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Freshwater algae of Cherrapunjee and Mawsynram, the wettest places on earth

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Abstract

Cherrapunjee and Mawsynram in Meghalaya state in the north eastern region of India receive excessive rainfall which is second highest in the world hence regarded as one of the "Wettest places on Earth". Several perennial lentic and lotic water bodies are found in the area however, the algal species occurring there-in has not yet been surveyed. A total of 48 algal taxa belonging to Cyanophyta (6), Chlorophyta (26), Euglenophyta (1) and Heterokontophyta (15) were recorded from these water bodies.

Key words - Algae, Freshwater, Systematic enumeration, Wettest places

Introduction

Cherrapunjee and Mawsynram are located in the Meghalayan plateau region, close to Indo-Burma biodiversity hotspot. As the annual average rainfall of 11,820 to 11,872 mm at these locations is second highest in the world, a bountiful of perennial water bodies are found in this region. The algal diversity in the water bodies of such an ecologically important habitat is still unexplored. There are only five earlier records on algae belonging to Cyanophyta (Cyanoprokaryota/Cyanobacteria) on the moist soil surfaces and rice fields of the area. Biswas (1934) reported two species of *Lyngbya* and one species each of *Spirulina*, *Schizothrix*, *Scytonema* and *Stigonema* from moist soils of Khasi and Jaintia hills of the region. Parukutty (1939) reported *Oscillatoria variabilis* C.B. Rao from the soil surface of the locality. Reddy *et al*. (1986) documented two species of *Nostoc* and one species of *Cylindrospermum* from the rice fields and *Stigonema dendroideum* Frémy from the moist soils of Cherrapunjee. Oinam *et al.* (2010) and Devi *et al.* (2010) recorded five cyanophytes, e.g. *Anabaena doliolum* Bharadwaja, *Phormidium tenue* (Menegh.) Gomont, *Oscillatoria laevittae* Buell, *Plectonema nostocorum* Bornet ex Gomont and *Calothrix marchica* Lemmerm. from the soil surfaces of the area. No other algal taxa belonging to other division of algae has been recorded yet from the water bodies of these wettest places. In the present work the algal taxa occurring in the water bodies of Cherrapunjee and Mawsynram were documented for the first time.

Materials and methods

Study sites

Cherrapunjee (25°15' N, 91°44' E) is a small town located in the East Khasi hills district of Meghalaya at an altitude of 1484 m above mean sea level and at a distance of 59 km from Shillong, the capital of the state (Figure 1). It receives an average annual rain fall of 11,820 mm, hence regarded as the 'wettest place on earth' along with its neighboring village Mawsynram (25°18' N, 91°35' E) 16 km west to Cherrapunjee, with annual average rainfall of 11,872 mm. The National Oceanic and Atmospheric Administration (NOAA), United States of America also documented these localities as the "wettest place" receiving annual rainfall next to Lloro of Columbia.

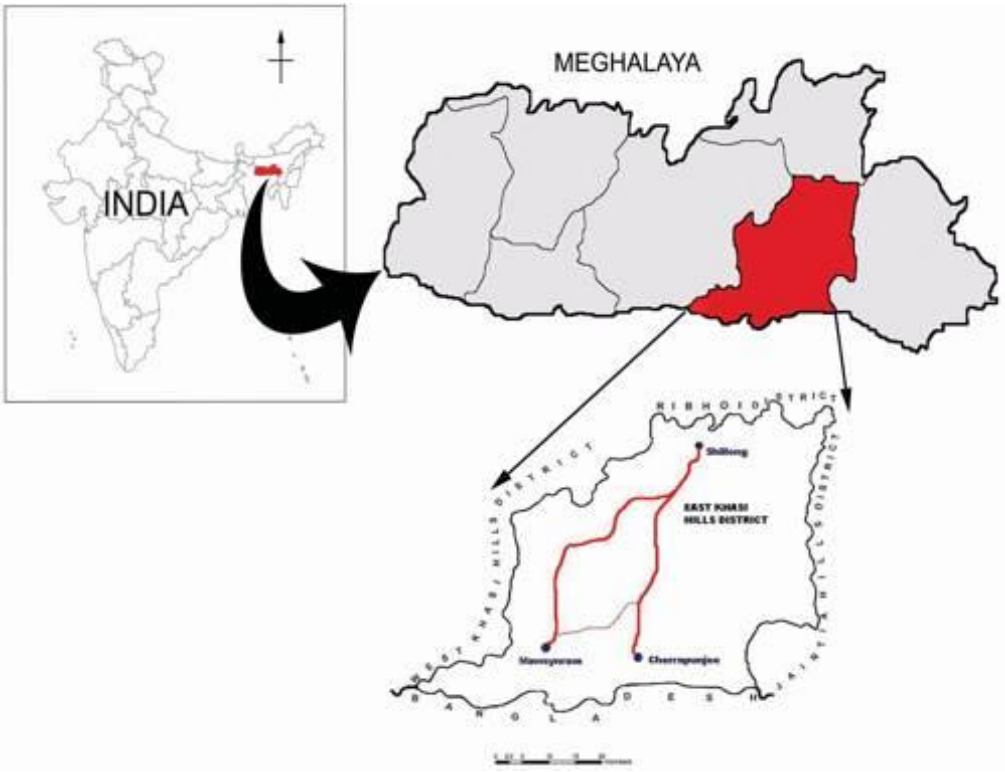

Figure 1: Location map of Cherrapunjee and Mawsynram in the East Khasi Hills district in Meghalaya state of India.

Geographically, Cherrapunjee and Mawsynram are located in the southern part of Meghalayan plateau, close to the Indo-Bangladesh border. Though subtropical forest was the characteristic feature of the region, in recent years extensive deforestation leads to loss of canopy cover resulting in soil erosion due to heavy rain fall in the area. Hence, grassland vegetation is found in most of these places and large trees are now only confined to protected sacred forests. The climate of this region remains almost dry during the winter (November – February) but daily rainfall is observed in rest of the eight months.

Collection and study of algal samples

A total of 31 samples were collected from five different freshwater bodies at Cherrapunjee and Mawsynram during September, 2010 soon after monsoon when maximum rain fall occurs (Figure 2). Geographical position, altitude and physic-chemical parameters like, temperature, pH, conductivity and transparency (by sachhi disc) were measured on the spot (Table 1). Each sample was assigned with voucher number, preserved in formaldehyde (4 %, v/v) and deposited at the Department of Biotechnology, Visva Bharati, Santiniketan, India. Microphotograph of each specimen was taken using an Olympus epifluoroscence microscope BX - 41 fitted with Nikon Coolpix 4500 digital camera. The organisms were identified by following the monographs of Kützing (1865), West and West (1897, 1904, 1905), Huber-Pestalozii (1942), Desikachary (1959), Ramanathan (1964), Philipose (1967), Gonzalves (1981), Krammer and Lange-Bertalot (1986, 1988), Ettl and Gärtner (1995), Krammer (2003), Komárek and Anagnostidis (2005), Wołowski and Hindák (2005), Komárek (2013) and research publications e.g. Iyengar and Vimala Bai (1941), Prescott (1961), Prasad and Misra (1992), Cox (1996), Kant and Gupta (1998), Misra and Srivastava (2003).

Table 1 – Geographical position, altitude and physico-chemical parameters like, temperature, pH, conductivity and transparency of the water bodies of different collection sites of Cherrapunjee & Mawsynram

Sites (S)	Water bodies	Longitude	Latitude	Altitude (m)	Temperature (°C)	pH	Conductivity (µS)	Transparency (m)
S1	Seven Sister waterfall, Cherrapunjee	25°14'40.7" N	91°44'18.3" E	1333	24	6.0	029	NA
S2	Stream 1, Mawsynram	25°15'37.3" N	91°43'21.4" E	1458	25	6.5	027	0.4
S3	Pond, Cherrapunjee	25°16'33.9" N	91°41'30.6" E	1333	22	5.8	018	0.9
S4	Nohkalikai waterfall, Cherrapunjee	25°16'17.5" N	91°41'23.8" E	1318	22	5.5	021	NA
S5	Mawsynram waterfall	25°19'11.8" N	91°35'52.3" E	1568	20	6.0	027	NA

NA: Not Available (Transparency of the water falls cannot be recorded due to shallowness)

Figure 2: Photograph of the sampling sites at Cherrapunjee: A. Nohkalikai fall, B. Seven Sister's fall, C and D. Stream near Sohra, E. Fish pond and F. Waterfall in Mawsynram .

Results and discussion

A total of forty eight algal taxa were recorded from five different water bodies of Cherrapunjee and Mawsynram in the state Meghalaya. These belonged to Cyanophyta (6), Chlorophyta (26), Euglenophyta (1) and class Bacillariophyceae under Heterokontophyta (15). They mostly occur as planktonic or as epilith of the submerged stones inside the water. All these taxa were arranged systematically along with their respective place of collection, mode of occurrence and voucher number. The Cyanophyta/Cyanoprokaryota taxa were enumerated systematically as per the classification of Komárek and Anagnostidis (1989, 2005). For algal taxa belonging to Chlorophyta, Euglenophyta, Heterokontophyta the classification of Lee (1999) was followed. Microscopic photograph of all the recorded taxa is given in Figure 3 – 5.

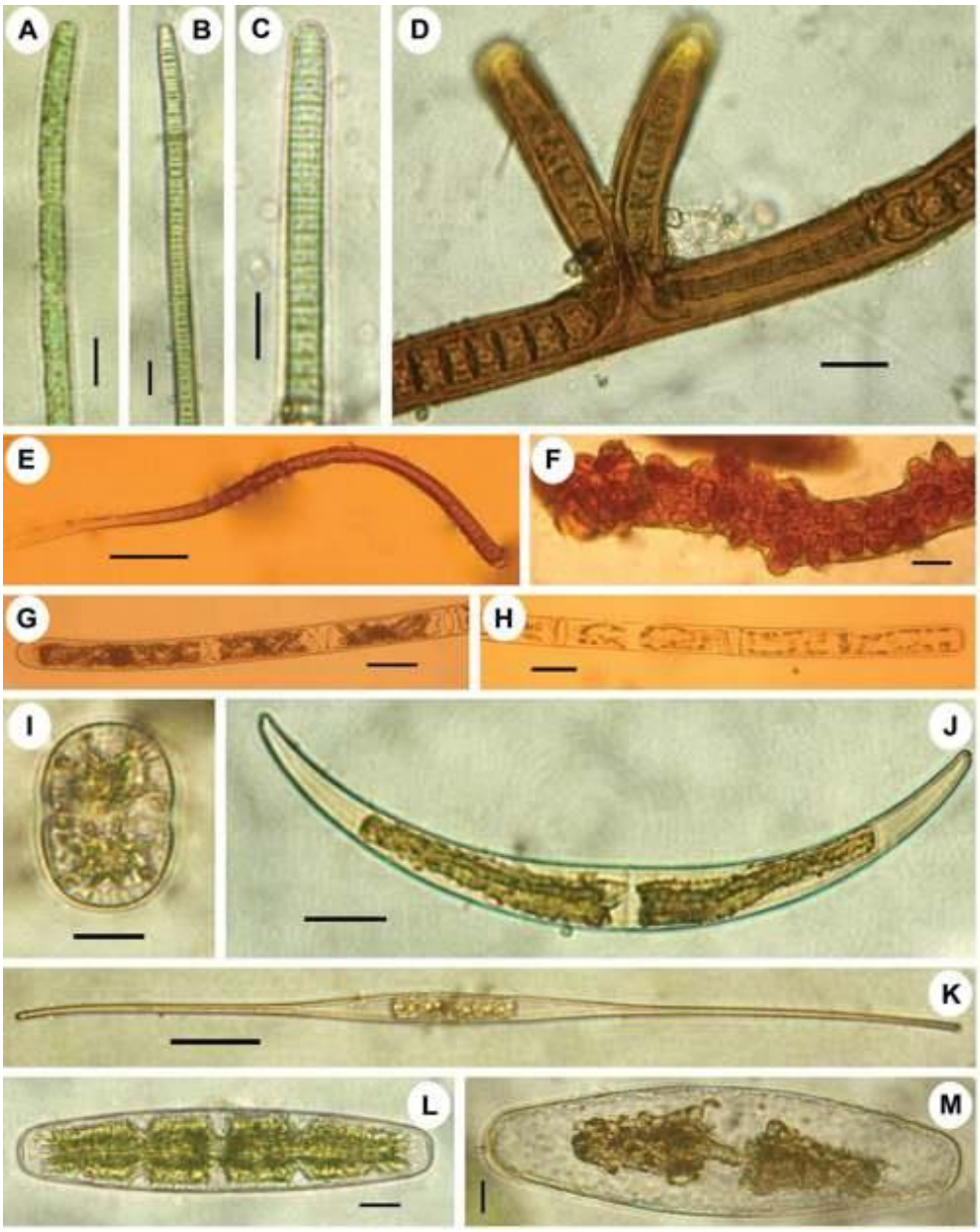

FIGURE 3: A. *Phormidium chlorinum*, B. *Oscillatoria jenensis*, C. *Oscillatoria limosa*, D. *Scytonema ocellatum*, E. *Calothrix marchica* var. *crassa*, F. *Stigonema minutum*, G. *Spirogyra* sp. 1, H. *Spirogyra* sp. 2, I. *Cylindrocystis subpyramidata*, J. *Closterium calosporum*, K. *Closterium kützingii*, L. *Closterium libellula* var. *pulneyensis*, M. *Closterium navicula* (Scale: Figure E, G – H = 50 μm; Figure D, F, J – K = 20 μm; Figure A – C, I, L – M = 10 μm)

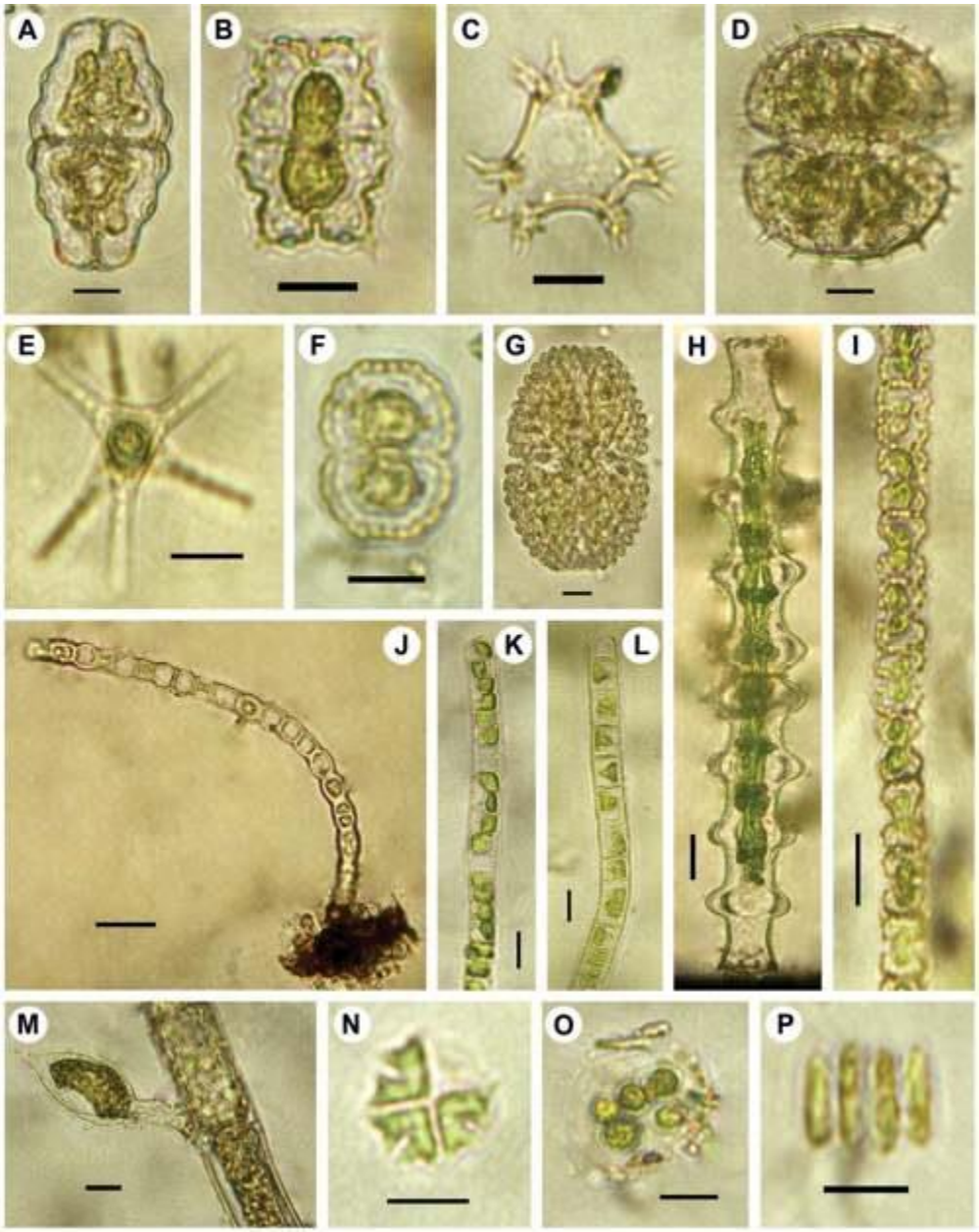

FIGURE 4: A. *Euastrum ansatum* f. *pyxidatum*, B. *Euastrum dubium*, C. *Staurastrum egregium*, D. *Staurastrum gladiosum*, E. *Staurastrum gracile*, F. *Cosmarium awadhense*, G. *Cosmarium decoratum*, H. *Pleurotaenium kayei*, I. *Spondylosium nitens* f. *major*, J. *Binuclearia tectorum*, K. *Hormidiospora verrucosa*, L. *Hormidium subtile*, M. *Characium acuminatum*, N. *Pediastrum tetras* var. *tetraodon*, O. *Planktosphaeria gelatinosa*, P. *Scenedesmus bijugatus* (Scale: Figure H = 20 μm; Figure A – G, I – P = 10 μm)

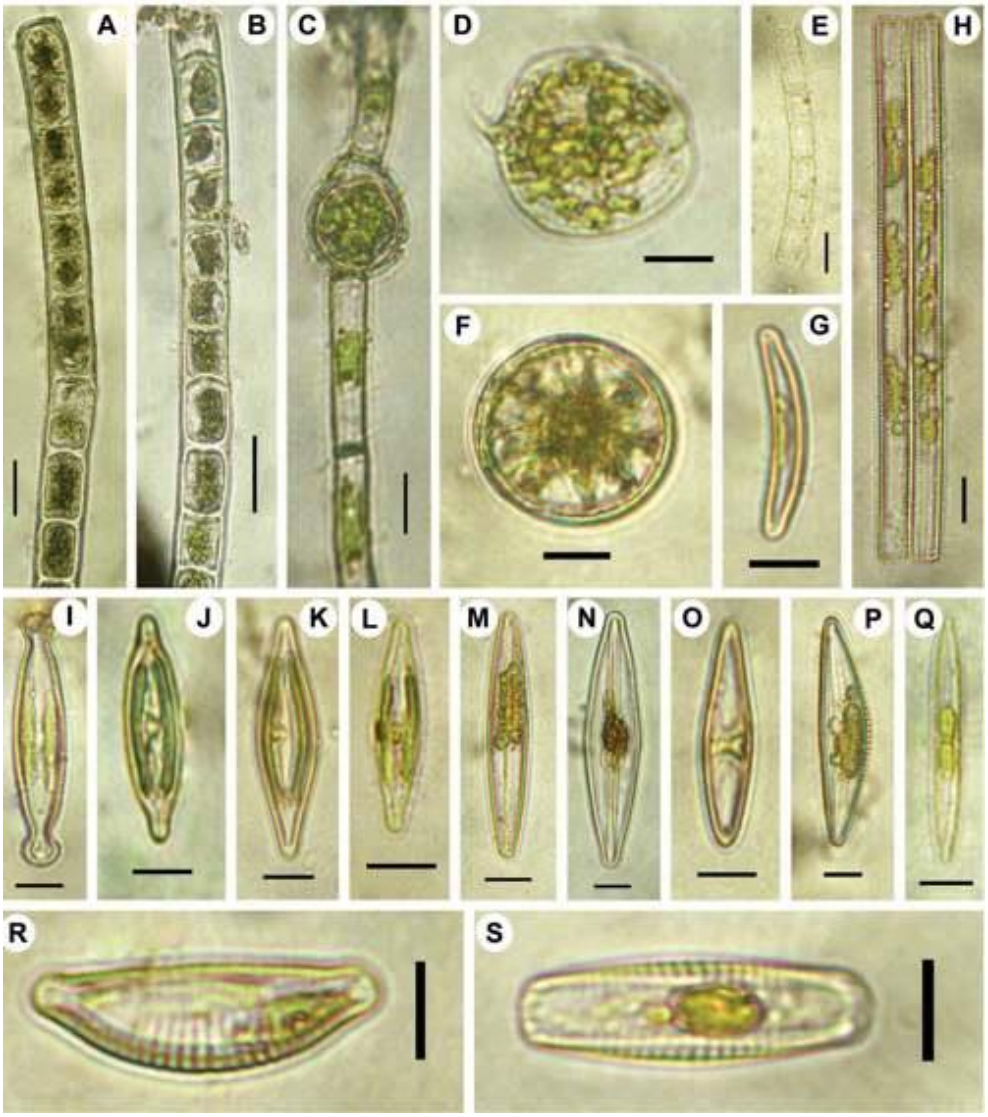

FIGURE 5: A. *Microspora indica*, B. *Microspora pachyderma*, C. *Oedogonium globosum* D. *Phacus pleuronectes*, E. *Aulacoseira granulata*, F. *Cyclotella meneghiana*, G. *Synedra cyclopum* var. *robustum*, H. *Synedra ulna* var. *amphirhynchus*, I. *Pinnularia viridis*, J. *Navicula amphirhynchus*, K. *Navicula microspora*, L. *Navicula tripunctata*, M. *Navicula viridula*, N. *Navicula cuspidata*, O. *Gomphonema augur* var. *sphaerophorum*, P. *Cymbella affinis*, Q. *Nitzschia frustulum*, R. *Cymbopleura inaequalis*, S. *Amphora elleptica* (Scale: Fig. A – B = *20 µm*; Fig. C – S = 10 *µm*)

Systematic enumeration
Phylum – Cyanobacteria
Class – Cyanophyceae
Order – Oscillatoriales
Family – Phormidiaceae
Genus – *Phormidium* Kütz.
1. *Phormidium chlorinum* (Kütz. ex Gomont) Umezaki & M. Watan. (Figure 3 A)
Komárek and Anagnostidis 2005, p. 436, fig. 634
Filaments solitary, no sheath, trichomes straight, 5 *µm* in diameter, cross walls very slightly constricted, cells almost isodiametric, 2 – 4 *µm* long, apical cell broadly rounded.
Planktonic in S1 (voucher no. 2595)

Family- Oscillatoriaceae
Genus- *Oscillatoria* Vaucher
2. *Oscillatoria jenensis* G. Schmid (Figure 3 B)
Komárek and Anagnostidis 2005, p. 590, fig. 882 C
Thallus dark bluish green, trichomes without sheath, cells 18 *μm* broad , 4.5 – 5.5 *μm* long, cell wall thick, filament not constricted, cross walls indistinctly granulated, trichomes shortly attenuated at the ends, hook like bent, 11 *μm* wide near the ends, apical cell convex, rounded, not capitate.
Epilithic in S2 (voucher no. 2605), S5 (voucher no. 2619)
3. *Oscillatoria limosa* C. Agardh ex Gomont (Figure 3 C)
Komárek and Anagnostidis 2005, p. 593, fig. 886
Thallus bluish green, filamentous, unbranched, unsheathed; trichomes straight, not constricted at cross walls, ungranulated, cylindrical, not attenuated; cells broader than long, 1 – 2 *μm* long , 6 – 7 *μm* broad, sometimes with scattered granules, apical cell rounded, not capitate.
Epilithic in S5 (voucher no. 2619)
Order – Nostocales
Family – Scytonemataceae
Genus – *Scytonema* C.Agardh ex Bornet & Flahault
4. *Scytonema ocellatum* (Dillwyn) Lyngb. ex Bornet & Flahault (Figure 3 D)
Komárek 2013, p. 73, fig. 37
Thallus blackish to blackish green in colour, 24 – 25 *μm* broad, short false branches present, cells are shorter than broad, 8 – 9 *μm* long and 14 – 15 *μm* broad, sheath firm, brownish, lamellated, heterocysts quadrate, yellowish in colour, 15 – 16 *μm* in diameter.
Epilithic in S1 (voucher no. 2593)
Family – Rivulariaceae
Genus – *Calothrix* C.Agardh ex Bornet & Flahault
5. *Calothrix marchica* var. *crassa* C.B. Rao (Figure 3 E)
Desikachary 1959, p. 543, pl. 113, figs. 3, 4
Filaments yellowish in colour, 11 *μm* broad, trichome about 377 *μm* long, sheath very thin, almost invisible, cells quadratic at the tail and becomes rectangular towards the apices, 5 – 6 *μm* long, heterocyst basal, subspherical, 5.5 *μm* long and 8.5 *μm* broad.
Epilithic in S1 (voucher no. 2594)
Order – Stigonematales
Family – Stigonemataceae
Genus – *Stigonema* C.Agardh ex Bornet & Flahault
6. *Stigonema minutum* (C.Agardh) Hassall ex Bornet & Flahault (Figure 3 F)
Komárek 2013, p. 620, fig. 739, 744a
Filaments with 2 – 3 rows of cells, yellowish brown in colour, 36 – 40 *μm* broad, cells are globose, 16 – 20 *μm* long and 12 – 14 *μm* broad, sheath thick, homogenous.
Epilithic in S1 (voucher no. 2593)
Phylum - Chlorophyta
Class – Charophyceae
Order – Zygnematales
Family – Zygnemataceae
Genus – *Spirogyra* Link
7. *Spirogyra sp.* 1 (Figure 3 G)
Filaments are straight, cells are 115 – 150 *μm* long and 30 *μm* broad, chloroplasts spirally arranged, 3 numbers of chloroplasts present making 4 – 5 coils.
Floating in S1 (voucher no. 2590)
8. *Spirogyra sp.* 2 (Figure 3 H)
Filaments are straight, stout, cells are 110 – 190 *μm* long and 24 *μm* broad, chloroplasts spirally arranged, 3 numbers of chloroplasts present making 3 – 4 coils.
Floating in S2 (voucher no. 2607)
Family – Mesotaeniaceae
Genus – *Cylindrocystis* Menegh. ex De Bary

9. *Cylindrocystis subpyramidata* W. & G.S. West (Figure 3 I)
Prasad and Misra 1992, p. 89, pl. 15, fig. 11
Cells cylindrical, slightly constricted at the middle, cell apices subpyramidal with rounded ends, chloroplasts sub-stellate with one large pyrenoid in each semicell, cells 30 – 31 *µm* long and 20 *µm* broad.
Epiphytic in S3 (voucher no. 2587)
Family – Desmidiaceae
Genus – *Closterium* Nitzsch ex Ralfs
10. *Closterium calosporum* Wittr. (Figure 3 J)
West and West 1904, p. 138, pl. 16, fig. 1 – 4
Cells small, much longer than broad, outer margin strongly curved, inner margin parallel to outer near the apices and somewhat straight in the middle, cells gradually attenuated to sub acute apices, cell wall smooth, chloroplast with single series of 10 – 12 pyrenoids, cells 190 – 194 *µm* long and 15 – 16 *µm* broad at the centre.
Benthic in S3 (voucher no. 2589)
11. *Closterium kuetzingii* Bréb. (Figure 3 K)
Iyengar and Vimala Bai 1942, p. 77, fig. 16
Cells single, median part fusiform, outer and inner margins almost equally convex, attenuated towards each extremity into long processes, apices slightly curved, round, cells 210 – 217 *µm* long, 8 – 9 *µm* broad at the centre and 1 – 2 *µm* broad at the tip.
Benthic in S3 (voucher no. 2589)
12. *Closterium libellula* var. *pulneyensis* M.O.P. Iyengar & B.V. Bai (Figure 3 L)
Iyengar and Vimala Bai 1942, p. 75, fig. 7
Cells single, large, much longer than broad, gradually attenuated from middle towards the apices, apex broadly rounded, cell wall smooth, chloroplast is slightly notched or constricted and not separated, with about 8 long plates, cells 110 – 128 *µm* long, 22 – 23.5 *µm* broad at centre and 10 *µm* broad at the tip.
Epilithic in S5 (voucher no. 2622)
13. *Closterium navicula* (Bréb.) Lütkem. (Figure 3 M)
Ettl and Gärtner 1995, p. 620, fig. 209. a
Cells are solitary, straight, ellipsoid, 140 – 143 *µm* long, gradually narrowed towards both the ends, breadth 42 – 43 *µm* at the centre and 18 – 20 *µm* at the tip, chloroplasts 2, one on each side, with 2 pyrenoids.
Planktonic in S1 (voucher no. 2595)
Genus – *Euastrum* Ehrenb. ex Ralfs
14. *Euastrum ansatum* var. *pyxidatum* Delponte (Figure 4 A)
Prasad and Misra 1992, p. 134, pl. 19, fig. 1
Cells small, deeply constricted, sinus narrowly linear with dialted extremity, semicells pyramidate with broadly rounded basal angles, lower part of sides convex and upper part is slightly concave, apex subquadrate with a deep incision, each semicell with one slight and one prominent protuberances above isthmus and two across centre, cells 58.2 – 60 *µm* long, 32 – 32.8 *µm* broad, isthmus 7 – 8 *µm* broad.
Benthic in S3 (voucher no. 2589)
15. *Euastrum dubium* Nägeli (Figure 4 B)
West and West 1905, p. 43, pl. 38, fig. 5 – 8
Cells solitary, green, longer than broad, semicells trapeziform, basal angles broadly rounded, upper and lower lateral margins equally rounded, upper and lower lateral margins equally rounded, apical angles broadly rounded, upper and lower lateral margins equally rounded, apical angles stout spine, apical margin of polar lobe with a "u-shaped" invagination in the middle, sinus narrow and linear, cells 25 – 27 *µm* long, 18 – 21 *µm* broad, isthmus is 5 – 5.5 *µm* broad.
Epiphytic in S3 (voucher no. 2587)
Genus – *Staurastrum* Meyen ex Ralfs
16. *Staurastrum egregium* West & G.S. West (Figure 4 C)
West and West 1897, p. 177, pl. 369, fig. 12
Cells dumbbell shaped, each semicell is with 4 ring of short, stout spines of almost equal size, the second ring exhibit two projecting, slightly curved and large spines at cell apices, top view is triangular with concave sides and rounded angles, cells 32 – 32.5 *µm* broad with spines.
Benthic in S3 (voucher no. 2589)
17. *Staurastrum gladiosum* W.B. Turner (Figure 4 D)

Iyengar and Vimala Bai 1942, p. 92, fig. 69
Cells of médium size, about as long as broad, sinus acute and not very widely open, semicells elliptic reniform, cell wall covered with spines, arranged in circles, chloroplast axial, one in each semicell with a central big pyrenoid, cells 58 – 60 *µm* long, 50 – 52 *µm* broad, isthmus 6 *µm* broad.
Epiphytic in S3 (voucher no. 2587)
18. *Staurastrum gracile* Ralfs (Figure 4 E)
Iyengar and Vimala Bai 1942, p. 96, fig. 64
Vertical view of the cell is triangular, with sides straight or slightly concave and the angles produced to form long processes, elongated ridges seen inside the lateral sides running parallel to it, cells 29 – 32.6 *µm* broad.
Epiphytic in S3 (voucher no. 2587)
Genus – *Cosmarium* Corda ex Ralfs
19. *Cosmarium awadhense* B.N. Prasad & R.K. Mehrotra (Figure 4 F)
Prasad and Mishra 1992, p. 153, pl. 21, fig. 17
Cells small, slightly longer than broad, constriction deep, sinus narrowly linear towards apex and slightly open outwards, semicells sub-semicircular, apex truncate, each semi cell is with one chloroplast, one pyrenoid, cells 23 – 24 *µm* long and 17 – 18 *µm* broad, isthmus 4 – 5 *µm* broad.
Epilithic in S2 (voucher no. 2603)
20. *Cosmarium decoratum* West & G.S. West (Figure 4 G)
Prasad and Mishra 1992, p. 158, pl. 24, fig. 9
Cells slightly longer than broad, deeply constricted, sinus narrowly linear, semicells semi elliptic, apex flattened, truncated with round angles, margins deeply crenate, triangular pits surrounded granules in irregular fashion at the centre, semi cells with 2 chloroplasts, each of one pyrenoid, cells 70 – 72 *µm* long, 50 *µm* broad, isthmus 18 – 20 *µm* broad.
Epiphytic in S3 (voucher no. 2587)
Genus – *Pleurotaenium* Nägeli
21. *Pleurotaenium kayei* Rabenh. (Figure 4 H)
Iyengar and Vimala Bai 1942, p. 80, fig. 22, 31
Cells big, 4 – 5 times longer than their breadth, semicells with spinous margins caused by 4 rings of double headed spines, gradually tapering from base to the apex, apex slightly dilated, cells 310 – 315 *µm* long and 40 – 42.5 *µm* broad at the centre.
Planktonic in S3 (voucher no. 2585)
Genus – *Spondylosium* Bréb. ex Kütz.
22. *Spondylosium nitens* f. *major* W.B. Turner (Figure 4 I)
Mishra and Srivastava 2003, p. 90, pl. 2, fig. 6, 7
Cells wider than long, compressed, deeply constricted, apex broadly rounded, semicells oblong elliptic, cell wall smooth, cells 10 – 11.3 *µm* broad and 8.5 – 9 *µm* long.
Planktonic in S3 (voucher no. 2585)
Class – Ulvophyceae
Order – Ulotrichales
Family – Gloeotilaceae
Genus – *Binuclearia* Wittr.
23. *Binuclearia tectorum* (Kütz.) Beger ex Wichmann (Figure 4 J)
Ramanathan 1964, p. 60, pl. 17, fig. A – V
Filaments with a prominent basal cell, cells are cylindrical with thick lamellated walls, the protoplast occupies a very small portion, mature cells appear somewhat vacuolated, cell walls are separated by thickened and stratified septa, which in older cells appear as H – pieces, cells 6.5 – 8.5 *µm* broad and 7.5 – 10.5 *µm* long.
Epilithic in S4 (voucher no. 2581)
Family – Ulotrichaceae
Genus – *Hormidiospora* Vinatzer
24. *Hormidiospora verrucosa* Vinatzer (Figure 4 K)
Ettl and Gärtner 1995, p. 514, fig. 164. e
Simple unbranched filaments, cells are cylindrical, 7 – 7.5 *µm* broad and 2.8 – 5.7 *µm* long, chloroplasts relatively small, plate like or disc shaped, parietal, covering half or less the circumference of the cell.
Epilithic in S1 (voucher no. 2596)

Genus – *Hormidium* Kütz.
25. *Hormidium subtile* (Kütz.) Heering (Figure 4 L)
Ramanathan 1964, p. 83, pl. 22, fig. F
Cells cylindrical, united to form a filament, 10 – 11.5 μm long and 8 – 8.5 μm broad, cell wall thin, chloroplasts elliptical.
Epilithic in S4 (voucher no. 2579)
Class – Chlorophyceae
Order – Chlorococcales
Family – Characiaceae
Genus – *Characium* A. Braun ex Kütz.
26. *Characium acuminatum* A. Braun ex Kütz. (Figure 4 M)
Prescott 1961, p. 216, pl. 46, fig. 7
Cells oblong, narrowly ovate, anterior part is narrowed to form apiculate end, cells 39 – 40 μm long and 18 μm in diameter, attached to filamentous algae.
Epiphytic in S1 (voucher no. 2591)
Family – Hydrodictyaceae
Genus – *Pediastrum* Meyen
27. *Pediastrum tetras* var. *tetraodon* (Corda) Hansg. (Figure 4 N)
Prescott 1961, p. 227, pl. 50, fig. 7
Colonies 4 celled, outer margins of the peripheral cells with deep incisions, the lobes extended into horn like processes, cells 7 – 8 μm long and 9 – 10 μm broad.
Epilithic in S2 (voucher no. 2604) and S4 (voucher no. 2583)
Family – Neochloridaceae
Genus – *Planktosphaeria* G.M. Sm.
28. *Planktosphaeria gelatinosa* G.M. Sm. (Figure 4 O)
Prescott 1961, p. 240, pl. 53, fig. 23
Cells loosely arranged, embeded within homogenous mucilage, chloroplasts several, angular, parietal discs, each with a pyrenoid, cells 6 – 7 μm in diameter.
Epilithic in S2 (voucher no. 2604)
Family – Scenedesmaceae
Genus – *Scenedesmus* Meyen
29. *Scenedesmus bijugatus* Kütz. (Figure 4 P)
Philipose 1967, p. 252, fig. 164
Colonies consisting of 4 cells in a linear series, cells oblong, ellipsoid to ovoid with broadly rounded ends, cell wall smooth, each cell with one parietal chloroplast, containing single pyrenoid, cells 9.3 – 13 μm long and 3 – 4 μm broad.
Epilithic in S2 (voucher no. 2603) and epiphytic in S3 (2587)
Order – Sphaeropleales
Family – Microsporaceae
Genus – *Microspora* Thuret
30. *Microspora indica* Randhawa (Figure 5 A)
Ramanathan 1964, p. 132, pl. 37, fig. L – O
Cells cylindrical, 14.3 – 25.7 μm long and 20 – 20.5 μm broad, composed of H-shaped overlapping halves, chloroplasts parietal with dense cushion like outgrowths at sides.
Epilithic in S4 (voucher no. 2579)
31. *Microspora pachyderma* (Wille) Lagerh. (Figure 5 B)
Ramanathan 1964, p. 128, pl. 36, fig. E – K
Cells cylindrical, 12 – 18 μm long and 16 – 16.5 μm broad, cell walls are separated by H – pieces, chloroplasts perforated plate like, covering more than half of the cell.
Epilithic in S2 (voucher no. 2615)
Order – Oedogoniales
Family – Oedogoniaceae
Genus – *Oedogonium* Link ex Hirn
32. *Oedogonium globosum* Nordst (Figure 5 C)
Gonzalves 1981, p. 166, fig. 9. 29

Macrandrous, monoecious, vegetative cells cylindrical, 30 – 31.5 *μm* long and 5 – 6 *μm* broad, oogonium solitary, globose, 18.5 *μm* in diameter, oospore is globose, filling up the oogonium.
Epiphytic in S2 (voucher no. 2609)
Phylum – Euglenophyta
Class – Euglenophyceae
Order – Euglenales
Family – Phacaceae
Genus – *Phacus* Deflandre
33. *Phacus pleuronectes* (O.F. Müll.) Nitzsch ex Dujard. (Figure 5 D)
Wołowski and Hindák 2005, p. 36, fig. 204, 205
Cells ovoid to suborbicular in outline, posteriorly a stout caudus which is obliquely turned to the right anterior end, broadly rounded, paramylon bodies 1 – 2, disc shaped, cells 35 – 37 *μm* long and 24 – 25 *μm* broad.
Planktonic in S2 (voucher no. 2605)
Division – Heterokontophyta
Class – Bacillariophyceae
Order – Biddulphiales
Family – Aulacoseiraceae
Genus – *Aulacoseira* Thwaites
34. *Aulacoseira granulata* (Ehrenb.) Simonsen (Figure 5 E)
Cox 1996, p. 113, fig. 11 a
Frustules cylindrical, attached continuously to form chain like structures, walls punctuate, end cells with long marginal spines, valve 15 – 17 *μm* long and 7 – 8 *μm* broad.
Epiphytic in S2 (voucher no. 2604)
Family – Stephanodiscaceae
Genus – *Cyclotella* (Kütz.) Bréb.
35. *Cyclotella meneghiniana* Kütz. (Figure 5 F)
Cox 1996, p. 112, fig. 11 l
Frustules discoid in valve view, rectangular and undulated in girdle view, margin well defined, coarsely striated and striae wedge shaped, 8 – 10 in 10 *μm,* frustules 30 – 32 *μm* in diameter.
Planktonic in S3 (voucher no. 2587)
Order – Bacillariales
Family – Fragilariaceae
Genus – *Synedra* Ehrenb.
36. *Synedra cyclopum* var. *robustum* F.E. Schulze (Figure 5 G)
Huber – Pestalozii 1942, p. 464, pl. CXXXVII, fig. 553
Frustules linear, slightly bent, middle portion is slightly wide, the apical area is attenuated to an obtuse end, 33 – 37 *μm* long and 5 – 6 *μm* broad, striation is not clearly visible in fresh material.
Epiphytic in S1 (voucher no. 2595)
37. *Synedra ulna* var. *amphirhynchus* (Ehrenb.) Grunow (Figure 5 H)
Kützing 1865, p. 66, pl. 14, fig. 15
Long slender valves, slightly constricted towards the apices to form capitate end, longer than broad, 96 – 112.8 *μm* long and 6.6 – 8 *μm* broad, striation regular, 9 – 12 in 10 *μm*.
Epilithic in S1 (voucher no. 2591) and epiphytic in S1 (voucher no. 2595, 2600)
Family – Pinnulariaceae
Genus – *Pinnularia* Ehrenb.
38. *Pinnularia viridis* (Nitzsch) Ehrenb. (Figure 5 I)
Krammer and Lange-Bertalot 1986, p. 428, fig. 194: 1-4, 195: 1-6
Frustules linear-lanceolate, slightly wider at the middle, axial area wide, end broad and rounded, striation transverse at the margin, almost parallel except at the middle, slightly radial, striae thin, delicate, 10 – 12 in 10 *μm*, frustules 48 – 50 *μm* long and 10 – 11.5 *μm* broad.
Epiphytic in S1 (voucher no. 2600) and epilithic in S4 (voucher no. 2580)
Family – Naviculaceae
Genus – *Navicula* Bory
39. *Navicula amphirhynchus* Ehrenb. (Figure 5 J)

Kützing 1865, p. 95, pl. 4, fig. XIII
Frustules elliptical – lanceolate and is slightly constricted to form rostrate apices, raphe thin and the central area is slightly widened, frustules 33 – 35.5 *µm* long and 9.5 – 10 *µm* broad, striation is not clearly visible.
Epilithic in S5 (voucher no. 2619)
40. *Navicula cuspidata* (Kütz.) Kütz. (Figure 5 N)
Krammer and Lange-Bertalot 1986, p. 126, fig. 43: 1-8
Long, lanceolate valve with gently inflated rostrate ends, raphe thin, median, terminal fissures slightly curved to form hook like structures, axial area narrow, linear, central area longitudinally widened, valves 47 – 71 *µm* long and 13 – 17 *µm* broad, striae linear, distinct, parallel throughout the valve, 7 – 8 in 10 *µm*.
Epilithic in S5 (voucher no. 2622), epiphytic in S2 (voucher no. 2613, 2614, 2615) and S3 (voucher no. 2587)
41. *Navicula microspora* Kant & P. Gupta (Figure 5 K)
Kant and Gupta 1998, p. 27, pl. 127, fig. 12
Frustules elliptical – lanceolate, rostrate apices, capitate, pseudoraphae at the centre, axial area broad, striation not visible in fresh material, longer than broad, 31 – 44.2 *µm* long and 9 – 11 *µm* broad.
Epilithic in S4 (voucher no. 2580)
42. *Navicula tripunctata* (O.F. Müll.) Bory (Figure 5 L)
Krammer and Lange-Bertalot 1986, p. 95, fig. 27: 1-3
Frustules linear lanceolate, elongated, end obtuse, axial area narrow, central area wide, raphae thin, straight, 50 – 51.5 *µm* long, 13 *µm* broad, striation barely visible in fresh material.
Epiphytic in S2 (voucher no. 2603)
43. *Navicula viridula* (Kütz.) Kütz. (Figure 5 M)
Krammer and Lange-Bertalot 1986, p. 114, fig. 37: 1-9
Elongated and lanceolate frustules, attenuated towards the apices to form obtuse ends, 53 – 58.5 *µm* long and 8 – 9.3 *µm* broad, striation is not clearly visible in fresh materials.
Epiphytic in S1 (voucher no. 2595, 2600)
Family – Gomphonemataceae
Genus – *Gomphonema* Ehrenb.
44. *Gomphonema augur* var. *sphaerophorum* Ehrenb. (Figure 5 O)
Krammer and Lange-Bertalot 1986, p. 363, fig. 157: 9
Frustules clavate-lanceolate, one end gradually tapering towards apices, apex rostrate, forming a stigma like structure, central area unilateral, axial area narrow, raphe not seen, frustules 35 – 36 *µm* long and 9 *µm* broad, striation is not clear in fresh materials, sometimes having big stalk and attached to aquatic plants or filamentous algae.
Epiphytic in S1 (voucher no. 2595)
Family – Cymbellaceae
Genus – *Cymbella* C. Agardh
45. *Cymbella affinis* Kütz. (Figure 5 P)
Krammer and Lange-Bertalot 1986, p. 314, fig. 125: 1-22
Frustules are elliptic – oblong, obtuse end, dorsal side convex, ventral margin slightly gibbous, raphe arcuate towards the ventral margin, frustules 57 – 60 *µm* long and 14 – 15 *µm* broad, striation distinct, transverse, parallel, 9 – 10 in 10 *µm*.
Epiphytic in S1 (voucher no. 2595)
Genus – *Cymbopleura* (Krammer) Krammer
46. *Cymbopleura inaequalis* (Ehrenb.) Krammer (Figure 5 R)
Krammer 2003, pl. 25, fig. 29: 1-9, 34: 1-3
Frustules biraphid, lanceolate, dorsal side is slightly convex than ventral side, slightly bent, 33 – 37 *µm* long and 11 – 14 *µm* broad, striation distinct, transverse, radial towards the centre, striae 5 – 8 in 10 *µm*.
Epiphytic in S1 (voucher no. 2595)
Family – Catenulaceae
Genus – *Amphora* Ehrenb. ex Kütz.
47. *Amphora elleptica* (C. Agardh) Kütz. (Figure 5 S)
Kützing 1865, p. 107, pl. 5, fig. 31
Frustules in girdle view elliptic lanceolate, slightly biconvex, apices slightly attenuated, obtuse, central area is wider, 28 – 35 *µm* long and 10 – 11.5 *µm* broad, striation distinct, transverse, 8 – 9 in 10 *µm*.
Epilithic in S1 (voucher no. 2596) and S2 (voucher no. 2603, 2609)

Family – Bacillariaceae
Genus – *Nitzschia* Hassall
48. *Nitzschia frustulum* (Kütz.) Grunow (Figure 5 Q)
Krammer and Lange-Bertalot 1988, p. 94, fig. 68: 1-19
Valve linear with parallel margins, narrowed and slightly constricted to form rounded ends, carinal dots distinct and coarse, 43 – 46 *µm* long and 6 – 7 *µm* broad, striation fine, lineate and parallel throughout the valve, 10 – 11 in 10 *µm*.
Epilithic in S2 (voucher no. 2603) and S5 (voucher no. 2619) and epiphytic in S2 (voucher no. 2607, 2609)

The low algal diversity in these wettest places showed the uniqueness with species which are representative ones, indicating oligotrophic character of the water bodies of the region (Palmer 1962). The temperature at the collection sites are very congenial being within the range of 20 to 25 °C, the pH was in acidic range varying from 5.5 to 6.5 and with low conductivity values from 018 to 029 µS which possibly are the regulating factors for the low diversity. Further, the water bodies of the regions in the close vicinity of this locality did not receive such higher rainfall intensity are nutritionally rich due to loading of anthropogenic wastes and showed excessive growth of algal taxa predominantly under Cyanophyta, Chlorococcales under Chlorophyta, Euglenophytes and diatoms (Das *et al.*, 2009; Das and Adhikary, 2014; Siangbood and Ramanujam, 2014). Habitat wise distributional pattern of the algal taxa showed that the diversity is maximum in the waterfalls (25), specifically in the Seven Sister fall, in comparison to the diversity in streams (14) and pond (14). Only one species of diatom (*Navicula cuspidata*) is common between all the three habitats. There is more commonality of taxa between stream and waterfall (*Oscillatoria jenensis, Pediastrum tetras* var. *tetraodon, Amphora elliptica* and *Nitzschia frustulum*) than between stream and pond (*Scenedesmus bijugatus*). But there are no common taxa between pond and waterfalls. This shows the habitat specificity of the algal taxa to their respective localities. A further analysis specifies that most of the species of Chlorophycean genera (other than Desmids) like, *Characium, Hormidiospora, Microspora, Binuclearia, Hormidium, Pediastrum*. *Planktosphaeria, Oedogonium* etc. and Bacillariophycean genera like, *Navicula, Gomphonema, Synedra* etc. were from epilithic or epiphytic habitats. Desmids (*Closterium, Cosmarium, Pleurotaenium, Euastrum, Staurastrum and Cylindrocystis*) which are important ecological indicators for oligotrophic water were planktonic in the pond in Cherrapunjee. All the Cyanoprokaryotes/Cyanophytes were confined to the lotic water habitats, i.e. waterfalls and streams.

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