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Measuring erosion risk of cohesive sediments: vertical profiles of relevant sedimentary and biological variables

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Background

As many anthropogenic pollutants preferentially bind to small particles with high specific surface areas, their fate is strongly coupled with the ETDC-Cycle (Erosion Transport Deposition Consolidation) of cohesive sediments. Hence, knowledge of erosion and resuspension properties and of how they change with sediment depth is crucial for determining the erosion risk of long-deposited contaminated sediments especially with regard to flood events. In contrast to non-cohesive sediments, the dynamics of cohesive sediments are not yet fully understood mainly because of multiple physico-chemical factors and variable biological influences. Hence, site-specific investigations are required to develop water management strategies as well as modelling approaches to predict the dynamic behavior of cohesive materials.

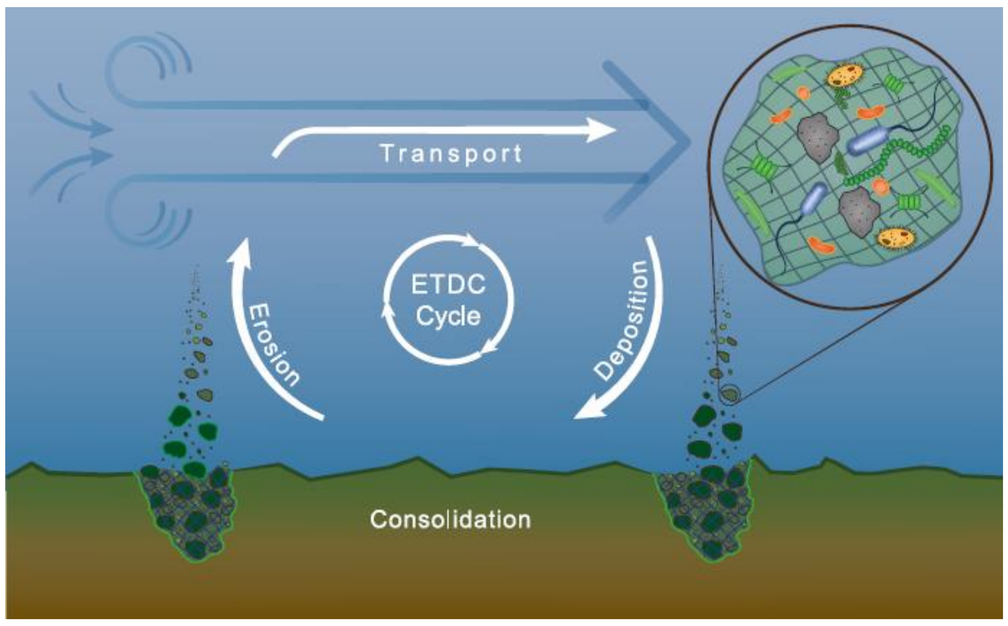
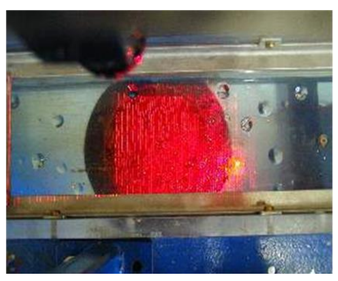


Fig. 1: The ETDC-Cycle (Erosion Transport Deposition Consolidation)

Methods and Model Setup

Fig. 2: Sampling of undisturbed cohesive sediment cores.



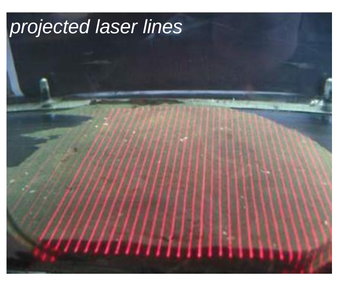


Fig. 4: SEDICA: computer based image analysis for the determination of vertical profiles of erosion rates.

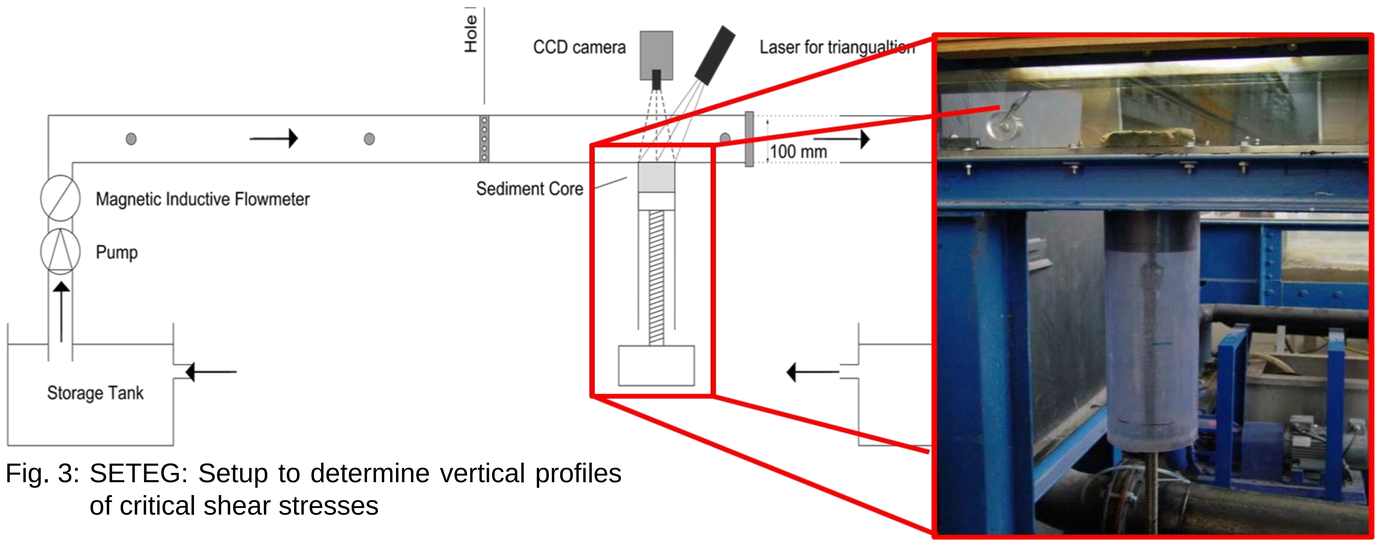


Fig. 3: SETEG: Setup to determine vertical profiles of critical shear stresses

- Sampling of undisturbed sediment cores by cylindrical coring tubes with a length of 115 cm and a diameter of 14 cm
- Non-destructive method for measuring vertical bulk density profiles (γ-ray absorption)
- SETEG-Flume for measuring vertical profiles of critical shear stresses
- SEDICA to detect the erosion rates for shear stresses exceeding the critical shear stresses
- Vertical profiles of additional sedimentary and biological parameters that influence erosion stability: particle size distributions, TOC-contents and Chlorophyll-*a* concentrations

Fig. 5: Sediment core surfaces at different depths

Exemplary Results

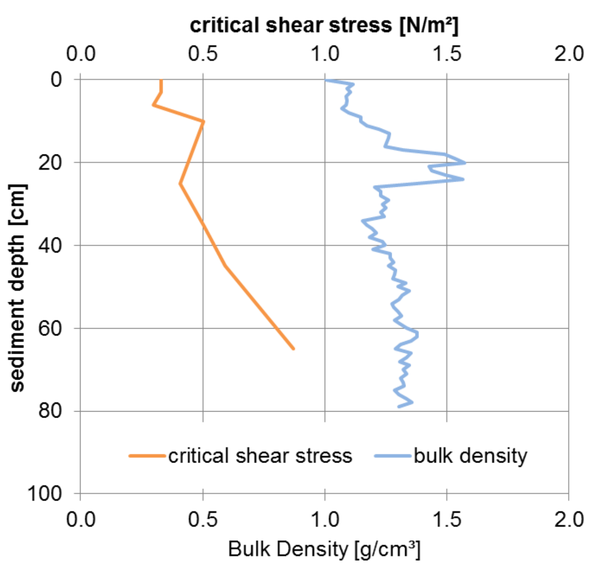


Fig. 6: Vertical profiles of critical shear stresses and sediment bulk density of a sediment core. The shear stresses are indicating an increasing consolidation with increasing sediment depth while the sediment bulk density is only slightly increasing over depth. The higher density values at 20 cm correspond with a decrease in shear stress indicating an area of lower sediment stability.

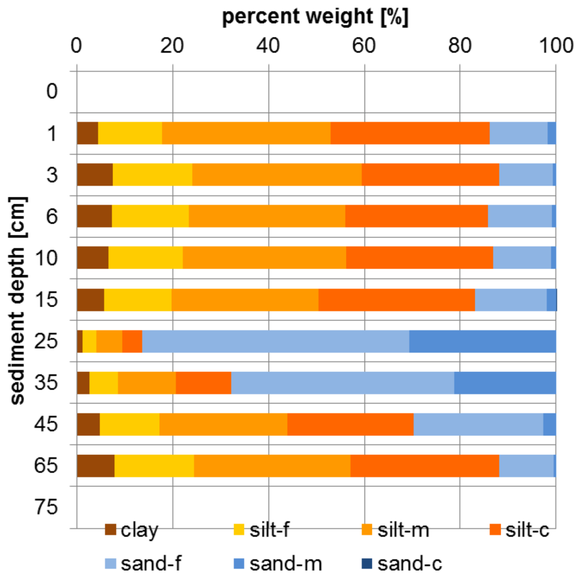


Fig. 7: Varying particle size distributions over sediment depth. At a depth of 25 to 35 cm a significant increase in sandy materials can be identified. This is reflected in higher bulk densities and lower shear stresses due to non-cohesive properties of sandy materials.

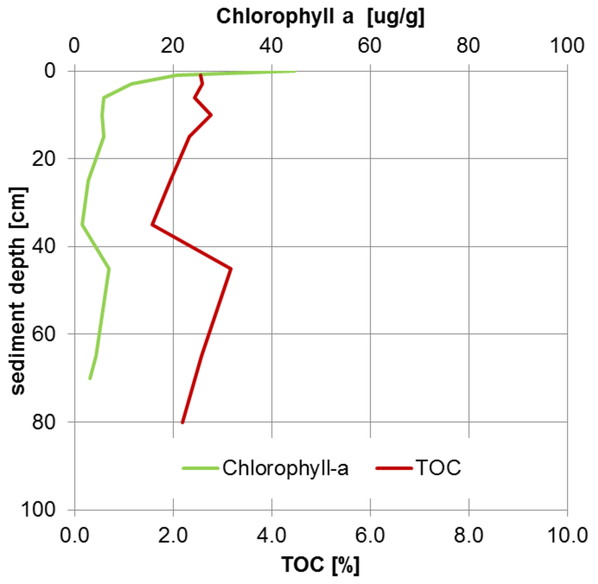


Fig. 8: Vertical profiles of chlorophyll-*a* concentration and TOC-content. The highest concentration of chlorophyll-*a* is at the sediment surface since microalgae generally depend on light for photosynthesis. The TOC-content includes all - active and inactive - organic material. Both parameters are indicators for biostabilization.

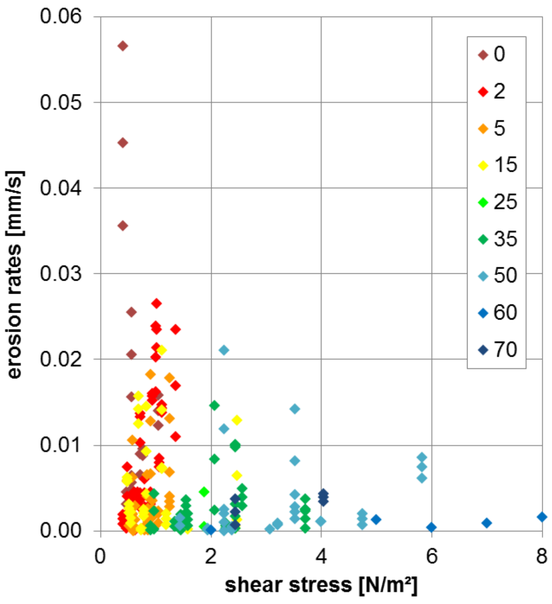


Fig. 9: Measured erosion rates for varying shear stresses ($\tau_0 > \tau_{crit}$) at different sediment depths. The high erosion rates close to sediment surface (<15cm) indicate a low sediment stability while for deeper sediment layers higher shear stresses are required to obtain measurable erosions rates (higher sediment stability).