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Soil Crust Algae of Similipal Biosphere Reserve (SBR), Odisha

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Abstract: Cyanobacteria and microalgae are important components of biological soil crusts (BSC) as they improve soil structure, stabilize soil erosion, enhancing plant seedling establishment and increase of infiltration of rain water into soil. During present study, algal samples were collected from 3 sampling sites namely Badamakabadi, Chahala and Barehipani of the Similipal Biosphere Reserve (21°28" and 22°08" N; 86°04" and 86°37" E) and documented. A total of 14 algal taxa were recorded comprised of 9 species of cyanobacteria and 5 green algae. The major dominant cyanobacterial taxa were *Scytonema* (3) followed by single species each of genera *Gloeocapsa*, *Psudocapsa*, *Leptolyngbya*, *Porphyrosiphon*, *Synechocystis* and *Tolypothrix*. Chlorophyta occurred both in coccid and filamentous forms were recorded single species each of *Coccomyxa*, *Microspora*, *Cylindrocapsopsis*, *Ulothrix* and *Trentepohlia*. The light and the humidity of the forest type may be the factors of the cyanobacterial abundance than the green algal forms. Cyanobacterial species under genera *Scytonema, Tolypothrix* and *Leptolyngbya,* one green algae *Coccomyxa* were isolated into pure form for the purpose of germplasm collection.

Key words: Algae, Soil crusts, SBR, Odisha.

Introduction

Terrestrial algae usually live on stable exposed surfaces above the soil [22] perhaps the most obviously neglected group of algae. They grow rich in form of green, red, brown or black patches on wide range of surfaces including rocks, building walls, wood surfaces, metal, tree bark and leaves of trees and on surface of animals [21]. Biological soil crusts are usually composed of multiple, unrelated organisms that occur together on the soil surface that share some interesting physiological traits. They are generally formed by micro-organism viz. algae, cyanobacteria, fungi, lichen and sometimes bryophytes which are closely associated with the substratum forming a mat like structure [3,24]. Such crusts occur on a variety of substratum ranging from exposed rock to hot desert, arid areas, forest soils and rice fields [1,6,14]. Biological soil crusts have both macro and microscopic components. The phototrophic microbial communities, mainly the terrestrial algae are important components of soil ecosystem around the world and found on the surface of soil crust [10] and remain in dormant condition during desiccation. However, these organisms in tropical countries like India breaks dormancy within few hours of receiving water especially during monsoon [20].

Soil crust cyanobacteria and eukaryotic micro-algae are important components of these environments around the world improve soil structure, stabilize the soil against erosion, and increase infiltration of rain water into soil enhancing plant seedling establishment [13]. However, little information is available on the composition of cyano-bacteria and algal communities in the biological

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soil crusts, especially in the Indian subcontinent [32]. The Similipal Biosphere Reserve, Odisha in this context is an unexplored habitat which needs to be assessed for soil crust algal diversity.

Materials and methods

The study sites

Similipal Biosphere Reserve is extended over an area of 5569 km^2 is located in the central part of the Mayurbhanj district of Odisha. Similipal lies between 21° 28" and 22° 08" North latitude and 86° 04" and 86 ° 37" East longitudes. The surface soil has been eroded exposing subsoil and parent rock at most of the places. Similipal hills mostly produce a reddish soil. The climate of SBR is subtropical with warm and humid summer temperature over around 40°C during the peak of the season. The area gets an average annual rainfall of 1850 mm from the South-West monsoon (June to September) and the retreating North-East monsoon (November). Humidity varies between 70 to 100% in core region due to the presence of dense forest (Fig. 1).

Sampling of soil crust algae

The algae, occurring as biological soil crusts, scrapped from their substratum using forcep or scalpel. For demarcation and area calculation a periphery was drawn using a Petridish and crusts were taken from those regions only. All the samples

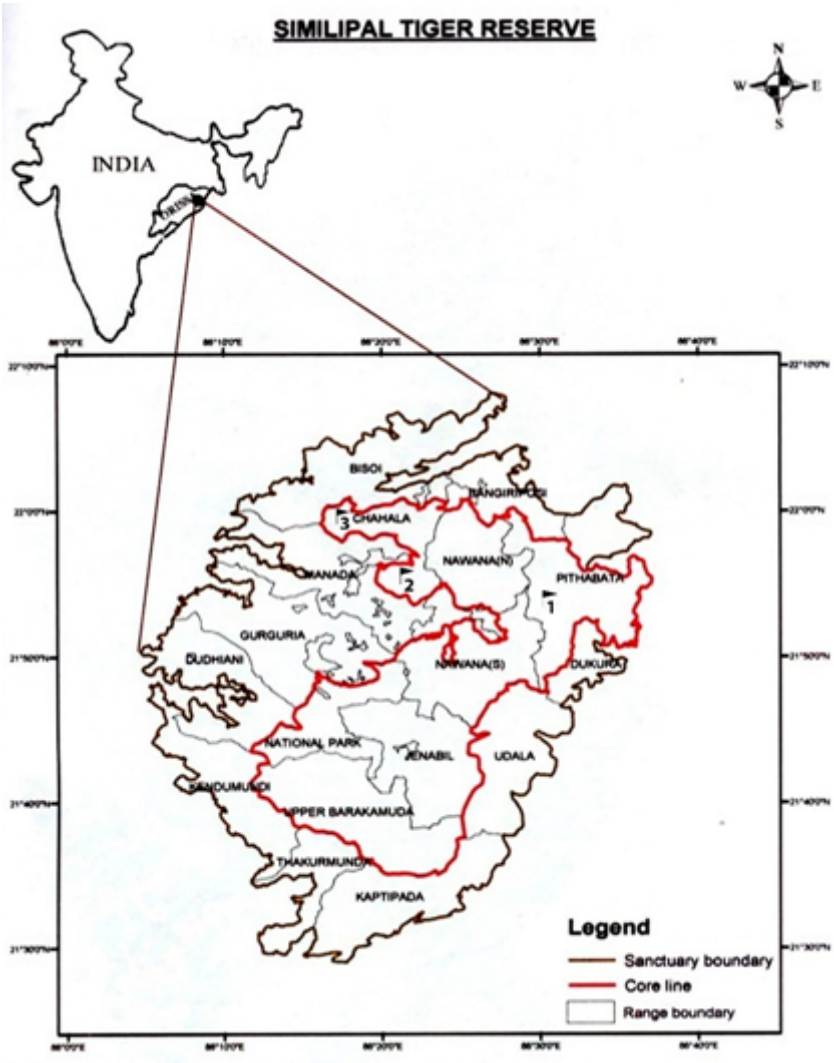


Fig. 1. Sampling sites of biological soil crust from Similipal Biosphere Reserve (1-3): 1. Badamakabadi, 2. Barehipani, 3. Chahala

were collected in sterile specimen tubes (Tarson) of 25 X 50 mm size and brought to the laboratory for further analysis (Plate 1). For preservation, the samples were dried and kept in a dark place assigned with a voucher number in Department of Botany, North Orissa University, Baripada, Mayurbhanj, Odisha.

Microphotography, Micrometry and Identification

For identification of certain taxa under cyanophyta and chlorophyta, which was otherwise difficult with natural sample because of the crust and soil type, the collected samples were first soaked with distilled water in a petriplate and incubated under white fluorescence light. The growth was observed under microscope at 24 hrs interval. The pH of the soaked water also recorded in the lab condition. After growth observation each filament or colony or a consortia was taken for microscopic photography. Two to three slides were prepared from each sample and observed under compound and/or phase contrast microscope, and the characters were enumerated. Microphotographs were taken using Hund Wetzlar Trinocular Research Microscope with Canon-EOS 550D camera attachment. Micrometry was done using ocular and stage micrometers (Erma, Japan) to determine the cell dimensions. The algal species were identified using the monographs and standard literatures as follows: Geitler [12], Desikachary [8], Randhawa [30], Prescott [28], Ramanathan [29], Philipose

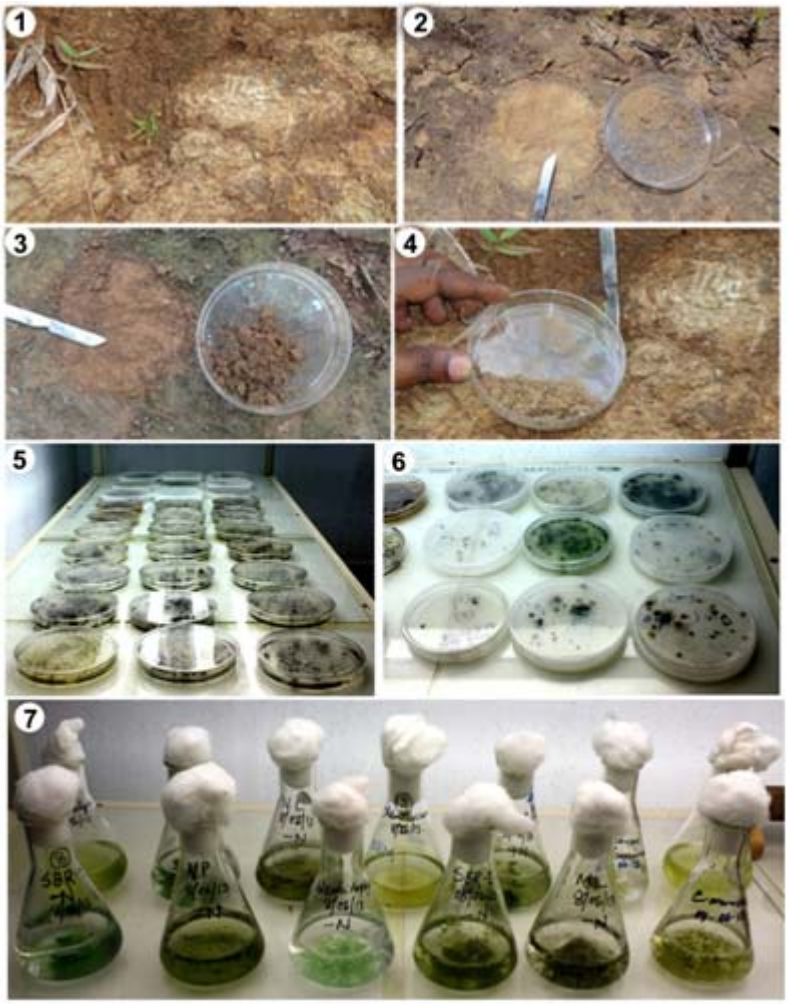


Plate 1. (Figs. 1-7). Collection and isolation of soil crust algae from Similipal Biosphere Reserve, Odisha; **1-4:** Mode of occurrence of soil crust algae and sampling; **5-7:** Isolation and pure culture of soil crust algae for germplasm collection

[25], Prasad & Srivastava [26], Prasad & Misra [27], Ettl & Gärtner [9]. Komárek & Anagnostidis [16], Krishnamurthy [19], Komárek & Anagnostidis [17].

Culture conditions and maintenance

The identified algal samples were cultured in agar slants in screw cap glass tubes containing 1.2 % (w/v) agar-agar in the basal inorganic medium and in 100 ml capacity conical flasks containing 50 ml medium. The axenic cultures were maintained in culture racks in a temperature-controlled room at 25±1°C under continuous light intensity of 7.5 W/m² from day light fluorescent tubes and examined from time to time (Plate 1).

Statistical analysis

Relative abundance 'A' (%): Y/X (100)

Where, X= Total number of samples collected; Y= Number of samples from which a particular species identified.

Sorenson's community similarity coefficient

(CC) = 2C/S1+S2

Where C = Number of species the two community have in common; S1 & S2 = Total number of species found in individual community.

Results and discussion

In the present investigation a total of 14 algal species were recorded from the biological soil crusts of Similipal Biosphere Reserve belonging to two major classes i.e. Cyanophyceae and chlorophyceae. Mainly Cyanophyceae have 9 species belonging to 7 genera and Chlorophyceae having 5 species under 5 genera. Of these, 9 species belong to Cyanobacteria the genus *Scytonema* found dominant with 3 species viz. *Scytonema burmanicum*, *Scytonema schmidtii, Scytonema guya-nense* followed by other genera with single species each i.e. *Gloeocapsa novacekii*, *Psudocapsa dubia, Leptolynbya cebennensis, Porphyrosiphon notarisii, Synechocystis pevalekii* and *Tolypothrix campalenemoides.* All five genera of Chlorophyceae occurred with a single species each i.e. *Coccomyxa confluens*, *Microspora* sp., *Cylindrocapsopsis indica*, *Ulothrix tenerrima* and *Trentepohlia tenuis* (Table 1). Similar to the present result, the blackish brown soil crusts in Indian climate give rise mainly cyanobacteria but onset of rain due to monsoon several green algal

Table 1. Distribution of algae on biological soil crust in different sampling sites (1. Badamakabadi, 2. Barehipani, 3. Chahala) and their relative abundance

No.	Algal Taxa	1	2	3	Relative Abundance %
	Cyanoprokaryota/Cyanophyta				
1	*Synechocystis pevalekii* Ercegoviæ	+	+	-	13.3
2	*Gloeocapsa novacekii* Komárek et Anagnostidis	-	-	+	20.0
3	*Pseudocapsa dubia* Ercegoviæ	-	-	+	13.3
4	*Leptolynbya cebennensis* (Gomont) Umezakiet Watanabe	+	+	-	13.3
5	*Porphyrosiphon notarisii* Kützing ex Gomont	+	+	-	13.3
6	*Scytonema burmanicum* Skuja	-	+	-	26.6
7	*Scytonema schmidtii* Gomont	-	+	-	20.0
8	*Scytonema guyanense* (Mont.) Born. et Flah	-	+	+	20.0
9	*Tolypothrix campylonemoides* Ghose	-	+	+	13.3
10	**Chlorophyta**				
10	*Coccomyxa confluens* (Kütz) Fott	+	-	-	6.67
11	*Microspora sp.*	+	-	+	20.0
12	*Cylindrocapsopsis indica* Iyengar	+	-	-	6.67
13	*Ulothrix tenerrima* Kützing	+	-	-	6.67
14	*Trentepohlia tenuis* (Zell) De Toni	+	-	-	6.67

genus occurs [2].

Relative abundance percent showed that *Scytonema sp.* are most abundant in these habitats. The Sorenson's similarity coefficient between the sampling sites showed the index value between site 1, 2 (0.5); 1, 3 (0.17) and 2, 3 (0.4) respectively. However, due to the similar ecological niche the frequency of algal taxa is not mentioned in enumeration. Reports are available on more algal forms found in the biological soil crusts, such populations occur when there is combination of high temperature with high humidity [31].

Systematic enumeration

I. Division: Cyanophyta (Cyanoprokaryota/ Cyanobacteria)
Class: Cyanophyceae
Order: Croococcales
Family: Microcystaceae
Genus: *Synechocystis* Sauvageau
1. *Synechocystis pevalekii* Ercegovic (Plate 2, Fig. 5)

Komárek and Anagnostidis 1999, P. 143, Fig. 163

Thallus unicellular or colonial, bluish green in colour, mucilaginous on adverse condition,

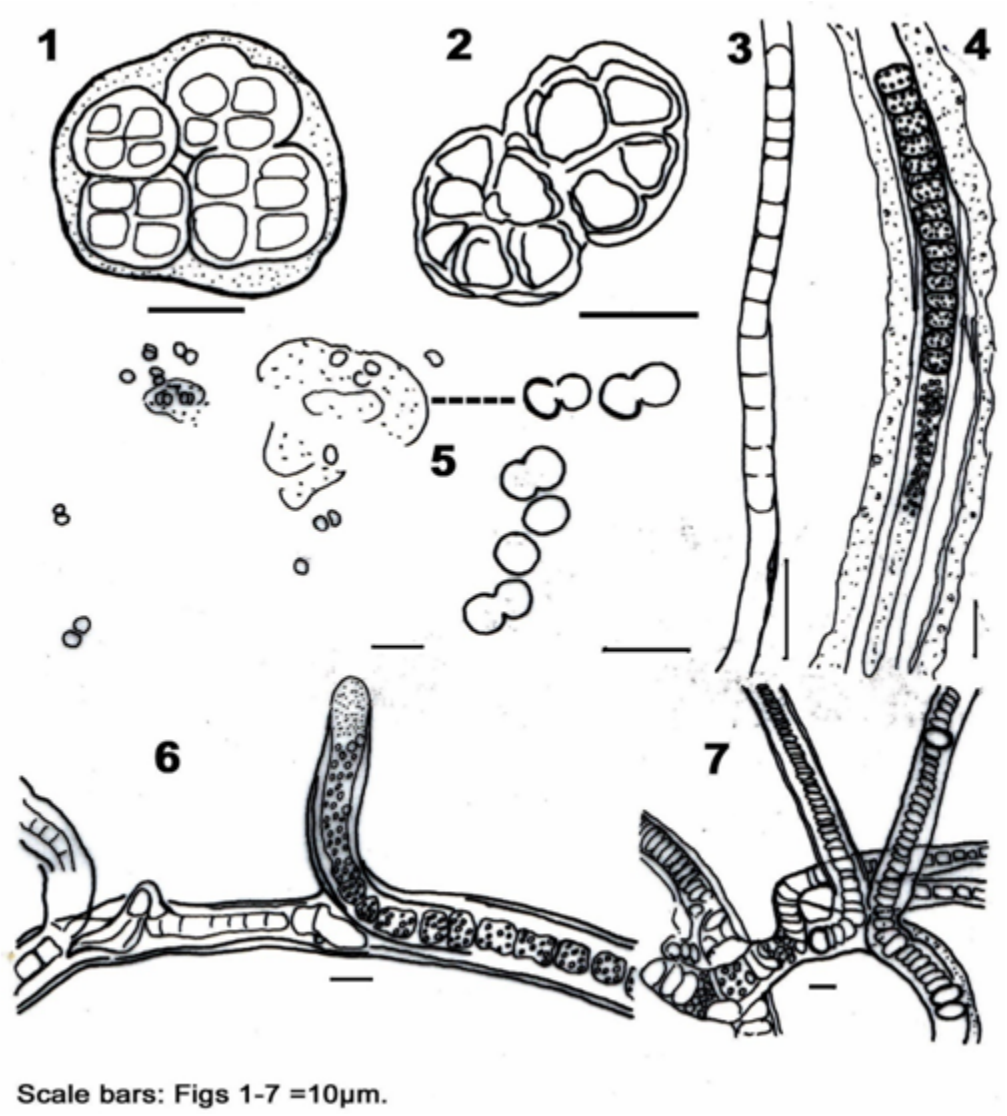


Plate 2. (Figs. 1-7). 1. *Gloeocapsa novacekii* **2.** *Psudocapsa dubia* **3.** *Leptolynbya cebennensis* **4.** *Porphyrosiphon notarisii* **5.** *Synechocystis pevalekii* **6.** *Scytonema burmanicum* **7.** *Scytonema schmidtii*

mucilage brownish to pale yellow, cells spherical to hemispherical, cell content homogenous , semi cells or dividing cells 8-10 µm in diameter.
Habitat: Bluish green crust in soil, Badamakabadi; Voucher no. 7; Date of collection: 10.05.13.

Genus: *Gloeocapsa* Kützing

2. *Gloeocapsa novacekii* Komárek and Anagnostidis (Plate 2, Fig.1)
Komárek and Anagnostidis 1999, P. 252, Fig. 328

Thallus colonial, mucilaginous, blackish patch on soil surface, brown to pale bluish green in color after soaking in water. Mucilage lamellated, just copying the cell surface, sheath on each cell as well as on colony, distinct, colony spherical to irregular in shape, cells hemispherical, granulated, 3.54 µm long, 5.31 µm broad.
Habitat: Blackish crust in rocky soil, Chahala; Voucher no. 64; Date of collection: 10.05.13

Family: Chroococcaceae, Genus: *Pseudocapsa* Ercegovic

3. *Pseudocapsa dubia* Ercegovic (Plate 2, Fig. 2)
Komárek and Anagnostidis 1999, P. 318, Fig. 426

Thallus brownish, colonial, colony rounded to irregular cells, irregular in out line, brownish in colour, 4.7 µm in long, 2.82 µm to 3.76 µm broad.
Habitat: Blackish crust in rocky soil, Chahala; Voucher no. 51; Date of collection: 10.05.13.

Order: Oscillatoriales, Family: Pseudanabaenaceae, Genus: *Leptolyngbya* Anagnostidis et Komàrek

4. *Leptolynbya cebennensis* (Gomont) Umezakiet Watanabe (Plate 2, Fig. 3)
Komárek and Anagnostidis 2005, P. 192, Fig. 631

Thallus bluish green, filamentous enlarged, trichome solitary, sheathed, slightly constricted at cross wall, cells slightly longer than broad 1.56 µm long, 2.6 µm broad, cell content slightly granulated, apical cell broadly rounded.
Habitat: Bluish green crust in rocky soil, Chahala; Voucher no. 49; Date of collection: 10.05.13.

Family: Phormidiaceae, Genus: *Porphyrosiphon* Kützing ex Gomont

5. *Porphyrosiphon notarisii* Kützing ex Gomont (Plate 2, Fig. 4)
Komárek and Anagnostidis 2005, P. 501, Fig. 751,752

Thallus bluish green, solitary or in a group, sheathed, unbranched, sheath thick- 6.0 µm in wide, lamellated, trichome slightly constricted at cross wall, necredia or degenerating cells present, cells rectangular, 5.0 µm long, 8.0 µm broad, cell content granular, apical cell widely rounded, trichome shrinks into attenuated part on diverse condition.
Habitat: Bluish green crust in soil, Badamakabadi; Voucher no. 7; Date of collection: 10.05.13.

Order: Nostocales, Family: Scytonemataceae, Genus: *Scytonema* Ag.

6. *Scytonema burmanicum* Skuja (Plate 2, Fig. 6)
Desikachary 1959, P. 460, Pl. 97, Figs. 1-9

Thallus brownish, sheathed, sheath lamellated, brownish to clear, thick 4.3 µm, broad, filament pseudo branched, trichome slightly constricted at cross walls, heterocyst intercalary, rectangular to compressed, cells barrel shaped to compressed, broader than long, 8.6 µm long, 7.2 µm to 10 µm broad, cell content granular.
Habitat: Blackish crust on soil, Barehipani; Voucher no. 47; Date of collection: 10.05.13.

7. *Scytonema schmidtii* Gomont(Plate 2, Fig. 7)
Desikachary 1959, P. 459, Pl. 92, Fig. 1

Thallus brownish, sheathed, sheath lamellated, brownish, thick 4.3 µm, broad, filament pseudo branched, profusely branched, trichome slightly constricted at cross walls, heterocyst intercalary, oval to compressed, cells compressed, broader than long, 5 µm long, 10 µm broad, cell content granular.
Habitat: Blackish crust on soil, Barehipani; Voucher no. 47; Date of collection: 10.05.13.

8. *Scytonema guyanense* (Mont.) Born. et Flah (Plate 3, Fig. 1)
Desikachary 1959, P. 469, Pl. 92, Fig. 5

Thallus brownish, filamentous, heterocystous, pseudo branched, heterocyst intercalary or base of the pseudo branched, sheath thick, 16.25 µm to 10 µm broad, lamellated, cells broader than long, slightly constricted at cross wall, cell content granular 8.75 µm long, 13.75 µm broad, apical

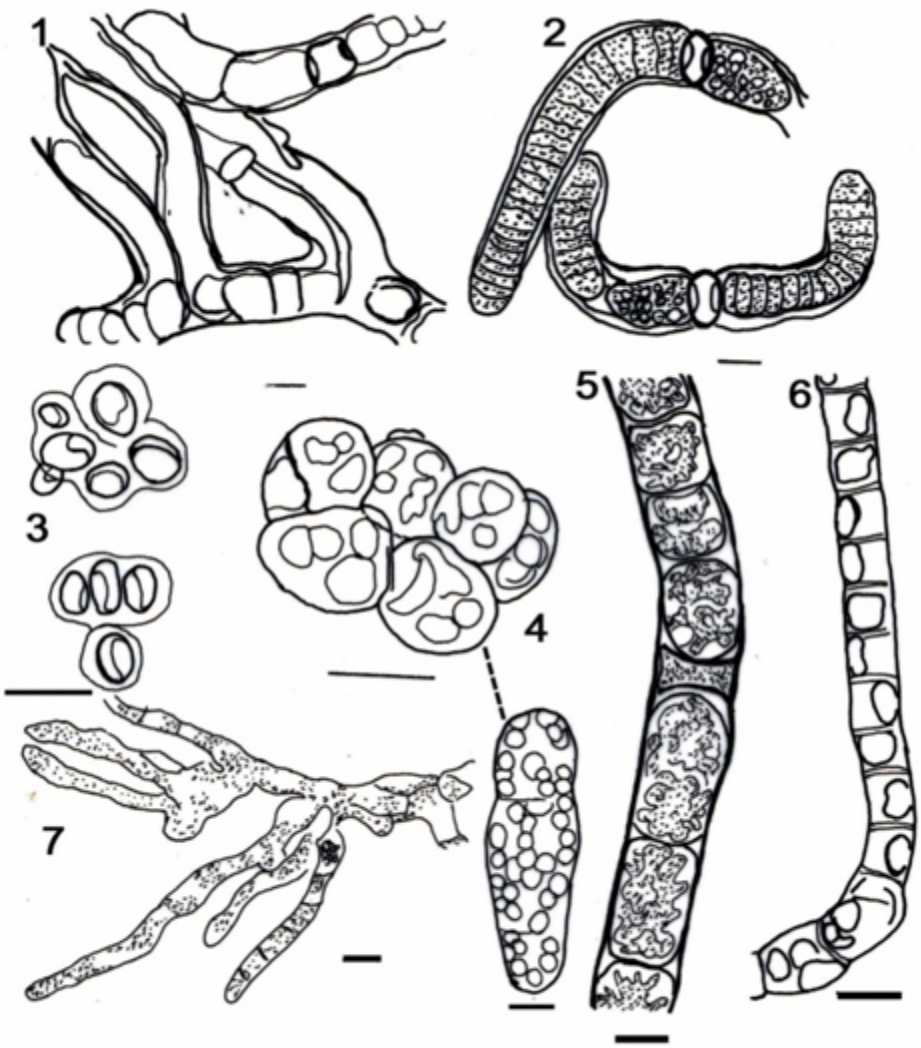
cell widely rounded ends.
Habitat: Blackish crust on rock, Chahala; Voucher no. 51; Date of collection: 10.05.13.

Genus: *Tolypothrix* Kützing

9. *Tolypothrix campylonemoides* Ghose (Plate 3, Fig. 2)
Geitler 1925, P. 258, Fig. 307

Thallus brownish, filamentous, heterocystous, pseudo branched, filament crescent shaped, both ends erected slightly upwards, heterocyst intercalary or base of the pseudo branch, sheath thick, 16.25 µm to 10 µm broad, not lamellated, cells broader than long, slightly constricted at cross wall, cell content granular 8.75 µm long, 13.75 µm broad, apical cell slightly narrowed to a widely rounded ends.
Habitat: Blackish crust on rock, Chahala; Voucher no. 51; Date of collection: 10.05.13.

II. Phylum: Chlorophyta
Class: Charophyceae
Order: Chlorococcales
Family: Radiococcaceae



Scale bars: Figs 1- 6 = 10µm; fig. 7 =20µm

Plate 3. (Figs. 1-7). 1. *Scytonema guyanense* **2.** *Tolypothrix campalenemoides* **3.** *Coccomyxa confluens* **4.** *Microspora* sp. (germinating spore and juvenile stage) **5.** *Cylindrocapsopsis indica* **6.** *Ulothrix tenerrima* **7.** *Trentepohlia tenuis*

Genus: *Coccomyxa* Schmidle

10. *Coccomyxa confluens* (Kütz) Fott (Plate 3, Fig. 3)

Komárek and Fott [18], P. 416, Pl. 126, Fig. 1

Thallus greenish, colonial, mucilaginous, mucilage hyaline, wide, rounded to irregular, cells oval, 2-8 in a colony, chloroplast parietal, homogenous, filled half of the cells, cells 5.58 µm long, 3.1 µm broad.

Habitat: Greenish crust on soil, Badamakabadi; Voucher no. 9; Date of collection: 09.05.13.

Order: Sphaeropleales, Family: Microsporaceae, Genus: *Microspora* Thuret

11. *Microspora* sp. (Plate 3, Fig. 4)

Thallus greenish, greenish, cells rounded in prostrate thallus, filamentous, cross wall plane, elongated to barrel shaped in erect thallus, chloroplast degenerative, cells 9.54 µm long, 9.01 µm broad, cell division transverse.

Habitat: Crust on rock surface, Chahala; Voucher no. – 67; Date of collection: 10.05.13.

Genus: *Cylindrocapsopsis* Iyengar

12. *Cylindrocapsopsis indica* Iyengar **(**Plate 3, Fig. 5)

Ramanathan 1964, P. 152, Pl. 42, Figs. A-X

Thallus greenish, filamentous unbranched, cells elliptical to barrel shaped arranged end to end, chloroplast asteric, granulated, cross wall plane, cell wall mucilaginous, cells 14.56 µm long, 17.92 µm broad.

Habitat: Crust on soil, Badamakabadi; Voucher no. 9; Date of collection: 09.05.13.

Class: Ulvophyceae, Order: Ulotrichales, Family: Ulotrichaceae, Genus: *Ulothrix* Kützing

13. *Ulothrix tenerrima* Kützing (Plate 3, Fig. 6)

Ramanathan 1964, P. 37, Pl. 10, Figs. A-C

Thallus greenish, filamentous, unbranched, elongated, cross wall plane not constricted, cells 8.4 µm long, 7.56 µm broad, chloroplast girdle shaped, vacuolated.

Habitat: Crust on soil, Badamakabadi; Voucher no. 9; Date of collection: 09.05.13.

Order: Trentepohliales, Family: Trentepohliaceae, Genus: *Trentepohlia*

14. *Trentepohlia tenuis* (Zell) De Toni (Plate 3, Fig. 7)

Prasad and Mishra, 1992, Pl. 10, Fig. 4-6

Thallus brownish to pale green in colour, branched, sub aerial, filament nodular, cells elongated to bulged intercalary position, cross wall plane, cells long, broad, apical cells narrowly rounded, cell content granulated.

Habitat: Crust on soil, Badamakabadi; Voucher no. 7; Date of collection: 09.05.13.

The study reveals, cyanobacteria occurred dominant in the samples having less moisture content, whereas green algae in the sample having more moisture. This may be due to presence of thick sheath and mucilaginous envelop produced during adverse conditions. As pH of the distilled water after soaking the organism overnight ranges from 5.9 - 6.8 and remains slightly acidic, the crust organisms upon wetting leach nutrients into surrounding medium resulting favorable environment for the growth of these algae. However, low pH known to be intolerant for the growth of blue green algae and lower cyanophyte number in forest in comparison to other previous records may reflect this characteristics [4,5]. With respect to summer sampling, the lower diversity is may be due to decline in pH.

The organisms collected from the core regions of the forest were mainly blue-greens and green algae occur in the samples collected from the buffer region. Light may be one of the limiting factors which control the growth of these organisms. Although some algae are capable of heterotrophic growth, nutritive correlation known to occur with photoautotrophic and the present observation of decline were probably due to obligate autotrophic metabolism of algae [23,33]. Cyanobacterial species under genus *Scytonema, Tolypothrix* and *Leptolyngbya,* and one green algae under genera *Coccomyxa* were isolated into pure form and deposited in the P.G. Department of botany, North Orissa University with an assigned strain number for the purpose of germplasm collection. This result shows that the cultivable forms were the main counterpart of the biological soil crusts of these typical locations associated with the other reported algal species.

Conclusion

Though soil crust algae are economically and

ecologically significant, it have been poorly studied for their diversity when compared to freshwater and marine algae. However, majority of the taxonomic work were carried out during 19th century. The recent works were only few and mostly focused on different aspects on bioprospecting and bio-deterioration [7,11,15]. Since morpho-taxonomy is a basic datasets for molecular phylogeny the present study is most significant from the locality and the further study correlating the molecular aspects through polyphasic approach is needed to explore the soil crust algal diversity.

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