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Microscale drivers of oxygen dynamics during emersion: Microphytobenthic production, sediment compaction and shifts on diffusivity.

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In muddy intertidal areas, photosynthetic activity of microphytobenthos is one of the key factors regulating the oxygen availability in the sediment, and hence organic matter mineralization pathways. Measuring microphytobenthic production by oxygen microprofiling is based on the correct estimation of the reaction, diffusion and advective terms prevailing under specific conditions. This fact becomes critical for emerged sediments, since the combined effects of porewater evaporation/loss and the quick diffusion of oxygen to the atmosphere presumably result in an understimation of the community metabolism. To account for the processes underlying oxygen levels during immersion-emersion transitions, the present study simulates in a microcosm a transient oxygen “peak” (O_2 max) of a microphytobenthic community exposed to experimental emersion (2 h) during the light period. In addition to a reduction of porewater content (ie from 69 to 63 % of wet weight), a compaction of surface sediment was observed as evident by the displacement of O_2 max with respect to a fixed reference position, and corroborated by digital microscopy. Continuous measurements of O_2 max revealed a linear decrease with time (c.a. -0.20 - -0.03 μM s-1, β). This decrease was mostly attributed to the downward displacement of the oxygen “peak” (21-97%) and to a higher loss rate of oxygen to the atmosphere, as bulk diffusivity increased. Modeling microphytobenthic biomass as a mobile source of oxygen also provided a reasonable explanation for the observed advective process. Furthermore, the associated gross production rate (GP) was determined by the “light-dark” shift method and corrected for the increase in diffusion as sediment dried. Estimates of GP (ie. from 40% to 200% of GP under immersion) greatly depended on the bulk diffusivity considered (ie. from 7.5*10-5 to 3.25*10-4 cm2 s-1), highlighting that the contribution of air phase to diffusion cannot be neglected. Results quantified adequately the main drivers affecting oxygen-based measurements of production with microsensors, and can be used to validate estimations made under emersion conditions.