Interactions between nutrient induced changes in algal community structure and hydrogen isotopes of lipid biomarkers

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δ^2H ($^2H/^1H$) values of sedimentary algal lipids are useful as a proxy for past hydroclimate variability. However, it has become increasingly apparent that a number of factors, including growth rate and species assemblage, can influence the magnitude of $^2H/^1H$ fractionation between algal lipids and environmental water. These effects have been observed in controlled laboraty cultures of single species, but have not been investigated in complex communities of algae.

In order to assess how nutrient availability, algal community structure, and interactions between the two affect the δ^2H values of lipids exported to sediments, we collected suspended particles from 20 large volume (10,000L) mesocosm cultures at three time points interspersed with sequential nutrient additions. We measured δ^2H values of short and mid-chain length fatty acids. As algal productivity increased, δ^2H values of fatty acids increased, opposite to the response seen in cultures of a single species. Close to half of the variance in $^2H/^1H$ fractionation can be explained by changes in the algal community structure, with fatty acids tending to become more enriched in ^2H as the relative abundance of cyanobacteria to larger eukaryotic phytoplankton increases ($p < 0.0001$; $n = 58$).

We applied these results to a 200-year sediment core from Lake Baldegg, a central Swiss lake that experienced well-documented extreme changes in nutrient loading during the 20th century. We measured δ^2H values of fatty acids in this core and compared them to an existing record of $\delta^{18}O$ values of authigenic carbonates. Prior to the mid-20th century, both proxies indicate that lake water isotopes were fairly stable, and are consistent with water δ^2H values of ~ -70‰. Then, as phosphorus loading began to increase rapidly in the 1950s, fatty acid δ^2H values increased by 50‰. We suggest that this H isotope excursion – which is ~5x too large to be consistent with the carbonate $\delta^{18}O$ values – could be due to changes in the algal community structure, such as cyanobacterial blooms.