Research article

Chlorophycean algae in Khumbu Himalaya region of Nepal, including four new records.

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Abstract
A study was conducted to document the chlorophycean algae in the waterbodies of Sagarmatha National Park and Buffer zone, Solukhumbu, Nepal. A total 27 taxa of green algae including four new records were identified. The following algae viz., Euastrum oblongum, Penium cylindrus, Scenedesmus quadricauda and Spirogyra amplectens were found new to Nepal. These species were collected from running water, stagnant water, rocky and sloppy moist habitats at Pheriche, luza khola, below 1st lake, in 1st lake, Namche and Larcha dovan between 2700-4600 m elevation. Copyright © WJSTR, all rights reserved.

Key words: Algae, Chlorophyceae, Sagarmatha National Park, Khumbu Himalaya, Nepal

Introduction
Information about taxonomy and diversity of algae in Nepal is inadequate, particularly from high lands of Nepal. Hutchinson (1937) observed algae in two high altitude lakes of Nepal. More than 176 taxa from high altitude Himalayan region of eastern and central Nepal were recorded by Hirano (1963, 1984), which is the major contribution in the Nepalese algal flora. Suxena et al. (1972), Hickel (1973), Shrestha and Manandhar (1983), Ishida (1986), Aizaki (1987), Habib (1997), Rothfritz et al. (1997), Rai (2005) and Ghimire et al (2012a) and Ghimire et al (2012 b) have also made important contribution in high altitude algal flora of Nepal. Loffler (1960) studied the lakes in Khumbu valley and mentioned very poor phytoplankton assemblages. Ruggia et al. (1998) identified thirteen species were, most of them were not recorded previously in the Khumbu region. Kumar and Rai (2005) also recorded 13 taxa of chlorophyceae from Sikkim-Himalayas. These studies on chlorophyceae provide new information and the paper focuses on the enumeration of chlorophyceae in high altitude area in Sagarmatha National Park (SNP), Nepal.
Materials and Methods

Study Area: SNP located in the southern slope of Sagarmatha (Mt. Everest), lies in the Solukhumbu district of the north eastern region of Nepal and covers 1148 sq. km (Fig. 1). It ranges between 27°30'19" and 27°06'45"N latitude to 86°30'53" to 86°06'45"E longitude. The park is characterized by rugged topography with altitude ranging from 2845 m at Jorsalle to 8848 m at the top of Mt. Everest. About 80% of the precipitation falls in the monsoon season from June to September. An average minimum temperature is in January where as maximum during August (-7.7 to 16.2°C). Four major rivers namely Dudh Koshi, Lobuche Khola, Imja Khola and Bhote Koshi drain from north to south. Dudh Koshi originates from Ngozumpa glacier and Gokyo lake system. Lobuche Khola originates in Khumbu Glacier, and Imja Khola from Imja Lake and Glaciers. The Lobuche and Imja Khola meet with each other below Dingboche and in Imja Khola. This Imja Khola meets Dudh Koshi below Phortse, and again called Dudh Koshi. Bhote Koshi originates in Tibet and it meets Dudh Koshi at Larjado dbhan below the Namche Bazar. Several tributaries feed these major river systems. The major lake systems in the SNP are Imja and Gokyo.

Figure 1: Map showing sampling points, Sagarmatha National Park.

Sample collection

Three visits to SNPBZ were made in October, 2007; May, 2008 and October, 2008 for exploration of algae. The sampling sites were mostly selected along the trekking routes from Lukla to Everest base camp, Gokyo, Imja Lake and Thame (Fig. 1). Samples of algae were collected from different corners of lakes, different sides of
rivers as well as moist rocks near water courses between 9:00 to 12:00 am. Samples were preserved in 4% unbuffered formalin and collected into plastic bottle. Identification of species was made by the use of a Leica binocular microscope and consulting relevant monographs. The classification of taxa was done according to Prescott (1951). Forty five samples (fifteen in each visit) were collected from three visits.

Results and Discussion

A total of twenty seven chlorophyceaean algae under 20 genera were recorded from SNP and its buffer zone area, a high altitude region, Nepal (Table 1). Out of these, 20 algae were identified up to species level where as seven were identified only up to genus level. Twenty genera were Actinotaenium (1 sp.), Bulbochaete (1 sp.), Chlorella (1 sp.), Closterium (1 sp.), Cosmarium (4 spp.), Cylindrocapsa (1 sp.), Cylindrocystis (1 sp.), Euastrum (2 spp.), Hyalotheca (1 sp.), Mougeotia (1 sp.), Nettia (1 sp.), Oedogonium (1 sp.), Pediasastrum (1 sp.), Penium (1 sp.), Phacus (1 sp.), Scenedesmus (4 spp.), Sphaerocystis (1 sp.), Spirogyra (1 sp.), Staurastrum (1 sp.) and Zygnema (1 sp.). In the present study, four algal taxa viz., Euastrum coralloides Jos. var. trigibberum Lagerheim, Euastrum oblongum (Grev.) Ralfs ex Ralfs, Penium cylindrus (Ehr.) ex Bréb. and Spirogyra amplectens Skuja were reported for the first time from Nepal.

Generally unicellular, colonial algae and desmids were found to be dominant in stagnant waters where as filamentous green algae were common in both running and stagnant water bodies. Due to chilling temperature, chlorophyceaean algae were not as much dominant as in warm climate of Terai of the country.

Green algae common to this area like Closterium, Scenedesmus, Cosmerium, Spirogyra genera have also been reported from Sikkim Himalaya range, 300-5,500 m elevations (Kumar and Rai, 2005). Yoshimura et al. (1997) also reported five species of algae from Yala glacier, central Nepal (Lantang region). Among them one species Cylindrocystis brebissonii is also found in Khumbu region. Takeuchi et al. (1998) also reported Cylindrocystis brebissonii from Himalayan glacier (Shorong region of East Nepal) altitude between 4950-5380 m.

Table 1: Chlorophyceaean algae from Sagarmatha National Park and Buffer Zone.

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Species</th>
<th>Locality</th>
<th>Altitude (m)</th>
<th>Habitat</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Actinotaenium cf. subgloboseum</td>
<td>Larcha dovan</td>
<td>2700</td>
<td>Stagnant water at edge of Duddh kosi river</td>
</tr>
<tr>
<td>2</td>
<td>Bulbochaete sp.</td>
<td>1st Lake gokyo</td>
<td>4660</td>
<td>From outlet of 1st lake Gokyo</td>
</tr>
<tr>
<td>3</td>
<td>Chlorella vulgaris</td>
<td>Between 1st and 2nd lake</td>
<td>4650</td>
<td>Slow running water</td>
</tr>
<tr>
<td>4</td>
<td>Closterium acerosum</td>
<td>Between 1st and 2nd lake, Namche, Pheriche, Thamo, 2nd and 3rd lake</td>
<td>3400-4700</td>
<td>Running water</td>
</tr>
<tr>
<td>5</td>
<td>Cosmarium subspeciosum</td>
<td>Luza, Pheriche</td>
<td>4300</td>
<td>Stagnant as well as running</td>
</tr>
<tr>
<td>6</td>
<td>Cosmarium awadhense</td>
<td>Thame, 1st lake</td>
<td>3700-4660</td>
<td>Stagnant water</td>
</tr>
<tr>
<td>7</td>
<td>Cosmarium cf. sublateriundatum</td>
<td>Larcha dovan</td>
<td>2700</td>
<td>Stagnant water with rocky habitat</td>
</tr>
</tbody>
</table>
8. *Cosmarium nudum* Just below to 1st lake 4600 Moist sloppy rocks

19. *Cylindrocapsa sp.* Namche spring 3400 Running water

10. *Cylindrocystis brebissonii* Luza khola 4300 Running water

11. *Euastrum coralloide var. trigibberum* Luza khola 4300 Running water

12. *Euastrum oblongum* Pheriche 4300 Stagnant water

13. *Hyalotheca dissiliens* Pheriche 4300 Stagnant water

14. *Mougeotia sp.* Below 1st lake, between 1st and 2nd lake, Luza, pheriche 4300-4700 Moist steep rocks, stagnant as well as running water

15. *Netrium digitus* Luza 4300 Running water

16. *Oedogonium sp.* Between pheriche and lobuche, 1st lake 4300-4660 Stagnant water

17. *Pediastrum duplex* Between pheriche and lobuche 4300 Stagnant water

18. *Penium cylindrus* Pheriche 4300 Stagnant water

19. *Phacus sp.* Namche 3400 Running water

20. *Scenedesmus bijugatus* Pheriche, Namche 3400-4300 Running water

21. *S. quadricauda* Just below to 1st lake, Pheriche 4300-4600 Sloppy moist rocky region and running water

22. *S. bijuga* Below pheriche and lobuche 4300 Stagnant water

23. *S. obliquus* Namche 3400 Running water

24. *Sphaerocystis Schroeteri* Between pheriche and lobuche 4300 Stagnant water

25. *Spirogyra amplectens* Below 1st lake, 1st lake, Namche, Larcha dovan 2700-4660 Rocky sloppy region, running water, stagnant water

26. *Staurastrum sp.* Larcha dovan, Luza, Namche, between 1st and 2nd lake, between pheriche and lobuche 2700-4700 Running as well as stagnant water

27. *Zygnema sp.* Lobuche khola, Just below to 1st lake, between 2nd and 3rd lake. 4700-4900 Moist rocky habitat as well as running water

(Source: field study, 2007-08)

Taxonomical descriptions of new algae are as follows:

1. *Euastrum coralloides* Josh. var. *trigibberum* Lagerheim (Fig. 2)
   - Class- Zygnematophyceae
   - Order- Desmidiales
   - Family- Desmidiaceae
   - Genus- *Euastrum*
   - Species- *E. coralloides*

   Cell 40 µm long, 30 µm broad; semicell has five facial swellings; isthmus 13 µm wide; thickness 19 µm.

2. *Euastrum oblongum* (Grev.) Ralfs ex Ralfs (Fig. 3)
   - Class- Zygnematoophyceae
   - Order- Desmidiales
   - Family- Desmidiaceae
Genus- *Euastrum*
Species- *E. oblongum*
Cell 148 µm long, 74 µm broad; a deep, closed median apical invagination, lateral invaginations many.

3. *Penium cylindrus* (Ehr.) ex Bréb.(Fig. 4)
   - Class- Zygnematoophyceae
   - Order- Zygnematales
   - Family- Peniaceae
   - Genus- *Penium*
   - Species- *P. cylindrus*
Cell 41 µm long, 11.5 µm broad, cylindrical with truncately rounded ends; cell wall dotted, bands present.

4. *Spirogyra amplectens* Skuja (Fig. 5)
   - Class- Zygnematoophyceae
   - Order- Zygnematales
   - Family- Zygnemataceae
   - Genus- *Spirogyra*
   - Species- *S. amplectens*
Vegetative cell 143 µm long, 18 µm broad; chloroplast single; conjugation lateral; zygospore 61 µm long, 36 µm broad, ellipsoid.

**Figure 2:** *E. coralloides var. trigibberum*  
**Figure 3:** *Euastrum oblongum*

**Figure 4:** *Penium cylindrus*  
**Figure 5:** *Spirogyra amplectens*

**Plate 1:** Photographs of new taxa of chlorophycean algae.
Acknowledgements

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References
