 μ long. Not granulated at the cross-walls; end cell rounded, calyptra absent; Epipsammic

48. *Oscillatoria subuliformis* Kutz. ex Gomont.

Desikachary⁸, p. 213, Pl. 49, fig. 10

Trichome yellow-green, 3.5-5 μ broad; Cells nearly quadrate, 5-6.5 μ long, longer near tips; Plank tonic

49. *Oscillatoria sancta* (Kutz.) Gomont

Desikachary⁸, p. 203, Pl. 42, fig. 10

Thallus dark blue, shining, thin, gelatinous; trichome straight or bent, 10-20 μ broad, dull blue-green or olive-green; cells 1/3-1/6 times as long as broad, 2.5-6 μ long, granulated at

the cross-walls. Plank tonic.

50. *Oscillatoria tenuis* Ag. ex Gomont
Desikachary⁸, p. 222, Pl. 42, fig. 15

Thallus thin blue-green or olive-green, trichome straight fragile, Cells 6.5-7.5 μ broad, 4.5-6 μ long, apex convex; Plank tonic.

51. *Oscillatoria vizagapatensis* Rao, C.B.
Desikachary⁸, p. 205, Pl. 39, figs. 16, 18

Thallus uniformly broad blue-green except at tip; cells 10-11.5 μ in diameter, 1.5-2.5 μ long, cells much shorter than broad, 1.6-2 μ long, granular; end cell broadly rounded; Epilithic.

52. *Phormidium autumnale* (Ag.) Gomont.
Desikachary⁸, p. 276, Pl. 44, figs. 24, 25

Thallus expended, dark blue-green or brownish-green, filament straight, rarely flexuous, sheath firm, mucilaginous, trichome blue-green, 4-7 μ broad, end mostly briefly attenuated, cells quadrate as long as broad, 2-5 μ long, septa granulated. Epilithic

53. *Porphyrosiphon notarisii* (menegh) Kutz.
Ex Gomont.

Desikachary⁸, p. 248, Pl. 47, fig. 9

Thallus thin, mucilaginous, Trichome 1.5-2 μ broad, cell 1.5-2 μ long; contents homogenous, septa feedle Epiphytic

54. *Lyngbya ceylanica* Wille.

Desikachary⁸, p. 299, Pl. 54, fig. 4

Filaments 11-12.3 μ broad; Cells 3.5-6 μ long, 8-10 μ broad, end cell rotund, Planktonic

55. *Lyngbya dendrobia* Bruhl et Biswas.

Desikachary⁸, p. 302, Pl. 50, fig. 3, 10

Stratum more or less expended, compact, thin, tomentose; filament long and flexible; sheath 10-11 μ thick; hyaline, colourless, old brownish, trichome 9-10 μ broad, cells 1.7-2.5 times as broad as long, 4-6 μ long, Planktonic

56. *Lyngbya hieronymusii* Lem. Var *crassivaginate* Ghose.

Desikachary⁸, p. 297, Pl. 55, fig. 8

Filaments 18-20.75 μ broad; sheath thick and hyaline; cells 12.75-14 μ broad; 2.5-3.5 μ long, Planktonic;

57. *Lyngbya magnifica* Gardner.

Geitler, Kryptogamenflora, 1067, fig. 680b, 1932.

Desikachary⁸, p. 320

Filaments long, forming a loose net, 35-38 μ broad; Cells 28-35 μ broad, 3.5-5 μ long, Epilithic;

58. *Lyngbya majuscula* Harvey ex Gomont.
Geitler,⁹ Kryptogamenflora, 1060, fig. 672c, d, 1932.

Desikachary⁸, p. 313, Pl. 48, fig. 7, Pl. 48, Fig. 12 and Pl. 52, Fig. 10

Thallus expended, up to 3 cm long, dull blue-green to brown or yellowish brown; filament very long, sheath colourless, Planktonic

59. *Schizothrix lacustris* A. Br. ex Gomont.
Geitler,⁹ Kryptogamenflora, 1092, figs. 698, 699, 1932.

Desikachary⁸, p. 325, Pl. 56, figs. 6, 10

Thallus cushion shaped, filament aggregated at the ends branched; sheath colourless thick, 1-1.5 μ broad; cells longer than broad, Planktonic

60. *Anabaenopsis arnoldii* Aptekarj.

Desikachary⁸, p. 356, Pl. 5, figs. 2-7

Trichome spirally coiled with gelatinous sheath; cells spherical; gas vacuoles present; heterocyst intercalary and terminal. d – of cell 5.5 μ , d – of heterocyst 5.5 μ . Planktonic

61. *Cylindrospermum doryphorum* Bruhl et Biswas.

Desikachary⁸, p. 368, Pl. 65, fig. 2

Thallus floating, cloud-like, indefinite outline, green; Trichome not at all or slightly constricted, 2-4 μ broad, cells cylindrical, 4-8 μ long; 2-4 μ broad, and 4-8 μ long; spores scarce nearly always single, Planktonic

62. *Cylindrospermum indicum* Rao, C. B., orth. mut. De Toni.

Desikachary⁸, p. 369, Pl. 64, figs. 4, 11

Trichome constricted; cells quadrate; heterocyst spherical; spore ellipsoid to cylindrical, l x b of cells 3 x 3 μ , l x b of heterocyst 5.5 x 4.5 μ , l x b of spore 16 x 10 μ . Planktonic;

- 63. *Cylindrospermum musicola*** Kutzing ex Born. et Flah.
Desikachary⁸, p. 366, Pl.65, Fig. 3
Trichome 3-4.4 μ broad; cells 3.5-5 μ long; heterocyst 3.32-4 μ in diameter; 4.5-5 μ long; spores oval, 9-10.5 μ broad, 18.5-20 μ long. Planktonic;
- 64. *Cylindrospermum sphaerica*** Prasad, B.N. Desikachary⁸, p. 363, Pl.64, figs. 7, 8
Trichome blue-green, 3.5-4 μ broad; cells barrel shaped, 7-8 μ long; heterocyst ellipsoidal, at both ends of the trichome, 7.7-8.5 μ long, 4.2-5 μ broad; spores sub-terminal, spherical, 14-18.5 μ broad. Planktonic;
- 65. *Cylindrospermum stagnale*** (Kutz.) Born. et Flah.
Desikachary⁸, p. 363, Pl. 65, fig. 9
Trichomes 3.8-4.5 μ broad, constricted at the cross-walls; cells cylindrical, d; heterocyst oblong, 6-7 μ broad, 8-14.5 μ long. Planktonic;
- 66. *Nostoc commune*** Vaucher ex Born. et Flah.
Geitler⁹, Kryptogamenflora, 845, figs. 536,537, Thallus firm, gelatinous, at first globose, later flattened, hyaline; trichome 4.5-6 μ broad, cells short barrel-shaped or nearly spherical, about 7 μ broad; spore only one observed, as big as the vegetative cells epispore smooth colourless. Planktonic;
- 67. *Nostoc linckia*** Var. arvense Rao, C. B. Desikachary⁸, p. 387, Pl. 67, fig. 1
Thallus gelatinous, yellowish brown to blue-green; trichome 4-5.5 μ broad, cells spherical, 5.2-6.6 μ long; heterocyst almost spherical 4.8-7.2 μ broad. Plank tonic,
- 68. *Nostoc sphericum*** Voucher ex Born. et Flash.
Desikachary⁸, p. 390
Thallus irregular, big in size; greenish brown in colour, cells spherical, heterocyst terminal and intercalary, d – of heterocyst 6 – 7 μ , l x b of spore 7.5 x 5.5 μ ; Occurrence – Epileptic;
- 69. *Anabaena ambigua*** Rao, C.B. Desikachary⁸, p. 400, Pl. 76, fig. 2
Trichome free in mucilaginous envelope; in the latter case occurring in group; trichome without sheaths free-floating, generally occurring single, but occasionally in dense clusters, usually 300-500 μ long 10-50 μ broad, septa indistinct, 4.5-6.6 μ broad; 3.5-5 μ long, cell content deep blue-green. Planktonic
- 70. *Anabaena aphanizominoides*** Forti Desikachary⁸, p. 405, Pl. 71, fig. 4
Trichome single, straight bent, 1-2 mm long, 4-5 μ broad, slightly constricted at the cross-walls; cell barrel-shaped, cylindrical, 1-3 times as long as broad, with gas-vacuoles; heterocyst subspherical 5.5-7 μ broad, 6-7.5 μ long; spores single, colourless wall. Planktonic;
- 71. *Anabaena circinailis*** Rabenhorst Geitler⁹, Kryptogamenflora, 981, fig. 572a, 1932 Prescott, 1951, p. 514, Pl.116, figs.1-2
Trichome constricted; heterocyst spherical; spores remote from the heterocyst, l x b of cells 6-8.5 μ , d – of heterocyst 7-8 μ , l x b of spore 14.75 x 7-8 μ Occurrence – Planktonic;
- 72. *Anabaena flos-aquae*** (Lyngb.) Breb. ex. Born. et Flah.
Geitler⁹, Kryptogamenflora, 890, fig. 571a, b, Desikachary⁸, p. 414.
Trichome constricted; cells with vacuoles; heterocyst ellipsoidal; spore ellipsoid cylindrical smooth, l x b of cells 5-7.5 x 5.5 μ , l x b of heterocyst 7.5 x 6.5-7.5 μ , l x b of spore 11 x 7.5 μ . Planktonic
- 73. *Anabaena iyengarai*** Bharadwaja var. *tenuis* Rao, C.B. Desikachary⁸, p. 408, Pl.76, fig. 1
Filaments curved; spores on either side of heterocyst; Cells 3.3-4.5 μ broad; heterocyst 6.64 μ broad, 8.5 μ long, spores 11.68-15 μ long, 8.5-9 μ broad; Planktonic

74. *Anabaena orientalis* DixitDesikachary⁸, p. 405, Pl.77, fig. 6

Trichome single, straight or slightly curved, 2.5-4 μ broad, cylindrical, barrel-shaped, 3.7-4.8 μ long, heterocyst single, intercalary, cylindrical or slightly ellipsoidal with rounded end wall, 4.8-5.5 μ broad, and 7.4-9.2 μ long; spore one on each side of heterocyst, Planktonic;

75. *Anabaena oscillarioides* Bory ex Born. et Flah var. *angustus* Bharadwaj.Desikachary⁸, p. 418, Pl. 78, fig. 1

Trichome irregularly bent; cells barrel shaped; heterocyst intercalary, ellipsoidal; spore long, cylindrical, episore smooth, l x b of cell 4.5-5.5 x 5 μ , l x b of heterocyst 7-9 x 6-7 μ , l x b of spore 11-19 x 5-5.5 μ . Occurrence – Planktonic,

76. *Anabaena sphaerica* Bornet et Flahault var. *attenuata* BharadwajaDesikachary⁸, p. 395, Pl.71, fig. 8

Trichome straight; cells barrel spherical; heterocyst intercalary, d – of cell 5 – 6 μ , d – of heterocyst 7.5 – 8.5 μ , d - of spore 11-13.5 μ . Occurrence – Planktonic,

77. *Anabaena spiroides* KlebahnGeitler⁹, Kryptogamenflora, 881, 1932.Desikachary⁸, p. 395, Pl.71, fig. 9

Trichome single, free-floating, spirally coiled, spirals 45-54 μ broad and 40-50 μ distant; cells spherical, 6.5-8 μ broad, heterocyst subspherical, 7 μ broad; spores at first spherical, later elongated. Planktonic

78. *Anabaena vaginicola* Fritsch et rich f. *fertilissima* Prasad.Desikachary⁸, p. 401, Pl.73, fig. 3

Many trichome on walls of *Oedogonium spp.*, Covered by a sheath; Cells 6.16-7.7 μ long, 3-4.6 μ broad; heterocysts abundant, 6-7.7 broad, 4.5-5.5 μ long; spores 9.3-10 μ long, 6.5-8 μ broad.

79. *Anabaena variabilis* Kutzing ex Born et Flah.Desikachary⁸, p. 410, Pl.71, fig. 5

Trichome 3.8-4.6 μ broad; heterocyst 6-7 μ broad, 6-8 μ long; spores formed away from heterocyst, spores 10-16 μ long, 6.5 μ broad. Planktonic;

80. *Scytonema cincinnatum* Thuret ex Born. et Flah.Desikachary⁸, p. 453, Pl.93, fig. 1

Thallus olivaceous, filaments irregularly curved; 16.5-19 μ broad, trichome 8-11.5 μ broad. Tycho planktonic

81. *Tolypothrix distorta* Kutzing ex Born et Flah.Desikachary⁸, p. 495, Pl.102, fig. 1

Thallus blue-green, encrusted with calcium; filaments 13.6-16.5 μ broad; trichome 8.3-10 μ broad; cells 3.8-5.5 μ long; heterocyst cylindrical, 8-10 μ broad; 11.5-14 μ long; Epilithic;

82. *Tolypothrix nodosa* Bharadwaja.Desikachary⁸, p. 494, Pl.98, fig. 5

Filaments 6-7.5 μ broad, false branching rare; geminate heterocyst one pored; cells 8.5-11.5 μ long, 3.5-4.5 μ broad; heterocyst 8.5-20 μ long, 6 μ broad; Epilithic.

83. *Rivularia dura* Roth ex Born. et Flah.Desikachary⁸, p. 551, Pl. 115, fig. 2

Thallus blackish green; filaments densely arranged; sheath thin. d – of colony 800 – 866 μ , l x b of cells 7.5 – 14.5 x 5 – 6.5 μ , d – of heterocyst 7.5 μ . Occurrence – Epilithic

84. *Gloeotrichia ghosei* Singh R.N.Desikachary⁸, p. 561, Pl. 118, figs. 1- 3

Thallus spherical, brown; trichome 7.5-9 μ broad at the base, at tip 12-14 μ long, heterocyst 9-11 in diameter; spores long; ellipsoidal, 25-28 μ long, 13.5-16 μ broad. Epiphytic;

85. *Gloeotrichia kurziana* Zeller orth. mut. Desikachary⁸, p. 562.

Thallus spherical, trichome broader at the base sheath colourless; spherical; spore blue-green

cylindrical swollen at the middle; heterocyst spherical, b-of filament 22 μ , d-of heterocyst 10 μ , l x b of spore 45.5 x 13.5 μ , l-of trichome 436–455 μ , l x b of cells 7.5 x 7.5 μ Occurrence–Epiphytic;

86. *Gloeotrichia natans* Rabenhorst ex Born et Flah

Prescott, 1982, p. 559, Pl. 134, fig. 67

Desikachary⁸, p. 561. Pl. 118, figs. 7, 15
Trichome at base 9–11 μ broad; heterocyst 9–11.5 μ in diameter; spore 53–56 μ long, 12–15 μ broad; Epiphytic;

Seasonal variations are evident in all the physico-chemical parameters examined. Temperature is one of the most important ecological features that is a limiting factor for the growth and distribution of flora and fauna in any aquatic ecosystem. Many workers while discussing the periodicity distribution and growth of Cyanophyta have laid much stress on the water temperature. According to Stroikine²², Hutchinson¹¹, Hammer¹⁰ and Lin¹⁵ dense population blue-green algae are often associated with fairly high water temperature. The distribution and growth of Cyanophyta members is attributed to high temperature by Butcher⁶. Chakaraborty *et al.*⁷, Venkateshwarlu (1969) and Wilde and Tilly (1981) have also stressed the importance of water temperature in the periodicity of blue-green algae. Chu and Tiffany (1951) and Rao (1955) have stressed more on the significance of bright sunshine than temperature. Lin¹⁵ observed that relatively high summer water temperature favored the blue-green algal blooms and results in high concentration of organic matter. Pearsall (1932) have pointed out that blue-green were observed in summer. Kaliyamurthi (1975) observed peak of blue-green algae in January

to April and Singh and Swarup (1979) noted peak in April to October, Zafar (1967), Biswas (1972), Khare¹³, Khare and Patil¹⁴, Mahajan *et al.*¹⁶ and Anand⁵ have reported that blue-green started increasing in early summer and attained their maxima in the middle of summer season. According to Spancar and King (1989) surface bloom of blue-green algae are present during the summer in many eutrophic lakes. Singhal (1986) found Cyanophyta group dominating over other groups throughout the year and with peak in April. In previous observation on lake, Valecha (1985) observed maxima growth of Cyanophyta in the month of June and minima in winter.

In the month of April, May and June oxidizable organic matter were increased with the increased temperature. Rao (1955), Zafar (1967), Parmasivam and sreenivasan (1981) have also confirmed the maximum of blue-greens with high concentration of oxidizable organic matter. Desikachary⁸ supported that bicarbonates plays significant role in the maxima of Cyanophyceae.

In the Shahpura Lake, 86 species were recorded in two consecutive years 2007–2009. The Cyanophyta showed variations in their quantity and quality. In the present study 86 species belonging to 26 genera viz. 6 species of *Microcystis*, 6 species of *Chroococcus*, 1 species of *Gleocapsa*, 2 species of *Gloeothece*, 4 species of *Aphanocapsa*, 3 species of *Aphanothece*, 1 species of *Synechococcus*, 2 species of *Dactylococcopsis*, 1 species of *Coelosphaerium*, 4 species of *Merismopedia*, 1 species of *Stichosiphon*, 1 species of *Arthospira*, 1 species of *Spirulina*, 18 species of *Oscillatoria*, 1 species of *Phormidium*, 1

species of *Porphyrosiphon*, 5 species of *Lyngbya*, 1 species of *Schizothrix*, 1 species of *Anabaenopsis*, 5 species of *Cylindrospermum*, 3 species of *Nostoc*, 11 species of *Anabaena*, 1 species of *Scytonema*, 2 species of *Tolypothrix*, 1 species of *Rivularia*, 3 species of *Gloeotrichia*. Four genera *Oscillatoria*, *Anabaena*, *Microcystis* and *Chroococcus* were dominant in this pond.

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