Soil organic matter in soils of the Russian Arctic: insights from ^{13}C-NMR spectroscopy

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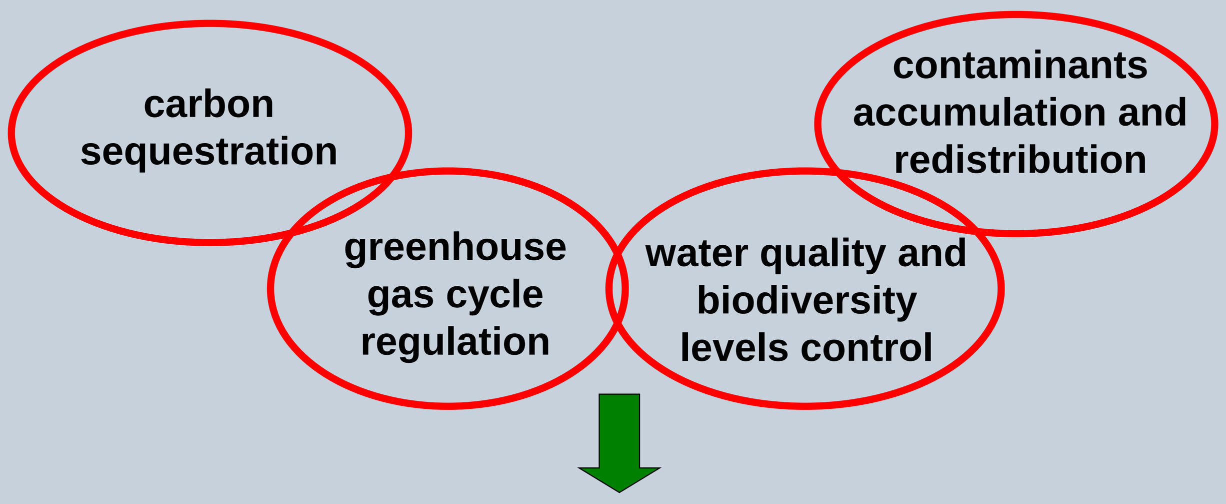
Introduction

Arctic biome provides many crucial soil ecosystem services: carbon sequestration and greenhouse gas cycle regulation, water quality and biodiversity levels control, contaminants accumulation and redistribution. Intensification of human activities in the Arctic and high vulnerability of the Arctic environments results in soil degradation and further degradation of soil ecosystems benefits.

Soil ecosystem services in the Arctic

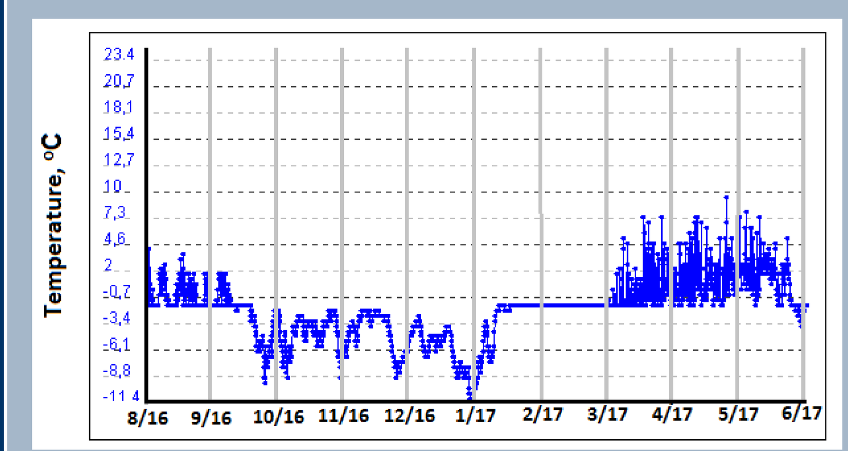


There are many gaps in current state of knowledge of organic matter in permafrost-affected soils. Enhanced quantity of research on qualitative assessment of organic matter, its distribution in permafrost-affected landscapes and soils, carbon and nitrogen pools, their dynamics and stabilization, climate-relevant gases release from the soil – this is not an exhaustive list of topics need to be investigated and summarized for adequate assessment of current state of permafrost-affected regions and their fate in conditions of predicted climate change.

Area of study

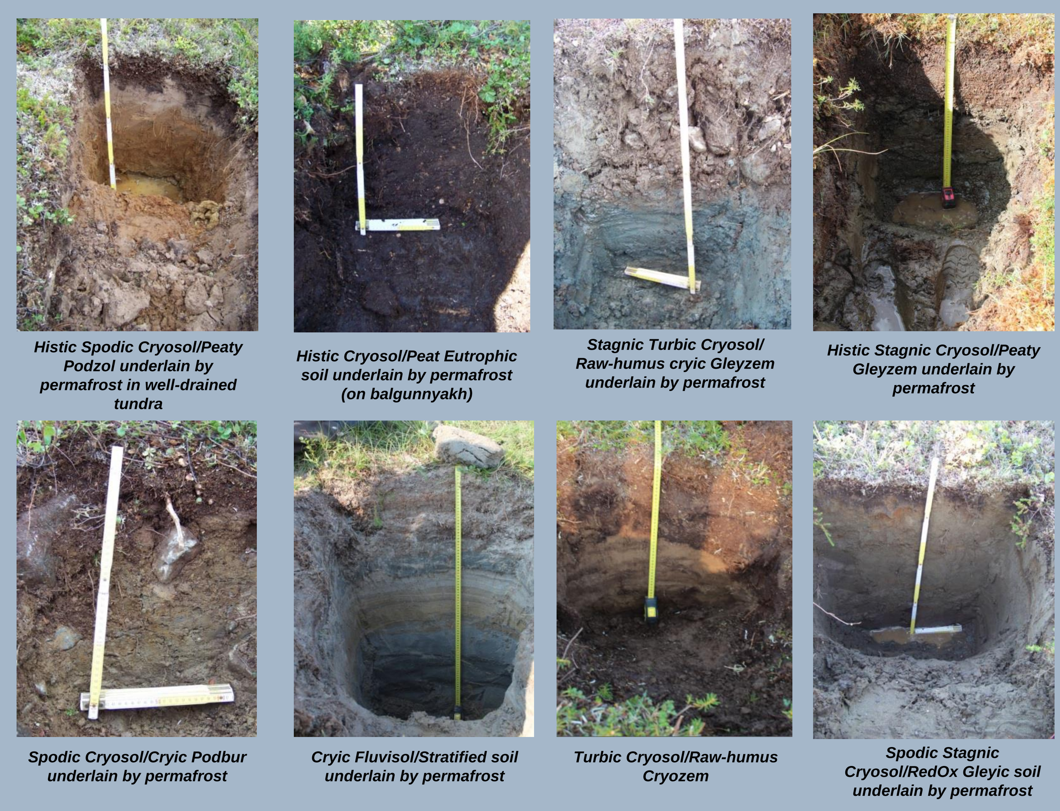

Area of investigation. 1 – Surroundings of Salekhard; 2 - the Polar Urals (Chyornaya mountain and Kerdamon-Shor valley); 3- Khalyatalbey river; 4 – Bolshaya Hadata river; 5 – Bolshoe Schuchie lake; 6 – Erkuta river

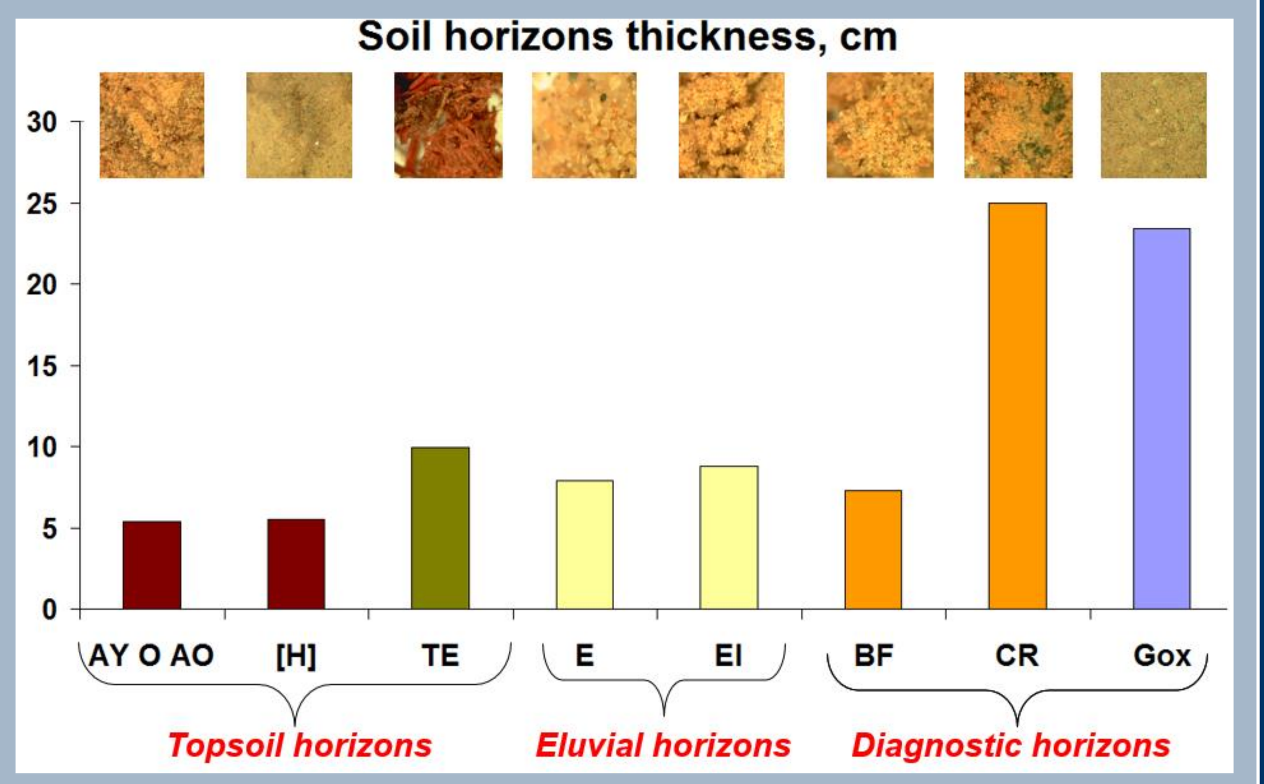
Yamal region was very sensitive to climate warming, during last 30 years. Forbes et al. reported 1-2 ºC increase in the average air temperature (Forbes et al., 2009). This is significant for enhancing of rates of soil organic matter humification and climate-relevant gases emission to the atmosphere (McGuire et al., 2009). It is potentially a factor of unbalancing the current carbon balance.



Soil temperatures (0-10 cm) over the season August 2016-June 2017 as collected from permanent monitoring plot at Erkuta river derived from thermologgers

Soil morphology

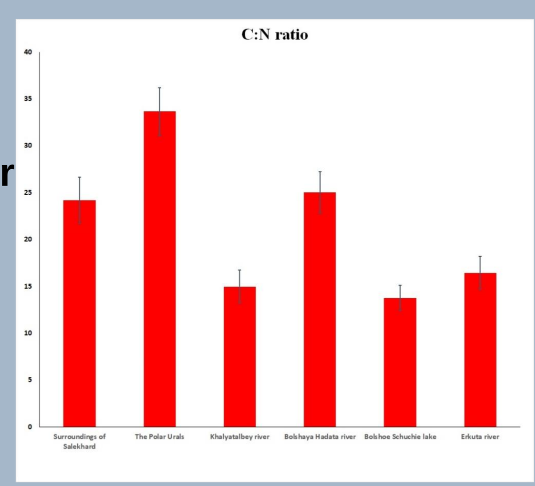


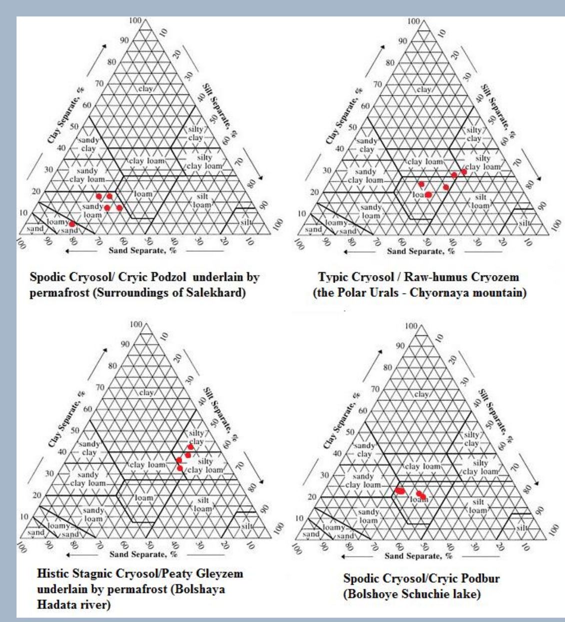


Soil properties. Highlights

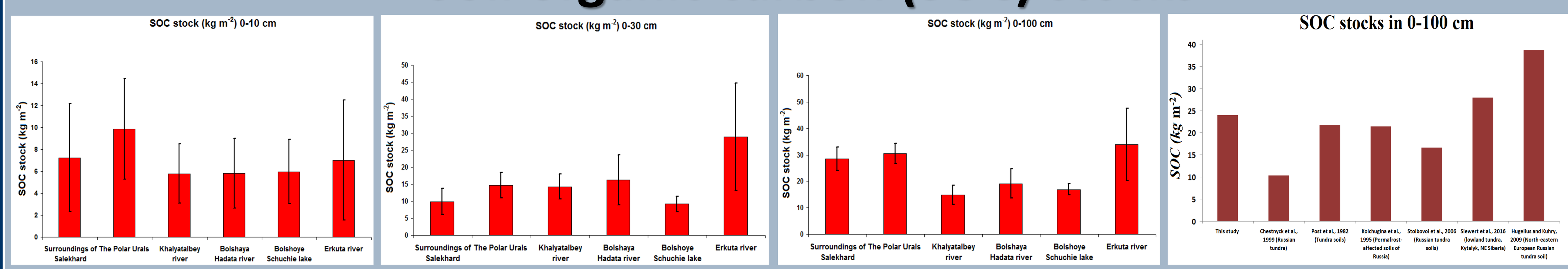
<u>pH</u>: strong acidic to acidic
<u>Delta pH</u>: significant (>1) in soils of 3 sites
<u>OC, nitrogen</u>: max in topsoil horizons (litter or Histic material), but complicated in case of cryogenic mass transfer
<u>C:N ratio</u>: widest in topsoil horizons, widest ratios at sites with predominance of soils with litter topsoils
<u>Texture class (mineral soils)</u>: predominantly loamy fractions

<u>C/N</u> ≠ 30 → underestimation of nitrogen in calculations for Arctic soils, *<u>degree of stabilization of organic matter in studied soil should be assessed by instrumental molecular methods</u>*

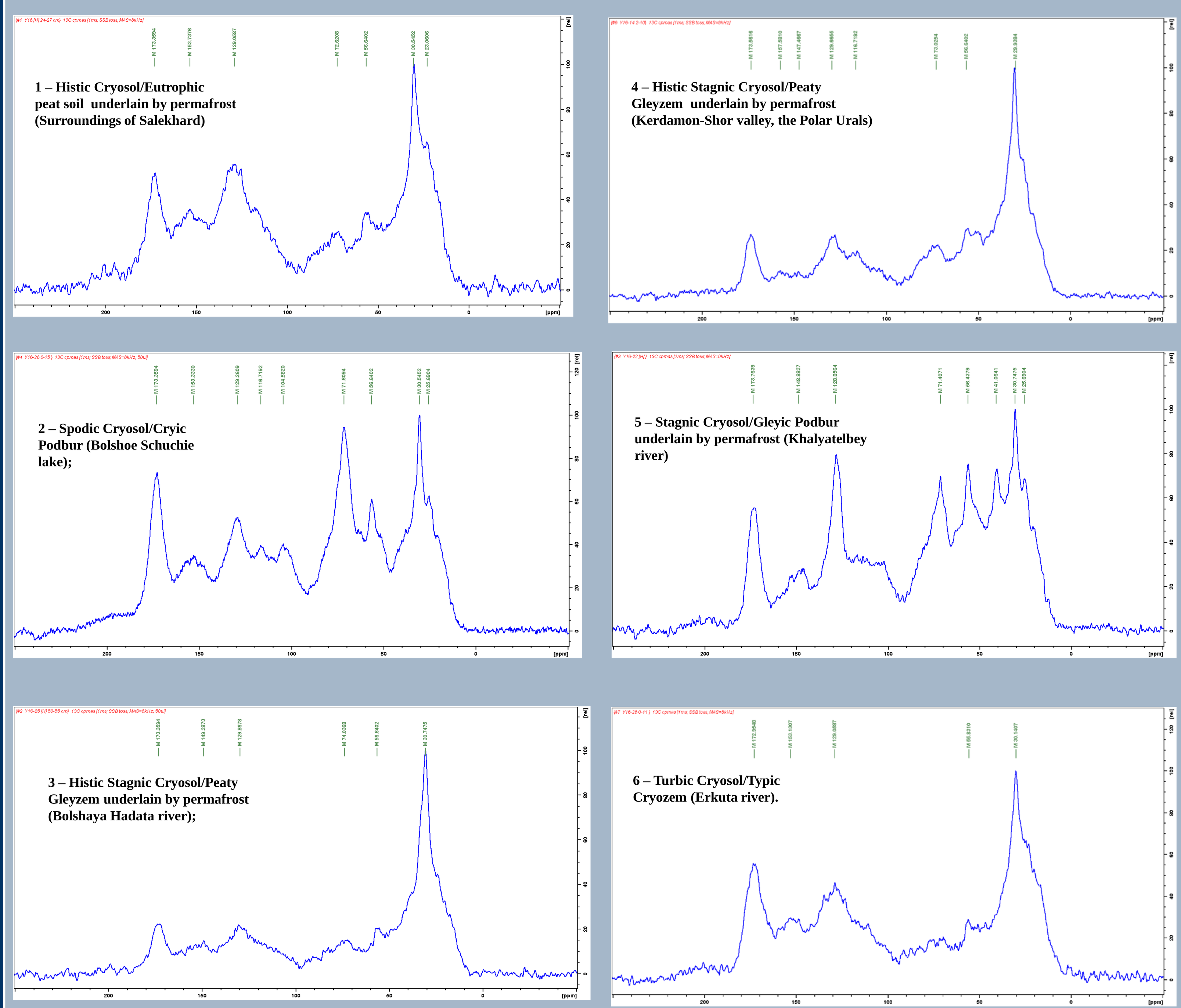




Soil organic carbon (SOC) stocks



SOM characterization



Soil ID	Chemical shifts, ppm				Aromatic groups, %	Aliphatic groups, %
	10-45	*45-110*	*110-160*	*160-220*		
Histic Cryosol	28.36	24.52	36.31	10.81	40.71	59.29
Spodic Cryosol	25.56	38.95	31.43	4.06	32.76	67.24
Stagnic Cryosol	20.97	32.8	35.47	10.76	39.75	60.25
Histic Stagnic Cryosol	20.97	32.8	35.47	10.76	39.75	60.25
Histic Stagnic Cryosol	28.21	30.4	32.88	8.51	35.94	64.06
Turbic Cryosol	25.75	28.99	34.55	10.71	38.69	61.31
Mean±SD	24.97±3.31	31.41±4.80	34.35±1.84	9.26±2.70	37.93±3.02	62.07±3.02

t test, $p<0.0001$

Results obtained on ^{13}C-NMR spectra revealed only small variability of humic acids across the latitudinal gradient of studied sites. It is explained by relative homogeneity of vegetation and climate conditions as well as water and temperature regimes (which are the main drivers of humification) of soil at investigated sites.

Acknowledgements

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Conclusions

- The mean soil organic carbon stock for study area were 7.85±2.24 kg m^{-2} (for 0-10 cm layer), 14.97±5.53 kg m^{-2} (for 0-30 cm), 23.99±8.00 kg m^{-2} (for 0-100 cm).
- This work revealed that studied soils demonstrate increased portion of aliphaticity and decreased portion of aromaticity, which is caused by the predominance of non-ligneous vegetation as the main precursor of soil humic acids. Low stabilization rate of organic matter in studied soils can be explained by low mineralization rates and correspondingly increased C/N ratios. The predominance of aliphatic carbon species also reveals early stages of humification process in studied soils.
- The data reported in this work should be assessed as a contribution for global estimations of organic carbon budget and dataset on soil characteristics of permafrost-affected soils of the Arctic. Detailed and comprehensive investigations of properties and dynamics of landscapes in conditions of permafrost influence should be enhanced and spatially more distributed.

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