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Research Article

An annotated checklist of cyanobacterial flora in Rudrasagar Ramsar site, Tripura, India

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ABSTRACT

A checklist of the cyanobacterial flora of Rudrasagar Ramsar site of Tripura (India) bordering Bangladesh was compiled based on field surveys. Altogether 98 cyanobacterial species representing 16 families and 34 genera were recorded, of which a total of 71 species were reported from Tripura for the first time and 15 species from Northeastern Region of India. The present checklist is an inclusive document of cyanobacterial diversity which could be utilized by fishery managers, conservationists, students and research scientists in Northeast India and boarding areas for designing and implementing of management strategies and scientific monitoring in future.

Key words: Cyanobacteria, Checklist, Inventory, Rudrasagar, Ramsar site, Northeast India

INTRODUCTION

Cyanobacteria, popularly known as blue green algae (BGA) constitute one of the major groups of prokaryotes. The phycocyanin, an accessory protein pigment universally present in each of the members of the group provide a bluish colouration to the cells leading to named them as BGA (Osorio *et al.,* 2020), whereas, structurally they are more closely related to the prokaryotic bacteria than to the eukaryotic algae. Cyanobacteria comprises of very simple unicellular organism to branched filamentous forms. Simple unicellular organisms may be ovoid, spherical, and cylindrical. A few filamentous forms harbour a specialized cell "heterocyst" which is best known as site for N_2 fixation.

Cyanobacteria are ubiquitous and are widely present in freshwater, seas to oceans, biological soil crusts to desert soils (Kulasooriya, 2011). Some are reported to be found in snowcapped mountains and Polar Regions to volcanic ash (Gerasimenko *et al.,* 2013) and salted soils (Oren, 2015). A few have shown symbiotic growth with different higher plants. Phytoplankton forms, either in oceanic or fresh water, are very common which use to take part in maintaining base level of all the trophic structures therein. Cyanobacteria in many occasions, play a pivotal role in enhancing soil fertility as natural biofertilizers (Chittora *et al.,* 2020) and take part in degradation of a wide range of pollutants (Zahra *et al.,*2020). A few like *Spirulina* and *Chlorella* are used as food supplements for inherent nutritive and therapeutic values. In contrast, harmful effects of a few members are also recently recognized in interfering water quality and odour of the water body where they grow and causing diseases to human (Zahra *et al.,*2020).

Immense ecological and economical potential, therefore, make the cyanobacteria a suitable subject of research throughout the globe and have been incorporated into traditional classifications of Thuret (1875), Gomont (1892) to modern classification as proposed by Komarek (2013). In the updated taxonomic review and determination manual, Geitler (1932) listed a total of 1,300 species of cyanobacteria belonging to 145 genera under 20 families and 3 orders. Geitler's contribution was later acknowledged by Desikachary (1959), Tiwari (1972), Anand and Hopper (1987), Anand (1990) etc. in proposing different revised systems of classification for cyanobacteria. However, the recent systematic revisions made by Guiry and Guiry are the commendable piece of work in cyanobacterial database.

In India, diversity of cyanobacteria was studied first by Bruhl and Biswas (1922) followed by Ghose (1924), Drouet (1938), Parukutty (1940), Gomont (1892), Geitler (1932), Desikachary (1959), Anand and Hopper (1987), Tripathy *et al*. (1999), Pattanaik and Adhikary (2002), Tirkey and Adhikary (2006),Vijayakumar *et al.* (2007), Patil and Nandan (2011), Ghosh and Keshri (2011), Hazarika (2012), Kumar *et al.* (2013), Kamble and Karande (2014) of which, Desikachary's contribution was overwhelming in the contemporary period. In recent years research on cyanobacterial diversity has been found to be piled up (Ray, 2006) gradually from different parts of the country, although a limited contributions were from the entire Northeastern Region including Tripura, a biodiversity rich state bordering Bangladesh. There have been only a few published records on the cyanobacterial (Cyanophyta) diversity from the rice fields and water bodies of Tripura (Reddy *et al*., 1986; Singh *et al.*, 1997). Reddy *et al*. (1986) reported 8 species of Cyanophyta belonging to 5 genera, whereas Singh *et al.* (1997) documented 79 species under 30 genera. From their exploration in different aquatic habitats in the

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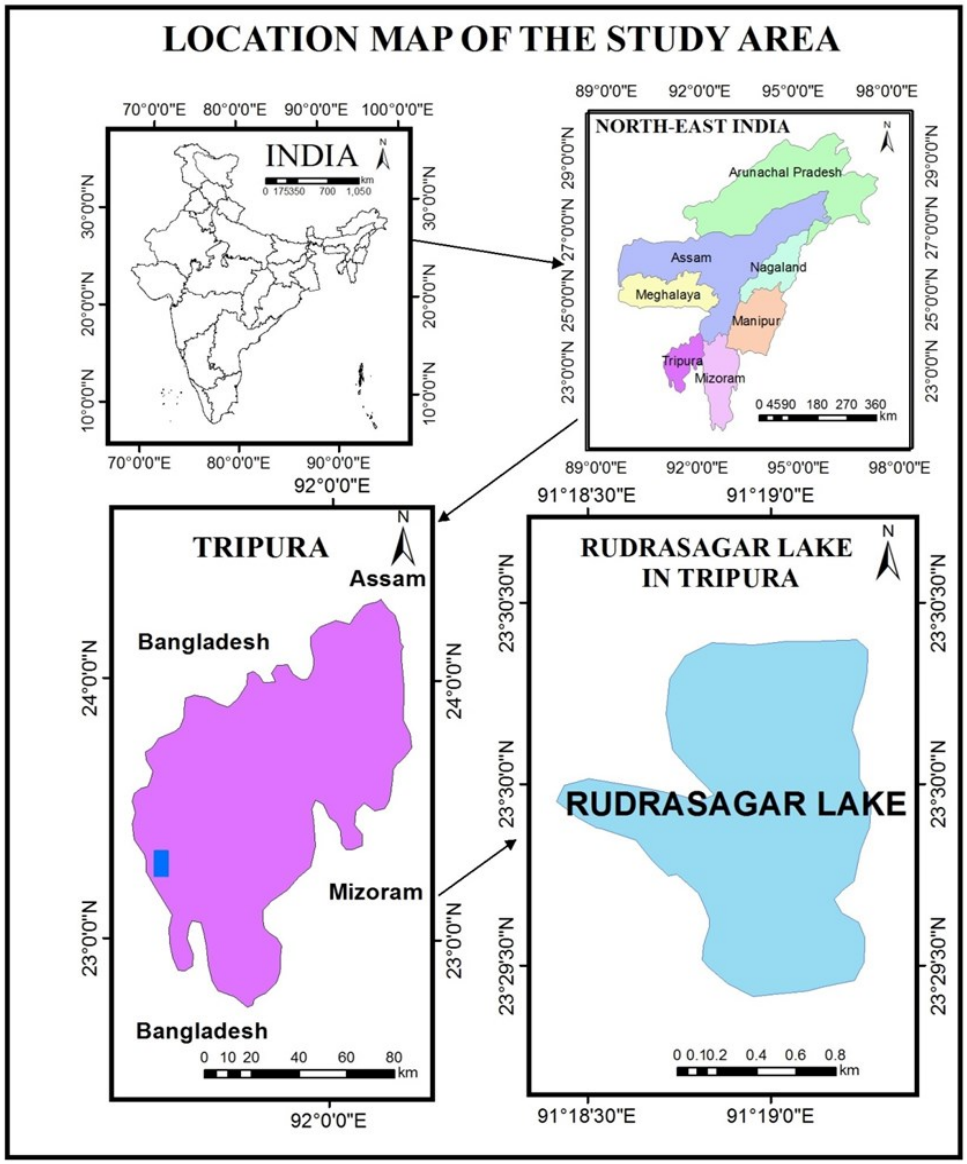

Figure 1. Map of Rudrasagar lake showing its location in India.

state, Das *et al*. (2010) reported 27 cyanobacterial species and Bharati *et al*. (2020) reported only 7 species.

Tripura is blessed with so many lentic water bodies, Rudrasagar is one of them. The Rudrasagar lake is ecologically important for freshwater endemic fishes and a prominent natural habitat for many migratory and resident birds and waterfowls (Barman *et al.,* 2013). The lake also houses endangered Baer's Pochard, nearly threatened Ferruginous Duck, the IUCN red listed roof turtle *Kachuga dhongka*. Considering its different ecological services such as, flood mitigation, recharge / discharge of ground water, providing shelter and feeding ground to a good number of residents and migratory fowls and above all, a repository of the local breed fishes, the Rudrasagar Lake has been accorded as one of the prominent Ramsar sites of Northeast India in the year 2005 (Taran and Deb, 2017). Later in 2007, the lake was certified as "wetland of international importance" and conservation initiatives speeded up (Barman *et al.,* 2013). As an updated document on cyanobacterial diversity in the water body was not available, compilation of this annotated checklist on cyanobacterial flora of Rudrasagar lake was therefore planned and presented in a tabular form.

MATERIALS AND METHODS

Study Area:

With about 240 ha, Rudrasagar lake is situated in the Melaghar of West Tripura district at about 53 km from the state capital Agartala and located between the latitudes 23°30′34′′to 23°50′45′′N and longitudes 91° 16′59′′ to 91°29′56′′ E. The lake is replenished with the water of the Gomati, one of the foremost rivers of Tripura through a connective channel, called as Kachigan during rainy season. Noacherra, Durlavnarayacherra and Kemtalicherra are other few natural streams which regularly discharge water as well as sediment to the lake to make the same a natural sedimentation reservoir.

Sampling:

The water samples were collected from different sampling locations of the Lake (Figure 1) using Nansen sampler and were allowed to pass through planktonic mesh of mesh size 20 µm. Approximately 50 L of water were passed through the plankton net, collected mass was kept in amber coloured sampling bottles with 300

ml sampling water and the samples bottles were then marked with collection no. and date. A few terrestrial samples were also collected from the surfaces of pebbles and soil crusts. Four percent Formalin and Lugol's solution were used to preserve the samples (Banerjee and Pal, 2017). Sample bottles were brought to the Plant Ecology Laboratory of the Department of Botany, Gauhati University for further analysis to identify planktonic cyanobacterial species. The Cyanobacterial samples were observed under Euromex Delphi-X Microscope using Image Viewer Software and measurements were taken under different magnifications. Cyanobacterial taxa were then identified in consultation with the standard literatures and monographs written by Desikachary (1959), Gonzalves (1981), Iyenger and Desikachary (1981), Prasad and Srivastava (1992), Anand (1993), Perumal and Anand (2009), Yamagishi (2010) and Komarek (2013).

RESULTS AND DISCUSSION

The present study revealed that Rudrasagar Ramsar site currently houses altogether 98 cyanobacterial species (Table 1) belonging to 34 genera under 16 families representing from 6 orders. Of the recorded 98 species, about 71 species were reported from Tripura for the first time and a total of 15 species (Figure 2) were new from the Northeast Region of India. Bharati *et al*. (2020) reported 7 cyanobacterial taxa only from Rudrasagar Ramsar site which were identified upto genus level only, whereas Das *et al*. (2010) reported around 27 species of the group from entire Tripura including Rudrasagar Lake. In Deepor beel, another Ramsar site of Northeast India which was explored so far for the purpose reported to harbour only 41 number of cyanobacterial species (Baruah *et al*., 2020) whereas Rudrasagar lake houses 98 species.

Members of order Oscillatoriales were outnumbered with 28.57 per cent of species representation followed by Chroococcales (26.53%), Nostocales (18.36 %), Synechococcales (15.30%) and Spirulinales (10.20%) respectively. With 20 species Oscillatoriaceae was dominant family which was followed by Nostocaceae (15), Microcystaceae (12), Merismopediaceae(11), Aphanothecaceae(8), Chroococcaeae(6), Microcoleaceae(6), Spirulinaceae (4), Coelosphariaceae(4), Calothicaceae (3), Scytonemaceae(3), Synechococcaceae(2) respectively. Four families viz. Borziaceae, Cyanothecaeae, Radiococcaceae, Psudeoanabaenaceae were represented by only 1 species each.

Genus *Oscillatoria* was dominating in the Lake with 8 species followed by *Aphanothece* (7), *Gloeocapsa* (7), *Anabaena* (6), *Microcystis* (5), *Aphanocapsa* (5), *Merismopedia* (5) and *Nostoc* (5) respectively. Though it is a natural water body, reporting of so many cyanotoxins producing cyanobacterial species (Drobac *et al.,* 2021) belonging to genera *Anabaena, Microcystis, Nostoc, Lyngbya*, and *Oscillatoria* is a matter of great concern which needs proper scientific and systematic interventions. However, the present checklist is an inclusive document of the cyanobacterial diversity of Rudrasagar Ramsar Site of Tripura which will certainly act as a baseline database in designing management strategies and scientific monitoring in future.

Table 1. Cyanobacterial flora recorded from Rudrasagar Ramsar site arranged according to the Algaebase (Guiry&Guiry, 2021) . "*" indicates New to Tripura, "**" indicates New to North-East India

Sl. No.	Order /Family/ Species/ Basionym (s)	Habit	Cell Size	Cell/Thallus Structure
	Order: Chroococcales **Family: Aphanothecaceae**			
1	*Aphanothece bullosa* (Meneghini) Rabenhorst 1865: 65	Free floating	Cells 5 µm broad, 9 µm long	Colonial; colonies many-celled, mucilaginous, irregularly spherical
2	*Aphanothece microspora* (Meneghini) Rabenhorst 1863: 76 * /** (Figure 2a) Basionym: *Microcystis microspora* Meneghini 1842: 80, pl. XI: Figure 1	Free floating	Cells 3-5 µm broad, 5µm long	Colonial; colonies many-celled, mucilaginous, irregularly spherical
3	*Aphanothece microscopica* Nageli 1849: 59, Figure 1 ; pl. 1: H	Free floating	Cells 3-5µm broad, 5µm long	Colonial; colonies many-celled, mucilaginous, irregularly spherical
4	*Aphanothece naegelii*Wartmann in Rabenhorst 1865: 65	Free floating	Cells 3.5-5 µm and 6.5-8.5 µm long;	Colonial; colonies many-celled, mucilaginous, irregularly spherical
5	*Aphanothece pallida* (Kutzing) Rabenhorst 1863: 76 Basionym:*Palmella pallida* Kutzing	Free floating / Epipelic	Cells 3-8 µm broad and 4.5-24 µm long.	Colonial; colonies many-celled, mucilaginous, irregularly spherical

Table 1 continued in next page

6	*Aphanothece saxicola* Nageli 1849: 60, pl. I H: Figure 2	Free floating / Epipelic	Cells 2-3 µm broad, 5µm long	Colonial; colonies many-celled, mucilaginous, irregularly spherical
7	*Aphanothece stagnina* (Sprengel) A. Braun in Rabenhorst 1863: no. 1572 */**(Figure 2b) Basionym: *Coccochloris stagnina* Sprengel 1807: 14	Free floating	Cells 3-3.5 µm broad, 6-8µm long	Colonial; colonies many-celled, mucilaginous, irregularly spherical
8	*Gloeothece samoensis* Wille 1913: 144*	Free floating	Cells 5.4–8.4 µm long,3.3–5.8 µm broad	Unicellular-colonial; Multicellular aggregations of small colonies
	Family: Chroococcaceae			
9	*Chroococcus dispersus* (Keissler) Lemmermann 1904: 102	Free floating	Cells 3.5-4.5µm in diameter.	Unicellular - colonial; more or less spherical
10	*Chroococcus minutus* (Kutzing) Nageli 1849: 46 Basionym: *Protococcus minutus* Kutzing 1843: 168	Free floating	Cells 4-6 µm in diameter.	Unicellular - colonial; more or less spherical
11	*Chroococcus turgidus* (Kutzing) Nageli 1849: 46* Basionym: *Protococcus turgidus* Kutzing 1846: 5, pl. 6	Free floating	Cells 12.5-14 µm in diameter.	Unicellular - colonial; more or less spherical
12	*Chroococcus varius* A. Braun in Rabenhorst 1876: no. 2451*	Aerophytic	Cells 2-4 µm in diameter.	Unicellular - colonial; more or less spherical
13	*Cyanosarcina burmensis* (Skuja) Kovacik 1988: 176* Basionym: *Myxosarcina burmensis* Skuja 1949	Free floating or Epiphytic	Cells 2-3µm in diameter.	Unicellular colonial, Multicelled, sarcinoid
14	*Cyanosarcina spectabilis* (Geitler) Kovacik 1988: 176 * Basionym: *Myxosarcina spectabilis* Geitler	Free floating	Cells 1.5-2 µm in diameter	Unicellular-colonial; colonies microscopic, multicelled, sarcinoid.
	Family: Microcystaceae			
15	*Gloeocapsa alpicola* (Lyngbye) Bornet in Wittrock, Nordstedt & Lagerheim 1903: 1540* Basionym: *Palmella alpicola* Lyngbye 1819: 206, nom. Illeg.	Free floating or Epiphytic	Cells 1.5-3 µm in diameter.	Unicellular-colonial; small in a form of irregular aggregations
16	*Gloeocapsa atrata* Kutzing 1843: 174, nom. Illeg*	Wetland species	Cells 3.5 to 4.5 µm diameter	Unicellular-colonial, crustaceous; small in a form of irregular aggregations, Blackish.
17	*Gloeocapsa gelatinosa* Kutzing 1843: 174*	Free floating or Epiphytic	Cells 3-5µm in diameter.	Unicellular-colonial; small in a form of irregular aggregations
18	*Gloeocapsa luteofusca* Martens 1871: 462*	Free floating or Epiphytic	Cells 4-5 µm wide, 6-8 µm long	Unicellular-colonial; small in a form of irregular aggregations
19	*Gloeocapsa magma* (Brebisson) Kutzing 1847: 17* Basionym: *Protococcus magma* Brebisson 1835: 40, pl. IV [pl. 4 p.p.]	Free floating or Epiphytic	Cells 3-12 µm in diameter	Unicellular-colonial; small in a form of irregular aggregations
20	*Gloeocapsa nigrescens* Nageli in Rabenhorst 1865: 40*	Aerophytic	Sheath 3.3 µm diameter, cells about 32 µm diameter	Unicellular-colonial; small in a form of irregular aggregations

Table 1 continued in next page

21	*Gloeocapsa stegophila* (Itzigsohn) Rabenhorst 1863: 7* Basionym: *Monocapsa stegophila* Itzigsohn in Rabenhorst 1853: no. 263a	Free floating or Epiphytic	Cells 14 µm broad; sheath 14 broad and 9.6 – 19.2 µm long, sheath up to 3.2 µm thick	Unicellular-colonial; small in a form of irregular aggregations
22	*Microcystis aeruginosa* (Kutzing) Kutzing 1846: 6 Basionym: *Micraloa aeruginosa* Kutzing 1833: 371, pl. VIII: Figure 23	Free floating or attached to the substrate	Cells 4-9 µm in diameter	Unicellular, colonial; (spherical, discoid, irregular)
23	*Microcystis bengalensis* Banerjii 1936:295, Figure 2 A, B*	Free floating or attached to the substrate	Cells 4-9 µm in diameter	Unicellular, colonial; (spherical, discoid, irregular)
24	*Microcystis flosaquae* (Wittrock) Kirchner 1898: 56 Basionym: *Polycystis flosaquae* Wittrock in Wittrock, Nordstedt & Lagerheim 1879: no. 201	Free floating or attached to the substrate	Cells 2.5-5 µm diameter	Unicellular, colonial; (spherical, discoid, irregular)
25	*Microcystis orissica* West 1911: 84, Figure 2 9*/**(Figure 2c)	Free floating or attached to the substrate	Cells 2.4- 4.0 µm diameter	Unicellular, colonial; (spherical, discoid, irregular)
26	*Microcystis smithii* Komarek & Anagnostidis 1995: 21 *	Free floating or attached to the substrate	3.2-5.6 µm diameter	Unicellular, colonial; (spherical, discoid, irregular)
	Order: Nostocales			
	Family: Calothricaceae			
27	*Calothrix clavata* G. S. West 1914: 1019, pl. XXI [21]: Figure 6-7	Free floating	Cells 12-13 µm long, 5-6 µm broad	Filaments heteropolar, differentiated into basal and apical parts, simple, solitary or in small groups
28	*Calothrix ghosei* Bharadwaja 1935: 99, Figure 3C-F*	Free floating	Cells 12-13 µm long, 5-6 µm broad	Filaments heteropolar, differentiated into basal and apical parts, simple, solitary or in small groups
29	*Calothrix marchica* Lemmermann 1914: 248, Figure 1, 2	Free floating	Filaments 7-10µm, cells 4-7µm long and 3-7µm broad	Filaments heteropolar, differentiated into basal and apical parts, simple, solitary or in small groups
	Family: Nostocaceae			
30	*Anabaena fullebornii* Schmidle 1902: 61, pl. 1, Figure 4	Free floating	Cells 10-10.52 µm broad and 7.89-9.21 µm long.	Filamentous; filaments solitary or in free clusters / macroscopic mats/ coiled and tangled
31	*Anabaena iyengarii* Bharadwaja 1935: 105, Figure 6 H-K*	Free floating	Trichomes 5.2 - 6.3 µm broad; heterocysts 7.3-8.4 µm broad, 7.3 -10.5 µm long.	Filamentous; filaments solitary or in free clusters / macroscopic mats/ coiled and tangled
32	*Anabaena iyengarii* var. *tenuis* C.B.Rao 1937: 361, Figure 5 A-C*	Free floating	Cells 5-6 µm broad, 4-5 µm long.	Filamentous; filaments solitary or in free clusters / macroscopic mats/ coiled and tangled

Table 1 continued in next page

33	*Anabaena orientalis* S.C.Dixit 1936: 101, Figure 3 D, E*	Free floating	Cells 5-6µm broad, 7-8 µm long. Heterocyst-7-8 µm broad, 9-10 µm long.	Filamentous; filaments solitary or in free clusters / macroscopic mats/ coiled and tangled
34	*Anabaena sphaerica* Bornet & Flahault 1886: 228*	Free floating	Cells discoid, 8-9 µm broad, 5-7 µm long, Heterocysts 8-11 µm broad	Filamentous; filaments solitary or in free clusters / macroscopic mats/ coiled and tangled
35	*Anabaena torulosa* Lagerheim ex Bornet & Flahault 1886: 236	Free floating	Cells 3.5 µm broad, 3.5-5.5 µm long	Filamentous; filaments solitary or in free clusters / macroscopic mats/ coiled and tangled
36	*Aulosira fertilissima* S.L.Ghose 1924: 342, pl. 31: Figure 9	Free floating	Cells 8-10 µm broad and 5.5-9.5 µm long.	Filamentous; filaments solitary or in free clusters / macroscopic mats/ coiled and tangled
37	*Aulosira fertilissima* var. *tenuis* C.B.Rao 1937: 353, Figure 3F-I *	Free floating	Cells 8-10 µm broad and 5.5-9.5 µm long	Filamentous; filaments solitary or in free clusters
38	*Cylindrospermum muscicola* Kutzing ex Bornet & Flahault 1886: 254 *	Wetland species.	Cells 3-4.7µm broad, 4-5 µm long; Hterocysts 4-5 µm wide ,5-7 µm long.	Filamentous; filaments solitary or in free clusters
39	*Nostoc calcicola* Brebisson ex Bornet & Flahault 1886: 202*	Wetland species	Trichomes 3.2 µm; heterocyst 4.2 µm broad	Thallose; thallus microscopic gelatinous, amorphous or spherical
40	*Nostoc commune* Vaucher ex Bornet & Flahault 1888: 203	Free floating / Wetland species	Trichomes 5-6 µm broad, cells 7 µm broad.	Thallose; thallus microscopic gelatinous, amorphous or spherical
41	*Nostoc hatei* S.C. Dixit 1936: 101, Figure 30*	Free floating	Trichome 3.8 µm; heterocyst 4.5 µm broad; 5.2 µm long	Thallose; thallus microscopic gelatinous, amorphous or spherical
42	*Nostoc linckia* Bornet ex Bornet & Flahault 1886: 193*	Free floating	Trichomes 4-5 µm broad	Thallose; thallus microscopic gelatinous, amorphous or spherical
43	*Nostoc linckia* var. *arvense* C. B. Rao 1937: 358 *	Free floating / Wetland species	Cells length 3.0–4.2µm;width 3.2–3.4 µm	Thallose; thallus microscopic gelatinous, amorphous or spherical
44	*Trichormus fertilissimus* (C.B.Rao) Komarek & Anagnostidis 1989: 303 */**(Figure 2d) Basionym: *Anabaena fertilissima* C.B.Rao	Free floating	cells 2-5 µm long and 2 µm broad, heterocyst 4-6 µm and 3-5 µm broad.	Filamentous- Thallose; solitary filaments
	Family: Scytonemataceae			
45	*Scytonema coactile* Montagne ex Bornet&Flahault 1886: 90*	Submerged / rocky littoral of lakes	Filaments 16 µm wide	Filamentous - thallose; solitary branched filaments or mats on the substrate. Filaments free or in fascicles,
46	*Scytonema hofmanii* C. Agardh ex Bornet & Flahault 1886: 97*	Wetland species.	Cells 5-6 µm wide, filaments 7-8 µmwide	Filamentous - thallose; solitary branched filaments or mats on the substrate. Filaments free or in fascicles.

Table 1 continued in next page

47	*Scytonema simplex* Bharadwaja 1934: 157, Figure 1A, B */** (Figure 2e)	Free floating	Filaments 14.0–15.7 µm broad; Trichomes 9.4–11.5 µm broad	Filamentous - thallose; solitary branched filaments or mats on the substrate. Filaments free or in fascicles.
	Order:Oscillatoriales **Family: Borziaceae**			
48	*Borzia curta* (Lemmermann) Anagnostidis & Komárek 1988: 370 * Basionym: *Arthrospira curta* Lemmermann	Free floating	Trichomes 3 µm wide; Cells 2-3 µm long	Filamentous; solitary filaments or small groups of Trichomes
	Family: Cyanothecaceae			
49	*Cyanothece aeruginosa* (Nageli) Komarek 1976: 150 Basionym: *Synechococcus aeruginosus* Nageli 1849: 56, pl. I [1]:E: Figure 1*/**(Figure 2f)	Free floating	Cells 2-3 µm broad, 5µm long	Unicellular; cells solitary or in irregular groups, oval or almost cylindrical with widely rounded ends
	Family: Microcoleaceae			
50	*Arthrospira gigantea* (Schmidle) Anagnostidis 1998 Basionym: *Spirulina gigantea* Schmidle 1902: 59, pl. I, Figure 5 *	Free floating	Trichomes2.5-4 µm width; cells 7 -15 µm long; 8-16 µm width	Filaments unbranched, solitary
51	*Oxynema acuminatum* (Gomont) Chatchawan, Komárek, Strunecky, Smarda & Peerapornpisal 2012: 56, Figure 35-40 */**(Figure 2g) Basionym: *Oscillatoria acuminata* Gomont 1892: 227, pl. VII [7]: Figure 12	Free floating	Cell length 4.3 µm; Cell breadth 3.8 µm	The filaments of are cylindrical, narrowed and bent at the ends, commonly attenuated to a terminal elongated.
52	*Kamptonema chlorinum* (Kutzing ex Gomont) Strunecky, Komarek& J. Smarda 2014: 204*/**(Figure 2h) Basionym:*Oscillatoria chlorina* Kutzing ex Gomont	Free floating	Trichomes 2.5 µm wide	Filaments solitary, without sheaths, or with very fine,
53	*Kamptonema formosum* (Bory ex Gomont) Strunecky, Komarek& J. Smarda 2014: 204* Basionym: *Oscillatoria formosa* Bory ex Gomont 1892: 230, pl. VII [7]: Figure 16	Free floating	Trichomes 4–5.5 µm broad, cells 3 –4.5 µm long	Filaments solitary, without sheaths, or with very fine,
54	*Planktothrix rubescens* (De Candolle ex Gomont) Anagnostidis & Komárek 1988: 416 */** (Figure 2i) Basionym:*Oscillatoria rubescens* De Candolle ex Gomont	Free floating	Trichomes 4-8 µm in diameter	Filaments solitary, rarely in small irregular and easy disintegrating fascicles, less straight or slightly waved
55	*Symploca dubia* Gomont 1892: 115 *	Free floating	Cells 1.2-2.8 µm wide ;2.5-8 µm long	Filamentous - colonial; colonies in form of flat mats on the substrates
	Family: Oscillatoriaceae			
56	*Lyngbya laxespiralis* Skuja 1949: 53, pl. IX [9]: Figure 10, 11*/**(Figure 2j)	Free floating	Trichome 8.2-10µm broad	Filamentous; filaments thick, rarely solitary
57	*Lyngbya majuscula* Harvey ex Gomont 1892: 131, pl. III [3]: Figure 3, 4*	Free floating	Trichomes 2-4 µm broad	Filamentous; filaments thick, rarely solitary
58	*Lyngbya spiralis* Geitler 1932: 1042, Figure 659	Free floating	Trichomes 3 µm broad	Filamentous; filaments thick, rarely solitary
59	*Lyngbya truncicola* Ghose*	Aerophytic	Filaments 15µm broad; Trichome 13 µm broad	Filamentous; filaments thick, rarely solitary

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60	*Oscillatoria crassa* (C.B.Rao) Anagnostidis 2001: 372 */** (Figure 2k) Basionym:*Oscillatoria ornata* var. *crassa* C.B.Rao	Free floating	Trichome 12.0–15.0 µm broad and cells 2.8–5.2 µm long	Trichomes blue - green ,highly motile ; walls narrowing toward the bent ends
61	*Oscillatoria perornata* Skuja 1949: 47, pl. VIII [8]: Figure 7-9 */** (Figure 2l)	Free floating	Trichome 9.3–11.8 µm broad and cells 2.8–5.8 µm broad.	Trichomes blue- green to brownish-green, highly motile, slightly constricted at the cross-walls, bent ends
62	*Oscillatoria princeps* Vaucher ex Gomont	Free floating / free floating.	Trichome 1.0–1.8 µm broad and cells 5.0–7.5 µm long.	Trichomes blue - green , highly motile ; walls narrowing toward the bent ends
63	*Oscillatoria princeps* var. *pseudolimosa* Ghose*	Free floating	Trichome 2.4 µm broad and cells 6.8 µm long.	Trichomes blue - green , highly motile ; walls narrowing toward the bent ends
64	*Oscillatoria proboscidea* Gomont 1892: 209, pl. VI/6: Figure 10, 11*	Free floating	Trichome 2-15 µm broad; cells 0.5-0.8 µm broad, 2-4 µm long	Trichomes blue - green , highly motile ; walls narrowing toward the bent ends
65	*Oscillatoria sancta* Kutzing ex Gomont 1892: 209, pl. VI/6: Figure 12	Free floating	Trichome 10-20 µm broad; cells 0.5-0.8 µm broad, 2.5-6 µm long	Trichomes blue - green ,highly motile ; walls narrowing toward the bent ends
66	*Oscillatoria subbrevis* Schmidle 1901: 243, pl. IV [4]: Figure 7*	Ubiquitous species.	Trichomes 7-9 µm wide; cells 1-2 µm long.	Trichomes blue - green ,highly motile ; walls narrowing toward the bent ends
67	*Oscillatoria tenuis* C.Agardh ex Gomont 1892: 220, pl. VII/7: Figure 2, 3 *	Free floating	Cells 4-10 µm broad, 2-7µm long	Trichomes blue - green ,highly motile ; walls narrowing toward the bent ends
68	*Phormidium ambiguum* Gomont 1892: 178, pl. V [5]: Figure 10	Free floating	Filaments 8-12 µm wide; Trichomes 9-10 µm; Cells 2.3 µm long.	Filamentous; filaments unbranched, rarely solitary, usually in fine, smooth
69	*Phormidium calcicola* N.L. Gardner 1927: 44, pl. 9: Figure 87*	Free floating	Filaments 10-11 µm wide; Trichomes 8-11 µm; Cells 2.5 µm long.	Filamentous; filaments unbranched, rarely solitary, usually in fine, smooth
70	*Phormidium chalybeum* (Mertens ex Gomont) Anagnostidis & Komarek 1988: 405 Basionym: *Oscillatoria chalybea* Mertens ex Gomont 1892: 232, pl. VII [7]: Figure 19	Free floating	Filaments 8-10 µm wide; Trichomes 7-8 µm; Cells 1.8 µm long.	Filamentous; filaments unbranched, rarely solitary, usually in fine, smooth
71	*Phormidium incrustatum* Gomont ex Gomont 1892: 170, pl. IV/4: Figure 27	Free floating	Filaments 9-10 µm wide; Trichomes 8-9 µm; Cells 2.2 µm long.	Filamentous; filaments unbranched, rarely solitary, usually in fine, smooth
72	*Phormidium inundatum* Kutzing ex Gomont 1892: 172, pl. IV[4]: Figure 31, 32*	Free floating	Filaments 7-13 µm wide; Trichomes 6-8 µm; Cells 2.4 µm long.	Filamentous; filaments unbranched, rarely solitary, usually in fine, smooth

Table 1 continued in next page

73	*Phormidiu mputeale* (Montagne ex Gomont) Anagnostidis &Komarek 1988: 408 Basionym: *Lyngbya putealis* Montagne ex Gomont	Free floating	Cells broader than long, 5-9 µm long and 13 µm broad	Filamentous; filaments unbranched, rarely solitary, usually in fine, smooth
74	*Phormidium retzii* Kutzing ex Gomont 1892: 175, pl. V [5]: Figure 6-9*	Free floating	Filaments 11-12 µm wide; Trichomes 8-10 µm; Cells 2.1 µm long.	Filamentous; filaments unbranched, rarely solitary, usually in fine, smooth
75	*Phormidium stagninum* C.B.Rao 1938: 93, Figure 4-7	Free floating	Filaments 11-12 µm wide; Trichomes 9-10 µm; Cells 2 µm long.	Filamentous; filaments unbranched, rarely solitary, usually in fine, smooth
	Order:Sphaeropleales **Family: Radiococcaceae**			
76	*Sporotetraspoly dermatica* (Kutzing) Kostikov, Darienko, Lukesova & L.Hoffmann 2002: 48* Basionym: *Gloeocapsa polydermatica* Kützing 1846: 15, pl. 20: Figure 3	Free floating	Cells 5-6 µm broad, 4-5 µm long.	Halli forming plate-like to spherical colonies
	Order: Spirulinales			
	Family: Spirulinaceae			
77	*Glaucospira laxissima* (G.S.West) Simic, Komarek & Dordevic 2014: 262, Figure 2-11* Basionym: *Spirulina laxissima* G.S.West 1907: 178, pl. 9: Figure 6	Free floating.	Cells 2.7- 6.1 µm long; 0.5 - 0.6 µm broad	Filaments unbranched, solitary, thin without sheaths
78	*Spirulina corakiana* Playfair 1914: 135, pl. 6: Figure 17*	Free floating	Trichomes 1.8 µm wide, 53 µm long, coils 6 µm	Filaments unbranched, solitary
79	*Spirulina meneghiniana* Zanardini ex Gomont 1892: 250, pl. VII/7: Figure 28*	Free floating	Trichome 1.5-2.3 µm broad; spirals 1.8-3.6 µm broad and 2.2-4 µm apart	Filaments unbranched, solitary
80	*Spirulina princeps* West & G.S. West 1902: 205 *	Free floating	Spirals 9.5-10 µm,10µm broad; trichomes 4.5 µm broad.	Filaments unbranched, solitary
	Order: Synechococcales			
	Family: Coelosphaeriaceae			
81	*Coelosphaerium aerugineum* Lemmermann 1898: 154*	Free floating	Cells 2-5.5 µm in diameter	Unicellular colonial; spherical, mainly distant from one another, peripherally situated.
82	*Coelosphaerium kuetzingianum* Nageli 1849: 54, pl. 1c *	Free floating	Cells 1.8-3 µm in diameter	Unicellular colonial; spherical, mainly distant from one another, peripherally situated.
83	*Snowella lacustris* (Chodat) Komárek & Hindák 1988: 212 */** (Figure 2m)	Free floating	Cells 2.5 µm in diameter	Unicellular-colonial; spherical or irregularly oval
	Family: Leptolyngbyaceae			
84	*Planktolyngbya contorta* (Lemmermann) Anagnostidis & Komarek 1988: 394 * Basionym: *Lyngbya contorta* Lemmermann	Free floating	Cells 1.3-1.7 µm broad,2.8-4.5 µm long	Filamentous; filaments solitary, with thin, rarely false-branched; Trichomes cylindrical

Table 1 continued in next page

	Family: Merismopediaceae			
85	*Aphanocapsa banaresensis* Bharadwaja 1935: 96, Figure 1 B	Benthic/Free floating,	Cells 4.4µm in diameter	Colonies many-celled, irregular, usually amorphic
86	*Aphanocapsa delicatissima* West & G.S.West 1912: 431, pl. 19: Figure 2-3*	Benthic/Free floating	Cells 0.5-0.8 µm in diameter	Colonies many-celled, irregular, usually amorphic
87	*Aphanocapsa elachista* West & G.S.West 1894: 276, pl. XV [15]: Figure 9, 10*	Benthic/Free floating	Cells 2-3.3µm in diameter.	Colonies many-celled, irregular, usually amorphic
88	*Aphanocapsa litoralis* Hpansgirg 1892: 229	Benthic/Free floating	Cells 4-6 µm in diameter.	Colonies many-celled, irregular, usually amorphic
89	*Aphanocapsa parasitica* (Kützing) Komárek & Anagnostidis 1995: 16 */ **(Figure 2n) Basionym: *Microcystis parasitica* Kutzing 1843: 170	Benthic/Free floating	Cells 1.8-2.3 µm diameter	Colonies many-celled, irregular, usually amorphic
90	*Limnococcus limneticus* (Lemmermann) Komarkova, Jezberova, O. Komarek & Zapomelova 2010: 79 * Basionym: *Chroococcus limneticus* Lemmermann 1898: 153	Free floating	Cells 5-6.5 µm in diameter.	Distantly placed microscopic colonies usually of a small number of cells, Cells spherical.
91	*Merismopedia convoluta* Brebisson ex Kutzing 1849: 472*/** (Figure 2o)	Free floating	Cells 3.7–5.1 µm in diameter	Unicellular-colonial; colonies free floating, cells situated in one plane, in rows more or less perpendicular one to another
92	*Merismopedia glauca* (Ehrenberg) Kutzing 1845: 142* Basionym: *Gonium glaucum* Ehrenberg 1838: 58, pl. III: Figure V	Free floating	Colonies 45-50 µm diameter; cells 3-6 µm broad	Unicellular-colonial; colonies free floating, cells situated in one plane, in rows more or less perpendicular one to another
93	*Merismopedia minima* G.Beck in G. Beck & Zahlbruckner 1897: 83*	Free floating	Cells 2-3 µm broad 3 µm long	Unicellular-colonial; colonies free floating, cells situated in one plane, in rows more or less perpendicular one to another
94	*Merismopedia tenuissima* Lemmermann 1898: 154	Free floating	Cells 1.3-3 µm diameter 3-4 µm long	Unicellular-colonial; colonies free floating, cells situated in one plane, in rows more or less perpendicular one to another
95	*Merismopedia smithii* De Toni 1939 *	Free floating	Cells 10-11 µm broad, 12-14 µm long	Unicellular-colonial; colonies free floating, cells situated in one plane, in rows more or less perpendicular one to another
	Family: Pseudanabaenaceae			
96	*Pseudanabaena limnetica* (Lemmermann) Komarek 1974: 1629 Basionym: *Oscillatoria limnetica* Lemmermann 1900: 310	Free floating	Trichome 2.0–2.7 µm broad; cells 4.0–6.0 µm long	Filamentous; filaments solitary or agglomerated in very fine,
	Family: Synechococcaceae			
97	*Synechococcus arcuatus* J. J. Copeland 1936: 63, Figure 28*	Free floating	Cells 1.5-2.5 µm broad, 6-11µm long	Unicellular; cells solitary or agglomerated in groups, oval in shape
98	*Synechococcus elongatus* (Nageli) Nageli 1849: 56* Basionym: *Protococcus elongatus* Nageli	Free floating/ wetland species	Cells 1.2-3 µm broad, 2-9µm long	Unicellular; cells solitary or agglomerated in groups, oval in shape

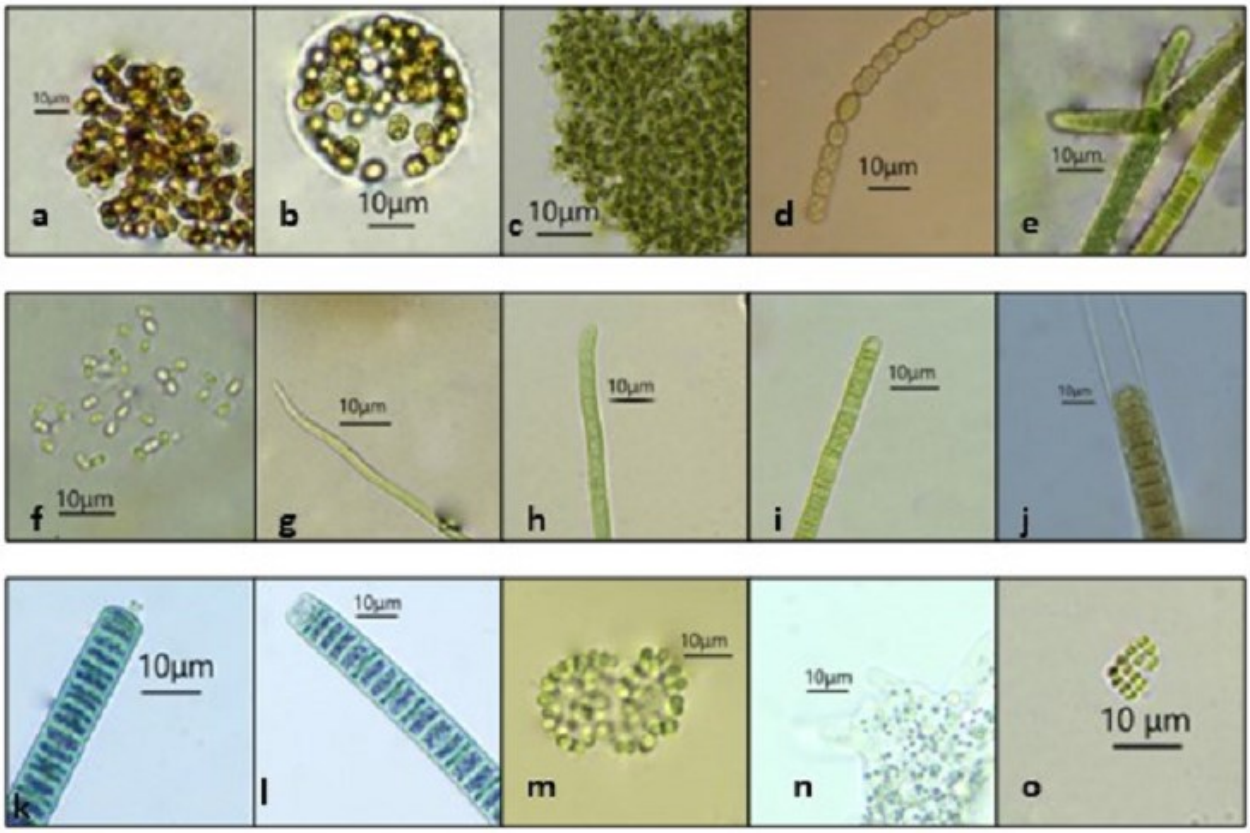

Figure 2. a. *Aphanothece microspora* b. *Aphanothece stagnina* c. *Microcystis orissica* d. *Trichormus fertilissimus* e. *Scytonema simplex* f. *Cyanothece aeruginosa* g. *Oxynema acuminatum* h. *Kamptonema chlorinum* i. *Planktothrix rubescens* j. *Lyngbya laxespiralis* k. *Oscillatoria crassa* l. *Oscillatoria perornata* m. *Snowella lacustris* n. *Aphanocapsa parasitica* o. *Merismopedia convoluta* (Scale bar = 10 µm)

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