A novel approach to assess biotic oxygen consumption in marine sediment communities

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Background information

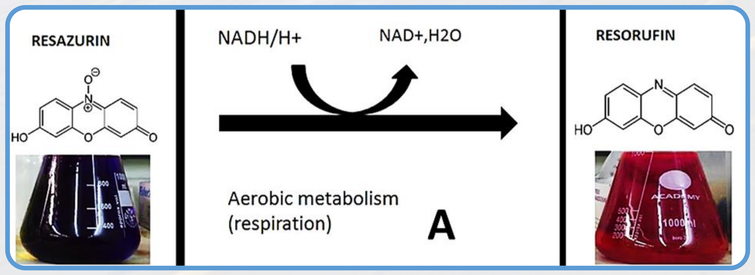
Bioturbation, the mixing of the sediment matrix by burrowing animals, is an important control of the costal sediment metabolism. Sedimentary oxygen consumption is often taken as a proxy for the faunal activity in the sediment. Limitations exist in current methodologies, and numerous confounding factors are hampering progress in this area.

Main aim

Here we are proposing new quantitative technique for measuring oxygen consumption of bioturbated sediment.

Method

We have combined traditional approaches of the quantification of bioturbation (luminophore tracer) and oxygen consumption (oxygen optodes) with a novel method to quantify aquatic sediment metabolism, the bioreactive tracer resazurin. The new method is capable of measurement of oxygen consumption in systems with constant oxygen supply.



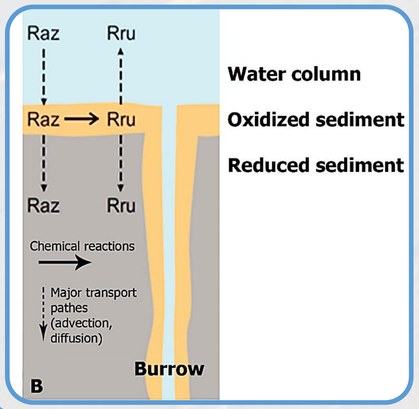


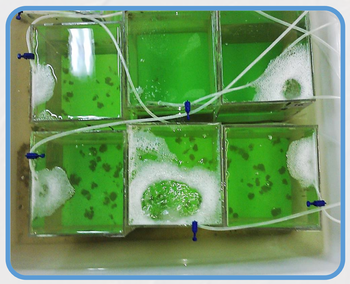
Fig. 1. A. Depiction of resazurin (RAZ) – resorufin (RRU) bioreactive tracer system. B. Fate of resazurin behaviour in the bioturbated sediment.

The novel method is based on:

the assessment of the oxygen consumption with the bioreactive tracer **resazurin (Raz)**. The Raz transformation into the fluorescent product **resorufin** (**Rru**) is well correlated with aerobic oxygen consumption (r=0.8-0.986). The Raz turnover rate (ln(Rru/Raz+1)*Δt) is a good proxy of respiration in the system.

To prove that the concept of the new method is viable, microcosm experiments with the common European bioturbator, brittlestar *(Amphiura filiformis)* were conducted. Animals and sediment were collected in Cawsand Bay, Plymouth, UK.

Fig. 2. Sediment sampling on the deck of the "Plymouth Quest" (left) and *Amphiura filiformis* (right).



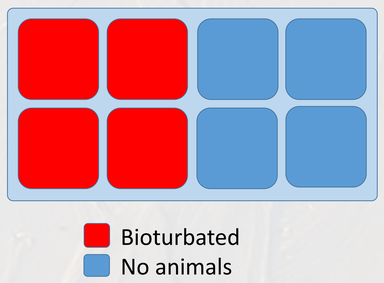


Fig. 3. Two sets of eight microcosms were deployed: 8 without animals and 8 with animals.

Method validation and results

Raz reduction was about 30% higher in bioturbated sediment than in defaunated controls. Correlation between Raz reduction and oxygen consumption was high (r=0.92). In contrast to our previous research in the freshwater, sediment oxygen consumption inferred from Raz was higher than those measured within the sealed sediment cores.

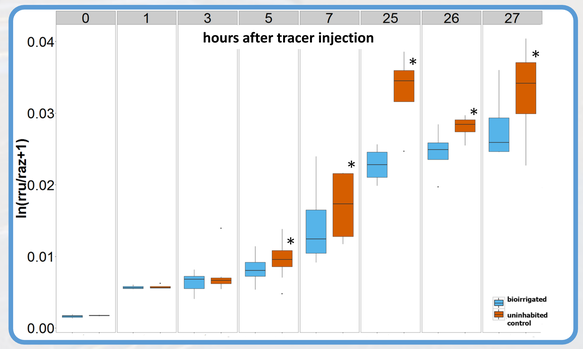


Fig. 4. Resazurin turnover rate in the bioturbated and control microcosms. Asterisks(*) are representing significant ($p<0.005$) difference between the values. Rate changes are recorded within the span of the 27 hours after tracer injection.

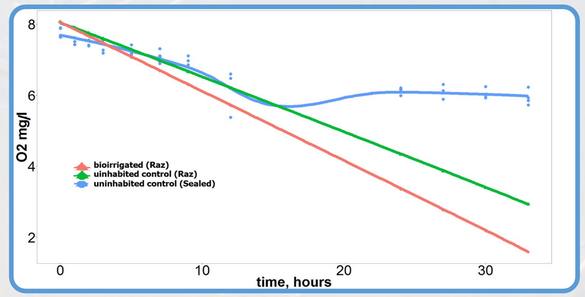
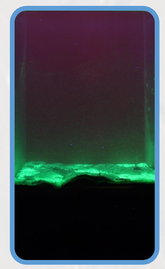
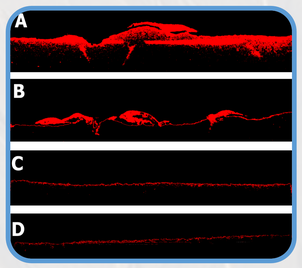


Fig. 5. Sediment oxygen consumption measured in the sealed sediment column, and inferred from resazurin turnover rate for non-sealed columns with and without bioturbating benthos.





Luminophore test is allowing to quantify the bioturbation in the system, based on the displacement of the luminescent sand layer over time. We have conducted this test to see how the results are correlating with the resazurin essay. Figs. A and B are presenting (in red) luminophore displacement after two weeks in bioturbated cores, while C and D, are the same for non-bioirrigated cores.

Discussion and further implications

The Raz-Rru tracer system is a suitable method to study bioturbation impact on sediment respiration in the marine ecosystems. Raz is able to discriminate between respiration of uninhabited controls and sparsely bioturbated (animals biomass 120 g/m^2) sediments. Raz behaves slightly different in marine environments than in freshwaters, thus further adjustments of the methodology are required.

Check out our work on resazurin in freshwater!

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