Extreme 13C enrichments in a shallow hypereutrophic lake: Implications for carbon cycling

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ABSTRACT: An analysis of stable carbon isotope ($\delta^{13}C$) ratios in Lake Apopka, Florida, reveals extreme ^{13}C enrichments of dissolved inorganic carbon (DIC) pools in the water column and sediment pore water of this shallow polymictic and hypereutrophic lake. The sediment pore water had high average $\delta^{13}C$ of DIC (26.4‰), DIC (8.37 mmol L^{-1}), and methane (CH_4) concentrations (1.23 mmol L^{-1}). The extreme ^{13}C enrichment in the sediment pore-water DIC pool is attributed to methanogenesis, which produces ^{13}C-rich carbon dioxide (CO_2) and ^{13}C-poor CH_4 during the bacterial fermentation of organic matter. The $\delta^{13}C$ in the water-column DIC pool ranged from 5‰ to 13‰ with an average of 9.0‰. The flux-weighted $\delta^{13}C$ from the DIC due to external loading and sediment respiration was estimated as -12‰, whereas the $\delta^{13}C$ from particulate organic carbon (POC) due to water-column production was -13‰. The ^{13}C enrichment in the water column is attributed directly to the diffusion and advection of isotopically heavy DIC from the sediment and to the isotopic fractionation by phytoplankton photosynthesis and is attributed indirectly to the removal of isotopically light CH4 by ebullition and organic matter by sedimentation and outflow. Atmospheric invasion and sedimentation were the most important source and sink, respectively, in the carbon mass balance. CH_4 oxidation, atmospheric invasion, anaerobic respiration, and sedimentation are the important flux terms affecting the isotopic mass balance. A combination of shallow water depth, frequent wind mixing, anoxic sediments with high rates of methanogenesis, high phytoplankton productivity, and lack of external loading dominated by terrestrial carbon led to the ^{13}C enrichment of the water-column DIC pool in Lake Apopka.

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