Landscape and hydrological controls on the downstream transport of dissolved organic matter in the Congo and Zambezi rivers

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Abstract

Conceptual models have recently emerged to describe the relative importance of catchment or in-stream controls on dissolved organic matter (DOM) concentration and composition along fluvial networks (the chemostat hypothesis, Creed et al. 2015) as well as the role of hydrological variations in regulating the passive or active character of inland waters in processing DOM during transport (the pulse-shunt concept, Raymond et al. 2016). However, the downstream evolution of DOM in large rivers is poorly documented and these concepts need be tested by empirical data acquired through extensive field studies. This is particularly relevant for tropical rivers as the chemostat hypothesis and the pulse-shunt concept are built on the river continuum concept that is typically applicable to rivers at temperate and high latitudes (Vannote et al., 1980).

Water samples including both mainstem and tributaries were collected along the Congo River (from Kisangani to Kinshasa, ~ 1700 km) and the Zambezi River (from the source to the mouth, ~ 3000 km) during contrasting hydrological periods between 2012 and 2014. Stable carbon isotopes and absorbance and fluorescence measurements coupled with parallel factor analysis (PARAFAC) were combined to investigate longitudinal patterns of dissolved organic carbon (DOC) concentrations and DOM composition. Data showed a shift in DOM during downstream transport from an aromatic- to aliphatic-dominant composition in both river networks, in agreement with the chemostat hypothesis. This transition was however mainly driven by the in-stream degradation of terrestrial DOM rather than autochthonous production and was highly dependent of the landscape morphology and environmental conditions. The degree of DOM degradation was also controlled by changes in water levels between high flow and low flow periods, as suggested by the pulse-shunt concept. Seasonal changes in longitudinal patterns of DOM composition were however more contrasted in the Zambezi relative to the Congo, due to large attenuation of seasonal water height variations in the latter compared to the former.

Overall, our data support recent conceptual models proposed to describe how DOM in large drainage networks varies both spatially and temporally, but also highlight the critical importance of the river-floodplain connectivity in tropical rivers in controlling DOM biogeochemistry at large spatial scales.