Seasonal variation of the d13C and d15N of particulate and dissolved carbon and nitrogen in Lake Lugano: Constraints on biogeochemical cycling in a eutrophic lake

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Limnol. Oceanogr., 49(2), 2004, 415-429 | DOI: 10.4319/lo.2004.49.2.0415

ABSTRACT: We determined the δ'³C and δ'⁵N of water-column particulate organic matter (POM), dissolved inorganic carbon, and nitrate, together with water chemistry and phytoplankton biomass and species composition every month in eutrophic Lake Lugano. As primary productivity increased during spring, the δ'³C of photic-zone POM increased from -34‰ to -24‰. This '³C enrichment reflects decreasing C-isotope fractionation between organic and inorganic carbon pools in response to decreasing surface water [$CO_{2(aq)}$]. Variations in the δ'⁵N of surface-water POM (+2‰ to +8‰) collected during the productive period were attributed to isotope effects associated with nitrate uptake, nitrogen fixation, and mixing of different organic matter sources. The apparent N-isotope enrichment (ε) associated with nitrate assimilation varied with ε = -1.0‰ ± 0.9 for diatoms and ε = -3.4‰ ± 0.4 for green algae. The mechanisms controlling the N-isotopic composition of surface-water nitrate include the combined processes of nitrate assimilation, nitrification, mixing of water masses, and external nitrate loading. There was no consistent relation between the δ'⁵N of POM, the δ'⁵N of nitrate, and the nitrate concentration in surface waters. Low δ'³C (-60‰) of POM from the benthic nepheloid layer (BNL) indicated that as much as 80% of the POM in the BNL consisted of methanotrophic bacteria. The δ'³C and δ'⁵N of near-bottom POM allowed tracing a [□]bacteriocline[□], which rose with the expanding volume of bottom-water suboxia. Associated with the development of anaerobic conditions and coupled to decreasing [NO_3^-], the δ'⁵N of bottom-water nitrate progressively increased from +8‰ to +27‰, indicating active denitrification in the hypolimnion. This study demonstrates the potential of natural-abundance level measurements of stable carbon and nitrogen isotopes to trace biogeochemical processes in lakes. However, the δ'⁵N of POM in eutrophic lakes is of limited use as an indicator of the degree of nitrate utilization and trophic state.

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