SLATT UNDERGRADUATE RESEARCH FELLOWSHIP
FINAL REPORT

SCHOLAR NAME:	Jacob Novitch
FACULTY ADVISOR:	Dr. Robert Nerenberg
PROJECT PERIOD:	Fall 2020
PROJECT TITLE:	Effect of Hydroxylamine on the Structure and Function of Nitrifying Biofilms
CONNECTION TO ONE OR MORE ENERGY-RELATED RESEARCH AREAS (CHECK ALL THAT APPLY):	**(x) Energy Conversion and Efficiency** **( ) Sustainable and Secure Nuclear** **( ) Smart Storage and Distribution** **( ) Transformation Solar** **(x) Sustainable Bio/Fossil Fuels** **( ) Transformative Wind**

MAJOR GOALS AND ACCOMPLISHMENTS

Summarize your research goals and provide a brief statement of your accomplishments (no more than 1-2 sentences). Indicate whether you were able to accomplish your goals by estimating the percentage completed for each one. Use the next page for your written report.

RESEARCH GOALS	ACTUAL PERFORMANCE AND ACCOMPLISHMENTS	% OF GOAL COMPLETED
Establish a Baseline Microbial Community	The anoxic biofilm reactor reached steady state with no chemical addition and a microbial community DNA extraction was collected. This DNA will be analyzed along with other DNA extractions from subsequent phases of the project.	100%
Examine Effects of Perchlorate Addition on Microbial Community	The same biofilm reactor from the control phase of the project was not introduced to perchlorate through the hollow fiber membrane. Again, steady state was reached and a microbial community DNA extraction was performed for future analysis.	100%
Examine Effects of Predation Inhibitor on Nitrifying Biofilm	For this phase of the project, which is currently in progress, an aerobic biofilm reactor was curated to examine the effects of protozoa predation on a nitrifying biofilm. Once this setup reaches steady state, a DNA analysis will be performed and compared to a new phase of the experiment where an inhibitor will be added through the hollow fiber membrane.	25%
Examine Effects of Hydroxylamine Addition on Biofilm Community and Treatment Performance	With the phases of the project outlined above as a foundation, the effects of hydroxylamine addition on treatment performance will be evaluated. This phase of the project will commence after the completion of the project phase which is currently in progress.	0%

RESEARCH OUTPUT

Please provide any output that may have resulted from your research project. You may leave any and all categories blank or check with your faculty advisor if you are unsure how to respond.

CATEGORY	INFORMATION
EXTERNAL PROPOSALS SUBMITTED	(Sponsor, Project Title, PIs, Submission Date, Proposal Amount)
EXTERNAL AWARDS RECEIVED	(Sponsor, Project Title, PIs, Award Date, Award Amount)
JOURNAL ARTICLES IN PROCESS OR PUBLISHED	(Journal Name, Title, Authors, Submission Date, Publication Date, Volume #, Page #s)
BOOKS AND CHAPTERS RELATED TO YOUR RESEARCH	(Book Title, Chapter Title, Authors, Submission Date, Publication Date, Volume #, Page #s)
PUBLIC PRESENTATIONS YOU MADE ABOUT YOUR RESEARCH	(Event, Presentation Title, Presentation Date, Location)
AWARDS OR RECOGNITIONS YOU RECEIVED FOR YOUR RESEARCH PROJECT	(Purpose, Title, Date Received)
INTERNAL COLLABORATIONS FOSTERED	(Name, Organization, Purpose of Affiliation, and Frequency of Interactions)
EXTERNAL COLLABORATIONS FOSTERED	(Name, Organization, Purpose of Affiliation, and Frequency of Interactions)

WEBSITE(S) FEATURING RESEARCH PROJECT	(URL)
OTHER PRODUCTS AND SERVICES (e.g., media reports, databases, software, models, curricula, instruments, education programs, outreach for ND Energy and other groups)	(Please describe each item in detail)

RESEARCH EXPERIENCE

Please let us know what you thought of your research experience: Did this experience meet your expectations? Were lab personnel helpful and responsive to your needs? What else could have been done to improve your experience or achieve additional results?

My research experience has exceeded my expectations. I have gained valuable lab experience and learned huge amounts about research and biofilms in general. I hope to attend graduate school, and the experience I have gained thus far and will continue to gain through my Slatt Fellowship will be invaluable during that next phase of my education. ND Energy and the lab personnel I have worked with have all been exceedingly supportive and helped make this research such a good experience. I have really enjoyed this learning experience and am excited to continue work in 2021.

FINAL WRITTEN REPORT

This project is in the process of studying a novel, biofilm-based treatment technology for wastewater treatment. Wastewater treatment is a major energy sink, accounting for 2 - 4% of electrical energy consumption in the United States. The proposed treatment could greatly reduce these energy demands, or even make wastewater treatment energy positive. The Nerenberg group proposes a new biofilm process combining gas-permeable membranes with water- permeable membranes. The gas-permeable membranes supply oxygen with nearly 100% efficiency. The water-permeable membranes supply a chemical to alter the microbial community of the biofilm growing on the membrane assembly. Specifically, supplying hydroxylamine is proposed, which the group hypothesizes can alter the biofilm community in ways that reduce the oxygen requirements and allow more wastewater organic matter to be directed to the anaerobic digesters. These anaerobic digesters produce methane, an energy carrier that can be used to fuel cars, produce electricity, or provide heat.

As intermediate steps in the project, the membrane system under examination has been or will be studied for effectiveness under a variety of conditions in addition to exposure to hydroxylamine through the hollow fiber membrane. These intermediate phases include studying the effects of chlorate addition through the membrane on the microbial community and treatment effectiveness and also studying the effect of predation on a nitrifying biofilm. For each phase, a baseline microbial community is first established, and a DNA extraction is performed. After the DNA extraction, the chemical of interest is added through the hollow fiber membrane until steady state is again reached. For the first phase outlined above, this chemical is chlorate. For the second phase, this chemical will be a predation inhibitor. At this point, another DNA extraction is performed to analyze differences in the microbial community due to the chemical addition through the membrane. Throughout operation, influent and effluent physical and chemical parameters are documented to track changes in treatment efficiency and reactor stability.

Initially, the project examined delivery of chlorate through a hollow fiber membrane in order to select for perchlorate reducing bacteria in the biofilm community. This approach has proven effective in other applications and will provide insight into the effectiveness of chemical delivery through a membrane as proposed in this project. As outlined above, a baseline microbial community was established, and chlorate addition was then conducted to induce changes in the microbial community. Resulting changes in the microbial community after chlorate addition will be analyzed through the DNA sample collected to determine the effects of chlorate delivery through the membrane on the microbial community. This analysis will take place at the end of the study when all collected DNA samples are sent to an off-campus company which will provide a community breakdown for each phase of the project. Currently, a baseline nitrifying biofilm is being established to examine the effects of predation on the microbial community of the biofilm and treatment performance, following a similar approach to the chlorate phase of the project. Knowledge obtained through this phase will supplement other work and publications in progress within the research group. Following the conclusion of this phase of the project, the same approach will be taken to evaluate the effects of hydroxylamine addition on the microbial community of the biofilm, growing a baseline biofilm and monitoring changes to the biofilm upon addition of hydroxylamine. The information gathered from this research has the potential to significantly reduce energy demand in wastewater treatment, thus lowering costs and improving environmental conditions.