



Research article

Fresh water Cyanobacteria of Sai River near Lucknow, Uttar Pradesh

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Abstract: The present paper deals with the identification of 23 fresh water cyanobacterial species belonging to 14 genera from Sai river, Lucknow, Uttar Pradesh (India). A total of 15 algal samples were collected from 5 different sites of Sai River in March 2013. In the present study *Anabaena* (5), *Scytonema* (2), *Oscillatoria* (3), *Chroococcus* (2), *Gloeothece* (1) and *Lyngbya* (2) were found to be the dominant forms, whereas *Gloeothece* (1), *Microcystis* (1), *Aphanothece* (1), *Phormidium* (1) were shown common occurrence and *Spirulina* (1), *Gloecapsa* (1), *Cylindrospermum* (1), *Nostoc* (1) were found rare. All these forms were reported for the first time from the study site.

Keywords: Blue green algae - Diversity - Abundance.

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INTRODUCTION

Sai River is a tributary of Gomti River which originates in Hardoi district of Uttar Pradesh and separates the district of Lucknow with Unnao. The river flows towards south and enters in the district of Pratapgarh through west, then it turns east. Many districts of Uttar Pradesh are situated on the banks of Sai river and it is one of the most sacred rivers of Hindus. The total course of the river in the district is about 100 km in length and the banks of river are precipitous in many places. The study site is located within the coordination of E 26° 13'43" N 81° 13'6" at the elevation of 106.7 m.

Cyanobacteria (blue green algae) comprise unique group of organisms. They are microscopic, unicellular and filamentous forms. They are the major primary producers in all habitats occupying about 75% of the earth's surface and produce 80% oxygen. Cyanobacteria is a large group of structurally complex and ecologically significant gram-negative prokaryotes which flourish in lotic and lentic water bodies, and play a major role in sustaining the fertility of the ecosystem.

Cyanobacterial taxonomy has a diverse and great diagnostic importance in floristic analysis as well as basic applied aspects of research. Studies on Cyanophyceae algae from saline-alkali soils of Sikanderpur, Hardoi, Uttar Pradesh was carried out by Singh *et al.* (1995). Prasad & Mehrotra (1978, 1979) reported 39 taxa of blue-green algae from various crop fields of Uttar Pradesh. But absolutely there are no reports on Cyanobacterial flora of Sai River. Therefore, the present investigation has been carried out to enumerate Cyanobacterial flora of Sai River near Lucknow.

MATERIAL AND METHODS

Fresh water algal samples were collected from different sites of Sai River, Lucknow Uttar Pradesh (India) in month of March, 2013. Collected samples were preserved in 10% formalin and deposited at phycology laboratory of CSIR-National Botanical Research Institute, Lucknow. Microscopic observation was done by Lieca DM.500 research microscope and photomicrography was done with attached camera EC-3. The identification of taxa was done by referring standard taxonomic manuals of Desikachary (1959) and Prescott (1951). The physico-chemical analysis of the water was measured by HACH instrument.

RESULTS AND DISCUSSION

The physico-chemical characteristics of water collected from Sai river shows its pH 8.4, dissolve oxygen, 8.46, conductivity 547 $\mu\text{s.cm}^{-1}$, temperature 20.2°C, nitrate 4.1 mg.L^{-1} , phosphate 1.38 mg.L^{-1} , sulphate 27 mg.L^{-1} , iron 0.03 mg.L^{-1} and silicate 5.6 mg.L^{-1} . In the present study a total of 23 Cyanobacterial taxa with 14

genera belonging to 2 orders Chroococcales and Nostocales have been reported. Species of *Anabaena* (5), *Scytonema* (2), *Oscillatoria* (3), *Chroococcus* (2), *Gloeothece* (1) and *Lyngbya* (2) were found to be the dominant forms, where as *Gloeothece* (1), *Microcystis* (1), *Aphanothece* (1), *Phormidium* (1) were shown common occurrence and *Spirulina* (1), *Gloecapsa* (1), *Cylindrospermum* (1), *Nostoc* (1) were found rare (Table 1).

Table 1. Diversity, distribution and abundance of Cyanobacterial flora in various sites of Sai river.

Sl. No.	Name of organism	Abundance		
		Dominant	Common	Rare
1.	<i>Chroococcus minor</i> (Kuitz.) Nag.	+++	-	-
2.	<i>Chroococcus turgidus</i> (Kuitz) Nag.	+++	-	-
3.	<i>Gloeothece rupestris</i> (Lyngb.) Bornet	+++	-	-
4.	<i>Aphanothece saxicola</i> Nag.	-	++	-
5.	<i>Gloecapsa gelatinosa</i> Kuitz.	-	-	+
6.	<i>Microcystis aeruginosa</i> Kuitz.	-	++	-
7.	<i>Anabaena circinalis</i> Rabenhorst ex Born.et Flash.	+++	-	-
8.	<i>Anabaena doliolum</i> Bharadwaja	+++	-	-
9.	<i>Anabaena flos-aque</i> Ralfs ex Born	+++	-	-
10.	<i>Anabaena iyengarii</i> Bharadwaja	+++	-	-
11.	<i>Anabaena torulosa</i> Lagerheim ex Bornet & Flahault	+++	-	-
12.	<i>Cylindrospermum stagnale</i> (Kuitz) Born. et Flah.	-	-	+
13.	<i>Nostoc punctiforme</i> (Kuitz.) Hariot	-	-	+
14.	<i>Gloeothece longicauda</i> Schmidle	-	++	-
15.	<i>Scytonema mirabile</i> (Dillw.) Born.	+++	-	-
16.	<i>Scytonema simplex</i> Bharadwaja	+++	-	-
17.	<i>Lyngbya allorgei</i> Frey	+++	-	-
18.	<i>Lyngbya confervoides</i> C. Ag. ex Gomont	+++	-	-
19.	<i>Oscillatoria limosa</i> Ag. ex Gomont	+++	-	-
20.	<i>Oscillatoria prolifica</i> (Grev.) Gomont	+++	-	-
21.	<i>Oscillatoria tenuis</i> Ag. ex Gomont	+++	-	-
22.	<i>Spirulina major</i> Kuitz. ex Gomont	-	-	+
23.	<i>Phormidium mucicola</i> Hub. Pestalozzi et Naumann	-	++	-

+++ : Dominant; ++ : Common; + : Rare; - : Absent

Taxonomic enumeration of all 23 species with classification details were described below

Division: Cyanophyta

Class: Cyanophyceae

Order: Chroococcales

Family: Chroococcaceae

Genus: Chroococcus

1. *Chroococcus minor* (Kuitz.) Nag. (Fig. 1E)

Colony slimy-gelatinous, dirty blue-green, or olive green; cells spherical, 3–4 µm in diameter, singly or in pairs, seldom 4 or 8; sheath colorless, very thin, hardly visible.

2. *Chroococcus turgidus* (Kuitz) Nag. (Fig. 1N)

Cells spherical or ellipsoidal single, or in groups of mostly 2–4, seldom many, blue green or olive green or yellowish, without sheath 8–32 µm, with sheath 13–35 µm, in diameter; rarely 40 µm; sheath colourless, not distinctly lamellated.

Genus: *Gloeothece*

3. *Gloeothece rupestris* (Lyngb.) Bornet (Fig. 1P)

Cells ellipsoidal to cylindrical, without envelope 4.0–6.0 µm broad, 1.5–3.0 times as long as broad, with envelope 08–12µm broad, contents mostly blue-green, 2–4 rarely 8 together in oval to subglobose colonies,

colonies 25–41 µm diameter, envelopes colourless or brownish at the periphery, lamellated or unlamellated; inside the colonies diffluent.

Family: Microcystaceae

Genus: *Aphanothece*

4. *Aphanothece saxicola* Nag. (Fig. 1M)

Thallus mucilaginous, colorless or yellowish; cells cylindrical, 1–2 µm broad and 2–3 times long, single or in pairs, seldom many in a common, mucilaginous envelope, pale blue-green.

Genus: *Gloeocapsa*

5. *Gloeocapsa gelatinosa* Kuitz. (Fig. 1F)

Cells without sheath about 2.5 µm and with sheath 6.2–10.0 µm diameter, blue-green in colour; colonies about 25 µm diameter; sheath colorless, seemingly thin, older colonies lamellated.

Genus: *Microcystis*

6. *Microcystis aeruginosa* Kuitz. (Fig. 1L)

Colonies when young round or slightly longer than broad, solid, old colonies clathrate, with distinct hyaline colonial mucilage; cells 3–7 µm in diameter, spherical, generally with gas vacuoles.

Order: Nostocales

Family: Nostocaceae

Genus: *Anabaena*

7. *Anabaena circinalis* Rabenhorst ex Bornet. et Flah. (Fig. 1A)

Colony frothy, floating; trichome mostly circinate, seldom straight, mostly without a sheath, 8–14 µm broad; cells barrel-shaped or spherical, somewhat shorter than broad, heterocysts subspherical, 8–10 µm broad; spores cylindrical, sometimes curved, ends rounded, 16–18 µm broad up to 34 µm long.

8. *Anabaena doliolum* Bharadwaja (Fig. 1J)

Thallus mass mucilaginous, pale blue-green; trichome single, free-swimming, straight, curved or slightly coiled, 3.6–4.2 µm broad, slightly tapering at the ends, with conical apical cell, possessing almost pointed apex, cells barrel-shaped, as long as broad or a little longer or shorter than broad; heterocysts barrel-shaped, 5.2–6.3 µm broad and 6.3–9.4 µm long; spores ellipsoidal, with almost pointed apices in short or long chains, adjoining the heterocysts but developed centrifugally, epispore thick, smooth and hyaline or yellow brown, 4.2–6.2 µm broad and 6.3–11.5 µm long.

9. *Anabaena flos-aquae* Ralfs ex Bornet (Fig. 1H)

Trichome single, straight or bent, with almost rounded end cells, up to 350 µm long, 5.0–5.6 µm broad, at the apex 4 µm broad; cells barrel-shaped, 4.8–8.0 µm long; heterocysts almost spherical, 6.4–8.4 µm broad; spores in long chains, often making the whole trichome sporogenous, adjoining the heterocysts but formed centrifugally, almost spherical, with a smooth hyaline outer wall, 4.8–8.0 µm broad and 3.2–8.8 µm long.

10. *Anabaena iyengarii* Bharadwaja (Fig. 1W)

Trichome single or irregularly curved, 5.2–6.3 µm broad, end-cell conical with rounded apex; cells barrel-shaped, as long as broad, or slightly shorter or longer than broad; heterocysts barrel-shaped, 7.3–8.4 µm broad and 7.3–10.5 µm long; spores ellipsoidal often in long or short chains, rarely single on both sides of the heterocysts, 8.4–10.5 µm broad and 10.5–21.0 µm long, epispore thick, smooth and yellowish brown.

11. *Anabaena torulosa* Lagerheim ex Bornet & Flahault (Fig. 1X)

Thallus mucilaginous, thin, blue-green, trichome 4.2–5.0 µm broad, apical cell acutely conical, cells barrel-shaped, as long as or somewhat shorter than broad, heterocysts subspherical or ovoid, 6 µm broad and 6–10 µm long, spores on both sides of the heterocysts developed centripetally in the middle, 7–12 µm broad up to twice as long as broad, epispore smooth and pale brown in colour.

Genus: *Cylindrospermum*

12. *Cylindrospermum stagnale* (Kuitz) Bornet. et Flah. (Fig. 1V)

Thallus floccose, expanded, attached or free-floating, blue-green; trichomes 3.8–4.5 µm broad, constricted at the cross-walls; cells nearly quadrate, or cylindrical, and often 3–4 times long; spores cylindrical with rounded ends, 10–16 µm broad and 32–40 µm long, with smooth yellowish brown outer layer.

Genus: *Nostoc*

13. *Nostoc punctiforme* (Kuitz.) Hariot (Fig. 1K)

Colony sub-globose up to 2 mm diameter, scattered or confluent, attached; filaments flexuous, densely entangled; sheath delicate, hyaline, mucous; trichome 3–4 µm broad, cells short, barrel-shaped or ellipsoidal, blue-green; heterocysts 4.0–6.5 µm broad; spores subspherical, or oblong, 5–6 µm broad and 5–8 µm long, epispore thick and smooth.

Family: Rivulariaceae

Genus: *Gloeotrichia*

14. *Gloeotrichia longicauda* Schmidle (Fig. 1R)

Thallus hemispherical, mostly solid filaments radiating about 1 mm long, 24–30 µm broad; sheath somewhat diffluent, not lamellated, colourless; trichome gradually attenuated into a long hair; cells as long as broad or somewhat longer or shorter than broad, 6–8 µm broad; heterocysts mostly many, of varying diameter; immature spores rounded, cylindrical or long ellipsoidal, later bent or curved, about 16 µm broad and 40 µm long, epispore colourless.

Family: Scytonemataceae

Genus: *Scytonema*

15. *Scytonema mirabile* (Dillw.) Bornet. (Fig. 1C&D)

Colony expanded spongy, tomentose, brownish black, blackish green, or seldom more or less blue-green; filaments tortuous, intricate, 15–21 µm broad, 2–12 mm (rarely 1 cm) long, false-branched; sheath lamellated with slightly divergent lamellation, yellowish brown, sometimes outside colourless or slightly gelatinous; trichome 6–12 µm broad, yellow to blue-green or olive-green; cells cylindrical, at the ends discoid or more or less barrel-shaped; heterocysts nearly quadratic or longer than broad, brownish.

16. *Scytonema simplex* Bharadwaja (Fig. 1I)

Colony dense, dirty blue-green or pale blue-green; filaments 14.0–15.7 µm broad, irregularly bent and loosely entangled; false branches long, geminate and single in equal numbers; sheath up to 2.1 µm thick, hyaline, unstratified; trichomes sometimes with indistinct septa and occasionally with slight constrictions at the joints, 9.4–11.5 µm broad; cells usually elongate cylindrical up to four times as long as broad, sometimes quadratic, at the growing region flattened and barrel-shaped; heterocysts single, sometimes in pairs, usually elongate, cylindrical, rarely more or less quadratic, with convex end walls thicker than the longitudinal ones, as broad as the trichome, 9.4–11.5 µm broad and 11.5–46.2 µm long.

Order: Oscillatoriales

Family: Oscillatoriaceae

Genus: *Lyngbya*

17. *Lyngbya allorgei* Frey (Fig. 1B)

Filaments solitary or united and caespitose, fasciculate; intricate, elongate; sheath very thin, papyraceous, colourless, trichome pale violet, not constricted at the cross-walls, 3.5–4.0 µm broad, cells nearly quadrate or up to 1 ½ times as long as broad, cross-walls not granulated; end cell rotund, calyptra absent.

18. *Lyngbya confervoides* C. Ag. ex Gomont (Fig. 1Q)

Yellowish brown or dull green biomass, when dried often violet, filament at the base decumbent, above ascending and entangled, straight, sheath colourless, when old lamellated, outside rough up to 5 µm thick, not coloured violet by chlor-zinc-iodide trichome olive-green or blue-green not constricted at the cross-walls commonly granulated, not attenuated at the apices, 9–25 µm mostly 10–16 µm broad, cells 1/3–1/8 times as long as broad, 2–4 µm long, end cell rotund, calyptra absent.

Genus: *Oscillatoria*

19. *Oscillatoria limosa* Ag. ex Gomont (Fig. 1U)

Thallus dark blue-green; trichome more or less straight, dull blue-green, brown or olive-green, not constricted at the cross-walls, or only slightly constricted, 11–20 µm, commonly 13–16 µm broad; cells 1/3–1/6 as long as broad, 2–5 µm long, cross-walls frequently granulated; end-cell flatly rounded with slightly thickened membrane.

20. *Oscillatoria prolifica* (Grev.) Gomont (Fig. 1G)

Trichome straight or curved, not constricted at the cross-walls, at the ends gradually attenuated, 2.2–5.0 μm broad, seldom single, mostly forming purple red, in irregular groups or bundles; cells nearly quadrate or longer, seldom shorter than broad, 4–6 μm long, septa often granulated, gas-vacuoles present, end cells capitate with calyptra.

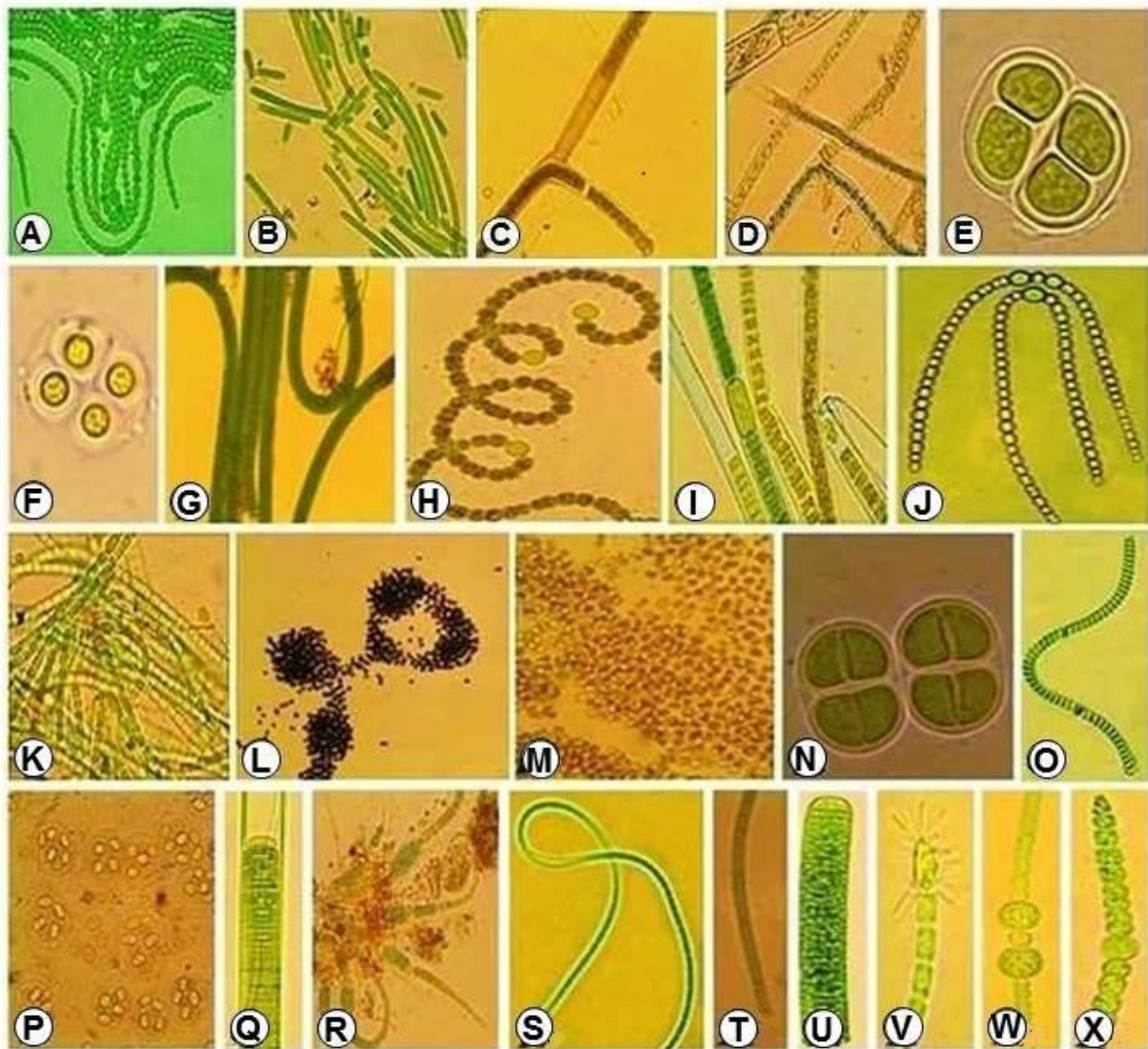


Figure 1. A, *Anabaena circinalis* Rabenhorst ex Bornet et Flah.; B, *Lyngbya allorgei* Frey; C–D, *Scytonema mirabile* (Dillw) Born.; E, *Chroococcus minor* (Kuitz.) Nag.; F, *Gloeocapsa gelatinosa* Kuitz.; G, *Oscillatoria prolifica* (Grev.) Gomont; H, *Anabaena flos-aquae* Ralfs ex Bornet; I, *Scytonema simplex* Bhardwaja; J, *Anabaena doliolum* Bharadwaja; K, *Nostoc punctiforme* (Kuitz) Hariot; L, *Microcystis aeruginosa* Kuitz; M, *Aphanothece saxicola* Nag.; N, *Chroococcus turgidus* (Kuitz.) Nag.; O, *Spirulina major* Kuitz. ex Gomont; P, *Gloeotheca rupestris* (Lyngb.) Bornet; Q, *Lyngbya confervoides* C. Ag. ex Gomont; R, *Gloeotrichia longicauda* Schmidle; S, *Phormidium mucicola* Hub. Pestalozzi et Naumann; T, *Oscillatoria tenuis* Ag. ex Gomont; U, *Oscillatoria limosa* Ag. ex Gomont; V, *Cyndrospermum stagnale* (Kuitz.) Born. et Flah.; W, *Anabaena iyengarii* Bharadwaja; X, *Anabaena torulosa* Lagerheim ex Bornet & Flahault.

21. *Oscillatoria tenuis* Ag. ex Gomont (Fig. 1T)

Thallus thin blue-green or olive-green, slimy; trichome straight, fragile slightly constricted at the cross-walls, 4–10 μm broad, blue-green, sometimes bent at the ends, not attenuated at the apices, not capitate; cells up to 1/3 as long as broad, 2.6–5.0 μm long, at the septa mostly granulated; end cell more or less hemispherical with thickened outer membrane.

Genus: *Spirulina*

22. *Spirulina major* Kuitz. ex Gomont (Fig. 1O)

Trichome 1.2–2.0 μm broad, regularly spirally coiled, blue-green, spirals 2.5–4.0 μm broad and 2.7–5.0 μm distant.

Family: Phormidiaceae

Genus: *Phormidium*

23. *Phormidium mucicola* Hub. Pestalozzi et Naumann (**Fig. 1S**)

Filaments short, straight, 10–20 µm, occasionally up to 50 µm long; sheath very thin, not coloured blue by chlor-zinc-iodide; trichome not attenuated at the end, more or less distinctly constricted at the cross-walls; cells 1.5–2.0 µm seldom 1.3 µm broad and more or less twice as long as broad; end cells rounded, seldom slightly conical, calyptra absent; contents granulated, pale bluish.

CONCLUSION

Cyanobacterial taxonomy has diverse and great diagnostic importance in floristic analysis as well as basic and applied aspects of research. In the present study a total of 23 taxa of 14 genera belonging to class Cyanophyceae have been described. Most of the genera isolated from various sites belong to two orders Chroococcales and Nostocales of class Cyanophyceae. In the present study the *Microcystis*, *Chroococcus*, *Gloeocapsa*, *Oscillatoria*, *Phormidium*, *Spirulina* and *Scytonema* have been found as the common blue-green algal forms.

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