



ISSN (E): 2320-3862  
ISSN (P): 2394-0530  
<https://www.plantsjournal.com>  
JMPS 2023; 11(5): 55-60  
© 2023 JMPS  
Received: 01-08-2023  
Accepted: 04-09-2023

**Deepak Kumar Jha**  
Department of Botany, L.N.  
Mithila University, Darbhanga,  
Bihar, India

## A taxonomic investigation on cyanobacteria from Supaul district of north Bihar, India

**Deepak Kumar Jha**

### Abstract

Present study deals with morphotaxonomic study of 9 taxa belonging to the class Cyanophyceae (Blue-green algae). These taxa were collected from different freshwater habitats of Supaul district of North Bihar. Of these, two taxa viz. *Anabaena orientalis* S.C. Dixit. and *Phormidium rubroterricola* Gardner are being recorded for the first time from Bihar.

**Keywords:** Cyanobacteria, cyanophyceae, north - Bihar, taxonomy

### Introduction

Blue-green algae, also known as cyanobacteria, are a group of photosynthetic bacteria that can be found in various aquatic environments. They are capable of producing oxygen through photosynthesis, but under certain conditions, they can rapidly multiply and create harmful algal blooms. These blooms can release toxins that are harmful to aquatic life, animals, and humans, posing a threat to water quality and ecosystem health. Monitoring and managing the growth of blue-green algae are important for maintaining the balance of aquatic ecosystems. Among nitrogen fixing cyanobacteria, *Anabaena* species are mainly reported from paddy fields (Turkey & Adhikary, 2005) [23]. Cyanobacteria play an important role in maintenance and build-up of soil fertility, consequently increasing rice growth and yield as a natural biofertilizer (Song *et al.* 2005) [20]. Incorporating the findings of Mishra and Pabbi (2004) [9], it becomes evident that the majority of paddy soils harbor indigenous cyanobacteria populations, offering an inherent avenue for nitrogen fixation without additional costs.

North Bihar in general and the district Supaul, in particular, is known as paradise to those interested in Algae. The area under investigation is practically unexplored except a few very short reports (Ahmad and Siddiqui 1990; Jha *et al.* 1986; Jha and Jha 1989; Jha 2001; Kargupta and Dubey 1994; Sachi *et al.* 2021) [2, 13, 12, 11, 15, 26]. Practically no systematic work has been done on algal taxonomy of this district (Supaul). Therefore, floristic survey of algal flora of Supaul district in North Bihar, has been taken up.

The main objectives of the present investigation are:

1. To gather information regarding the diversity of freshwater algae along river Koshi basin in Supaul district upto species level.
2. To evaluate the seasonal and spatial variation of algal flora and the relative abundance of algae in the study area.
3. To evaluate the habitat preferences of taxa.
4. To find out the floral resemblances between habitats and to know how closely they are related in terms of floral similarities.

### Materials and Methods

#### A. Meteorological Data

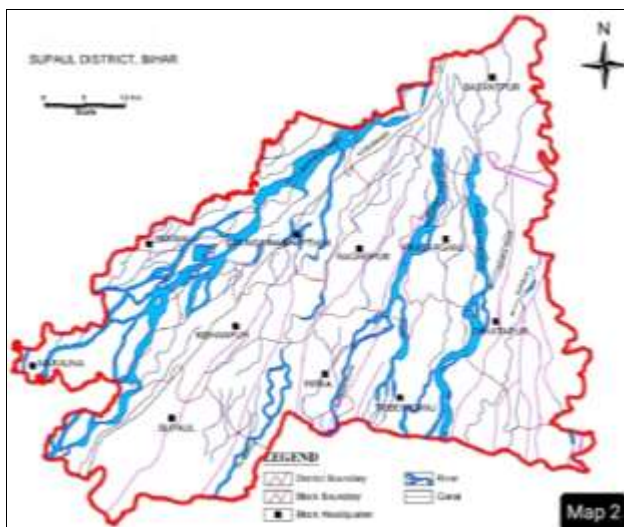
Supaul district is one of the thirty-eight districts of Bihar, and situated at 25°37' to 26°25'N latitude and 86°22' to 87°10' longitude. The district is a part of Koshi Division and covers an area of 2,420 square kilometers. There are total 11 blocks (Basantpur, Chhatapur, Kishanpur, Marauna, Nirmali, Pipra, Pratapganj, Raghapur, Saraigarh Bhaptiyahi, Supaul and Tribeniganj) in Supaul district.

**Corresponding Author:**  
**Deepak Kumar Jha**  
Department of Botany, L. N.  
Mithila University, Darbhanga,  
Bihar, India



**Fig 1:** Map of Bihar showing Supaul District

This district is bounded by Nepal to the north, Araria district to the east, Madhepura and Saharsa districts to the south, and Madhubani district to the west. The Koshi River flows through the district, which is regularly affected by flood. The climate of the district is monsoon type. From early June to late September experiences good rainfall. The climate during October to November and February to March is pleasant and December to January temp. Comes down to 8-12 °C. During the period from April to July, the average temperature often reaches between 35 °C – 40 °C, making it a particularly hot time of year.



**Fig 2:** Map of Supaul District

### B. Field Survey (Material Collection)

During the course of present taxonomic study altogether 550 samples (during January 2020 - January 2023) were collected from different localities of the Supaul district. Some physico-chemical parameters (pH and Temp.) of water were also recorded at the collection sites. Localities were frequently visited and random collections were made from different habitat conditions including stagnant and flowing water, deep and shallow water and muddy bottoms etc. Polythene bags were used to bring the algal samples from the fields. The materials were washed thoroughly and kept in previously prepared preservative.

### C. Laboratory Study

Collected algal materials were preserved with FAA (Formaldehyde, Glacial acetic acid and 90% Alcohol). Each litre of preservative contained: 40% commercial formalin -

100 C.C., 60% ethyl alcohol - 500 C.C., glacial acetic acid - 50 C.C. and water - 350 C.C. to each litre of this solution, 50 C.C. of pure glycerine was added to prevent the material from desiccation. Several temporary slides were made with 10% glycerine and important taxonomic characters was observed and noted. The useful specimens having mature stages and interesting algal taxa were selected and kept carefully for further study. Observations were made on Olympus research microscope (Olympus 7213). Prism type camera Lucida was used for drawing and microphotographs of the material were taken.

### D. Literature consulted

Consulted different monographs (Desikachary 1959 etc.) [7] and standard Literature (Anand and Revati 1987; Das & Keshri 2017; Halder 2017; Chatterjee 2020; Singh *et al* 2022; etc.) [1, 6, 8, 4, 21] for the identification of taxa and their distribution in India.

### Results and Discussion

#### Class: Cyanophyceae (Myxophyceae)

Prokaryotic, unicellular, colonial or form chains of cells-trichomes; protoplasm differentiated into chromatoplasm (with photosynthetic pigments) and the central, centropylasm (With a generative function); chief pigments are chlorophyll a, c- phycocyanin and c- phycoerythrin; food reserve is special type of starch (Cyanophycin starch) and protein (Cyanophycin granules); cell wall is made up of mucopolymers; reproduction by cell division, fragmentation, hormogones, endospores, heterocysts and nannocytes; sexual reproduction absent. The class comprises five orders: (1) Chroococcales (2) Chamaesiphonales (3) Pleurocapsales (4) Nostocales and (5) Stigonematales (Fritsch 1935).

The present taxonomic investigation includes the members of two orders: (1) Chroococcales and (2) Nostocales.

#### Key to the order investigated

- Plant body unicellular or colonial; never show trichome organization; without base - apex differentiation; endospores not formed in sporangia; exospore absent; nanocytes present.

#### Chroococcales

- Plant body filamentous with trichome organization; true branching absent or with false branching; reproduction by fragmentation, hormogonia, endospores and akinete; heterocysts may be present or absent.

#### Nostocales

##### Order: Chroococcales

Fresh water, marine or terrestrial; plant body unicellular or colonial; colonies without polarity; never show trichome organization, without base- apex differentiation; endospores not formed in sporangia; exospore absent; Nanocytes present. The order comprises two families: (1) Chroococcaceae and (2) Entophysalidaceae (Fritsch 1935).

##### Family: Chroococcaceae

##### Genus: *Merismopedia* Meyen

Colonies usually microscopic, plate- like, more or less rectangular, free living; cells usually blue-green, spherical or ovate, enclosed by fine, colourless, usually indistinct mucilage.

##### 1. *Merismopedia convoluta* Brébisson ex Kützing 1849

(Desikachary 1959; P.152; Pl.29; Figs.8, 12,13; Chatterjee 2020; P.1163; Pl.-VI; Fig.17; Das & Keshri 2017; P.68; Pl.1; Fig.7; Pl.2; Fig.7) [7, 4, 6]

**(Pl.MP.1: Fig.1; Pl.CLD.1: Fig.1)**

Plant microscopic; colonial; deep blue green and many sub-spherical to oblong cells (3.5-5.5 µm × 4.5-8.5 µm) constitute the convoluted colony (42-102µm broad) which is very long and flat.

The present specimen resembles the type species.

**Habitat**

Collection No.DK-63, Date- February 17, 2022, collected from a drain carrying polluted waters (pH 5.0, Temp. 24 °C) at Bagheli, Tribeniganj (Dist. Supaul).

**Distribution:** Karnataka, Andamam and Nicobar, Chattisgarh, Jammu & Kashmir, Maharashtra, Tamil Nadu, Uttar Pradesh, West Bengal(in FLORA OF KARNATAKA- A Checklist, Karnataka Biodiversity Bord 2019), Bihar.

**This is probably the second record of the species from Bihar**

**Order: Nostocales**

Plant body filamentous with trichome organization; true branching absent, but some members show false branching; heterocyst may be present or absent; reproduction by fragmentation, hormogonia, endospores and akinetes. The order comprises five families: (1) Oscillatoriaceae (2) Microchaetaceae (3) Nostocaceae (4) Scytonemataceae and (5) Rivulariaceae.

The present taxonomic investigation includes the members of two families: (1) Oscillatoriaceae and (2) Nostocaceae.

**Key to the investigated families**

1. Heterocysts absent; spores commonly absent.

**Oscillatoriaceae**

1. Heterocysts and spores present.
2. Nostocaceae.

**Family: Nostocaceae**

**Key to the investigated genera of the family Nostocaceae:**

1. Filaments single or in a formless gelatinous mass. (1) *Anabaena*.
2. Many filaments are aggregated together within a gelatinous mass to form a definite colony.
3. *Nostoc*

**Genus: *Anabaena* Bory**

Thallus filamentous, filament consists of string of beaded cells; several intercalary heterocysts are present in the trichome; sheath absent or more or less diffluent; spores single or in a series, near the heterocyst or between the heterocysts.

**Key to the taxa investigated**

1. Trichome straight or slightly curved; heterocyst cylindrical with rounded apex.
2. *orientalis*
3. Trichome nearly straight or irregularly curved; heterocyst barrel shaped.
4. *iyengari* var. *tenuis*

**1. *Anabaena orientalis* S.C. Dixit**

(Shariatmadari *et al.* 2011; P.108; Fig.3B) [19]

**(Pl.CLD.1: Figs.2-3)**

Trichome pale blue green, single, straight or slightly curved; cells 2.8-4µm long, 2.5-3.5µm broad; sub-quadrate; apical cell conical with rounded apex; heterocyst cylindrical with rounded apex, 5.6-7.5µm long, 3.5-4.5µm broad; akinete ellipsoidal, 7.6-16.5µm long, 5.6-6.5µm broad.

The present specimen is similar to the type species.

**Habitat:** Collection No.DK-436; January15, 2023, collected from a canal (pH 6.0, Temp. 22 °C) of Supaul (Dist. Supaul).

**Distribution:** Karnataka, Tamilnadu, Andhra Pradesh, Assam, Odisha, Rajasthan, U.P., West Bengal(in FLORA OF KARNATAKA- A Checklist, Karnataka Biodiversity Bord 2019).

**This is the first record of the species from Bihar**

**2. *Anabaena iyengari* Bhardwaja var. *tenuis* Rao, C.B.**

(Desikachary 1959; P.406-409, Pl.76; Fig.1,5; Pl.78; Fig.2, 5, 7)

**(Pl.MP. 1: Figs.2-3; Pl.CLD.1: Figs.4-5)**

Plant mass mucilaginous, pale blue green; trichome single, nearly straight or irregularly curved; 3.5-4.5 µm broad; end cell conical with rounded apex; cells barrel shaped; 3.5-4.5 µm broad, 2.5-4 µm long; heterocyst barrel shaped, sometimes spherical, 4.5-6.5 µm broad and 5.5-8.5 µm long.

The present species resembles the type variety.

**Habitat:** Collection No.DK-18, Date- April 21, 2021, from a ditch (pH 6.0, Temp. 32 °C) of Basantpur (Dist. Supaul) growing along with *Spirogyra* species.

**Distribution:** Karnataka (Tiwari and Pandey 1976) [22], Orrisa (Mohanty and Padhi 1980) [17], U.P., (Chadha and Pandey 1983) [5], West Bengal (Maity and Santra 1985) [16], Madhya Pradesh (Prasad *et al.* 1986) [18], Tamil Nadu (Anand and Revati 1987) [1], Bihar (Jha & Jha 1989; Jha 2001) [11-12], Maharashtra (Jaiswal 2017) [10], Punjab (Singh *et al.* 2022) [21]

**Genus: *Nostoc* Vaucher**

Thallus filamentous, many filaments are aggregated together within a gelatinous mass to form a definite colony; filament flexous, curved or entangled; trichome are composed of spherical, barrel-shaped or cylindrical cells; heterocyst usually intercalary or occasionally terminal.

**1. *Nostoc calcicola* Brébisson ex Born. et Flash.**

(Desikachary 1959; P. 384-385, Pl.68; Fig.1) [7]

**(Pl.MP.1: Fig.4; Pl.CLD.1: Fig.6)**

Thallus grey or blue green, mucilaginous, filaments numerous, loosely entangled, trichome not covered by sheath, 2.80-3.5µm broad; cells barrel shaped, 2.6-3.8µm long; heterocyst terminal and intercalary, subspherical, 3.5µm in diameter.

The present specimen resembles the type species.

**Habitat:** Collection No. 435, January15, 2023; collected from a ditch (pH 6.5, Temp. 22 °C) of Supaul (Dist. Supaul).

**Distribution:** Karnataka, Andhra Pradesh, Maharashtra, Arunachal Pradesh, Assam, Bihar, Jammu & Kashmir,

Kerala, Madhya Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Rajasthan, Tamil Nadu, U.P., West Bengal (In flora of Karnataka- A Checklist, Karnataka Biodiversity Bord 2019).

### Family: Oscillatoriaceae

#### Key to the investigated genera of the family Oscillatoriaceae

1. Trichome without a sheath. (1) *Oscillatoria*
1. Trichome with a sheath. (2) *Phormidium*
1. Trichome regularly spirally coiled. (3) *Spirulina*

#### Genus: *Oscillatoria* Vaucher

Thallus filamentous and unbranched; trichome are naked (sheath absent) or rarely enveloped in a thin gelatinous sheath; motile; trichome ends are distinctly marked, pointed, bent like a sickle or coiled more or less like a screw; hormogones present; cells are usually more broad than long; in some species the apical cell of the filament carries a thickened membrane, known as calyptra.

#### Key to the species investigated

1. Trichome without constriction at the cross walls. 2. *O. limosa*
1. Trichome constricted at the cross walls. 2
2. End cells capitate. 3. *O. sancta*
3. End cell not not capitate. 1. *O. chalybea*

#### 1. *Oscillatoria chalybea* (Martens) Gomont

(Desikachary 1959; P.218; Pl.38; Fig. 3; Behere Patil & Deore 2014; P.2007; Pl.3; Fig.13-15)

#### (Pl.CLD.1: Fig.7)

Thallus blue green, trichome straight and slightly constricted at the cross- walls, apex bent; 7.5-12.5µm broad; cells 3.5-6.5µm long; septa not granulated; end cell not capitate, obtuse; calyptra absent.

The present species resembles the type species.

**Habitat:** Collection No. DK-514; Date- January 22, 2023; from a ditch (pH 6.5, Temp. 34 °C) at Mahua, Nirmali (Dist. Supaul) along with *Oscillatoria sancta* (Kuetz.) Gomont.

**Distribution:** Karnataka, Andhra Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Jammu & Kashmir, Kerala, Madhya Pradesh, Maharashtra, Odisha, Tamil Nadu, U.P., West Bengal (In flora of Karnataka- A Checklist, Karnataka Biodiversity Bord 2019).

#### 2. *Oscillatoria limosa* Ag. ex. Gomont.

(Desikachary 1959; P. 206; Pl. 42; Fig.11; Halder 2017; P. 93; Fig. 1.D-E)

#### (Pl.CLD.1: Fig.8)

Trichome dark blue-green, straight, without constriction at the cross walls, 11.5- 13µm broad; cells 3.0-4.5µm long, cross wall distinct and granulated; apical cell flatly rounded, covered by slightly thickened membrane.

The present specimen is very much similar to the type species.

**Habitat:** Collection No. DK-501; Date- January 21, 2023; collected from a road side canal(pH 6.5, Temp.26°C) of Pilwaha, Tribeniganj (Dist. Supaul) along with *Phormidium rubroterricola* Gardner.

**Distribution:** Karnataka, Andaman & Nicobar, Andhra Pradesh, Assam, Bihar, Chhattisgarh, Gujarat, Himachal Pradesh, Jammu & Kashmir, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Nagaland, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttarakhand, U.P., West Bengal (In Flora of Karnataka- A Checklist, Karnataka Biodiversity Bord 2019).

#### 3. *Oscillatoria sancta* (Kuetz.) Gomont

(Desikachary 1959; P.203; Pl.42; Fig.10; Halder 2017; P.92; Fig.1A)

#### (Pl.CLD.1: Fig.9)

Thallus deep blue green; trichome single, slightly bent; 14.5-17.5µm broad; cells 4.5-7.6µm long, slightly constricted at the cross walls; end cells hemispherical and attenuated; capitate with a thickened membrane.

The present species resembles the type species.

**Habitat:** Collection No. DK-514; Date- January 22, 2023; from a ditch(pH 6.5, Temp. 34°C)at Mahua, Nirmali (Dist. Supaul) along with *Oscillatoria chalybea* (Martens) Gomont.

**Distribution:** Karnataka (Dharwad), Andaman & Nicobar, Andhra Pradesh, Assam, Bihar, Chattisgarh, Delhi, Gujarat, Himachal Pradesh, Jammu & Kashmir, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Odisha, Rajasthan, Tamil Nadu, Uttar Pradesh, West Bengal(in FLORA OF KARNATAKA- A Checklist, Karnataka Biodiversity Bord 2019)

#### Genus: *Phormidium* Kuetz.

Thallus filamentous, unbranched; sheath present; trichome cylindrical, may be constricted or unconstricted at cross walls; end cells rounded, attenuated or pointed and sometimes with calyptra; heterocyst and akinete absent.

#### 1. *Phormidium rubroterricola* Gardner

(Desikachary 1959; P.261; Pl.43; Fig.3)

#### (Pl.CLD.1: Fig.10)

Trichome blue- green, without constriction at the cross walls; 2.6-3.4µm broad; cells shorter or longer than broad, 2.6-4.5µm long; quadrate and cylindrical; end cell obtuse conical and sheath not diffuent.

The present specimen is similar to the type species.

**Habitat:** Collection No. DK-501; Date- January 21, 2023; collected from a road side canal(pH 6.5, Temp.26°C) of Pilwaha, Tribeniganj(Dist. Supaul) along with *Oscillatoria limosa* Ag. ex. Gomont.

**Distribution:** Karnataka, Maharashtra, Rajasthan, U.P.(in flora of Karnataka- A Checklist, Karnataka Biodiversity Bord 2019).

#### This is the first record of the species from Bihar

#### Genus: *Spirulina* Turnip em. Gardner

Plant body unicellular or multicellular, spiral shaped, spirals more or less regular; sheath absent; apices usually not attenuated; terminal cell rounded and calyptra absent.

#### 1. *Spirulina princeps* W. et G.S. West

(Desikachary 1959; P.197; Pl.36; Fig.7)

**(Pl.MP.1: Fig.5; Pl.CLD.1: Fig.11)**

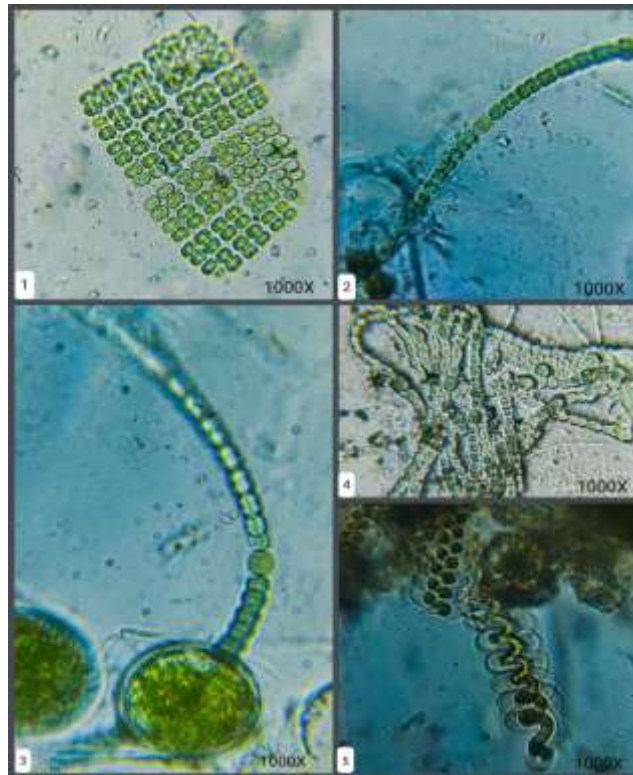
Thallus blue green, filamentous, trichome 4.5- 5.6µm broad, 82-180µm long, regularly spirally coiled, distance between spirals 8-10.5µm.

The present specimen is similar to the type species.

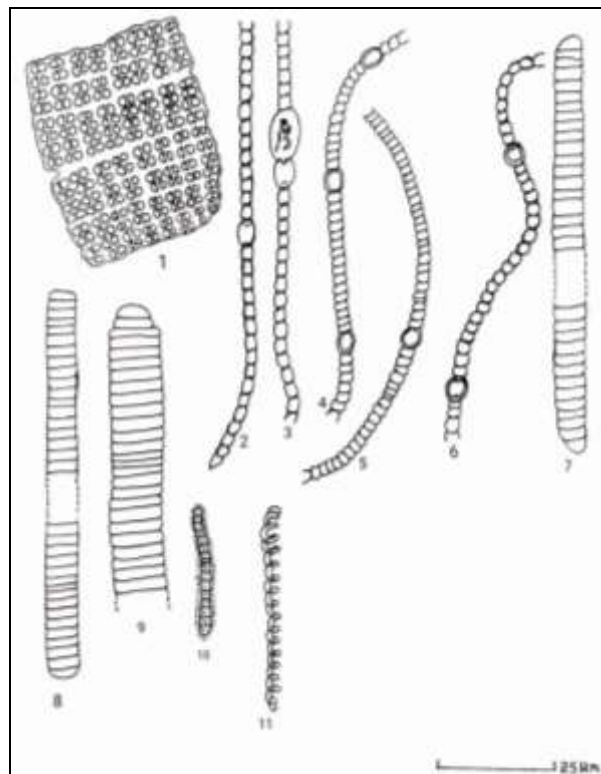
**Habitat:** Collection No.DK-41; Date- January 3, 2022, from a ditch (pH 6.5, Temp.12°C) at Parsauni (Dist. Supaul) along

with *Spirogyra angolensis* WELWITSCH.

**Distribution:** Karnataka, Assam, Bihar, Chattisgarh, Assam, Bihar, Chattisgarh, Gujarat, Jammu & Kashmir, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttarakhand, Uttar Pradesh, West Bengal (in FLORA OF KARNATAKA- A Checklist, Karnataka Biodiversity Board 2019).



**Pl.MP.1: Fig 3:** *Merismopedia convoluta* Brébisson ex Kützing 1849; Figs.2-3: *Anabaena iyengari* Bhardwaja var. *tenuis* Rao, C.B.; Fig.4: *Nostoc calciola* Brébisson ex Born. et Flash.; Fig.5: *Spirulina princeps* W. et G.S. West



**Pl.CLD.1: Fig 4:** *Merismopedia convoluta* Brébisson ex Kützing 1849; Figs.2-3: *Anabaena orientalis* S.C. Dixit; Figs.4-5: *Anabaena iyengari* var. *tenuis* Rao, C.B; Fig.6: *Nostoc calciola* Brébisson ex Born. et Flash; Fig.7: *Oscillatoria chalybea* (Martens) Gomont; Fig.8: *O. limosa* Ag. ex. Gomont.; Fig.9: *O. sancta* (Kuetz.) Gomont; Fig.10: *Phormidium rubroterricola* Gardner Fig.11: *Spirulina princeps* W. et G.S. West

## Conclusion

In the present study only one taxon (*Merismopedia*) belonging to order Chroococcales and 8 taxa (2 taxa of *Anabaena*, one taxon each of *Nostoc*, *Phormidium* and *Spirulina* and 3 taxa of *Oscillatoria*) belonging to order Nostocales were identified. The genus *Oscillatoria* (Nostocales) was most common and dominating member of the group. The members of Cyanophyceae usually associated with their own member species and sometimes with members of Oedogoniales and Zygnematales. Many genera are valuable for its economic importance e.g., *Spirulina* because of its nutritional value for mankind. The author also notified some heterocystous genera such as *Nostoc* and *Anabaena*, which play a vital role in nitrogen fixation.

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