The Use of Hydraulic Selector Technology for the Improvement of Activated Sludge Settling

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Re-Inventing the Nation's Urban Water Infrastructure (ReNUWIt)

Background

- Conventional activated sludge (CAS) is a widely used, low-cost treatment technique that utilizes microorganisms to remove nitrogen, phosphorus, and carbon from wastewater (Figure 1A).
- Wastewater treatment plants (WWTP) often struggle with poor settling sludge in the secondary clarifier.
- Slow settling sludge is the result of an overabundance of filamentous bacteria (Figure 1B).

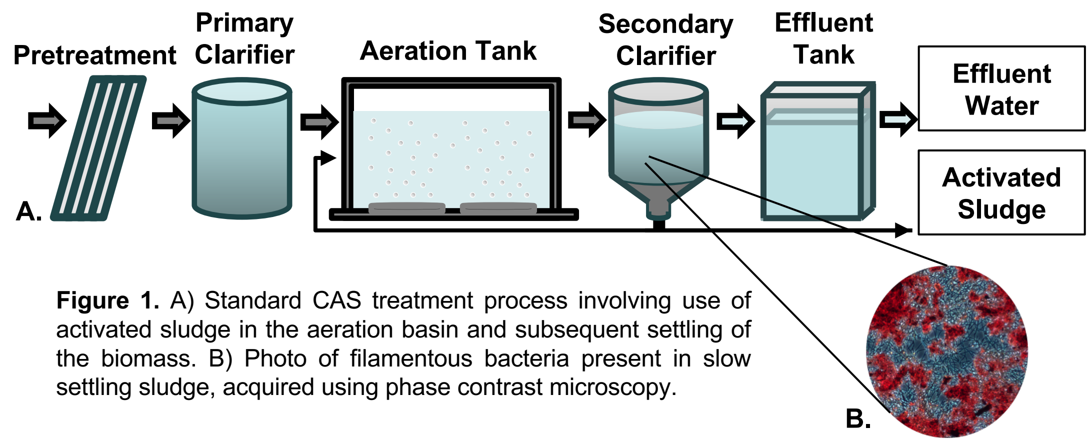

Figure 1. A) Standard CAS treatment process involving use of activated sludge in the aeration basin and subsequent settling of the biomass. B) Photo of filamentous bacteria present in slow settling sludge, acquired using phase contrast microscopy.

Implications of Slow Settling Sludge

- A longer hydraulic retention time is required to achieve effluent water quality requirements
- Wasted sludge may have a high water content, leading to less efficient energy gain in the subsequent anaerobic digestion process
- Solids may be washed out with the effluent water, which could lead to serious human and environmental health impacts.

Research Objective

Implement hydraulic selection technology in a batch reactor to improve settleability of activated sludge by decreasing the concentration of filamentous bacteria while maintaining nitrogen removal.

Hydraulic Selection Technology

Settling basins in existing WWTPs may be retrofitted with hydraulic selectors, which are placed at a depth near the surface of the settled sludge blanket. The selector uses hydrodynamic forces to develop a vacuum that provides enough lift force to remove sludge dominated by filaments (Figure 2).

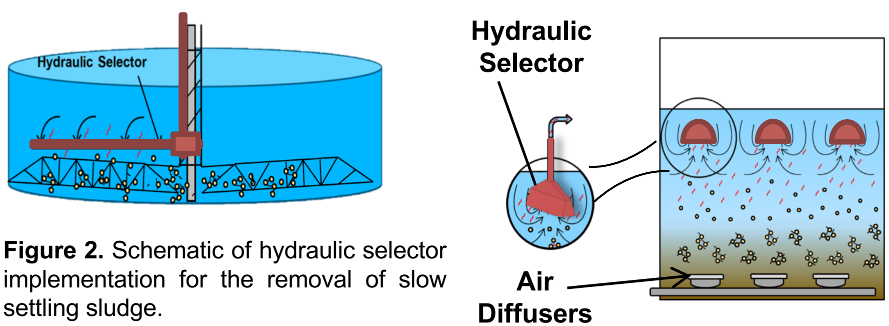

Figure 2. Schematic of hydraulic selector implementation for the removal of slow settling sludge.

Methods and Materials

A pilot-scale sequencing batch reactor (SBR) with two 114 L bioreactors was operated for 137 days (Figure 3). Bioreactor 1 (BR1) served as the control and bioreactor 2 (BR2) had an identical setup but was also equipped with two hydraulic selectors.

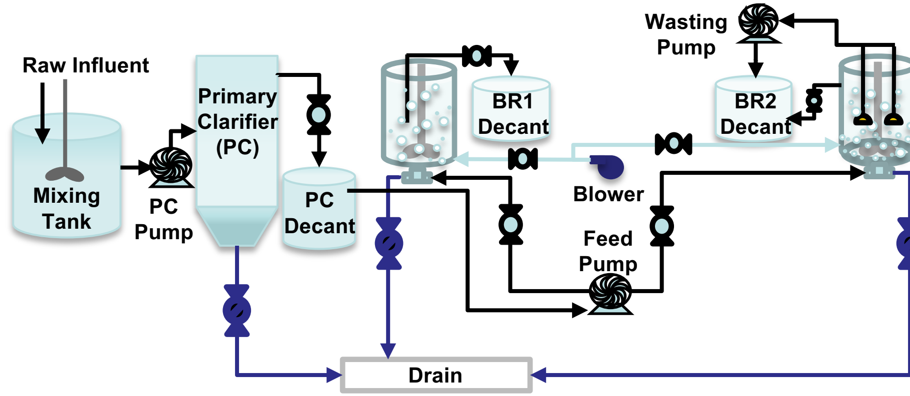

Figure 3. Schematic of the pilot scale system of the control bioreactor, BR1, and batch bioreactor equipped with hydraulic selectors, BR2.

Results

Over the 137-day timeframe BR2 differentiated itself and developed a faster settling sludge. Figure 4 indicates that BR2 achieved a reduced sludge volume faster than BR1; BR2 measurements were also less variable. Figure 5 illustrates BR2's ability to nitrify ammonia beginning May 30th when the influent ammonia concentration decreased, while BR1 was still unable to nitrify the ammonia. The June average percent ammonia removal for BR1 and BR2 was 29.5% and 94.2%, respectively.

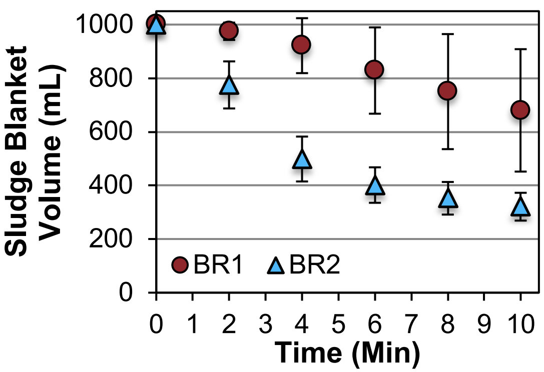

Figure 4. Averaged sludge blanket volumes for BR1 and BR2 from experimental day 118 (May 30th) through 137 (June 18th). Error bars represent standard deviation.

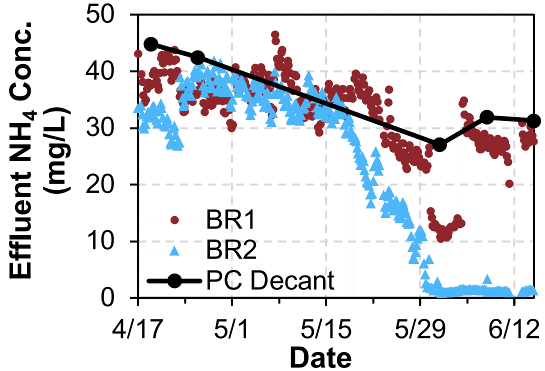

Figure 5. As the ammonia loading to BR1 and BR2 decreased, BR2 had better ammonia removal compared to BR1.

Conclusion

The 137-day experiment validated the potential of hydraulic selection technology to improve sludge settling speed while maintaining ammonia removal. When compared to BR1, BR2 exhibited superior settling qualities and was able to achieve low effluent ammonia concentrations.

Future Work

The next phase of the project will involve retrofitting the pilot scale system with new tank configurations, air diffusers, and online probes. The success of the hydraulic selector technology will be quantified by monitoring the sludge settling velocity, zeta potential, and particle size. If activated sludge particles have a large magnitude zeta potential they will repel each other, thus inhibiting flocculation and causing slow settling (Figure 6). Particle size will provide insight on particle density (Figure 7).

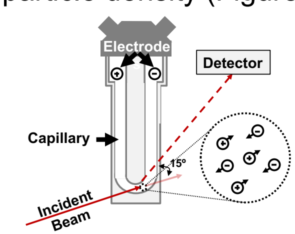

Figure 6. Zeta potential is obtained by running a charge through the solution and measuring particle velocity with laser doppler velocimetry.

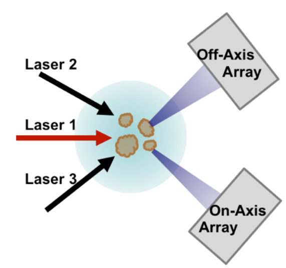

Figure 7. A tri-laser system is used to scatter the beams onto detector arrays, which will scatter light at different angles depending on particle size.