Effect of alternating redox conditions on organic matter decay in sediments

Julia Gebert[1], **Lucia Alconchel Ibarrola**[1], **Florian Zander**[1]

[1]Faculty of Civil Engineering and Geosciences, Department of Geoscience and Engineering, Delft University of Technology, 2628 CN Delft, The Netherlands

Phone: +31 152 782 798
E-mail: j.gebert@tudelft.nl

Introduction: Depending on the presence of available terminal electron acceptors, microbial degradation of sediment organic matter (SOM) follows either aerobic or anaerobic metabolic pathways. Consolidated fine-grained sediments usually show negative redox potentials. Under these conditions of oxygen deficiency less carbon is released and degradation eventually diminishes altogether as specific organic components are not anaerobically degradable and the potential energy yield of SOM decay is lower. Dredging, including water injection dredging, and relocation, however, bring these sediments back in contact with the oxygenated water phase, and elute metabolic products accumulated in the pore water, both potentially re-activating SOM decay [1]. Amongst others, reactivated SOM decay can promote oxygen-minimum zones or change the sediment's rheological properties. The focus of this study is to (i) quantify differences in aerobic and anaerobic SOM decay over time and to (ii) characterize differences in the susceptibility of SOM decay to changing redox conditions along a transect through the Port of Hamburg, Germany.

Methods: Between 2018 and 2020, sediment samples were collected from nine locations along an upstream-downstream gradient through the Port of Hamburg, Germany, using a one meter core sampler. Long-term (>250 days) release of CO_2-C and CH_4-C under aerobic and anaerobic conditions was analysed as described in [2]. In as second step, anaerobically incubated sediments where SOM decay had nearly terminated were exposed to aerobic conditions. Aliquots were washed with Elbe river water to elute accumulated pore water components and then either exposed to aerobic conditions or re-incubated under anaerobic conditions.

Results: Differences between SOM decay, expressed as mg C released per g dry mass sediment, varied between factor 2 and factor 18 for aerobic an anaerobic conditions (Fig. 1). Changes in aerobic and anaerobic C release over time (21 days, 100 days and 250 days) varied by location. At upstream locations, characterized by input of fresh, easily degradable organic matter from algal biomass, the ratio between aerobic and anaerobic decay was smallest (on average around 2.5) and did not vary significantly over time. In contrast, aerobic decay exceeded anaerobic decay by an average factor of 10 on the short term (21 days) and diminished steeply over time to eventually converge to a similar factor as for the upstream locations. If data were grouped by layers (depth) instead of by location, it was found that the upper, younger layers harbouring the more easily degradable SOM showed the largest differences in ratio between aerobic and anaerobic C release, diminishing over time, while this ratio remained more constant for material from deeper, older material. First analyses show that SOM decay in old, anaerobically stabilised samples is re-activated by pore water exchange and subsequent aerobic and anaerobic incubation. The effect of re-exposure to oxygen exceeds the effect of pore water exchange on the rate of microbial SOM degradation.

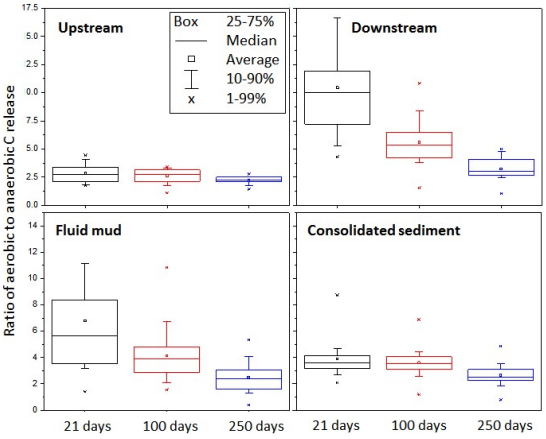

Fig. 1: Ratio of aerobic to anaerobic C release over time. Upper panel: data grouped by location; lower panel: data grouped by sediment layer (depth).

It is preliminarily concluded that upstream sediments containing most labile organic matter are least sensitive to changes in redox conditions while in downstream sediments with more stabilised, older SOM, showing higher levels of organo-mineral complexation [2], the redox conditions are of great importance for the magnitude of SOM decay. Differences are most significant in the short term; long-term SOM decay stabilises at a factor of 2.5 between aerobic and anaerobic conditions.

This study is funded by Hamburg Port Authority and carried out within the framework of the MUDNET academic network: https://www.tudelft.nl/mudnet/

References: [1] Bastviken et al. (2004) *Limnol Oceanogr*, 49:109–116; [2] Zander et al. (2020) *J Soils Sediments* **20**:2573-2587.