Carbon isotope composition of dissolved inorganic carbon and atmospheric CO_2 of Lake Geneva: is DIC a mixing or process tracer?

TORSTEN VENNEMANN[1], JANINE HALDER[1], LAURENT DECROUY[1] AND MAËL BOURQUARD[2]

[1]IDYST, University of Lausanne, Lausanne, Switzerland (Torsten.Vennemann@unil.ch)
[2]CSD Ingénieurs, Porrentruy, Switzerland

Depth profiles analyzed for the stable carbon isotope composition of DIC, as well as some profiles of atmospheric CO_2 were taken in and above Lake Geneva, a large peri-alpine lake, between 2009-2011. $\delta^{13}C_{DIC}$ values of –10.1 ‰ (VPDB) were measured at the water-sediment interface (310m depth) while high values of up to –3.2 ‰ were measured at the surface in summer. $\delta^{13}C$ values of atmospheric CO_2 30 cm's to 10 m above the water is relatively constant at –9.3 ‰ in summer but can be –10.4 ‰ in winter. Corresponding $\delta^{13}C_{DIC}$ of surface waters sampled at the same time are –3.6 ‰ and –7.5 ‰, respectively, out of equilibrium with the CO_2. The CO_2 partial pressure is below atmospheric equilibrium from spring through summer, but higher during winter. Lake Geneva thus takes up CO_2 from the atmosphere between spring and fall and emits CO_2 during winter. Depth profiles of DIC indicate that the maximum gross primary productivity (and also peak in mg/l of O_2) is not directly linked to the $\delta^{13}C_{DIC}$ in Lake Geneva. In addition, $\delta^{13}C_{DIC}$ profiles are nearly identical at 4 different locations over two years, even though primary production differs markedly for the two years. Instead, smooth profiles with maximum $\delta^{13}C_{DIC}$ values at the surface suggest a diffusive uptake of atmospheric CO_2 and its subsequent dissolution. The uptake of CO_2 is, however, still considered to be driven by photosynthesis that lowers the pCO_2 in surface waters. The profiles are compatible with progressive depletion of ^{13}C in DIC with depth in the metalimnion, related to density stratification and mixing in surface layers. A study from 2005 measured relatively homogeneous $\delta^{13}C_{DIC}$ profiles after a complete annual overturn in winter with average $\delta^{13}C_{DIC}$ in the epi-, meta- and hypolimnion below 60 m of –7.2 ‰. This corresponds to mixing proportions of 25:75 for Jura and pre-Alpine rivers (–11.1 ‰) relative to the Rhône river (–5.7 ‰). In contrast, a further ^{13}C depletion with depth below the metalimnion was measured in the hypolimnetic layers of Lake Geneva during 2010/11, down to –10.1 ‰, in parallel to a decrease in O_2 from 10 to 4 mg/l, below 120 down to 300 m, compatible with remineralization of organic matter at depth.