Simulating the Influence of Saltwater Intrusion on Coupled Element Cycles in Coastal Plain Wetlands

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Saltwater intrusion within historically freshwater coastal wetlands is expanding due to sea-level rise and more frequent drought conditions. Saltwater intrusion changes the flux of solutes (e.g., sulfate) into wetlands, which alters biogeochemical cycling by introducing potential new interactions between biogeochemical cycles (e.g., sulfur and nitrogen) and a new suite of microbial metabolic pathways (e.g., sulfate reduction and sulfide oxidation). However, the rate and character of these changes are uncertain. We developed a simulation model of linked oxygen, carbon, nitrogen, sulfur, and iron cycling to explore the potential range of wetland biogeochemical processes both before and after salt water intrusion events. The model is based on fundamental principles of stoichiometry and thermodynamics, and assumes that microbial assemblages will use the suite of metabolic pathways that maximize microbial growth, given the available electron donors/acceptors and the stoichiometric ratio of carbon and nitrogen required for building biomass. We implemented the model under three differing redox scenarios based on observed solute concentrations from coastal wetlands experiencing saltwater intrusion. The first scenario includes only carbon, nitrogen and oxygen microbial pathways. The second scenario adds both iron and sulfur cycling, and is representative of pathways likely occurring after a saltwater intrusion event. The third scenario also adds alternate anaerobic microbial pathways: anaerobic oxidation of methane (AOM) and anaerobic oxidation of sulfide (AOS), which are likely important microbial processes under some anoxic conditions, but are not typically considered in biogeochemical models. We compare model results to preliminary assays of wetland soils, and explore potential patterns of microbial trace gas production. Modeled interactions among elemental cycles vary depending on the redox conditions specified in the model scenario. Variability in simulated electron donor and acceptor availabilities changes the distribution and magnitude of biogeochemical pathways, which alters carbon and nitrogen cycling as well as trace gas (e.g., methane) emissions. This modeling approach provides a tool for hypothesis-based exploration of complex interactions among multiple elemental cycles within wetlands under changing climatic conditions.

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