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Spatial and Seasonal Dynamics of Dissolved and Suspended Nutrients in the Water Column of Meromictic Lake Shira

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1 Introduction

The vertical stratification of the water column has a significant impact on the spatial distribution of aquatic organisms, the dynamics and structure of the food web in the lakes (Degermendzhy et al., 2010). A special case is a meromictic lake where the bottom layer of the water column (monimolimnion) for a long time isolated from the exchange with the upper layers (mixolimnion). In these lakes the water column due to gradients in the water density (that are usually caused by changes in temperature or salinity) is divided into several hydrodynamically isolated zones (Boehrer, Schultze, 2008). Such zones can act as barriers to vertical fluxes of matter in a lake (Kufel, Kalinowska, 1997).

The stability of stratification in a lake can vary. There have been many examples of mixing of lakes that was stratified for the long period of time with consequent degradation of water quality (Miller et al., 1993). On the other hand increased stability of stratification may also lead to changes in water quality and lake productivity (Kaden, 2010). Among the main factors affecting the stability of stratification are weather and climatic conditions and, in particular, air temperature (Livingstone, 2003). Variations in air temperatures lead to a shift in time of freezing and ice melting, establishing of temperature stratification (Fang, Stefan, 1999), change the rate of the primary and secondary production (O'Reilly, 2003).

The aim of this study was to monitor the depth of the thermocline and chemocline, seasonal and spatial dynamics of dissolved and suspended nutrients in the water column of meromictic Lake Shira (South Siberia) for several consecutive years and assess the impact of variations in weather conditions on these parameters. At the same time, we have formulated several hypotheses to check: 1) weather conditions, primarily air temperature, influence the stratification of the water column of the lake, 2) the degree of mixing of the water column and the depth of the mixolimnion in autumn should affect the concentration of dissolved and suspended nutrients in the water column during the subsequent season, and 3) the depth of the stratification of the water column should affect the rate of production of organic matter and the degree of its limitation by various nutrients.

2 Results

The depths of the thermocline and redox zone (Fig. 1), dissolved and particulate seston nutrients (nitrogen and phosphorus) (Fig. 2) in the water column of the salt meromictic Lake Shira were measured seasonally from 2007 to 2011.

The data were used to estimate the relationships between variability of weather conditions expressed in air temperature variations and values of measured parameters. We observed positive correlations between the air

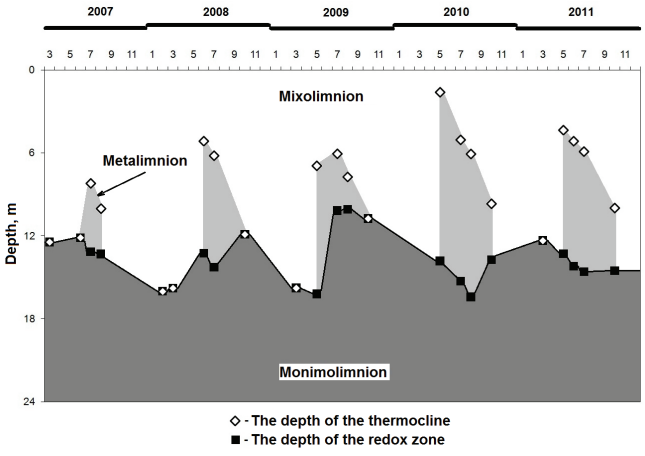

Fig. 1. Annual dynamics of the depth of the thermocline and redox zone in Lake Shira in 2007-2011.

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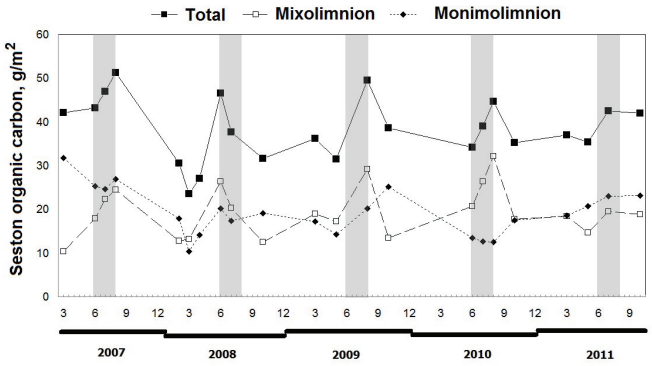

Fig. 2. Annual dynamics of the amount of seston organic carbon (g/m^2) in the water column (total) and in the mixolimnion and monimolimnion of Lake Shira.

temperature in the previous year and the depth of the redox-zone in the winter, the average air temperature in April and the depth of the thermocline in the summer.

The maximum concentrations of dissolved and particulate nutrients were observed in the monimolimnion. Throughout the year seston in the monimolimnion was relatively rich in both nitrogen and phosphorus, indicating the accumulation of nutrients in the bottom layer. The total nitrogen to total phosphorus ratio in the mixolimnion for almost all depths and seasons exceeded the Retfielde ratio of 16. We observed the deficiency of seston both in nitrogen and in phosphorus, which indicates that primary production in the lake at different times and different depths is limited by different nutrients (Fig. 3).

Effects of the interannual variations of weather conditions and depths of the vertical stratification of the water column on the total amount of organic carbon in the mixo- and monimolimnion were different. The amount of seston in the monimolimnion was different in different

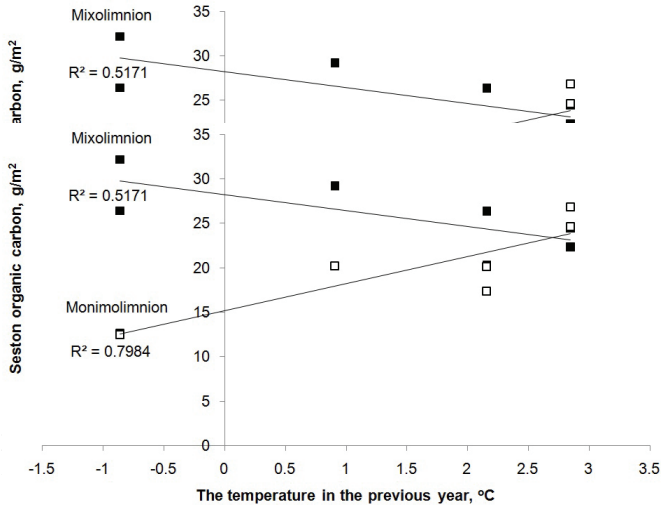

Fig. 3. The correlation between the amount of organic carbon in the pelagic of Lake Shira in the middle of vegetation season (July-August) and the average air temperature at the previous year.

years. The temperature in the previous year and the size of the monimolimnion positively correlated with the amount of seston in the monimolimnion.

The amount of seston in the mixolimnion was similar between different years but differs between seasons. The amount of seston in the mixolimnion in summer almost doubled the amount of seston in the mixolimnion in winter. At the same time the depth of the thermocline in summer positively correlated with the total amount of seston in the epilimnion.

Thus, we have shown that the air temperature affects the stratification of the water column, the depth of the stratification affect the amount of organic carbon in different water layers of the lake, and the vertical gradients of water density support the deposition of nutrients in the bottom layers of the lake.

Key words: Meromictic lake, air temperature, stratification, seston, nutrients, stoichiometric ratios

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