MUDNET

https://www.tudelft.nl/mudnet

Effect of redox conditions on organic matter decay in sediments

BIO MUD

Dr. Julia Gebert
Associate professor

Lucia Alconchel
BSc candidate

Florian Zander
PhD candidate

Delft University of Technology, Geoscience & Engineering

TU Delft

Investigation area

Mud is not just mud...

Oxidized **Suspended particulate matter SPM**

Fluid mud FM

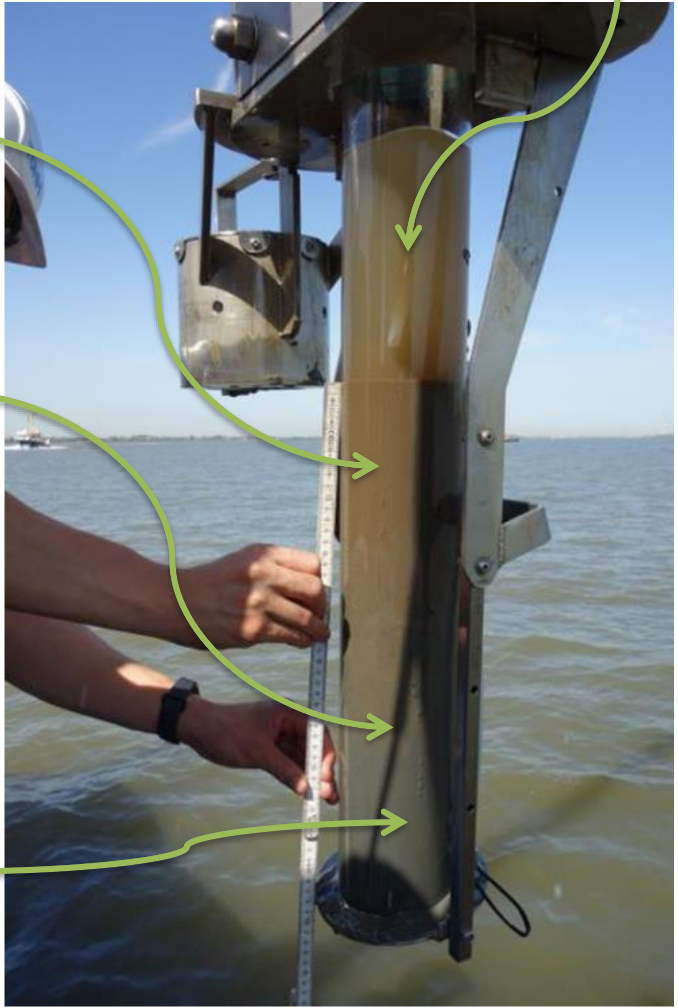
Oxidized or reduced

Pre-consolidated sediment PS

Reduced

Consolidated sediment CS

Reduced



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A detailed look reveals...

- A multi-layered system
- Chrono-sequence of consolidation, redox potential, pore water composition
- > 80% fines (< 63 µm)
- **~ 10% organic matter**

Gas in the Port of Hamburg

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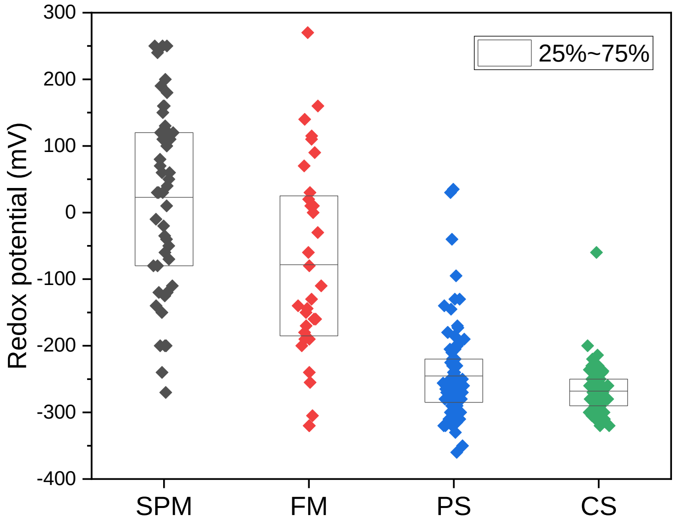
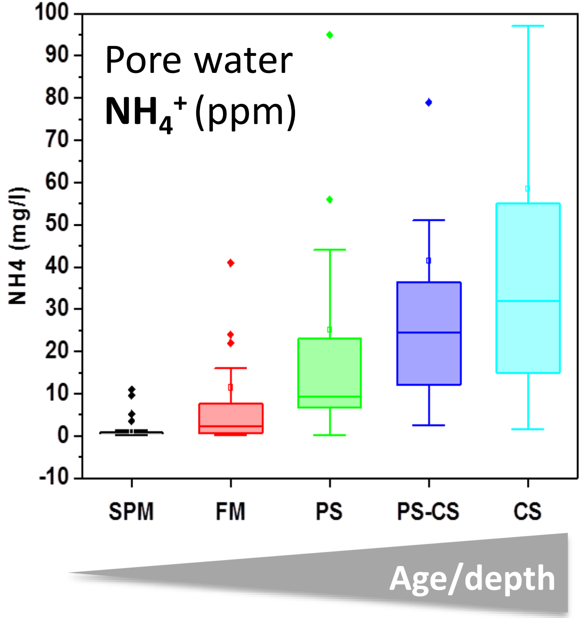
Intense microbial activity degrading sediment organic matter

Redox potentials and pore water NH_4^+





- Mostly, sediments are under anoxic conditions (negative RP)
- Pore water nitrogen dominated by NH_4^+
- RP gets more negative and NH_4^+ increases with depth/age

Objectives

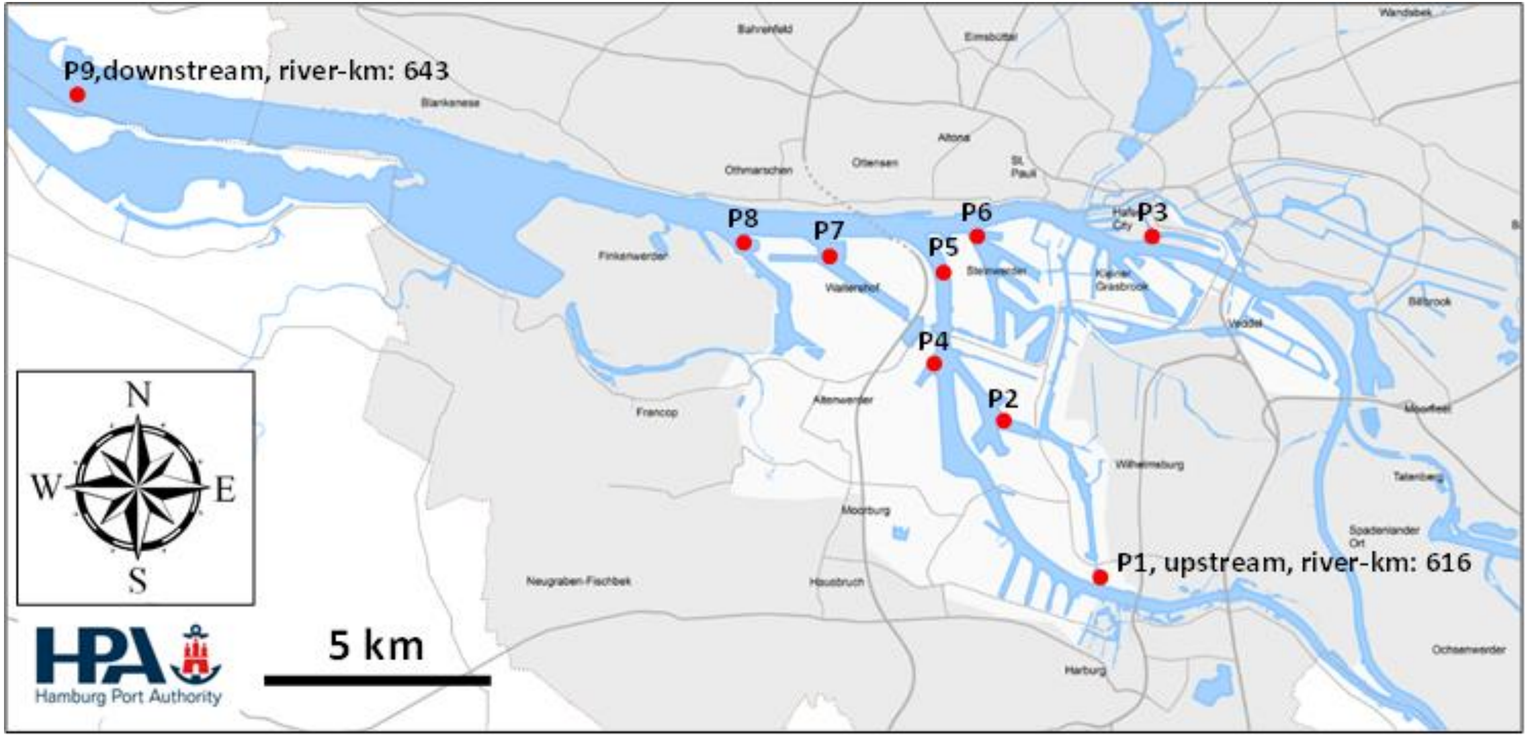
Anaerobic sediments come in content with the oxygenated water phase during water injection dredging or relocation, therefore…

1) Quantify differences in C mineralization under aerobic and anaerobic conditions
2) Investigate susceptibility of SOM decay to changes in redox conditions

Insights useful for

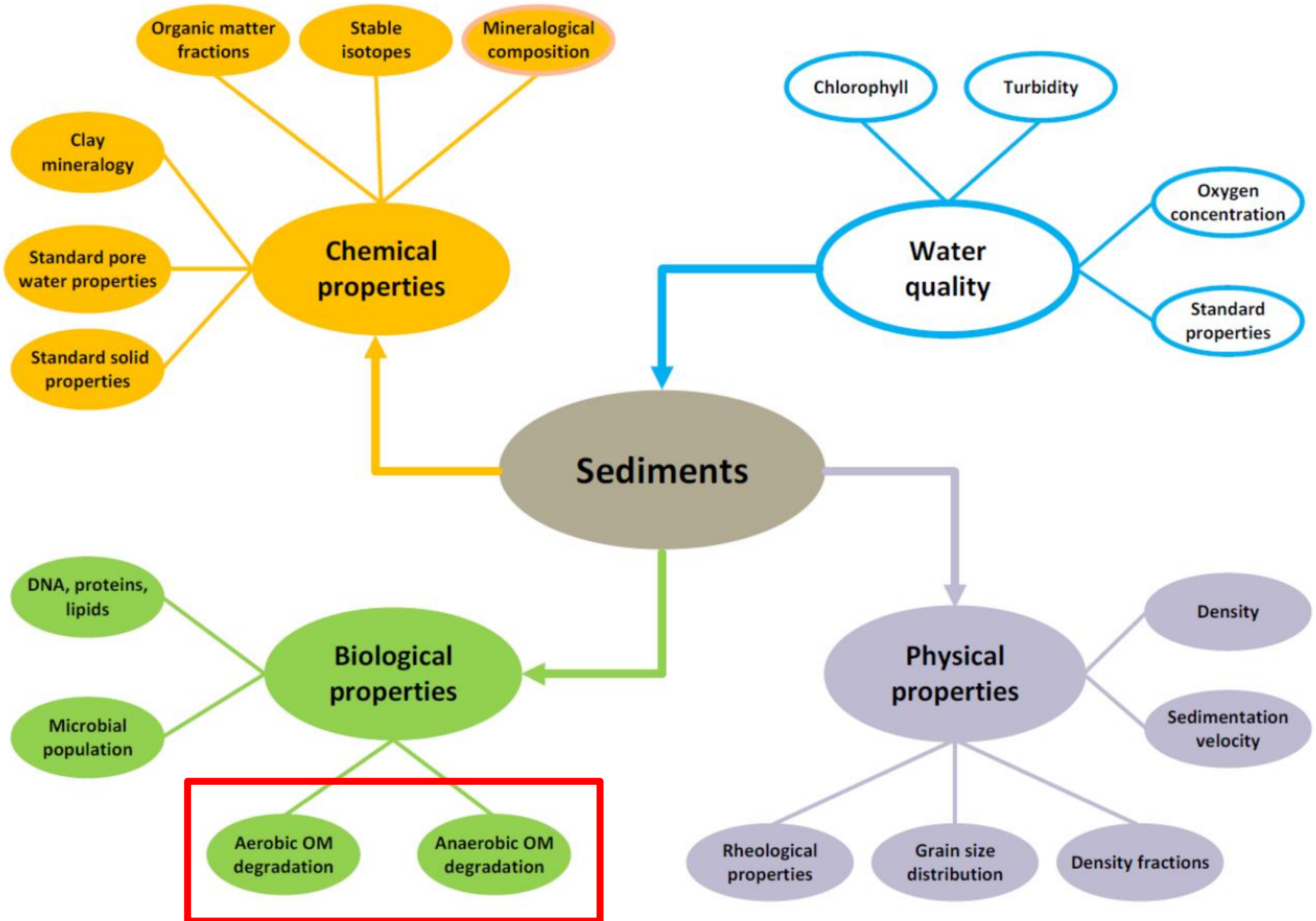
1) Carbon balancing along river continuum
2) Carbon foot printing of port maintenance
3) Assessing effects of SOM decay on sediment properties at the nautical bottom
4) Prediction of SOM decay during use of sediments on land

Zooming in on the investigation area



Sampling every 4-6 weeks over 3 years

Analyses



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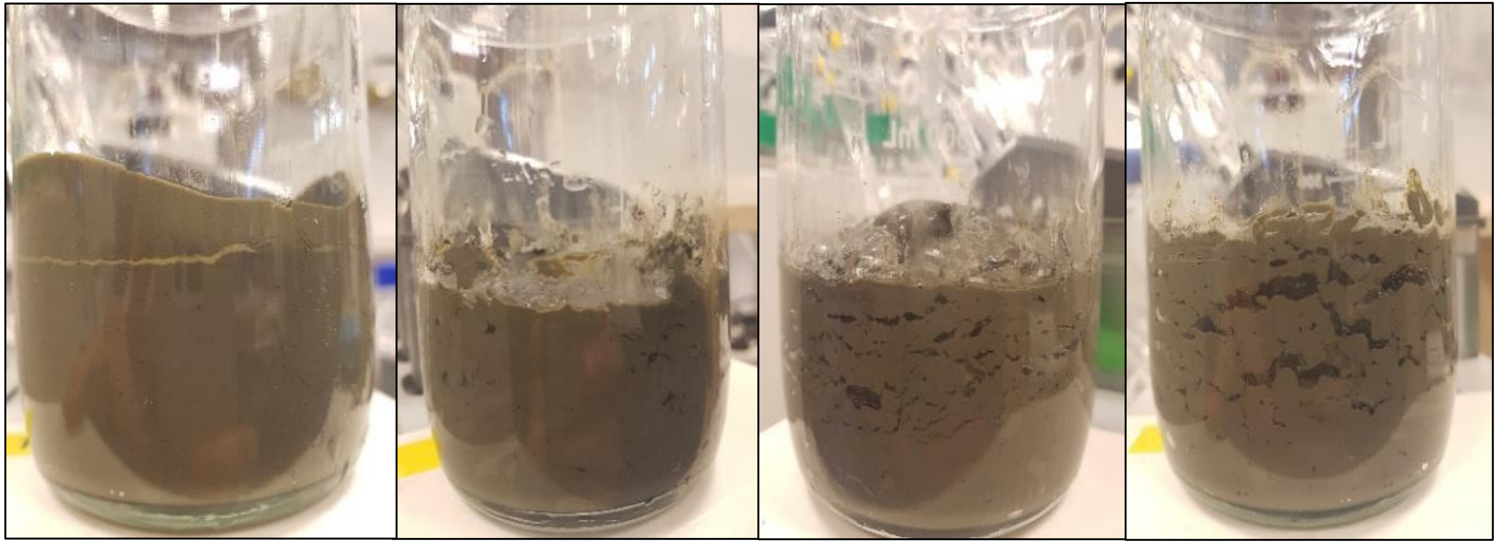
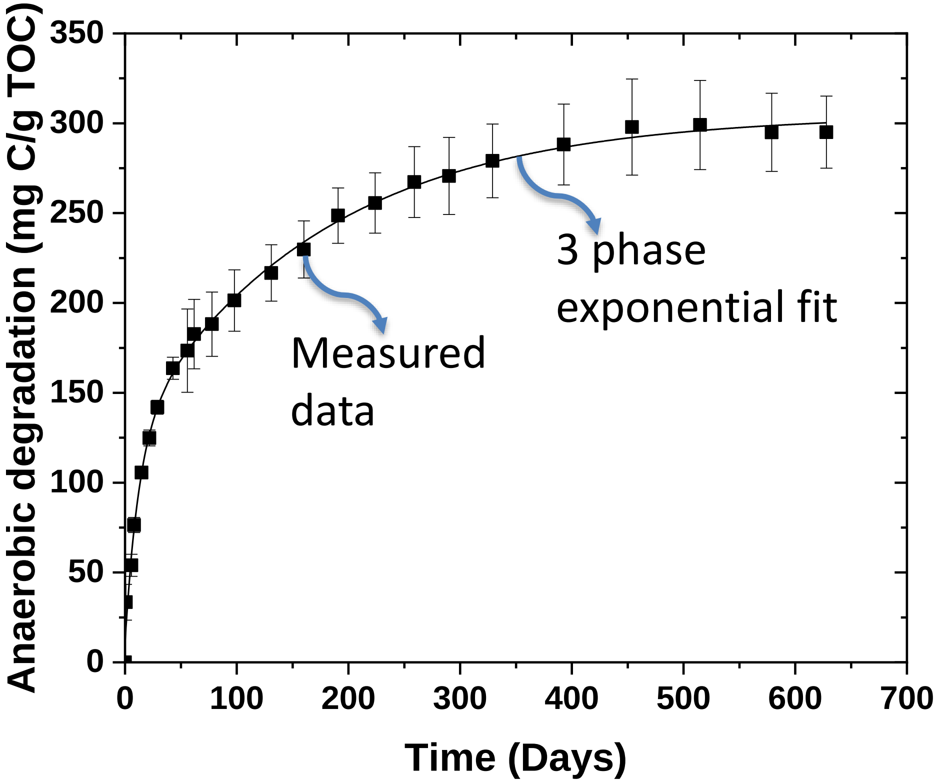
Results

- Sediment in bottle
- Anaerobic or aerobic incubation
- Measurement of pressure, CH_4 and CO_2 concentrations in bottle headspace
- Calculate C release per mass unit TOC or per unit weight



Time

Kinetics of SOM degradation



- SOM decay can be described using multiphase exponential fits
- Decay kinetics over time are the same for anaerobic and aerobic degradation

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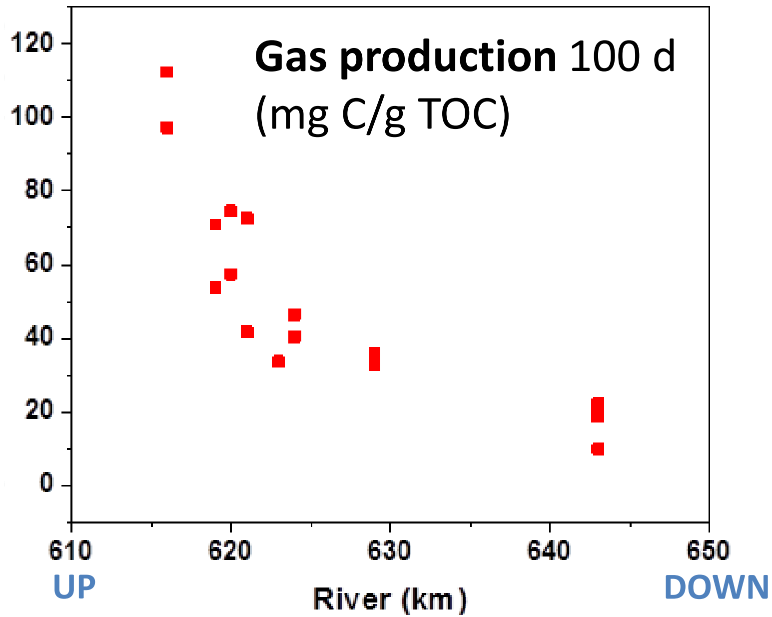
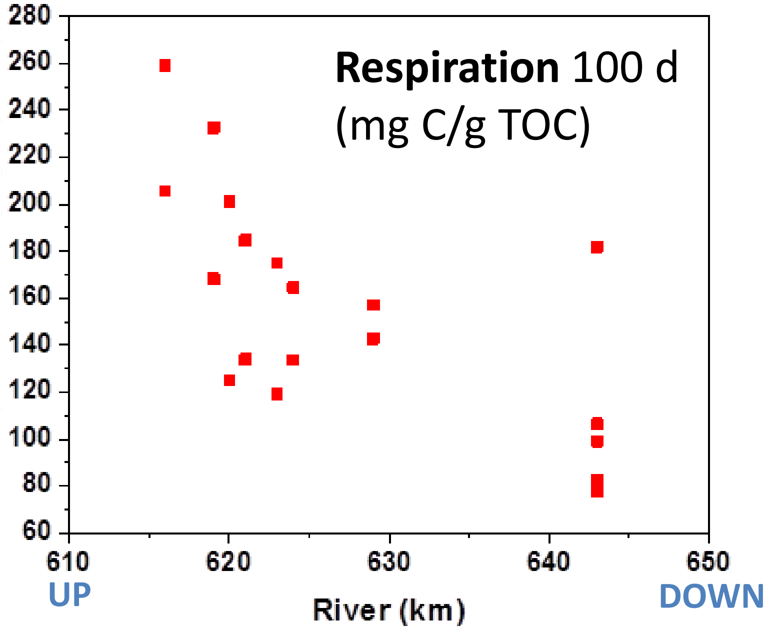
Kinetics of SOM degradation vary along transect





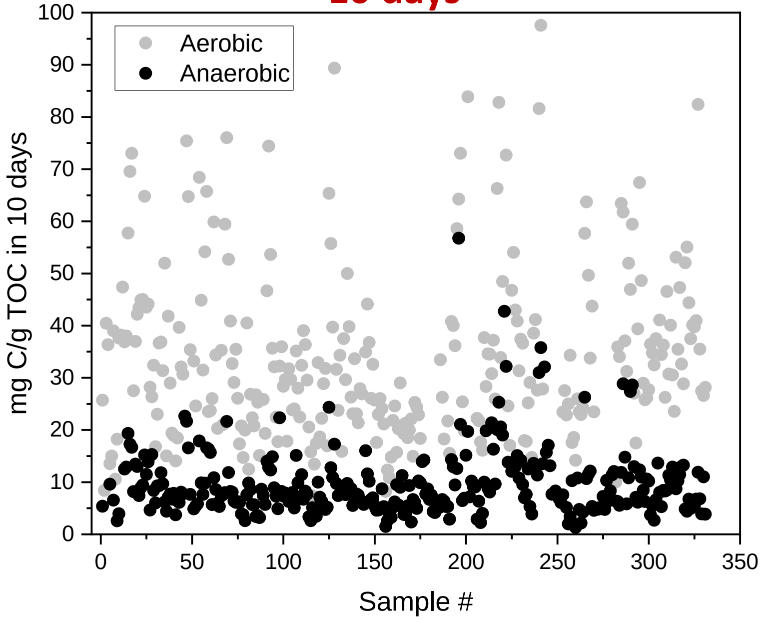
- Up to factor 10 in SOM degradability between upstream and downstream
- Factor 8 between respiration and gas production

More in Zander et al. (2020) in JSS: https://link.springer.com/article/10.1007/s11368-020-02569-4

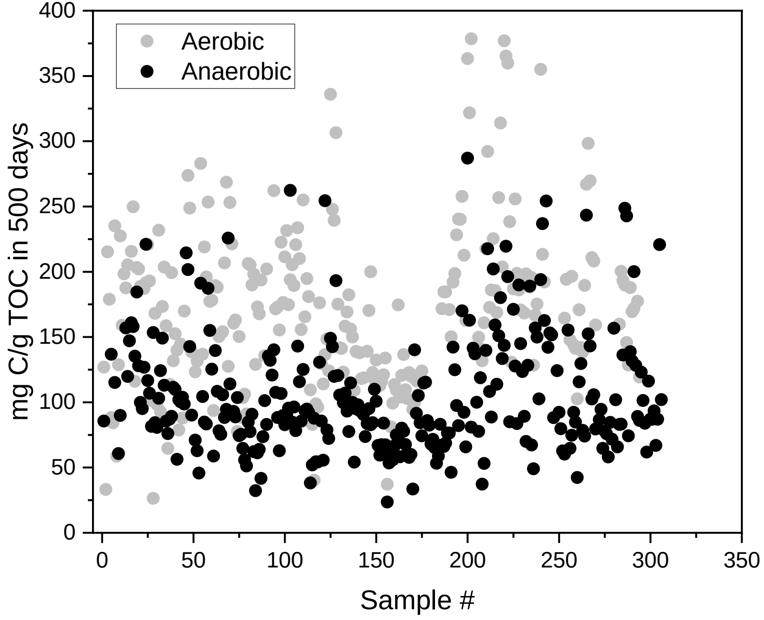
Relationship between aerobic and anaerobic decay

mg C/g TOC released

10 days

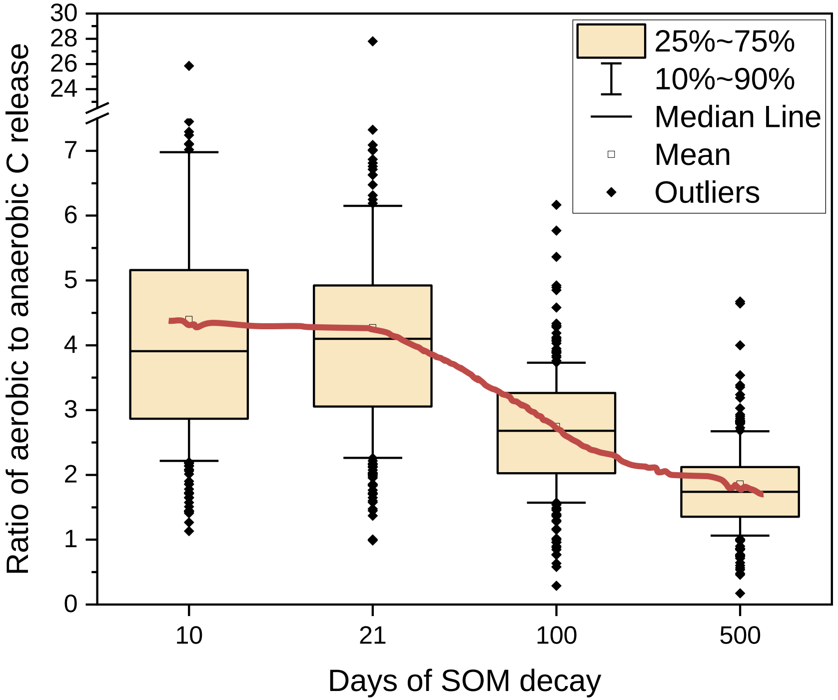


500 days



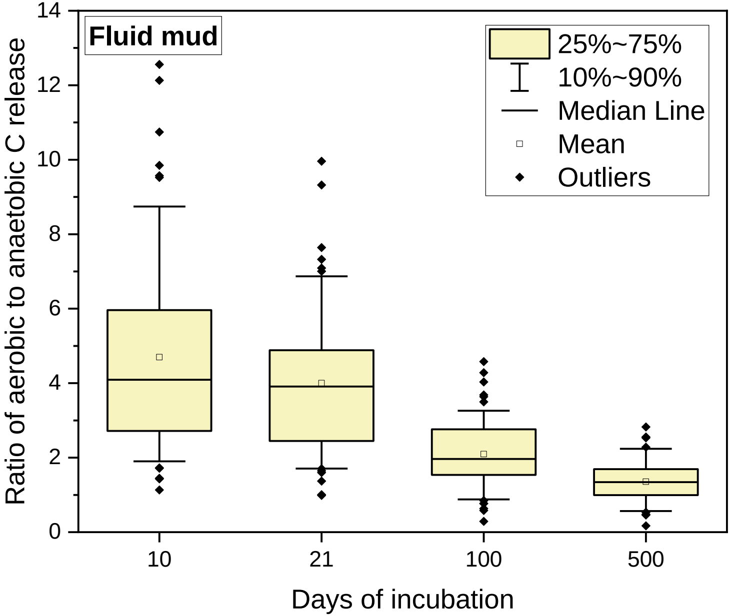
- Differences between aerobic and anaerobic decay are largest in the short-term (e.g. in the days after dredging and relocation interventions)
- Within 10 days, up to 10% of SOM are degradable, within 500 days up to 37%

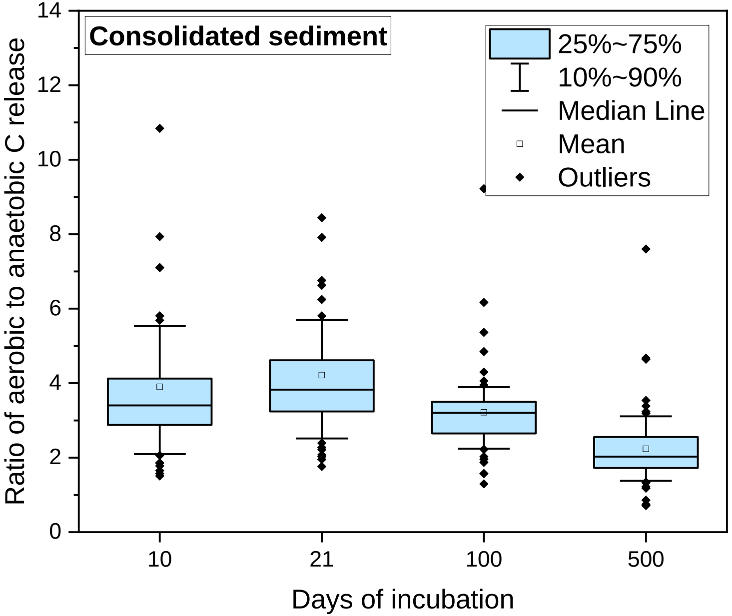
Ratio between aerobic and anaerobic degradability



- Short-term ratios can exceed Factor 25
- On average, aerobic decay exceeds anaerobic decay by factor 4.5, declining to a factor 2 in the long term

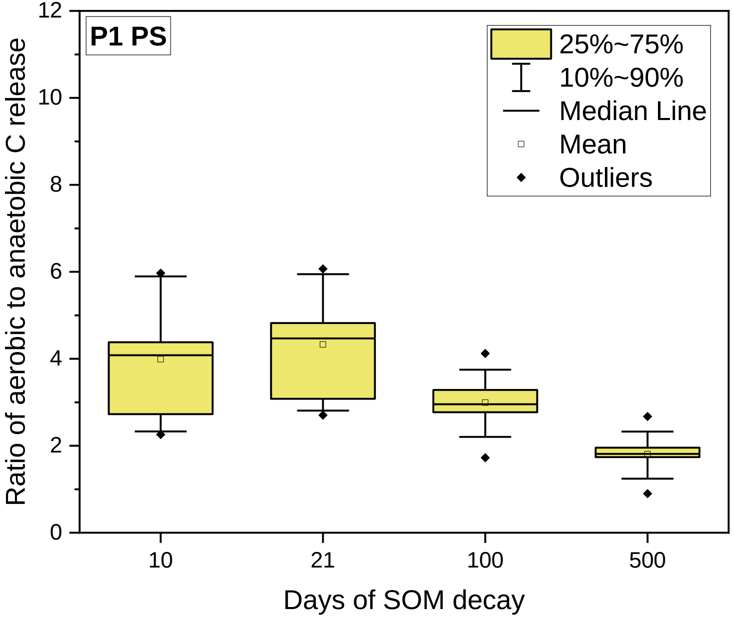
Ratio is different per layer!

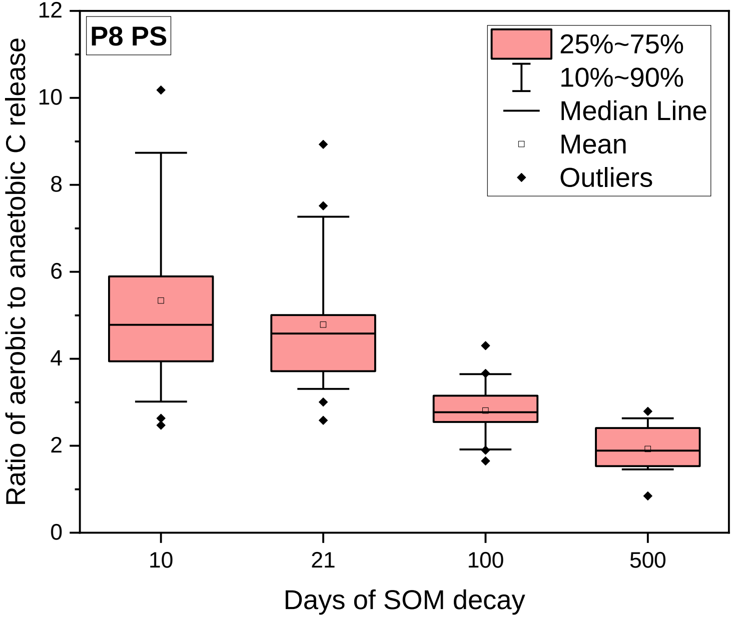




- Contact with O_2 enhances SOM degradability most in the upper layers
- In the upper layers the material is younger aerobic conditions prevail more often

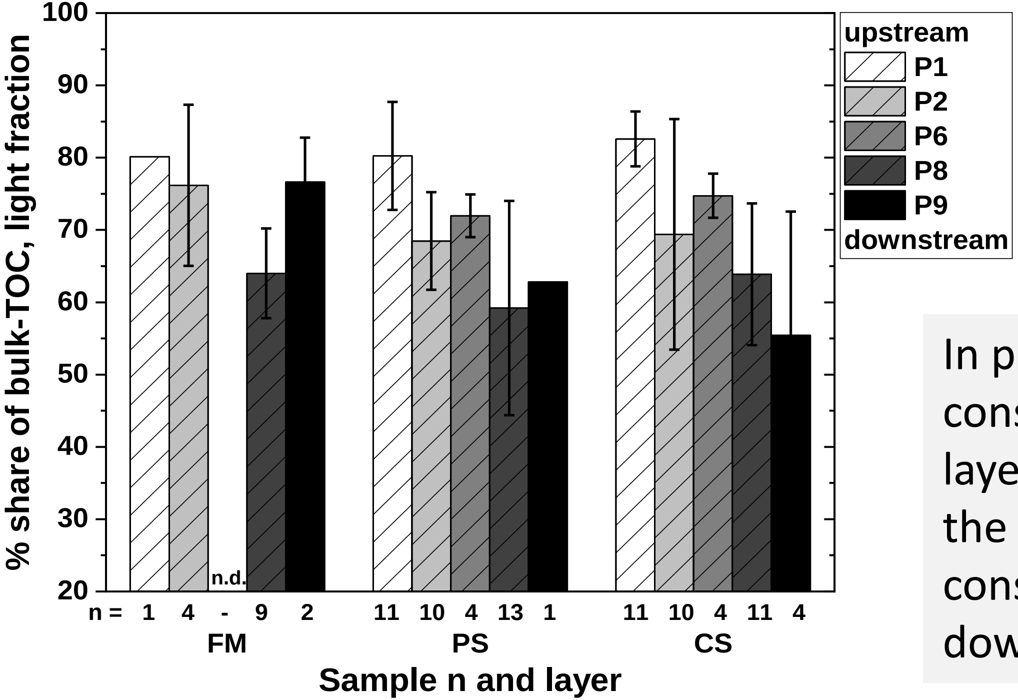
Ratio differs per site!





- Differences between aerobic and anaerobic SOM decay more pronounced at downstream sites
- Downstream, the share of easily degradable SOM is less

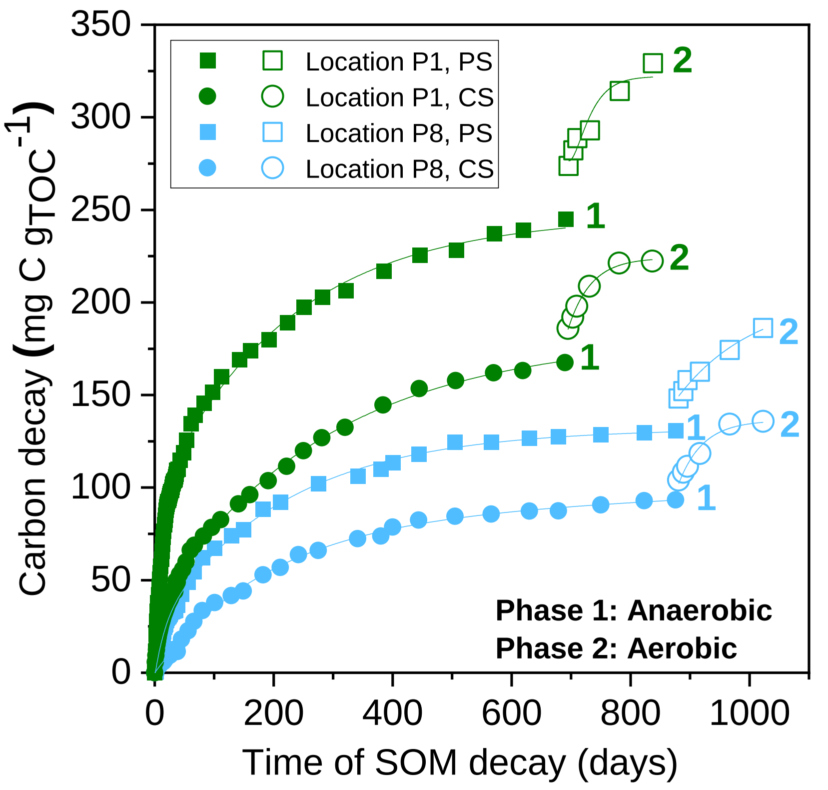
Share of SOM in light density fraction



In pre-consolidated (PS) and consolidated (CS) sediment layers, the share of TOC in the light density fraction is considerably less at downstream locations

Zander et al., in prep.

What happens if old sediment is relocated?



- 30-50% of the C released by previous anaerobic decay was released after re-exposure to O_2
- In CS samples, re-activation levels off faster than in PS samples

Conclusions

- In situ, sediment is mainly under anaerobic conditions (neg. redox potentials)
- 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)
- Factor is dependent on time and degradability of SOM (thus, location and depth)
- Significant shares of C can be re-activated when ‘exhausted’ anaerobic sediment is exposed to oxygenated water
- Basis for C foot printing and C balancing questions established, when coupling to temperature response of SOM degradation and in situ temperature data

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Dank u wel & tot ziens!

Contact:
Dr. Julia Gebert
j.gebert@tudelft.nl

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Please also see posters:
Zander et al.: Effect of degraded sediment organic carbon on rheological characteristics of tidal mud.
Shakeel et al.: Impact of organic matter degradation on rheological behavior of fine grained sediment

Hamburg Port Authority