



ALGAL DIVERSITY OF HIGH ALTITUDE ZONES IN GOVIND WILD LIFE SANCTUARY, UTTARAKHAND, INDIA

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The present paper deals with the morpho-taxonomic account of some high altitude algal flora of Govind wild life sanctuary of Uttarakhand, Western Himalaya India. A total number of 20 Cyanophyceae, 17 Chlorophyceae, 9 Bacillariophyceae, 2 Euglenophyceae and 1 Chrysophyceae taxa were reported for the first time from this region.

Key words: Biodiversity, high altitude, Protected area, Western Himalaya

Fresh water algal flora of Uttarakhand have been extensively studied by several researchers. To mention a few Khanna and Singh (2000) studied seasonal fluctuations in the plankton of Suswa River at Raiwala, Dehradun. Gupta (2003) enumerated a total of 318 algal species from Dehradun district. Kanawal and Pathani (2012) reported 63 taxa of Chlorophyceae, 40 taxa of Bacillariophyceae, 16 taxa of Protozoa and 6 taxa of rotifers in some tributaries of river Suyal of Kumaun Himalaya, Uttarakhand. Misra *et al.* (2008) have studied 42 taxa belonging to 7 genera of desmids (green algae) collected from two districts Haridwar and Dehradun of Garhwal region. Malik and Bharti (2012) have studied 40 taxa from different classes of plankton and zooplankton from Sahastradhara stream of Uttarakhand. Kumar (2014) studied diversity and abundance of 46 genera of phytoplankton in Glacial fed mountainous Goriganga River of Kumaun Himalaya. Chauhan *et al.* (2015) studied the seasonal variation in diversity of freshwater diatoms of Kumaun region and documented a total of 98 taxa belonging to class Bacillariophyceae, Coscinodiscophyceae and Fragilariophyceae. According to an ENVIS report Uttarakhand is represented by 346 species of algae (Anonymous 2013), which is a low estimate. Several ecologically interesting localities with the state are unexplored for algal diversity. Govind Wildlife Sanctuary (GWLS) is one such localities from where algal studies are meager.

GWLS is situated in the district Uttarkashi of Uttarakhand between north latitudes 31°17.30' to 35°55' and east longitudes 77°47.30' to 78°37.30'. It is popularly also known as Govind Pashu Vihar (Fig.1). The sanctuary covers an area of 957 km² with altitude ranging from 1300 m to 6323 m. The flora and fauna of GWLS are really unique due to its wide altitudinal variation and related climatic conditions.

MATERIALS AND METHODS

A total of 30 algal samples were collected in the month of October 2012 from five localities situated at different altitudinal zones such as Sankri (2000-2500 m), Taluka (2500-3000 m), Osla (3000-3500 m), Har Ki Dun (3500-4000 m) and Morinda (4000-4500 m) (Table 1) and from different habitats like soil, bark, ditch, small streams, rock and pebbles. The collected samples were preserved in 4% formaldehyde and deposited at the LWG Herbarium of CSIR-National Botanical Research Institute, Lucknow. For the morphological studies the fresh samples were examined using Leica DM 500 light microscope attached with Leica EC3 Camera with image analysis system. The identification of taxa were made by the following standard manuals Prescott (1951), Tiffany and Britton (1952), Desikachary (1959) and Philipose (1967).

RESULTS AND DISCUSSION

The study revealed that GWLS is enriched with

different groups of algal diversity represented by 49 algal taxa under 37 genera, 27 families and 5 different classes (Table 2). The class Cyanophyceae represented 20 taxa under 13 genera and 6 families; Chlorophyceae with 17 taxa under 14 genera and 11 families; Bacillariophyceae with 9 taxa under 7 genera and 6 families; Euglenophyceae with 2 taxa under 2 genera and 1 family and Chrysophyceae with 1 genus and 1 family. As evident from their numbers Cyanophyceae, Chlorophyceae, Bacillariophyceae were the most dominant flora but Chrysophyceae and Euglenophyceae were very rare due to their sensitivity to extreme climatic conditions. Out of these, Bacillariophyceae was the most frequently occurring representatives of algae. As per the diversity and abundance of microalgae, the members of the family Oscillatoriaceae were the dominant in all the samples. The most abundant group Cyanophyceae is dominated by *Anabaena constricta*, *Aphanothece microscopica*, *Chroococcus minor*, *C. turgidus*, *Nostoc punctiforme*, *Oscillatoria pseudogeminata*, *Phormidium valderianum* and *Scytonema crispum*. Chlorophyceae by *Chlorella vulgaris*, *Chlorococcum* sp., *Nannochloropsis*, *Scenedesmus bijugatus*, *Stichococcus bacillaris*. Bacillariophyceae by *Cymbella tumida*, *C. lanceolata*, *Encyonema silesiacum*, *Pinnularia* sp., *Spicaticribra kodaikanaliana* and *Synedra ulna*. Among various sites, Sankri (2000-2500m) where snowfall started from January to February and melting started from March, showed maximum algal diversity represented by 39 algal taxa and the second highest diversity with 35 algal taxa in Taluka (2000-3000 m) followed by Osla (3000-3500 m) and Har ki dun (3500-4000 m) represented with 28 and 25 algal taxa respectively. The least diversity was observed in Morinda Lake (4000-4500 m) with 12 algal taxa where snowfall started from December to June and melting started from August. According to Singh et al. (2014) high altitude lakes characterized by low temperature, generally low buffering capacity and low level

of nutrients and hence have scant biodiversity. The study clearly indicated that altitudinal variation influenced the algal diversity in studied localities (Fig.2). Among the different substrates the soil bears the maximum algal species represented by 18 species followed by stream, pebble, ditch and bark with 8, 7, 6 and 5 species respectively. The bark bears the lowest algal species represented by 3 species.

Studies on algal flora of high altitude areas in India are limited and Das and Keshri (2012) listed few such studies. The high altitude regions are unique in their ecology and meteorology with cold temperature, high irradiance, frequent rainfall and snowfall during winter. These factors greatly affect the occurrence of algae. We compared our results with other studies carried out elsewhere in high altitudinal areas. Kumar (2014) reported 46 genera of phytoplankton in Glacial fed mountainous Goriganga River of Kumaun Himalaya (altitude 600 – 1300 m) of which only 10 genera are common with GWLS. From Khumbu Himalayas (alt. 2845 – 8848 m) Ghimire (2013) reported total 27 green algae that also included four new records, among them at least eight taxa are common (*Chlorella*, *Cosmarium*, *Mougeotica*, *Oedogonium*, *Phacus*, *Scenedesmus*, *Spirogyra*, *Zygnema*) with GWLS. Singh et al. (2014) isolated 20 species of Cyanobacteria from high altitude lake Lahul-Spiti, Himachal Pradesh (altitude 3010 – 4883 m) where only genus *Nostoc* is common with GWLS. Comparatively, higher altitude algal studies are much frequent in eastern Himalayas. For example, Suseela and Toppo (2004) reported 28 algal taxa from Changu Lake, Sikkim Himalayas (3780 m), which included 12 green algae, 7 blue-green and 9 were diatoms. Chlorophycean genus *Spirogyra*, *Mougeotia*, *Zygnema* and *Closterium* and diatoms *Tabellaria* were the dominant algae. Although both Changu Lake and GWLS are at similar altitude only three taxa (*Chroococcus turgidus*, *Oscillatoria subbrevis* and *Nostoc punctiforme*) were common between these two studies. Das and

Keshri (2012) reported 16 algal taxa belonging to 9 genera from Bitang-cho Lake located at an altitude of 4500 m at Sikkim. Interestingly, most of them are new records for Sikkim or India and only one taxa (*Scenedesmus*) is common with GWLS. Similarly, in their study of fresh water algae from eastern Himalaya (alt. 304 – 8586 m) Das and Keshri (2014) reported more than 250 taxa, but only one taxa (*Cosmarium*) is common with GWLS. High number of novel taxa and very less similarity with GWLS also observed in algal flora of ice covered alpine lake of Arunachal Pradesh as enumerated by Das (2016). In another study Saikia *et al.* (2015) listed 62 algal taxa from high altitude (1500 m) rice fields in Apatani Plateau, Arunachal Pradesh of which 12 taxa are common with GWLS. There are not many studies on higher altitude localities of southern India. Kumar *et al.* (2012) reported 97 species of micro algae belonging to three different taxonomic groups viz. Cyanophyceae, Chlorophyceae and Bacillariophyceae from temperate places of Western and Eastern Ghats with altitudinal ranges of 1000 to 2135 m. In this study the predominant species belongs to Cyanophyceae and only some genera (*Chroococcus*, *Microcystis*, *Aphanothece*, *Lyngbya*, *Scytonema*, *Anabaena*, *Nostoc*, *Chlorella*, *Scenedesmus*, *Cosmarium*) are common with GWLS. These studies clearly suggest that high altitude algal communities are unique and varies from regions to region. In comparison algal flora of higher altitude localities of eastern Himalayas are much different than that of western Himalaya as observed in case of GWLS.

It is observed that Cyanobacteria are the most dominant group of algae in high altitude habitats. Cyanobacteria have their ecological tolerance to a broad range of temperatures, high salinity and adaptations to high and low light conditions contributes to their competitive success as planktonic or benthic organisms in a variety of environments (Sigh *et al.* 2014). Cyanobacterial tolerance of intense sunlight

including UV radiation may have contributed to their success in colonizing in high-altitude and high latitude environments (Sinha and Hader 2002). Species composition was significantly influenced by altitude, particularly for the orders Nostocales and Chroococcales. Nostocales were usually thought to be able to colonize in young undeveloped soils because of their ability to fix nitrogen (Whitton and Potts 2000). Perhaps *Nostoc* was better adapted than many other phototrophs to cryoturbation and desiccation because it has a well-developed mucilaginous sheath, which protects against the cold and desiccation. *Nostoc* might also do well at high altitudes because its biovolume is independent on the concentration of organic matter, unlike *Oscillatoria* (Suresh *et al.* 2012). Bright light favors the growth of the members of order Chroococcales, whereas dim light enhanced the presence of the members of order Nostocales. Similarly, a moderate temperature between 20-40°C was found suitable for the luxurious growth of Cyanobacterial taxa at all the sites (Khare 2007). The Chroococcales may have increased with altitude because, as unicellular organisms have rapid growth rates (Nielsen 2006). In the present study *Aphanothece*, *Chroococcus*, *Cyanothece*, *Microcystis* sp. were reported in luxurious growth in all altitudinal ranges and more intriguing are the morphological variation in *Nostoc* sp. *Scenedesmus* sp. and *Cosmarium* sp. and the variation in pigmentation of genus *Anabaena*. Bacillariophyceae were the other predominant group throughout the study. This group seems to be well adapted to the extreme abiotic conditions such as low temperature and potentially high light intensity of this high altitude zones in GWLS. Chrysophyceae and Euglenophyceae are very rare classes which occur mostly in lower altitude zone.

The biodiversity of high altitude microalgae in India are still fragmentary, especially in the high altitude zones in Western Himalayas. Our study is from GWLS, protected area, Uttarakhand, There is a wide scope for investigating mor-

phological diversity of algal population under stressed ecological and environmental conditions. Western Himalaya has shown that there is a rich diversity of algae in high altitude. The present enumeration of algae will act as baseline data which will be helpful in designing future monitoring schemes.

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