pH dynamics in bioirrigated permeable sediments

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Most biogeochemical processes in sediments have an impact on and/or are regulated by porewater concentrations of O_2 and pH. These master variables are strongly affected by intermittent activity of infaunal organisms, which exchange anoxic, low-pH porewater with oxic, high-pH overlying water. We have characterized O_2 and pH dynamics simultaneously using high spatial (mm) and temporal (min) resolved planar optode imaging in a permeable sediment perturbed by continuous and intermittent pumping, resembling redox oscillations representative for those induced by large infauna. Irrespective of pumping frequency (hourly or diurnal), porewater pH in bulk sediment was higher (pH ≈ 6.90) in the sediment affected by porewater advection than in non-irrigated sediment (pH ≈ 6.55). In sediment intermittently exposed to O_2, porewater pH declined by 0.7 and 0.2 units during the long (12 hr) and short (1/2 hr) resting intervals, respectively. Maximal rates of pH decline (up to 0.4 pH units h^{-1}) were found in sediment areas experiencing rapid oxic-anoxic oscillations (short cycles) and at the oxic/anoxic boundary (long cycles), which coincided with regions of highest oxygen consumption rates. During the long resting intervals the rate of pH decline was substantially higher when oxygen was present (0.12 pH units h^{-1}) than after its depletion (0.05 pH units h^{-1}). Our results illustrate the potential of and need for quasi-co-registered imaging of multiple dissolved chemicals for studying transitions between aerobic and anaerobic processes in bioirrigated sediments and their relevance in early sediment diagenesis.