Seasonal shifts in mineral and metabolic constraints regulate carbon export from floodplain soils

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Floodplain soils are large and dynamic reservoirs of carbon (C), where seasonal flooding regulates both C storage and downstream water quality. Timing and frequency of seasonal flooding events are altered by climate change, increasingly subjecting floodplain soils to extreme flooding or droughts. These changes may have profound implications for greenhouse gas emissions or dissolved organic carbon (DOC) export from floodplain soils. Yet, the underlying (hydro)biogeochemical controls on C retention and export in floodplain soils are poorly constrained, limiting our ability to predict responses to climate change. Here we aimed to determine how seasonal flooding, and associated variations in redox conditions, impact the dominant controls on microbial C cycling in floodplain soils. Using in-field monitoring with advanced analytical and molecular tools, we examined how changes in mineral interactions and microbial activity during flooding and subsequent drainage affected C export from floodplain soils of the mountaineous East River watershed (Gothic, Colorado). Our results show that reduced conditions during flooded periods caused reductive dissolution of Fe (hydr)oxide, mobilizing previously sorbed organic matter and enhancing DOC export. At the same time, flooding decreased CO_2 production and selectively preserved chemically reduced organic matter, likely due to metabolic constraints on microbial respiration. Upon drainage and re-oxygenation of floodplain soils, however, CO_2 production increased, partly due to the oxidation of reduced organic compounds, but was limited by the concurrant entrapment of DOC by newly precipitated Fe (hydr)oxides. Combined, our results reveal that temporal variations in redox conditions during seasonal flooding shift the relative and interactive effects of mineral and metabolic constraints on CO_2 and DOC export from floodplain soils. Implications of these findings for floodplain C vulnerability to future changes in timing, intensity and duration of flooding events will be discussed.