Redox Controls on Mobilization and Export of Mineral-bound Organic Carbon, Nitrogen, and Phosphorus in Floodplain Sediments

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Although depositional environments such as floodplains are key regulators of ecosystem carbon storage and downstream nutrient loadings, they are not very well represented in earth system models. Importantly, the fate of organic matter (OM), associated nutrients, and redox active metals are intimately linked, but highly variable. Alpine watersheds are particularly hydrodynamic systems, where spring snowmelt causes seasonal flooding of riparian sediments and promote carbon and nutrient export. What remains elusive is what biogeochemical processes control the fate of OM and associated nutrients during flooding. Here we hypothesized that redox-driven mobilization of mineral-associated OM (e.g., N and P) is a major loss pathway for C and nutrients. X-ray absorption spectroscopy (XAS) combined with density fractionation of samples collected from sediments across a floodplain transect in the East River watershed showed that OM bound to Fe hydroxides constitute the most significant C, N and P pool, particularly in deeper sediments. In addition, a combination of sequential extractions, incubations, and high-resolution mass spectrometry demonstrated that, because organic N and P is preferentially bound to easily reducible Fe hydroxides, these nutrients were preferentially mobilized under reducing conditions as experienced during flooding. In sum, our results indicate that OM associated with redox-active metals is an unexpectedly large and dynamic reservoir of organic N and P. Further research will assess the consequences of redox-mediated N and P mobilization on floodplain C storage (e.g., C oxidation rates) and downstream water quality (e.g., C and P export).