ABSTRACT

In regions worldwide, losing rivers are common and can introduce feedbacks affecting total transport of infiltration and nutrients. Permeability decline from hyporheic zone bioclogging is one feedback that is thought to depend on climatic events that control riverbed sediments, primary productivity, infiltration, and subsurface gas production. Results from a previous analysis show strong bioclogging controls on infiltration leading to dynamic permeability that depend on river gaining versus river losing conditions.*

River life-cycles are an important component of this cycle as they typically represent a sink of CO₂ gas from the atmosphere. When benthic organisms decay, however, this provides a source of dissolved organic carbon (DOC) to subsurface microorganisms for transformation back to CO₂. Net CO₂ and other greenhouse gas (GHG) fluxes from the surface–subsurface interface are highly dependent on synergistic hyporheic flows, infiltration rates, and transformations. Both surface and subsurface metabolism, leading to bioclogging is not well quantified in river–aquifer zones. Nor are their interactions understood in rivers that have variable surface-water flow regimes from climate controls on biogeochemical fluxes, infiltration, and subsurface gas transformations. These results provide a new understanding of nutrient cycling and subsurface transformations. Results show that GHG production is not only a function of surface ecology, but linked to the statistics of extreme climatic events that control riverbed initial conditions. Our work links climatic perturbations of surface water discharge as a major control on riverbed sediment GSD, bioclogging, and subsurface transformations. Results show that GHG production is not only a function of surface ecology, but linked to the statistics of extreme climatic events that control riverbed initial conditions.

CONCEPTUAL MODEL & STUDY SITES

Managed System
- Russian River, CA
- Riverbank Filtration
- Mediterranean climate
- Losing river

Natural System
- East River, CO
- SFA Watershed (Upper Colorado)
- Semi-arid, Montane climate
- Horizontal fluxes

HYPOTHESES & METHODS

To test the effect of large scale climate-controls on biogeochemical fluxes, we simulated riverbed biological growth and hyporheic zone carbon dynamics using 1D/2D MIN3P numerical models, allowing a range of initial grain size distributions (GSD) to represent ENSO control of riverbed scour.

BIOCLOGGING RESULTS

- Spatially variable C, N transformation
- Aerobic respiration and anaerobic denitrification are a function of surface conditions
- Redox-stratified microbial communities feedback into surface ecological growth

IMPLICATIONS FOR NUTRIENTS & METALS

Mackinawite Precipitation (FeS)

Reaction rates vary with sediment conditions and water table fluctuations

CONCLUSIONS

Our work links climatic perturbations of surface water discharge as a major control on riverbed sediment GSD, bioclogging, and subsurface transformations. Results show that GHG production is not only a function of surface ecology, but linked to the statistics of extreme climatic events that control riverbed initial conditions. These results provide a new understanding of nutrient cycling and hotspot bioclogging in losing rivers where climatic extremes occur.

Simulating Climate Controls on Hyporheic Zone Dynamics and Feedbacks Between Sediment Distribution, Riverbed Bioclogging, Infiltration, and Microbial CO₂ Production

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HORIZONTAL & VERTICAL HYPORHEIC FLUXES

HORIZONTAL HYPOREIC FLOW MODEL

Vertical Flow Model

SIMULATING AN ECOLOGICAL BOUNDARY

Dissolved oxygen was quantified from Primary Productivity (P), Respiration (R), Diffusion (D), and Heterotrophy (H):

Dissolved Oxygen Model

Horizontal Hyporheic Flow Model

CONCLUSIONS

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