Influence of hydrothermal conditions on algae of the Shurinda thermal spring (Bauntovsky district, Republic of Buryatia)

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Abstract. Studies of the water temperature in the Shurinda thermal spring in the winter of 2009 and 2021 showed lower values in 2021. The number of habitats with different temperatures increased in the space of the thermal field. In 2021, 10 previously unrecorded species were identified in the flora of macroalgae and cyanobacterial mats, including aggregations of Spirogyra sp. The greatest diversity of cyanobacterial mats was found in the temperature range of 50-25°C; in the range of 20-10°C, accumulations of Spirogyra sp. occupied the entire water column. Cyanobacteria again prevailed in the area with a temperature of 4.0°C. The higher species diversity of algae in March 2021 is due to the lower temperatures of the thersms and their lower flow, which led to a greater diversity of temperature within the thermal spring.

1 Introduction

The communities formed in hot springs can have significant biomass and form so-called microbial mats. They have been found in many regions of the world: in the hydrotherms of the USA [1], Iceland and New Zealand [2-3], East Africa [4], Kamchatka and the Kuril Islands [5], Buryatia and Mongolia [6]. Thermal waters at negative air temperatures in winter conditions contribute to the abundant vegetation of algae, which is a unique phenomenon and requires a comprehensive study. Most studies indicate the constancy of temperature and hydrochemical conditions in thermal springs, which determines the constancy of the flora. Fluctuations in the parameters of the aquatic environment and the effect of these fluctuations on the species diversity of photosynthetics are the subject of research. The purpose of the study of this article was to study the effect of changing temperature conditions in different years and in different parts of the Shurindinskiy thermal spring on the diversity of algae.

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2 Materials and methods

There are several hydrotherms on the southeastern flank of the central part of the Baikal Rift Zone (Fig. 1). The formation of hydrotherms is associated with the infiltration of atmospheric waters along active tectonic faults to depths of up to 4-6 km. Hydrothermal outlets are confined to an erosion cut, most often to river valleys, often to their channels. The Shurinda spring (55°13.502’ N, 113°30.932’ E) belongs to the Baunt group of nitrogen hot springs [7] and flows into the bed of the Goryachaya River, the right tributary of the Tsipa River, which flows into the Vitim River. The studies were carried out in November 2009 and March 2021; a total of 19 algae development sites were studied (7 stations in 2009 and 12 stations in 2021). The absence of a road network in the area of the spring makes it possible to study it mainly in winter, when the beds of frozen rivers are used as roads.

Analytical determinations of hydrochemical parameters were carried out in a certified laboratory of INREC SB RAS. The temperature of the water in the springs was measured with an electrothermometer (Checktemr 1 by HANNA) with an indication accuracy of 0.1°C, pH – with a portable potentiometer (pH-Meter CG 837).

3 Results and discussion

Over the entire period, more than 40 samples were collected for the study of species diversity and 9 samples for assessing the biomass produced by algae in areas with different thermal conditions. The collection of algae and cyanobacterial mats was carried out by the method of trial plots. Algae and cyanide species were identified using key tables [8,9]. The species list was compiled according to the classification system adopted in AlgaeBase [10]. Simultaneously with sampling, water temperatures and pH were measured. Analytical determinations of hydrochemical parameters were carried out in a certified laboratory of INREC SB RAS. Statistical processing of the obtained data was performed using the Microsoft Excel 2010 and STATISTICA 10 software package.
3.1 Dynamics of abiotic factors in the aquatic environment

3.1.1. Water temperature

Water temperatures in 2009 were higher than in 2021. The drop in temperature can presumably be explained by a sharp decrease in the total discharge of thermals and their transition into the understream flow due to a decrease in the groundwater level in the understream talik by spring. The total flow rate of the source in November 2009 was 35-40 l/s [7], while in March 2021 it did not exceed 5 l/s. The decrease in water temperatures at the exits at the Shurinda spring could occur due to an increase in heat losses for heat exchange in the aeration zone and the seasonal freezing layer, which increased in thickness, again, due to the general drop in the level of groundwater. With a higher flow rate of therm, such losses have less effect on their surface temperature. Additionally, the heat exchange with the atmosphere at the outlet of the thermals can also be affected, which is relatively more significant at low flow rates. Seasonal fluctuations in water temperature in the hydrothermal system itself, which, by analogy with determinations from thermal manifestations in other regions, should be at least several hundred and even thousands of years old, cannot occur.

3.1.2 Hydrochemistry

The chemical composition of the spring water for both periods of sampling is hydrocarbonate-sulfate sodium. Their mineralization at sampling points in the first period was 500-578 mg/l, in the second - 508-544 mg/l, temperatures 41.6-70.6 ºС and 27.6-46.5ºС, respectively. Mineralization in higher temperature outlets is higher. The pH values and silicon concentrations were 8.62-8.88 and 28.7-29.4 mg/l in 2009, in March 2021 they increased - pH to 9.28 and Si to 41.3, which indicates the absence of dilution of the thermal water with groundwater in the second period.

3.2 Algae and cyanobacterial mats

In previous studies, all hydrotherms indicated abundant development of cyanobacterial mats [11]. Studies of the flora of macroscopic algae have not been carried out. It is known [12] that algae are not an integral group of organisms united by the unity of their origin, but represent a combination of several independent types. According to the size of the thalli of algae and their colonies, microalgae (less than 0.5 mm), meioalgae (from 0.5 to 2 mm) and macroalgae (more than 2 mm) are distinguished. In this work, macroalgae proper and cyanobacterial mats are considered, which are comparable in size to macroalgae. Macroscopic algae master the aquatic environment, developing in the water column and on its surface (metaphyton), attaching to the bottom (phytobenthos) or to substrates in the water column (periphyton). Cyanobacterial mats develop at the bottom of thermal water outflow areas and in places where they spread along the riverbed (phytobenthos).

According to [13], in 2009, cyanobacterial mats were found in the Shurinda spring not at all stations, but only at three. Leptolyngbya valderiana (Gomont) Anagnostidis & Komárek 1988, found at all stations, was the most characteristic inhabitant of the Shurinda spring and the dominant species. Studies of the flora of macroalgae and cyanobacterial mats in 2021 showed a greater diversity in the species composition of algae. In the flora of the spring, 10 previously unrecorded species were found, including accumulations of Spirogyra sp. In relation to environmental factors, cyanobacteria species were divided into two clusters: species living in the temperature range of 70-45ºC (cluster 1) and species with a temperature range of 45-20ºC (cluster 2) (Fig. 2).
In the Shurinda spring, cyanobacterial mats occupy ecological niches with extreme conditions, developing at high (70-25ºC) and low (about 4ºC) temperatures. Eukaryotic organisms predominate in areas of open water with temperatures ranging from 10 to 25ºC. The thickness of cyanobacterial mats at the spring did not exceed 2 cm. The mats were formed by different species of cyanobacteria of the genera *Phormidium* and *Leptolyngbya*. Cyanobacterial mats are outperformed by charophytes, since filamentous characeae species are able to colonize not only the surface above the substrate, but also the water column. Macroscopic algae obscure cyanobacterial mats and prevent their development.

### 4 Conclusion

During the period of research, differences in the temperature of thermal outlets were established. In November 2009, high water temperatures, along with high water flow, determined the predominance of cyanobacterial mats within the thermal spring. In March 2021, lower outlet temperatures with lower water flow resulted in a wide range of temperature conditions. This led to an increase in the diversity of photosynthetics due to the emergence of eukaryotic species of filamentous charophytes of the genus *Spirogyra*. It has been established that cyanobacterial mats occupy ecological niches with extreme conditions, developing at high (70-25ºC) and low (about 4ºC) temperatures. Eukaryotic organisms predominate in areas of open water with temperatures ranging from 10 to 25ºC. It is necessary to continue research on the biota of the Shurindinsky thermal spring in order to understand the functioning of ecosystems under extreme temperature conditions.

### References


3. T.D. Brock, Thermophilic microorganism and life at high temperatures (Springer-Verlag, New York, 1978)


7. L.V. Zamanova, Sh.A. Askarov, BSU bulletin 3 (2010)


