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ASSESSMENT OF CYANOBACTERIAL DIVERSITY IN DIFFERENT HABITATS OF KLING AREA, RI-BHOI DISTRICT, MEGHALAYA

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ABSTRACT
Present study was conducted in Kling area of Ri-Bhoi district, Meghalaya located 25°46' to 26°49' N latitude and 90°48' to 91°50' E longitude. Details study was conducted with standard methods at different selected habitats during four seasons *i.e* winter, spring, summer and autumn. Investigation on Cyanobacteria in RiBhoi found 45 taxa belonging to 4 orders and 6 families. Nostocales with 27 numbers of highest species followed by Chroococcales with 14 numbers of species. In case of family, Oscillatoriaceae leads with 19 numbers of species and under 18 genera *Oscillatoria* consists of 12 taxa followed by 7 taxa of *Chroococcus*, 4 taxa of *Scytonema* and so on. From the study, it is found that Cyanobacteria are highly rich in diversity of Kling area, Ri-Bhoi district, Meghalaya.

KEYWORDS: Blue green Algae, ecological factor, nutrient cycle, monsoon, water quality.

INTRODUCTION
Cyanobacteria or Cyanophyta or Blue green algae (BGA) are most primitive type of plants having simple prokaryotic cellular structure. The vegetative body may be unicellular, multicellular filamentous or non-filamentous colonial types. They are found in diverse habitat. For this reason, these organisms are excellent materials for investigation by ecologists, physiologists, biochemists, microbiologists and biotechnologist (Dasgupta & Ahmed, 2013). However, growth and distribution of blue green algae seem to have a direct relation with the onset of monsoon or summer months or both together. If the monsoon starts early causing abundance of rain water in the lands and water bodies then blue green algae makes their appearances early and show vigorous growth. This group of algae is found more dominant compared to other algal groups in different habitat (Sharma and Naik, 1996). It has also important role in plant succession and primary producer whereas even in nitrogen fixation in paddy fields (Booth, 1941; Friedman & Ocampo, 1976). A central position in global nutrient cycling is being played by theis group of algae especially due to their inherent capacity to fix atmospheric CO_2 and N_2 through Rubisco and nitrogenase enzymes respectively (Sinha *et al.*, 1995; 1997). A very few studies was done in Meghalaya. Syiem *et al. (2010)* worked on an Ecological point of view of Cyanobacterial Diversity. Present study was undertaken to investigate the Cyanobacterial Diversity in different habitat of Ri-Bhoi district, Meghalaya.

MATERIAL AND METHOD
Study Site
Present study was conducted in Kling area of Ri-Bhoi district, Meghalaya located 25°46' to 26°49' N latitude and 90°48' to 91°50' E longitude. The average annual rainfall of the study area is 2935 mm. The temperature ranges from 10°C in December to 30°C in the month of July and August as recorded in Umsning Station, whereas in Byrnihat station. Normally January and August record minimum (12.3°C) and maximum (35.2°C) temperatures respectively. The maximum relative humidity found 89% in the month December and January at the 08.30 hours and highest 83.15 in the month of September at 17.39 hours.

Different sites were selected for details study. The specimens were collected from different habitats such as moist damp walls, ponds, ditches, moist soil, etc., in specimen bottles with the help of scalpel, blade, plankton net, forcep etc. The specimens were preserved in 2% formaldehyde in sterilized bottles. During the time of observation, a small amount was taken on microscopic slide (stain added if necessary) and mounted 2% glycerin, covered with cover slip and studied under microscope. In order to seal permanently, DPX or transparent nail paint is used. The magnification taken is

15*x* *X* 40*x* *(High power)* = 600*x* magnification. Measurements and photographs were done of the cell for identification.

The cyanobacteria were identified following the monographs and keys of Prescott (1951), Desikachary (1959) and Anand (1990). Laboratories of USTM were used during this research. Fritsch classification (1935) has been followed in arrangement of classes, families, orders and genus. However, in arranging the genera and species, alphabetical orders have been followed. Slides and bottle specimens have been preserved at Department of Botany, University of Science And Technology, Meghalaya, Ri-Bhoi district.

RESULT AND DISCUSSION

Total of 45 Cyanobacteria under 18 genera were recorded (Table 1) Among them genus *Oscillatoria* consisted of 12 species, *Chroococcus* of 7 species, *Scytonema* of 4 species, *Phormidium* of 3 species, *Aphanocapsa*, *Gleocapsa*, *Merismopedia*, *Lyngbya* and *Myxosarcina* of 2 species lastly *Gomphosphaeria*, *Spirulina*, *Anabaena*, *Aulosira*, *Nostoc*, *Homeothrix*, *Calothrix*, *Mastigocladus and Hapalosiphon* of 1 species. In case of order, Nostocales with highest number of 27 taxa followed by Chroococcales with 14 taxa (are shown in figure 1). Maximum species found belongs to family Oscillatoriaceae (19 species) followed by Chroococcaceae (14 species), Scytonemataceae (4 species), Rivulariaceae (2 species), Nostocaceae (2 species), Pleurocapsaceae (2 species) and Mastigocladaceae, Stigonemataceae both having 1 species (figure 2). Seasonal variation shown in figure 3 found autumn 19 with highest number of species and winter 3 with least number of species (figure 3). Highest number of species is mostly found in damp and moist wall habitat with 15 numbers of species followed by lithophytes with 10 species (figure 4). Due to early monsoon, BGA dominates the other algae. From the study, it is found that Cyanobacteria are highly rich in diversity of Kling area, Ri-Bhoi district, Meghalaya.

Table 1: Frequency distribution of algal species.

Sl. No.	Name of Genus	No. of species found	Relative frequency of species (%)
1	*Aphanocapsa*	2	2.22
2	*Chroococcus*	7	7.77
3	*Gleocapsa*	2	2.22
4	*Merismopedia*	2	2.22
5	*Gomphosphaeria*	1	1.11
6	*Myxosarcina*	2	2.22
7	*Lyngbya*	2	2.22
8	*Oscillatoria*	12	13.33
9	*Phormidium*	3	3.33
10	*Spirulina*	1	1.11
11	*Anabaena*	1	1.11
12	*Aulosira*	1	1.11
13	*Nostoc*	1	1.11
14	*Scytonema*	4	4.44
15	*Homeothrix*	1	1.11
16	Calothrix	1	1.11
17	*Mastigocladus*	1	1.11
18	*Hapalosiphon*	1	1.11

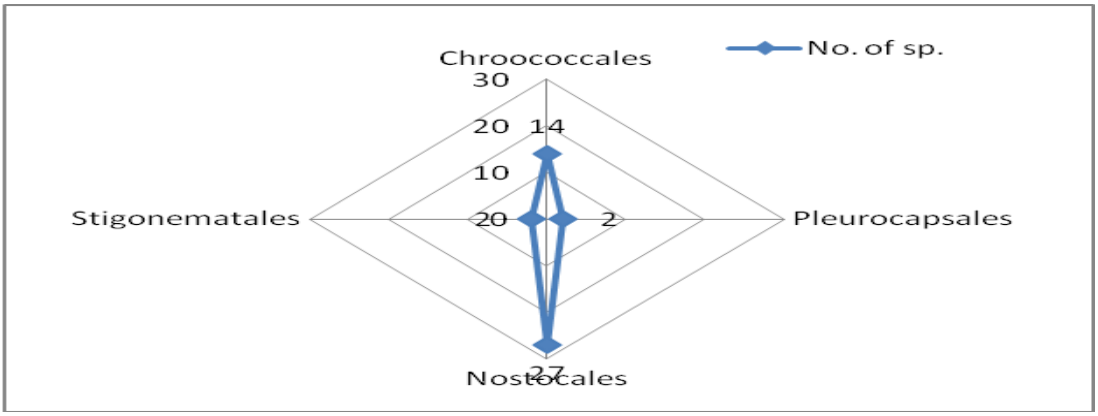


Figure 1: Number of species per order of cyanobacteria found in the study area.

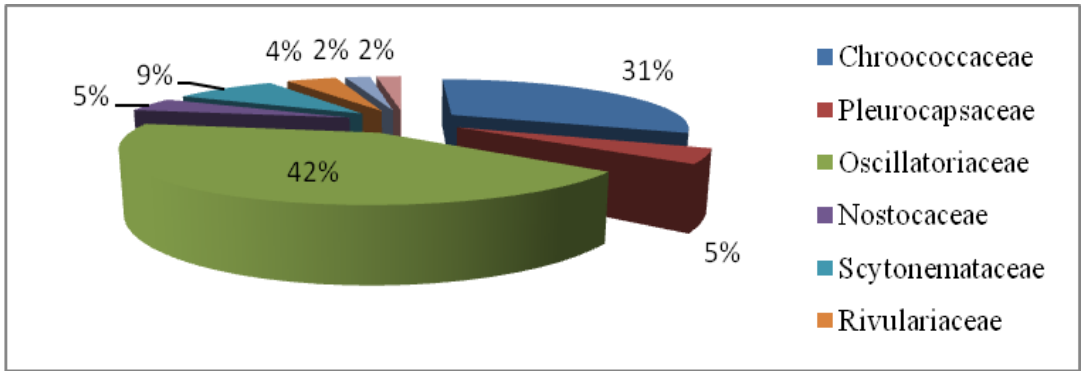


Figure 2. Number of species per family of cyanobacteria found in the study area.

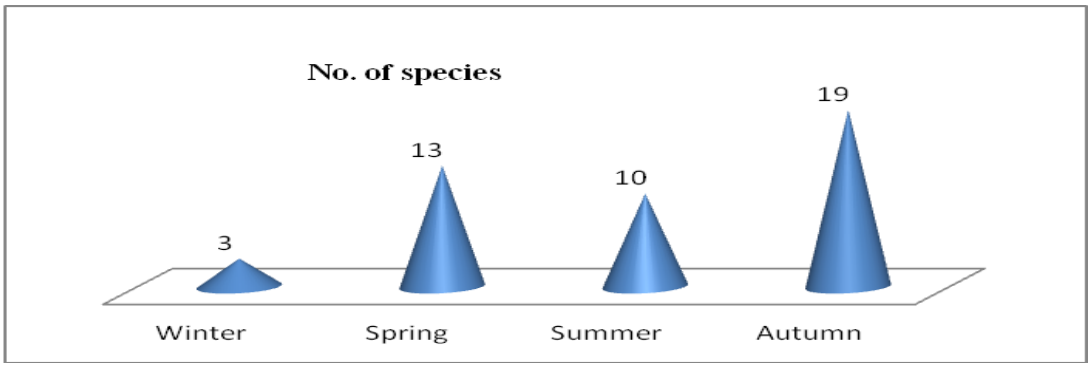


Figure 3. Seasonal variation of cyanobacterial species in the study area.

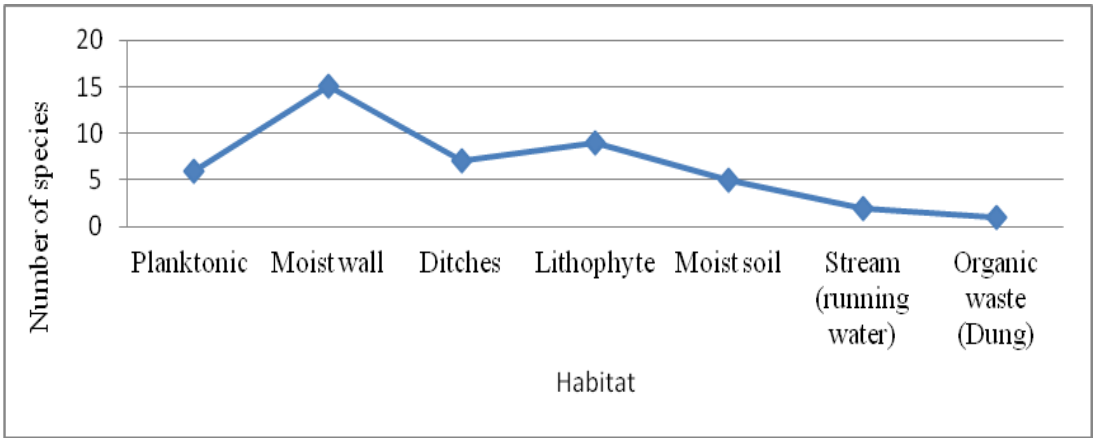
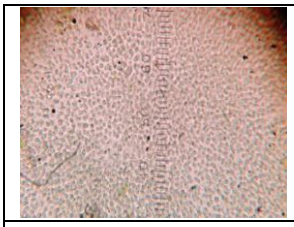
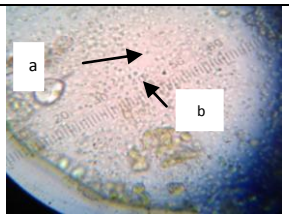
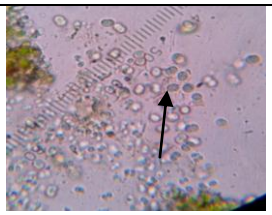
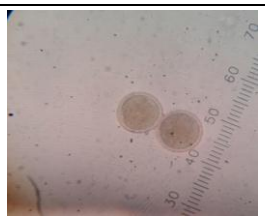
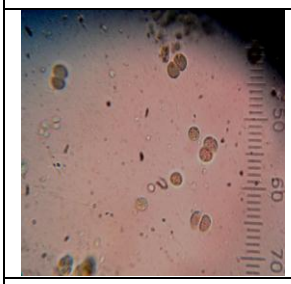
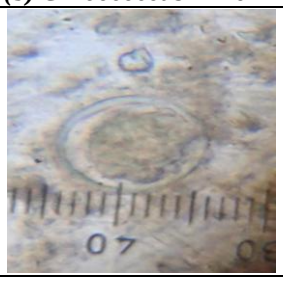
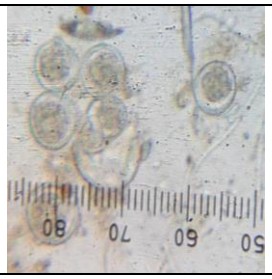
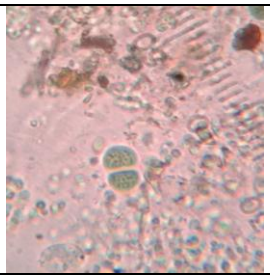
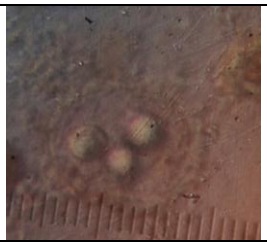
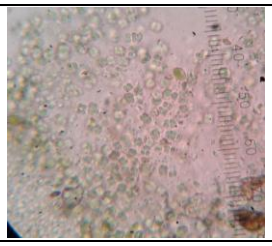
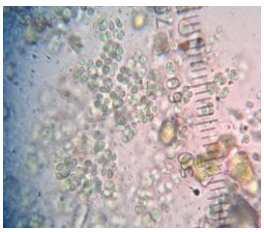
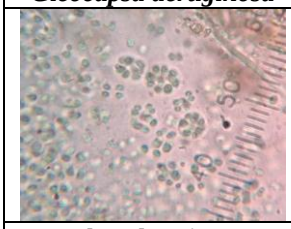
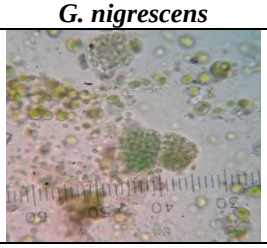
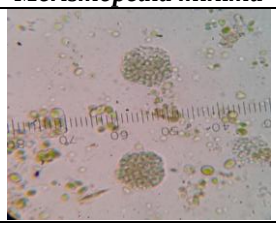
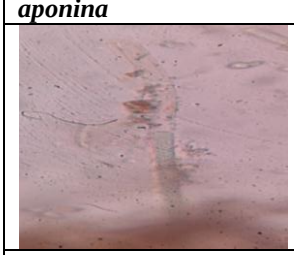
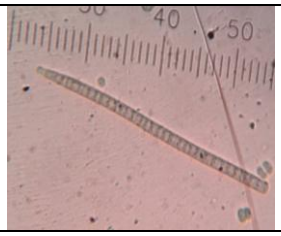
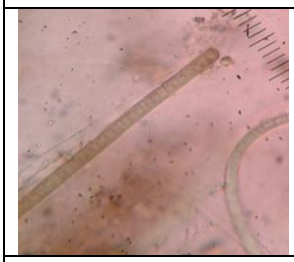
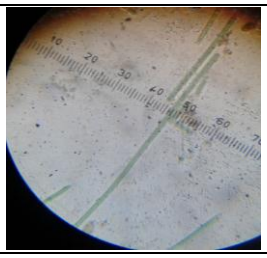
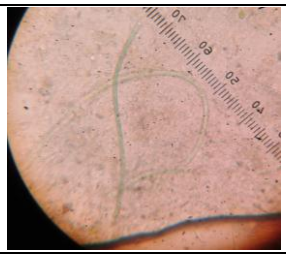
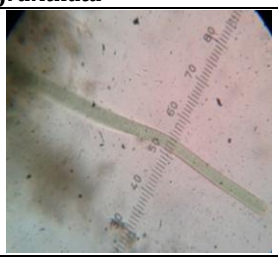


Figure 4: Number of cyanobacteria collected from different habitat of the study sites.

Table 2: Physico-chemical characteristics of the habitats.

Habitat	pH	Temperature (°C)	Conduct(ms)	BOD	DO
Planktonic	6.5-7.2	21.3-28.3	297-1034	20.0-70.0	5.6- 5.9
Moist wall	6.2-7.3	25.6-28.1	-	-	-
Ditches	6.8-7.3	23-26	-	-	-
Lithophyte	6.3	26.6	-	-	-
Moist soil	6.4-7.2	18-28.0	-	-	-
Stream (running water)	6.5	26.6-28.0	-	8.0	5.9
Organic waste (Dung)	6.32	28.5	-	-	-

			
Aphanocapsa montana	***(a)A. muscicola & (b) Chroococcus minor***	***Chroococcus minutus***	***C. turgidus***
			
C. indicus	***C. macrococcus***	***C. tenax***	***C. turgidus var. solitarius***
			
Gleocapsa aeruginosa	***G. nigrescens***	***Merismopedia minima***	***M. tenuissima***
			
Gomphosphaeria aponina	***Myxosarcina burmensis***	***M. spectabilis***	***Lyngbya aerugineo-coerulea***
			
L. gracilis	***Oscillatoria angusta***	***O. amoena***	***O. amoena var. non-granulata***
			
O. curviceps	***O. curviceps var.angusta***	***O. jasorvensis***	***O. limosa***

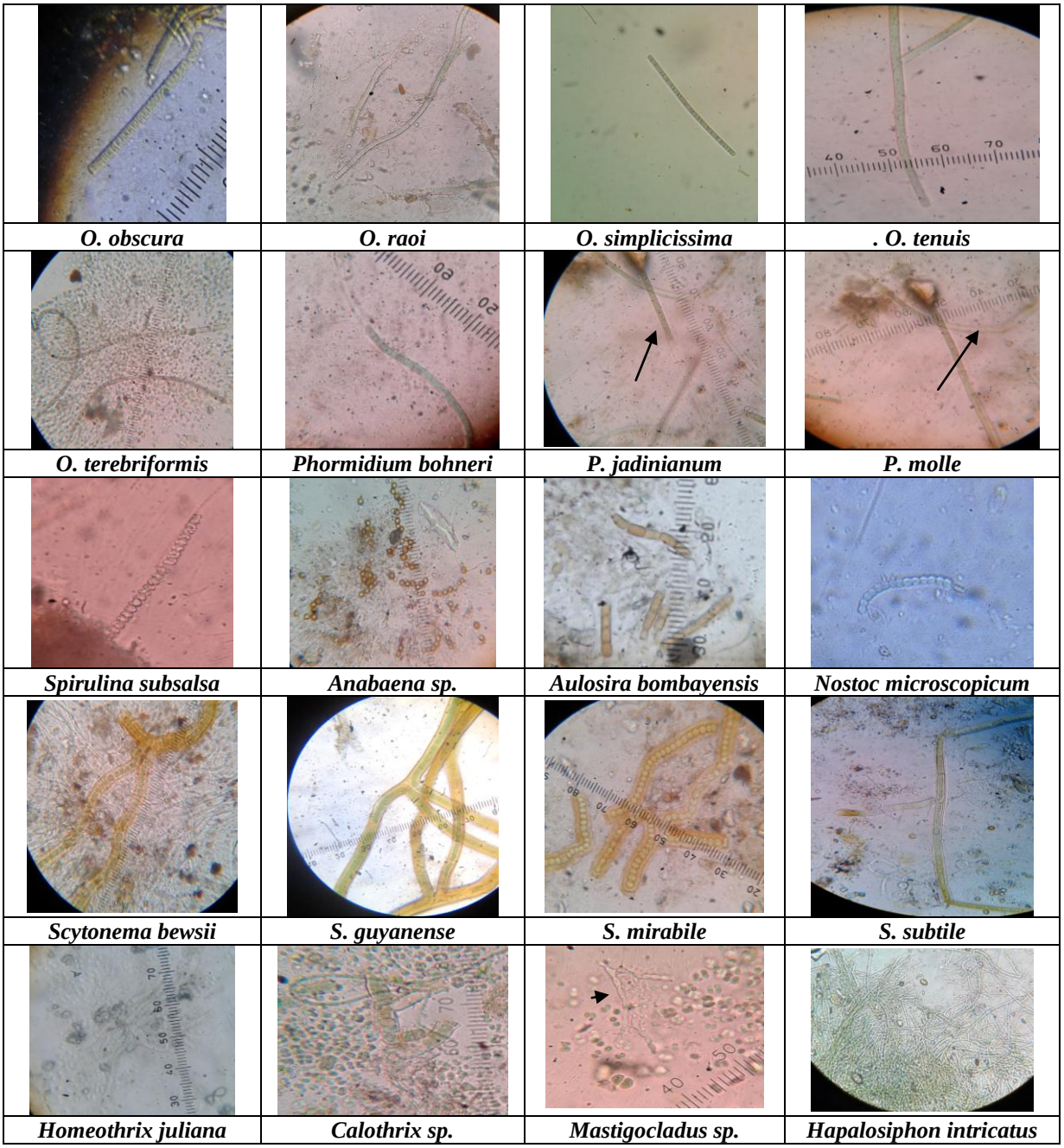


Figure 5: Photomicrographs of the cyanobacteria found in Kling area, Ri-Bhoi district.

Species and Habitat characteristics

***Aphanocapsa montana* Cramer**

Thallus of no definite shape, gelatinous, blue-green; cells 2.1-3 µm diam., light blue green, single. Habitat- Planktonic.

***A. muscicola* (Menegh.) Wille**

Colony microscopic; cells spherical 3µm diam., blue-green, 2-4 together. Habitat- Damp and moist wall.

Chroococcus minutes (Kütz) Nag

Cells pale green or brownish in colour. Cells broad 4.5µm and length 15µm. Habitat- Attached to ditches wall.

***C. turgidus* (Kutz.) Nag**

Cells single, each cell diam. 22.5µm and 24µm, together in total 54µm. Not lamellated, lamellae distinct. Habitat- Moist and damp rocks.

***C. indicus* Zeller**

Thallus gelatinous, thin, pale brownish; cells single oblong to sub spherical, 4.5µm breadth, 9.6µm long, greenish; sheath hyaline contents granular. Habitat- Attached to ditches wall.

***C. macrococcus* (Kutz.) Rabenh**

Thallus mucilaginous, somewhat broad, yellowish-brown, more or less dilated; cells spherical, 2-4 together, also single, 21µm diam., with sheath 36µm diam.; sheath

thick, colourless, lamellated. Habitat- Attached to rocks on slightly running water.

***C. tenax(*Kirchner*)* Hieronymus**
Cells spherical single, very seldom many, blue-green, without sheath 15µm diam., with sheath 21µm diam., sheath colourless, not distinctly lamellated. Habitat- Attached to rocks on slightly running water.

***C. turgidus Var. solitarius* Ghose**
Cells single globose-ellipsoid, bright blue green, with sheath 12 µm broad, 18µm long and without sheath 9µm broad, 6µm long; sheath thick, colourless, lamellated. Habitat- Damp and moist wall.

C. minor (Kütz.) Näg.
Thallus slimy gelatinous, dirty blue green; cells spherical 3µm in diam., in pairs; sheath colourless, hardly visible. Habitat- Damp and moist wall.

***Gleocapsa aeruġinosa* (Carm.) Kütz.**
Thallus crustaceous, granulose, mucilaginous, cells 2-3µm broad and with sheath 4.8µm broad; colonies spherical, 27µm diam., sheath indistinctly lamellated. Habitat- Moist and damp rocks.

***G. niġrescens* Näg**
Thallus crustaceous, thin, blackish; cells spherical, without sheath 6µm diam., and with sheath 10.5µm diam., contents blue-green. Habitat- attached to ditches wall.

***Merismopedia minima* Beck**
Cells pale blue green 4 to many in small colonies, 0.6µm broad, free swimming groups of four cells 4-6; colonies size 6µm broad and 5.4µm length. Habitat- Attached to ditches wall.

***M. tenuissima* Lemm.**
Cells pale blue-green, closely packed in colonies of 16-100 cells, subspherical, 1.5µm broad, sometimes individual cells with distinct mucilaginous envelopes. Habitat- Damp and moist wall.

***Gomphosphaeria aponina* Kütz.**
Cells pyriform, cordate at longitudinal cell division, 5.4µm long and 3µm broad, blue green to olive green, mostly with a distinct mucilaginous envelope, placed at the ends of regularly dichotomously branched radial mucilaginous stalks. Habitat- Damp and moist wall.

***Myxosarcina burmensis* Skuja**
Plants aquatic, minute, microscopic, rounded, sarcinoid; cells more or less, angular, often arranged in transverse, 3µm diam., pale blue-green, finely granular; individual sheaths thin, mucilaginous, hyaline; young colonies of four cells of about 25.5µm broad and 33µm long. Habitat- Attached to ditches wall.

***M. spectabilis* Geitler**
Cells in three dimensional colonies, 5.7µ broad; colonial sheath thin, distinct, hyaline, individual sheaths occasionally present, thin and hyaline; cell contents blue-green; endospores. Habitat- Attached to ditches wall.

***Lyngbya aerugineo-coerulea* (Kütz) Gomont**
Filaments single, intermixed with other algae, 7.5µm broad; sheath colourless, thin; trichome 6.5µm broad and 4.5µm long, unconstricted, dull blue-green; cross wall granulated; end cell flattened. Habitat- Moist and damp rocks.

***L. gracilis* (Menegh.) Rabenh.**
Thallus purplish violet; sheath thin, smooth; trichome constricted at the cross walls, 7.5µm broad, at the apex not attenuated; cells 1-½ times long as broad, 9 µm long, end cell rounded. Habitat-Planktonic.

***Oscillatoria angusta* Koppe**
Trichome colourless, 1.5µm broad, not constricted at the cross walls, at the ends rounded, straight; cells 5.4µm long, without gas vacuoles. Habitat- Moist and damp soil.

***O. amoena* (Kütz) Gomont**
Thallus more or less blue green; trichomes straight, slightly constricted at the cross walls, ends gradually attenuated, 3.6µm broad; cells nearly as long as broad, 3µm long, septa granulated, end cells capitates, broadly conical with calyptra. Habitat- Damp and moist wall.

***O. amoena(*Kutz.*) Var. non granulate* Ghose**
Stratum less blue green; trichome straight, flexible not constricted at the cross walls, occasionally constricted at the apices, 3 µm thick at the tip, cell 6 µm broad; 4.5 µm longer, cross walls not granulated, gradually attenuated at the apices, straight or slightly bent; end cell globose capitates with calyptra. Habitat- Damp wall.

***O. curviceps* Ag. ex Gomont**
Thallus light blue-green; trichomes more or less straight, bent at the end, not attenuated, not constricted at the cross walls, 9µm broad, cells 6µm long; end cells flat rounded, not capitate. Habitat- Moist soil

***O. curviceps Var. angusta* Ghose**
Trichome 9µm broad, cells 6µm long; capitate present. Habitat- Planktonic.

***O. jasorvensis* Vouk.**
Thallus pale blue-green, bent in the middle, 3µm broad, not attenuated, not capitates; cells as long as broad; end cells rounded, without calyptras. Habitat- Damp wall.

***O. limosa* Ag. ex Gomont.**
Thallus dark blue green; trichome straight, dull blue green, slightly constricted at the cross walls, 12µm broad and cells ⅓–⅙ as long as broad, 6µm long, cross walls

granulated; and cell flatly rounded with slightly thickened membrane. Habitat-Planktonic.

***O. obscura* Bruhl *et* Biswas**
Plate no. VIII; Fig. 69; Trichome about 3µm broad, attenuated at the apex, rounded, nearly straight, blue green, cells 0.6µm long, cross walls granulated and not constricted. Habitat- Moist and damp soil; Month- October; pH- 6.4; Temp- 28°C Ray7; Kling area.

***O. raoi* De Toni, J.**
Plant mass thin, membranous, pale blue green; trichome straight usually of uniform thickness, slightly constricted at the joint, 7.5µm broad, septa in distinct but with distinct granules closely arranged on either side; cells 6µm long, with homogenous contents, end cells rounded, not capitates, without any calyptra. Habitat-Planktonic.

***O. simplicissima* Gomont**
Thallus dark blue-green; trichome straight, not constricted at the cross walls, yellowish blue green, 7.5µm broad, not attenuated at the apices, not capitates; 5.5µm long, septa not granulated, end cells hemispherical, with a slightly thickened membrane. Habitat- Found on cow dung.

***O. tenuis* Ag. ex Gomont**
Thallus thin blue green, slimy, trichome straight, fragile slightly constricted at the cross walls, 7.5µm broad, blue green, sometimes bent at the ends, not attenuated at the apices, not capitate; cells upto ⅓ as long as broad 6µm long, at the septa mostly granulated; end cell hemispherical with thickened outer membrane. Habitat- Planktonic.

***O. terebriformis* Ag. ex Gomont**
Thallus dull blue; trichome end bent in a screw like manner, and slightly attenuated, unconstricted at the cross walls 4-6.5µm broad, 2.5-6µm long; end cell rounded, not capitate, calyptra absent. Habitat- Damp wall.

***Phormidium bohneri* Schmidle**
Trichome nearly straight, not constricted at the cross walls, 3µm broad, not attenuated at the ends, not capitate, blue green; sheath hyaline, cells not longer than broad, 3µm long, end cell rounded. Habitat- attached to ditches wall.

***P. jadinianum* Gomont**
Thallus dark green, thin, amorphous; filaments less parallel; sheath thin, not coloured; trichome olive-green, distinctly constricted at the cross walls, with straight long acuminated ends, 6µm broad; cells shorter than broad to nearly quadrate, 3µm long, contents granulated with a hyaline central area, septa not granulated; end cell acute conical, calyptra absent. Habitat- Damp wall.

***P. molle* (Kütz) Gomont**
Thallus mucilaginous, thin, light blue green, sheath more or less diffluent, colourless 4.5µm broad; trichome nearly straight, distinctly constricted at the cross walls, not attenuated at the ends; cells 3µm broad; cells quadrate, 5.4µm long, end cell rounded, calyptra absent. Habitat- Damp wall.

***Spirulina subsalsa* Oerst. ex Gomont.**
Trichomes 1.5µm broad, blue-green, mostly regularly spirally coiled, forming a bright blue-green, single among other algae, spirals very close to each other, 4.5µm broad. Habitat- Lithophyceae, under substratum level; Month- September.

Anabaena sp.
Trichomes moniliform, 6µm broad; cell spherical mostly, end cells rounded; cell wall are probably orange-yellowish colour. Habitat- Moist and damp rocks.

***Aulosira bombayensis* Gonzalves**
Filaments free, uniformly broad; trichome with sheath 2.4µm; heterocysts intercalary 6µm; cells broad 7.5µm, 10.5µm. Habitat- Moist and damp rocks.

***Nostoc microscopicum* Carm. ex Born. et Flah.**
Thallus spherical, soft, but with a firm outer surface; filaments loosely entangled; sheath less distinct; trichomes 7.5µm broad, blue-green; cells barrel shaped. Habitat-Damp wall.

***Scytonema bewsii* Fritsch et Rich**
Filaments intermingled with other algae, well branched, 15-18µm broad; false branches germinate, mostly abutting on one another; sheath thick, yellowish brown, lamellation parallel,slight divergent; cells 6µm broad, long cylindrical, not constricted at the cross walls; heterocysts 6µm broad and 9µm long. Habitat- Moist and damp rocks.

***S. guyanense* (Mont.) Bornet *et* Flahault**
Thallus expanded like a cushion, 1-2µm thick, blackish green, grown alongwith mosses, filaments 18µm broad, united in bundles; false branches long, bent, united at the base, sheath firm, lamellated, yellowish-brown, sheath 6µm broad; trichome 12µm longer; heterocyst 12µm broad and 15 µm longer. Habitat-Moist soil.

***S. mirabile* (Dillw) Born.**
Thallus expanded spongy, more or less blue-green; filament intricate, 21µm broad, mostly false branched; sheath lamellated with slightly divergent lamellation, sheath 12µm, yellowish-brown, outside colourless or slightly gelatinous; trichome 9µm broad, 8µm long, olive green, cells cylindrical, at the ends discoid, heterocyst nearly quadratic or longer than broad, 9µm broad and 12µm long, brownish. Habitat- Attached to moist stone.

***S. subtile* Möbius**
Filaments single, intermingled sparsely among other algae, 12µm broad; false branches germinate, generally narrower than the main filament; sheath colourless, with parallel lamellation; trichome 3µm broad; cells 3 times as long as broad, cylindrical, 9µm long; heterocysts oblong, 6µm broad and 12µm long. Habitat- Attached to moist stone.

***Homeothrix juliana* (Menegh) Kirchnn.**
Filaments many together forming a olive coloured thallus, erect, rigid, unbranched, 10.5µm broad, thickened at the base; sheath thin, close to the trichome, colourless, not lamellated; trichomes 9µm broad; cells discoid, 6µm long, ⅓ as long as broad. Habitat- Attaches to moist walls.

***Calothrix brevissima* West, G.S.**
Filaments single, caespitose; filaments broad, 9µm broad, 30µm long and filaments arranged less parallel, mostly erect, false-branched; sheath firm; trichome attenuated, trichome broad 7.5µm and 6µm long. Habitat- Damp and moist wall.

Mastigocladus sp.
3µm broad and 6µm long, filaments with a single series of cells with reverse 'V' shaped short branches arising on one side, 3µm broad and 4.5µm long, true lateral branching, sheath thin, heterocysts spherical, small than the actual size, i.e., 0.9µm diam., hormogones not known. Habitat- Damp and moist wall.

***Hapalosiphon intricatus* W. *et.* G.S West**
Thallus caespitose, blue-green, small, filament densely interwoven, sparsely branched, 6µm broad; sheath close to the trichome, colourless often indistinct; cells spherical to cylindrical, 1½ times as long as broad, 6µm longer; heterocyst intercalary, subquadrate; spores spherical to ellipsoidal, seldom nearly cylindrical. Habitat- Moist soil.

CONCLUSION

Rich in Cyanobacterial diversity in the study area can be exploited in the yield of different crop cultivation. Though Algal diversities are natural occurrences, however, it depends on water conditions of the particular habitat. Normally rich in diversity is found where there are high levels of nutrients present, together with the occurrence of favorable environmental conditions. However, due different factors their diversity is on risk. So, it is essential to conserve algal resources and local habitat.

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