Environment and Natural Resources Trust Fund

M.L. 2020 Approved Work Plan

General Information

ID Number: 2020-037

Staff Lead: Michael Varien

Date this document submitted to LCCMR: August 27, 2021

Project Title: Managing Highly Saline Waste From Municipal Water Treatment

Project Budget: $250,000

Project Manager Information

Name: Natasha Wright

Organization: U of MN - College of Science and Engineering

Office Telephone: (612) 219-3540

Email: wrigh677@umn.edu

Web Address: https://cse.umn.edu/

Project Reporting

Date Work Plan Approved by LCCMR: August 26, 2021

Reporting Schedule: March 1 / September 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. 5, Sec. 2, Subd. 04a

Appropriation Language: $250,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to develop a cost- and energy-efficient method of managing the concentrated saline waste from a municipal water treatment plant to increase the feasibility of using reverse osmosis for centralized water softening and sulfate removal. This appropriation is subject to Minnesota Statutes, section 116P.10.

Appropriation End Date: June 30, 2024

Narrative

Project Summary: We will develop a cost- and energy-efficient method of managing the concentrated saline waste from a municipal desalination plant, increasing the economic feasibility of centralized water softening and sulfate removal.

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

Levels of chloride and sulfate (both salts) in Minnesota waterways is a growing concern due to the potential for harm to aquatic life (chloride) and the quality of water used for growing wild rice (sulfate). Increased chloride comes from multiple sources including salt used for winter road maintenance, residential and commercial water softeners, industry, and agriculture. Sulfate also has multiple sources to surface water, including industrial waste, domestic waste, and use of groundwater for agricultural, industrial, and domestic needs. Because WWTPs are not equipped with the technology to remove dissolved salts, chloride and sulfate that enter these facilities end up back in waterways.

An opportunity exists to reduce this discharge to waterways by installing centralized water softening and desalination technology (such as reverse osmosis, RO) at the municipal scale. Doing so, however, results in a liquid waste stream that contains all the removed contaminants in highly concentrated form; this waste stream has to be treated and properly disposed of, which is expensive. A recent ENTRF-funded report to analyze sulfate treatment options indicates that brine management would represent >46% of the total capital cost and >81% of the operational cost of a newly installed RO system at sample POTWs (MPCA, 2018).

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.

While inland treatment plants using RO typically inject this concentrated waste into deep wells, evaporate the remaining water in large evaporation ponds, or use an evaporative crystallizer, none of these methods are viable for treatment plants in Minnesota. All three are far too expensive and standard evaporation ponds require too much land area, especially given the seasonal climate variation (temperature and humidity) in Minnesota.

One method that could be used to reduce the capital and energetic cost of brine management is convection enhanced evaporation (CEE). An example of CEE is Wind Aided Intensified eVaporation (WAIV), a system that utilizes hanging vertical sheets to increase the evaporative surface area for a given area of land (Gilron, 2003). Initial calculations show that WAIV could reduce the land area required by at least 30 times versus standard evaporation ponds, while avoiding the high capital cost and fuel required for a crystallizer. However, a number of questions remain about the optimal physical design, ideal material properties for the hanging sheets, and how precipitated salts could be removed from the sheets. Our goal is to answer those questions – and in the future, be able to reuse the precipitated salts for practical purposes.

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?

The target project outcome of our research will be a cost- and energy-efficient system for managing the brine (concentrated salt-laden liquid waste) from membrane-based water treatment plants at the municipal scale. This will increase the economic feasibility of utilizing reverse osmosis for centralized water softening and treatment, thereby substantially reducing the addition of chloride, sulfate, and other contaminants to Minnesota waterways.

Project Location

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

Statewide

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

Statewide

When will the work impact occur?

During the Project and In the Future

Activities and Milestones

Activity 1: Develop model for how the highly concentrated salt brine evaporates from vertical and horizontal surfaces

Activity Budget: $121,242

Activity Description:
Our current model for evaporation from horizontal surfaces will be extended to predict the evaporative behavior from vertical surfaces. This model will capture the interaction between the concentrated brine and the evaporative material. Modeling will include natural (wind), forced, and mixed convection scenarios as well as both vertical sheets and horizontal trays. The modeled results will be compared to data from an in-lab single surface system. The existing model will be also be extended to include expected performance in cold weather (e.g. Minnesota winters). Finally, all results will be synthesized in the form of peer-reviewed journal publication and a public facing summary.

Activity Milestones:

Description	Completion Date
1. Understand the fundamental equations governing evaporation of highly saline brines from vertical surfaces	September 30, 2021
2. Develop integrated model of enhanced evaporation from vertical and horizontal surfaces	May 31, 2022
3. Compare modeled results with experimental data from in-lab single surface system	September 30, 2022
4. Synthesize results in the form of peer-reviewed journal publication and public facing summary.	December 31, 2022

Activity 2: System optimization and piloting

Activity Budget: $128,758

Activity Description:
Once we have a predictive model, we will analyze the parametric relationships between various variables (for example water composition, ambient temperature and humidity, brine temperature, air speed, surface material). We will use this understanding to perform multi-objective design optimization, focused on reducing cost and energy consumption. A case study using a local wastewater composition (selected in partnership with our collaborators) and ambient weather conditions will be used to develop a MN-specific case study and techno-economic assessment. A small pilot-system will be prototyped and tested under simulated conditions in the lab.

Activity Milestones:

Description	Completion Date
1. Understanding of parametric relationships between system variables in vertical configuration	June 30, 2023
2. Develop theory for an optimized system design	December 31, 2023
3. Pilot system tested under simulated conditions and techno-economic assessment for a MN WWTP prepared.	May 31, 2024
4. Synthesize results in the form of peer-reviewed journal publication and public facing summary.	June 30, 2024

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Catherine Neuschler	Minnesota Pollution Control Agency	The MPCA continues to be interested in centralized water softening and treatment. Their staff will help us understand cost barriers and determine common operating points (flow rates, water quality parameters), enabling us to optimize and provide case studies on benefits achieved through this technology.	No

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 engineers and scientists in academia, professionals in the area of desalination and water treatment, city managers and other local government officials, industry and trade organization personnel (for example, the Minnesota Pollution Control Agency and Metropolitan Council Environmental Services (MCES). Results will be disseminated through scholarly publications in peer-reviewed journals. Funds have been allotted in the budget such that results can be published in open access journals whenever possible, maximizing data availability and dissemination. Results from the research project will also be presented at regional conferences such as the Conference on the Environment or the American Water Works Association: Minnesota Section Annual Conference.

The Minnesota Environment and Natural Resources Trust Fund (ENRTF) will be acknowledged through use of the trust fund logo or attribution language on project print and electronic media, publications, signage, and other communications per the ENRTF Acknowledgement Guidelines.

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?
We have been awarded federal funding for a project that complements the proposed research, leveraging LCCMR dollars. The federal grant will facilitate complementary experimental work for CEE systems that use the horizontal tray orientation with a focus on a larger-scale experiment in the hot and dry climate of New Mexico. This is in contrast to the predominately model-based/optimization work that is the focus of this study, with application to MN local climate. We also hope to work with a team at the Carlson School of Management to determine realistic value propositions for the technology as part of Activity 2.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Project Manager		Project coordination, guide development of model extension, supervise graduate students. 1 month/year, 3 years, including UMN rate of 36.5% benefits.			27%	0.24		$45,486
Graduate Research Assistant		Analytical model extension, prototype design, fabrication, and testing. Includes UMN rate of 19.9% benefits plus tuition.			43%	1.5		$156,021
Undergraduate Researcher		Assist with prototyping and data collection system. 2 students for 10 hours/wk at $12/hr.			0%	0.5		$12,480
							Sub Total	**$213,987**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								
	Tools and Supplies	Prototyping materials, consumable supplies, labortary notebooks, sensors and data aquisition equipment, operating costs for laboratory instruments required for analyses and experiments	Tools and supplies required to prototype the brine evaporation system and to collect the data necessary for data validation.					$28,013
							Sub Total	**$28,013**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								

	Miles/ Meals/ Lodging	University vehicle rental, hotel/meal charges	Site visits with WWTPs and other local stakeholders					$1,000
	Conference Registration Miles/ Meals/ Lodging	Conference Presentation	Attendance at local conferences to disseminate project findings.					$2,000
							Sub Total	**$3,000**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Publication	Publications charges (x3)	To make published journal articles immediately available via open access to maximize data availability and dissemination					$5,000
							Sub Total	**$5,000**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$250,000**

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				
In-Kind	University of Minnesota	Because the project is overhead free, laboratory space, electricity, and other facilities/administrative costs (54% of direct costs excluding permanent equipment and graduate student tuition benefits) are provided in-kind.	Secured	$109,000
			Non State Sub Total	**$109,000**
			Funds Total	**$109,000**

Attachments

Required Attachments

Visual Component

File: 47e038f8-07e.pdf

Alternate Text for Visual Component

Image shows current option for concentrate management from municipal treatment is prohibitively cost and energy intensive. Diagram of alternative treatment method....

Optional Attachments

Support Letter or Other

Title	File
Background Check Certification	da140a2d-207.pdf
Letter of Support - MPCA	4071bb42-39f.pdf

Difference between Proposal and Work Plan

Describe changes from Proposal to Work Plan Stage

Due to the delay in project start date, some milestone work from the originally proposed first Activity has already been completed. Edits were thus made to the project milestones to clarify the specific work yet to be completed. A fourth milestone was also added to each activity to indicate results synthesis and publication.

The proposed budget total was $262,000; the budget was adjusted to match the recommended amount of $250,000. This adjustment came from a re-evaluation of the funds to be used for supplies and prototyping and is not expected to impact the team's ability to complete the project milestones.

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 UMN Policy.

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

Yes

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

Yes

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

No

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

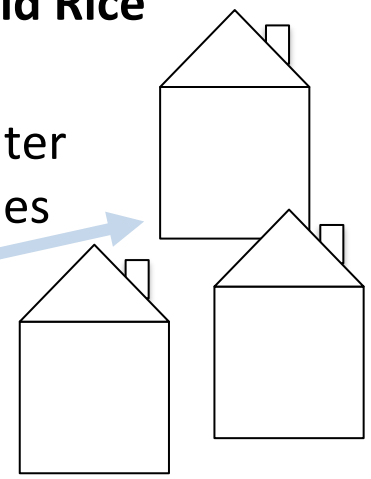
Yes, Sponsored Projects Administration

Protecting Minnesota Waterways, Aquatic Life, and Wild Rice

salty input water

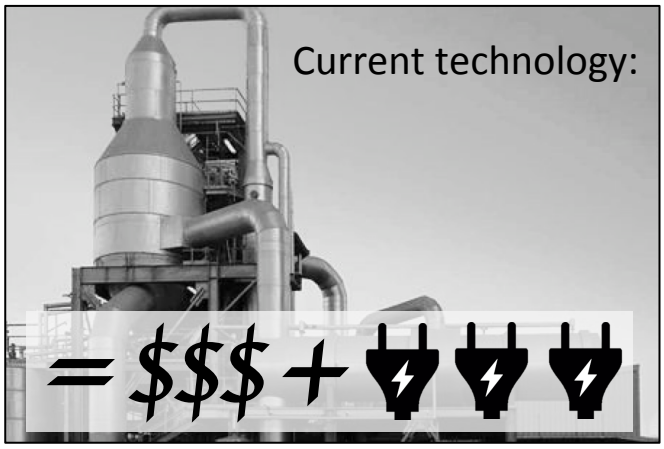
Centralized water softening and sulfate removal with **proven technology**: reverse osmosis (CCRO)

soft water to homes



no need for home water softeners that add chloride to our waterways

concentrated saltwater (liquid waste)



Proposed technology:

= $ +