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Sources and pathways of organic carbon export in the Congo River system

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The development of carbon-dense landscapes on continents and the transfer of organic carbon from these landscapes into the ocean, followed by efficient burial, are key mechanisms of carbon stabilization. The Congo Basin, the world's second-largest river system, is characterized by an exceptionally carbon-dense landscape: in addition to tropical forests storing ~36 petagrams of carbon, the world's largest peatlands in its central "Cuvette Centrale" hold another estimated 29 petagrams of carbon. The Congo River network traverses the Cuvette Centrale wetlands, and the deposition of aged organic carbon has been recorded in sediment cores from the Congo Fan. However, organic carbon sourcing and transfer by the Congo River and its tributaries remain incompletely understood.

Here, we present geochemical data from a 450 km transect of the Congo River and right-bank tributaries spanning peat-dominated swamp forests of the Cuvette Centrale, evergreen forests, and mixed forest-savanna catchments. We analyzed dissolved organic carbon (DOC), particulate organic carbon (POC), and riverbank sediments for bulk organic carbon and nitrogen concentrations and stable isotopes ($\delta^{15}N$ and $\delta^{13}C$), as well as radiocarbon contents ($\Delta^{14}C$) to trace carbon sources across these contrasting catchments.

Our results show that tributaries draining the peatlands of the Cuvette Centrale export substantially more DOC than POC, both generally characterized by modern $\Delta^{14}C$ content and low $\delta^{13}C$ values, typical for rainforest vegetation. These findings confirm the Cuvette Centrale as a major source of riverine DOC, with exported POC and DOC derived predominantly from recent vegetation rather than underlying peatlands. Some peat-draining tributary samples deviate from this pattern, with POC showing low $\Delta^{14}C$ and $\delta^{13}C$ values, potentially reflecting local peat erosion.

Tributaries outside of the Cuvette Centrale draining mixed forest-savanna landscapes show much lower DOC and POC concentrations, with low $\Delta^{14}C$ and higher $\delta^{13}C$ values suggesting potential sourcing from savanna soils.

Our results suggest that despite the large peatland carbon stock, carbon exported from the Cuvette Centrale is under current conditions dominated by modern vegetation. The composition and $\Delta^{14}C$ of organic carbon exported by the Congo River to the Atlantic Ocean are likely driven by hydrological connectivity regulating the relative contributions from different vegetation zones and catchments.