Tailings Ponds

- Tailings ponds containing oil sands tailings are an environmental concern currently facing the rapidly-expanding oil sands industry.
- During bitumen extraction, an aqueous mixture of fine silts, hydrocarbons, salts, and soluble organic compounds called oil sands tailings is produced.
- Naphthenic acids (NAs) are the primary toxic component of oil sands tailings [1] and unfortunately resist degradation, thus presenting a long-term environmental hazard.

Did you know?

By 2025, the total volume of accumulated tailings is expected to equal one billion m^3 [1].

'Slow' Sand Filters

- 'Slow' sand filters (SSFs) are a modern water treatment process invented in 1804 [2].
- These filters produce potable water by developing a biofilm called a *schmutzdecke* (German for 'dirt covering') on top of a sand bed which breaks down any contaminants.
- Despite their ability to promote biofilm growth, the potential of SSFs to biodegrade NAs has not been reported in any literature.
- These filters:
  - Rely on gravity.
  - Are relatively low-cost.
  - Are made with mostly natural material.
  - Can be located outdoors.
  - Rely on historical technology that has been proven effective for centuries.

Objective

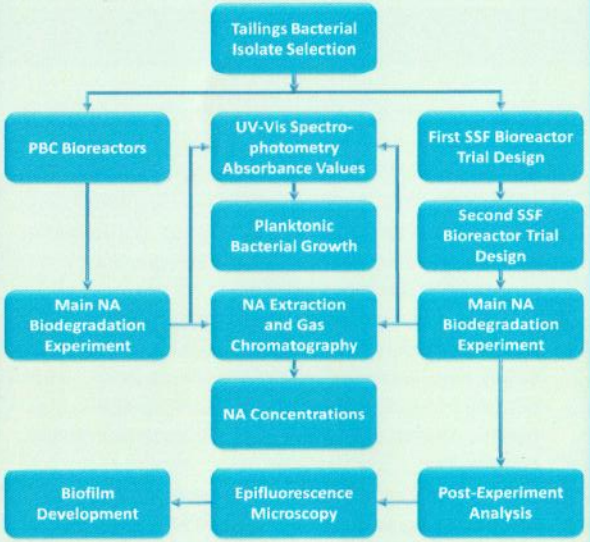
- The objective of my project was to design, construct, and investigate the use of SSFs newly applied as novel aerobic bioreactors to the microbial degradation of NAs.

SSF Bioreactors PBC Bioreactors

The effectiveness of bench-scale SSF bioreactors was assessed by comparing them to planktonic batch culture (PBC) bioreactors.

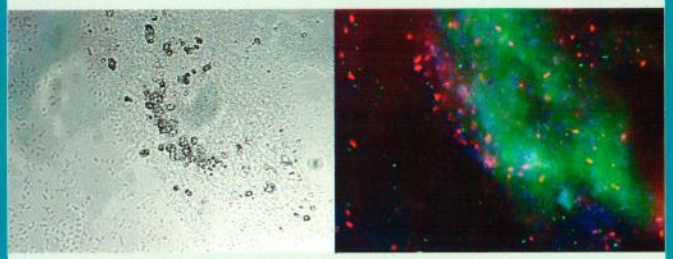
- I hypothesized that the SSF bioreactors would accomplish higher biodegradation due to the formation of biofilms on the sand particles.

Experimental Design



Results

- Two types of biofilms developed in the SSF bioreactors: an elastic pudding-like *schmutzdecke* and a white net-like streamer biofilm.
- Epifluorescence microscopy indicated the formation of the extracellular polymeric matrix of a biofilm (indicated by the presence of DNA stained green) around the sand.



Brightfield Merged

- In one week, the SSF bioreactors reduced the NA concentration from 100 mg/L to 7.67 mg/L (92.33% removed) on average.
  - PBC bioreactors only removed 37.55%.

Did you know?

Total NA concentrations below 5.00 mg/L are no longer acutely toxic to fish [1].

- The biodegradation rates in the SSF bioreactors were five times faster than the PBC bioreactors.
- Certain NAs might never be biodegraded in the PBC bioreactors; however, all the NAs tested were broken down by the biofilms in the SSF bioreactors (possibly due to enhanced metabolic capabilities from forming biofilms).
- Overall, my SSF bioreactors consistently outperformed the PBC bioreactors in terms of NA biodegradation and microbial growth.