WATER CHEMISTRY OF THE LOWER KOLYMA RIVER AND ITS TRIBUTARIES BASED ON DATA FOR THE SUMMER OF 2021

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INTRODUCTION

A widespread permafrost degradation is forecasted in the Northern Hemisphere throughout the 21st century, evoking an urgent need to study its impacts. We focus on the **potential influence of permafrost thaw on freshwater chemistry** in the lower Kolyma basin. Samples were collected during the research expedition beetwen 19th and 21st July 2021 from Kolyma river, its tributaries – Omolon and Anyui, creeks along a permafrost cliff, and from permafrost ice (from yedoma) (Fig. 1). **Ions, metals, non-metals, and organic carbon (OC)** were analysed in water samples (n = 18) in dissolved phase (filtered through Whatman® GFF 0.7 µm pore size membrane). Cluster analysis was performed to explore similarities between the sampled objects (samples) and parameters (variables) with the use of TIBCO® Statistica software (version 13.3). Variable clustering and sample clustering have both been run as tree diagrams, using Ward's method and squared Euclidean distance. Enrichment factors of elements were also calculated based on published mean concentrations in river water (dissolved phase).

SAMPLING AREA

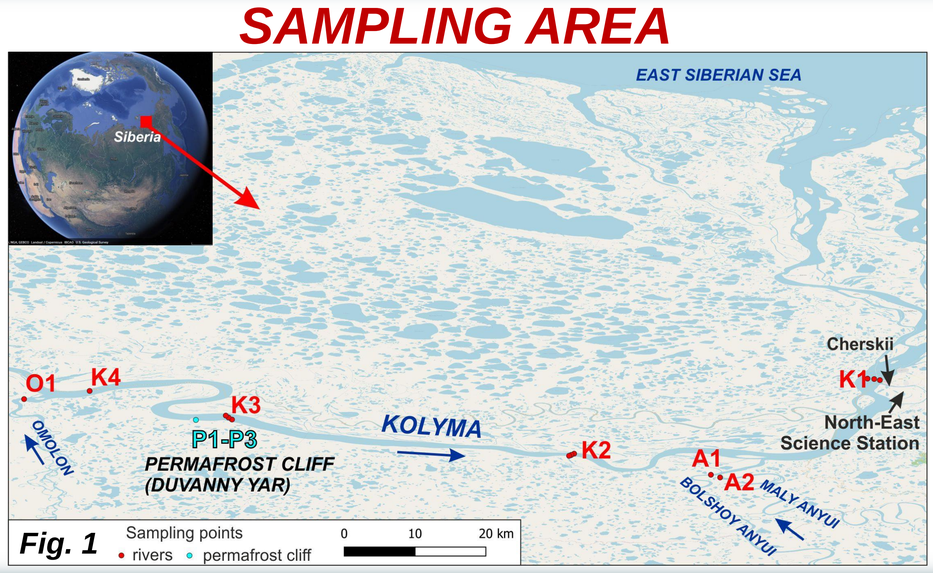

Fig. 1

RESULTS and DISCUSSION

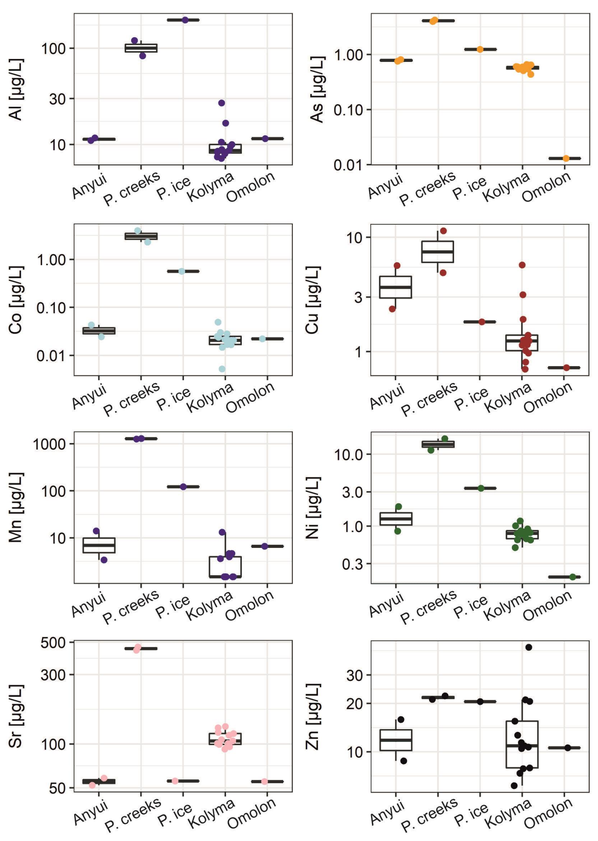

Fig. 2 Metals concentration in studied waters

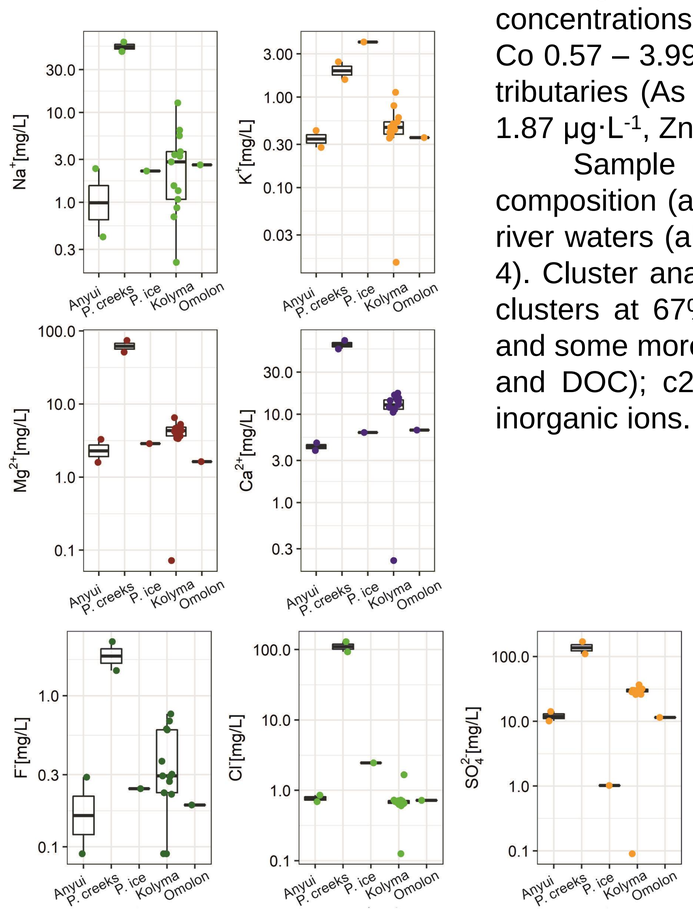

Fig. 3 Cations and anions in studied waters

We measured 9.1 mg L^{-1} DOC in permafrost ice, 1.9 – 4.8 mg L^{-1} in rivers, and 106 – 127 mg L^{-1} in yedoma-fed creeks (Table 1). Heavy metals showed much higher concentrations in permafrost creeks and ice (As 1.24 – 4.23 µg·L^{-1}, Cu 1.82 – 11.4 µg·L^{-1}, Co 0.57 – 3.99 µg·L^{-1}, Ni 3.36 – 16.5 µg·L^{-1}, Zn 20.5 – 22.3 µg·L^{-1}) than in Kolyma and its tributaries (As 0.22 – 0.81 µg·L^{-1}, Cu 0.70 – 5.72 µg·L^{-1}, Co 0.01 – 0.05 µg·L^{-1}, Ni 0.2 – 1.87 µg·L^{-1}, Zn 6.2 – 44.6 µg·L^{-1}) (Fig. 2).

Sample clustering showed objects with similar water properties and chemical composition (at the 33% maximum distance level): permafrost ice (P3) were grouped with river waters (all K, O & A), and permafrost creeks (P1, P2) formed a separate group (Fig. 4). Cluster analysis (Fig. 5), performed for river waters alone (K, O and A), yielded three clusters at 67% maximum distance level: c1 contained rock-derived elements, organics and some more typically anthropogenic contaminants (Si, Mn, Fe, Zn, Sb, Cu, V, Co, As, Ni and DOC); c2 grouped Li, Mo, Cd, Ba, Be, Al and Sr; and c3 joined Sr, Se, and all inorganic ions.

Table 1 *DOC,pH, conductivity and enrichment factor >1 for heavy metals*

Sample	DOC [mgL^{-1}]	pH	SpC [µS cm^{-1}]	EF>1
K1	3.88-3.94	7.5	124-132	As, Cu, Ni, Pb, Zn
K2	3.25-3.94	7.7	139-142	As, Ni, Zn
K3	3.01-3.59	7.8	135-148	As, Cd, Cu, Ni, Zn
K4	3.66	7.5	165	As, Ni
O1	1.87	7.3	69	-
A1	4.80	7.6	65	As, Ni
A2	3.36	7.6	67	As, Cu, Hg, Ni, Zn
P1	106	7.8	1270	As, Co, Hg, Mn, Ni
P2	127	7.5	1405	Co, Hg, Mn, Ni
P3	9.1	7.4	104	Hg

Fig. 4 *Tree diagram of the studied objects*

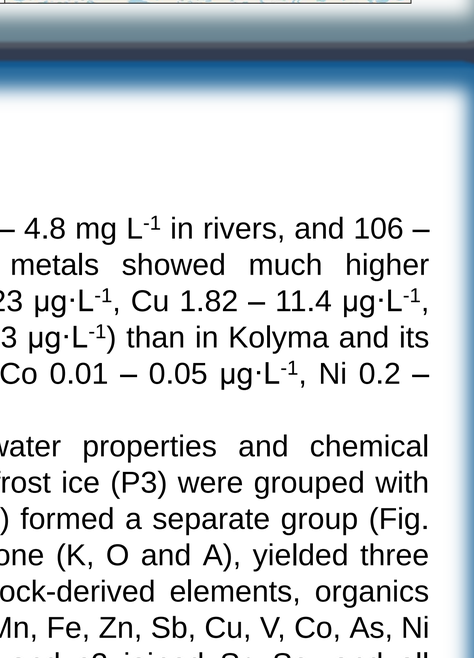

Fig. 5 *Tree diagram of variables →*

MEASUREMENT INSTRUMENTATION

Table 2 *Technical specifications used in the applied analytical procedures*

ANALYTES/ PARAMETERS	MEASUREMENT INSTRUMENTATION
Metals & metalloids	ICP-MS & ICP-OES Elan DRC, PerkinElmer, USA
cations & anions	ION CHROMATOGRAPH DIONEX 3000 chromatograph, USA
pH & conductivity	YSI multiparameter probe, Digital Professional Series

CONCLUSIONS

- In our study we found increased values of several metals in all studied fresh waters, which belong to the different levels of the hydrological network, including the waters fed directly by permafrost thaw. Some of the detected metals may be toxic for living organisms.
- Fresh waters originating from permafrost thaw and suprapermafrost aquifer are characterised by the highest concentration of DOC, inorganic ions, and selected heavy metals.
- The impact of changes in permafrost regions, occurring due to climate change, needs to be considered with respect to both the remobilisation from older permafrost (of organic carbon and other chemical components) and the interference with newly deposited anthropogenic contaminants

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