The "salt wedge pump": Convection-driven pore-water exchange as a source of dissolved organic and inorganic carbon and nitrogen to an estuary

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ABSTRACT: Hypoxia and anoxia in coastal waters have typically been explained by the respiration of sinking organic matter associated with nutrient over-enrichment and phytoplankton blooms. Here, we assess whether submarine groundwater discharge and seawater recirculation in sediments can explain widespread chemical anomalies, including low dissolved oxygen, in salt wedge estuaries. We rely on high-resolution radon (a natural groundwater and pore-water tracer), and dissolved carbon concentrations and stable isotope observations in the Yarra River estuary in Melbourne, Australia. Radon was highly enriched within the salt wedge, demonstrating enhanced pore-water exchange at this area. We use the term "salt wedge pump" to describe convection-driven advective pore-water exchange at the sediment – water interface during the upstream propagation of the salt wedge. Radon-derived convection-driven pore-water exchange rates within the salt wedge were estimated at 2.8 cm d^{-1}, a value equivalent to 2.4% of the total river freshwater runoff to the estuary. Pore-water exchange led to pulsed dissolved inorganic carbon (DIC) and ammonium fluxes ~ 10-fold higher than measured diffusive fluxes. In contrast, diffusive sediment oxygen uptake was 5-fold higher than oxygen uptake related to advective pore-water exchange. Estimated fluxes, associated with the nonconservative DIC, $\delta^{13}C$-DIC, and ammonium behavior within the estuary support convective pore-water exchange as a major source of DIC and ammonium to the estuary, but not of dissolved organic carbon, nitrate, dissolved organic nitrogen, and anoxia. Accounting for seawater recirculation in sediments may help reconcile unbalanced carbon and nitrogen budgets in several coastal systems.

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