

Survey and Documentation of Cyanobacteria from the Muthi Area of Jammu (J and K), India

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ABSTRACT

In the present paper a study was undertaken to enumerate the blue-green algae from the Muthi area of Jammu. A total of 21 Cyanobacteria pertaining to 15 genera and seven families have been identified. Nostocales dominate over other orders, with the major genus *Oscillatoria* having ten species, followed by Chroococcales with five genera and Stigonematales with two genera. Within the order Nostocales, the dominant family is Oscillatoriaceae, which is represented by 87% of all the species, followed by Nostocaceae (10%), Scytonemataceae (4%) and Rivulariaceae (3%). In the order Chroococcales, Chroococcaceae is the dominant with 86% species, followed by Entophysalidaceae with 16% cyanobacterial species under this order. Order Stigonematales is represented by a single family of Stigonemataceae with two cyanobacterial species. These cyanobacterial species belong to different habitats; 22 species are epilithic, followed by seven miscellaneous, seven epipellic, six terrestrial, three epiphytic, and three free-floating. The highest numbers of cyanobacterial species were epilithic, and the lowest numbers were epiphytic and free-floating.

Keywords: Blue green algae, Cynophyceae, Diversity.

Highlights

- It is the first report on the survey and documentation of cyanobacteria from the Muthi area of Jammu
- A total of 21 cyanobacteria pertaining to 15 genera and seven families have been identified.
- Most of the species were collected from different sites belonging to two orders, Crococcoceles and Nostoceles of Cyanophyceae class.
- The highest number of cyanobacteria was epilithic.

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INTRODUCTION

Algae play a significant role in earth's life processes. They are primary producers in the aquatic ecosystem's food chain, occupying about 75% of the earth's surface and producing 80% oxygen. Due to the presence of a blue pigment (c-phycoyanin) along with chlorophyll-a, β -carotene, a trace of myxoxanthin and c-phycoerythrin (Chapman *et al.*, 1962) one of the groups of algae is also known as "blue green algae" or Cyanobacteria. They are gram-negative prokaryotes without nuclei and assigned to the Kingdom Monera thus, they are closely related to bacteria. Cyanobacteria grow in lotic and lentic water bodies, and play a major role in maintaining soil fertility.

Cyanobacteria show a wide range of morphology in comparison to any other prokaryotes. The simplest one is free living, a unicellular minute less than one micrometer in diameter. The complex forms include colonies of the unbranched chains of cells known as trichomes. The adjoining of trichomes and its surrounding sheath is called filaments. In certain filamentous genera, two types of specialized cells, i.e., heterocysts and akinetes, are found. Therefore, on the basis of morphology, they are classified into five orders: (I) Pleurocapsales, (I) Oscillatoriales, (II) Chroococcales, (IV) Nostocales, and (v) Stigonematales (Faldu *et al.*, 2014).

A limited study on survey and documentation of cyanobacterial flora in Jammu division is available till date. A few workers reported the occurrence of cyanobacterial species in rainy and winter seasons (Anand, 1976a; 1979; Bhushan and Kumar, 2013 and 2018; Kumar *et al.*, 2022 and 2023;) and water productivity of different lakes in the Jammu division (Kundal *et al.*, 2018). It is the first report on cyanobacterial flora in Muthi town near Jammu headquarters.

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MATERIAL AND METHODS

Study Area

The Muthi is situated in the Jammu district (J and K UT), at the coordinates of 32.75° N latitude and 74.81° E longitudes with an altitude of 336 m, and comes under the block Bhalwal. Jammu is this area's Sub-district headquarters and is situated 7 km from Muthi (Fig. 1). The total geographical area in which this area is expanded 4.09 km². The Muthi is destined with a variety of plants, found in terrestrial as well as in aquatic conditions (ponds). *Azadirachta indica* (Neem), *Butea monosperma* (Palash), *Acacia nilotica* (Kikar) etc. are the common plants of this area.

Collection Sites

Samples were collected from different locations of the Muthi area, and each sample was labeled with a sample number.



Fig. 1: Location of Muthi in Jammu, Jammu (J and K, UT, India)

Table 1: Different sites of collection

JMU/M-2	JMU/M-2 : Epipellic – attached on the soil in drain, Muthi
JMU/M-3	JMU/M-3 : Epilithic – attached on cemented drains, Muthi
JMU/M-4	JMU/M-4 : Epilithic – attached on cemented wall near the tap of the temple, Muthi
JMU/M-5	JMU/M-5 : Free-floating on the surface of water in pond, Muthi
JMU/M-7	JMU/M-7 : Epilithic – attached on the cemented sides of the wall tank, Muthi
JMU/M-9	JMU/M-9 : Miscellaneous – grown on the debris, Muthi
JMU/M-12	JMU/M-12 : Epiphytic – attached on moist bark of <i>Eucalyptus citridora</i>

Depending upon the type of habitat, cyanobacterial species are categorized as epiphytic (on the plants), epipellic (on sediments, soil in drain), epilithic (on stony walls, rocks, etc.), free-floating (floating over the water surface), miscellaneous (on water cooler, debris), terrestrial (attached on moist soil) as given in Table 1 (Fig. 2, a-g).

Collected cyanobacterial samples were washed thoroughly in water transferred to air-tight glass vestibules, and preserved in 4% formalin solution, for further study. Algal materials from the fixed and fresh specimens were studied following general lab rules, and then the slides were preserved in a slide box for observation.

After staining cyanobacterial materials with thick mucilaginous sheath with methylene blue and other with aqueous safranin solution, mounted with glycerine (Fig. 2 h, i & j), the fresh materials needed no staining. On the basis of a few earlier work (Dash *et al.* 2011; Dhanalakshmi *et al.* 2020; Dubey *et al.* 2011; Fiore MF *et al.*, 2005; Keshari and Adhikary,

2014; Philip and Krishnan (2020); Saraf *et al.*, 2019; Singh *et al.*, 2013; Singh *et al.*, 2015; Suradkar *et al.*, 2017), it is realized that this methodology is applicable for the specimens growing under natural conditions of different habitats.

Various characters of genera and species were observed through microslides. Measurements of species were recorded with the help of an ocular micrometer fitted to a trinocular research microscope. Each taxon was photographed with the help of a camera in order to understand the details of various morphological characteristics. Then specimens were identified with the help of authentic literature (Desikachary, 1959; Prescott, 1948; Tiffany and Britton, 1952).

RESULTS AND DISCUSSION

This resulted in 21 cyanobacterial species under 15 genera and two orders, Chroococcales and Nostocales. It has been found that *Oscillatoria* (7), *Chroococcus* (3) and *Merismopedia* (2) species are available in dominant forms, whereas, *Anabaena* (1), *Spirulina* (1), *Microcystis* (1), *Lyngbya* (1), *Nostoc* (1) *Scytonema* (1) *Fischerella* (1) *Haplosiphon* (1) and *Chlorogloea* (1) species are rare and found in very less number.

Taxonomic account of all observed species (identification of the specimen is based on parameters given by Desikachary (1959)

Microcystis aeruginosa Kütz. (Fig. 3a)

Mostly rounded colonies with gas vacuoles.

Habitat and locality

JMU/M-5: Free-floating on the surface of water in pond at Muthi; JMU/M-2: Epipellic- attached on the soil in drain, Muthi; JMU/M-9: Miscellaneous- grown on the debris, Muthi.



Fig. 2 (a-j): Photographs of collection sites of Muthi, Jammu a, Blue-green algae in the paddy field b, Blue-green algae attached on the rock in drain outlet c, Blue – green algae in the drain d, Blue-green algae attached on the cemented wall e, Blue-green algae attached on the cemented tank of the Temple f, Blue-green algae present on the soil g, Blue-green algae from plant debris h, Preparation of slides i & j, Mounting of specimen in laboratory

***Chroococcus turgidus* (Kütz) Näg. (Fig. 3b)**

Cells spherical, sometimes in groups, generally with 2 cells, cells with sheath 14.7-17.8 μ diam., without sheath 10.2-12.8 μ , yellowish, thick

Habitat and locality

JMU/M-2: Epipellic- attached on the soil in drain, Muthi and JMU/M-3: Epilithic- attached on cemented drains, Muthi.

***Chroococcus macrococcus* (Kütz.) Rabenh. (Fig. 3c)**

Sheath is colorless.

Habitat and locality

JMU/M-5: Free-floating on the surface of the water in a pond at Muthi.; JMU/M-6: Epilithic- attached on the rocks near a stream, Muthi and JMU/M-7: Epilithic- attached on the cemented sides of the water tank, Muthi

***Merismopedia glauca* (Ehrenb.) Näg. (Fig. 3d)**

Colony ellipsoidal single, sometimes 2 cells, 2.9-5.3 μ diam., contents yellowish, thick

Habitat and locality

JMU/M-4: Epilithic- attached on the cemented wall near the tap

of a temple, Muthi and JMU/M-11: Terrestrial- attached on moist soil near the temple, Muthi.

***Chroococcus minutus* (Kütz) Näg. (Fig. 3e)**

Light blue-green, with sheath 7-12 μ diameter, colonies 11-13x 16-20 μ , colorless.

Habitat and locality

JMU/M-5: Free-floating on the surface of water in a pond at Muthi and JMU/M-11: Terrestrial- attached on moist soil near temple, Muthi

Habitat and locality

JMU/M-3: Epilithic- attached on cemented drains, Muthi; JMU/M-4: Epilithic- attached on the cemented wall near the tap of a temple, Muthi and JMU/M-9: Miscellaneous- grown on the debris, Muthi.

***Merismopedia elegans* A. Br. (Fig. 3f)**

More or less closely arranged, light blue.

Habitat and locality

JMU/M-2: Epipellic- attached on the soil in drain, Muthi and JMU/M-6: Epilithic- attached on the rocks near a stream, Muthi.

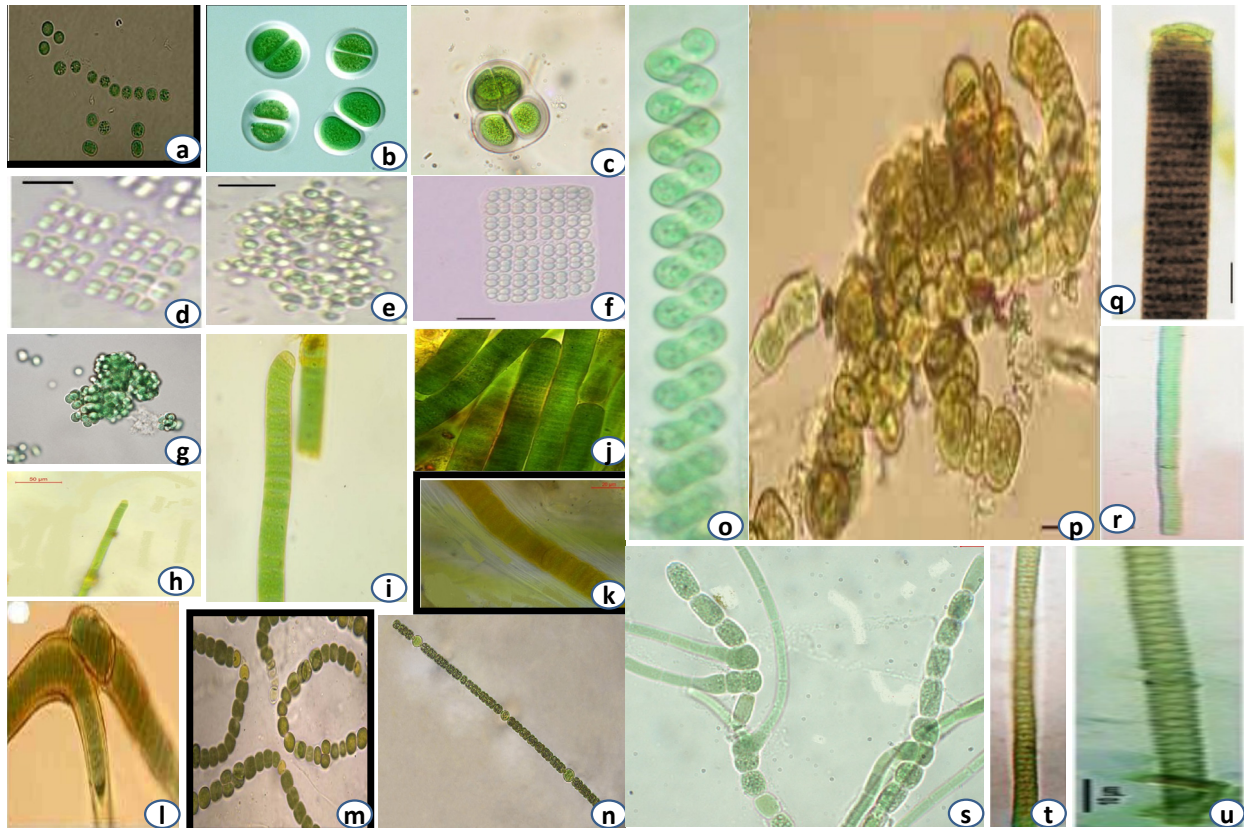


Fig. 3(a-u): *Microcystis aeruginosa* Kütz. b, *Chroococcus turgidus* (Kütz.) Näg. c, *Chroococcus micrococcus* (Kütz.) Rabenh. d, *Merismopedia glauca* (Ehrenb.) Näg.; e, *Chroococcus minutus* (Kuitz.) Nag. f, *Merismopedia elegans* A. Br.; g, *Chlorogloea fritschii* Mitra; h, *Oscillatoria limosa* Ag. ex Gomont; i, *Oscillatoria subbrevis* Schmidle; j, *Oscillatoria princeps* Vaucher ex Gomont; k, *Lyngbya majuscula* Harvey ex Gomont; l, *Scytonema mirabile* (Dillw.) Born; m, *Nostoc commune* Vaucher ex Born. et Flah.; n, *Anabaena circinalis* Rabenhorst ex Born. et Flah.; o, *Spirulina princeps* W. et G.S. West; p, *Fischerella muscicola* (Thuret) Gomont; q, *Oscillatoria sancta* (Kütz.) Gomont; r, *Oscillatoria obscura* Brühl et Biswas; s, *Haplosiphon welwitschii* W. et G.S. West; t, *Oscillatoria curviceps* Ag. ex Gomont; u, *Oscillatoria amoena* (Kuitz.) Gomont

***Chlorogloea fritschii* Mitra (Fig. 3g)**

Thallus made up of rounded or irregular cell packets blue-green in color; cells arranged vertically, rounded, without mucilage envelope, 5.5 to 6.3 μ diameter.

Habitat and locality

JMU/M-4: Epilithic- attached on the cemented wall near the tap of a temple, Muthi and JMU/M-6: Epilithic- attached on the rocks near a stream, Muthi.

***Oscillatoria limosa* Ag. ex Gomont (Fig. 3h)**

Dark blue-green to brown thallus; apices not attenuated

Habitat and locality

JMU/M-4: Epilithic- attached on cemented wall near the tap of a temple, Muthi and JMU/M-8: Epilithic- attached on cemented tiles, Muthi.

***Oscillatoria subbrevis* Schmidle (Fig. 3i)**

Straight, single trichomes, flattened at cross walls; Absence of calyptra

Habitat and locality

JMU/M-3: Attached on cemented drains, Muthi, and JMU/M-4:

Epilithic- attached on cemented wall near the tap of a temple, Muthi.

***Oscillatoria princeps* Vaucher ex Gomont (Fig. 3j)**

Blue-green trichomes, mostly straight, no limitation on cross walls

Habitat and locality

JMU/M-12: Epiphytic- attached on moist bark of *Eucalyptus citridora* and JMU/M-8: Epilithic- attached on cemented tiles, Muthi.

***Lyngbya majuscula* Harvey ex Gomont (Fig. 3k)**

Light blue-green thallus, sheath colorless, long filaments; blue-green trichome, 2.3-3.6 μ long, calyptras absent.

Habitat and locality

JMU/M-3: Epilithic- attached on cemented drains, Muthi and JMU/M-8: Epilithic- attached on cemented tiles, Muthi.

***Scytonema mirabile* (Dillw.) Born. (Fig. 3l)**

Spongy-like thallus, less blue-green; filaments is 15.1 to 16.9 μ broad, tortuous, intricate, mostly false branched; sheath lamellated, trichomes 11.0 to 12.1 μ .

Habitat and locality

JMU/M-12: Epiphytic- attached on moist bark of *Eucalyptus citridora*.

***Nostoc commune* Vaucher ex Born. et Flah. (Fig. 3m)**

Blue-green colored thallus, filaments flexuous, entangled; sheath-distinct present at the periphery, thick, yellowish brown, hyaline; 4.9 to 5.6 μ broad trichome, about 5.1 to 5.9 μ broad, barrel shaped, mostly shorter.

Habitat and locality

JMU/M-2: Epipellic- attached on the soil in drain, Muthi and JMU/M-10: Miscellaneous- attached on the water cooler, Muthi.

***Anabaena circinalis* Rabenhorst ex Born. et Flah (Fig. 3n)**

Loosely coiled single trichome, more or less spherical cells, 7 to 8 μ m broad globose heterocysts.

Habitat and locality

JMU/M-9: Miscellaneous- grown on the debris, Muthi.

***Spirulina princeps* W. et G.S. West (Fig. 3o)**

Blue-green trichome, spirally coiled, spirals 11 to 11.8 μ broad and 9.5 to 11 μ distant.

Habitat and locality

JMU/M-3: Epilithic- attached on cemented drains, Muthi and JMU/M-11: Terrestrial- attached on moist soil near the temple, Muthi.

***Fischerella muscicola* (Thuret) Gomont (Fig. 3p)**

Filaments is of creeping nature, thick blackish brown thallus, about 10 μ broad filament, 2 rows of cells.

Habitat and locality

JMU/M-3: Epilithic- attached on cemented drains, Muthi and JMU/M-11: Terrestrial- attached on moist soil near the temple, Muthi.

***Oscillatoria sancta* (Kütz.) Gomont (Fig. 3q)**

Thallus blue-green, thin, gelatinous; straight trichome of 14.6 to 17.5 μ , distinctly constricted at the cross walls; ends briefly attenuated, olive-green; 3.3 to 4.9 μ broad, cross walls with a thickened membrane.

Habitat and locality

JMU/M-3: Attached on drains, Muthi and JMU/M-11: Terrestrial- attached on moist soil near temple, Muthi.

***Oscillatoria obscura* Brühl et Biswas (Fig. 3r)**

Dark blue-green to brown thallus; trichome 3.6-5.0 μ broad and 1.0-1.8 μ long, straight, apices not attenuated; broad cells, granulated cross walls; rounded cell with thick membrane.

Habitat and locality

JMU/M-8: Epilithic- attached on cemented tiles, Muthi.

***Haplosiphon welwitschii* W. et G.S. West (Fig. 3s)**

Filamentous algae, 6.1 - 7.0 μ broad, sheath colorless; cells subspherical, 3.2-5.1 μ , slightly attenuated at the ends; heterocysts rare, intercalary, rounded, 5.6 μ broad, 7.1 μ long.

Habitat and locality

JMU/M-2: Epipellic- attached on the soil in drain, Muthi.

***Oscillatoria curviceps* Ag. ex Gomont (Fig. 3t)**

Blue-green colored thallus with 9.7 to 12.8 μ breadth, straight, Non-constricted cross walls; 2.5 to 4.6 μ cell length, cross walls sometimes granulated; end-cells flat rounded.

Habitat and locality

JMU/M-7: Epilithic- attached on the cemented sides of the water tank, Muthi and JMU/M-12: Epiphytic- attached on moist bark of *Eucalyptus citridora*

***Oscillatoria amoena* (Kütz.) Gomont (Fig. 3u)**

Light blue-green thallus, 2.9 to 5.0 μ broad trichomes, straight, constricted cross walls, ends gradually attenuated; cells 2.6 to 4.6 μ long, nearly as long as broad, septa granulated.

Habitat and locality

JMU/M-4: Epilithic- attached on cemented wall near the tap of a temple, Muthi and JMU/M-8: Epilithic- attached on cemented tiles, Muthi.

The species that belong to epilithic habitat are *Chroococcus micrococcus*, *Chroococcus turgidus*, *Merismopedia elegans*, *Chlorogloea fritschii*, *Spirulina princeps*, *Oscillatoria sancta*, *O. curviceps*, *O. limosa*, *O. amoena*, *O. princeps*, *O. subbrevis*, *O. obscura*, *Lyngbya majuscula*, *Fischerella muscicola*, species grow on miscellaneous habitat are - *Microcystis aeruginosa*, *Nostoc commune*, *Anabaena circinalis*, species grow on epipellic habitat are- *Microcystis aeruginosa*, *Chroococcus turgidus*, *Merismopedia elegans*, *Nostoc commune*, *Haplosiphon welwitschii*, species grow on terrestrial habitat are – *Chroococcus minutus*, *Merismopedia glauca*, *Spirulina princeps*, *Oscillatoria sancta* *Fischerella muscicola*, free-floating habitat comprising species are – *Microcystis aeruginosa*, *Chroococcus micrococcus*, *Chroococcus minutus*, and species grow on epiphytic habitat are- *Oscillatoria curviceps*, *Oscillatoria princeps* and *Scytonema mirabile* (Fig. 4).

A total of 7 cyanobacterial species have been recorded from the order Chroococcales which comprises of two families Chroococcaceae (7) and Entophysalidaceae (1). The family Chroococcaceae consist of six species which includes *Microcystis aeruginosa*, *Chroococcus micrococcus*, *Chroococcus turgidus*, *Chroococcus minutus*, *Merismopedia glauca*, *Merismopedia elegans*

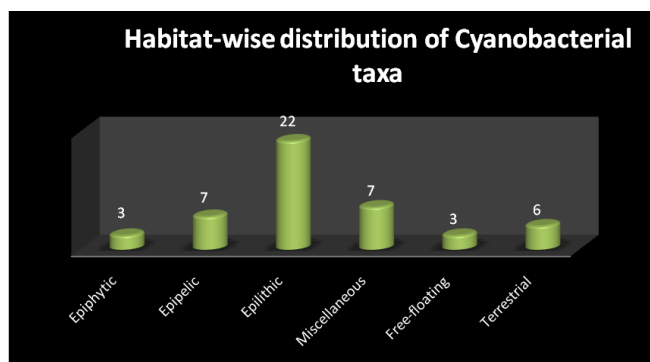


Fig. 4: Graph showing habitat-wise distribution of cyanobacterial species

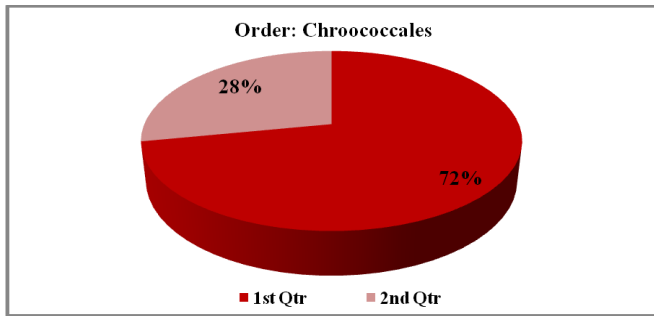


Fig. 5: Order-wise distribution of cyanobacterial taxa of order Chroococcales

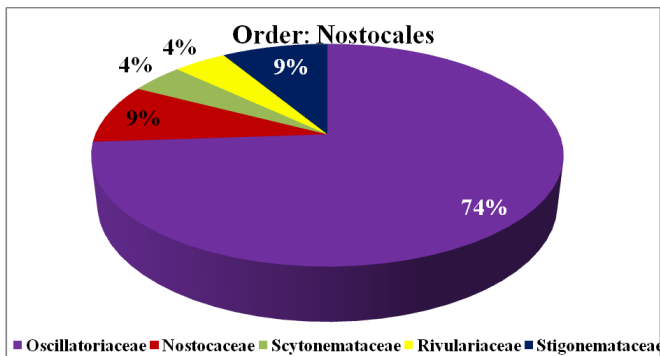


Fig. 6: Order-wise distribution of cyanobacterial taxa of Nostocales

whereas family Entophysalidaceae consist of only one species i.e., *Chlorogloea fritschii* have been represented below in Fig. 5.

The order Nostocales is the dominating order with a maximum number of cyanobacterial species. The family Oscillatoriaceae comprises of 3 genera, such as- *Spirulina* (2), *Oscillatoria* (7), and *Lyngbya* (4), family Nostocaceae consist of 2 genera – *Nostoc* (1) and *Anabaena* (1) whereas family Scytonemataceae and Rivulariaceae comprises of 1 genera each depicted in Fig. 6.

CONCLUSION

In the present field survey and documentation, a total of 21 taxa belonging to 14 genera of class Cyanophyceae have been identified and described from the collection of algal specimens. Most of the species were collected from different sites belonging to two orders, Crocococeles and Nostocales of Cyanophyceae class. *Microcystis*, *Crococcus*, *Oscillatoria*, *Spirulina*, *Merismopedia elegans* and *Scytonema* have been identified as common blue-green algae forms.

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AUTHOR CONTRIBUTION

Shastri Prasad Shukla conceptualized the idea, wrote the original MS and supervised the work. Khushbu Shrama performed the

experiment and collected data. Both authors have critically read the drafted manuscript and approved it for publication.

CONFLICT OF INTEREST

None

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