

## Original Research Article

### Some New and Interesting Cyanobacteria from Baghjoda Pond, Eastern Nepal

Ritu Rajopadhyaya<sup>1</sup>, Sangita Joshi<sup>1</sup>, Sabitri Shrestha<sup>2</sup> and Shiva Kumar Rai<sup>1</sup>

<sup>1</sup>Phycology Research Lab, Department of Botany, P.G. Campus, T.U., Biratnagar, Nepal

<sup>2</sup>Department of Biology, Central Campus of Technology, T.U., Dharan, Nepal

Corresponding Author: Ritu Rajopadhyaya, Research Lab, Department of Botany, P.G. Campus, T.U., Biratnagar, Nepal  
E-mail: riturajopadhyaya@gmail.com

#### Abstracts

Cyanobacteria of BaghJhoda pond in three different seasons have been studied. A total of 8 cyanophycean algae under 6 genera viz., *Anabaena*, *Aphanocapsa*, *Chroococcus*, *Oscillatoria*, *Phormidium* and *Spirulina* were recorded. *Anabaena*, *Oscillatoria* and *Phormidium* were dominant genera and occurred in all three seasons. All the 8 taxa were new for the study area and *Anabaena affinis* and *Anabaena subcylindrica* were new records for Nepal.

**Key words:** Blue-green algae, Cyanophyceae, *Anabaena affinis*, *Spirulina*

#### Introduction

Cyanobacteria are prokaryotic photosynthetic organisms generally occurring in unicellular, colonial and filamentous forms and some with a simple parenchymatous organization with or without mucilage sheath. Cells are generally blue-green to violet, sometimes red or green and pigments are chlorophyll a, phycocyanin, allophycocyanin and phycoerythrin. Presence of murein cell wall and cyanophycean starch as reserve food are interesting. They reproduce only by asexual methods but never formed agglutinated cells in the life cycle. They occur in diverse habitats. Most, however, are found in freshwater, frequently in still or slowly flowing freshwaters.

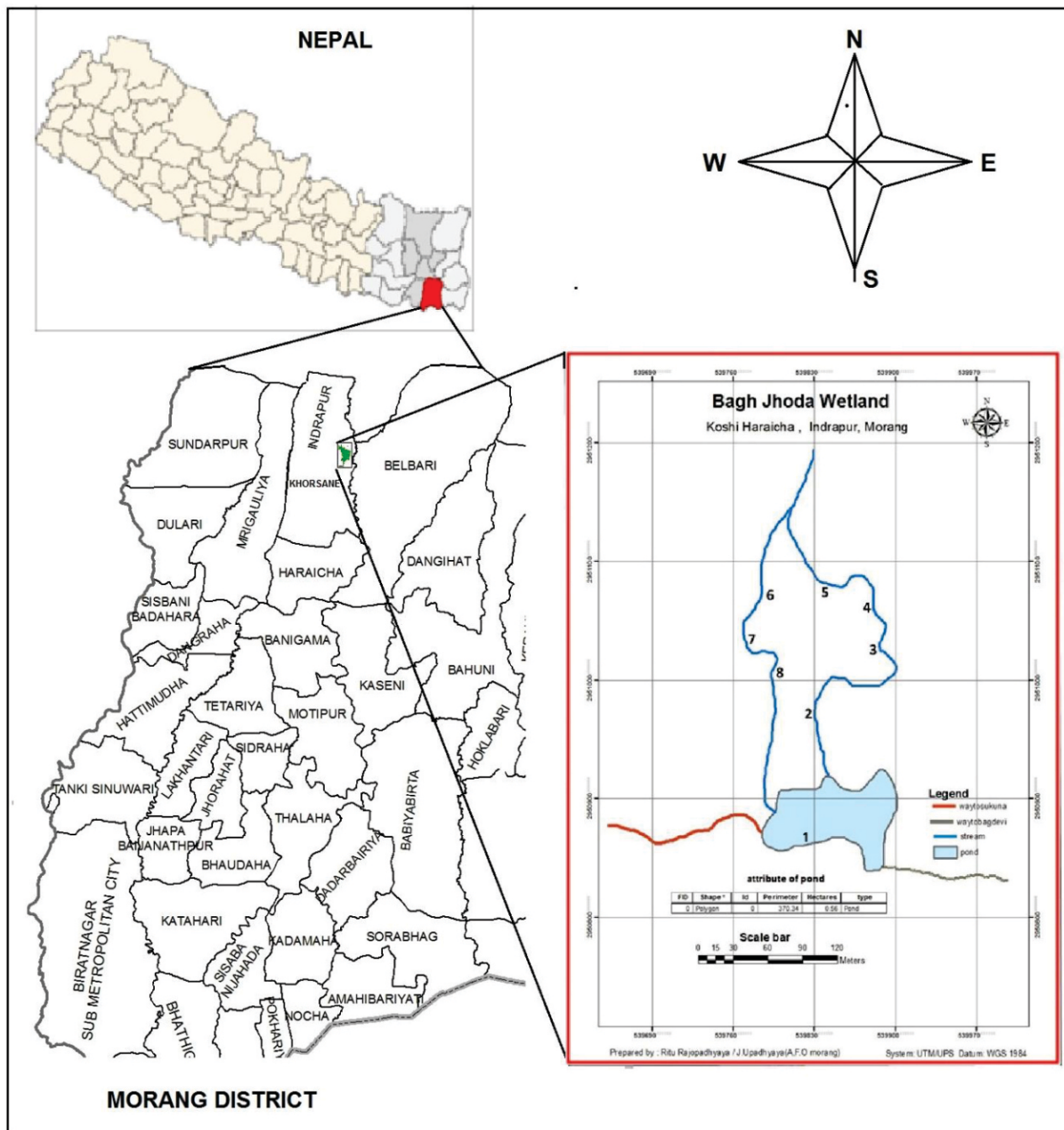
Bagh Jhoda pond (ca 1 hectare area) is situated at Koshi Haraicha Municipality of Morang district; E. 137m, Lat. 26°40'38" N, Long. 87°23'52.3" E. It is a natural pond situated on the southern margin of Charkoshe Jhadi, a few kilometers north from Khorsane. It is famous for turtle habitation.  *Eichhornia crassipes*, *Pistia stratiotes*, *Potamogeton crispus*, *Hydrilla verticillata*, and *Utricularia gibba* were common macrophytes in this pond.

#### Materials and Methods

Samples were collected from eight different sites of Baghjoda pond in three different seasons viz., winter, summer and rainy, 2014 (Map 1). Planktonic forms were collected with the help of plankton mesh net, epiphytic forms by squeezing macrophytes and distinct large filamentous forms by free hand picking and kept in polythene bottles separately. The collected samples were preserved in 4% formaldehyde solution. The temporary slides of each sample were prepared using glycerin jelly (Sharma, 1992) and were examined under different magnification of compound microscope. Separation of blue-

green algae from others was done by staining with iodine solution. Microphotography of algae was taken with the help of Olympus CH20i microscope and Canon Powershot A3300 IS camera. Identification of algae was made consulting Prescott (1951), Desikachary (1959), Prasad and Srivastava (1992), Komarek and Watanabe (1998), Hindak (2008) and Rai and Misra (2010). All the collected samples have been kept in the Phycological Research Lab, Department of Botany, P.G. Campus, Biratnagar, Nepal.

Contribution on the cyanophycean flora of Nepal has been made by Joshi (1977, 1979), Upadhyaya (1979), Watanabe and Komarek (1988), Prasad (1996), Komarek and Watanabe (1998), Prasad and Prasad (2001), Jha and Kargupta (2006, 2012), Prasad (2011a) etc. Rai and Misra (2010) reported 51 cyanobacteria from east Nepal including 19 taxa new to Nepal. A recent checklist of total blue green algae of Nepal comprises 274 taxa (Rai et al., 2010). Prasad (2011b) has also listed blue-green algae of Nepal. Rai (2011) has reported six blue green algae from Betana wetland which lies near to the present study area. Rai and Rai (2012) also reported 6 algae from Chimdi Lake including *Oscillatoria splendid*, *Cylindrospermum stagnale*, *Gloeotrichia raciborskii* Woloszynska var. *Kashiense*. Ghimire et al., (2012) studied the cyanobacteria and diatoms of Khumbu region. Recently, Shrestha et al., (2013) have studied algal flora of Itahari reporting 7 taxa of blue green algae including *Oscillatoria saratua*. Cyanobacterial Bagh Jhoda pond has not been studied before.



Map 1. Baghjoda pond showing algae collection sites (1 to 8)

## Results and Discussion

A total of 8 cyanophycean algae under 6 genera (*Anabaena*, *Aphanocapsa*, *Chroococcus*, *Oscillatoria*, *Phormidium*, *Spirulina*) were reported in three different seasons from 8 different sites of Bagh Jhoda pond. All 8 taxa were recorded from Bagh Jhoda pond. Among them *Anabaena affinis* and *Anabaena subcylindrica* were new records for Nepal. The taxonomic accounts of the algae are as follows.

**1.** *Chroococcus minutus* (Kütz.) Nsg. (Figures. 1, 2)  
 References: Prescott, G.W. (1951), p. 449, pl. 100, Fig. 9; Desikachary, T.V. 1959, p. 103, pl. 24, Fig. 4; pl. 26, Figs. 4, 15; Watanabe, M. and Komarek, J. 1994, p. 10, Fig. 10; Rai and Misra 2010, p. 123, pl. 1, Fig. 5.

Characters: Cells spherical or oblong, single or in groups of 2-4, light blue-green; sheath not lamellated, colorless.

Dimension: Colonies 33.5µm long, 27.5µm broad; cells 9-10 µm long, 7.5 µm broad.

Sample No. and Date: BJ-6, 23/07/2014

Distribution in Nepal: Kongmala lake, Solukhumbu (Watanabe and Komarek, 1994); Rara lake, Mugu (Watanabe, 1995), Narayanghat ditch, Chitwan (Das and Verma, 1996); Madhuban and Kusaha ditch, Sunsari (Jha and Kargupta, 2001); Koshi Tappu pond, Sunsari (Rai and Misra, 2010).

Worldwide distribution: Romania (Caraus 2002), Turkey (Europe) (Aysel 2005), Argentina (Rodriguez et al. 2006), China (Hu & Wei 2006), Pakistan (Gul et al. 2007), (Asia) (Taskin et al., 2008) Punjab (Anon 2012), Turkey, Taiwan (Shao 2003-2014), Germany (Tauscher 2011, 2014), Saudi Arabia (Mohamed & Al-Shehri 2015).

## 2. *Aphanocapsa rivularis* (Carm.) Rabenhorst (Figure. 3).

Reference: Prescott G.W. 1951, p. 454, pl. 101, Figure. 17

Characters: A free- oating or sessile, amorphous, or spherical colony of globose cells which have bright blue-green, granular contents; cells solitary or in pairs and scattered at some distance from one another within the colonial mucilage, spherical, loosely arranged.

Dimension: Cells 4-7µm in diameter

Sample No. and Date: BJ-1, 04/05/2014

Distribution in Nepal: KhairKhola, Tandi, Chitwan (Das and Verma, 1996)

Worldwide distribution: Argentina (Tell 1985), Spain (Alvarez-Cobelas & Gallardo 1988), Spain (Noguerol-Seoane and RifonLastra 1999) Baltic Sea (Hallfors 2004), China (Hu & Wei 2006), Israel ( Vinogradova et al.2000), Britain (John et al. 2011), Romania (Caraus 2012), Romania (Caraus 2012), Iraq ( Maulood et al.2013), Taiwan (Shao 2003-2014).

## 3. *Oscillatoria sancta* Kutz. ex Gomont (Figure. 4).

References: Tiffany, L.H. and Britton, M.E. (1952), p. 342, pl. 93, Fig. 1078; Desikachary, T.V. 1959, p. 203, pl. 42, Fig. 10.

Characters: Trichomes aggregated to form dark-green mass, usually on submerged vegetation, straight, scarcely tapering toward the apex; apical cell somewhat capitates, with a calyptra, and with a much thickened outer membrane; cross walls slightly constricted, which are conspicuously granular; cell contents coarsely granular, olive or green in color.

Dimension: Trichomes 17-20 µm broad; cells 2.8-3.3 µm long

Sample No. and Date: BJ- 1, 18/02/2014

Distribution in Nepal: Tikauli ditch, Chitwan (Das and Verma, 1996); Madhuban, Kusaha, Haripur pond, Sunsari (Jha and Karagupta, 2001); Raja Rani Lake, Bhogateni, Morang (Rai and Misra, 2010)

Worldwide distribution: Northwest Territories (Sheath & Steinman 1982), Ireland (Cotton 1912), Israel (Vinogradova et al., 2000), Pakistan (Shahnaz and Shameel 2005), Argentina (Rodriguez et al., 2006), Queensland (Bostock and Holland 2010), Britain (John et al., 2011) Punjab (Anon 2012), Iraq (Maulood et al., 2013), Taiwan (Shao 2003-2014), Germany (Tauscher 2014), Saudi Arabia (Mohamed & Al-Shehri 2015), India (Rao & Gupta 2015).

## 4. *Anabaena affinis* Lemmermann (Figure. 5).

Current accepted name: *Dolichospermum affine* (Lemmermann) Wacklin, Hoffmann & Komarek.

Reference: Prescott G.W. 1951, p. 513, pl. 115, Fig. 10, 14 and 15; Hindak, F. 2008, Fig 533-536.

Characters: Trichomes straight or exuous, solitary, free oating, enclosed in a thin mucilaginous sheath; cells spherical to spheroidal with either homogenous contents or with pseudovacuoles; heterocyst spherical, slightly larger th vegetative cell.

Dimension: Cells 6 µm in diameter, heterocyst 7 µm in diameter.

Sample No. and Date: BJ-3, 23/07/2014

Distribution in Nepal: Not reported earlier from Nepal.

Worldwide distribution: Ellesmere Island (Croasdale, 1973), Northwest Territories (Sheath & Steinman, 1982), Argentina (Tell 1985), Spain (Alvarez-Cobelas and Gallardo, 1988), South Australia (Day et al., (1995), Victoria (Day et al.,1995), New South Wales (Day et al.,1995), Lithuania (Vitenaitė, 2001), Romania (Caraus, 2002), Baltic Sea (Hallfors, 2004), Russia (Europe) (Patova & Demina 2008), Queensland (Bostock and Holland, 2010), Iraq (Maulood et al., 2013), Taiwan (Shao, 2003-2014).

## 5. *Anabaena subcylindrica* Borge (Figure. 6).

Reference: Prescott G.W. (1951), p. 518, pl. 118, Figs. 6 to 8; Hindak, F. 2008, Figs. 558-565.

Characters: Trichomes straight, solitary, epiphytic on macrophytes; cells short, cylindrical; heterocysts cylindrical.

Dimension: Cells 6-8µm long, 4-5µm in diameter; heterocysts 15-17µm long, 6-7µm in diameter.

Sample No. and Date: BJ-3, 18/02/2014

Distribution in Nepal: Not reported earlier from Nepal.

Worldwide distribution: Argentina (Tell 1985), Arkansas (Smith 2010), Romania (Caraus 2012), Iraq ( Maulood et al., 2013), Queensland (Holland 2010).

## 6. *Phormidium autumnale* Ag. ex Gomont (Fig. 7).

Current accepted name: *Microcoleus autumnalis* (Gomont) Strunecky, Komarek and J.R. Johansen

Reference: Prescott G.W. (1951), p. 493, pl. 107, Fig. 19 and 20; Desikachary, T.V. 1959, p. 276, pl. 44, Figs. 24-25.

Characters: Plant mass forming a broadly expanded, dark-green, mucilaginous layer; laments much entangled but may be either straight or curved and exuous; apex is slightly tapering, either straight or somewhat curved and capitates, with a calyptra.

Dimension: Trichome 4-7 µm broad; cells quadrate or ½ as long as broad, 2-5 µm long

Sample No. and Date: BJ-1, 18/02/2014

Distribution in Nepal: Chittrey Pass pond, Manang (Hirano, 1955); Thimi, Bhaktapur (Shrestha and Manandhar, 1983).

Worldwide distribution: Israel (Vinogradova et al.2000), Pakistan (Leghari et al., 2005), Argentina (Rodriguez et al. 2006), Russia (Europe) (Patova and Demina 2007), Turkey (Asia) (Taskin et al., 2008), Iraq (Maulood et al.2013), Italy (Di Pippo et al., 2014 (



7. *Spirulina princeps* (West and West) G.S. West (Figure. 8).  
Reference: Prescott, G.W. (1951), p. 480, pl. 108, Fig. 13;  
Desikachary, T.V. 1959, p. 197, pl. 36, Fig. 7

Characters: Trichomes loosely spiraled; cell contents bright blue-green, homogeneous or slightly granular.

Dimension: Spirals 9-10  $\mu\text{m}$  distant, 10-11  $\mu\text{m}$  broad; trichomes 4-4.7  $\mu\text{m}$  broad.

Sample No. and Date: BJ- 1, 23/07/2014

Distribution in Nepal: Fish pond in Hetauda, Makawanpur (Sahay et al., 1993); Madhuban, Kusaha, Haripur pond, Sunsari (Jha and Karagupta, 2001); Kamal Pokhari, Kechana, Morang (Rai and Misra, 2010)

Worldwide distribution: Northern Territory (Day, et al., 1995), Turkey (Europe) (Aysel, 2005), China (Hu & Wei, 2006), Arkansas (Smith, 2010), Queensland (Bostock & Holland, 2010), Punjab (Anon 2012), Iraq (Maulood et al., 2013), Taiwan (Shao, 2003-2014), Turkey (Asia) (Varol and Sen, 2014).

8. *Spirulina subsalsa* Oersted ex Gomont (Fig. 9)

Reference: Prescott, G.W. (1951), p. 480, pl. 108, Figure. 14;

Desikachary, T.V. 1959, p. 193, pl. 36, Figures. 3, 9; Prasad, B.N. and Srivastava, M.N. 1992, p. 54, pl. 7, Figures. 10-11.

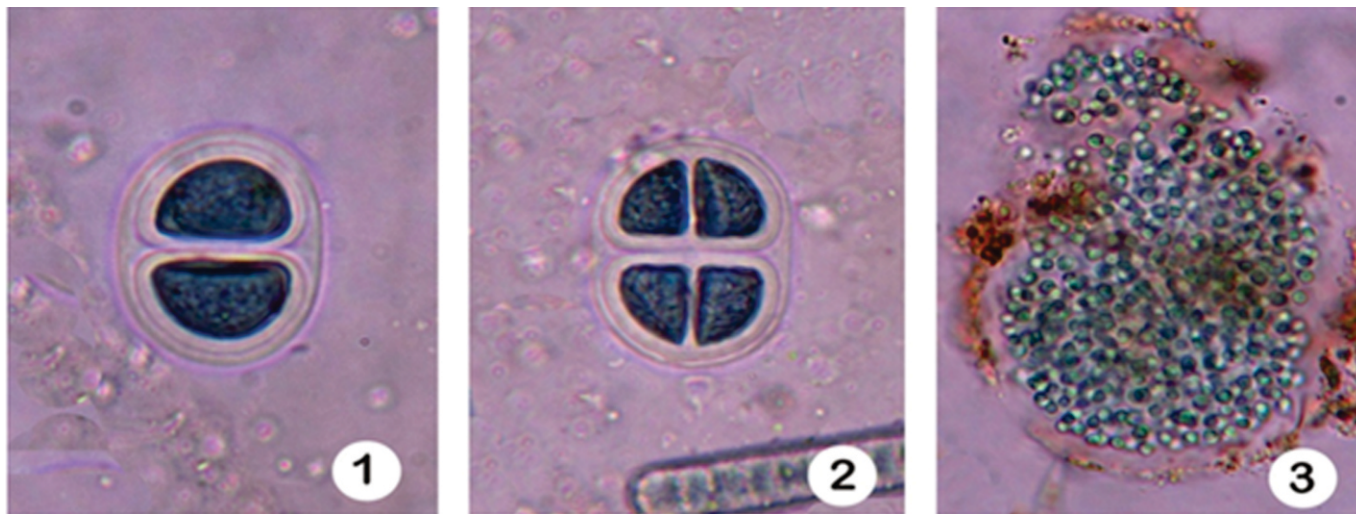
Characters: Trichomes both closely and loosely spiraled in the same individual, often tightly coiled, no space between the turns.

Dimension: Spirals 5.5  $\mu\text{m}$  broad; trichomes 2.3  $\mu\text{m}$  broad.

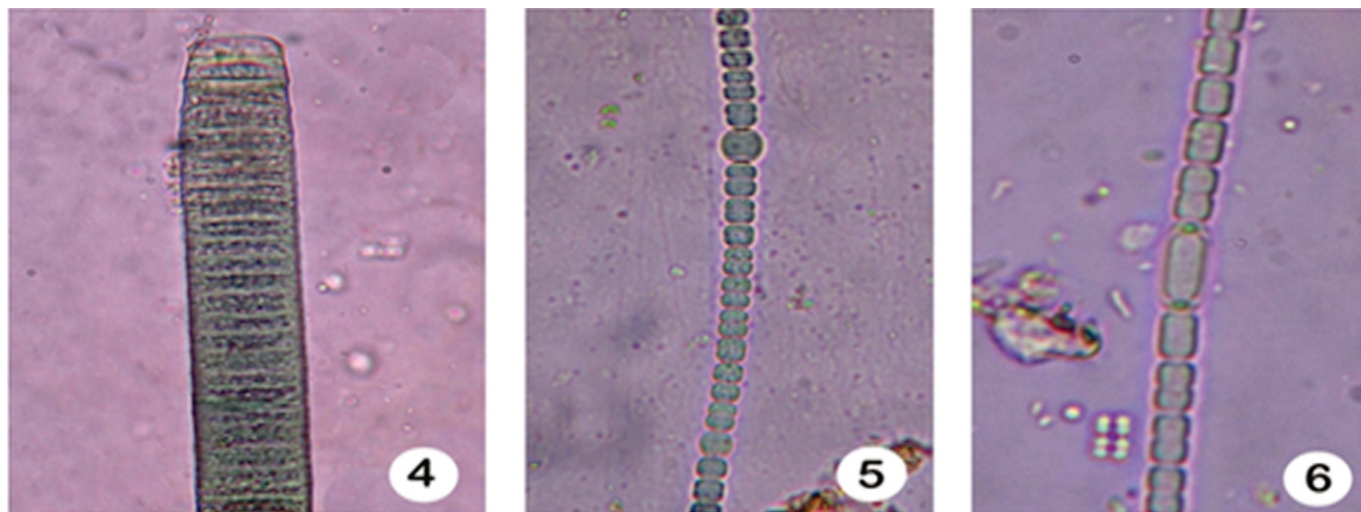
Sample No. and Date: BJ- 1, 23/07/2014

Distribution in Nepal: Bagmati River in Karmaiya, Rautahat Rice field in Malangwa, Sarlahi (Sahay et al., 1993); Madhuban and Kusaha, Sunsari (Jha and Kargupta, 2001); Pitchra pond, Biratnagar (Rai and Misra, 2010).

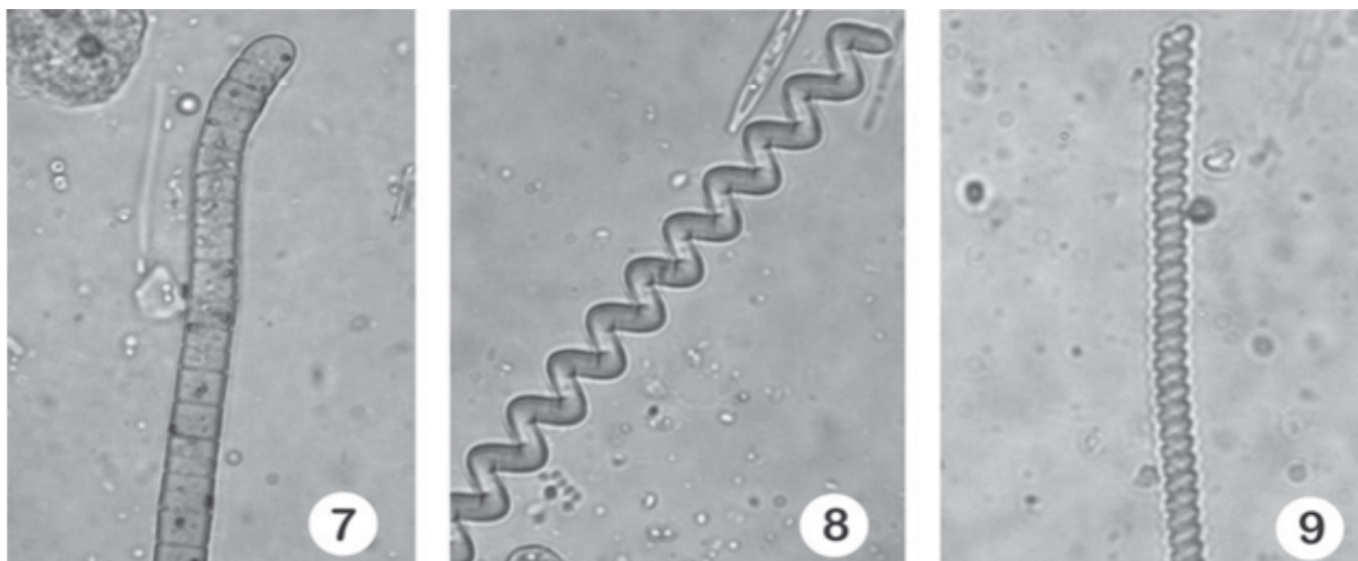
Worldwide distribution: Germany (Scholz and Liebezeit, 2012), Italy (Furnari et al., 2003), India (Rao and Gupta, 2015), Iran (Ramzannejad Ghadi, 2008), Iraq (Maulood et al., 2013), Kuwait (Silva et al., 1996), Pakistan (Mehwish and Aliya, 2005), Punjab (Anon, 2012), Saudi Arabia (Mohamed and Al-Shehri, 2015), Turkey (Taskin et al., 2008), China (Hu and Wei, 2006), Russia (Far East) Medvedeva and Nikulina 2014), Taiwan, (Shao 2003-2014), Turkey (Asia) (Varol and Sen 2014).



Figures: 1, 2. *Chroococcus minutus* 3. *Aphanocapsa rivularis*



4. *Oscillatoria sancta* 5. *Anabaena affinis* 6. *Anabaena subcylindrica*



7. *Phormidium autumnale* 8. *Spirulina princeps* 9. *Spirulina subsalsa*

*Anabaena*, *Oscillatoria* and *Phormidium* were common genera occurred in all three seasons (Table 1). *Aphanocapsa* was found only in summer and rainy collections, *Chroococcus* only in winter and rainy seasons and *Spirulina* only in rainy season. *Anabaena* and *Oscillatoria* were recorded from all eight sites, *Phormidium* from 7 sites, *Chroococcus* from 4 sites, *Spirulina* from 3 sites and *Aphanocapsa* from only 2 sites.

In winter, the dominant genera were *Oscillatoria* and *Phormidium* in 3<sup>rd</sup> site. In summer, the distinct dominance was not shown by any genera (Fig.10). In rainy season, *Anabaena* was dominant in 4<sup>th</sup> site and *Oscillatoria* in 1<sup>st</sup> site. In rainy season, site 2 was represented by all six genera.

**Table 1:** Distribution and dominancy of cyanophyceae genera in different sites of Baghjoda pond in different seasons.

| Winter season collection. |                     |                   |     |      |      |     |    |    |    |       |
|---------------------------|---------------------|-------------------|-----|------|------|-----|----|----|----|-------|
| S.N                       | Cyanobacteria       | Sites (Dominancy) |     |      |      |     |    |    |    | Total |
|                           |                     | 1                 | 2   | 3    | 4    | 5   | 6  | 7  | 8  |       |
| 1.                        | <i>Anabaena</i>     | ++                | +   | +++  | +    | +   | +  | +  | +  | 8     |
| 2.                        | <i>Aphanocapsa</i>  | -                 | -   | -    | -    | -   | -  | -  | -  | 0     |
| 3.                        | <i>Chroococcus</i>  | -                 | -   | +    | -    | -   | -  | -  | -  | 1     |
| 4.                        | <i>Oscillatoria</i> | ++                | -   | ++++ | +    | +   | +  | -  | +  | 6     |
| 5.                        | <i>Phormidium</i>   | +                 | -   | ++++ | -    | -   | +  | +  | ++ | 5     |
| 6.                        | <i>Spirulina</i>    | -                 | -   | -    | -    | -   | -  | -  | -  | 0     |
| Total                     |                     | 3                 | 1   | 4    | 2    | 2   | 3  | 2  | 3  |       |
| Summer season collection  |                     |                   |     |      |      |     |    |    |    |       |
| 1.                        | <i>Anabaena</i>     | ++                | +   | +    | +    | -   | ++ | +  | ++ | 7     |
| 2.                        | <i>Aphanocapsa</i>  | +                 | +   | -    | -    | -   | -  | -  | -  | 2     |
| 3.                        | <i>Chroococcus</i>  | -                 | -   | -    | -    | -   | -  | -  | -  | 0     |
| 4.                        | <i>Oscillatoria</i> | +                 | ++  | ++   | +    | +   | +  | ++ | ++ | 8     |
| 5.                        | <i>Phormidium</i>   | +                 | -   | -    | ++   | -   | -  | +  | -  | 3     |
| 6.                        | <i>Spirulina</i>    | -                 | -   | -    | -    | -   | -  | -  | -  | 0     |
| Total                     |                     | 4                 | 3   | 2    | 3    | 1   | 2  | 3  | 2  |       |
| Rainy season collection   |                     |                   |     |      |      |     |    |    |    |       |
| 1.                        | <i>Anabaena</i>     | +                 | +   | +    | ++++ | +++ | +  | +  | +  | 8     |
| 2.                        | <i>Aphanocapsa</i>  | -                 | +   | -    | -    | -   | -  | -  | -  | 1     |
| 3.                        | <i>Chroococcus</i>  | -                 | +   | -    | -    | +   | +  | -  | -  | 3     |
| 4.                        | <i>Oscillatoria</i> | ++++              | +++ | +++  | ++   | ++  | -  | +  | ++ | 7     |
| 5.                        | <i>Phormidium</i>   | ++                | ++  | +    | -    | -   | -  | -  | -  | 3     |
| 6.                        | <i>Spirulina</i>    | ++                | ++  | +    | -    | -   | -  | -  | -  | 3     |
| Total                     |                     | 4                 | 6   | 4    | 2    | 3   | 2  | 2  | 2  |       |

Among the sites, site 2 was followed by sites 1 and 3 with 5 genera each, site 6 by 4 genera and sites 4, 6, 7 and 8 by 3 genera each (Figure 11). Genus *Chroococcus* was absent in site 1; *Aphanocapsa* was absent in site 3; *Aphanocapsa*, *Chroococcus* and *Spirulina* were absent in sites 4, 7 and 8; *Aphanocapsa*, *Phormidium* and *Spirulina* were absent in site 5; and *Aphanocapsa* and *Spirulina* were absent in site 6 (Table 1).

The present study showed that sites first, second and third were found to be comparatively rich in algal diversity as they were least disturbed and received light for longer period. In the second site there was drastic change in algal diversity in

different collection, whereas, in other sites no such remarkable change in algal diversity was observed. During rainy season, there was more number of algae in the pond than in summer and winter seasons. Among six genera of algae, *Anabaena* and *Oscillatoria* were found in large number. *Anabaena*, *Oscillatoria* and *Phormidium* were found in all three seasons. *Merismopediael egans*, *Lyngbyabergei*, *L. majuscula*, *Anabaena iyengarii*, *Nostochopsis lobatus*, *Coelosphaerium dubium*, *Oscillatoria princeps* and *Anabaena orientalis* were reported from Betana pond (Rai, 2011), a nearest pond in Morang, but were not found in the present study from Baghjoda pond.

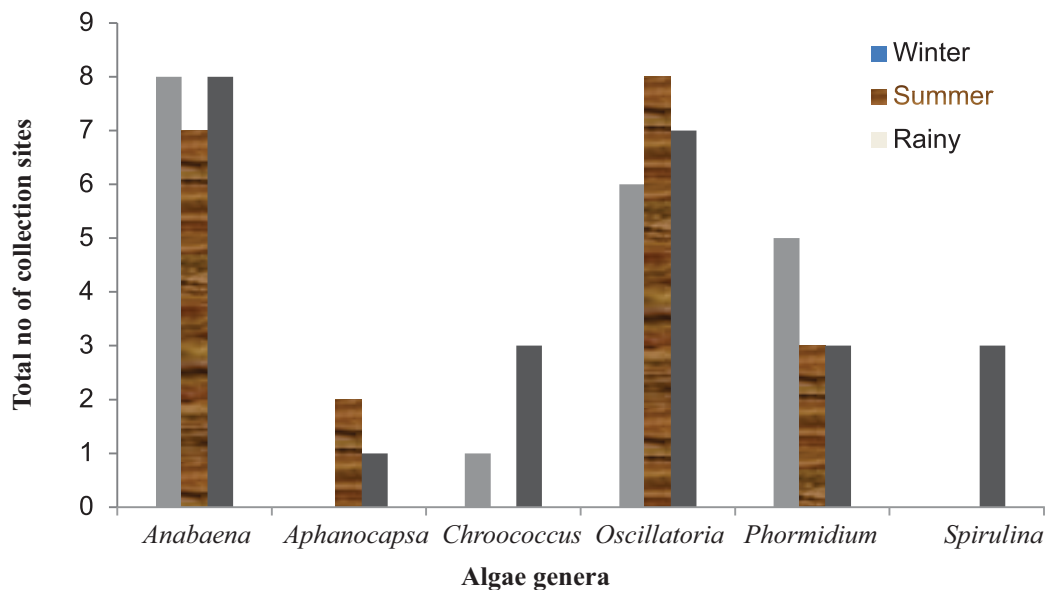


Figure 10. Occurrence of cyanophyceae genera at different sites in different seasons.

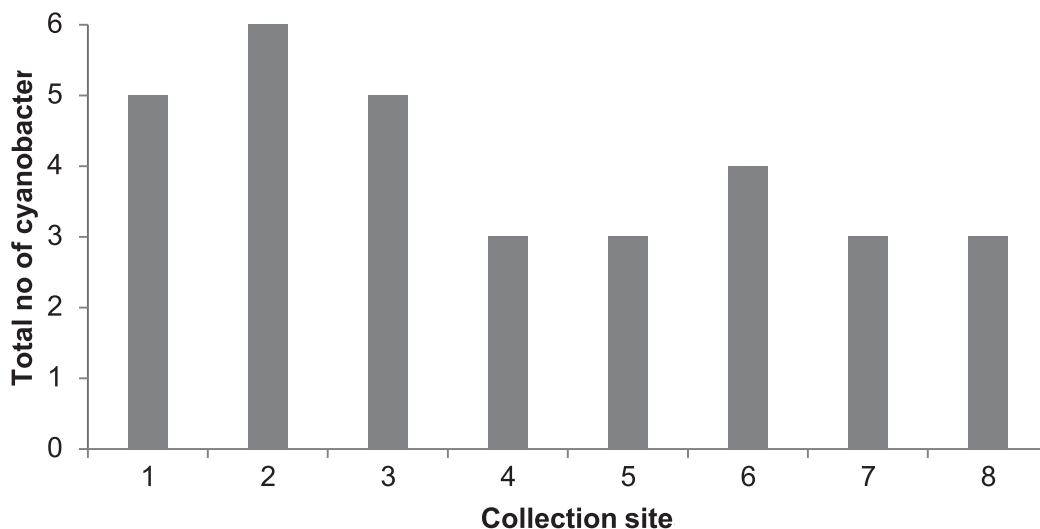


Figure 11. Total number of cyanobacteria from different sites of pond.



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