



Environment and Natural Resources Trust Fund

M.L. 2021 Approved Work Plan

General Information

ID Number: 2021-358

Staff Lead: Becca Nash

Date this document submitted to LCCMR: July 21, 2021

Project Title: Assessing Membrane Bioreactor Wastewater Treatment Efficacy

Project Budget: \$419,000

Project Manager Information

Name: Heiko Schoenfuss

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Project Reporting

Date Work Plan Approved by LCCMR: July 20, 2021

Reporting Schedule: December 1 / June 1 of each year.

Project Completion: June 30, 2024

Final Report Due Date: August 14, 2024

Legal Information

Legal Citation: M.L. 2021, First Special Session, Chp. 6, Art. 6, Sec. 2, Subd. 04f

Appropriation Language: \$419,000 the first year is from the trust fund to the Board of Trustees of the Minnesota State Colleges and Universities system for St. Cloud State University to conduct a comprehensive assessment of membrane bioreactor treatment of wastewater to inform managers of options for updating or replacing aging wastewater infrastructure.

Appropriation End Date: June 30, 2024

Narrative

Project Summary: A comprehensive assessment of membrane bioreactor efficacy will provide the best options and information to the wastewater treatment plant and natural resource managers to update or replace aging wastewater infrastructure.

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

Much of the rural wastewater treatment infrastructure in Minnesota has reached or exceeded its designed lifespan. Replacing existing aging infrastructure or adding new treatment components is expensive and often constrained by factors such as wastewater consistency, on-site logistics, operating expenses, and current and future permitting requirements. Membrane bioreactors have become an interesting alternative to standard secondary and tertiary treatment of wastewater due to their small footprints, low operating costs, and disinfection of effluent. However, information is currently lacking to inform Minnesota water resource managers to the treatment benefits of membrane bioreactors. This information is critically needed to provide Minnesota water resource managers for their decision making based on data. A comprehensive assessment of membrane bioreactor efficacy in Minnesota is required to inform the wastewater treatment plant (WWTP) operators and water resource managers of the best options for update and replace aging wastewater infrastructure in rural Minnesota.

What is your proposed solution to the problem or opportunity discussed above? i.e. What are you seeking funding to do? You will be asked to expand on this in Activities and Milestones.

The proposed study will:

- (i) Monitor a wide range of common and emerging contaminants in treated wastewater outflows of traditional tertiary or membrane bioreactor effluent using the same wastewater inflow stream.
- (ii) Measure microorganisms in wastewater effluent treated either with tertiary treatment or a membrane bioreactor using effluent from the same inflow source.
- (iii) Measure the biological responses to traditional tertiary and membrane bioreactor effluent in real-time flow-through exposure experiments with native fish.

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?

This study will provide a comprehensive assessment of membrane bioreactors vs. traditional tertiary treatment performances using a common source and a split-stream of wastewater flow at the Hutchinson WWTP. In general, membrane bioreactor technology is expected to efficiently remove pathogens and other bacterial community disruption common to streams receiving secondary treated effluents. These disruptions include fish microbiomes - an understudied cause of biological degradation in effluent dominated streams. The proposed project will provide critical information to renew or replace the aging infrastructure statewide.

Project Location

What is the best scale for describing where your work will take place?

Watershed(s): Crow Wing River

What is the best scale to describe the area impacted by your work?

Statewide

When will the work impact occur?

In the Future

Activities and Milestones

Activity 1: Monitor a wide range of common and emerging contaminants in two effluents

Activity Budget: \$188,500

Activity Description:

Designed to treat an average of 3.67 million gallons per day (MGD) of wastewater, the WWTP (Hutchinson, MN) will meet the wastewater treatment needs of the city through the year 2028. Hutchinson WWTP uses Biological (Oxidation) and Membrane Bioreactor (MBR) processes to remove impurities from the wastewater.

We will collect time-integrated inflow and outflow samples from both the traditional tertiary treatment and the membrane bioreactor treatment pathways within the Hutchinson, MN, wastewater treatment plant (WWTP). Both process paths in the plant will be sampled approximately monthly during the summer season and weekly during three weeks twice coincident with fish exposures outlined in Activity 3 and analyzed for over 200 trace-organic compounds of concern, including pharmaceuticals and surfactants. Comparison of detections and concentrations of compounds between the two types of wastewater treatment technology will assess the ability of membrane bioreactor treatment to remove or reduce a wide range of trace organic contaminants. A total of 57 environmental and quality assurance samples will be collected from these sites and analyzed by the USGS National Water Quality Laboratory (NWQL) and AXYS Laboratories. We will coordinate data analysis of all laboratory results with samples collected and analyzed under Activity 2.

Activity Milestones:

Description	Completion Date
Publish the data in a publicly-available, web-accessible database	June 30, 2023
Water sample correction and chemical analysis	June 30, 2023
Produce a final report summarizing the results of Activity-1	June 30, 2024

Activity 2: Measure the biological responses to traditional tertiary and membrane bioreactor effluent in real-time flow-through exposure experiments with native fish

Activity Budget: \$230,500

Activity Description:

We will expose native fathead minnows for 21 days to either treated wastewater following secondary treatment, wastewater treated with traditional tertiary disinfection, wastewater treated with a membrane bioreactor, or a control water source on-site utilizing our existing mobile exposure laboratory trailer (MELT). We will analyze essential biological endpoints such as physiological condition, reproductive ability, the gut microbiome community in fathead minnow. This approach will provide a holistic assessment of the totality of biological responses and health in native fish, and leading to a better understanding of aquatic environmental health in downstream of WWTP.

We will also characterize the bacteria communities found in the influent and effluents from the two treatment technologies using genetic-based methods that detect microbial genes associated with bacteria. A total of 40 samples will be analyzed using genetic material analysis of both raw water samples and viable, cultured organisms from the same samples. The sample collection will correspond to the same three weeks twice schedule under Activity 1. Results from the analysis will provide a microbial signature based on the viable bacterial community found in each effluent from the two treatment technologies. This is critical information in aquatic environmental health.

Activity Milestones:

Description	Completion Date
. Conduct repeat exposure experiments on-site	June 30, 2023

Measure the microbial community in water samples and fathead minnow intestines	December 31, 2023
Produce a final report summarizing the results of Activity-2	June 30, 2024

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Satomi Kohno	Saint Cloud State University	Running exposure experiments and assessing biological activity.	Yes
Sarah Elliott	U.S. Geological Survey	Contaminants of emerging concern data analysis, including data QA/QC and public database support	Yes
Richard Kiesling	U.S. Geological Survey	Water quality sampling and statistical analysis	Yes

Dissemination

Describe your plans for dissemination, presentation, documentation, or sharing of data, results, samples, physical collections, and other products and how they will follow ENRTF Acknowledgement Requirements and Guidelines.

The target audience for results from this research will be professionals in the areas of wastewater treatment and natural resource management. Specific targets will be wastewater and environmental engineers. In addition, scientists in academia, industry, state agencies such as the DNR and MPCA, and environmental consultants will be briefed on the findings from the proposed study. The regular meetings of the Contaminant Roundtable of MN State and federal agencies will provide another ready outlet for results from the current study. Results will be disseminated through scholarly publications in peer-reviewed journals such as Environmental Science and Technology. Results from the research project will also be presented at regional conferences such as the annual meeting of the Midwest Chapter of the Society for Environmental Toxicology & Chemistry (SETAC) and the Minnesota Water conference and if possible, at targeted seminars at the DNR and MPCA. Results will be used to determine whether membrane bioreactors provide adequate disinfection, nutrient removal and pollutant when compared to traditional activated sludge treatments.

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this be funded?

The proposed research supports a statewide research agenda focused on sources of contaminants of emerging concern and the protection of aquatic environments in Minnesota. The proposed research complements current and prior research that, to date, did not previously compare contaminants of emerging concern and their biological effect in effluents between Biological (Oxidation) and Membrane Bioreactor (MBR) processes at the same WWTP. This study will assess the efficacy of novel treatment technology to remove harmful contaminants from wastewater indirect chemical measurements and direct biological responses in rural municipalities in Minnesota.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Biological Consequences of Septic Pollution in Minnesota Lakes	M.L. 2015, Chp. 76, Sec. 2, Subd. 04c	\$364,000
Protect Water Quality with Efficient Removal of Contaminants in Treatment Ponds for Storm Water	M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 04d	\$325,000

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
Graduate student		To conduct MELT fish exposures and assist in analysis (Activity 2)			7.65%	0.5		\$8,612
Co-investigator		To conduct all activities and organizing data			40%	0.75		\$153,000
Principal Investigator		overall project oversight			40%	12		\$22,188
Undergraduate summer help		Assist in fish exposure experiments and water collections			0%	0.25		\$3,500
							Sub Total	\$187,300
Contracts and Services								
US Geological Survey	Professional or Technical Service Contract	2 USGS personnel (0.3FTE/ea.; 30% benefit; 1.5 years @\$55,000/ea.) \$110,000; Microbial analysis (Upper Midwest Science Center) \$11,000; National Water Quality Lab Analysis \$675/ea.x44 samples; shipping, mileage, supplies) \$30,000; Laboratory supplies \$14,000. AXYS analysis (525/ea.x40samples; setup) \$23,500				0.9		\$188,500
							Sub Total	\$188,500
Equipment, Tools, and Supplies								
	Tools and Supplies	Supplies for Biological Analysis. Egg your protein assay, \$15 x 400 fish = \$6,000; Hormone analysis, \$20 x 400 fish = \$8,000; Miscellaneous cost = \$1,000; Subtotal \$15,000 x 2 repeats = \$30,000.	Assess biological responses in the Lab.					\$30,000
	Tools and Supplies	Fish \$5 x 400 = \$2,000; Fish maintenance = \$500; exposure supplies = \$2,000; subtotal \$4,500 x 2 repeats = \$9,000.	Expose native fish, fathead minnow to effluents at the site.					\$9,000
							Sub Total	\$39,000
Capital Expenditures								

							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								
	Miles/ Meals/ Lodging	50 miles each way x \$0.55 x 20 trips x 2 repeat = \$2,200; AirBnB rental in Hutchinson during fish exposures; \$1,000 for three weeks x 2 = \$2,000	Drive between St Cloud and Hutchinson					\$4,200
							Sub Total	\$4,200
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
							Sub Total	-
Other Expenses								
							Sub Total	-
							Grand Total	\$419,000

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
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Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	-
Non-State				
Cash	US Geological Survey Cooperative Matching Funds	This will support part of chemical and microbiome analyses in the USGS laboratory as matching funds.	Pending	\$55,000
			Non State Sub Total	\$55,000
			Funds Total	\$55,000

Attachments

Required Attachments

Visual Component

File: [180dccbb-ea9.pdf](#)

Alternate Text for Visual Component

An assessment of efficacy in membrane bioreactor wastewater treatment. Wastewater Treatment Plant at Hutchinson is uniquely running both ordinary and novel membrane bioreactor treatments. We will assess if the membrane bioreactor treatment has any advantages in the removal of harmful contaminants, their biological effects, and microbial health in downstream using on-site mobile exposure Lab trailer. This project will provide the best options and information to the wastewater treatment plan...

Optional Attachments

Support Letter or Other

Title	File
Quotation for AXYS Chemical Analysis	c786b021-2c3.pdf
Research Addendum finalized 10.26.2020	07dde4e5-84c.docx
Background check form	97770e59-ea7.pdf

Difference between Proposal and Work Plan

Describe changes from Proposal to Work Plan Stage

We have made two substantive changes in developing the workplan from the original proposal. (i) We eliminated fall/spring semester funding for the prospective graduate student at St. Cloud State University. The selected student will still receive summer salary to allow her/his full attention to the exposure experiments to be conducted at the Hutchinson Wastewater Treatment Plant. To provide tuition and salary support during the academic year, the graduate student will be expected to serve as a graduate teaching assistant in the Department of Biological Sciences at SCSU during his participation in this research. This change is consistent with the mission of the university to provide graduate students with a broad set of applicable skills through their graduate education. (ii) We replaced the analysis of hormones through AXYS Laboratories with an in-house analysis of estrogenicity in collected water samples. This change will not affect our ability to assess the overall efficacy of membrane bioreactor treatments when compared to traditional activated sludge treatment. To fill any gap through this reduced analytical schedule we will rely on our previous data sets to estimate likely presence of key hormonal compounds in the effluent as a part of the total estrogenicity of the effluent. These two changes were made to accommodate the recommended funding level for our proposal. All proposal objectives will remain intact despite these changes.

Additional Acknowledgements and Conditions:

The following are acknowledgements and conditions beyond those already included in the above workplan:

Do you understand and acknowledge the ENRTF repayment requirements if the use of capital equipment changes?

N/A

Do you agree travel expenses must follow the "Commissioner's Plan" promulgated by the Commissioner of Management of Budget or, for University of Minnesota projects, the University of Minnesota plan?

Yes, I agree to the Commissioner's Plan.

Does your project have potential for royalties, copyrights, patents, or sale of products and assets?

No

Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?

N/A

Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?

N/A

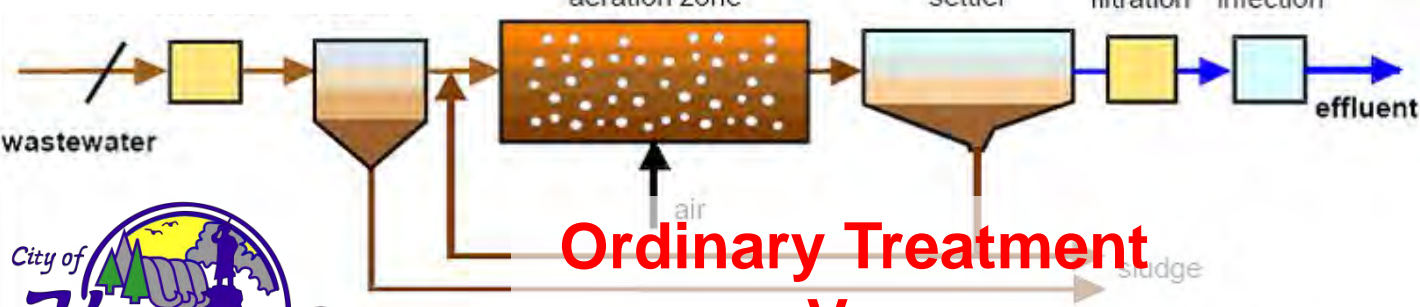
Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

No

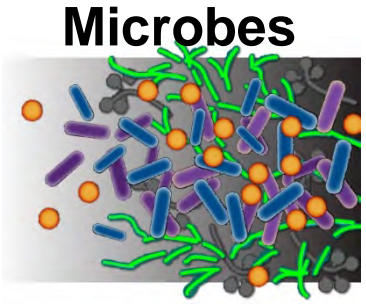
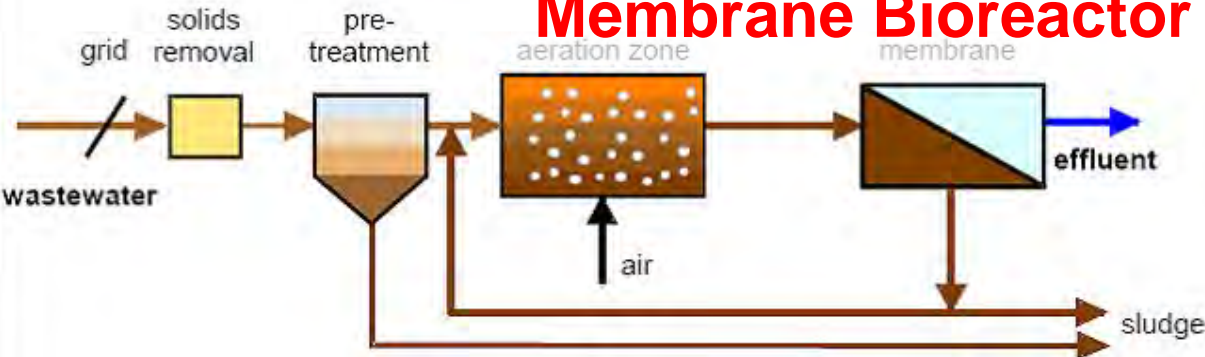
Wastewater Treatment



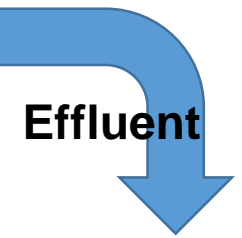
Ordinary Treatment

Vs.

Membrane Bioreactor



Microbes



Effluent

Mobile Exposure Laboratory Trailer (MELT)



Environmental Health

- Reproduction
- Behavior
- Hormone Production
- Microbe Health



