Nutrient Removal in Wastewater by a Constructed Wetland Following Vegetation Management

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Introduction

- Constructed surface flow wetlands utilize plant, microbial, sediment and photosynthetic processes to cost-effectively remove excess nutrients from wastewater.
- The Sewanee Constructed Wetland was established in 2016 and provides tertiary treatment to effluent from an established lagoon system at the Sewanee Utility District (SUD).
- Tertiary treatment may reduce excess nutrients entering the watershed through the spray field discharge of treated wastewater.
- Anaerobic denitrifying bacteria in the lagoon are able to convert nitrate to nitrogen gas (N_2) while the wetland vegetation is designed to assimilate ammonia.
- This wetland, in the first year after its commission, efficiently reduced the concentration of ammonia.
- The wetland filtration ability of ammonia has since demonstrated decline suggesting a need for vegetation management.
- Our data demonstrates the effect of vegetation removal on wetland filtration as a possible method to restore diminished wetland function.

Methods

- Water samples were collected from five locations representing different levels of treatment by the wetland: lagoon C, inflow from lagoon C, wetland basin 1, wetland basin 2 and wetland basin 3.
- 7 sampling events, with each season represented, have occurred since vegetation harvesting.
- Ammonia, pH and conductivity values were established using probes; nitrite and reactive phosphate were determined using color reagent and spectrophotometry; persulfate digestion was utilized to determine total nitrogen and total phosphorus concentrations.

The Study Site

Figure 1A Aerial View of lagoons Algae assimilate excess nitrogen and decompose. Depth allows for denitrification of organic nitrogen.

Figure 1B Planting of vegetation during wetland construction designed to assimilate ammonia.

Figure 1C Aerial view of constructed wetland basins. Wetland utilizes algae and plant assimilation and photosynthetic zones as tertiary treatment.

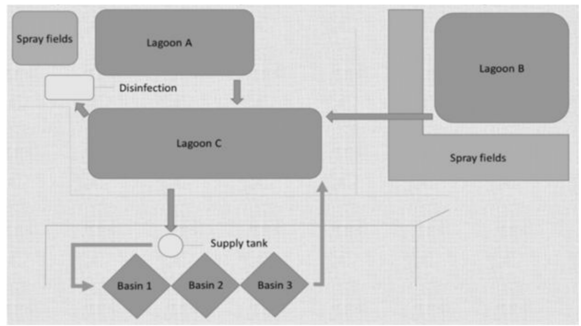

Figure 1D Diagram of effluent flow through lagoon and wetland system. Treated water is discharged onto surrounding forest where trees assimilate nutrients

Results

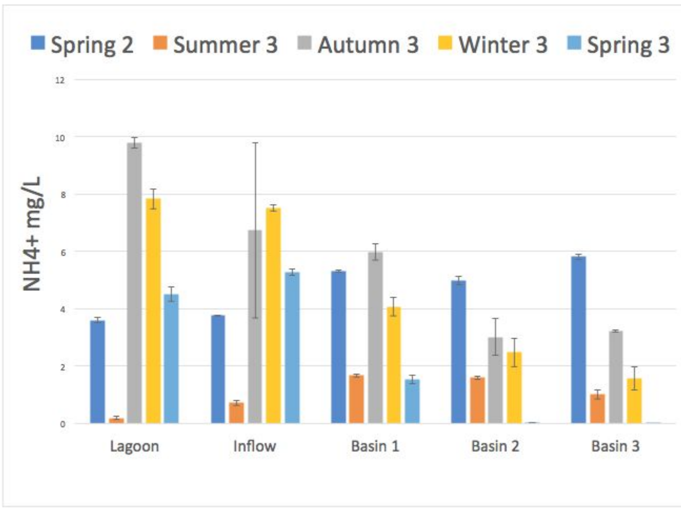

Figure 1. A seasonal comparison of ammonium concentrations in the lagoon-wetland effluent treatment continuum. Data were collected at the Sewanee Utility District from May 2018-April 2019. Ammonium decreased from lagoon to basin 3 outflow in the sampling periods of Autumn 3 – Spring 3 ($p<0.001$, n= 3 samples per location per season).

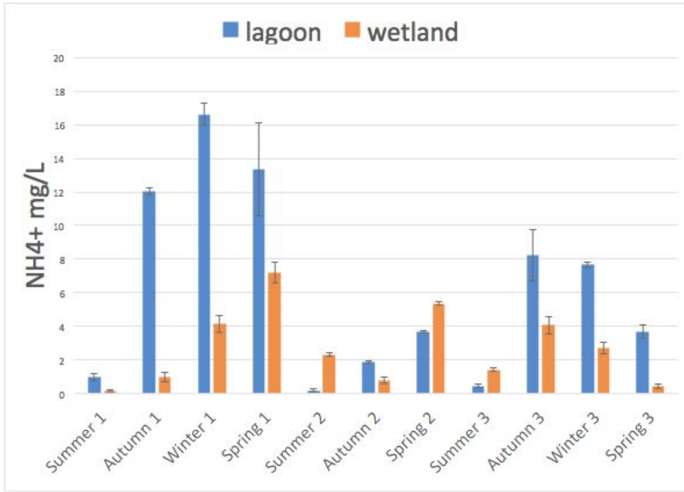

Figure 2. A seasonal comparison of ammonium concentrations in the lagoon-wetland effluent treatment continuum. Data were collected at the Sewanee Utility District from May 2018-April 2019. Across the 3-year sampling period, ammonium decreased significantly from lagoon to basin 3 outflow in the sampling periods of Autumn 3 – Spring 3 ($p<0.001$, n= 3 samples per location per season). Interestingly, ammonium increased slightly in basin 3 outflow during the summer 1 and 2 sampling periods.

Table 1. A summary of water chemistry across seasons in five locations of the lagoon-wetland treatment continuum. Data collected from May 2018, following biomass harvest in the wetland, to -April 2019.

Variable	**Lagoon**	**Basin 1 inflow**	**Basin 1 outflow**	**Basin 2 outflow**	**Basin 3 outflow**	**P-value**
Nitrate (mg/L)	0.115 ± 0.02	0.243 ± 0.05	0.404 ± 0.55	0.335 ± 0.09	0.201 ± 0.06	0.085
Phosphate (mg/L)	0.687 ± 0.22	0.539 ± 0.11	0.840 ±0.16	0.85 ± 0.24	0.991 ± 0.21	0.535
Conductivity (uS)	186 ± 15.6	181 ± 18.0	193 ± 12.4	180 ± 13.2	175 ± 13.9	0.932
Nitrite (mg/L)	0.060 ± 0.05	0.131 ± 0.03	0.037 ± 0.01	0.037 ± 0.01	0.027 ± 0.01	0.000
pH	8.04 ± 0.15	7.42 ± 0.04	7.14 ± 0.05	7.10 ± 0.05	7.29 ± 0.15	0.000
Turbidity (NTU)	12.9 ± 1.10	12.4 ± 0.88	5.66 ± 0.41	5.13 ± 0.51	4.44 ± 0.83	0.000

Conclusion

- The lagoon system does not efficiently remove ammonium and therefore the treated water discharged onto the spray fields includes excess ammonium which may enter the watershed.
- Since its commissiong the wetland appears to reduce ammonium concentrations in autumn, winter and spring.
- In the second summer of the wetland, ammonium concentrations increased after wetland treatment suggesting the plants were not assimilating ammonium effectively.
- In the summer of 2018, after the spring 2018 vegetation harvest, ammonium concentrations again increased in the wetland .
- The ammonification of organic nitrogen by flourishing microbial populations during the spring may cause a flush of ammonium into the wetland. After the initial spike in ammonium concentrations the excess ammonium may be assimilated by growing wetland plants. In order to determine this sampling must occur in both early and late summer.
- Duckweed, which invaded the wetland in the summer of 2017, may also contribute to increased ammonium concentrations by adding additional decomposing organic matter.
- The loss of wetland capacity to filter ammonium in the summer continued after vegetation harvest. Further research is necessary to determine the cause of this seasonal loss of function.
- Although the wetland does not reduce nitrate, the low concentrations of nitrate from the lagoon do not pose a significant threat to watershed quality.