Port Sediments as Carbon Sink and Source

Julia Gebert[1], Florian Zander[1], Nino Ohle[2]

[1]Department of Geoscience & Engineering, Delft University of Technology, Delft, the Netherlands

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

[2]Hamburg Port Authority AöR, Hamburg, Germany

Conference theme number(s): 1, 6

Introduction: Sediment organic matter (SOM) originates from autochthonous planktonic biomass [1, 2] or allochthonous sources such as eroded topsoils or effluents from wastewater treatment. In tidal systems such as the Port of Hamburg, allochthonous SOM is also imported with the upstream transport of marine sediment [3]. Microbial degradation of SOM is part of the natural carbon cycle and depends on the amount and lability of SOM, the environmental conditions driving microbial activity and the availability of terminal electron acceptors [4]. Depending on the latter, carbon can be released as CO_2, or, in addition, as CH_4, strongly changing the climate impact of SOM degradation. This study investigates the degradability of SOM and quantifies differently and non-degradable SOM pools in the tidal river Elbe.

Methods: Sediment was sampled every two months in 2018-2020 from nine locations along an upstream-downstream gradient through the Port of Hamburg. Standard solids properties, anaerobic and aerobic decay of organic matter and SOM pools based on degradation kinetics were analysed as described in [5].

Results: Total organic carbon (TOC) contents averaged around 4% (Fig. 1, left) and correlated closely with total nitrogen (TN), with 80% of all TOC/TN ratios between 7.4 and 10. The ratio of aerobic to anaerobic C release averaged around 3.5-4.5; however, also very high rations >15 were observed (Fig. 1, right).

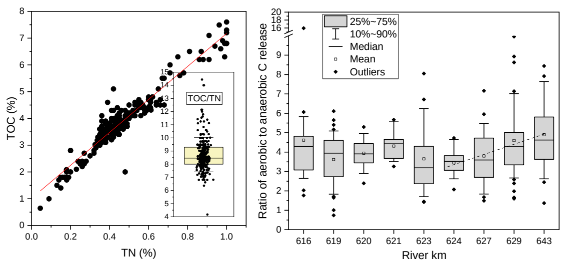

Fig. 1: Ratio of aerobic to anaerobic C release in 21 days per location P1 (left) to P9 (right).

Between km 624 and 643, a systematic increase in the ratio was observed. At all locations, the non-degradable pool 4 was the largest (Fig. 2 bottom right), for both, anaerobic and aerobic conditions, comprising around 67-85% (aerobic) and 78-85% (anaerobic) of TOC. This means that only 15-25% (anaerobic) or up to 33% (aerobic) of SOM is degradable. The fast pool 1 was only found at phytoplankton-fed upstream sites. While the medium degradable pool 1 decreased towards downstream, the slowly degradable pool 3, thought to be associated with mineral-bound SOM, did not show any spatial gradient and is assumed to represent a baseline of hardly accessible SOM (~12-16% of TOC).

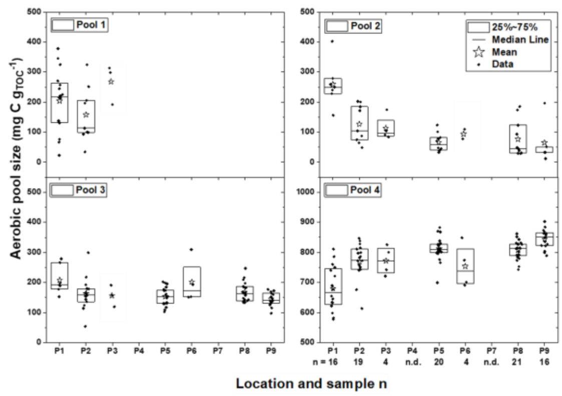

Fig. 2: Aerobically degradable SOM pools per location P1-P9 [5]. Line: med, star: mean, box: 25th, 75th percentile.

Discussion: Fine grained port sediments contain large quantities of recalcitrant, non-degradable SOM and hence present a large storage term for organic carbon. Aerobic decay on average releases by factor 4.5 (short-term) to 2 (long-term) more C than anaerobic decay (max. factors of 25 observed). Bringing anoxically buried sediments in contact with oxic conditions may hence result in increased release of organic carbon. The data of this study provide the basis for C foot-printing and balancing questions, when coupling SOM decay to in situ temperatures.

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

References: [1] Wolfstein et al. (2000) Estuar Coast Shelf Sci 51: 651-662; [2] Grasset et al. (2018) Limnol Oceanogr 9999: 1-13; [3] Kappenberg & Fanger (2007) GKSS report 2007/20; [4] Arndt et al. (2013) Earth Sci Reviews 123: 53-8; [5] Zander et al. (2022) Limnologica 96: 125997