Relations between variations in the lake bacterioplankton abundance and the lake trophic state: Evidence from the 20-year monitoring


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ABSTRACT

Trophic state is a key biological characteristic of water body that integrates the main hydroecological factors. However, the character of the interrelation between bacterioplankton dynamics and the lake trophic state remained obscure. The long-term (1995–2015) monitoring data were carried out to examine the relations between bacteriological parameters (abundance, biomass, and cell biovolume) and main hydroecological factors (chlorophyll, phosphorus, nitrogen, organic matter) in three water bodies: Lake Batorino, Lake Myastro, and Lake Naroch, which differ by trophic state. The results of the analysis of the data show that the growth of the chlorophyll-based trophic state index (TSIChl) as well as dissolved organic carbon (DOC), total phosphorus (TP) and 5-day biochemical oxygen demand (BOD5) in the chain Lake Naroch–Lake Myastro–Lake Batorino is accompanied by a linear increase in the bacterioplankton abundance, while fluctuations of bacterioplankton abundances and trophic state parameters in each of the Naroch Lakes are not correlated with each other. It is shown that temperature is the factor, which impacts seasonal bacterioplankton dynamics. The ratio of the time-averaged abundance of bacteria in July to the time-averaged abundance of bacteria in May remains virtually unchanged compared to the ratio between July and October. However, similar ratios for chlorophyll-a undergo significant changes. This result leaves room for further investigation of the factors, which can influence trophic state of the lakes, on the assumption that bacterial abundance is considered as an invariant measure.

1. Introduction

The concept of the trophic state was introduced in order to classify lake ecosystems in terms of productivity (Nauman, 1927). The trophic classification of lake ecosystems classically distinguishes three types of lakes: oligotrophic, mesotrophic and eutrophic. For introducing a numerical measure of the trophic state, trophic state indices (TSI), such as the chlorophyll (TSIChl), total phosphorus (TSITP), total nitrogen (TSITN), and Secchi depth (TSISD) (Carlson, 1977; Kratzer and Brezonik, 1981) indices were put forward. Among these four indices, TSIChl probably yields the most certain measures, as it is the most accurate predictor of the phytoplankton biomass (Carlson, 1977). However notice that the bacterioplankton abundances, even being related to trophic states (Wetzel, 2001; Nixdorf and Jander, 2003; Jekatierynszuk-Rudczysz et al., 2014), have not been directly related with numerical values of any TSI. Among several environmental factors exerting potential on TSI, temperature (which, for example, essentially drives seasonal changes in the phytoplankton abundance; see Scheffer, 2009; Quinn et al., 2013; Tammert et al., 2015) exhibits most critical effects. It is worth noting in this context that fluctuations of the bacterioplankton abundance have been shown to be phase-locked by oscillations in the water temperature (Medvinsky et al., 2017). In order to assess relative values of the temperature and TSI changes as the potential factors that may be related to the bacterioplankton dynamics, long-term monitoring of the lakes that are in close proximity to each other but differ in their trophic states is...