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river challenge

Bio-Engineering for Sediment Management And Removal of Turbidity Technologies: introduction, need, and research - implementation gap

Miguel de Lucas, Sr Researcher, Deltares
Renaat De Sutter, CEO, HAEDES
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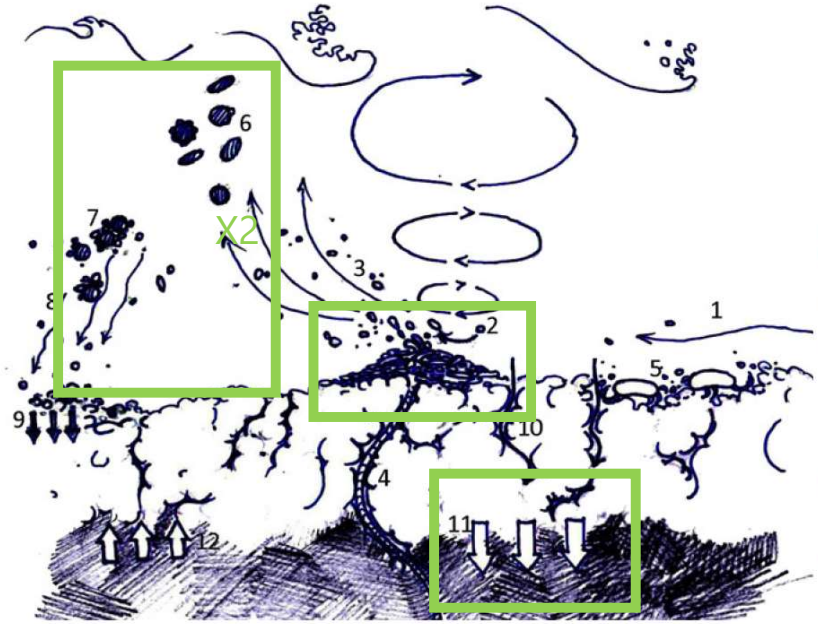
Outline

- Introduction to BESMART Technologies: Bio-Engineering for Sediment Management And Removal of Turbidity Technologies
- Dewatering by worms
- Implementation gap

BESMART Technologies: inspiration



1. Wind driven currents.
2. Wind driven waves, whose energy reaches the bottom and exerts a bed shear stress.
3. Erosion and re-suspension of sediments.
4. Bioturbation forming surface pelletization
5. Bioturbation disrupting the bed surface
6. Primary production of algae in the water column.
7. Flocculation, including biotic-abiotic interactions.
8. Settling of flocs and sediments particles.
9. Consolidation processes.
10. Diffusion of oxygen into the soil, facilitated by the burrowing of the meio-fauna.
11. Oxidation of sediments
12. Reduction of sediments by bacteria

Fig. 13 Sketch of the highly dynamic system driven by the interaction of physics, chemistry, and biology. All together, these processes determines Markermeer sediment dynamics

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BESMART Technologies: mission

- Incorporate **biological processes** into the (fine sediment management) **engineering toolbox**.
  - Because BESMART Tech. are passive, so very low (relative) carbon footprint.
  - Because technically BESMART Tech. are competitive (proven), I hypothesize superior once mastered.
  - Because we come from a tradition of mud engineers and now collaborate-coexist with ecologists.

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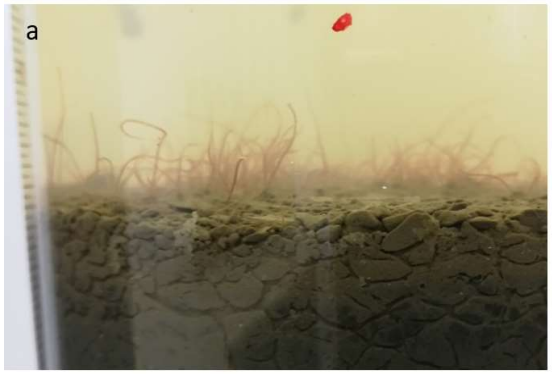
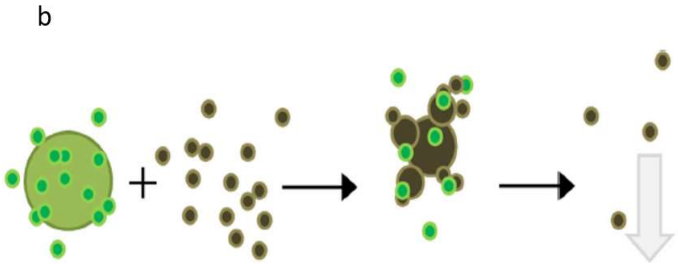
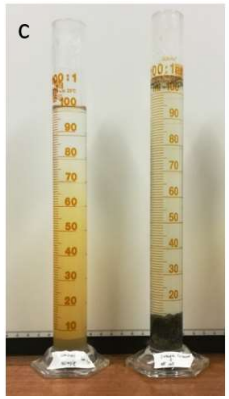
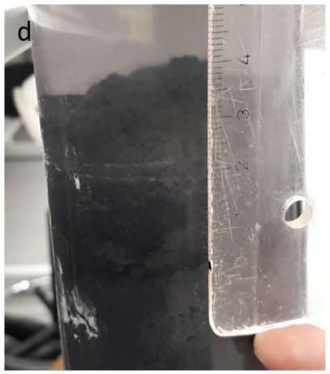
BESMART Research Lines: all apply to fines

- a. Dewatering and strengthening by Oligochaete worms
- b. & c. Use of algae or Kaumera® as flocculant
- d. Bed protection and Sulfur removal by Begiattoa
- e. Dewatering and strengthening by Vegetation

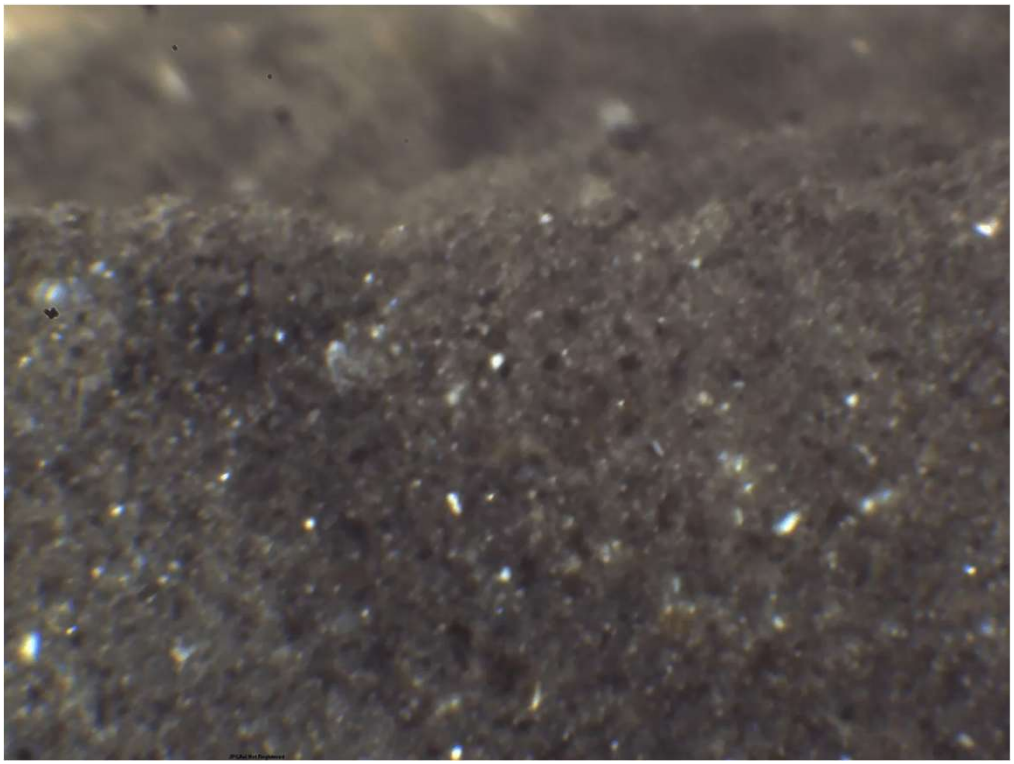








Dewatering by worms: inspiration (2012)



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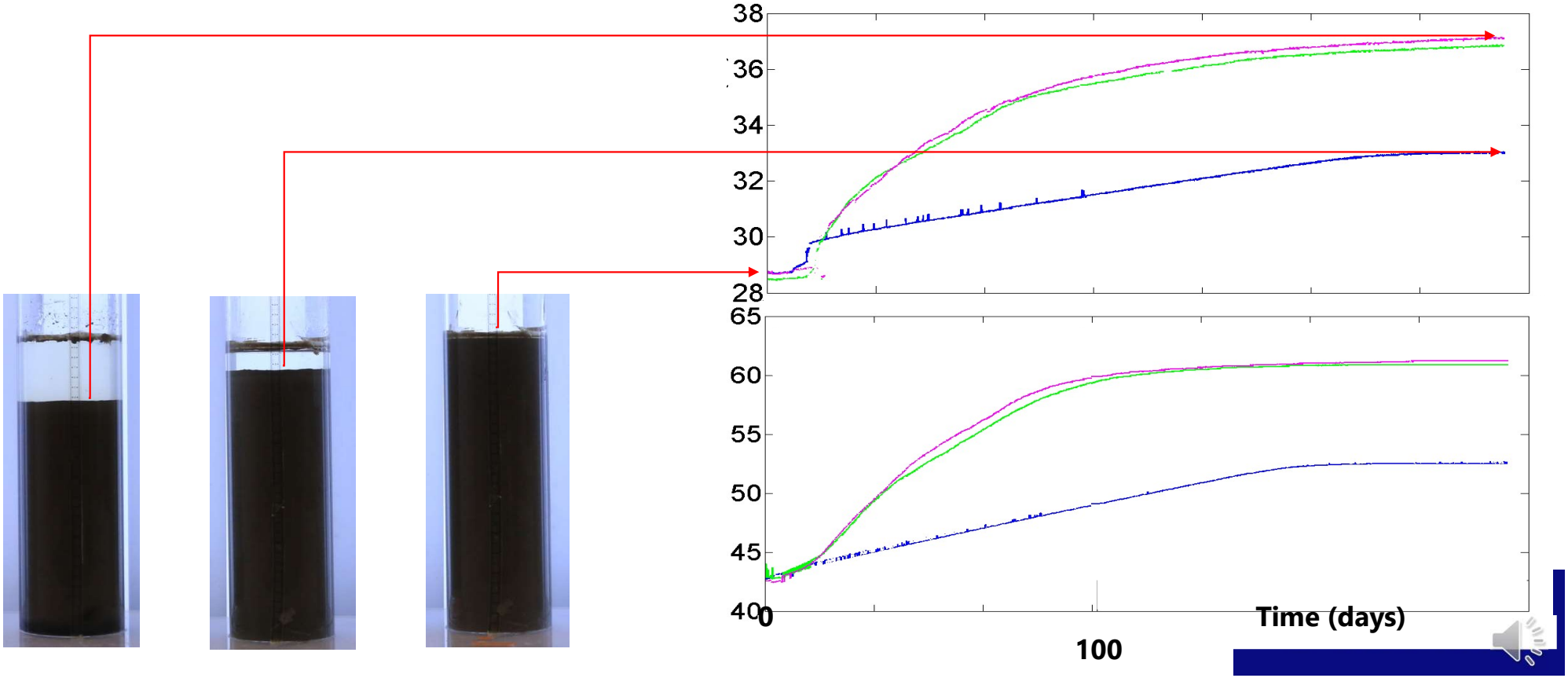
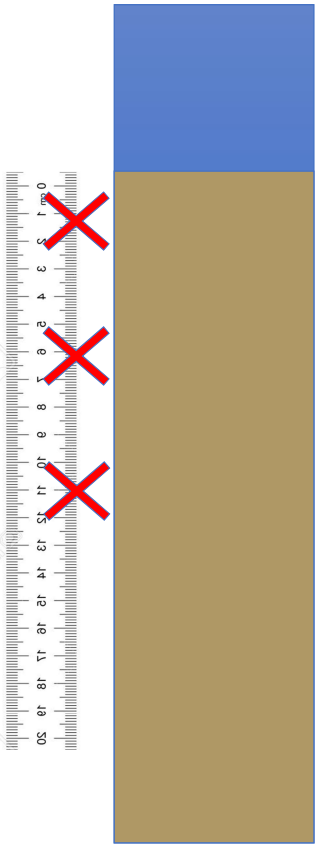
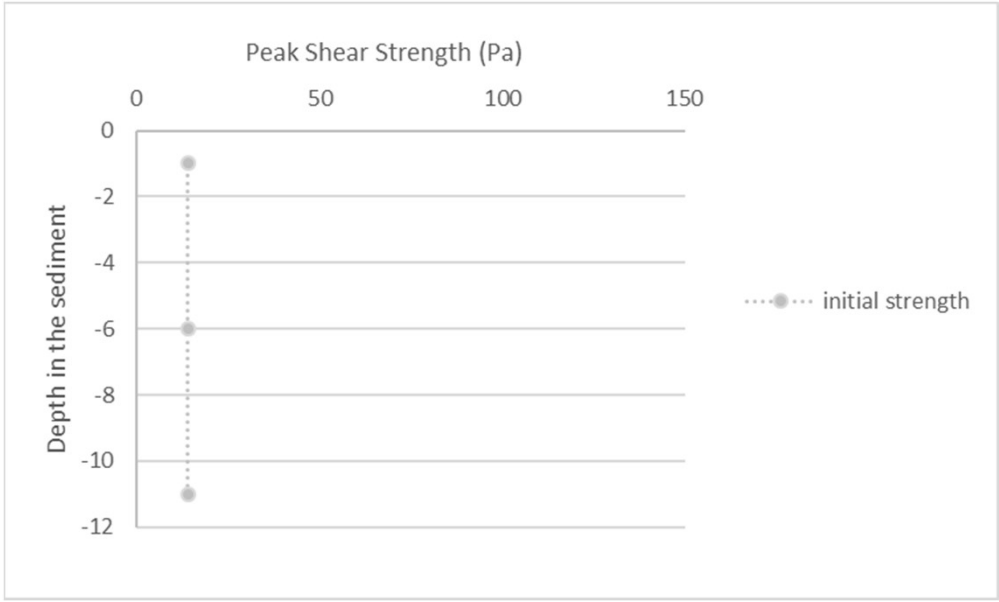
Worms dewatering in saturated conditions



Worms strengthening in saturated conditions





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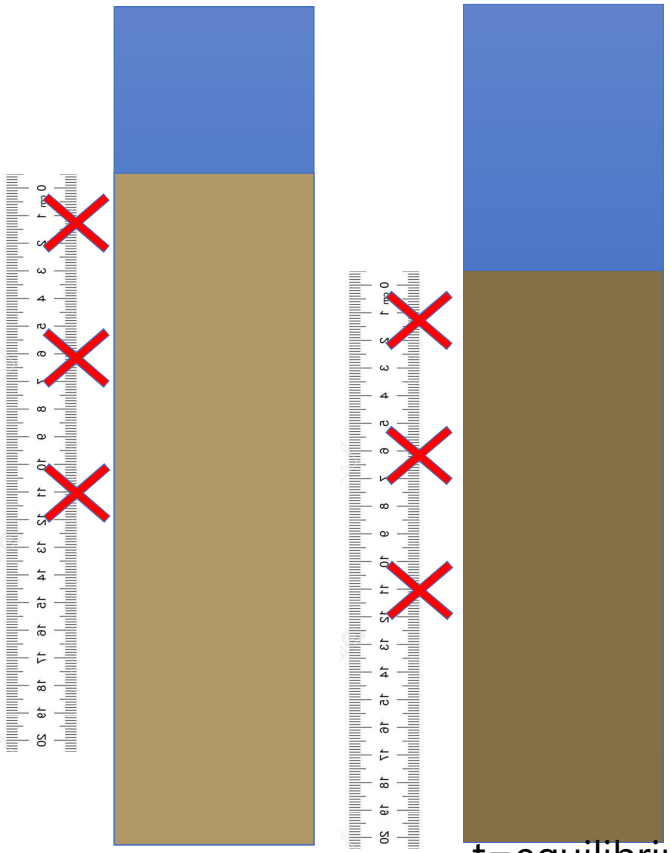
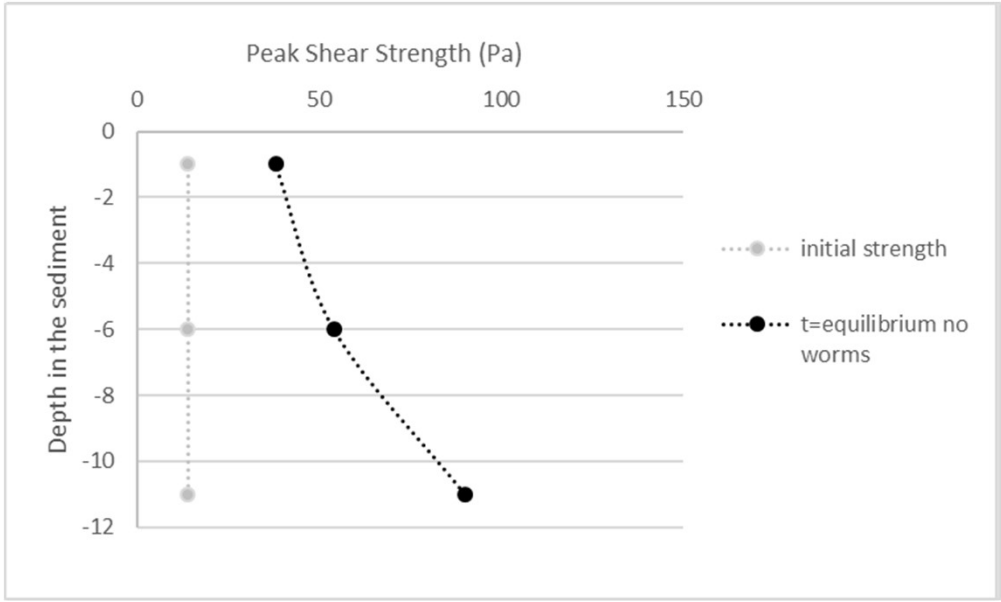
Worms strenghtening in saturated conditions



t=equilibrium
no worms



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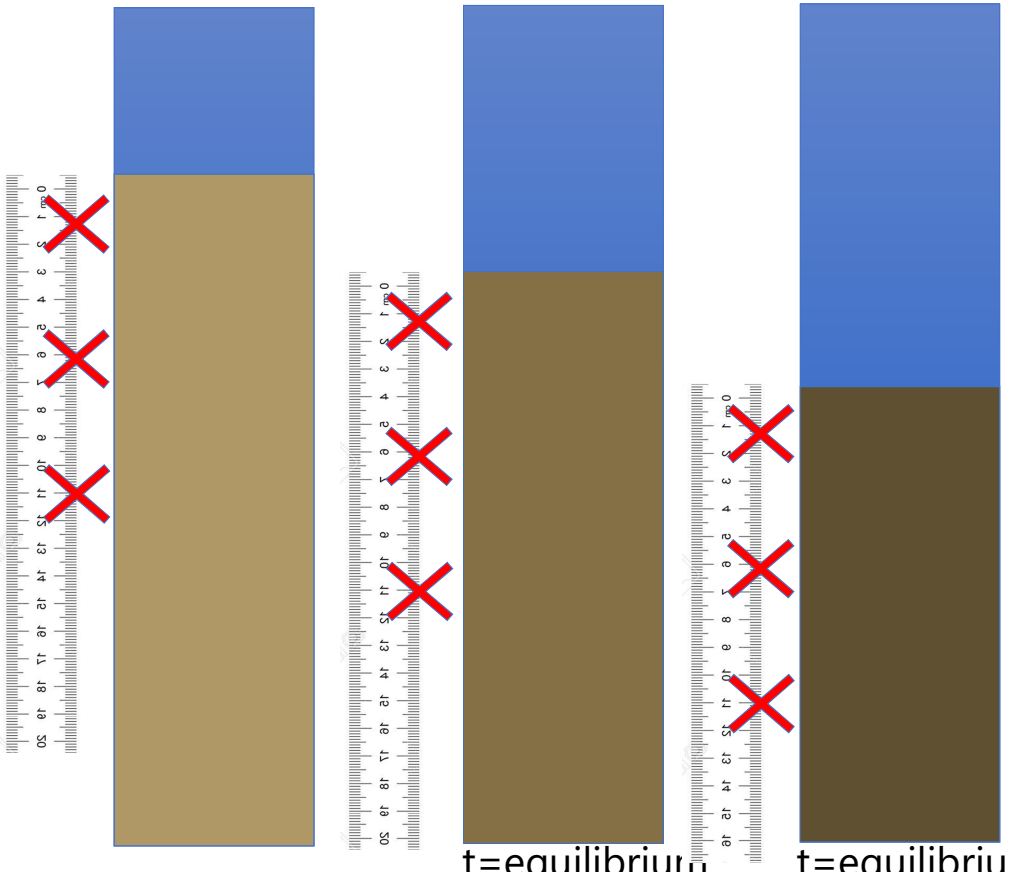
Worms strenghthening in saturated conditions



t=equilibrium no worms

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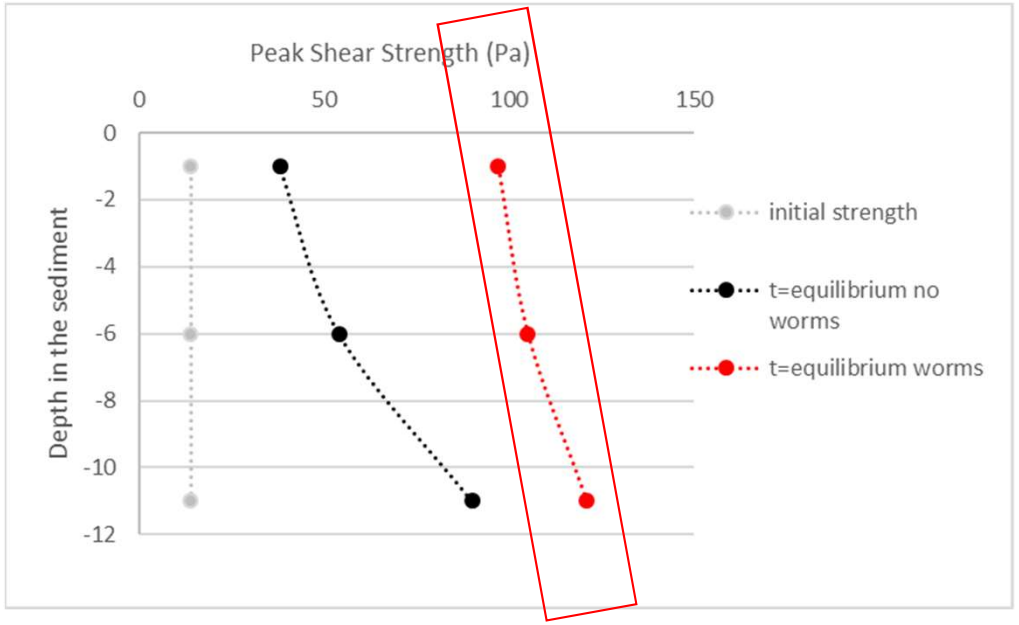

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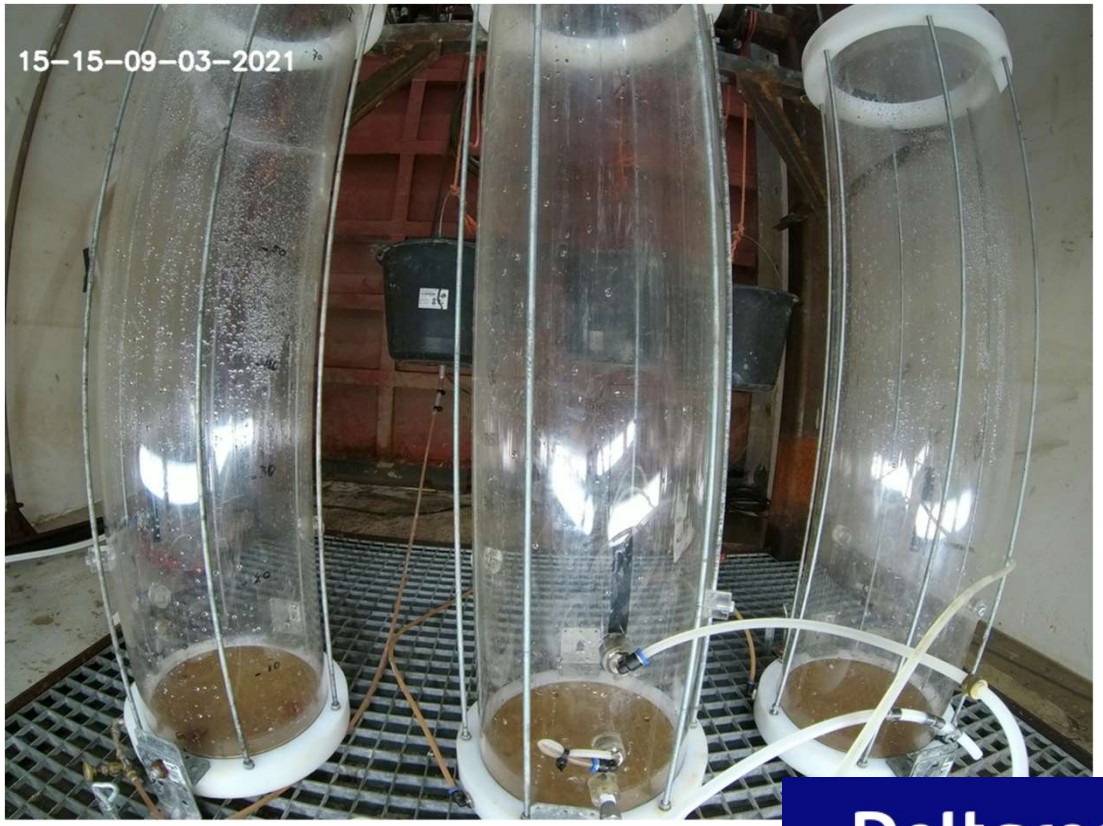
Worms dewatering: unsaturated, under load

	worms		no worms	
time	thickness	SC	thickness	SC
1 day	45 cm	0,23	50 cm	0,21
3 days	40 cm	0,26	49 cm	0,21
6 days	38 cm	0,27	48 cm	0,22
7 days	30 cm	0,33	45 cm	0,23

Load (0.5 bar)

No worms worms worms



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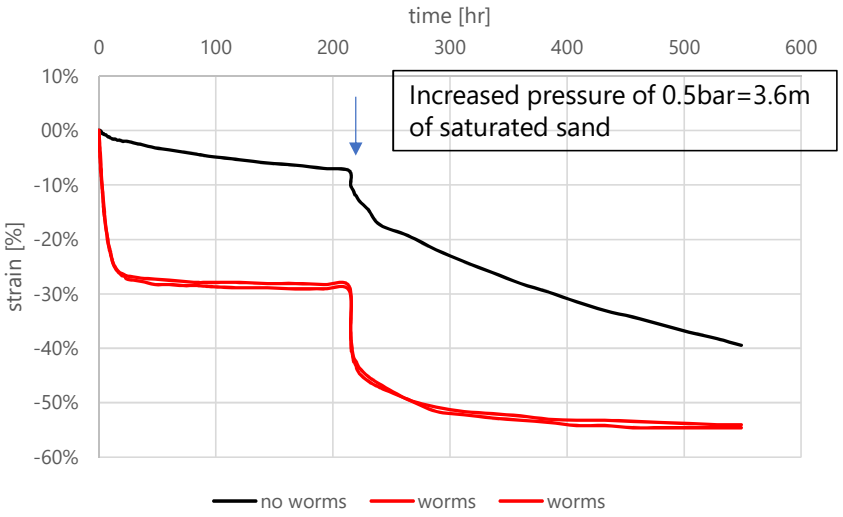
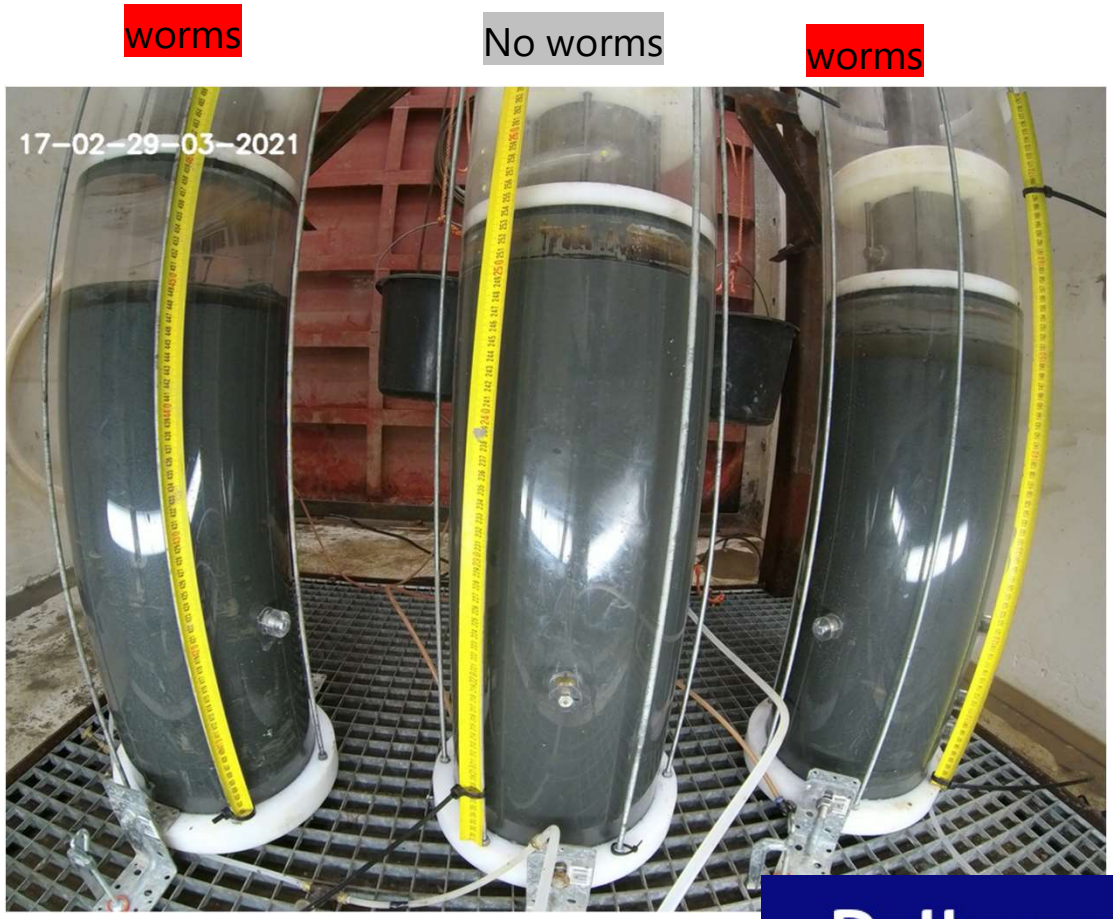
Worms dewatering: unsaturated, under load

Changes:

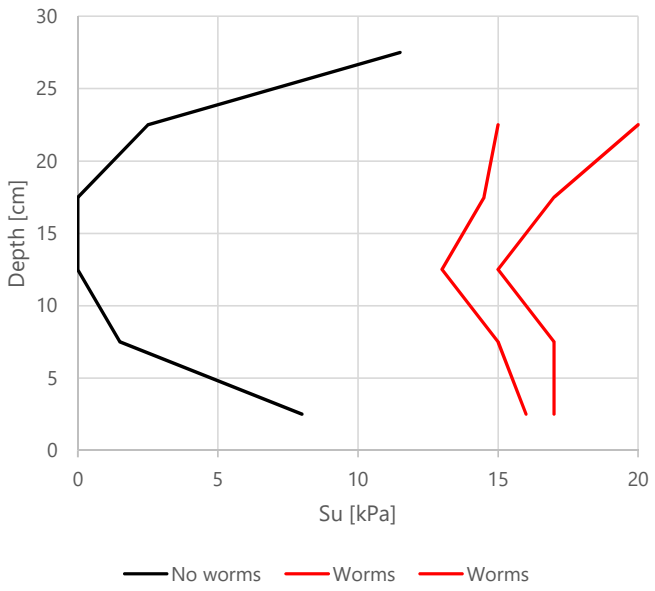
-slight salinity increase
-worms are mixed with the sediment



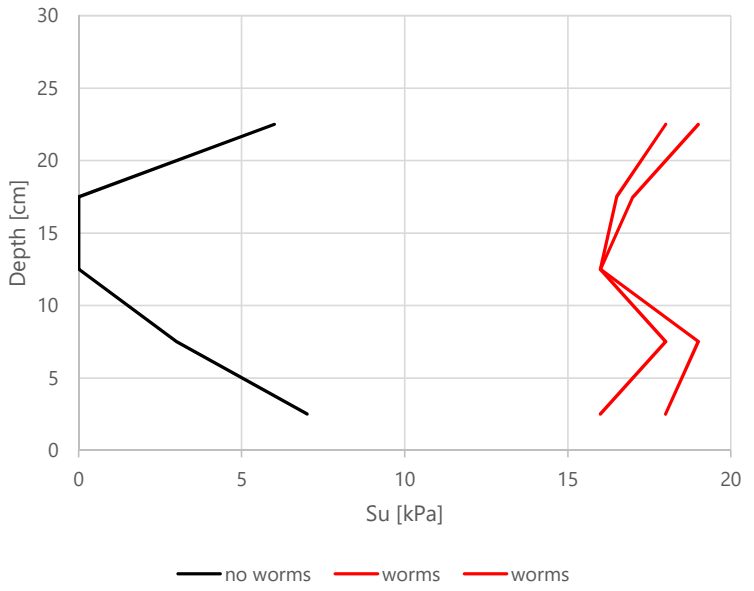


Worms dewatering: unsaturated, under load

Phase 1) not mixed



Phase 2) mixed, higher salinity



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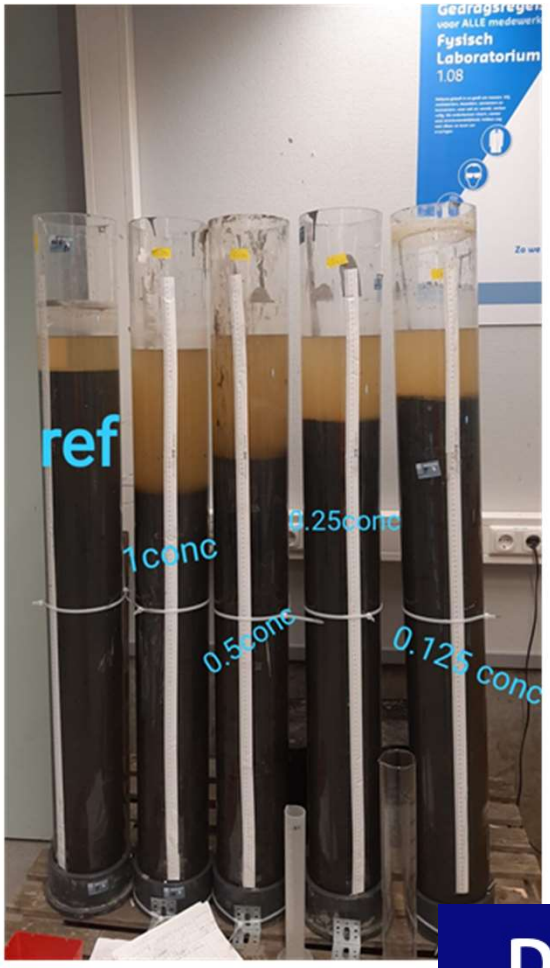
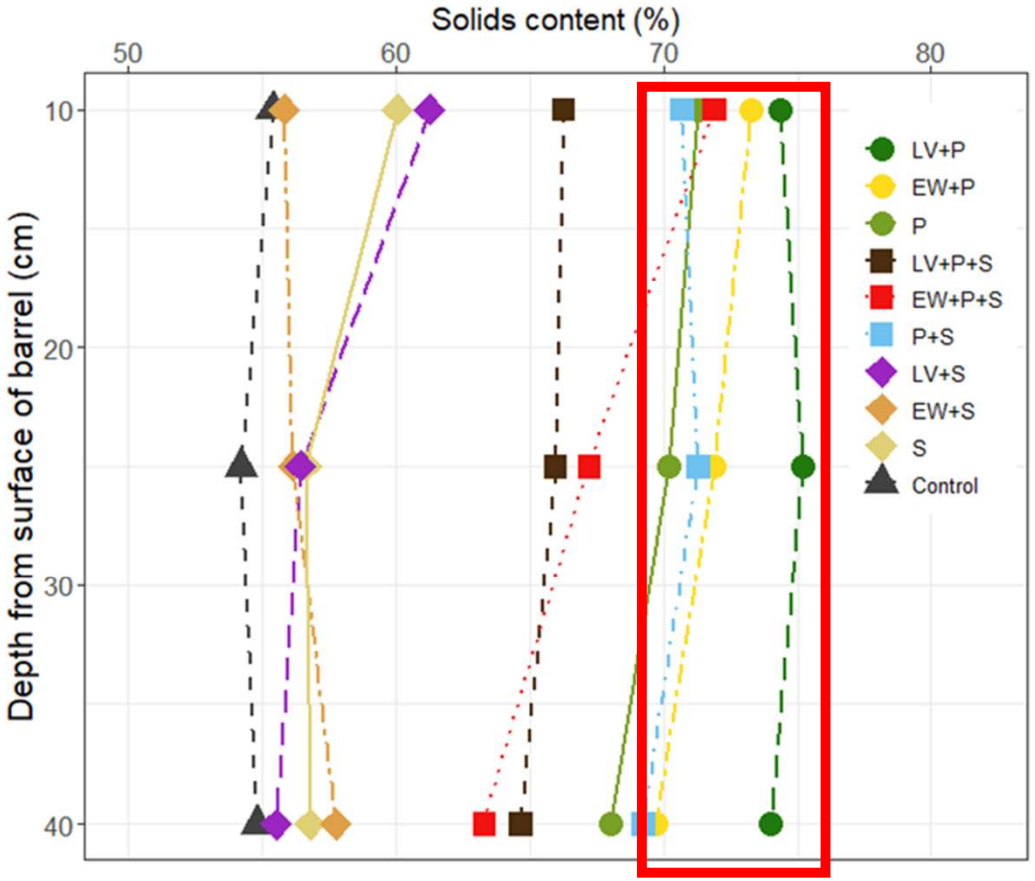
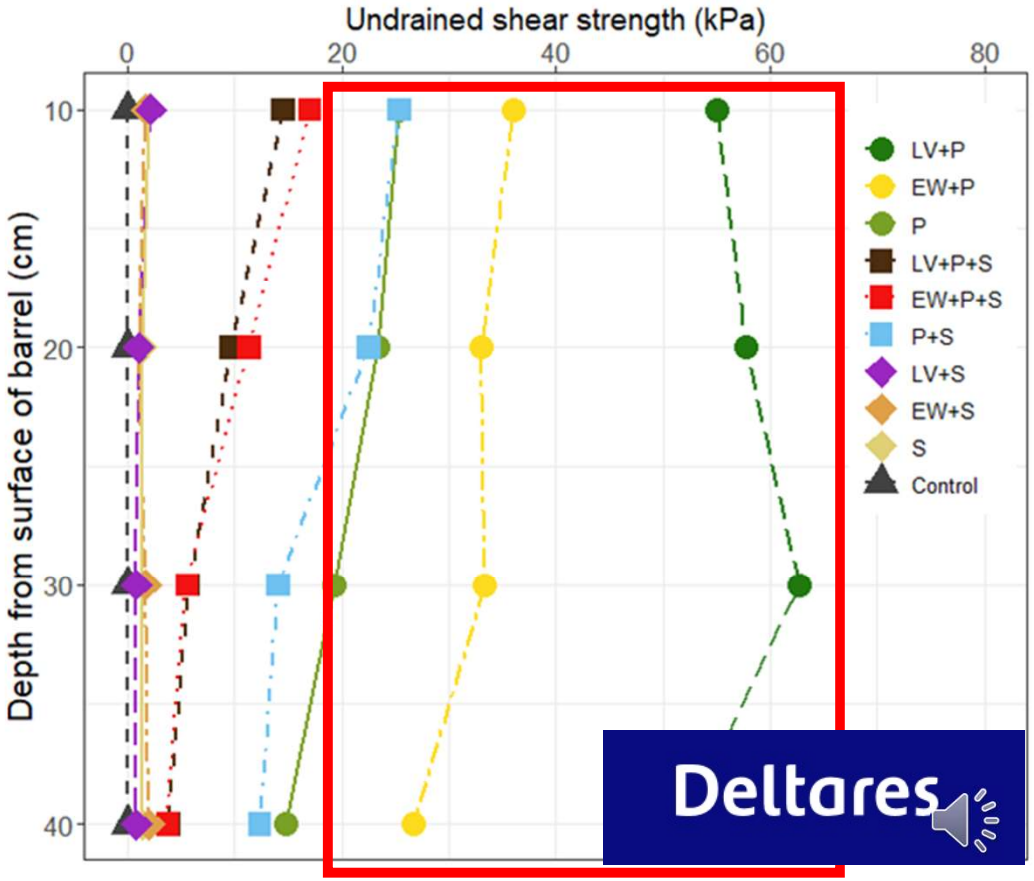
Effect of worm density



Worms and plants!





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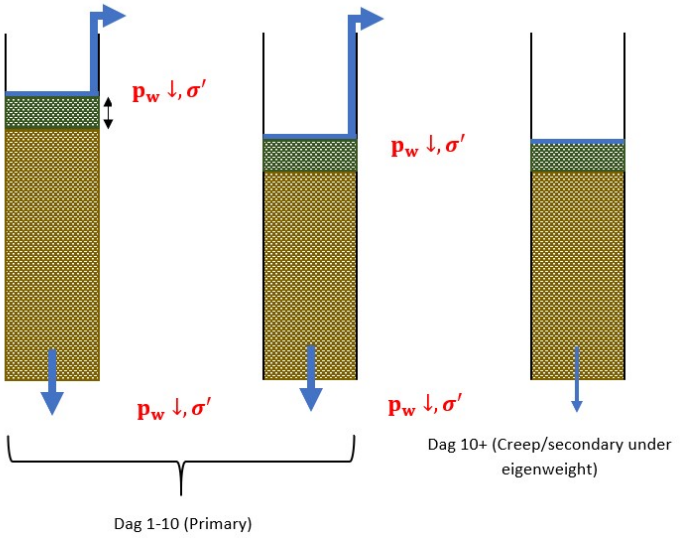
The gap between laboratory research and actual field applications

- Numerical modelling & meso-scale research as tool for design
- Side – effects and total benefit / cost , given the local environment
- Pilot testing and full scale testing for different applications

Numerical modelling – example for dewatering of dredged material in lagoons

- Either simplified 1-D model based on empirical considerations (Gibson as done per Merckelbach) with coefficients “tuned” to the rates observed for the worms

- Either detailed 3-D model coupling the pore water pressure p to the soil deformation p using the Biot equations



Impact of the bio-engineering on the local environment

- Fundamental questions on impact on the environment : introduction of invasive species ? Impact on the ecology ? What after ? Relative advantage of the technique versus “chemical alternative”…
- Practical questions : permitting & EIA ? Flexibility and adaptability of the permit ? Border transfer of species or local growth ? …

Towards field applications

- E.g. case of faster dewatering with worms in land reclamation projects
- A number of questions arise
  - Create optimal conditions for full-scale testing
  - Cost of bio-engineering at large scale
  - Operational flow
  - Health & safety

Conclusions

- X
- X
- Promising, ready for step towards full-scale pilots

Contact:

info@haedes.be
www.haedes.be

Miguel.DeLucasPardo@Deltares.nl

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