



Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-358

Proposal Title: Assessing Membrane Bioreactor Wastewater Treatment Efficacy

Project Manager Information

Name: Heiko Schoenfuss

Organization: Saint Cloud State University

Office Telephone: (320) 308-3130

Email: hschoenfuss@stcloudstate.edu

Project Basic Information

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.

Funds Requested: \$493,000

Proposed Project Completion: 2024-06-30

LCCMR Funding Category: Water Resources (B)

Project Location

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

Region(s): Central

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

Statewide

When will the work impact occur?

In the Future

Narrative

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.

Activities and Milestones

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

Activity Budget: \$254,500

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	2023-06-30
Water sample correction and chemical analysis	2023-06-30
Produce a final report summarizing the results of Activity-1	2024-06-30

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: \$238,500

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	2023-06-30
Measure the microbial community in water samples and fathead minnow intestines	2023-12-31
Produce a final report summarizing the results of Activity-2	2024-06-30

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

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
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
Biological Consequences of Septic Pollution in Minnesota Lakes	M.L. 2015, Chp. 76, Sec. 2, Subd. 04c	\$364,000

Project Manager and Organization Qualifications

Project Manager Name: Heiko Schoenfuss

Job Title: Professor

Provide description of the project manager's qualifications to manage the proposed project.

Schoenfuss has studied the biological impacts of contaminants of emerging concern in Minnesota water for the past 20 years and directed exposure studies using the Mobile Exposure Laboratory Trailer (MELT) in the past. Schoenfuss will supervise the entire project.

Organization: Saint Cloud State University

Organization Description:

The Aquatic Toxicology Laboratory at Saint Cloud State University investigates the costs of contaminants of emerging concern on aquatic life from the molecular level via organismal effects to trophic cascade consequences. The Aquatic Toxicology Laboratory has developed tools to enhance the linkage between controlled laboratory exposure experiments and collections of resident fish in environments impacted by endocrine active compounds. The Mobile Exposure Laboratory Trailer (MELT) is a fully mobile exposure platform housed in a 5 m x 2.5 m enclosed trailer with climate and

light cycle control. Up to 5 treatments with 5 aquarium replicates each can be accommodated for 21 day flow-through exposure experiments of fish. The trailer includes freezer and refrigerator space, a stainless steel work bench and adequate instrumentation to be self-sufficient as a laboratory facility. This exposure platform has contributed to several published studies including Kolok et al., 2012 (J Environ Monitoring) and Minarik et al., 2013 (JAWRA).

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
Co-investigator		To conduct all activities and organizing data			40%	0.75		\$153,000
A graduate student		To conduct sample collections (Activity-1) and fish exposure (Activity-2)			50%	2		\$48,000
Collaborator		To conduct activity-1			30%	0.3		\$62,000
Collaborator		To conduct activity-2			30%	0.3		\$64,000
							Sub Total	\$327,000
Contracts and Services								
SGS AXYS Analytical Services Ltd	Professional or Technical Service Contract	Activity 1: Monitor a wide range of common and emerging contaminants in two effluents. AXYS will analyze chemicals in effluent to assess chemical removal. Each analysis costs \$1,500. We will send 40 samples for this analysis. \$1,500 x 40 = \$60,000.				0		\$60,000
US Geological Survey	Professional or Technical Service Contract	Microbiological analysis coordinated by the US Geological Survey (Activity-2). Characterization of water & fish microbiome. At USGS Upper Midwest Water Science Center, \$275 per sample x 40 samples = \$11,000				-		\$11,000
US Geological Survey	Professional or Technical Service Contract	Lab & Supplies (NWQL) \$ 28,940.00 (\$657 x 44 samples) Shipping \$ 320.00 Mileage \$ 250.00 Misc supplies \$ 200.00				0		\$30,000
US Geological Survey	Professional or Technical Service Contract	Lab & supplies (MiBaRL) \$ 12,676.00 Shipping \$ 320.00 Mileage \$ 250.00				-		\$14,000
							Sub Total	\$115,000
Equipment, Tools, and Supplies								

	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
	Tools and Supplies	Supplies for Biological Analysis. Egg your protein assay, \$20 x 400 fish =\$8,000; Hormone analysis, \$25 x 400 fish = \$10,000; Miscellaneous cost = \$1,000; Subtotal \$19,000 x 2 repeats = \$38,000.	Assess biological responses in the Lab.						\$38,000
								Sub Total	\$47,000
Capital Expenditures									
								Sub Total	-
Acquisitions and Stewardship									
								Sub Total	-
Travel In Minnesota									
	Miles/ Meals/ Lodging	50 miles each way x \$0.55 x 30 trips x 2 repeat = \$3,300 --> round up \$4,000	Drive between St Cloud and Hutchinson						\$4,000
								Sub Total	\$4,000
Travel Outside Minnesota									
								Sub Total	-
Printing and Publication									
								Sub Total	-
Other Expenses									
								Sub Total	-
								Grand Total	\$493,000

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
---------------	---------------------	-------------	--

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.	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 plant and natural resource managers to update or replace aging wastewater infrastructure in Minnesota statewide.

Optional Attachments

Support Letter or Other

Title	File
Quotation for AXYS Chemical Analysis	c786b021-2c3.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Does your project have patent, royalties, or revenue potential?

No

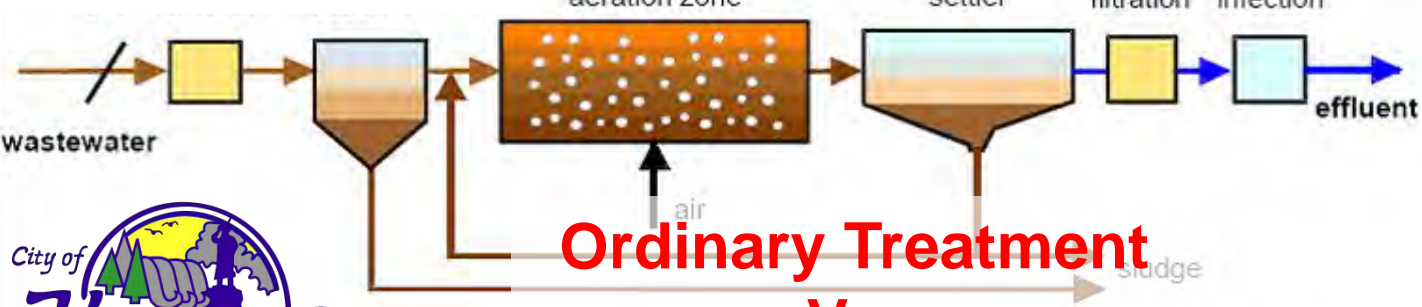
Does your project include research?

Yes

Does the organization have a fiscal agent for this project?

No

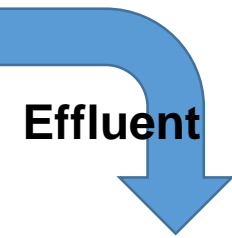
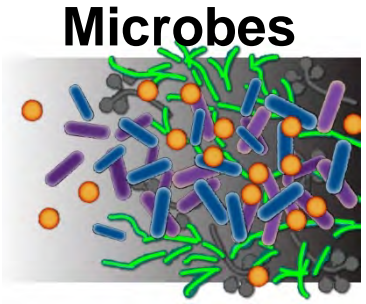
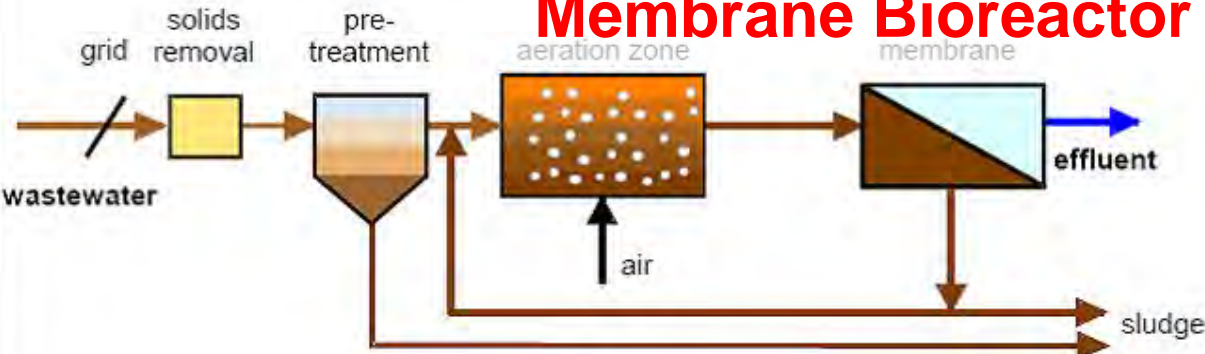
Wastewater Treatment



Ordinary Treatment

Vs.

Membrane Bioreactor



Mobile Exposure Laboratory Trailer (MELT)



Environmental Health

- Reproduction
- Behavior
- Hormone Production
- Microbe Health

