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Reconstructing the effects of anthropogenic eutrophication and climate change on lake carbon cycling using the δ13C and δ15N of sub-fossil chitinuous remains (Cladocerans, Chironomids) archived in sediment cores.

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Carbon and nitrogen stable isotope analyses are a common neo-ecological tool to study nutrient fluxes and carbon cycling in aquatic and terrestrial ecosytems. Transposing this isotopic tool to biological remains archived in sediment cores, such as the chitinuous remains of cladocerans and chironomids, would offer the opportunity to infer the past impacts of human activities or climate variability on lacustrine C and N processes.

In this work, we first checked that archived chitinuous remains would provide adequate material for the paleo-ecological use of stable isotope analyses, addressing, from experimental and field approaches, the following issues: (i) there is a predictable relationship between the C and N isotope composition of the archived remains and that of the organism's diet or whole body ; (ii) diagenetic processes do not affect the C and N isotopic composition of chitinous remains over time.

Once these crucial methodological requirements validated, we reconstructed the past changes in the carbon cycling of two large subalpine lakes (Annecy and Bourget), using a series of sediment cores covering the last 150 years. Long-term trends in the δ13C values of chironomid and cladoceran sub-fossil remains have been compared to more classical paleo-limnological proxies for lake trophic status and reconstructed climate variability (HISTALP). From the early XXth century, along with the settlement of eutrophication, the δ13C values of cladoceran and chironomid remains from all depths started to decrease, according to very similar trends. Such a 13C depletion in the food sources that sustained both the pelagic and benthic food webs likely resulted from an increase in lake respiration processes. From the mid-XXth century, while eutrophication had reached its paramount, δ13C values got even more depleted for chironomids retrieved from the deepest cores as compared to littoral chironomid remains or cladocerans, highlighting that methanogenetic processes developed at the lake bottom.

Both lakes have been under restoration programs over the last 40 years and their P concentrations have now reached values typical for oligo- or oligo-mesotrophic lakes. In spite of such remediation efforts, δ13C values of chironomid and cladoceran sub-fossil remains have remained low. The lack of reversibility of the δ13C trends highlights that P recovery did not restore the pre-eutrophication lake C cycling. In contrast, heterotrophic and methanogenic processes have still been increasing as a result of a warmer climate favoring lake bottom anoxia.