Within the Hamatum species complex, ITS is not a sufficiently informative marker, whereas phylogenetic analyses based on the *TEF* gene fragment allow assigning *T. atrobrunneum* to the *T. pleuroticola* group in a sister clade to the Hamatum species group. All strains identified to the species level according to Cai and Druzhinina (2021) are amenable to molecular identification, which adds significance to our results.

Overall, nine species were identified, with *T. atroviride* being dominant. All strains not assigned to a specific species belong to the polyphyletic *T. hamatum* species complex, the identification of which requires further molecular and ecological analysis. *T. pararogersonii* is reported for the first time in Ukraine. The strains obtained in this study will be used for subsequent ecological analysis.

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# COMPARATIVE CHARACTERISTICS OF SOME THERMAL WATER MICROBIOTA SAMPLES OF WESTERN UKRAINE

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**Abstract.** The physicochemical characteristics of thermal waters, particularly temperature, mineralization, and concentrations of major ions and dissolved gases, represent major environmental

determinants of microbial composition. The aim of this study was to compare the microbiota of three thermal water samples from western Ukraine. The results indicate that increasing mineralization and temperature are associated with a decrease of many heterotrophic and nutrient-transforming microorganisms.
**Keywords:** thermal water, total mineralization, temperature, microbial functional group

The physicochemical characteristics of thermal waters, such as temperature and mineral content, are key environmental factors that determine the composition and activity of microbial communities (Çelik et al., 2022). Temperature acts as a fundamental limiting factor: higher thermal stress usually reduces microbial diversity and favors thermophilic or thermotolerant microorganisms. Mineral content and ionic composition affect the microbiota through osmotic stress, specific ion effects, and changes in nutrient and electron acceptor availability, promoting the growth of microorganisms with corresponding adaptive mechanisms (Barbosa et al., 2023). So, the quality of thermal waters should be seen as a mix of physical, chemical and microbiological traits that significantly impact diversity, community structure and the ecological roles of microorganisms.

The composition of the microbiota of three thermal water wells in western Ukraine and its dependence on some physicochemical parameters, including temperature and mineralization, was determined.

The level of mineralization, temperature was determined according to DSTU 878-93 Packaged mineral waters. Technical specifications. With Changes and Amendments. Qualitative and quantitative indicators of the composition of the microbiota of the studied water samples were carried out according to Nikolenko S.I.

In the water from well I, characterized by the lowest mineralization (3–4 g/L) and moderate temperature (36–38 °C), the microbial community demonstrated comparatively high abundances of ammonifying aerobes and anaerobes ($10^6$–$10^8$ CFU/mL), oligocarbothrophs ($1.6 \cdot 10^3$ CFU/mL), microorganisms assimilating organic N-containing compounds ($2.1 \cdot 10^3$ CFU/mL), and lipid-degrading microorganisms ($4.2 \cdot 10^2$ CFU/mL), indicating the availability and active transformation of organic substrates. The relatively high abundance of heterotrophic and ammonifying microorganisms in this water type may reflect the more favorable combination of moderate salinity and temperature, which imposes less osmotic and thermal stress on metabolically versatile microorganisms (Nishiyama et al., 2018). In contrast, the water from well II, with a higher mineralization of 7–8 g/L and a broader temperature range of 30–45 °C, characterized by a marked reduction in several functional groups, including microorganisms assimilating organic N-containing compounds and oligocarbothrophs, while ammonifying anaerobes remained abundant ($10^8$ CFU/mL). This pattern suggests that increasing mineralization may act as an environmental filter, selectively suppressing less salt-tolerant microorganisms while preserving or favoring physiological groups capable of maintaining cellular homeostasis under increased osmotic pressure (Narsing Rao et al., 2021).

The most extreme physicochemical conditions were recorded for well III, where mineralization reached 18–22 g/L and temperature 56–60 °C; under these conditions, the total abundance and functional diversity of culturable microorganisms were substantially reduced, while oligocarbothrophs, amylolytic microorganisms, and methanogens remained detectable. The persistence of selected microbial groups under these conditions indicates that the combined effects of elevated salinity and temperature constitute a strong selective pressure, favoring microorganisms possessing specific osmotic and thermal adaptation mechanism (Barbosa et al., 2023).

A particularly important relationship was observed for sulfur-transforming microorganisms: sulfur-oxidizing *Thiobacillus thioparus* was detected at $10^3$ CFU/mL in well I but

was virtually absent from the more mineralized waters, whereas sulfate-reducing *Desulfovibrio desulfuricans* was detected only at a low abundance (2 CFU/mL) in well I. The occurrence of *T. thioparus* is consistent with its capacity for chemo-lithotrophic sulfur oxidation, whereas sulfate-reducing *D. desulfuricans* participates in the reductive branch of the sulfur cycle; therefore, their distribution may reflect differences in the availability of reduced sulfur compounds, electron donors, oxygen conditions, and other geochemical parameters rather than mineralization alone (Çelik et al., 2022).

The relatively high abundance of methanogenic microorganisms ($10^2$–$10^3$ CFU/mL) in all three water types, despite pronounced differences in mineralization and temperature, suggests that methanogenesis may represent an important anaerobic terminal process within these microbial communities. The simultaneous reduction of several heterotrophic functional groups and persistence of selected anaerobic and oligotrophic microorganisms in the most mineralized water indicates a shift from metabolically diverse communities toward physiologically specialized assemblages adapted to increased environmental stress (Narsing Rao et al., 2021).

Overall, the results indicate that increasing mineralization and temperature are associated with a decrease in the abundance of many heterotrophic and nutrient-transforming microorganisms and with the relative persistence of oligotrophic, anaerobic, methanogenic, and other physiologically specialized groups, demonstrating the strong role of physicochemical conditions in structuring the microbial communities of the studied mineral waters. These findings are consistent with contemporary microbial ecology, which considers salinity, temperature, pH, redox conditions, nutrient availability, and geochemical composition as interacting environmental filters that determine microbial community composition and the functioning of carbon, nitrogen, and sulfur biogeochemical cycles (Barbosa et al., 2023).

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