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Oxygen consumption along bed forms under losing and gaining streamflow conditions

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Recent studies have demonstrated that bed forms are the most significant geomorphological structure that drives hyporheic exchange and biogeochemical processes in stream networks. Other studies also demonstrated that due to the hyporheic flow patterns within bed form, biogeochemical processes do not occur uniformly along and within the bed forms. The objective of this work was to systematically evaluate how losing or gaining flow conditions affect oxygen consumption by biofilm along sandy bed forms. We measured the effects of losing and gaining flow conditions on oxygen consumption by combining modeling and experiments in a novel laboratory flume system that enable the control of losing and gaining fluxes. Oxygen consumption was measured after growing a benthic biofilm fed with Sodium Benzoate (as a carbon source) and measuring the distribution of oxygen in the streambed with microelectrodes. The experimental results were analyzed using a novel code that calculates vertical profiles of reaction rates in the presence of hyporheic water fluxes. These experimental observations and modeling revealed that oxygen distribution varied along the bed forms. The zone of oxygen consumption (i.e. depth of penetration) was the largest at the upstream side of the bed form and the smallest in the lee side (at the lowest part of the bed form), regardless of the flow conditions. Also, the zone of oxygen consumption was the largest under losing conditions, the smallest under gaining conditions, and in-between under neutral conditions. The distribution of oxygen consumption rates determined with our new model will be also discussed. Our preliminary results enable us to show the importance of the coupling between flow conditions and oxygen consumption along bed forms and are expected to improve our understanding of nutrient cycling in streams.