EGU21-1239, updated on 16 Oct 2021
https://doi.org/10.5194/egusphere-egu21-1239
EGU General Assembly 2021

Benthic Oxygen dynamics: Influence of pore water advection and microphytobenthos in a permeable sediment

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The benthic oxygen consumption rate (OCR) has been widely used to measure the total benthic organic carbon degradation rate, while the oxygen distribution provides the general biogeochemistry state of marine sediments. In shallow coastal environments the light driven photosynthesis by benthic microalgae, resulting in large diurnal oscillations of oxygen concentration, further affects the oxygenation of the sediment. Yet, for permeable sediments, studies incorporating pore water advection driven by physical forces into oxygen consumption and distribution measurements are still limited. Here we examine the combined effect of benthic oxygen production and advective oxygen transport on oxygen dynamics and consumption rate in a microphytobenthos-dominated sediment (permeability k =2 x 10^{-11} to 5 x 10^{-11} m^2) in a laboratory simulation with stirred benthic chambers at 40 rpm. Under alternating light (50 µE m^{-2} s^{-1}) and flow regimes, oxygen concentration, penetration depth and consumption rates were monitored by means of micro-profiling and planar optode measurements. In all cases, we found that oxygen penetration depth increased up to a factor of 2 with pore water flow simulation. On the other hand, advective transport was found to reduce maximum oxygen concentration in the sediment by up to 30 %. The OCR were up to 2-times higher with only light (28 ± 3.5 µM/min) compared to combined light and flow simulation, however the total oxygen uptake was generally uniform in all chambers (41.83 ± 5.9 mmol/m^2 d^{-1}), suggesting the local redistribution of oxygen with flow without marked overall changes in O_2 consumption. Our result emphasized the importance of advective transport controlling benthic oxygenation in photic permeable sediment.