

# Cyanobacteria from aeroterrestrial biofilms around Balasore, Odisha

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## ओडिशा बालासोर, के निकटवर्ती स्थानों में वायु-स्तरीय बायोफिल्मस से सायनोबैक्टिरिया का निष्कर्षण

धनेश कुमार, सौम्या रंजन साहू, सुदिप्त कुमार दास

### सारांश

वायु-स्तरीय वासस्थल पारितंत्र के महत्वपूर्ण प्राकृतवास हैं, जो माइक्रोबियल की वृद्धि के लिए उस आधार का निर्माण करते हैं, जो बायोफिल्म निर्माण के लिये उत्तरदायी होता है। ओडिशा के बालासोर के आस-पास ऐसे ही प्राकृतवास हैं जिनका प्रथम बार अध्ययन किया गया है। बालासोर के आस-पास विभिन्न प्रकार उप-वायु-स्तरीय वासस्थल में साइनो बैक्टिरिया की 16 जातियां प्रलेखित की गई हैं जिसमें 6 गैर-हेट्रोसिस्टस एवं 10 हेट्रोसिस्टस रूप शामिल हैं।

### ABSTRACT

Aeroterrestrial habitats are ecological significant as they act as a potential substrate for microbial growth causing biofilms. Such habitats around Balasore, Odisha are studied for the first time. A total of 16 cyanobacterial species are documented from various sub-aerophytic habitats around Balasore, which include 6 non-heterocystous and 10 heterocystous forms.

**Keywords:** Aeroterrestrial, Balasore, Cyanobacteria, Diversity, Odisha Coast

### INTRODUCTION

Aeroterrestrial biofilms are microbial mats consisting of both autotrophic and heterotrophic partners, located at the atmosphere and lithosphere interface. These biofilms with a wide range of temperature and radiation amplitude along with atmospheric moisture act as an ambience for cyanobacterial growth. The EPS (Extracellular Polymeric Substances) secreted by cyanobacteria also help in the adherence of these biofilms to the substratums (Kumar & Adhikary, 2016; Rosenberg, 1989). Climate is the

principal regulating factor in composition of microbes in these biofilms. In temperate climatic regions, the green micro-algae dominate in this biota, but in warm temperate to tropical climate, the cyanobacteria dominate (Samad & Adhikary 2008, Adhikary & al. 2015). Aeroterrestrial cyanobacteria are mostly overlooked by the survey researchers, due to the difficulties in their isolation as well as identification.

Balasore district is located in the northern part of Odisha, which stretches between 21°03' to 21°59' northern latitude and between 86°20' to 87°29' east longitude. The

annual rainfall of the district is 1601 mm and the average temperature is 26.7° C. Not much has been known about the cyanobacterial diversity in Balasore area. Thus, the present work was intended to document the diversity of these autotrophic prokaryotes of this region.

## MATERIALS AND METHODS

Cyanobacteria samples were collected from different sites around Balasore during November-December 2015. The cyanobacterial samples were isolated from different substrate including sandy soil, mortar, stone and brick surfaces which were taken out carefully with the help of sterile spatula, forceps and needles in sterilized collection tubes. Each specimen was given a voucher number, preserved in FAA solution, deposited at the Dept. of Bioscience and Biotechnology of Fakir Mohan University, Balasore. The crusts were examined under microscope for the presence of cyanobacteria after 12-24 hrs soaking with sterile distilled water. To observe their morphology at different growth phases, they were cultured on petri plates with agarized (1.2%) BG-11 media (with and without Nitrogen) (Rippka 1979) under fluorescent light of 7.5 Wm<sup>-2</sup> intensity and 25 ± 1 °C temperature. All the cultures are maintained at Department of Biosciences & Biotechnology, Fakir Mohan University, Balasore. Microscopic observations and morphological study were made with Nikon microscope Ni-11 fitted with Nikon Digital Camera DS-Ri1-U3 and operated by Nikon Imaging Software NIS-D+EDF. Identification of cyanobacteria was performed following the standard monographs, which includes Komárek (2013) and Komárek & Anagnostidis (2005). A total of 16 cyanobacterial species are documented from various sub-aerophytic habitats around Balasore, which include 6 non-heterocystous and 10 heterocystous forms. The species are arranged alphabetically with a full citation followed by the Order and family within parenthesis (Order : Family), short description and place of collection. Microscopic image of the species are depicted in a photoplate.

## SYSTEMATIC ENUMERATION

**Calothrix aeruginosa** Woron., Bot. Mater. 2: 115. 1923. (Nostocales: Rivulariaceae) (Fig. 1 h)

Filaments solitary, sometimes in small groups connected by their gelatinous bases, up to 148 µm long, 6.5-7.3 µm

wide near head and 3.5-4.9 µm wide near the apices, filaments continuously attenuated towards the end, constricted at the cross walls, bright blue-green, sheaths diffluent, apical cell slightly elongated and rounded, heterocysts basal, almost spherical.

*Place of Collection:* Bank of Subarnarekha river, Hathiagand bridge, Balasore; *Habitat:* Soil crusts

**Calothrix braunii** Bornet & Flahault, Mém. Soc. Natl. Sc. Nat. et Math. Cherbourg 25: 203. 1885. (Nostocales: Rivulariaceae) (Fig. 2 a)

Filaments unbranched, 73-85 µm long, 7-9 µm wide, sheath thin, colourless, yellowish to brownish, non-lamellated, open at the ends, trichomes blue-green, slightly constricted at the crosswalls, 6.2-6.5 µm wide at the base and 3.7-4.2 µm at the middle, cells isodiametric, cylindrical, heterocysts basal, solitary, hemispherical.

*Place of collection:* F. M. University new campus; *Habitat:* Mortar surface

**Calothrix fusca** (Kütz.) Bornet & Flahault, Mém. Soc. Natl. Sc. Nat. et Math. Cherbourg 25: 202. 1885. *Mastichothrix fusca* Kütz., Phyc. Gen.: 232. 1843. (Nostocales: Rivulariaceae) (Fig. 1 i)

Filaments solitary, short, 28.5-34.2 µm long, onion-like rounded near the base, 4.6-5.8 µm wide, sheaths thick, lamellated, towards end open like a funnel, yellowish brown in colour, trichome suddenly narrows towards the end, giving thin hair like appearance, cells blue green, shorter than wide, heterocyst solitary, basal, hemispherical.

*Place of collection:* Bank of Subarnarekha river, Nuapadhi village, Balasore; *Habitat:* Soil crusts

**Calothrix parietina** Thur. ex Bornet & Flahault, Ann. Sci. Nat. Bot., ser. 7, 3: 347. 1886. (Nostocales: Rivulariaceae) (Fig. 2 b)

Filaments densely entangled, straight, with profuse pseudo-branches, up to 1 mm long, 12.3-15.5 µm wide at base and 9.8-12.3 µm wide at the apex, sheaths thin, lamellated, bright blue-green in colour, cells slightly longer than broad, heterocysts basal, semispherical.

*Place of Collection:* F. M. University new campus; *Habitat:* Mortar surface

**Geitlerinema numidicum** (Gomont) Anagn., Plant Syst. Evol. 164: 39. 1989. *Oscillatoria numidica* Gomont, Ann. Sci. Nat. Bot., ser. 7, 16: 231. 1892. (Oscillatoriales: Coleofasciculaceae) (Fig. 1 d)

Trichome pale blue green, straight, 7.5-9.2 µm wide, slightly constricted at the crosswalls, cells little longer than broad. 7.8-9.5 µm long, apical cell rounded, without calyptra.

*Place of Collection:* F. M. University new campus; *Habitat:* Soil crusts, Mortar surface

**Hapalosiphon welwitschii** West & G.S.West, J. Bot. (London) 35: 242. 1897. (Stigonematales:Hapalosiphonaceae) (Fig. 2 f)

Filaments pale blue-green, straight, laterally branched, 6.2-8.5 µm wide, sheaths narrow, colourless, trichomes cylindrical, constricted at the cross walls, cells barrel shaped in main filaments and cylindrical with twice longer than broad in branches, heterocysts elliptical, intercalary.

*Place of Collection:* F. M. University new campus; *Habitat:* Soil crusts, Mortar surface

**Leptolyngbya foveolaria** (Gomont) Anagn. & Komárek, Arch. Hydrobiol. 80: 391. 1988. *Phormidium foveolarum* Gomont, Ann. Sci. Nat. Bot., ser. 7, 16: 164. 1892. (Oscillatoriales: Leptolyngbyaceae) (Fig. 1 b)

Filaments straight or sometimes variously curved, bright blue-green, sheaths colourless, diffuent, 0.8-1.7 µm wide, cells slightly barrel shaped, isodiametric, cell content homogenous with rounded apical cell.

*Place of Collection:* F. M. University new campus; *Habitat:* Red brick surface

**Leptolyngbya subtilis** (West) Anagn., Preslia 73: 367. 2001. *Lyngbya subtilis* West, J. Roy. Micr. Soc. 1892: 741. 1892. (Oscillatoriales: Leptolyngbyaceae) (Fig. 1 c)

Filaments free-floating, straight, 1.6-2.0 µm wide, sheaths very thin, smooth, hyaline, cells slightly longer than wide, pale blue-green, cell content delicately granulated, apical cell rounded.

*Place of Collection:* Bank of Subarnarekha river, Nuapadhi village, Balasore; *Habitat:* Soil crusts

**Nostoc calcicola** Bréb. ex Kütz., Tab. Phyc. 2: 4. 1850. (Nostocales: Nostocaceae) (Fig. 2 d)

Colonies irregular, flat, gelatinous, dirty olive-green, disintegrating, filaments freely entangled, sheath usually indistinct, more distinct at the colonial margin, yellowish, cells barrel shaped, shorter than wide, 1.8-2.5 µm long and 2.2-2.8 µm wide, heterocysts spherical, 3.5-4.5 µm in diameter.

*Place of Collection:* F. M. University new campus; *Habitat:* Mortar surface, Soil crusts

**Nostoc commune** Vaucher ex Bornet & Flahault, Ann. Sci. Nat. Bot., ser. 7, 7: 203. 1888. (Nostocales: Nostocaceae) (Fig. 2 e)

Filaments flexuous, sometimes densely entangled, yellowish brown sheath visible on the outline of the colonies, cells shorter barrel shaped to almost spherical, olive green in colour, 2.9-3.8 µm long and 2.5-3.0 µm broad, spherical heterocysts, both intercalary and apical.

*Place of Collection:* F. M. University new campus; *Habitat:* Soil crusts

**Nostoc pruniforme** C. Aagrdh ex Bornet & Flahault, Ann. Sci. Nat. Bot., ser. 7, 7: 215. 1888. (Nostocales: Nostocaceae) (Fig. 2 c)

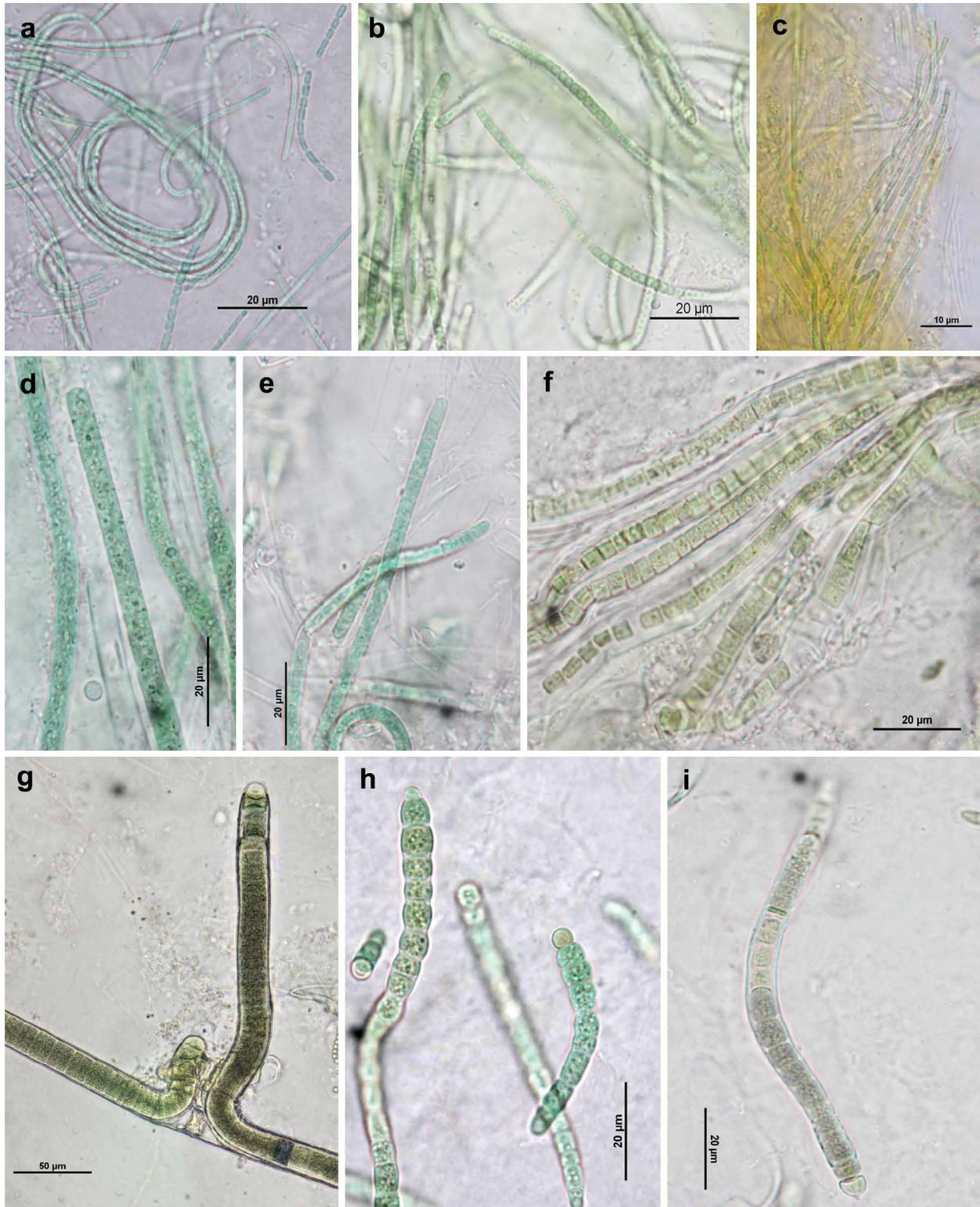
Colonies ovoid, with smooth periderm, inside with thin mucilage, pale blue-green, interior with irregularly entangled trichome, trichomes short, cells barrel shaped, isodiametric, 2.2- 2.7 µm long and 2.0-2.6 µm broad, heterocysts hemispherical, yellowish, akinetes rare.

*Place of Collection:* F. M. University new campus; *Habitat:* Soil crusts, mortar surface

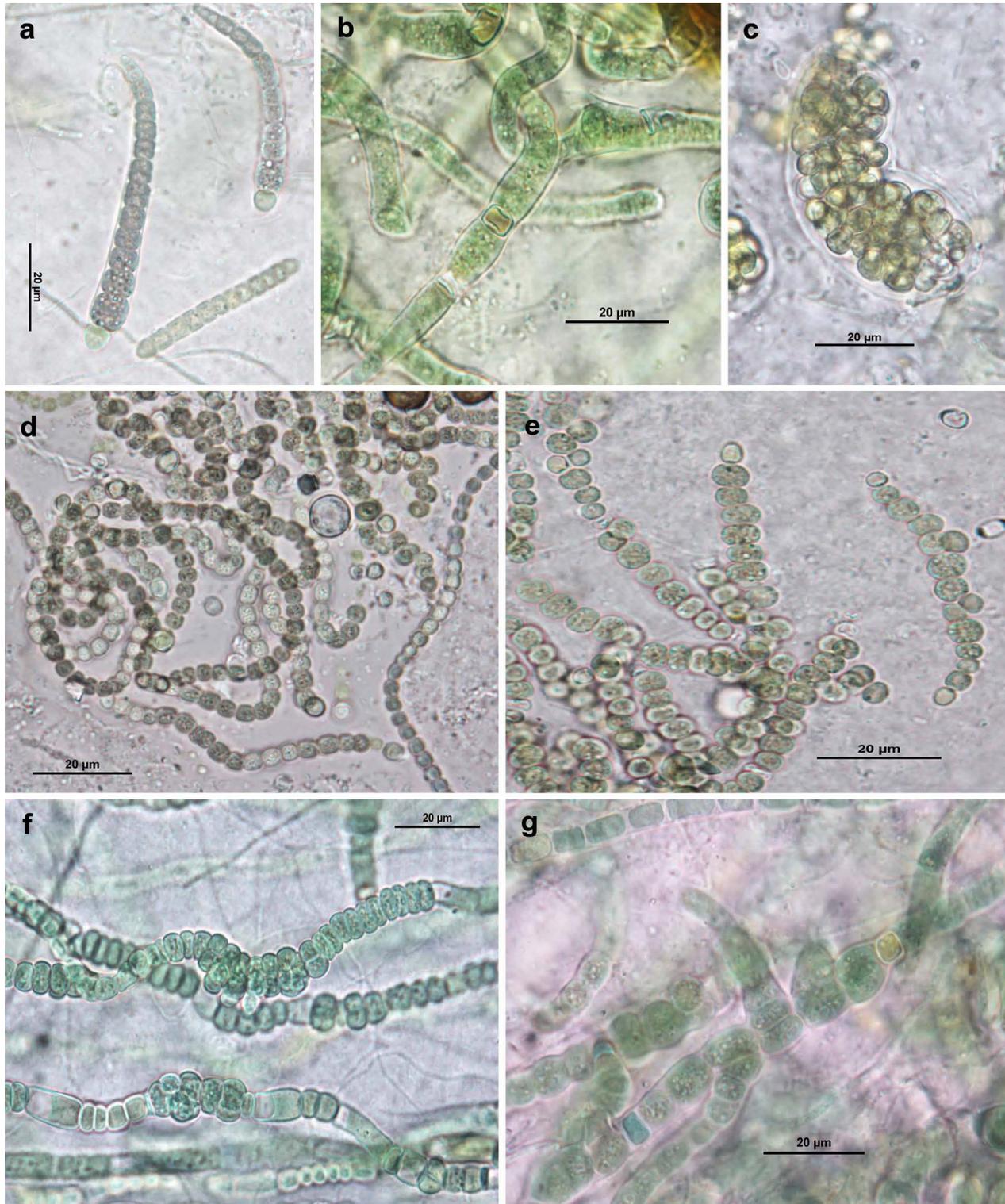
**Phormidium papyraceum** Gomont ex Gomont, Ann. Sci. Nat. Bot., ser. 7, 16: 173. 1892. (Oscillatoriales: Phormidiaceae) (Fig. 1 e)

Expanded dark green thallus, filaments long, slightly curved, trichomes blue green, 3.8-4.6 µm wide, not constricted at the ungranulated crosswalls, cells shorter than broad, with scattered granules on the protoplast, 2.7-3.2 µm long, apical cell obtusely rounded.

*Place of Collection:* Bank of Subarnarekha river, Hathiagand bridge, Balasore; *Habitat:* Soil crusts



**Figure 1.** a. *Pseudanabaena limnetica* (Lemmerm.) Komárek, b. *Leptolyngbya foveolaria* (Gomont) Anagn. & Komárek, c. *Leptolyngbya subtilis* (West) Anagn., d. *Geitlerinema numidicum* (Gomont) Anagn., e. *Phormidium papyraceum* Gomont ex Gomont, f. *Schizothrix lacustris* A.Braun ex Gomont, g. *Scytonema mirabile* (Dillwyn) Bornet, h. *Calothrix aeruginosa* Woron., i. *Calothrix fusca* (Kütz.) Bornet & Flahault



**Figure 2.** a. *Calothrix braunii* Bornet & Flahault, b. *Calothrix parietina* Thuret ex Bornet & Flahault, c. *Nostoc pruniforme* C.Aagrth ex Bornet & Flahault, d. *Nostoc calcicola* Bréb. ex Kütz., e. *Nostoc commune* Vaucher ex Bornet & Flahault, f. *Hapalosiphon welwitschii* West & G.S.West, g. *Westiellopsis prolifica* Janet

**Pseudanabaena limnetica** (Lemmerm.) Komárek, Acta Sc. Nat. Mus. Bohem. Merid. 14: 162. 1974. *Oscillatoria limnetica* Lemmerm., Ber. Deutsch. Bot. Ges. 18: 310. 1900. (Oscillatoriales: Pseudanabaenaceae) (Fig. 1 a)

Trichomes solitary, straight to slightly curved, 0.8-1.4 µm wide, unconstructed, without aerotopes, not attenuated towards the apices, occasionally thin mucilaginous sheath, cell long cylindrical, pale blue-green, apical cell rounded.

*Place of Collection*: Bank of Subarnarekha river, Nuapadhi village, Balasore; *Habitat*: Soil crusts

**Schizothrix lacustris** A. Braun ex Gomont, Ann. Sci. Nat. Bot., ser. 7, 15: 295. 1892. (Oscillatoriales: Schizotrichaceae) (Fig. 1 f)

Fasciculate, heteropolar thallus, pale greyish in colour, filaments densely entangled, 7.5-8.8 µm wide, pseudo-branched mostly towards the apices, colourless uneven sheaths, acuminate at the ends, trichomes pale blue-green, 0.7-1.2 µm broad, cell content with large prominent granules, cells 1.2 times longer than wide, apical cell rounded.

*Place of Collection*: F. M. University new campus; *Habitat*: Soil crusts

**Scytonema mirabile** (Dillwyn) Bornet, Bull. Soc. Bot. France 36: 155. 1889. *Conferva mirabilis* Dillwyn, Conf.: 14, pl. 96. 1808. (Nostocales: Scytonemataceae) (Fig. 1 g)

Thallus cushion-like, blackish green, filaments entangled, straight, olive greenish in colour, 9.8-12.2 µm wide, trichomes cylindrical, slightly constricted at the cross walls, sheaths relatively thin, parallel, non-lamellated, cells quadratic with apical cell rounded, 7.8-8.3 µm in diameter, heterocysts intercalary, quadratic.

*Place of Collection*: F. M. University new campus; *Habitat*: Soil crusts, Red brick

**Westiellopsis prolifica** Janet, Ann. Bot. 5 (17): 170. 1941. (Stigonematales: Hapalosiphonaceae) (Fig. 2 g)

Thallus bluish-green, filamentous, heterocystous, branched; main branch broader than lateral,

polyseriate; cross walls distinctly constricted; cells elliptical or barrel shaped; 4-6.8 µm broad, 6-12.4 µm long; cells of lateral branch 2.6-4.5 µm broad, 2-11 µm long; heterocyst intercalary, spherical or cylindrical, 4.3-7.8 µm diameter or 4.5-5.8 µm broad, 10-12 µm long.

*Place of Collection*: Bank of Subarnarekha river, Nuapadhi village, Balasore; *Habitat*: Soil crusts

Aero-terrestrial cyanobacteria are the primary components of the biofilms in desiccated and UV exposed substrates. Their adaptive mechanisms can help in developing a stress tolerant strategy for other living organisms in the present day climate change scenario. Thus it is very important not only to know these organisms but also to isolate and maintain them in culture conditions, so that these can be utilized for understanding their stress biology as well as can be exploited biotechnologically for various pharmaceutical and cosmetic products. So, the present study can provide a useful baseline information in this context.

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