Today's Date: July 29, 2019

Date of Next Status Update Report: April 1, 2021

Date of Work Plan Approval:

Project Completion Date: June 30, 2023

Does this submission include an amendment request? No

PROJECT TITLE: Technology for Energy Generating Onsite Industrial Wastewater Treatment

Project Manager: Paige J. Novak

Organization: University of Minnesota

College, Department, or Division: Department of Civil, Environmental, and Geo- Engineering

Mailing Address: 122 Civil Engineering Building, 500 Pillsbury Drive SE

City, State, Zip Code: Minneapolis, MN 55455

Project Manager Direct Telephone Number: (612) 626-9846

Email Address: novak010@umn.edu

Web Address: N/A

Location: Minneapolis, MN 55455 and Statewide

Total Project Budget: $450,000

Amount Spent: $0

Balance: $450,000

Legal Citation: M.L. 2020, Chp. xx, Sec. xx, Subd. xx

Appropriation Language:

PROJECT STATEMENT:

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.

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 industry facilities,
- Consists of two reactor stages, 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 onsite treatment options by being very compact, and therefore less expensive to install, and by not only creating energy from pollutants in the waste, but requiring much less energy to operate when compared to competing technologies.

After onsite treatment of this very concentrated industrial wastewater, the treated wastewater is then discharged to the municipal wastewater treatment plant. Because the industrial waste is pre-treated, it should not disrupt their operation and will be much easier for the municipality to manage and further treat, requiring less energy and cost to do so. All of this should result in water quality and quantity benefits.

Unfortunately, although we have demonstrated successful deployment of the technology with real wastewater, in its current form, this technology is not easily scaled up and each new application (*e.g.*, breweries vs. dairies) requires customization in terms of the bacteria within the beads, the type of beads made, their size, and their number. All of 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." We will create an adaptable bacterial community that can be encapsulated in beads and used with a wide variety of wastewaters from the food- and beverage-processing industry. We will determine the optimal bead material to allow for bacterial growth within the beads. We will test the system at a pilot scale with

multiple wastewaters. We will perform system optimization to decrease energy use (pumping, etc.) and maximize energy production.

II. OVERALL PROJECT STATUS UPDATES:

First Update April 1, 2021

Second Update October 1, 2021

Third Update April 1, 2022

Fourth Update October 1, 2022

Fifth Update April 1, 2023

Final Report between project end (June 30) and August 15, 2023

III. PROJECT ACTIVITIES AND OUTCOMES:

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

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 1 ENRTF BUDGET: $162,361

Outcome	Completion Date
1. Understand how a mixed hydrogen-producing community develops and grows when treating a variety of wastewaters	*01/31/22*
2. Understand how a mixed methane-producing community develops and grows when treating a variety of wastewaters	*06/31/22*

Outcome	Completion Date
3. Demonstration of the two-stage hydrogen- and methane-producing technology with a range of wastewaters in the laboratory	*10/31/22*

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

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 2 ENRTF BUDGET: $287,639

Outcome	Completion Date
1. Scale up and demonstration of the technology at a pilot scale at multiple industries	*01/31/23*
2. Optimization of system design and energy efficiency	*6/30/23*

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Fourth Update October 1, 2022

Fifth Update April 1, 2023

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IV. DISSEMINATION:

Description:

The target audience for results from this research will be environmental engineers and scientists in academia, professionals in the area of wastewater treatment, city managers and other local government officials, industry and trade organization personnel (for example, the Minnesota Craft Brewers Guild), the Minnesota Pollution Control Agency, Minnesota Department of Employment and Economic Development (DEED) and Metropolitan Council Environmental Services (MCES). Results will be disseminated through scholarly publications in peer-reviewed journals such as *Environmental Science and Technology* and *Environmental Science: Water Research and Technology.* Results from the research project will also be presented at regional conferences such as the *Conference on the Environment* and seminars and roundtables hosted by project partners (DEED and MCES).

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.

First Update April 1, 2021

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Fourth Update October 1, 2022

Final Report between project end (June 30) and August 15, 2023

V. ADDITIONAL BUDGET INFORMATION:

A. Personnel and Capital Expenditures

Explanation of Capital Expenditures Greater Than $5,000: N/A

Explanation of Use of Classified Staff: N/A

Total Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation:

Enter Total Estimated Personnel Hours for entire duration of project: 8,280	Divide total personnel hours by 2,080 hours in 1 yr = TOTAL FTE: 3.98 total, 1.33/yr

Total Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation:

Enter Total Estimated Contract Personnel Hours for entire duration of project: N/A	Divide total contract hours by 2,080 hours in 1 yr = TOTAL FTE: N/A

VI. PROJECT PARTNERS:

A. Partners outside of project manager's organization receiving ENRTF funding
N/A

B. Partners outside of project manager's organization NOT receiving ENRTF funding
Our primary project partners are Minnesota DEED and MCES. Neither will be funded as part of this project but will assist with dissemination.

VII. LONG-TERM- IMPLEMENTATION AND FUNDING:

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.

VIII. REPORTING REQUIREMENTS:

- Project status update reports will be submitted April 1 and October 1 each year of the project
- A final report and associated products will be submitted between June 30 and August 15, 2023

IX. SEE ADDITIONAL WORK PLAN COMPONENTS:

A. Budget Spreadsheet

B. Visual Component or Map

C. Parcel List Spreadsheet: N/A

D. Acquisition, Easements, and Restoration Requirements: N/A

E. Research Addendum

Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: Paige Novak
Project Title: TECHNOLOGY FOR ENERGY-GENERATING ONSITE INDUSTRIAL WASTEWATER TREATMENT
Organization: University of Minnesota
Project Budget: $450,000
Project Length and Completion Date: 3 years, June 30, 2023
Today's Date: July 29, 2019

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$ 387,800	$ -	$ 387,800
Novak, PI (4% time for the first year, 6% time per year for two years, salary 74% of cost, fringe benefits 26% of cost). Overall project supervision, microbial encapsulation and monitoring, provide guidance on the lab- and pilot-scale reactor construction and operation. Total estimated cost is			
Arnold, Co-PI (4% time for the first year, 6% time per year for two years, salary 74% of cost, fringe benefits 26% of cost). Encapsulant chemistry modification, provide guidance on the on the lab- and pilot-scale reactor construction and operation. Total estimated cost is $39,098.			
Wright, Co-PI (6% time per year for three years, salary 74% of cost, fringe benefits 26% of cost). Energy production and use optimization, provide guidance on the on the on the lab- and pilot-scale pilot-scale reactor construction and operation. Total estimated cost is $34,330.			
One Postdoctoral Researcher (one FTE per year for two years, salary 80% of cost, fringe benefits 20% of cost). Will focus on the lab- and pilot-scale reactor construction and operation. Total estimated cost is $126,487.			
One Graduate Research Assistant (50% FTE per year for three years, salary 58% of cost, fringe benefits 10% of cost, tuition 32% of cost). Will focus on the development of a flexible microbial community for encapsulation and the encapsulant chemistry. Total estimated cost is $148,841.			
Equipment/Tools/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.	$ 60,200	$ -	$ 60,200
Travel expenses in Minnesota			
Travel costs for sample collection, and pilot system set-up and monitoring.	$ 2,000	$ -	$ 2,000
COLUMN TOTAL	$ 450,000	$ -	$ 450,000

SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State: None		$ -	$ -	$ -
State: None		$ -	$ -	$ -
In kind: Because the project is overhead-free, laboratory space, electricity, and other overhead costs are provided in kind. The University of Minnesota overhead rate is 54% (equivalent to $230,010).	Estimated	$ -	$ -	$ -

Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	Amount legally obligated but not yet spent	Budget	Spent	Balance
Active: M.L. 2017, Chp. 96, Sec. 2, Subd. 04b		$ 450,000	$ 208,594	$ 241,406
Completed: M.L. 2014, Chp. 226, Sec. 2, Subd. 03d; M.L. 2017, Chapter 96, Section 2, Subdivision 18		$ 500,000	$ 454,288	$ 45,712
Completed: M.L. 2014, Chp. 226, Sec. 2, Subd. 03b		$ 279,000	$ 277,935	$ 1,065

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

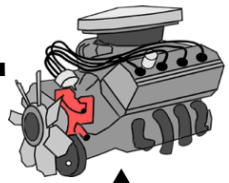
START

Food- or beverage- processing industry

Untreated wastewater

Treatment technology

Hydrogen and methane gas to an engine



electricity

Treated water

END

Centralized municipal treatment plant

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