Design approach to extend longevity of woodchip denitrification bioreactors treating wastewater

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Woodchip bioreactors' successful low-cost mitigation treatment of non-point source nitrogen (N) from agricultural tile drainage has captured the interest of industries with point source discharge regulations, creating opportunity for new and unique applications.

Introduction

Point sources, such as wastewater, with consistent flow, loading rates, and temperature may provide engineering advantages enhancing N removal and decreasing cost per kg N removed.

Bioreactors show potential for treatment of wastewater high in NO_3. However, total suspended solids (TSS) and chemical oxygen demand (COD) may decrease the lifespan as inlets clog.

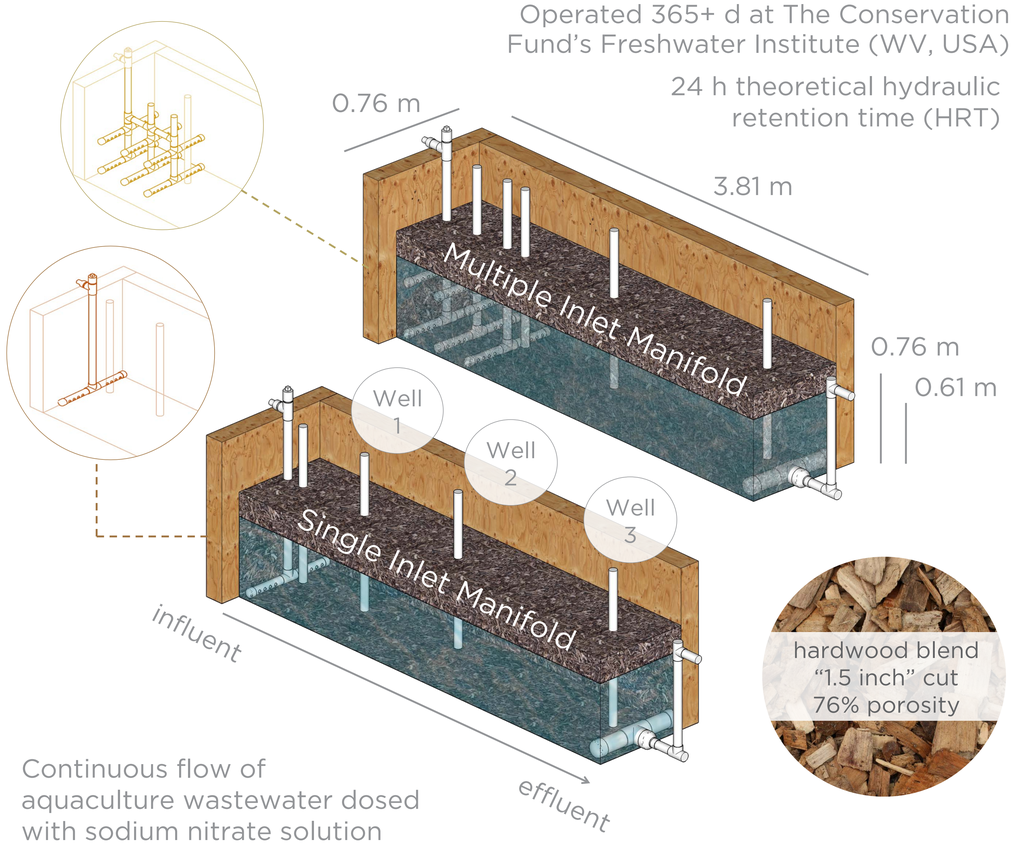
Objectives

- Evaluate longevity and cost of woodchip bioreactors treating aquaculture wastewater through multi-year observation.
- Compare single (*n*=2) and multiple (*n*=2) "feed forward" inlet manifold designs assessing bioreactor clogging potential.

Materials and Methods

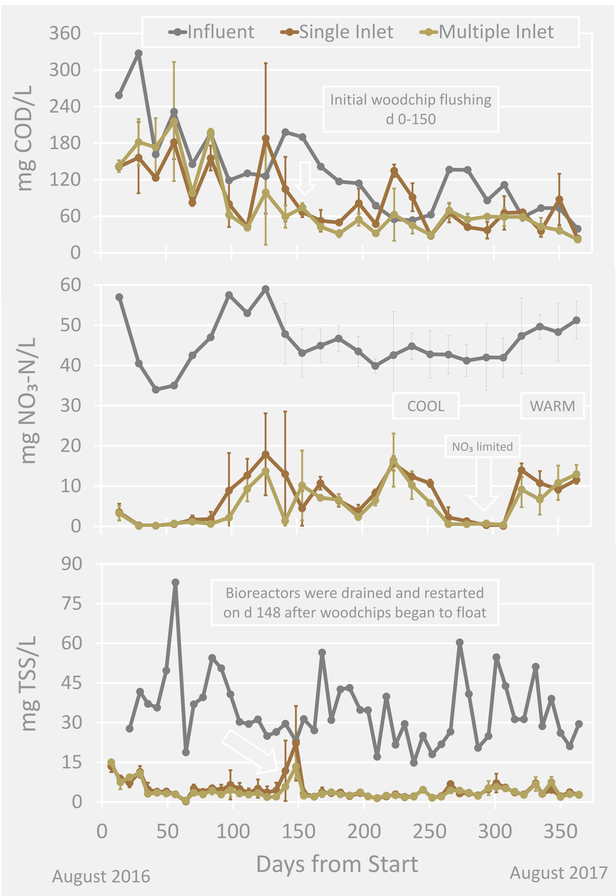
Operated 365+ d at The Conservation Fund's Freshwater Institute (WV, USA)

24 h theoretical hydraulic retention time (HRT)



Continuous flow of aquaculture wastewater dosed with sodium nitrate solution

Results



After the initial startup phase (i.e., woodchips flushing and leaching), **removal of influent COD was observed.**

Influent **COD:NO_3-N ranged 0.8:1 to 4.4:1** (average 2.17:1, *n*=16). Optimal denitrification range is 3:1 to 6:1, indicating wastewater may partially fuel denitrification.

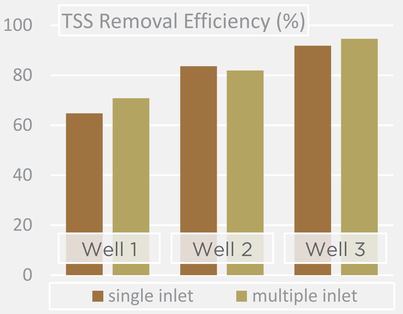
No notable difference in N removal between manifolds during cool or warm water temperatures.

d	Water temp. °C	Influent mg NO_3-N/L	Hydraulic retention time h		NO_3-N removal rate g N m^{-3} d^{-1}	
			single inlet	multiple inlet	single inlet	multiple inlet
163-210	13.7 (0.8)	44 (3)	24.8 (0.2)	25.3 (0.3)	21.49 (2.52)	22.13 (2.07)
322-364	17.5 (1.0)	49 (2)	25.1 (0.3)	25.1 (0.3)	22.83 (1.98)	22.99 (1.71)

One Way ANOVA demonstrated no significance between treatments (p=0.513).

Internal sampling (d 182) verified **>60% of TSS was removed by the first 26% of bioreactor volume** (Well 1).

Effluent TSS was reduced by an average of 88±5% & 89±6% for single & multiple inlets over the first year.



Conclusions

- First-year results indicated no notable differences in NO_3-N removal efficiency, water elevation at the inlet, or TSS deposition between manifold designs.
- Successful wastewater treatment demonstrated woodchip bioreactors can continually perform beyond traditional-use applications, benefitting point source facilities.
- Continued operation of the bioreactors will determine maximum system life expectancy and provide an engineering cost-assessment.

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