Influence of Temperature on Denitrification of Mesophilic Bacterial Communities in Woodchip Bioreactors

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Introduction

Agricultural products are an important staple to California's economy, and to meet market demands the region's agrarian landscape requires an abundance of nutrient rich irrigation. One of these nutrients, nitrate, can be reduced when runoff flows through a wetland. Wetlands improve the water with their denitrifying microbial populations . Woodchip bioreactors can be used to analyze the variables that affect the rate of denitrification of these populations. This study evaluated the influence of temperature and carbon supplementation in the productivity of the denitrifying bacteria in the woodchip bioreactors.

Methods

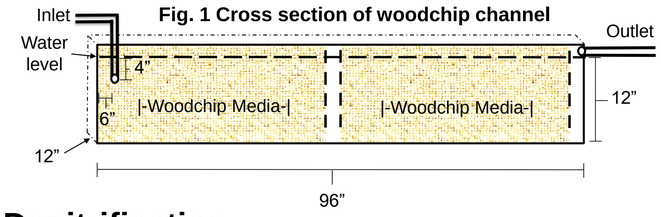
Temperature

Temperature sensors were placed at varying locations under ambient air, ambient water, experimental, control, and insulated structure conditions.

Supplemental Carbon Source

Cornstarch in solution was added to the system to achieve a 6:1 Carbon to Nitrogen ratio. Initial and final levels of cornstarch in the system were measured using iodine treatment and a calibrated standard curve.

Fig. 1 Cross section of woodchip channel



Denitrification

Flow rates were set to achieve a 1 hour hydraulic residence time (HRT). Nitrate concentrations were measured every 30 minutes at upstream and downstream locations using a HACH colorimeter through cadmium reduction.

Fig 2. Researcher Rene Nunez checks flow rates in preparation for an experiment in the bioreactor.

Results

Spring Denitrification

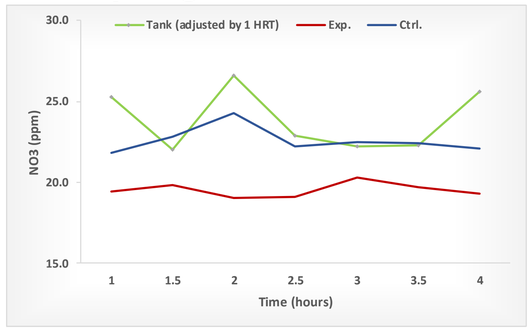


Fig 3. NO^{3-} readings between four HRT's during spring weather

	Experimental (NO^{3-} Reduction)	Control (NO^{3-} Reduction)
HRT (1)	23%	14%
HRT (2)	29%	9%
HRT (3)	9%	-1%
HRT (4)	25%	14%
AVG.	21%	9%
ST. DEV.	8	6

Spring Temperature

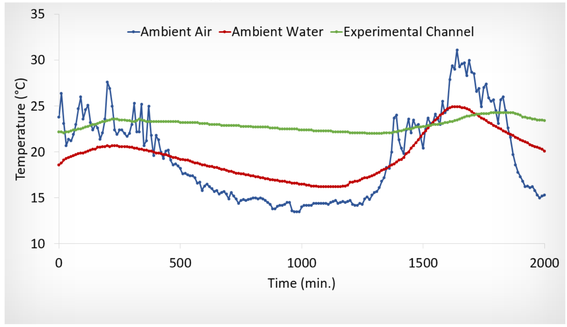


Fig 4. Temperature readings between four HRT's during spring weather

Location	Average Temp (°C)	Standard Deviation
Experimental Channel	19.5	4.7
Ambient Air	19.6	2.5
Ambient Water	23.0	0.6

Winter Denitrification

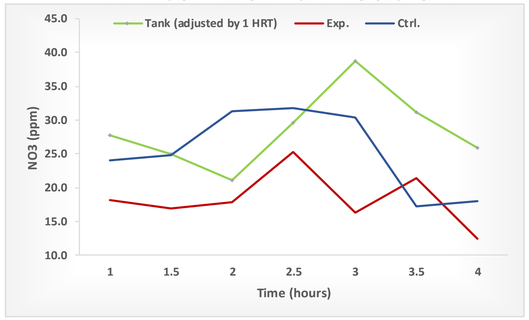


Fig 5. NO^{3-} readings between four HRT's during winter weather

	Experimental (NO^{3-} Reduction)	Control (NO^{3-} Reduction)
HRT (1)	34%	13%
HRT (2)	15%	- 48%
HRT (3)	58%	21%
HRT (4)	52%	30%
AVG.	34%	7%
ST. DEV.	16	30

Winter Temperature

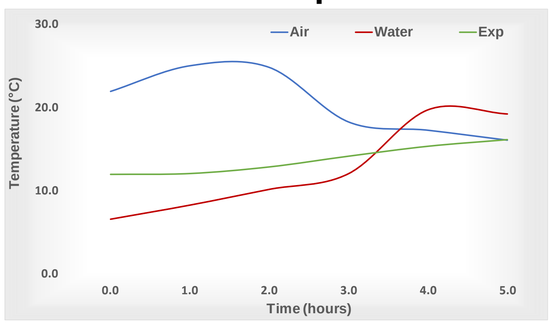


Fig 6. Temperature readings between four HRT's during winter weather

Location	Average Temp (°C)	Standard Deviation
Experimental Channel	13.5	1.6
Ambient Air	20.5	3.4
Ambient Water	12.4	5.7

Conclusion

Temperature and carbon levels are known limiting factors of the metabolic processes of denitrifying bacteria. Under the controlled conditions of the woodchip bioreactor, it is possible to observe the effects of these limiting factors. Containing our system within an insulated structure allowed us to promote productivity among the mesophilic bacteria during the temperate season such that carbon became the limiting factor. During colder weather, the addition of a supplemental carbon source did not improve the efficiency of the bacteria, indicating temperature had become the limiting factor. Despite seasonal reductions in efficiency due to low temperatures, large-scale bioreactors would remain most efficient at times of peak fertilizer use.

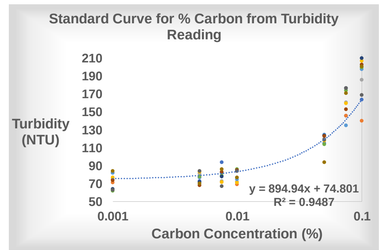


Fig 7. Left: Sample cells used in HACH Colorimeters for NO^{3-} readings. Right: Standard curve allows carbon concentration to be calculated from turbidity.

Future Work

Our results suggest that temperature is the current limiting factor on the rate of denitrification by cultivated bacteria. Further research during the warm season will examine the effect of cornstarch as a carbon supplement when microbial populations are most efficient. Filtration methods should be tested to see if they improve accuracy of results.

Fig 8. Hand pump filtration device used to separate particles from sample water.

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