Permafrost thaw lakes natural organic matter degradation and the potential impact on water quality

João Coelho[1], Diogo Folhas Ferreira[1], Leonor Carvalho[1], Rute Cesário[1], Nicholas Hasson[2], Sarah Ellen[2], Katey Walter-Anthony[2], Raoul Couture[3], João Canário[1]

[1]Centro de Química Estrutural, Institute of Molecular Sciences and Department of Chemical Engineering, Instituto Superior Técnico, Universidade de Lisboa, Lisboa, Portugal

[2]University of Alaska Fairbanks, Fairbanks, Alaska, USA

[3]Department of Chemistry, University Laval, Quebec City, Canada

Corresponding author: João Coelho[1] - joaomacoelho@tecnico.ulisboa.pt

Besides the potential effects on Arctic infrastructures, permafrost thaw poses a serious risk to Indigenous Communities due to the release of great amounts of natural organic matter (NOM) with potential impact on the access to potable drinking water and, after its degradation, the greenhouse gases release.

Redox processes govern the degradation of organic matter. Microbial communities that precipitate these processes, often compete for chemical moieties acting as electron donors. This competition favors the most energy efficient process. While the use of dissolved oxygen (O_2) generates the greatest energy per mole of oxidized organic carbon (OC), in high anoxic systems, NOM degradation is associated with the release of carbon dioxide (CO_2) and methane (CH_4).

Five permafrost thaw lakes were sampled - two lakes near Kangiqsualujjuaq (Nunavik, Canada), the Big Trail Lake (BTL) near Fairbanks (Alaska, USA), and two lakes (SAS 1A and SAS 2A) near Whapmagoostui-Kuujjuarapik (also Nunavik, Canada). In these lakes water samples were taken with 25-cm resolution and analyzed for Dissolved Organic Carbon (DOC) and terminal electron acceptors (TEAs: O_2, NO_3^-, Mn(IV), Fe(III), SO_4^{2-}, CO_2).

Results showed high variability of DOC concentrations with BTL and both SAS lakes presenting the highest concentrations. Iron (Fe) levels were incredibly high in SAS lakes (up to 429 mg/L) compared to the other sampled freshwater systems. Anyway, Fe seems to be the main species used in NOM degradation in all lakes.

These results indicate a strong potential for NOM degradation in the studied thermokarst lakes during winter due to the high concentration of TEAs, particularly Fe. These processes lead to an increase of more labile organic matter species that is released to the adjacent aquatic systems during spring thaw increasing the browning of this waters and therefore its quality. These overall processes could have a strong impact on the access of Indigenous Communities to drinking water.