Uncovering the effect of molecular organic matter composition on trace elements fate in lake sediments

JULIE TOLU[1*], S. BOUCHET[2], A. G. BRAVO[3], J. RYDBERG[1], E. BJÖRN[2], S. BERTILSSON[3], C. MEYER-JACOB[1], AND R. BINDLER[1]

[1] Dept. of Ecology and Environmental Science, Umeå University, Sweden (*julietolu@hotmail.com)
[2] Dept. of Chemistry, Umeå University, Sweden
[3] Dept. of Ecology and Genetics, Uppsala University, Sweden

While organic matter (OM) is a key component of trace elements cycle, the effect of its molecular composition is only partially investigated because of analytical restrictions.

We have developed a method for high-throughput characterization of OM molecular composition that requires as little as ~200 µg sample mass, by combining pyrolysis-gas chromatography-mass spectrometry with a semi-automated data processing pipeline [1]. This method provides semi-quantitative data with a high degree of precision on >100 organic compounds belonging to different OM biochemical classes (e.g., carbohydrate, protein, chlorophyll, lignin). This new method was then applied to studies of the transformation and fate of trace elements in boreal lake ecosystems.

In a first study, we demonstrated that sediment OM molecular composition controls the formation rates of neurotoxic monomethylmercury (MMHg) mainly through its control on bacterial activity, but also by modulating bioavailability of inorganic Hg, which is the MMHg precursor [2]. Sediments of eutrophic lakes rich in fresh planktonic organic compounds have 2 to 11 times higher Hg methylation rates than sediments dominated by terrestrial OM (oligotrophic lakes) or rich in degraded planktonic OM.

In a second study, we showed that the in-lake spatial heterogeneity of inorganic sediment constituents, including trace metals, is closely linked to OM molecular composition [3]. This relationship is driven by the preferential transport of fine-grained algal OM that sorb trace metals but also by the specific accumulation of OM originating from aquatic macrophytes or from the catchment. These results suggest that the deepest lake areas, most commonly sampled, are not necessarily representative of the reactivity (e.g., sorption, transformations) of trace elements in a lake ecosystem.

Overall, our work underlines the importance of characterizing OM composition at the molecular level to fully understand the cycling of trace metals and metalloids at the mechanism scale and ecosystem or regional level.

[1] Tolu *et al.* (2015) *Anal. Chim. Acta* **880**, 93-102; [2] Bravo *et al.* (2017) *Nat. Comm.* **8**, **14255** ; [3] Tolu et al. (2017) *Biogeosciences* **14**, 1-20