RIVERINE CARBON CYCLE

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The study of the riverine biogeochemical processes has implication for our understanding of the present global carbon cycle and its ramification for the greenhouse effect. One of the most puzzling issues of the present-day carbon budget is the so called “missing sink”. The problem is that about 1/2 of the CO_2 released by burning of fossil fuels and deforestation is not accounted for by the post-industrial increase of ~70 ppm CO_2 in the atmosphere. Until very recently, it was believed that this “missing” CO_2 was taken up by the oceans, but even this scenario was based on the assumption that the entire CO_2 increase was due to anthropogenic sources. The problem would only be exacerbated if the observed CO_2 increase contained a natural component, an alternative not precluded by the available constraints. The latest research results show, however, that the net ingassing by the oceans is insufficient to account for the “missing” CO_2. It was therefore proposed that it is the terrestrial biosphere (and soils) that acts as the mysterious sink. In particular, the temperate forest ecosystems should have been “fertilized” to such a degree that their regrowth should have exceeded deforestation of the tropics. Alternatively, or complementarily, the rivers can transport large quantities of carbon (DIC, DOC, POC) directly into the ocean where it is remineralized. In either case, transport of CO_2 from soils into ground waters and rivers and the subsequent transport into the oceans plays a crucial role in quantifying the discrepancies in the global carbon budget.

We have studied a number of world rivers (Rhine, Danube, Elbe, Indus, St. Lawrence–Niagara–Detroit, Ottawa, Fraser and most of their larger tributaries). Carbon isotopic techniques are particularly suitable for tracing the origin of carbon and quantifying the fluxes. Carbon from respiration of organic matter has $\delta^{13}C_{DIC}$ of about −18 ‰ (e.g. the Amazon), but after reacting the soil and bedrock carbonate, it is about −10 ‰ (e.g. the lower Rhine). On the other hand, rivers that derive their carbon mostly from ingassing of atmospheric CO_2 (e.g. St. Lawrence) have $\delta^{13}C_{DIC}$ close to 0 ‰. Most rivers actively degrade carbon dioxide fed into them by groundwater discharges, but the CO_2 overpressures — up to 2 orders of magnitude — are inversely proportional to the residence time of the water in the system. Lacustrine rivers, with water residing in the lakes for many months to decades, may be completely degassed and equilibrated with the atmosphere. The pCO_2 in such rivers fluctuates seasonally by only about a factor of 2, due to photosynthetic drawdown of carbon dioxide in the warm season and its release from deeper portions of the lakes following a fall overturn (e.g. Great Lakes).

In detail, however, every river system is characterized by superimposed specific attributes that are controlled by an interplay of geology, population density and land utilization patterns, water budget, and by respiration/photosynthesis balance within the aquatic system; an interplay to be documented particularly on the example of the Ottawa river basin.