Diversity of cyanobacteria in biofilms on building facades of Western Maharasthra

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ABSTRACT
Occurrence of cyanobacteria in the biofilms on building facades of Western Maharasthra was studied. In all 23 cyanobacterial taxa were recorded of which 8 were unicellular and 15 filamentous forms.

KEYWORDS: Biofilms, cyanobacteria, facades, Western Maharasthra.

INTRODUCTION
Biofilms are the thin mucilaginous layers of varied colours formed by the growth of algae and cyanobacteria on the exposed surface of buildings during rainy season. These biofilms get slowly dried after rain and remain perched throughout the year to the stones. Attempts have been made to analyze such biofilms from on the sub-aerial habitats in different parts of the world (Anagnostidis et al. 1983, Ortega-Cavo et al 1991, Kovacik 2000, Gartner and Stoyneva 2003, Uher et al. 2006). Such attempts have also been made in Indian subcontinent by some workers (Samad and Adhikary 2008, Pattanaik and Adhikary 2002, Adhikary 2002, Tripathi et al. 1991; Tripathy et al. 1997, 1999, Marathe and Chaudhari 1975). In this work the cyanobacteria occurring of the building facaes in the Western Maharasthra region is presented.

MATERIALS AND METHODS
Biofilms growing attached to the surfaces of old buildings facades, forts and temples were collected from different places of Western Maharasthra (Table 1; Plate). Biofilms were collected in sterile polyethylene bags and bottles and brought to the laboratory. Initially films were soaked in the sterile water and observed under microscope. Then small part of the film was chopped and inoculated in BG-11 medium with and without nitrogen (Rippka et al. 1979) and BBM medium (Bold 1949). The cultures were incubated at 25°C under continuous illumination till visible growth of organisms occurred. The Cyanobacteria grown were examined and identified using standard references (Desikachary 1959, Komarek and Anagnostidis K 2005, Rippka et al. 1979)

Table 1. List of the sampling sites from building facades of Western Maharasthra

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Name of the locality</th>
<th>District</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Yewteshwar</td>
<td>Satara</td>
</tr>
<tr>
<td>2</td>
<td>Pateshwar</td>
<td>Satara</td>
</tr>
<tr>
<td>3</td>
<td>Jarandeshwar</td>
<td>Satara</td>
</tr>
<tr>
<td>4</td>
<td>Ajinkyatara fort</td>
<td>Satara</td>
</tr>
<tr>
<td>5</td>
<td>Temple near Lingamala fall Mahabaleshwar</td>
<td>Satara</td>
</tr>
<tr>
<td>6</td>
<td>Old monuments at Koyananagar</td>
<td>Satara</td>
</tr>
<tr>
<td>7</td>
<td>Sagareshwar temple</td>
<td>Sangali</td>
</tr>
<tr>
<td>8</td>
<td>Willingdon College</td>
<td>Sangali</td>
</tr>
<tr>
<td>9</td>
<td>Panhala</td>
<td>Kolhapur</td>
</tr>
<tr>
<td>10</td>
<td>Caves at Karla</td>
<td>Raigad</td>
</tr>
<tr>
<td>11</td>
<td>Temple near Apta railway station</td>
<td>Raigad</td>
</tr>
</tbody>
</table>
OBSERVATIONS

Following forms were taxa were recorded in the culture of the biofilm samples. Locality wise distribution of Cyanobacteria in the biofilms is given in Table-2.

1. *Aphanocapsa montana* Carmer
   Desikachary 1959, pp 135; Pl.20, fig. 8.
   Pl. IIIa fig. 4.
   Thallus of no definite shape, gelatinous, blue green colored.
   Cells 3 - 5 μm in diameter, cells spherical, blue green,
   single or sometimes in pairs, mucilage colorless.

   Desikachary 1959, pp 118; Pl. 23, fig.4, Pl. 24, fig. 12.
   Pl. IIIa fig. 3.
   Thallus thin, soft, blackish in color, cells densely arranged
   in colonies, without sheath 4-5 μm in diameter and with
   sheath 5-7.5μm in diameter, blue green, sheath not lamellate.

   Desikachary 1959, pp 116; Pl. 24, fig.8
   Pl. IIIa fig. 2.
   Thallus crustaceous, mucilaginous, blackish, cells without
   sheath 3.5-4 μm in diameter, with sheath 10-14.5 μm
   diameter, pale blue-green, mostly many in a colony, sheath
   colorless, distinctly lamellated.

4. *Synechococcus elongates* Nag
   Desikachary 1959, pp 143; Pl. 25, fig 7, 8
   Pl. IIIa fig. 5.
   Cells cylindrical, 1.5-2 μm broad, about twice as long as
   broad, single or two cells together, contents homogeneous,
   blue green.

5. *Gloeothecae rupestris* (Lyngb) Bornet.
   Desikachary 1959, pp 127; Pl. 25, fig. 4
   Pl. IIIa fig. 6.
   Cells ellipsoidal, without envelop 4-5.5 μm broad, 1.5-3
   times as long as broad, with envelop 8-13 μm broad, blue
   green, with 6-8 in a group, envelop colorless.

   Desikachary 1959, pp 115; Pl. 25, fig. 1
   Pl. IIIa fig. 1.
Cells compact, spherical without sheath, 3-3.5 \( \mu \)m broad, sheath thick and lamellated.
7. Chlorogloeopsis microcystoides Geitler
Desikachary 1959, pp 163; Pl. 19, fig. 8
Pl. IIIa fig. 7.
Thallus thin, gelatinous; cells spherical, closely arranged without distinct individual sheath, cells 3-3.5 \( \mu \)m in diameter, blue green.
8. Myxosarcina spectabilis Geitler
Desikachary 1959, pp 178; Pl. 30, fig. 1-5 & Pl. 31 figs. 17-22
Pl. IIIa fig. 8.
Cells in three dimensional colonies, 6.5-10 \( \mu \)m broad, colonial sheath thin, hyaline, cell content blue green.
9. Oscillatoria subbrevis Schmidt
Desikachary 1959, pp. 207; Pl.37, fig. 2 and Pl. 40, fig. 1
Pl. IIIa fig. 9.
Trichome single, 5-6 \( \mu \)m broad, nearly straight, not attenuated at the apices, cells 1-2 \( \mu \)m long, end cell rounded, calyptras absent.
Desikachary 1959, pp. 240; Pl.39, fig 5, 8
Pl. IIIa fig. 12.
Trichome solitary, parallel to each other, brittle, not constricted at cross walls, 4-7 \( \mu \)m thick, 70-400 \( \mu \)m long, straight, not capitates, bluish green, apex slightly bent.
11. Oscillatoria curviceps Ag.ex. Geomont
Desikachary 1959, pp. 209; Pl.38, fig. 2
Pl. IIIa fig. 11.
Thallus dark blue-green, trichomes straight, not attenuated, not constricted at cross walls, 12-15 \( \mu \)m broad, cells 1/3-1/6 as long as broad 2-4 \( \mu \)m long cross walls granulated, end cells flat rounded not capitate.
12. Oscillatoria sancta (Kutz.) Gomont
Desikachary 1959, pp. 203; Pl.42, fig 10
Pl. IIIa fig. 10.
Thallus dark blue green, shining, gelatinous, trichomes straight, constricted at cross walls, ends attenuated, 10-20 \( \mu \)m broad, 2.5-6 \( \mu \)m long, granulated at the cross walls, end-cell flattened hemispherical, with thickened membrane.
13. Phormidium subincrustatum Fritsch et Rich
Desikachary 1959, pp 267.
Pl. IIIa fig. 13.
Filaments parallel, sheath thin, trichome 4.5-5 \( \mu \)m broad, end cell rounded.
14. Lyngbya martensiana Menegh. Ex Gomont Var. calcarea Tilden
Desikachary 1959, pp 318; Pl. 52, fig. 6
Pl. IIIa fig. 14.
Filaments 6.5-\( \mu \)m in diameter, straight, flexible, sheath distinct, colorless, smooth. Trichomes 5-6.5 \( \mu \)m in diameter, not constricted, apex of trichome not tapering, cells content blue green, cells about 2.5 \( \mu \)m in length.
15. Plectonema radiosum (Schiederm.) Gomont
Desikachary 1959, pp 437; Pl. 83, fig.6, 8
Pl. IIIa fig. 18.
Filaments irregularly curved, reddish brown; false branches geminate; sheath in lower part of filament thick, lamellated, golden yellow; in upper parts thin, cells constricted at cross wall, cross wall granulated, 10.5-11.5 \( \mu \)m broad, 6-7.5 \( \mu \)m long, end cell rounded.
16. Microcoleus paludosus (Kutz.) Gomont
Desikachary 1959, pp 344; Pl. 56, fig. 2
Pl. IIIa fig. 16.
Filaments single forming a dark blue green stratum, unbranched, sheath slightly gelatinous, with many rope like trichomes, trichomes blue green, trichomes not granulated at cross walls, constricted at cross walls, 5-7.5 \( \mu \)m broad, cells as long as broad, 4-12 \( \mu \)m long, end cell slightly conical.
17. Microcoleus vaginatus (Vaucher) Gomont
Desikachary 1959, pp. 334; Pl.56, fig. 3
Pl. IIIa fig. 15.
Filaments single, creeping forming a dark green thallus, coiled, sometimes sparsely branched, sheath colourless, uneven, often agglutinated with one another, attenuated at the ends; cells 3.5-4.5 \( \mu \)m broad, cells 6-7.5 \( \mu \)m long, often granulated at cross walls, not constricted, dirty green; end cells capitiate with a flat conical calyptra.
18. Scytonema amplum West et West
Desikachary 1959, pp. 469; Pl.89, fig. 4
Pl. IIIa fig. 19.
Thallus small wrinkled, brownish, filaments 20-24 \( \mu \)m broad, false branches sparse, 13-16 \( \mu \)m in diameter. False branches are narrower than main filament, sheath broad with parallel lamellate, cell twice or more as length, heterocyst 3-4 time longer than breadth.
19. Scytonema hofmanni Ag. Ex Born. et Flah
Desikachary 1959, pp. 476; Pl. 91, fig. 2
Pl. IIIa fig. 20.
Thallus blackish blue green, filaments 8-12 \( \mu \)m broad, false branches aggregated, sheath firm, membranous, trichome 6-10 \( \mu \)m broad, heterocyst nearly oblong.
20. Scytonema pseudohofmanni Bharadwaja
Desikachary 1959, pp. 478; Pl. 94, fig. 2
Pl. IIIa fig. **
Filaments 13-13.5 \( \mu \)m broad, false branched, sheath firm, 1-1.5 \( \mu \)m thick, trichome 7.5-8 \( \mu \)m broad, cells cylindrical; heterocyst single ellipsoidal, 13.5 \( \mu \)m long 10.5 \( \mu \)m broad.
21. Nostoc microscopicum Carm. ex Born. et Flah
Desikachary 1959, pp. 387, 388
Pl. IIIa fig. 17.
Thallus spherical, filaments loosely entangled, sheath distinct, yellowish, trichome 5.6 \( \mu \)m broad, blue-green, cells sub-spherical, heterocyst nearly spherical 7 \( \mu \)m broad.
22. Tolypothrix fragilis (Gardner) Geitler
Desikachary 1959, pp. 500; Pl.103, fig. 4
Pl. IIlb fig. 23
Filaments 6.5-7 µm broad, short straight, forming a thin thallus, sheath colorless not lamellated, at the bottom of the branch, trichome 5.5-6.5 µm broad, not constricted at the cross walls, cells in the older parts of the trichome as long as broad heterocyst spherical.

23. Tolypothrix crassa West et West
Desikachary 1959, pp. 504 fig. **
Pl. IIIb fig. 22.
Thallus thick, spongy, blackish green, filaments 25-28 µm broad densely entangled; sparsely false branched, sheath very thick, firm, distinct, dirty yellow, cells nearly quadratic, 12-14.5 µm broad, blue green, heterocyst single nearly quadratic.

RESULT AND DISCUSSION

Biofilms from old buildings/ monuments from 11 localities were collected and analyzed for the cyanobacterial diversity. Localities from which biofilms were collected comprised of 7 temples two forts and two old buildings. The study revealed occurrence of 23 species belonging to 14 genera. Of these 6 were unicellular and 8 were filamentous. Genus Oscillatoria was represented maximum by 4 species. The biofilms from Yewteshwar temple showed maximum number of species (10) while biofilms from facades of Willingdon college showed 4 species followed by exterior of Sagareshwar temple (2). Relatively higher number of organisms were recorded in the biofilms collected from the buildings at higher altitudes e.g. Yewteshwar temple, Pateshwar temple, temple from Mahabaleshwar (Lingamala) while comparatively less forms were detected in the biofilms collected from the localities situated at lower altitude.

Analysis of these results revealed the taxa of cyanobacteria like Gloeocapsa kuetzingiana, G. atrata, Gloeotheca rupestris, Microcoleus paludosus, M. vaginatus, Nostoc microscopicum, Tolypothrix fragilis are similar to those occurred in biofilms on the surfaces of monuments or temples in Bhubaneswar recorded earlier (Tripathy et al. 1997, 1999). While the others were different and specific to the building facades of Western Maharashtra. Further studies on understanding the physiology and ecology of the cyanobacterial forms occurring in the biofilms of sub-aerial habitats need further investigation.

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