Development of a two-layer transport model in layered muddy - permeable marsh sediments using ^{224}Ra-^{228}Th disequilibria

X. SHI[1,2]*, C. R. BENITEZ-NELSON[2], P. CAI[1], L. HE[3], W. S. MOORE[2]

[1]State Key Laboratory of Marine Environmental Science, Xiamen University, Xiamen, 361005, P. R. China. (*kidsxm@stu.xmu.edu.cn)

[2]School of the Earth, Ocean & Environment, University of South Carolina, Columbia, SC 29208, USA

[3]Department of Chemistry and Biochemistry, University of South Carolina, Columbia, SC 29208, USA

Underground seepage and the sediment-water interface are important pathways for transporting concentrated pore water solutes through permeable sediments. In this study, we utilized radium-224/thorium-228 disequilibria to examine solute transport throughout shallow sediments (depth < 30 cm) of a tidal marshland, North Inlet, South Carolina, over a seasonal cycle. Distinct ^{224}Ra-^{228}Th disequilibria patterns indicate that significant pore water exchange occurred both directly across the sediment-water interface and at depth as underground seepage. Temporal variations in phosphorus (P), iron (Fe), and manganese (Mn) pore water concentrations also support this two-layer transport model. Solute transport across the interface was influenced by seasonal bioirrigation, with highest exchange rates occurring in the late spring. Interfacial flux of dissolved Fe ranged over two orders of magnitude, from 0.5 to 134 mmol m^{-2} d^{-1}, and fluxes of soluble reactive phosphate (SRP) and dissolved Mn varied from 0.01 to 0.72 mmol m^{-2} d^{-1} and from 0.04 to 2.7 mmol m^{-2} d^{-1}, respectively. Seepage occurs year-round, with fluid exchange rates related to the distance from the tidal creek. SRP transport via seepage ranged from 0.98 to 5.0 mmol m^{-2} d^{-1}, one order of magnitude higher than across the sediment-water interface. Reduction/oxidation reactions at depth diminished trace metal concentrations in deep pore water, and lowered the transport efficiency of Fe and Mn along seepage paths. Although an appreciable fraction of exported solutes likely returns to marsh sediments during tidal circulation, our results indicate that organic-rich sediments provide a potentially large source of nutrients and trace elements to the coastal ecosystem.