Tubifex: a biological method for enhancing dewatering of oil sands tailings. An update on the on-going research program

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What are *Tubifex*?

- Sludge worm/sewage worm
- Inhabit the bottom sediments of lakes, rivers and occasionally sewer lines and outlets
- Very resistant to contamination, in fact, Tubifex density is often used as indicator of ecological deterioration of water bodies
Objective

Objective of these studies: assess and quantify whether *Tubifex* can improve dewatering and strength of oil sands tailings deposit, and is a feasible technology at operational scale.

1. Phase 0, 2014, simple trial on beakers
2. Phase I, 2015: Settling columns at 5% solids content (SC) old FMFT
3. Phase II, 2016: Settling columns at 30% SC on same old FMFT
4. Phase III, 2017 & 2018: Settling columns on fresh FFT and TT + beaker tests for survival (IOSI) + Large settling column

Results presented as:
- Survival rate
- Solids content performance
- Strength of tailings
- Consolidation parameters (draft)
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Inspiration

Many years of working with mud and sediment dynamics in the Markermeer, to understand why the turbidity was so high

Realized:

• Interaction sediment-biota was critical
• *Tubifex* accelerate dewatering of natural mud (de Lucas Pardo, 2014)
Phase 0 – 2014 quick tests on Canadian soil

First test on small beakers (total ~ 12 days) showed:

- Enhance consolidation
- Enhanced strength

![Mudline vs time graph](image)

- Bed Height (cm)
- Time (hours)
- Black line: fauna
- Gray line: no fauna

![Photos of samples](image)
Survival Rate

- Tests in small beakers, with 8 Tubifex per beaker initially
- Tests at 20 °C with air pumping, no air pumping and 4 °C no air

- Tubifex are able to survive in oil sands tailings, and weakly reproduce
- No major difference between air and no air
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*Tubifex* are able to survive in oil sands tailings, and weakly reproduce
• No major difference between air and no air
• No major difference between 20 °C and 4 °C
• Monitored mudline continuously during sedimentation and consolidation
• Derived solids content from mudline.

Phase I, initial concentration 40 g/l (~5% SC), ~2 months. C2, no worms; C4, C5, C6 worms (triplicate)

Phase II: Initial SC 30%. ~3 months. Dashed, no Tubifex, solid Tubifex with darker implying higher Tubifex concentration
Solids Content

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Phase II: measured at two depths in columns, near the top and bottom

- Near the bed results are consistently show SC and strength generally proportional to *Tubifex* concentration.
- Near the top, scatter is larger
Dewatering performance

Application of the equations of Merckelbach and Kranenburg to mudline allows for derivation of sedimentation and consolidation parameters.

Obtained: $K_k$, $K_p$, $n_f$, $\Gamma_c (C_v)$. These can be correlated to p-e-k (in progress)

\[
\sigma_{zz}^{sk} = K_p \left( \frac{\Theta_S^m}{1-\Theta_S^m} \right)^{\frac{2}{3-n_f}} - K_{p,0}
\]

\[
k = K_k \left( \frac{\Theta_S^m}{1-\Theta_S^m} \right)^{\frac{2}{3-n_f}}
\]

\[
\Gamma_c = \frac{2}{3-n_f} \frac{K_k K_p}{g \rho_w}
\]
• Same effective stress -> lower void ratio (more compressible?)
• Same void ratio -> higher permeability
• Different soil structure ($n_f$)
Conclusions

- **Tubifex can survive in oil sands tailings.** Reproduction is weak. Next phase will investigate how to optimize / enhance *Tubifex* survival and reproduction in oil sands tailings.

- **Tubifex accelerate dewatering** with 10 – 20% relative increase in SC after two to three months (test duration). Interesting to compare to polymeric flocculant.

- **Tubifex influence the soil structure** forming channels and (possibly) modifying the micro clay-water system structure. This **increases the permeability** On-going data analysis and next phase will quantify consolidation parameters in relation to polymeric treated tailings.

- **Tubifex increase tailings strength**, possibly due to geochemical reaction caused by biological activity.

- **Relative increase** in SC and strength is generally proportional to *Tubifex* density.
What is next

This study will continue in 2017 and 2018 with an additional experimental program co-funded by IOSI and Deltares to further test this technology towards pilot.

Specific objectives are:
1. Quantify dewatering properties on different tailings types (fFFT, TT) in relation to polymeric flocculants
2. Optimize *Tubifex* survival and reproduction in oil sands environment
3. Scale up to larger columns.