Reducing Nitrogen Concentrations in ABR Effluent using Partial Nitritation-Anammox

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Background

- The anaerobic baffled reactor (ABR) operated by the Colorado School of Mines treats raw domestic wastewater at pilot-scale.
- The ABR produces a unique low-carbon, high-ammonium effluent, requiring an additional treatment process.
- Partial nitritation-anammox (PN/A) couples ammonia-oxidizing bacteria (AOB) and anaerobic ammonia oxidizing (anammox) bacteria. AOB oxidize ~50% of ammonium to nitrite. The resulting nitrite and remaining ammonium are converted primarily into nitrogen gas under anoxic conditions by anammox.

Objective

- Develop a bioreactor to remove inorganic nitrogen from the unique ABR effluent to achieve wastewater treatment standards.

System Description

- PN/A was operated in a 9-liter bench-scale moving bed biofilm reactor (MBBR) (Figure 1).
- Receives anaerobically pretreated raw domestic wastewater
- Operated in sequencing batch mode, under an HRT of 24hrs
- Oxygen was supplied by continuous air flow at 100 mL/min via an air diffuser plate.
- Continuously mixed with a low-shear impeller
- Dissolved oxygen constantly monitored using a DO probe

Methods

Table 1: Sampling plan for a typical week of data collection

	M	*T*	*W*	*Th*	*F*
NH_4^+	Inf	Inf, Eff	Inf, Eff	Inf, Eff	Eff
NO_2^-	Inf	Inf, Eff	Inf, Eff	Inf, Eff	Eff
NO_3^-	Inf	Inf, Eff	Inf, Eff	Inf, Eff	Eff
DOC[a]	Inf	Inf, Eff	Inf, Eff	Inf, Eff	Inf, Eff
BOD[b]			Inf	Inf, Eff	Eff
CODs/t[c]	Inf	Inf, Eff	Inf, Eff	Inf, Eff	Eff
pH	Inf	Inf, Eff	Inf, Eff	Inf, Eff	Eff
DO[d]	Constant	Constant	Constant	Constant	Constant
dCH_4[e]	Inf	Eff	Inf, Eff	Inf, Eff	Eff

[a]dissolved organic carbon, [b]biological oxygen demand, [c]soluble and total chemical oxygen demand, [d]dissolved oxygen, [e]dissolved methane

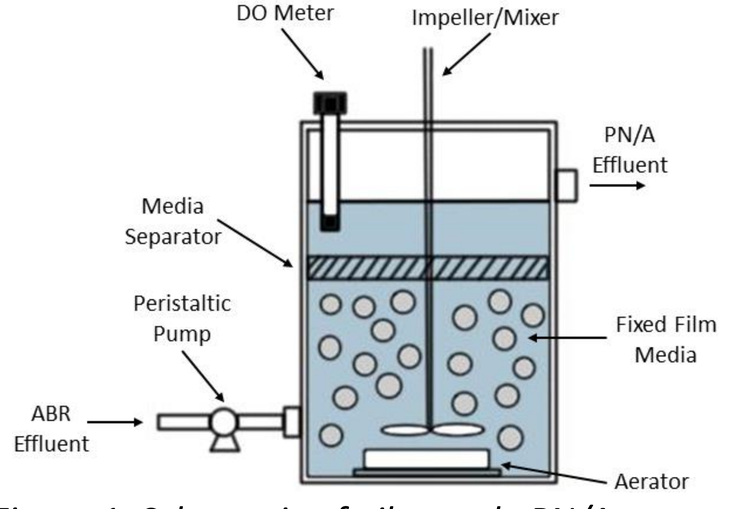

Figure 1: Schematic of pilot-scale PN/A reactor

Results

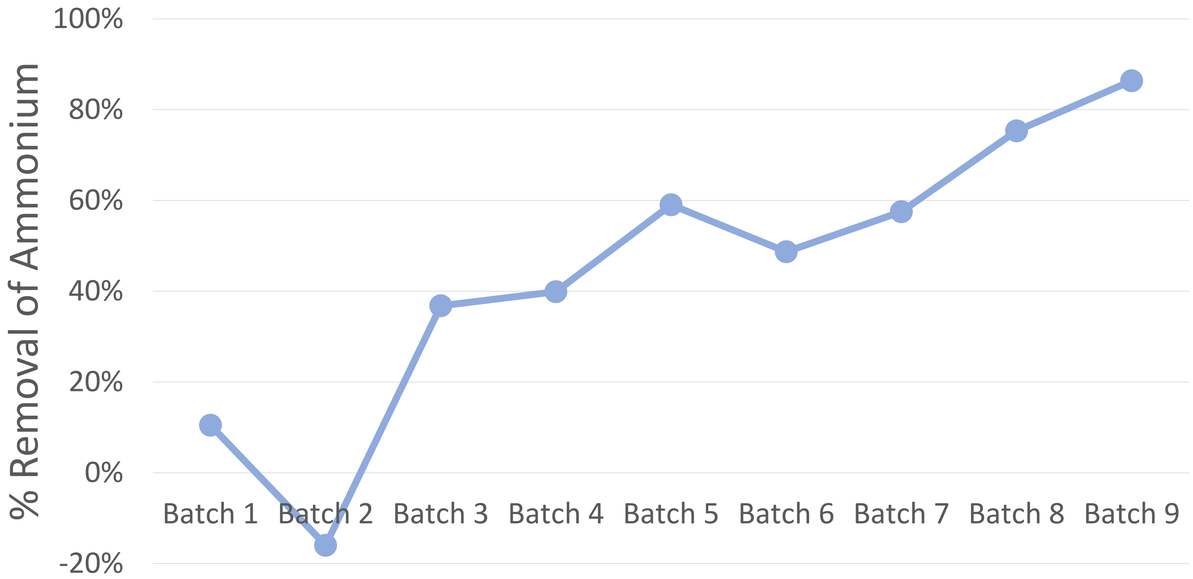

Figure 2: Ammonium removal over nine individual PN/A batch treatments

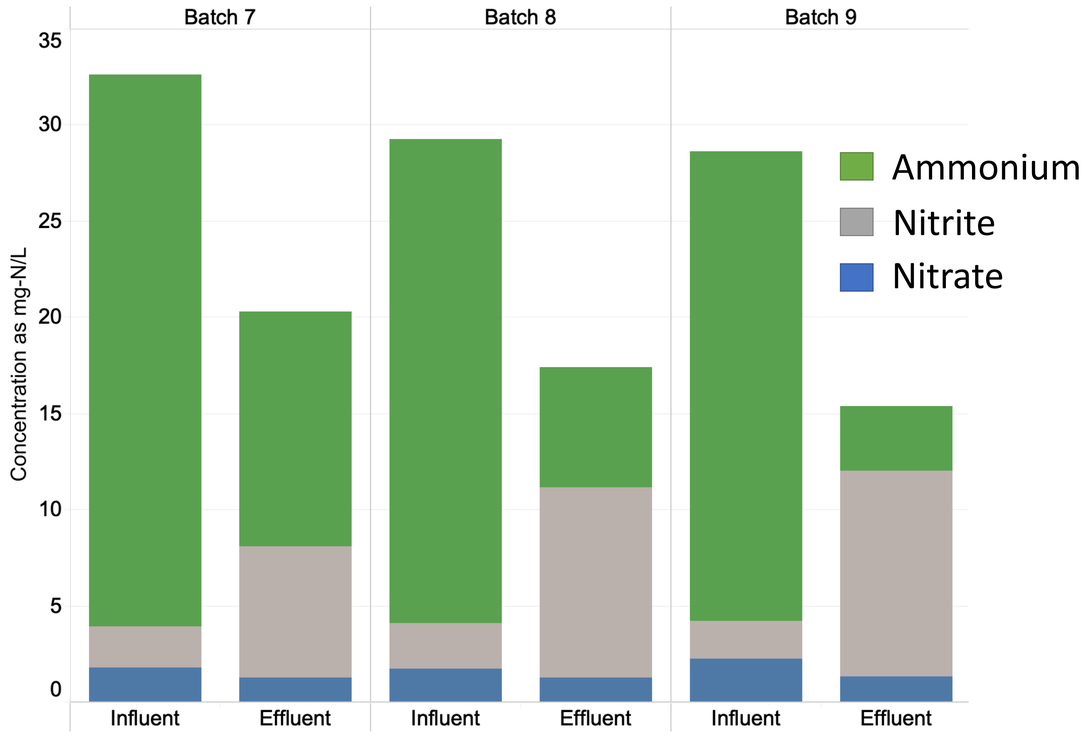

Figure 3: Initial and final concentration of inorganic nitrogen over three PN/A batches, each with a 24-hr HRT.

Conclusion

- Significant ammonium removal by PN/A treatment process (Figure 2). Removal increased over time as the PN/A reactor stabilized.
- Conversion of ammonium to nitrogen gas demonstrated by a decrease in total inorganic nitrogen (Figure 3).
- Evidence of undesired nitrite accumulation, potentially due to over aeration (Figure 3). Excessive nitrite can inhibit anammox.
- Unexpected decrease in nitrate concentrations, suggesting heterotrophic denitrification occurred in the PN/A reactor (Figure 3), supported by decreases observed in BOD.

Future Work

- Conduct a full-time course study through a batch to better understand the kinetics occurring in the PN/A reactor
- Investigate shift in microbial community characterizations
  - How does the PN/A community shift with ABR effluent?
- Implement DO control to mitigate NO_2^- accumulation which is likely inhibiting anammox activity

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