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Exploring the impact of river engineering on carbon dynamics of fluvial landscapes

River systems are a critical link between the short-term biological and long-term geological global carbon cycles. Fluvially transported organic matter and carbon sequestered by biomass can be stored and transformed in floodplain sediments before being transferred by rivers to long-term sinks in the deep ocean. Carbon fixed by plants from atmospheric CO2 can be stored as soil organic carbon (OC) in the floodplain. Conversely, oxidation of organic matter in these environments has been shown to represent a significant CO2 source. The reworking of particulate organic matter during river transport and its intermediate storage in floodplains can promote formation of organo-mineral complexes, facilitating the formation of stable soil OC that eventually feeds back into the geological carbon cycle. Over the past several thousand years, human activities in fluvial landscapes, including river engineering and land use changes, have profoundly altered these biogeochemical fluxes. River straightening and floodplain drainage have disrupted channel–floodplain connectivity, but the net effect on OC dynamics remains poorly constrained. This study traces OC fluxes in both (near-)natural and engineered river systems in Central Europe, focusing on the Odra (Oder) River catchment in Poland and northeastern Germany.

We investigate the record of OC dynamics within a meander loop of the Odra River that was active prior to river straightening in the late 18th century. By analyzing total organic carbon (TOC) content and bulk carbon isotopes (d13Cbulk), we quantify soil carbon stocks and identify carbon sources. Radiocarbon dating (14C), alongside independent sediment age constraints, will be used to estimate OC residence times. Integrating geochemical analyses with remote sensing data will allow to reconstruct baseline, i.e. pre-engineering, river and carbon dynamics at the site. This will inform implications of meander cut-off on the export of aged soil OC downstream. Planned complementary measurements include assessments of CO2 outgassing from fluvial deposits in the river basin and OC fluxes in the modern, engineered river channel. Together, these efforts aim to advance understanding of the short- and long-term impacts of river management practices on fluvial landscape carbon budgets. This framework is critical for evaluating future landscape management strategies aligned with net-negative land use goals.

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