Oxygen dynamics in permeable sediments with wave-driven pore water exchange

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ABSTRACT: The effects of advective pore water exchange driven by shallow water waves on the oxygen distribution in a permeable ($k = 3.3 \times 10^{-12}$ to 4.9×10^{-11} m^2) natural sediment were studied with a planar oxygen optode in a wave tank. Our experiments demonstrate that pore water flow driven by the interaction of sediment topography and oscillating boundary flow changes the spatial and temporal oxygen distribution in the upper sediment layer. Oxygenated water intruding in the ripple troughs and deep anoxic pore water drawn to the surface under the ripple crests create an undulating oxic-anoxic boundary within the upper sediment layer, mirroring the topographical features of the sediment bed. Anoxic upwelling zones under ripple crests can separate the oxic sediment areas of neighboring ripple troughs with steep horizontal oxygen concentration gradients. The optode showed that migrating wave ripples are trailed by their pore water flow field, alternately exposing sediment volumes to oxic and anoxic pore water, which can be a mechanism for remobilizing particulate oxidized metal precipitates and for promoting coupled nitrification-denitrification. More rapid ripple migration (experimental threshold ~20 cm h^{-1}) produces a continuous oxic surface layer that inhibits the release of reduced substances from the bed, which under slowly moving ripples is possible through the anoxic vertical upwelling zones. Swift, dramatic changes in oxygen concentration in the upper layers of permeable seabeds because of surface gravity waves require that sediment-dwelling organisms are tolerant to anoxia or highly mobile and enhance organic matter mineralization.

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