Uranium Mobilization Across Saturated-Unsaturated Interfaces

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Groundwater quality can be profoundly altered when robust flow coincides spatially or temporally with enhanced biogeochemical activity. Such conditions can be triggered by hydrological transitions (*e.g.*, flooding or drought) and amplify uptake or mobilizaiton of contaminants and nutrients. The unsaturated - saturated zone interface is a hot spot for such hydrological-biogeochemical coupling because multiple types of transport can occur (percolation, capillary rise, advection) and are intermittent across days (e.g., rainfall), seasons (wet-dry variability), or years (drought). Vertical movement, and in particular capillary rise, is particularly important in this transition zone. However, its coupling and impact on biogeochemical release processes has received relatively little research attention.

We have investigated the impact of hydrological-biogeochemical coupling on uranium mobilization in the shallow contaminated floodplain aquifer at the Riverton, WY legacy uranium ore processing site. This work shows that seasonal changes in moisture content (inundation and drying) trigger strong downward and upward uranium transport as the depth of saturated-unsaturated interface varies. These perturbations trigger changes in uranium speciation and sediment redox status that influence uranium mobility between the solid and water phases. Evaporite-associated, sorbed, and carbonate-associated uranium is rapidly flushed from soils during spring flooding. However, under warm summer conditions, capillary rise driven by evapotranspiration rapidly transports uranium from the shallow aquifer up into the unsaturated zone. These findings show that biogeochemical processes can couple across varying unsaturated-saturated zone interfaces, with important implications for water quality.