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FULL LENGTH ARTICLE

The influence of physico-chemical parameters on phytoplankton distribution in a head water stream of Garhwal Himalayas: A case study

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Abstract Physico-chemical parameters play a major role in determining the density, diversity and occurrence of phytoplankton in a headwater stream. The present study was conducted to assess the relationship between physico-chemical parameters and phytoplankton assemblages of Baldi stream of Garhwal Himalayas, India. Results showed an increased concentration in physico-chemical parameters (turbidity, total dissolved solids, nitrates and phosphates) has an adverse impact on the density of phytoplankton during monsoon season at the sampling site S_2, where maximum disturbances were recorded. Karl Pearson's correlation coefficient calculated between physico-chemical parameters and density of phytoplankton revealed that as sediment load increases in the stream, the growth of phytoplankton decreases. Canonical Correspondence Analysis (CCA) between environmental variables and dominant taxa of phytoplankton indicated the influence of physico-chemical parameters on phytoplankton distribution in freshwater ecosystem of Baldi stream of Garhwal Himalayas, India.

Introduction

Headwater streams are important freshwater ecosystems of the Himalayas. These freshwater ecosystems are nurseries of primary production due to high clarity of water. A minor change in physico-chemical parameters can influence the primary production (Sharma et al., 2007).

Phytoplankton are vital and important organisms which act as producer to the primary food supply in any aquatic ecosystem. They are the initial biological components from which the energy is transferred to higher organisms through food chain (Tiwari and Chauhan, 2006; Saifullah et al., 2014). The physico-chemical parameters are the major factors that control the dynamics and structure of the phytoplankton of aquatic ecosystem (Hulyal and Kaliwal, 2009). Changes in physico-chemical parameters of ecosystems have a substantial impact on the species that live within them. Seasonal variations in these parameters have an important role in the distribution, periodicity and quantitative and qualitative composition of freshwater biota.

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Several recent studies on physico-chemical parameters and phytoplankton community of rivers are conducted on the Greater Zab River, Iraq (Ali, 2010), River Haraz, Iran (Jafari et al., 2011), Imo River, Nigeria (Ogbuagu and Ayoade, 2012), River Thames, UK (Waylett et al., 2013), and Kenti River, Republic of Karelia (Chekryzheva, 2014). In North India, many recent studies have been conducted. These were focussed on the Chandrabhaga River (Sharma et al., 2007), Yamuna River (Chopra et al., 2012), Ganga River and its tributaries (Negi et al., 2012), Sutlej River (Sharma et al., 2013) and Jhelum River (Hafiz et al., 2014). However, no study has been conducted on physico-chemical parameters and phytoplankton composition of head water stream Baldi of Garhwal Himalayas. Therefore, the present study aims to determine the influence of physico-chemical parameters on phytoplankton composition of Baldi, the headwater stream ecosystem, which is prone to anthropogenic pressures.

Materials and methods

The head water stream Baldi is one of the important tributaries of the Song River flowing in Doon Valley of the Garhwal Himalayas. It lies in the coordinates of 30° 23′ N; 78° 08′ E in Raipur Block of Dehradun district of Uttarakhand state, India. The Baldi meets the Song River at Maldevta (Dehradun) after covering a distance of 14 km (Fig. 1). Three sampling sites on the Baldi stream were chosen on the basis of level of anthropogenic pressures. The upstream site S_1 (undisturbed site), the midstream site S_2 (highly disturbed site) and the downstream site S_3 (least disturbed site) were identified. Discharge of municipal waste water, use of soap and detergents for bathing and washing clothes, dumping of solid waste by tourists and locals were the common anthropogenic disturbances recorded at S_2, whereas only occasional washing of clothes was recorded at S_3. Monthly sampling was undertaken between 08:00 to 10:00 a.m. from the depth of 10 to 20 cm during November 2011–October 2012, representing three seasons (winter season = November–February; summer season = March–June; monsoon season = July–October). Five replicates of samples were obtained for each parameter and the results were integrated and recorded.

Water temperature, turbidity and pH were measured *in-situ* using the centigrade (0–110 °C) thermometer, Metzer Digital Turbidity Meter (Model-5D1M) and Toshcon Multiparameter Analyser, respectively. Dissolved oxygen, total dissolved solids (TDS), alkalinity, Calcium, Magnesium, hardness, nitrates, phosphates, Sodium and Potassium were analysed by using standard methods (Wetzel and Likens, 1991; APHA, 2005).

For phytoplankton analysis, one litre of sample water was collected and filtered through silk plankton net of mesh size 20 μm and was immediately preserved in opaque sample bottles containing 4% formalin solution for analyses by using the Sedgwick Rafter counting cell. Results were recorded in individuals per litre (ind. L^{-1}). Reimer (1962) method was followed to process the samples for light microscopy. The identification of phytoplankton was made with the help of Sarode and Kamat (1984), Ward and Whipple (1992), Munshi et al. (2010) and Bellinger and Sigee (2010).

The Karl Pearson's correlation coefficient was performed using Microsoft Excel 2007 to determine the relationship among the various physico-chemical attributes and different phytoplankton assemblages. Canonical Correspondence Analysis (CCA) was performed using Palaeontological STatistics (PAST) Software Version 3.06 to determine relationship between dominant phytoplankton taxa and physico-chemical parameters. Dominant phytoplankton species were selected on the basis of density (individuals L^{-1}). The species having more than 250 individuals L^{-1} annually were taken for analysis. The length of arrow is relative to the importance of the explanatory variable in the ordination, and arrow direction indicates positive and negative correlations (Jasprica et al., 2012; Laskar and Gupta, 2013).

Results and discussion

Monitoring the physico-chemical parameters is very important for studying the influence of these parameters on the distribution of various components of biodiversity in headwater stream (Sharma et al., 2007). Water quality is influenced by geological, hydrological, climatic and anthropogenic factors (Boon et al., 1992; Bartram and Balance, 1996). The physico-chemical parameters of water of Baldi stream have been presented in Table 1. Water temperature is considered as one of the important factors that controls aquatic life in a headwater stream (Wetzel, 1983). The lowest water temperature was recorded (10.95 °C) in winter season at S_1 and highest (15.03 °C) in summer season at S_3 in Baldi stream.

Maximum turbidity (52.58 NTU) was recorded at S_2 and minimum (40.49 NTU) at S_1 in the Baldi stream. Higher turbidity (95.23 NTU) was recorded at S_2 during in July–August (monsoon season) and a low turbidity (10.00 NTU) during January–February (winter season) in the Baldi stream. Similar findings were reported from the Chandrabhaga River in Garhwal Himalayas (Sharma et al., 2007) and Sutlej River of Himachal Pradesh (Jindal and Sharma, 2011). Maximum concentration (226.75 mg L^{-1}) of total dissolved solids was found in monsoon season at S_2 and minimum (45.00 mg L^{-1}) at S_1 the winter season.

Dissolved oxygen, is an important environmental parameter that decides ecological health of a stream and protects aquatic life (Chang, 2002). On annual average basis, maximum (8.56 mg L^{-1}) dissolved oxygen was recorded at S_1 and minimum (7.09 mg L^{-1}) at S_2. High dissolved oxygen was recorded during winter season at all the sites. It may be due to high photosynthetic rate of phytoplankton communities in clear water that results in higher values of dissolved oxygen (Sharma and Rathore, 2000; Ravindra et al., 2003). Higher dissolved oxygen in winter season and lower oxygen in monsoon were also recorded in Haraz River in Iran (Pejman et al., 2009), many rivers of Gangetic plain, India (Rani et al., 2011) and several rivers of the Central Himalayas including the Chandrabhaga River (Sharma et al., 2007) and the Tons River (Sharma et al., 2009).

The higher value (7.76) of pH was recorded at S_1 (Table 1) as, this site is rich in limestone rocks. The presence of limestone rocks results in higher pH (Ormerod et al., 1990). Alkaline water promotes high primary productivity (Kumar and Prabhahar, 2012). The water of Baldi stream was alkaline in nature throughout the study period. Alkaline nature of water was also reported in Greater Zab River, Iraq (Ali, 2010). Alkalinity (20–200 mg L^{-1}) is common in most of the fresh water ecosystems (Ishaq and Khan, 2013). Maximum alkalinity