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RESEARCH PAPER

V. K. Singh http:// <u>www.sasjournals.com</u> http:// <u>www.jbcr.co.in</u> jbiolchemres@gmail.com

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The Study of Cyanobacterial Flora from Jeori Thermal Spring, Himachal Pradesh, India – First Report Vinay Kumar Singh

Department of Botany, University of Lucknow, Lucknow-226007, U.P., India

ABSTRACT

Thermal springs are widely distributed throughout the world but are most numerous in areas in which there has been volcanic activity in late geological time. These thermal springs are inhabited by thermophilic organisms including Cyanobacteria. In present study Cyanobacterial flora of Jeori thermal spring of Shimla district first time investigated. Total 15 taxa of Cyanobacteria belonging to 9 genera obtained.

Keywords: Thermal springs, Cyanobacteria and Shimla.

INTRODUCTION

The Cyanobacteria are also known as blue-green algae. They are a group of photo-oxygenic bacteria found in aquatic, aerophytic and terrestrial habitats. They are among the most ancient lineages of prokaryotes and are some of the most ubiquitous organisms on Earth (Falcon *et al.* 2010). Previously algal flora of thermal spring of Himachal Pradesh studied by Prasad and Srivastava (1965), Vasistha (1968), Chander (1994), Bhardwaj (2010), Kumar (2009), Mongra (2012), Dwivedi (2014). Cyanobacterial diversity from thermal springs of India have been reported by Thomas and Gonzalves, 1965; Jha, 1992; Adhikary, 2006; Debnath, 2009; Asir and Nandan, 2013; Hazarika, 2014; Bhakta et al. 2016; Roy, 2017. Primary productivity on earth is mainly dependent on oxygenic photosynthesis. It is unique to Cyanobacteria and their descendants. The Cyanobacteria are ecosystem engineers, they produce 20–30 % of total global oxygen (Pisciotta et al. 2010). Cyanobacteria are also known to fix atmospheric nitrogen, contributing greatly to the global nitrogen budget (Karl et al. 2002), serve as the main component of aquatic foodwebs and help to stabilize substrates (Scott and Marcarelli 2012). So, in this paper we are presenting for the first time Cyanobacterial diversity of Jeori thermal spring, Shimla along with some physico-chemical parameters of thermal water.

MATERIAL AND METHODS

Samples were collected by random sampling technique from Jeori thermal spring of Shimla, Himachal Pradesh during October 2015 to October 2017. It lies between latitude 31.5264 and longitude 77.7767. All these collections were fixed in 3-4% formalin. Water temperature of thermal spring and bathing pool near thermal spring recorded by mercury celsius thermometer and pH of the water taken by portable pH meter and D.O. taken on site by Wrinkler's method.

Microscopic identification of the algal samples were done using microscope (Leica DM 500 attached with EC3 Camera). For microscopic identification one drop of algal sample was placed on the centre of the glass slide and covered with a cover slip.

Year	Site	Parameters		
		Temperature (°C)	pН	Dissolved oxygen (mg/l)
2015	S-14	65°C	7.1	2.9
	S-15	68°C	7.1	2.9
	S-16	44°C	7.2	3.8
2016	S-14	64°C	7.1	2.8
	S-15	64°C	7.1	2.9
	S-16	43°C	7.2	3.8
2017	S-14	65°C	7.2	2.7
	S-15	68°C	7.1	2.9
	S-16	44°C	7.1	3.7

Table 1. Physico-chemical parameters of Jeori thermal spring.



Jeori Thermal Spring, Shimla

Map not on scale

Morphological identification: Identification of algal samples were done following monographs by Desikachary (1959), Komarek et al. (2005); and Komarek (2014) and conformed with Cyano Database. Samples were submitted to Phycology Research Laboratory, Department of Botany, University of Lucknow, Lucknow.

RESULTS

1. Johannesbaptistia pellucida (Dickie) Taylor and Drouet (Pl. 1, Fig.A)

Desikachary, T.V., 1959, pl. 32, pg. 164, fig. 14-19; Komárek J and Anagnostidis K 2005, pg. 134, fig. 151; Sikdar, J., 2015, pl. 4, fig. 88 & 89.

Description: Filaments blue-green or olive green, straight or curved; cells discoid, round at the apices of the filaments, arranged in a single series, in a cylindrical hyaline mucilage, cells 3-4 µm broad and 1.5-2 µm long, mucilage homogeneous; sheath round, the cell visible after division firm or diffluent, content homogeneous or granular.

Habitat: Planktonic among other algae in thermal freshwaters.

Locality: Mid area of Shiv temple, Jeori, Shimla.

Collection number & Date: HP/SH/JE/S15; 22/05/2016.

Water temperature: 64°C; pH: 7.1; D.O.: 2.9 mg/l.

2. Gloeocapsa pleurocapsoides Novacek (Pl. 1, Fig. B)

Desikachary, T.V., 1959, pl. 24, pg. 122, fig. 3.

Description: Colonies microscopically small, more or less roundish or irregular, dull olive green; cells olive coloured or pale blue-green, homogeneous, granular, 2-3 µm in diam., elongated or angular, closely arranged; sheath thin, colored lamellated sheath.

Habitat: Freshwater, on the wet walls of the pools.

Locality: Bathing pool in Shiv temple, Jeori, Shimla

Collection number & Date: HP/SH/JE/S16; 20/10/2015.

Water temperature: 44°C; **pH:** 7.2; **D.O.:** 3.8 mg/l.

3. Planktolyngbya brevicellularis Cronberg et Komarek (Pl. 1, Fig. M)

Komárek J and Anagnostidis K 2005, pg. 159, fig. 191

Description: Filaments, solitary free-floating, straight, slightly arcuate or irregularly waved, to 200 μ m long; sheath thin firm, colourless, tightly joined to trichomes; trichomes cylindrical, not constricted or slightly constricted at cross-walls, not attenuated towards ends; cells cylindrical, short up to isodiametric, 1-1.5 μ m long and 1 μ m wide.

Habitat: Planktonic with other algae in mineral and thermal springs.

Locality: At entrance of Shiv temple, Jeori, Shimla.

Collection number & Date: HP/SH/JE/S14; 20/10/2015.

Water temperature: 65°C; **pH:** 7.1; **D.O.:** 2.9 mg/l.

4. Planktolyngbya holsatica (Lemmermann) Anagnotidis et Komrek (Pl. 1, Fig. C)

Komárek J and Anagnostidis K 2005, pg. 159, fig. 192

Description: Filaments free-floating, upto 3.5 μ m wide, regularly screw-like coiled, with loose coils; sheath is narrow, colorless and trichomes blue-green; cells 0.7 μ m wide, 0.7 μ m long, with homogeneous content; apical cell rounded, not attenuated.

Habitat: Freshwater, planktic with oher algae, reported from thermal springs.

Locality: At entrance of Shiv temple, Jeori, Shimla.

Collection number & Date: HP/SH/JE/S14; 22/05/2016.

Water temperature: 64°C; pH: 7.1; D.O.: 2.8 mg/l.

5. Leptolyngbya boryana (Gomont) Anagnostidis et Komarek (Pl. 1, Fig. N)

Komárek J and Anagnostidis K 2005, pg. 189, fig. 230

Description: Filaments curved, densely entangled, sometimes pseudobranched, 1.5-2 µm wide; trichome pale blue-green, 1.8 µm wide, strongly constricted at the ungranulated cross-walls.

Habitat: Freshwater, also reported from thermal and mineral springs.

Locality: Mid area of Shiv temple, Jeori, Shimla.

Collection number & Date: HP/SH/JE/S15; 8/10/2017.

Water temperature: 68°C; **pH:** 7.1; **(D.O.):** 2.9 mg/l.

6. Leptolyngbya laminosa (Gomont) Anagnostidis et Komarek (Pl. 1, Fig. L)

Komárek J and Anagnostidis K 2005, pg. 214, fig. 263; Bhattacharya et al. 2016, pg. 34, pl. 2, fig. 2.

Description: Thallus pale or bright blue-green, mostly thin, membranaceous or gelatinous, often forming clusters or fascicles; cells usually longer than wide, $2 \mu m \log and 1.5 \mu m$ wide.

Habitat: Freshwater found with other algae in thermal springs.

Locality: Mid area of Shiv temple, Jeori, Shimla.

Collection number & Date: HP/SH/JE/S15; 8/10/2017.

Water temperature: 68°C; pH: 7.1; (D.O.): 2.9 mg/l.

7. Symploca thermalis (Kuetzing) Gomont (Pl. 1, Fig. D)

Desikachary, T.V., 1959, pg. 339; Komárek J and Anagnostidis K 2005, pg. 489, fig. 727.

Description: Filaments forming densely arranged erect bundles, bright blue-green in colour, densely arranged, sometimes branched; sheath very thin, sometimes slimy; trichome blue-green, constricted at the cross walls, with a single granule; cells 2-3 times as long as broad, 1.5–2.5 μ m long and 1.8-2 μ m broad, end cell rounded.

Habitat: In thermal springs, epilithic on wet rocks, walls, stones, also on other objects close to the influence of thermal stream.

Locality: At entrance of Shiv temple, Jeori, Shimla.

Collection number & Date: HP/SH/JE/S14; 22/05/2016.

Water temperature: 64°C; pH: 7.1; D.O.: 2.8 mg/l.

8. Phormidium corium (Agardha) Gomont (Pl. 1, Fig. E)

Desikachary, T.V., 1959, pg. 264, pl. 44, figs. 10-11; Komárek J and Anagnostidis K 2005, pg. 452, fig. 660.

Description: Thallus expanded, membranous, blackish to brownish green; filaments long, more or less flexuous, densely entangled; sheath thin; trichome blue-green, not constricted at the cross walls, ends straight, briefly attenuated, not capitates, 3-4.5 µm broad; cell nearly quadrate, up to twice as long as broad, 2 µm long, not granulated at the cross walls, end cell obtuse conical, calyptras absent. **Habitat:** Freshwater, periphytic, epilithic on stones, in Rivers, from thermal springs.

Locality: At entrance of Shiv temple, Jeori, Shimla.

Collection number & Date: HP/SH/JE/S14; 22/05/2016.

Water temperature: 64°C; **pH:** 7.1; **D.O.:** 2.8 mg/l.

9. Phormidium formosum (Bory ex Gomont) Anagnotidis et Komarek (Pl. 1, Fig. F)

Komárek J and Anagnostidis K 2005, pg. 423, fig. 602

Description: Thallus dull blue-green to blackish-green; trichomes straight, long, bright blue-green, 4-6 µm wide, intensely motile with oscillation and clockwise rotation; cells nearly isodiametric or up to 2 times shorter than wide, 3-4 µm long; apical cells obtuse-conical, not capitate, without calyptra.

Habitat: Periphytic in stagnant waters, pools, also found in salty waters.

Locality: Bathing pool in Shiv temple, Jeori, Shimla.

Collection number & Date: HP/SH/JE/S16; 20/10/2015.

Water temperature: 43°C; pH: 7.2; D.O.: 3.8 mg/l.

10. Phormidium hamelii (Fremy) Anagnotidis et Komarek 1988 (Pl. 1, Fig. O)

Komárek J and Anagnostidis K 2005, pg. 448, fig. 659.

Description: Trichomes solitary or in clusters, without sheath, greyish blue-green, flexible, wavily curved; cells 0.7 µm wide, 0.7 µm long; apical cell rounded with calyptra.

Habitat: Freshwater, mainly in thermal springs or in stagnant waters.

Locality: Bathing pool in Shiv temple, Jeori, Shimla.

Collection number & Date: HP/SH/JE/S16; 22/05/2016.

Water temperature: 43°C; **pH:** 7.2; **D.O.:** 3.8 mg/l.

11. Phormidium inundatum Kuetzing ex Gomont (Pl. 1, Fig. G)

Komárek J and Anagnostidis K, 2005, pg. 448, fig. 659.

Description: Trichomes solitary or loosely arranged pale blue-green; sheath thin or diffluent; cells 0.8 μ m long and 0.7 μ m broad.

Habitat: Freshwater, on moist rocks and thermal springs.

Locality: Bathing pool in Shiv temple, Jeori, Shimla.

Collection number & Date: HP/SH/JE/S16; 22/05/2016.

Water temperature: 43°C; **pH:** 7.2; **D.O.:** 3.8 mg/l.

12. Phormidium sp. 1 (Pl. 1, Fig. H)

Description: Thallus thick, blue-green to olive-green; filaments thin, loosely arranged. Sheath very thin, sometimes diffluent. Cells quadrate or cylindrical not constricted at cross-walls, 1.2 µm long and 0.8 µm broad; cell content homogenous without gas vacuoles.

Habitat: Freshwater, in stagnant waters, also on moist rocks and thermal springs.

Locality: Mid area of Shiv temple, Jeori, Shimla.

Collection number & Date: HP/SH/JE/S15; 8/10/2017.

Water temperature: 68°C; pH: 7.1; (D.O.): 2.9 mg/l.

13. Oscillatoria amphibia Agardha ex Gomont (Pl. 1, Fig. I)

Desikachary, T.V., 1959, pg. 204, pl. 37, fig. 6.

Description: Thallus deep blue-green; trichomes straight; apices not attenuated, not capitate, not constricted at the cross walls, 2-3 μ m broad, pale blue-green; cells 2-3 times broader than long, cells 2 μ m broad, with two granules at the septa, end cells rounded, calyptra absent.

Plate-1



A. Johannesbaptistia pellucida, B. Gloeocapsa pleurocapsoides, C. Planktolyngbya holsatica, D. Symploca thermalis, E. Phormidium corium, F. Phormidium formosum, G. Phormidium inundatum, H. Phormidium sp.1, I. Oscillatoria amphibia, J. Lyngbya putealis, K. Scytonema sp.1, L. Leptolyngbya. laminosa, M. Planktolyngbya brevicellularis, N. Leptolyngbya boryana, O. Phormidium hamelii,

Habitat: Planktonic in freshwater tanks, in thermal springs, on moist soil.
Locality: At entrance of Shiv temple, Jeori, Shimla.
Collection number & Date: HP/SH/JE/S14; 22/05/2016.
Water temperature: 64°C; pH: 7.1; D.O.: 2.8 mg/l.
14. Lyngbya putealis Mont ex Gomont (Pl. 1, Fig. J)
Desikachary, T.V., 1959, pg. 317, pl. 52, fig. 12.

Description: Thallus blue-green; filaments long more or less flexible; sheath colourless, thick, trichome not constricted at the cross-walls; cells 1/3 times as long as broad, 3 µm long; cross-walls sometimes granulated, pale blue-green; end cells rounded, not attenuated at the ends.

Habitat: Freshwater, on moist rocks and thermal springs.

Locality: Bathing pool in Shiv temple, Jeori, Shimla.

Collection number & Date: HP/SH/JE/S16; 22/05/2016.

Water temperature: 43°C; **pH:** 7.2; **D.O.:** 3.8 mg/l.

15. Scytonema sp.1 (Pl. 1, Fig. K)

Description: Filaments false branched; cells 2-3 µm broad and 2 µm long; with false branches single or germinate, formed laterally, generally in between heterocysts; trichomes single in each sheath, straight; hormogones terminal, solitary.

Habitat: Freshwater, on wet soil, rocks and pools.

Locality: At entrance of Shiv temple, Jeori, Shimla.

Collection number & Date: HP/SH/JE/S14; 22/05/2016.

Water temperature: 64°C, pH: 7.1, D.O.: 2.8 mg/l.

DISCUSSION

Jeori thermal spring of Shimla district has been studied first time for the algal community. In the present study total 15 taxa were recorded belonging to 9 genera. Previously all these taxa reported from thermal springs of India (Thomas and Gonzalves 1965; Vashista, 1968; Kha, 2014; Shikdar, 2015). Out of these 9 taxa are reported for the first time from Himachal Pradesh *viz.* 1. *Johannesbaptistia pellucida*, 2. *Gloeocapsa pleurocapsoides*, 3. *Planktolyngbya brevicellularis*, 4. *Planktolyngbya holsatica*, 5. *Leptolyngbya boryana*, 6. *Leptolyngbya laminosa*, 7. *Phormidium hamelii*, 8. *Phormidium inundatum*, 9. *Oscillatoria amphibia* while *Symploca thermalis* (Vasishta, 1968), *Phormidium corium* (Srivastava and Gupta, 2004), *Phormidium formosum* (Kamat 1968, Vasishta, 1968) *and Lyngbya putealis* (Dwivedi, 2014) known to Himachal Pradesh. Water of spring has neutral or slightly alkaline pH (table 1); supports Cyanobacterial growth. Banerjee (1967) reported higher algal productivity at pH 6.5 to 7. It is also noticed during study that algal diversity decreases with rise in temperature.

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Corresponding author: Vinay Kumar Singh, Department of Botany, University of Lucknow, Lucknow-226007, U.P., India Email: vinaysingh198638@gmail.com