Subsurface carbon inventories and fluxes in a semi-arid region floodplain, Rifle Colorado

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Most understanding on terrestrial carbon cycling is based on investigations of topsoil (typically < 0.3 m, and seldom deeper than 1.0 m), yet about half of the terrestrial organic carbon inventory resides at greater depths. How carbon cycles through the subsurface requires integration of measurements that account for exchanges among atmosphere, vadose zone and groundwater, and eventual exports to rivers. Semi-arid and arid regions account for a large and growing fraction of Earth's surface, where tracking subsurface C fluxes is difficult because of generally lower organic C inventories, low net infiltration, and low rates of groundwater flow. As part of the Berkeley Laboratory's Subsurface Biogeochemistry Genomes-to-Watersheds SFA effort, we are conducting field and laboratory studies on C cycling in a semi-arid floodplain within the Colorado Plateau, at the Rifle, Colorado. Five sampling and monitoring sites were established along a transect aligned with the general direction of groundwater flow, which discharges into the Colorado River at the southern edge of the floodplain. Analyses of soils, vadose zone and aquifer sediments, pore water chemistry, organic carbon (OC) speciation, vadose zone gas composition, soil and sediment respiration rates, combined with measurements of gas and water fluxes provide information needed to quantify inventories and fluxes of inorganic and organic C within the floodplain. These measurements showed that the deeper vadose zone (subrhizosphere) contains total and dissolved organic and inorganic carbon inventories as high as those of the rhizosphere, and DOC levels much higher than in the aquifer. OC is transported to the subrhizosphere from the rhizosphere via spring season infiltration and water table decline following annual recession of the Colorado River's snowmelt dominated stage. Spectroscopic analyses suggest that OC annually transported into the subrhizosphere is relatively bioavailable. Labile OC annual delivery of into the deeper vadose zone is largely metabolized, given moisture, oxygen, and temperature conditions that remain favorable for microbial activity throughout the year. This results in a significant (18%) contribution from the subrhizosphere to the annual floodplain CO_2 flux (~330 g C m^{-2} y^{-1}). Very low net infiltration in this semi-arid floodplain combined with elevated respiration rates in the subrhizosphere limit OC transport into groundwater. Relatively low DOC in the aquifer (~0.3 mM) combined with low groundwater velocities (~0.3 m day^{-1}) limit DOC exports from the floodplain into the Colorado River. Thus, vadose zone CO_2 fluxes constitute by far the largest C export from this semi-arid region floodplain.