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Assessing the fate of a long-term C sink: organic carbon loss in lake sediments as a consequence of permanent drying

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The stability of long-term carbon (C) sinks is especially relevant for the global C balance, as they withdraw C from the active cycling loop at larger time scales than the CO_2 atmospheric residence time. Organic C buried in sediments of freshwater ecosystems can remain there during millennia, representing a long-term C sink of similar magnitude than the organic C buried in the whole ocean floor. Therefore, it is crucial to assess the stability of the inland waters' sediments C sink to complete our understanding on C cycling and its potential feedbacks with global warming. At present, freshwater ecosystems are contracting and even disappearing in some regions, including some of the largest lakes and reservoirs worldwide. When the water shed disappears, sediments become exposed to oxygen, changing redox conditions that increase the potential for sedimentary organic materials of being degraded. Accordingly, recent investigations have shown that drying sediments of inland water bodies emit large quantities of CO_2 to the atmosphere.

Our overarching goal is to study the loss of organic carbon compounds from a drying lake, in order to determine the long-term organic C loss rates. Particularly, we aimed to: (1) better understand the link between organic C losses and CO_2 emissions, (2) check whether organic compounds are deferentially lost as a function of their chemical properties, (3) determine changes in the microbial community function linked to drying and organic C losses.

To do so, we present a double approach; first, to determine OC loss rates in natural conditions, we sampled cores in following a gradient of drought in a contracting lake. Thus, from sediments that had been dry for decades down to sediments with overlaying water. Our results indicate losses of 50% of organic compounds across depths with 30% of these losses occurring the first years of drought. We explored the organic compounds present across the gradient through FT-IR, XRF and isotopic signals, finding differences between the cores that point towards differential losses of compounds during drought as a function of their chemical properties. Second, we performed in-situ and laboratory experiments consisting in re-wetting dry sediments and drying wet sediments to elucidate the mechanisms governing C fluxes. Gas fluxes were bi-directional, with influxes and effluxes occurring as a function of sediment humidity and time since drought. Organic C losses and gas fluxes became increasingly decoupled throughout the drying process, indicating that gas emissions might be a poor proxy for organic C mineralization processes in very dry sediments. Changes in the metabolic activity of the sedimentary bacterial community such as transitions between dormant and active states might be key to understand the processes governing organic C loss in drying sediments.