J. Environ. Sci. & Natural Resources, **5(2): 185 - 192 , 2012** ISSN 1999-7361

Investigation on the Nitrogen Fixing Cyanobacteria (BGA) in Rice Fields of North-West Region of Bangladesh. I: Nonfilamentous

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Abstract

The experiment was conducted to carry out the nitrogen fixing cyanobaterial (BGA) resources and their distribution pattern in rice fields of North-West region of Bangladesh during the period of 2011. Considering the vast importance of Blue-green algae (BGA) in agricultural land especially in rice fields, twelve months long systematic observation was undertaken. A total of 15 genera with 42 species of non-filamentous (unicellular and colonial) blue-green algal forms were identified and recorded from this region. Out of 42 species, 9 species belonging to the genus *Aphanocapsa*, 8 to *Chroococcus*, 5 to *Gloeocapsa*, 4 to *Aphanothece*, 3 to *Gloeothece*, 3 to *Merismopedia* and 2 to *Coelosphaerium*; while 1 species belonging to each genus of *Chroococcidiopsis*, *Synechococcus*, *Synechocystis*, *Dactylococcopsis*, *Microcystis*, *Myxosarcina*, *Hydrococcus* and *Xenococcus*. The distribution pattern of non-filamentous BGA in rice fields over the study area has also been observed in this study. With few exceptions, the non-filamentous BGA are more or less uniformly distributed all over the study areas. All of the BGA members have a tremendous ability to contribute on enhancing agricultural production by fixing atmospheric nitrogen and adding organic matter, vitamins, growth promoting substances etc to the soil and crops.

Keywords: Bangladesh, Nitrogen fixing cyanobateria (BGA), Non-filamentous, Rice fields

Introduction

Bangladesh is an agriculture base country due to ever-growing population. Day by day, the demand of agricultural products is increased significantly. Moreover, most of the farmers of Bangladesh are marginal and of low living standard. It is difficult to them to maintain balance nutrients management with the application of highly cost chemical fertilizers. To enhance their scio-economic standard and meet the challenge of ever increasing food demand, there is no alternative but increase the crop production and reduce the production cost. Blue-green algae especially their bio-fertilizers are the right ones for meeting this challenge as they are capable to increase crop yield in 10-15% by fixing 20-30 Kg N/ha. Cyanobacteria (Blue-Green Algae) are one of the major components of the nitrogen fixing biomass in paddy fields. The agricultural importance of cyanobacteria in rice cultivation is directly related with their ability to fix nitrogen and other positive effects for plants and soil. After water, nitrogen is the second limiting factor for plant growth in many fields and deficiency of this element is met by fertilizers application (Malik *et al.*, 2001). The excessive use of chemical fertilizers has generated several environmental problems including the greenhouse effect, ozone layer depletion and acidification of soil and water. These problems can be tackled by use of bio-fertilizers (Choudhury and Kennedy 2005, Rai 2006). Bio-fertilizers, more commonly known as microbial inoculants, include bacteria (*Rhizobium*, *Azotobacter* etc.), algae (Blue-green algae) and mycorrhizal fungi; they are natural, beneficial and ecological, and they provide nutrients for the plants and maintain soil structure (Board 2004). Specially, cyanobacteria (BGA) along play an important role in maintenance and build-up of soil fertility, consequently increasing rice growth and yield as a natural bio-fertilizer (Song et al. 2005). The acts of these algae include: (1) They converted huge amount of CO_2 into O_2 as they bear photosynthetic pigments and thus putting a vital role in repairing environmental pollution. (2) Increase in soil pores and production of adhesive substances (3) The same way, they enhance the soil aeration results in supplying a considerable amount of O_2 to the crop rhizosphere. (4) Excretion of growth-promoting substances such as hormones (auxin, gibberellins), vitamins, amino acids (Roger and Reynaud 1982, Rodriguez et al. 2006). (5) Increase in water-holding capacity through their jelly structure (Roger and Reynaud 1982). (6) Increase in soil biomass after their death and decomposition. (7) Decrease in soil salinity. (8) Preventing weeds growth. (9) Increase in soil phosphate by excretion of organic acids (Wilson 2006). Most paddy soils have a natural population of cyanobacteria which provides a potential source of nitrogen fixation at no cost (Mishra and Pabbi 2004). Considering the tremendous important of BGA, it should be the first priority to search out and identify this resources and their distribution pattern in our rice fields. Only then, they may be used in producing algal bio-fertilizer, enhancing soil fertility and rice production, reducing chemical fertilizer utilization and production cost, ensuring friendly environment to agriculture.

Therefore, the present paper deals with: i. Carry out the members of blue-green algal resources in the rice fields of North-West region of Bangladesh, ii. Find out their distribution pattern over the same.

[Amongst BGA, this paper is concerned only with non-filamentous: unicellular and colonial members.]

Material and Method

Five districts viz. Serajgonj, Pabna, Natore. Rajshahi and Naogoan of North-West part of Bangladesh have been considered as study zone. Rice field of two upozillas of each district like as Ullapar and Tarash of Serajgonj, Chatmohore and Ishwardi of Pabna, Gurudashpur and Singra of Natore, Rajshahi proper and Godagari of Rajshahi and Atri and Patnitala of Naogaon district have been selected as sampling spot. In all sampling spots spread over the study zone were selected for the collection of blue-green algal sample. The climatological and ecological variations have been intensively considered during the spot selection.

Sampling was made at monthly interval from ten study spots. Commonly confined the surface layers, soil algal samples were collected by means of a diminutive rectangular shovel having a sharp blade. While the study field was damp, a small block could be removed directly by cutting with a scalpel. It is often difficult to separate algal specimen from soil particles. To obtain relatively clean samples, the soil blocks, were kept in a petri-dish and added enough water to saturate them. A few cover glasses were placed on the soil block and the dish was left open until the excess water had evaporated. Within in one or two days, motile algae in the soil crept up on the underside of the cover glasses and began to multiply. According to necessity, the samples were preserved by spraying Transeau's solution on the petri-dish. A drop of 10% glycerin was placed on a clean slide and the algae contain cover slip was mounted on it and examined under the microscope. During the microscopic observation, only the BGA members are considered to be the desired specimen for the present study. Three slides of each sample have been observed under microscope to ensure the appearance or disappearance of any blue-green algal genus and species under themselves and also to confirm their distribution pattern. The drawing of blue-green algal specimen was done by using Camera Lucida. The measurement and microscopic calibration is done usually by the ocular micrometer which consists of an oculometer or eye piece micrometer and a stage micrometer. The systematic identification was done with the help of standard works by Dsikachary (1959), Pandey (1965), Prescott (1951), Islam (1967, 1973 and 1979) and Alison (2007).

Results and Discussion

Taxonomy: In all 15 genera with 42 species of cyanobacterial (non-filamentous: unicellular, colonial) taxa have been described systematically and illustrated in this paper. Out of 42 species, 9 species belonging to the genus *Aphanocapsa*, 8 to *Chroococcus*, 5 to *Gloeocapsa*, 4 to *Aphanothece*, 3 to *Gloeothece*, 3 to *Merismopedia* and 2 to *Coelosphaerium*; while 1 species belonging to each genus of *Chroococcidiopsis*, *Synechococcus*, *Synechocystis*, *Dactylococcopsis*, *Microcystis*, *Myxosarcina*, *Hydrococcus* and *Xenococcus*. However, 42 species under 15 genera are plotted in several plates viz. plate-1, plate- 2 and plate- 3. [All the measurements are expressed in µ].

CLASS: CYANOPHYCEAE
ORDER: CHROOCOCCALES
FAMILY: CHROOCOCCACEAE

1. *Chroococcus cohaerens* (Breb.) Nāg (Pl. 2, Fig. 12)

Dsikachary, 1959, 111, Pl. 26, Fig. 3

Thallus slimy or gelatinous, blue or dark green; cells single or up to 2-8 in groups, without envelope3.3-7.2 diam. and with sheath 3.2- 8.4 diam.; colony 8.3-16.5 diam.; sheath, colorless, unlamellated.

2. *Chroococcus minutus* (Kütz.) Näg [Pl. 2, Figs. 13 (a-c)]

Dsikachary, 1959, 103, Pl. 24, Fig. 4 & Pl. 26, Figs. 4 & 15

Plant solitary or ingroups of 24 cells; cell spherical, with sheath 4.5-12.4 diam., without sheath 3.3-10.23 diam.; colony 19.0-23.5 diam., colonial sheath hyaline, unlamellated.

3. *Chroococcus minor* (Kütz.) Näg (Pl. 2, Fig. 14)

Dsikachary, 1959, 105, Pl. 24, Fig. 1; Islam, 1972, Pl. 12, Fig. 8

Thallus dull blue-green, free floating, gelatinous; cells 2-4 in a colony, 3.3-4.0 diam.; sheath thin, hyaline.

4. *Chroococcus turgidus* (Kütz.) Näg [Pl. 3, Figs. 1 (a-b)]

Dsikachary, 1959, 101, Pl. 26, Fig. 6; Islam and Nahar, 1967, 143, Pl. 2, Figs. 1-3

Plant mass in groups of 2-4 cells, slightly yellowish; cells spherical, with sheath 19.0-26.0 diam. without sheath 8.6-13.5 diam.; sheath hyaline, distinctly lamellated.

5. *Chroococcus montanus* Hansging (Pl. 3, Fig. 2)

Dsikachary, 1959, 108, Pl. 26, Fig. 12

Plant mass gelatinous, forming brownish patches; cells in groups of 4 or 8 in a colony. Colony 17.5- 30.0 diam., cells spherical with individual sheath, with sheath 5.0- 7.5 diam., without sheath 3.5- 5.2 diam.

6. *Chroococcus limneticus* Lemn. [Pl. 3, Figs. 3 (a-b)]

Dsikachary, 1959, 107, Pl. 26, Fig. 2**;** Islam and Uddin, 1973, 79, Pl. 3, Fig. 17

Cells spherical or sub-spherical after division, 4-32 cells mostly in a tabular gelatinous layer, cells without sheath 4.5-9.3 diam., with sheath 8.0-16.5; sheath distinct or diffluent, colonial mucilage broad..

7. *Chroococcus macrococcus* (Kütz.) Rabens [Pl. 3, Figs. 4 (a-b)]

Dsikachary, 1959, 101, Pl. 27, Figs. 3 & 9

Thallus mucilaginous, yellowish brown, more or less dilated; cells spherical, 2-4 together, also single, without sheath 23.5- 50.0 diam., with sheath 27.5-80.0 diam.; sheath thick, lamellated.

8. *Chroococcus pallidus* Näg [Pl. 3, Figs. 5 (a-b)]

Dsikachary, 1959, 109, Pl. 26, Fig. 5

Thallus gelatinous, yellowish or colorless cells single or 2-4, seldom up to 8 in elliptic oblong colonies, without sheath 4.5-9.5 diam., with sheath 7.5-14.0 diam., blue-green or yellowish in color.

9. *Chroococcidiopsis indica* [Pl. 3, Figs. 6 (a-b)]

Dsikachary, 1959, 167, Pl. 31, Fig. 29

Cells solitary, rarely many together, spherical or sub-spherical, 4.3- 5.5 broad with a firm wall, endospores 8-12 formed by successive division

10. *Coelosphaerium kuetzingianum* Näg (Pl. 3, Fig. 9)

Dsikachary, 1959, 148, Pl. 28, Figs. 7-8

Colony more or less spherical, colonial mucilage envelop thin, 32.5-72.5 broad; cells spherical, loosely arranged, somewhat irregular, 3.3-5.8 broad.

11. *Coelosphaerium dubium* Grum. [Pl. 3, Figs. 14 (a-b)]

Dsikachary, 1959, 147, Pl. 28, Figs. 10, 15

Colony more or less spherical, colonial mucilage firms, not lamellated, up to 6.2-8.0 thick; cells spherical, closely arranged, 5.2-7.5 broad, dark blue green in color, gas-vacuoles present.

12. *Synechocystis aquatilis* Sauv. [Pl. 3, Figs. 10 (a-b)]

Dsikachary, 1959, 144, Pl. 25, Fig. 9; Geitler, 1925, 110, Fig. 130

Cells spherical, solitary or in pairs without mucilaginous sheath, pale blue-green; cells 3.5-6.2 broad.

13. *Synechococcus aeruginosus* Näg (Pl. 3, Fig. 11)

Dsikachary, 1959, 143, Pl. 25, Figs. 6, 12

Cells solitary or in groups of 2, cylindrical, 4.2-9.3 diam., 12.6-18.0 longs, cell's apices round.

14. *Aphanocapsa muscicola* (Menegh.) Wille (Pl. 1, Fig. 1)

Dsikachary, 1959, 135, Pl. 21, Fig. 7

Colony microscopic; cells spherical, 2.0-2.8 diam., 2-4 together, daughter cells often together thick, colorless, white or grayish blue.

15. *Aphanocapsa virescens* (Hass.) [Pl. 1, Figs. 2 (a-b)]

Dsikachary, 1959, 100, Pl. 21, Fig. 6; Islam and Nahar, 1967, 144, Pl. 3, Fig. 7

Cells light blue-green, cell division generally in two, cells without sheath 6.5-9.3 in diam., with sheath 7.8-13.9 in diam.; sheath colorless, lamellated (1 layer), seldom unlamellated.

16. *Aphanocapsa gravellei* (Hass.) Rabenh. [Pl. 1, Figs. 3 (a-b)]

Dsikachary, 1959, 134, Pl. 21, Fig. 9

Plant mass gelatinous, spherical, on shallow mud bottom, 38.3-60.0 diam.; cells spherical, 2.9-4.5 diam. without individual sheath, loosely arranged in the homogeneous matrix.

17. *Aphanocapsa biformis* A. Br. [Pl. 1 Figs. 4 (a-c)]

Dsikachary, 1959, 134, Pl. 21, Figs. 3-4; Islam and Nahar, 1967, 144, Pl. 3, Fig. 1

Thallus blue-green, expanded, many cells loosely and scatteredly arranged in the gelatinous matrix; colony sometimes broken into masses; cells spherical, 5.00-6.6 diam. without individual sheath.

18. *Aphanocapsa pulchra* (Kütz.) Rabenh. (Pl. 1, Fig. 5)

Dsikachary, 1959, 132, Pl. 21, Fig. 2; Pandey, 1965, 182, Pl. 2, Fig. 3

Thallus gelatinous, bluish green; cells in a common mucilage matrix; cells spherical, 3.8-6.6 diam., loosely arranged singly or in groups; individual cell-sheath not distinct.

19. *Aphanocapsa montana* Cremer (Pl. 1, Fig. 6)

Dsikachary, 1959, 135, Pl. 20, Fig. 8

Thallus of no definite shapes, gelatinous, yellow-green or blue-green; cells spherical or sub-sperical, single or in pairs, 2.5-5.4 diam.; mucilage colorless, diffluent.

20. *Aphanocapsa littoralis* var. *macrococca* Hansg. (Pl. 1, Fig. 7)
Dsikachary, 1959, 131, Pl. 21, Figs. 1; Islam and Aziz, 1979, 115, Pl. 4, Fig. 61
Colony discoid; cells unequal insize, embedded in granular mucilage; each cell with bluish sheath, non-stratified, 5.3-11.5 diam.

21. *Aphanocapsa crassa* Ghose (Pl. 1, Fig. 8)
Dsikachary, 1959, 136, Pl. 22, Figs. 6
Stratum gelatinous, delicate, brownish; cells generally single, globose, not very closely arranged, 6.6-11.9 thick, brownish green.

22. *Aphanocapsa koordesi* Strom (Pl. 2, Fig. 1)
Dsikachary, 1959, 132, Pl. 23, Figs. 1
Colony spherical, dull green to blue-green, 2-3 mm. in diam,; cells loosely arranged or in groups of four, spherical, 3.8-4.9 in diam.

23. *Aphanothece microscopica* Nāg. (Pl. 1, Fig. 9)
Dsikachary, 1959, 142, Pl. 22, Figs. 4, 5 & 9
Thallus small, gelatinous, round or amorphous; cells oblong or cylindrical, 4.9 diam., 6.5-8.4 long; cells with individual sheath

24 . *Aphanothece saxicola* Nāg [Pl. 2, Fig. 2(a-b)]
Dsikachary, 1959, 138, Pl. 22, Fig. 11
Thallus mucilaginous, colorless; cells cylindrical, 1.8-2.0 broad and 2.0-3.5 times as long as broad, single or in pairs, seldom many in a common mucilaginous envelope, pale blue-green

25. *Aphanothece pallida* (Kütz.) Rabenh. (Pl. 2, Fig. 3)
Dsikachary, 1959, 140-141, Pl. 22, Fig. 3
Plant mass gelatinous, light brownish blue-green, on the mud with thin film of water; many cells in a colony; cells cylindrical or ellipsoidal, without individual sheath, 4.8-6.0 diam., 8.0-11.5 long; colonial sheath yellowish dark.

26. *Aphanothece naegellii* Wartm. (Pl. 2, Fig. 4)
Dsikachary, 1959, 141, Pl. 22, Fig. 7
Plant mass gelatinous, bluish green, irregularly expanded; cells oval, spherical or ellipsoidal, many in a colony, 4.6-6.0 diam. 6.2-7.5 long.

27. *Gloeocapsa livida* (Carm.) Kütz. (Pl. 2, Fig. 5)
Dsikachary, 1959, 116, Pl. 27, Fig. 8
Thallus mucilaginous, first rounded or lobed, later expanded, hyaline, greenish to olive brown in color; cells small, with sheath 6.0-7.3 in diam. and without sheath 3.0-3.6 in diam.; colonies of 16.0-85.8 diam.; sheath light bluish, hyaline, contents densely bluish-green.

28. *Gloeocapsa lute-fusca* Martens (Pl. 1, Fig. 10)
Dsikachary, 1959, 119, Pl. 24, Fig. 16
Thallus compact, expanded leathery, blackish to olive-green in color; cell with colorless sheath at fast, later dull brown or yellowish, 5.1-7.0 long, 3.6- 4 broad.

29. *Gloeocapsa granosa* (Brek.) Kütz. (Pl. 2, Fig. 6)
Islam and Nahar, 1967, 144, Pl. 1, Fig. 8; Dsikachary, 1959, 123, Pl. 24, Fig. 10
Thallus with a mucillagenous sheath containing several daughter colonies; each daughter colony contains usually four cells and with individual sheath; cells spherical, 6.3-7.9 in diam.

30. *Gloeocapsa decorticans* (A. Br.) Richter (Pl. 2, Fig. 7)
Dsikachary, 1959, 114, Pl. 24, Fig. 9; Pandey, 1965, 181, Pl. 51, Fig. 1
Colonies with 2-4 cells, bluish green, 21.5-26.0 long, 12.0-16.7 diam.; cells with stratified sheath; single cell with sheath 9.9-12.0 long, 6.6-9.5 diam., without sheath 3.5-6.6 diam., 5.5-7.5 long.

31. *Gloeocapsa quaternata* (Breb.) Kütz (Pl. 2, Fig. 8)
Dsikachary, 1959, 120, Pl. 20, Fig. 9; Islam, 1973, 36, Pl. 12, Fig. 56
Plant mas sub-spherical, pale blackish green; cells 1-5 in a colony; cells without individual sheath, spherical, each cell 3.3-9.0 diam.

32. *Gloeothece rupestris* (Lyngb.) Bornet (Pl. 2, Fig. 9)
Dsikachary, 1959, 127, Pl. 25, Fig. 4
Plant mass light blue green, spherical to ellipsoidal, 2-6 cells in a colony, 12.5-17.0 diam.; common envelope thin, hyaline; cells ellipsoidal to cylindrical, individual cells without envelope 4.5-6.6 diam., 4.2-8.0 long.

33. *Gloeothece fusco-lutea* Näg [Pl. 2, Figs. 10(a-c)]
Dsikachary, 1959, 125, Pl. 25, Fig. 5
Thallus mucilaginous, blue-green to brown, 4-8 cells in a colony; cells ellipsoidal with individual envelope; with envelope 7.9- 8.8 long, 4.9-6.6 diam.; without envelope 3.9-6.4 long, 3.6-4.5 diam.

34. *Gloeothece* sp. [Pl. 2, Figs. 11(a-b)]
Cells spherical, 4 cells in a group, dark blue-green, enveloped with very thick mucilaginous sheath, 3.8-4.9 in diam.; sheath colorless.

35. *Merismopedia minima* Beck. (Pl. 2, Fig. 15)
Dsikachary, 1959, 154, Pl. 29, Fig. 11
Cells pale blue green, 4 to many in small colonies, 0.6-1.5 broad; groups of four cells 3.2× 4.5.

36. *Merismopedia glauca* (Elir.) (Pl. 3, Fig. 12)
Islam and Nahar, 1967, 144, Pl. 1, Fig. 4
Colony mostly with 16-64 cells, rarely more, 40-150diam.; cells oval or spherical, closely arranged, 2.9-6.8 broad.

37. *Merismopedia punctata* Meyen [Pl. 3, Figs. 13(a-b)]
Dsikachary, 1959, 155, Pl. 23, Fig. 5
Colonies small, 4-64 cells, about 30-60 broad; cells not closely packed, spherical or ovoid, 3.2-4.7 broad, pale blue-green

38. *Dactylococcopsis raphidioides* Hansg (Pl. 1, Fig. 12
Dsikachary, 1959, 158, Pl. 29, Fig. 1
Cells spindle-shaped, sigmoid or lunulately bent, 2-3.3 broad, 5-6-8 times as long as broad, up to 25.4 long, light blue green, single or a few together in a little mucilage.

39. *Microcystis ramosa* Bhar. (Pl. 1, Fig. 13)
Islam and Uddin, 1973, 78, Pl. 1, Fig. 6
Colonies long, varying in form and size, irregularly branched; sheath thick, un-stratified, hyaline; cells spherical, 3.9-4.4 in diam.

ORDER: PLEUROCAPSALES
FAMILY: PLEUROCAPSACEAE

40. *Myxosarcina spectabilis* Geilter [Pl. 1, Figs. 11(a-b)]
Dsikachary, 1959, 178, Pl. 30, Figs. 1-5 & Pl. 31, Figs. 18-19
Cells in three dimensional colonies, 6.5-10 broad; colonial sheath thin, distinct; cell-contents blue-green, cells cubical round, densely packed, arranged overlapping the others.

ORDER: CHAMAESIPHONALES
FAMILY: HYELLACEAE

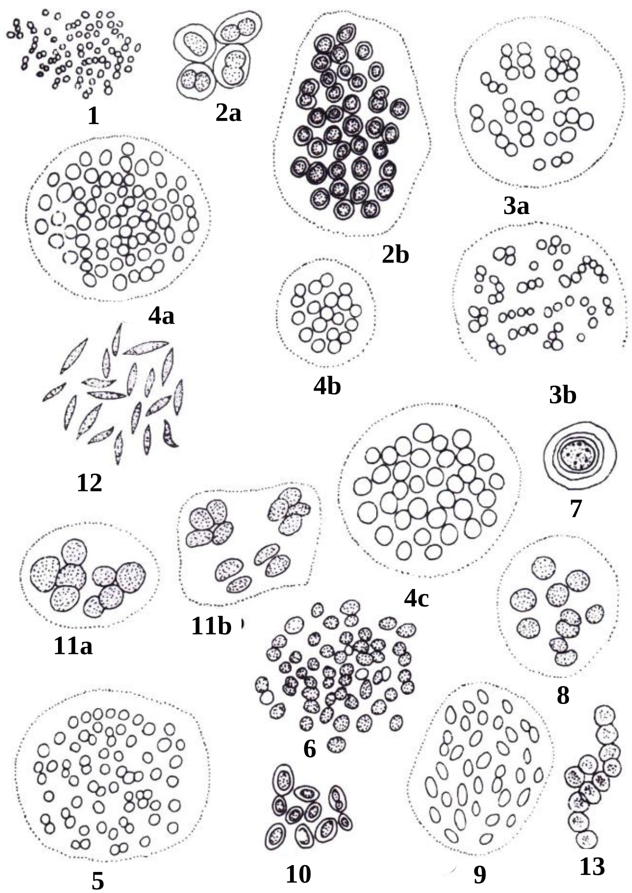
41. *Hydrococcus rivularis* Kütz. (Pl. 3, Fig. 7)
Dsikachary, 1959, 180, Pl. 30, Figs. 10-14
Thallus made of more or less creeping, nematoparenchymatous; cells 3-6 broad, seldom broader, as long as broad, or some what longer with more or les gelatinous sheath, special envelopes present, cells closely arranged and polygonaly ad-pressed; often with calcium crystals in the inside of the thallus.

42. *Xenococcus kerneri* Hansg. [Pl. 3, Figs. 8(a-b)]
Dsikachary, 1959, 181, Pl. 31, Figs. 23 & 24
Colonies at first single layered, discoid and blastoparenchymatous, later forming a parenchymatous thallus by the lateral approximation of the vertical branches; cells in groups of 4 or 8, membrane thick, lamellated or unlamellated, at the margins of the thallus with a diffluent or gelatinous envelop; cells 3.9-5.9 broad, up to 10 long.

Distribution of Cyanobacteria (BGA): Out of 15 genera, *Chroococcus*, *Aphanocapsa Aphanothece* and *Gloeocapsa* are distributed all over the study region with higher abundant; while *Coelosphaerium***,** *Synechococcus*, *Microcystis*, *Gloeothece*, *Merismopedia*, *Myxosarcina* and *Synechocystis* are distributed with moderately abundant. Contrary to this, *Chroococcidiopsis*, *Dactylococcopsis*, *Hydrococcus* and *Xenococcus* are distributed all over the study areas with less abundant. *Chroococcidiopsis* is not found in the rice fields of Natore and Naongoan district; while *Dactylococcopsis* is not observed in Rajshai and Naongoan district; similarly *Xenococcus* is absent in the rice fields of Serajgonj, Pabna and Rajshahi. *Hydrococcus* is alone absent in the field of Naogoan area (Table. 1).

A profusely distribution of cyanobacteria (BGA) is observed in the rice fields of Serajgonj district followed by Pabna and Natore. All the members of BGA are more or less uniformly distributed in these areas. Probably, it may due to the medium to high soil organic matter content and higher soil fertility status of these areas which favor the usual growth of cyanobacteria. On the other hand, comparatively a poor and slightly fluctuated distribution of cyanobacteria is found in the rice fields of Rajshahi and Naogoan district. Such findings probably due to the medium to low soil organic matter content with low moisture holding capacity and lower soil fertility status of these areas which may adversely affect the usual growth of cyanobacteria as the upper part of both the Rajshahi and Naogoan district are in level, level and high Barind-Tract atmosphere, respectively. However, with few exceptions, more or less a uniform distribution of non-filamentous Cyanobacteria (BGA) has been found all over the study region.

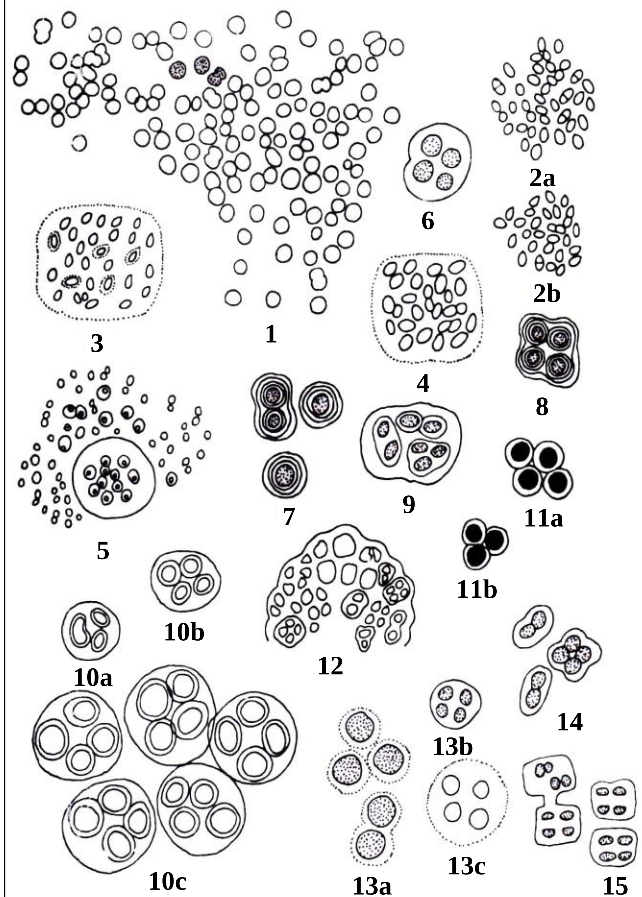
PLATE-1



Figures:

1. *Aphanocapsa muscicola*, **2(a-b)**. *Aphanocapsa virescens*, **3(a-b).** *Aphanocapsa gravellei*, **4(a-c).** *Aphanocapsa biformis*, **5.** *Aphanocapsa pulchra*, **6.** *Aphanocapsa montana*, **7.** *Aphanocapsa littoralis* var. *macrococca*, **8.** *Aphanocapsa crassa*, **9.** *Aphanothece microscopica*, **10.** *Gloeocapsa lute-fusca*, **11(a-b)**. *Myxosarcina spectabilis*, **12.** *Dactylococcopsis raphidioides*, **13.** *Microcystis ramosa*

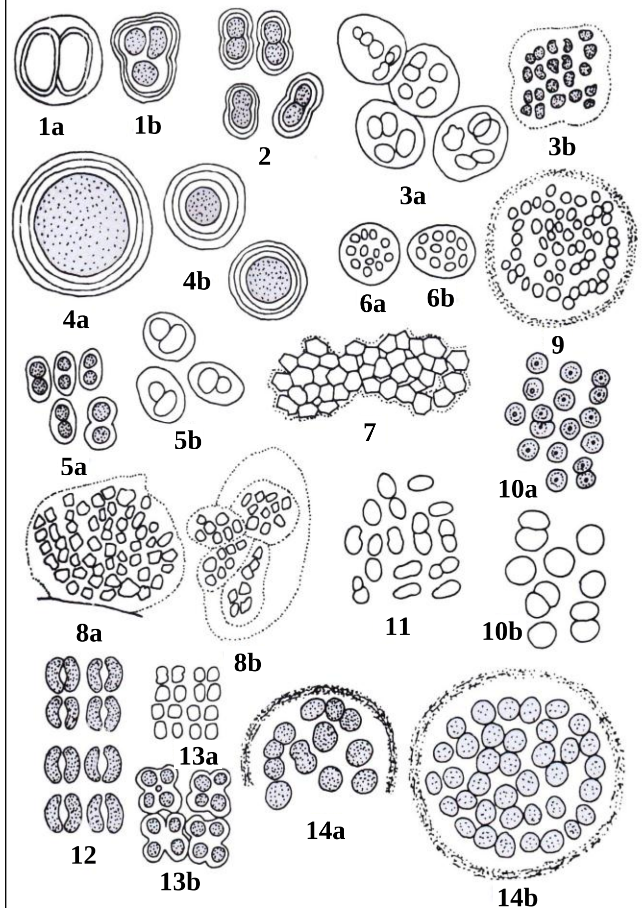
PLATE-2



Figures:

1. *Aphanocapsa koordesi*, **2(a-b).** *Aphanothece saxicola*, **3.** *Aphanothece pallida*, **4.** *Aphanothece naegellii*, **5.** *Gloeocapsa livida*, **6.** *Gloeocapsa granosa*, **7.** *Gloeocapsa decorticans*, **8.** *Gloeocapsa quaternata*, **9.** *Gloeothece rupestris*, **10(a-c).** *Gloeothece fuscolutea*, **11(a-b).** *Gloeothece* sp., **12.** *Chroococcus cohaerens*, **13(a-c).** *Chroococcus minutus*, **14.** *Chroococcus minor*, **15.** *Merismopedia minima*

PLATE-3



Figures:

1(a-b). *Chroococcus turgidus*, **2.** *Chroococcus montanus*, **3(a-b).** *Chroococcus limneticus*, **4(a-b).** *Chroococcus macrococcus*, **5(a-b).** *Chroococcus pallidus*, **6(a-b).** *Chroococcidiopsis indica*, **7.** *Hydrococcus rivularis*, **8(a-b).** *Xenococcus kerneri*, **9.** *Coelosphaerium kuetzingianum*, **10(a-b).** *Synechocystis aquatilis*, **11.** *Synechococcus aeruginosus*, **12.** *Merismopedia glauca*, **13(a-b).** *Merismopedia punctata*, **14(a-b).** *Coelosphaerium dubium*,

Table 1. The distribution of Cyanobacteria (non-filamentous: unicellular and colonial) in rice fields of North-West region of Bangladesh

Genera	Mode of Existence				
	Serajgonj	Pabna	Natore	Rajshahi	Naogoan
Chroococcus	+++	+++	+++	+++	+++
Chroococcidiopsis	++	+	-	+	-
Coelosphaerium	+++	++	++	++	+
Synechocystis	++	+	+	+	+
Synechococcus	++	+	++	+	+
Microcystis	++	++	++	+	++
Aphanocapsa	+++	+++	+++	+++	+++
Aphanothece	+++	+++	++	++	++
Gloeocapsa	+++	+++	+++	++	++
Gloeothece	++	++	++	++	+
Merismopedia	++	++	++	+	++
Dactylococcopsis	+	++	+	-	-
Myxosarcina	++	+	++	+	+
Hydrococcus	++	+	+	+	-
Xenococcus	-	-	+	-	+

+ = Less abundant, ++ = Moderately abundant, +++ = Highly abundant, - = Absent

Conclusions

The present investigation notices that the nitrogen fixing non-filamentous Cyanobacteria (BGA) is more or less uniformly distributed all over the study region with few exceptions. However, in the present study, 42 nitrogen fixing non-filamentous blue-green algal (cyanobacteria) specimens under 15 genera are introduced to us which may be used in producing algal bio-fertilizer, enhancing soil fertility and rice production, reducing chemical fertilizer utilization and production cost, ensuring friendly environment to agriculture as they are capable to fix atmospheric nitrogen by no cost and produce organic manures, vitamins and growth promoting substances naturally.

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