MONTANA STATE UNIVERSITY
Norm Asbjornson College of Engineering

Doctoral Defense
Stephanie Hall Ayotte
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Department of Civil Engineering
Bozeman, Montana

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10:00 am MST

Alumni Legacy Lounge, Student Union Building

Wastewater (WW) treatment is a critical process that protects public health and natural waters. Approximately 20 % of United States (US) citizens rely on on-site systems for wastewater treatment; however, septic systems are often unmonitored, resulting in inadequate treatment, and release of excess nutrient pollution. Treatment Wetlands (TWs) present a less costly and more environmentally friendly approach for centralized-rural WW treatment. Skeptics of TW technology often cite limitations for robust operation in cold climates. Therefore, research must investigate TWs in extreme climates at the field scale for the most accurate assessment of performance.

TWs and WW treatment plants alike rely on microbial mediated processes for nutrient degradation and removal, which can release greenhouse gases (GHGs). Currently in the US, WW treatment is the second largest contributor of nitrous oxide (N2O) emissions. Current climate change efforts are moving toward the assessment, inventorying, and mitigation of a broader range of contaminants, including GHGs. Enhanced nutrient removal and mitigation of GHGs can be targeted through the monitoring and analysis of emissions, as well as proper characterization of the spatial-temporal microbial dynamics that exist in TWs. In this dissertation, field-scale monitoring was used to investigate the effects of operational changes on the subsequent water treatment efficacy, resulting GHG emission profiles, and microbial community dynamics.

Typically, microorganisms conserve energy at low temperatures, resulting in decreased performance. This dissertation investigated a cold-climate Montana TW over three ski seasons and observed high removal of influent nutrients and comparable total nitrogen removal to mechanical WW treatment plants. Emissions of methane and N2O were found to be heavily influenced by intermittent dosing and mass transport effects.

In general, microbial communities showed specialization over the course of the operational season but maintained similar richness and evenness during the annual 8-month rest period. Communities additionally formed distinct niches due to redox conditions in the TW, indicating that oxygen abundance played a more significant role in community development than nutrient availability. Altogether, this dissertation has demonstrated that TWs are a resilient and robust technology for efficient removal of target nutrients (carbon and total nitrogen) in cold-climates due to persistent biofilm communities.

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