



Environment and Natural Resources Trust Fund

M.L. 2024 Approved Work Plan

General Information

ID Number: 2024-098

Staff Lead: Noah Fribley

Date this document submitted to LCCMR: June 5, 2024

Project Title: Advanced Biofilter for N₂O Removal

Project Budget: \$325,000

Project Manager Information

Name: Satoshi Ishii

Organization: U of MN - College of Biological Sciences

Office Telephone: (612) 624-7902

Email: ishi0040@umn.edu

Web Address: <https://cbs.umn.edu/>

Project Reporting

Date Work Plan Approved by LCCMR: June 20, 2024

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

Project Completion: June 30, 2026

Final Report Due Date: August 14, 2026

Legal Information

Legal Citation: M.L. 2024, Chp. 83, Sec. 2, Subd. 07d

Appropriation Language: \$325,000 the second year is from the trust fund to the Board of Regents of the University of Minnesota to develop innovative and low-cost biofilters to decrease the concentration of nitrous oxide (N₂O) from various point sources. This appropriation is subject to Minnesota Statutes, section 116P.10.

Appropriation End Date: June 30, 2027

Narrative

Project Summary: This project will develop innovative and low-cost biofilters to decrease the concentration of nitrous oxide (N₂O), a strong greenhouse gas and ozone layer destructor.

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

The emission of nitrous oxide gas (N₂O) is of great concern because N₂O is a potent greenhouse gas and a stratospheric ozone layer destructor. Its greenhouse effect is about 300-fold stronger than carbon dioxide (CO₂). Agriculture (including animal husbandries), wastewater treatment plants, and chemical production facilities (especially those producing adipic acid and nitric acid, important chemicals for nylon and fertilizer syntheses, respectively) are considered the major sources of N₂O emission. Efforts have been made to reduce N₂O production; however, it is difficult to reduce N₂O production without major impacts on the industry business (e.g., nitrogen removal from wastewater). Currently, chemical catalysis is used to transform N₂O into harmless nitrogen (N₂) and oxygen (O₂) gases; however, this reaction requires high-temperature conditions (>100-200 degrees C), which limits its application to various N₂O-emitting industries. Alternative low-cost technology is clearly needed.

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

The overall goal of this project is to mitigate global warming by removing N₂O from various point sources. We will achieve this goal by developing and testing a low-cost biofilter for N₂O removal. Specifically, we will use bacteria to remove N₂O from the air. We recently identified bacteria strains capable of reducing N₂O to N₂ under ambient conditions (10-30 degrees C and 20% O₂ in the atmosphere). Reduction of N₂O in the presence of O₂ (i.e., aerobic N₂O reduction) is a very unique and important characteristic of our strains. In contrast to most other bacteria, our strains have the potential to remove N₂O in various environments where N₂O and O₂ co-occur. We will leverage our aerobic N₂O-reducing bacteria to develop an innovative biofilter to remove N₂O.

The specific objectives of this project are to (1) develop an N₂O-removing biofilter by using aerobic N₂O-reducing bacteria and (2) conduct field testing of our N₂O-removing biofilters.

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 specific outcome of this project is the innovative and low-cost biofilters for N₂O removal. These biofilters can be used to remove N₂O from various sources such as wastewater treatment plants and manure storage and composting facilities, thereby contributing to improving Minnesota's air quality and easing global warming.

Project Location

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

Region(s): Metro

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 laboratory-scale N₂O-removing biofilters

Activity Budget: \$231,000

Activity Description:

The objective of this activity is to design, operate, and optimize laboratory-scale N₂O-removing biofilters.

Task 1: We will design and construct N₂O-removing biofilters by using aerobic N₂O-reducing bacteria previously identified in our group. N₂O-containing gas will be passed through the medium where aerobic N₂O-reducing bacteria grow. The concentrations of N₂O and O₂ in the medium will be measured in real-time by using N₂O and O₂ microsensors, respectively. In addition, N₂O concentrations in the air will be measured by a real-time N₂O monitoring system. Based on these measurements, we will calculate the N₂O removal rate of the biofilter.

Deliverable 1: The lab-scale N₂O-removing biofilters and their N₂O removal rates.

Task 2: The N₂O removal rate will be optimized by changing the air flow rate, bacteria biomass, and hydraulic retention time of the bacteria growth medium. Our goal is to remove >99% of the environmentally relevant N₂O concentrations (100-400 ppm).

Deliverable 2: The biofilter operating conditions that give >99% removal of N₂O.

Task 3: We will operate the biofilter for >6 months to examine the long-term operation capability of the biofilter system.

Deliverable 3: The long-term biofilter operation data.

The outcomes of Activity 1 will be used in Activity 2.

Activity Milestones:

Description	Approximate Completion Date
Design and operate laboratory-scale N ₂ O-removing biofilters	June 30, 2025
Optimize biofilter operating conditions to achieve >99% N ₂ O removal	December 31, 2025
Long-term (>6 months) operation of the biofilters	June 30, 2026

Activity 2: Conduct field testing of the N₂O-removing biofilter

Activity Budget: \$94,000

Activity Description:

This activity aims to examine the performance of our N₂O-removing biofilter in the field.

Task 1: We will identify the facilities to test our N₂O-removing biofilters, such as wastewater treatment plants and manure storage and composting facilities.

Deliverable 1: The list of facilities and their N₂O concentrations.

Task 2: Gas samples will be collected from these facilities and fed to the N₂O-removing biofilters operated in the laboratory.

Deliverable 2: N₂O removal data of the biofilters fed with real environmental samples.

Task 3: We will also install and operate the N₂O-removing biofilters on-site to examine the stability of our biofilter.

Deliverable 3: N₂O removal data of the biofilters installed in the field.

Activity Milestones:

Description	Approximate Completion Date
Identify the facilities for field testing	December 31, 2024
Examine the performance of N2O-removing biofilters with field-collected gas samples	December 31, 2025
Install and operate N2O-removing biofilters on-site	June 30, 2026

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.

Findings will be disseminated and archived via reports to LCCMR, peer-reviewed publications, and presentations at conferences. These publications will be publicly available. Environment and Natural Resources Trust Fund will be acknowledged in the publications, presentations, and other media per the ENTRF Acknowledgment Guidelines. The ENTRF logos and signage will appear on the biofilters in the lab and field settings.

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 work be funded?

The results will be disseminated to agencies, industries, and other interested parties, through open-access publications and conference presentations. We will seek industry partners to scale up our N₂O-removing biofilters. If additional work is needed, funding from federal sources will be sought.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Assessment of Water Quality for Reuse	M.L. 2017, Chp. 96, Sec. 2, Subd. 04f	\$148,000

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
Satoshi Ishii		Project manager			27%	0.12		\$25,000
Postdoctoral Research Associate		Perform experiments and analyze data for Activity 1 and 2			20%	2		\$145,000
							Sub Total	\$170,000
Contracts and Services								
							Sub Total	-
Equipment, Tools, and Supplies								
	Equipment	Real-time N2O analyzer	The real-time N2O analyzer is necessary to monitor the level of N2O in the air.	X				\$132,000
	Tools and Supplies	N2O and O2 microsensors	Measure the concentration of water-dissolved N2O and O2					\$5,000
	Tools and Supplies	N2O and O2 standard gases	Necessary to calibrate the instruments					\$1,000
	Tools and Supplies	Materials for N2O biofilter construction	Pumps, reactors, and filter media necessary to construct N2O biofilters					\$3,000
	Tools and Supplies	Miscellaneous laboratory supplies and consumables	Various supplies and consumables are needed to collect and process samples (chemicals, glassware, plastic consumables, etc.)					\$10,000
							Sub Total	\$151,000
Capital Expenditures								
							Sub Total	-
Acquisitions and Stewardship								

							Sub Total	-
Travel In Minnesota								
	Miles/ Meals/ Lodging	A total of 10 trips (1,700 miles) are planned (60 miles/trip for Twin Cities metro areas and 300 miles/trip for the rest of MN) at a rate of \$0.585/mile.	Necessary to test the N2O biofilters					\$1,000
	Conference Registration Miles/ Meals/ Lodging	Trips and registration fees to present our research results at a conference in MN (\$500/person x 2 researchers)	To disseminate the results					\$1,000
							Sub Total	\$2,000
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
	Publication	Open access publication fee	Necessary to make our results publicly available					\$2,000
							Sub Total	\$2,000
Other Expenses								
							Sub Total	-
							Grand Total	\$325,000

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Equipment, Tools, and Supplies		Real-time N2O analyzer	This is a specialized instrument necessary for the N2O monitoring for this project. Without this instrument, we cannot achieve the project goals.

Non ENRTF Funds

Category	Specific Source	Use	Status	\$ Amount
State				
In-Kind	University of Minnesota	The University of Minnesota is not allowed to charge the State of Minnesota its typical overhead rate of 55% of the total modified direct costs. We are listing our unrecoverable indirect cost as in-kind contribution.	Secured	\$106,000
			State Sub Total	\$106,000
Non-State				
			Non State Sub Total	-
			Funds Total	\$106,000

Attachments

Required Attachments

Visual Component

File: [08f584e6-a8e.pdf](#)

Alternate Text for Visual Component

Special bacteria in the biofilter break down N2O into harmless N2 and O2....

Supplemental Attachments

Capital Project Questionnaire, Budget Supplements, Support Letter, Photos, Media, Other

Title	File
U of MN SPA letter	53c80441-263.pdf

Difference between Proposal and Work Plan

Describe changes from Proposal to Work Plan Stage

- Project location has been specified.
- Change in the reporting dates (July 1 / Jan. 1) has been requested.
- Budget has been modified to fit within \$325,000 (original requested budget was \$335,000).
- Dissemination plan has been added.

1/3/24

- Activity 1 and 2 descriptions are now more clearly described. Each activity now has several tasks, corresponding to its milestones and deliverables.
- The completion dates of some milestones have been moved to Year 1 (Dec. 31, 2024, and June 30, 2025).
- How we acknowledge ENTRF is now described in the dissemination section.
- Real-time N2O analyzer is now categorized as a capital expenditure with "generally ineligible" check-marked. The justification for this request is explained.

6/5/24

- The fiscal agent contact information has been updated (on the Project Collaborators - Organization page).
- Appropriation language has been reviewed and confirmed (no change needed).

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, sale of products and assets, or revenue generation?

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?

Yes, Sponsored Projects Administration

Does your project include the pre-design, design, construction, or renovation of a building, trail, campground, or other fixed capital asset costing \$10,000 or more or large-scale stream or wetland restoration?

No

Do you propose using an appropriation from the Environment and Natural Resources Trust Fund to conduct a project that provides children's services (as defined in Minnesota Statutes section 299C.61 Subd.7 as "the provision of care, treatment, education, training, instruction, or recreation to children")?

No