

**Supplementary Material S1: Research Methods to Characterize Thermokarst Lakes and the Chemistry of their Water**

Five lakes were sampled in the Tazovsky District (Table S1).

**Table S1:** Coordinates of the studied lakes.

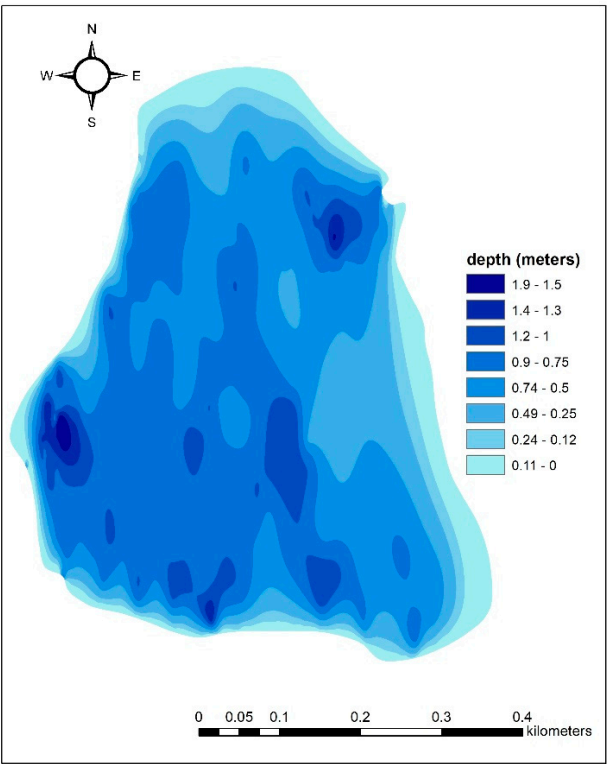
Lake	Lake 1	Lake 2	Lake 3	Lake 4	Lake 5
Coordinates	67°11'51.27"N 78°49'58.19"E	67°11'38.70"N 78°48'29.83"E	67° 4'26.98"N 79° 1'5.45"E	67° 8'17.46"N 78°58'59.22"E	67°11'21.60"N 78°54'54.80"E

**Morphometry of lakes**

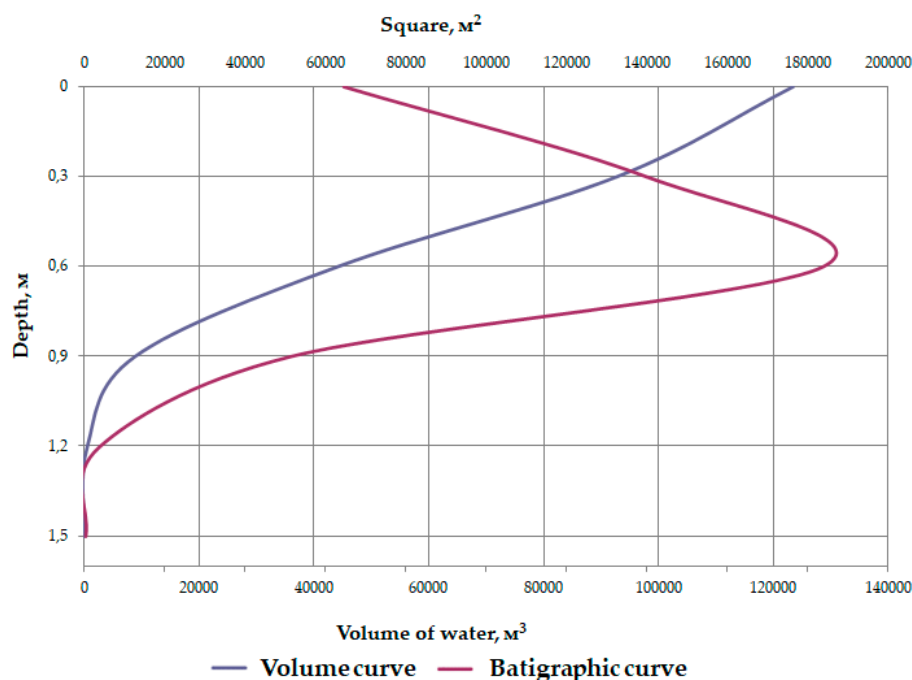
Depth measurements of the lakes were carried out using a Garmin EchoMAP 42CV echo sounder equipped with a GPS navigator, placed on a rubber boat with a Yamaha 2 engine. The measurements were carried out at a speed of 5–10 km/h. The number of depth measurement points ranged from 440 to 735, their number depending on the area of the water body. The route of the boat was a concentric curve, and the distance between the turns of this curve was about 10–20 meters. This made it possible to provide the most optimal density of measurement points and speed of measurements.

The morphometric characteristics of the lakes were determined based on the results of a bathymetric survey using a GPSmap 421s Garmin echo sounder and by developing bathymetric maps using ArcGis 10.2, Global Mapper 14, SAS.Planet, MS Excel 2010. We used a satellite image Landsat-8 of 17 July, 2018. The use of satellite images was important for refining the binding of lake shorelines. The depths of the lakes were tied to GPS and from the echo sounder. Hypsometric maps were made in the ArcGIS 10.0 program, using interpolation based on the inverse distance weighted method (IDW).

Typical structure of a thermokarst lake of the Tazovsky Peninsula is shown in Figures S1 and S2.



**Figure S1:** Typical structure of an unnamed thermokarst lake of the Tazovsky Peninsula: depth map.



**Figure S2:** Typical structure of an unnamed thermokarst lake of the Tazovsky Peninsula: bathymetric and volumetric plots (see main text for an illustration of a typical thermokarst lake).

Based on the results of fieldwork, bathymetric and volumetric curves were developed. With an increase in the depth of a lake, the volume of water decreases. This is also associated with the cone-shaped and paraboloidal forms of the basins of the studied water reservoirs.

Analysis of the lake (Figures S1 and S2) showed that the maximum area of the lake bottom has minimum depths, up to 0.6 m, which is 41.4% of the total area of the lake. The smallest area, only 0.07%, is occupied by the deepest part of the lake basin, deeper than 1.5 m. This reflects the idea of decreased availability of drinking lake water, since in winter it can be found unfrozen only in bottom depressions. All shallow water freezes in the winter period.

### Physical-chemical characteristics

Lake water samples were collected twice in 2018: snowmelt water from the surface of the lakes (late March–April) and lake water (August). The samples were: three liters of water and 2–2.5 liters of snowmelt water from each of the five lakes.

The physicochemical parameters of lake waters were determined during the summer low water period of 2018 directly in the field using HM Digital (USA) instruments for measuring temperature, pH, redox potential, electrical conductivity, and total mineralization. The measurements were carried out from a rubber boat by immersing the device in water to a depth of 5 cm (five samples).

The pH, salinity (TDS), and conductivity (EC) were determined *in situ* using a PH-200, ORP-200 and COM-100 (HM digital, USA).

The color of water samples was determined in accordance with the cobalt-chromium scale according to RD 52.24.497-2005 [123]. To determine the color, five samples of lake waters were taken, a funnel was installed in a clean container, in which the Blue Tape filter discs were placed. The water was filtered, then poured into a clean volumetric flask and compared with a simulated scale on a white background in daylight.

Sampling of surface waters from reservoirs was carried out using a sampler from a depth of 0.5 m and followed the GOST 31861-2012 [124] protocol.

Sampling of the snow cover was carried out based on the GOST 17.1.5.05-85 protocol with a carbon plastic shovel, 21x21 cm in size [125]. Also, during the sampling process, a snow gauge and plastic bags with a capacity of 10–12 liters were used. The combined snow cover sample (one sample from each lake) at the sampling point was compiled from the sum of single snow cores (three sample from each lake).

The snow core included the entire depth of the snow cover. Before placing the snow in a bag, the lower end of the core was cleaned from particles of plant material and soil. As the bag was filled, the snow was compacted through the plastic film. For shipment to the chemical laboratory, snow samples were packed in plastic bags and covered with a special heat-insulating coating with a silvery reflective surface. In the chemical laboratory, snow samples were placed in plastic containers with a capacity of up to 10 liters, where the snow melted at room temperature. The entire volume of the sample was subject to melting and filtering. Twigs, leaves, needles, grass and other plant residues were selected and discarded from snow and melt water, due to the fact that it is detrimental to do this after the start of filtering from the filter surface. Filtration was started immediately after the appearance of the first portions of melt water. The melted sample was filtered through a Blue Ribbon filter.

### **Chemical analyses**

Determination of the content of anions and cations was carried out according to standard methods [47–49].

Mass concentrations of sodium, magnesium, potassium, and calcium cations in lake waters were measured by capillary electrophoresis using the Kapel capillary electrophoresis system at the Institute of Chemistry of Tyumen State University according to the GOST 31869-2012 protocol [126].

Measurements of the mass concentrations of chloride, sulfate, and phosphate ions in lake waters were determined by electrophoresis using the Kapel capillary electrophoresis system at the Institute of Chemistry of the Tyumen State University according to the GOST 31867-2012 protocol [127].

Measurements of the mass concentrations of the bicarbonate ion in lake waters were carried out by the titration method at the Institute of Chemistry of the Tyumen State University according to the GOST 31957-2012 protocol [128].

The chemical composition of water samples was investigated by inductive coupled plasma mass spectrometry (ICP-MS) and inductive coupled plasma atom emission spectrometry (ICP-AES). The contents of the macrocomponents (Na, Mg, Al, P, K, Ca, Fe) and some trace elements (Li, V, Cr, Ti, Mn, Co, Ni, Cu, Zn, Sr, Ba) were determined by ICP-AES (iCAP 6500, Thermo Scientific, Waltham, MA, USA). Contents of trace elements and rare earth elements (REEs) were determined by ICP-MC Thermo Elemental-X7 spectrometer (Thermo Scientific, Waltham, MA, USA). Several elements (Li, Ti, V, Cr, Co, Mn, Cu, Zn, Sr, and Ba) were determined by two methods to check the correctness of the analyses. In all cases, the discrepancy in the content of these elements determined by the two methods did not exceed 15%. For elements which were determined both by ICP-AES and ICP-MS, average values were used. In addition, to check the correctness of the analysis of samples, a Certified Reference Material (CRM) "Trace Metals" was used.

Elemental analysis of lake water samples was carried out at the Analytical Certification Testing Center of the Federal State Budgetary Institution of Science, Institute for Problems of Microelectronics Technology and High-Purity Materials of the Russian Academy of Sciences (ASIC IPTM RAS).

Contents of Li, Be, B, Na, Mg, Al, Si, P, S, K, Ca, Sc, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, Se, Br, Rb, Sr, Y, Zr, Mo, Nb, Ru, Rh, Ag, Cd, In, Sn, Sb, Te, Cs, Ba, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu, Hf, Ta, W, Re, Os, Ir, Pt, Au, Hg, Tl, Pb, Bi, Th and U in the samples were determined by atomic emission (iCAP-6500, Thermo Scientific, USA) and mass spectral (X-7, Thermo Elemental, USA) methods of analysis. To check the correctness of the analysis, a standard sample of drinking water "Trace Metals in Drinking Water" manufactured by High-Purity Standards (USA) was used.

Also, to check the correctness of the analysis, we compared the results of atomic emission and mass spectral determination of Li, Al, Mn, Cu, Zn, Sr, and Ba. In all cases, the discrepancy in the contents of these elements, determined by two methods, did not exceed the permissible errors of the methods.

Full details of the results of the chemical analyses are given in the research by A.V. Soromotin et al. [129].