Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-432

Proposal Title: Technology for Energy-Generating Onsite Industrial Wastewater Treatment

Project Manager Information

Name: Paige Novak

Organization: U of MN - College of Science and Engineering

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Project Basic Information

Project Summary: We will develop “off the shelf” technology to treat industrial wastewater onsite, turning pollutants into hydrogen and methane for energy. This will lead to water quality benefits and cost savings.

Funds Requested: $475,000

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?

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

Narrative

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

In Minnesota the food- and beverage-processing industry, including dairies, malting plants, potato processing facilities, and breweries, is vibrant and provides economic opportunities in both urban and greater Minnesota communities. These industries are water intensive and many do not treat their wastewater onsite. Instead, they discharge their untreated wastewater, typically 20-100 times "stronger" or more concentrated than municipal wastewater, to a centralized municipal treatment plant. As a result:

- The industry is required to pay fees to the municipality to discharge the water to the municipal treatment plant, and
- The municipality has to expend energy to treat the (much stronger, more challenging, and potentially disruptive) industrial wastewater.

Our goal is to expand previous LCCMR-funded research to enable widespread onsite industrial wastewater treatment that turns pollutants into hydrogen and methane fuels and provides benefits to municipalities in the form of more predictable and easier wastewater treatment and lowered treatment costs.

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.

A previous successful LCCMR project formed the basis for this research, resulting in the development of first-generation technology that we have since improved upon. This new technology

- Is designed to be installed onsite at food- and beverage-processing facilities,
- Consists of two reactors, one to turn pollutants into hydrogen and a second to clean the water further and turn remaining pollutants into methane,
- Treats the wastewater using bacteria that are encased (or encapsulated) in non-toxic gel-like beads,
- Easily retains the beads within the reactor and protects the bacteria within the beads,
- Turns pollutants in the wastewater into hydrogen and methane by allowing the encapsulated bacteria to "eat" the pollutants in the wastewater much as we eat food, "exhaling" hydrogen and methane. The hydrogen and methane are used directly onsite as fuels for energy generation.

In addition, this new technology improves upon other treatment options by being very compact, creating energy from pollutants in the waste, and requiring much less energy to operate when compared to competing technologies.

After onsite treatment of this concentrated industrial wastewater, the treated wastewater is discharged to the municipal wastewater treatment plant. Because the industrial waste is pre-treated, it should be easier and cheaper to manage.

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?

Although we have demonstrated successful deployment of the technology with real wastewater, in its current form it is not easily scaled up and each new application (e.g., breweries vs. dairies) requires customization. This increases the cost of the technology and limits its use. The proposed research would advance this technology to the point of being "off the shelf" by creating an adaptable bacterial community that can be encapsulated in beads and used with a wide variety of wastewaters, further (and broadly) pilot testing the technology, and optimizing the system to decrease energy use (pumping, etc.) and maximize energy production.

Activities and Milestones

Activity 1: Develop an adaptable bacterial community and refine the encapsulating chemistry to enable reliable treatment of a range of industrial wastewaters

Activity Budget: $179,131

Activity Description:
A mixed bacterial community will be developed and tested that will grow within the encapsulation matrix (beads) and consume the wide variety of compounds in different wastewater streams. The encapsulation matrix will be optimized to protect the bacteria inside, provide space for them to grow, and enable the bacteria within the encapsulation matrix to access the variety of wastes that need to be consumed. The robustness of the treatment will be tested with a variety of wastewaters from food- and beverage-processing industries.

Activity Milestones:

Description	Completion Date
Understand how a mixed hydrogen-producing community develops and grows when treating a variety of wastewaters	2023-01-31
Understand how a mixed methane-producing community develops and grows when treating a variety of wastewaters	2023-06-30
Demonstration of the two-stage system with a range of wastewaters in the laboratory	2023-10-31

Activity 2: Pilot scale testing and design optimization of the wastewater treatment system

Activity Budget: $295,869

Activity Description:
Using the microbial communities developed in Activity 1, the technology will be tested at the pilot scale at various industries (potato processing, candy manufacturing, brewery). A full evaluation of the design and operation of the system will be used to determine how to best maximize hydrogen and methane production while minimizing energy and equipment costs (e.g., pumping, gas collection)

Activity Milestones:

Description	Completion Date
Scale up and demonstration of the technology at a pilot scale at multiple industries	2024-01-31
Optimization of system design and energy efficiency	2024-06-30

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Natasha Wright	University of Minnesota College of Science and Engineering	Dr. Wright is a co-investigator on the project. She focuses on the design and system optimization of decentralized water treatment systems, with a specialty in membrane-based separation processes. Over the last 6 years, she has piloted combined energy generation / water treatment systems in the United States, India, and Gaza.	Yes
William Arnold	University of Minnesota College of Science and Engineering	Dr. Arnold is a co-investigator on the project. He is an expert in chemical fate, transport, and water treatment. For the past 10 years he has been a pioneer in the development and modeling of polymer films for chemical containment. We have worked together on similar projects.	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?

We have been pursuing National-scale funding for the project and will continue to do so. The project is currently being tested at a small pilot-scale at the Fulton Brewery. We have worked with a team at the Carlson School of Management to determine realistic value propositions for the technology. If a truly robust system can be developed and tested, communication efforts through MN DEED, MCES, and trade organizations will be used to further our implementation activities. We will work with the Venture Center at the University of Minnesota on additional implementation efforts.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Degrading Chlorinated Industrial Contaminants with Bacteria	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04s	$150,000
Improving Nitrogen Removal in Greater Minnesota Wastewater Treatment Ponds	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04e	$325,000
Wastewater Nitrogen Removal Technology to Protect Water Quality	M.L. 2017, Chp. 96, Sec. 2, Subd. 04b	$450,000
Evaluation of Wastewater Nitrogen and Estrogen Treatment Options	M.L. 2014, Chp. 226, Sec. 2, Subd. 03d	$500,000
Methods to Protect Beneficial Bacteria from Contaminants to Preserve Water Quality	M.L. 2014, Chp. 226, Sec. 2, Subd. 03b	$279,000

Project Manager and Organization Qualifications

Project Manager Name: Paige Novak

Job Title: Professor and Joseph T. and Rose S. Ling Chair of Environmental Engineering, Department of Civil, Environmental, and Geo- Engineering, University of Minnesota

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

B.S., Chemical Engineering, 1992, The University of Virginia, Charlottesville, VA.
M.S., Environmental Engineering, 1994, The University of Iowa, Iowa City, IA.
Ph.D., Environmental Engineering, 1997, The University of Iowa, Iowa City, IA.

Dr. Paige Novak will be responsible for overall project coordination. She has been studying the biological treatment of water and wastewater for over 20 years. Recent work has focused on the generation of energy from high-strength wastewater and the degradation of pollutants in wastewater to facilitate water reuse. She and Dr. William Arnold completed an LCCMR-funded project on the generation of energy from high-strength wastewater and obtained a patent and have an additional provision patent filed on that work. They have also published several high-profile papers related to that work.

Organization: U of MN - College of Science and Engineering

Organization Description:
The University of Minnesota is one of the largest, most comprehensive, and most prestigious public universities in the United States (http://www1.umn.edu/twincities/01_about.php). The laboratories and offices of the PI and co-PIs contain all of the necessary fixed and moveable equipment and facilities needed for the proposed studies.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Novak, PI		Overall project supervision, microbial encapsulation and monitoring, provide guidance on the lab- and pilot-scale reactor construction and operation.			26%	0.18		$51,513
Arnold, Co-PI		Encapsulant chemistry modification, provide guidance on the on the lab- and pilot-scale reactor construction and operation.			26%	0.18		$51,567
Wright, Co-PI		Energy production and use optimization, provide guidance on the on the on the lab- and pilot-scale pilot-scale reactor construction and operation.			26%	0.18		$34,330
Postdoctoral Researcher		Will focus on the lab- and pilot-scale reactor construction and operation.			20%	2		$126,487
Graduate Research Assistant		Will focus on the development of a flexible microbial community for encapsulation and the encapsulant chemistry.			42%	1.5		$148,841
							Sub Total	**$412,738**
Contracts and Services								
							Sub Total	-
Equipment, Tools, and Supplies								
	Tools and Supplies	Laboratory supplies, services, and analytical costs (includes, but is not limited to, chemicals for all analyses, supplies to maintain analytical equipment, supplies for reactor construction, including pilot reactor construction, pumps for lab- and pilot-scale systems, monitoring equipment for pilot-scale systems, controllers for pilot-scale systems, gas extraction membranes, microbial analysis costs, analytical fees). These are all required and standard costs.	Supplies, pumps, controllers, and in-line monitoring equipment are needed to construct and operate reactors in the lab and at the pilot scale. Additional supplies and chemicals are required to perform the experiments and pilot tests described, including analysis of the microbial community to see how it changes over time, analysis of the wastewater itself to determine treatment efficacy, analysis of the gases produced (quantity and chemical					$60,262

			make-up) to determine how efficient the system is.					
							Sub Total	**$60,262**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	Mileage costs to go to pilot sites.	Travel to pilot sites is needed for sample collection, and pilot system set-up and monitoring.					$2,000
							Sub Total	**$2,000**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$475,000**

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	Because the project is overhead-free, overhead costs are provided in kind. The University of Minnesota overhead rate is 54% (equivalent to $230,010).	Laboratory space, electricity, and other overhead costs are provided in kind.	Pending	$230,010
			Non State Sub Total	**$230,010**
			Funds Total	**$230,010**

Attachments

Required Attachments

Visual Component

File: 5792afbd-16c.pdf

Alternate Text for Visual Component

The visual shows a picture of our current small pilot system set up at the Fulton Brewery and shows how the system can provide electricity for use at the industry site and discharges wastewater that has been pre-treated to a municipal wastewater treatment plant. The following benefits are shown: 1) Decreased costs for the municipality and industry, 2) Decreased energy use for the municipality for treatment, and 3) Resource Recovery. The following project outcomes are shown: 1) New "off the shelf" treatment technology, 2) Cleaner water, 3) Energy production.

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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

Yes,

- Potential revenue generated or net income from the sale of products or assets developed or acquired with ENRTF funding

Does your project include research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

Onsite wastewater treatment from food- and beverage-based industries will lead to clean water, energy production, and reduced costs.

START

Food- or beverage- processing industry

Untreated wastewater

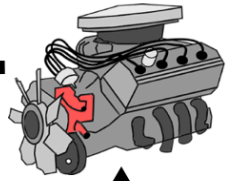
Treatment technology

Treated water

END

Centralized municipal treatment plant

Hydrogen and methane gas to an engine



electricity

Benefits

- Decreased costs for the municipality and industry
- Decreased energy use for the municipality for treatment
- Resource Recovery

Outcomes

- New “off the shelf” treatment technology
- Cleaner water
- Energy production