A CENTURY-LONG RECORD OF ANTHROPOGENIC NUTRIENT LOADING PROVIDED BY $\delta^{15}N$ VALUES IN SEDIMENT FROM A EUTROPHIC LAKE.

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Introduction: The nitrogen isotopic composition of organic matter has become a valuable tool for reconstructing past productivity and changes in the nutrient availability in ocean surface waters [1]. Yet, nutrient utilization and paleoproductivity have not been as successfully inferred from N-isotopes in lake sediments. This is because P, and not N, commonly limits primary productivity in lakes. Under conditions of unlimited supply of nitrate, phytoplankton can continue to preferentially uptake ^{14}N.

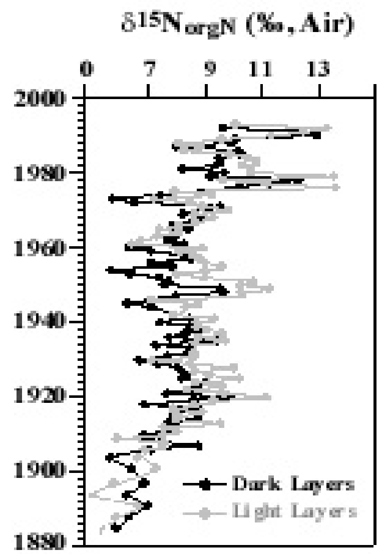
In addition, factors other than primary productivity can influence the N isotopic composition of lacustrine organic matter. For example, the nitrogen isotope composition of dissolved inorganic nitrogen (DIN) in lakes can significantly increase through time by external nitrate loading (i.e. anthropogenic eutrophication) and/or by water column denitrification in low-oxygen environments. Nitrate derived from human and animal waster is enriched in ^{15}N ($\delta^{15}N$ = 10-20‰ [2]).

Changes in the source of organic matter, due to either shifts in species composition of phytoplankton or addition of organic matter from heterotrophs, can also overwhelm any $\delta^{15}N$-productivity signal.

In this study, we present nitrogen isotopic data from individually sampled light and dark annual laminae from a century-long (1885-1993) sediment record recovered from Baldeggersee, a small lake located in central Switzerland. Due to dramatic and well-monitored changes in anthropogenic nitrate loading and environmental conditions during this century, Baldeggersee provides an ideal system to quantitatively document and evaluate the N-isotope response of nutrient loading, nitrate utilization and N-limitation.

Results: Nitrogen isotope ratios in Baldeggersee organic matter are significantly higher than other reports of nitrogen isotopes in lake sediment (e.g. reported average values of 1-5‰ [3]). $\delta^{15}N$ values increase generally from the beginning of the record ($\delta^{15}N$ ~ 6-7‰) to the top of the core ($\delta^{15}N$ ~ 10-11‰; Fig. 1). Several abrupt positive N-isotope excursions are superimposed on the increasing trend. A 6‰ positive $\delta^{15}N$ shift occurred between 1972-1976, coincident with the time of maximum P-loading, meromixis in the water column, strongest N-limitation of phytoplankton and maximum extent of the anoxia hypolimnion [4]. Another abrupt nitrogen isotope increase (4‰) occurred in the most recent few years, when $\delta^{15}N$ values in the light layers again reached values >13‰.

Figure 1. Stratigraphic plot of $\delta^{15}N$ from the Baldeggersee laminated sequence.



Discussion: Nitrogen isotopes measured in the uppermost core samples were compared with surface water [NO_3^-] for the period of 1976-1993. The abrupt positive $\delta^{15}N$ shifts occurred when large seasonal phytoplankton blooms significantly decreased surface water [NO_3^-], thus providing conclusive evidence that N-isotopes in organic matter can record NO_3^- utilization by phytoplankton.

The first-order increase in $\delta^{15}N$ values (~6‰ over the period 1885-1993) cannot be explained exclusively by nitrate utilization in response to increase primary productivity. Rather, the increasing trend dominantly reflects progressive ^{15}N-enrichment of the Baldeggersee DIN pool due to external N-loading from animal manure in the watershed and/or increase of denitrification processes in the anoxia hypolimnion over the last 100 years.

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