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

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Introduction

Hydraulic selection technology holds substantial promise for the wastewater treatment industry. Approximately 70% of existing wastewater treatment plants (WWTPs) in the United States use conventional activated sludge (CAS) systems to treat wastewater [1, 2]. CAS is a low-cost treatment technique that utilizes microorganisms to remove nitrogen, phosphorus, and carbon from wastewater. Unfortunately, WWTPs often struggle with poor settling sludge during the sedimentation stage. Slow settling sludge is the result of an overabundance of filamentous bacteria. The settling rate can have serious implications on the rest of the treatment process. When sludge settles slowly, a longer hydraulic retention time is required to achieve effluent water quality requirements. If adjustments to the treatment process are not made, the wasted sludge may have a high water content, leading to less efficient energy gain in the subsequent anaerobic digestion process. More importantly, poor settling floc may cause solids to wash out with the effluent water, which could lead to serious human and environmental health impacts. Facilities without additional clarifiers must construct new infrastructure, which can be expensive and lead to intended and unintended plant shutdowns. Additionally, this approach may not be feasible for landlocked WWTPs that lack the space to expand their facility.

Hydraulic selection technology has the potential to improve sludge settling rates. 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, as depicted in Figure 1.

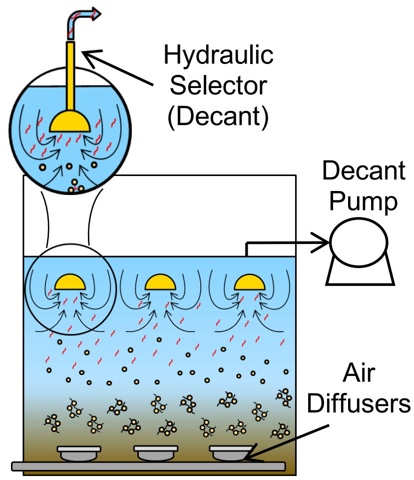

Figure 1. *Schematic of hydraulic selection technology, which selectively removes slow-settling sludge.*

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.

Methods and Materials

A pilot-scale sequencing batch reactor (SBR) equipped with two 114 L bioreactors was operated for 137 days at the Colorado School of Mines – Mines Park Water Reclamation test bed (Figure 2). Bioreactor 1 (BR1) served as the control and bioreactor 2 (BR2) had an identical setup but was also equipped with two hydraulic selectors. Both bioreactors operated with a 30% exchange ratio and had the following operation schedule: fill (20 minutes), mixing (15 minutes), aeration with mixing (170 minutes), settling (6 minutes), decant (12.5 minutes). Three times a week 1-L samples were drawn from BR1 and BR2 during the mixing with aeration stage and the following parameters were measured: sludge volume index (SVI), sludge settling rate, total suspended solids (TSS), and volatile suspended solids (VSS). Additionally, weekly composite samples of the influent wastewater, primary clarifier decant, BR1 decant, and BR2 decant were analyzed to determine the following values: chemical oxygen demand (COD), soluble COD (sCOD), total nitrogen (TN), total phosphorus (TP), nitrates (NO_3), ammonia (NH_4), conductivity, pH, and alkalinity. Online probes measured temperature, TSS, ammonia, nitrates, and dissolved oxygen (DO) concentrations of BR1 and BR2 every 2 minutes.

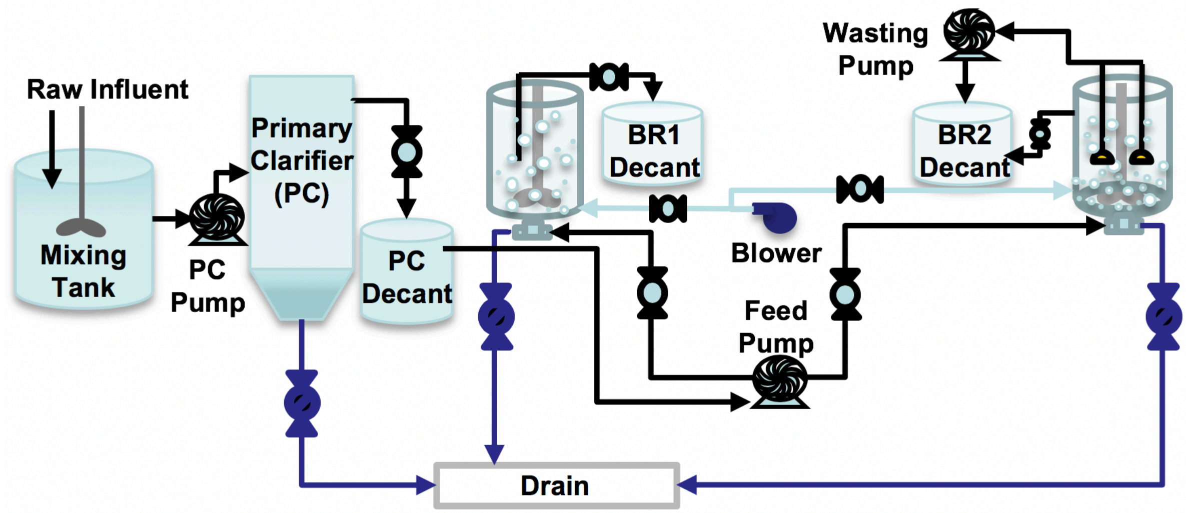

Figure 2. Schematic of the pilot scale system of the control bioreactor, BR1, and batch bioreactor equipped with hydraulic selectors, BR2.

Results and Discussion

Over the 137-day timeframe BR2 differentiated itself and developed a faster settling sludge. This improvement was validated with data collected from the final two weeks of system operation. An SVI test was conducted five times over the two-week timeframe and the two-minute interval measurements were averaged (Figure 3). BR2 achieved a reduced sludge volume faster than BR1, indicating faster settling sludge; BR2 measurements were also less variable. The sludge settling for BR1 was inconsistent, which is reflected by the larger standard deviations shown in Figure 3. Figure 4 depicts the settling velocity of the activated sludge during the last two weeks of operation. The results indicate that BR2, the bioreactor equipped with hydraulic selection technology, consistently settled faster than BR1. The SVI and settling velocity measurements clearly show that the implementation of hydraulic selectors in BR2 successfully led to a faster settling sludge. In addition, the sludge must also nitrify and denitrify to remove ammonia from the wastewater. 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 primary clarifier ammonia concentration reflects the fluctuating influent wastewater ammonia concentrations over time. The June average percent ammonia removal for BR1 and BR2 was 29.5% and 94.2%, respectively.

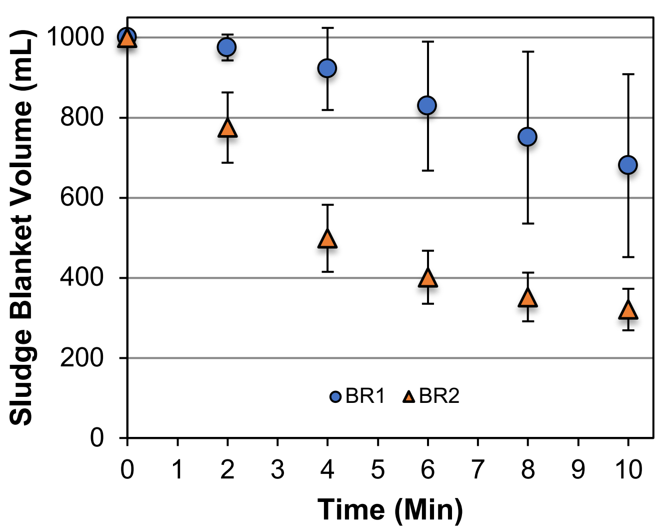

__Figure 3.__ Averaged sludge blanket volumes for BR1 and BR2 from experimental day 118 (May 30th) through 137 (June 18th). Error bars represent standard deviation.

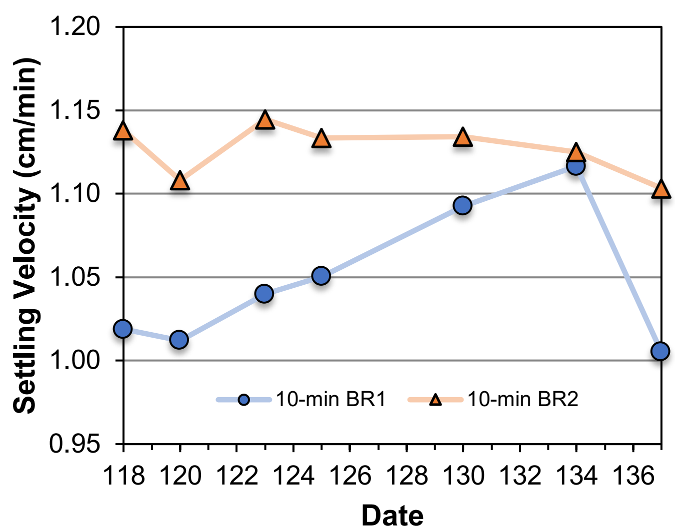

__Figure 4.__ 10-minute settling velocity for BR1 and BR2 from experimental day 118 (May 30th) through 137 (June 18th).

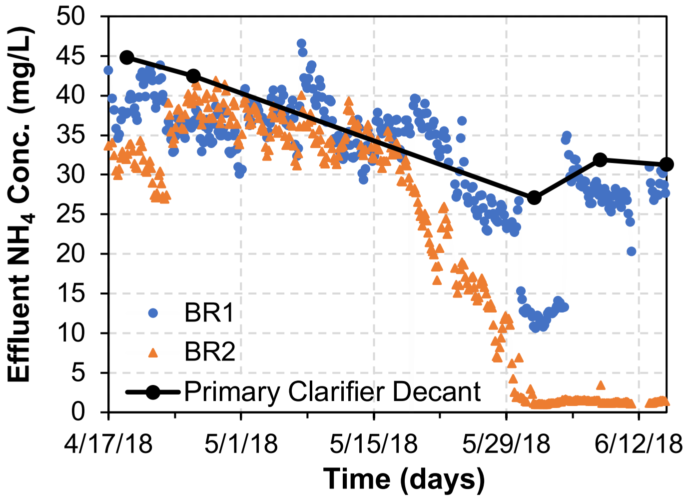

Figure 5. *As the ammonia loading to BR1 and BR2 decreased, BR2 had better ammonia removal compared to BR1.*

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 in its last two weeks of operation it achieved low effluent ammonia concentrations. It is recommended that additional research be conducted to determine the optimal hydraulic selector design and further prove the potential of hydraulic selection technology as a method to remove slow settling sludge.

References

[1] T. Sato, M. Qadir, and S. Yamamoto, "Global , regional , and country level need for data on wastewater generation, treatment , and use," Agric. Water Manag., vol. 130, pp. 1–13, 2013.

[2] "United States Environmental Protection Agency. Basic Information about Water Security.pdf."