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Phytoplankton dynamics and water quality of Prashar Lake, Himachal Pradesh, India

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ABSTRACT

Prashar Lake, an unexplored, high-altitude, shallow, and cold water body located in Himachal Pradesh (India) was studied through monthly surveys in two consecutive years (March 2008 to February 2010). The seasonal variations in chlorophyll *a*, abundance, and species composition of plankton in relation to hydrography were studied. A total of 67 species belonging to eight groups of phytoplankton were identified. Among 67 phytoplankton species, 19 species exhibited perennial habit. Both plankton and chlorophyll *a* showed bimodal pattern of fluctuation with peaks in May and September. Annual mean concentrations of chlorophyll *a* (mg L^{-1}) were recorded as 4.87 in 2008–09, and 4.03 in 2009–10. Palmer pollution index indicated absence of all the 20 pollution tolerant algal species. Pearson correlation revealed a significant relationship between physicochemical parameters and different algal groups. Important physicochemical parameters responsible for distribution of phytoplankton have been studied taking into account the portability of water for irrigation and drinking purposes as per permissible limits of WHO, ICMR, and ISI standards. The values of water quality index were 14.42 during 2008–09 and 16.51 during 2009–10. Based on water quality standards given by Central Pollution Control Board, the water quality at Prashar Lake was between "A and B". Carlson's trophic status classified Prashar Lake as oligotrophic with TSI values 17.085 (2008–09) and 14.57 (2009–10). The phytoplankton assemblage, as well as water quality data, suggest that water at Prashar Lake is unpolluted and could be used for various human purposes after disinfection.

1. Introduction

High-altitude lakes are defined as Remote Mountain Lakes situated above or beyond the potential treeline (Clarke et al., 2005). Lakes are one of the important inland freshwater resources for meeting increasing water demand. Lakes supply water for irrigation, drinking, fisheries, etc. and thus have significant economic and recreational value. In limnetic ecosystem, water quality depends upon physical, chemical, and biological factors (Upadhyay et al., 2012). Phytoplankton dynamics influence trophic levels and portability of water for human uses (Fisher et al., 2009; Sharma et al., 2013). In addition to a general responsibility to conserve ecosystems, deterioration in lake water quality affects human interests directly. Access to safe drinking-water is essential to human health, and a satisfactory (adequate, safe and accessible) supply must be available to all (WHO, 2011). The UN General Assembly declared the period from 2005 to 2015 as the International Decade for Action,

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"Water for Life". Access to safe drinking-water is important as a health and development issue at national, regional and local levels.

Phytoplanktons are important indicators of the ecological status of a lake, and their composition and dynamics play an important role in biodiversity and energy flow in lake ecosystem. Phytoplankton or microalgae are phototrophic microorganisms with simple nutritional requirements, be they eukaryotes (for instance, green algae) or prokaryotes e.g. cyanobacteria (Singh and Ahluwalia, 2013). Phytoplankton forms the basic link in the food chain of an aquatic ecosystem and virtually all the dynamic features of lakes such as color, clarity, trophic state, zooplankton, and fish production depend to a large extent on the phytoplankton. Freshwater communities are very much sensitive to environmental variables (Darchambeau et al., 2014). Phytoplanktons are considered good indicators of water quality and trophic conditions because of their rapid response to environmental changes and deterioration of water quality (Thakur et al., 2013). The quality and quantity of phytoplankton and their seasonal successional patterns have been successfully utilized to assess the quality of water (Sharma and Singh, 2014). Local and regional processes interact to produce phytoplankton patterns of species density and diversity in freshwater ecosystem (Verma et al., 2012; Singh and Sharma, 2014). Shallow lakes differ markedly from deep stratified lakes, especially with respect to matter exchange and plankton dynamics (Petaloti et al., 2004). However, water quality and plankton dynamics are affected by many factors. The cumulative effects of environmental factors on organisms will ultimately result in changes in population and structure of the community (Singh et al., 2013a). Accordingly, use of phytoplankton assemblages for monitoring the ecological status of lakes has been recommended (Fetahi et al., 2014). Little information is available on the phytoplankton dynamics and water quality studies on Himachal Pradesh lakes are worth mentioning – Lower Western Himachal Lakes (Sidhu and Ahluwalia, 2011), Himachal Lakes (Thakur et al., 2013), Rewalsar Lake (Jindal et al., 2014), Lahaul–Spiti Lakes (Singh et al., 2014). During present study, in addition to phytoplankton composition, different indices (WQI, Palmer's index, Carlson's index) were used to assess the overall water quality of the lake. Water quality index (WQI) provides a single number that expresses overall water quality at a certain location and time, based on several water quality parameters. The objective of water quality index is to turn complex water quality data into information that is understandable and used by the public. Since high-altitude lakes remains poorly investigated to date, our study is the first on the quality of the Prashar Lake waters.

This study was designed to evaluate the water quality and portability of water using different indices and comparing with standards. The concentrations of physicochemical parameters examined are presented. Seasonal influences of water quality on phytoplankton were examined to give base-line data for assessment of future change. Results of routine monthly sampling of phytoplankton composition together with water quality parameters over two years are reported.

2. Materials and methods

2.1. Study area

Prashar Lake is located in Mandi district (longitude, 76°37′20″–77°23′15″ E; latitude, 31°13′50″–32°04′30″ N) of Himachal Pradesh, India (Fig. 1). The lake is situated at 2,730 m above sea level (77°06′ E, 31°45′30″ N). It is oval in shape, with a depth of 4–5 meters and an area of 2.3 ha. It is surrounded by snow-capped mountains and is bordered by thick macrophytic vegetation. In winters, the lake is surrounded by snow. With deep blue waters, the lake is held sacred to the sage Prashar and he is regarded to have meditated there. In this lake, there is a floating island made of thick growth of *Saccharum munja* Roxb. *s* that keeps changing its position through-out the year. This religious lake has a great attraction for the tourists during summers. Three fish species i.e. *Cyprinus carpio communis* L., *C. carpio specularis* Lacepede and *Salmo trutta fario* L. were found in Prashar Lake. Water of this lake is being used for drinking and domestic purposes.

2.2. Physicochemical analyses

Water samples for the estimation of DO were collected directly in 300 ml glass BOD bottles avoiding air bubbles, and were fixed immediately by adding alkali-iodide azide and manganese sulfate reagents. Parameters such as temperature, pH, TDS, and electrical conductance were measured on the spot (Singh et al., 2013b). Free carbon dioxide was also estimated at the spot by titrating samples against 0.041 N sodium hydroxide using phenolphthalein as an indicator. For estimation of the remaining parameters, collections were made using plastic containers of 2 L capacity. The plastic containers were rinsed thoroughly with sampling water before using them. After filling the containers they were sealed and transferred to the laboratory for physicochemical analysis. Physicochemical parameters of the water were analyzed according to the standard methods (APHA et al., 2005).

2.3. Phytoplankton analysis

The phytoplankton was concentrated by filtering 50 L of water through a net made up of blotting silk No. 25 (0.03 mm mesh). Then at very low speed horizontal trawling was done and net was allowed to sink to a depth of about 1 meter below the water surface to prevent the formation of a bow wave. Sample were fixed in Lugol's Iodine and transported to laboratory in polythene bottles. Phytoplankton enumeration was performed as described (Rodhe et al., 1958; Anderson, 2005; Thakur