Environment and Natural Resources Trust Fund

2024 Request for Proposal

General Information

Proposal ID: 2024-098

Proposal Title: Advanced Biofilter for N2O Removal

Project Manager Information

Name: Satoshi Ishii

Organization: U of MN - College of Biological Sciences

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Project Basic Information

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.

Funds Requested: $335,000

Proposed Project Completion: June 30, 2026

LCCMR Funding Category: Air Quality, Climate Change, and Renewable Energy (E)

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.

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.

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. We will use aerobic N2O-reducing bacteria previously identified in our group. Various concentrations of 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. 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). The long-term (>6 months) operation capability of the biofilter system will be also examined.

Activity Milestones:

Description	Approximate Completion Date
Design and operate laboratory-scale N2O-removing biofilters	June 30, 2025
Optimize biofilter operating conditions to achieve >99% N2O 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: $104,000

Activity Description:
This activity aims to examine the performance of our N2O-removing biofilter in the field. We will identify the facilities to test our N2O-removing biofilters, such as wastewater treatment plants and manure storage and composting facilities. Gas samples will be collected from these facilities and fed to the N2O-removing biofilters operated in the laboratory. We will also install and operate the N2O-removing biofilters on-site to examine the stability of our biofilter.

Activity Milestones:

Description	Approximate Completion Date
Identify the facilities for field testing	June 30, 2025
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

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

Project Manager and Organization Qualifications

Project Manager Name: Satoshi Ishii

Job Title: Associate Professor

Provide description of the project manager's qualifications to manage the proposed project.
Satoshi Ishii is an Associate Professor at the BioTechnology Institute (BTI) and the Department of Soil, Water, and Climate (SWC) at the University of Minnesota. Dr. Ishii's research focuses on environmental microbiology and biotechnology, including microbial N2O reduction. Dr. Ishii has managed multiple projects related to the proposed subject.

Organization: U of MN - College of Biological Sciences

Organization Description:
The University of Minnesota is the main research and graduate teaching institution in the state of Minnesota. The BioTechnology Institute provides advanced research, training, and university-industry interaction in biological process technology. In the Department of Soil, Water, and Climate, we seek to improve and protect the quality of soil, air, and water resources in natural and managed ecosystems, through research, teaching, and extension.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Satoshi Ishii		Project manager			27%	0.16		$32,000
Postdoctoral Research Associate		Perform experiments and analyze data for Activity 1 and 2			20%	2		$145,200
							Sub Total	**$177,200**
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. This is a specialized instrument and will be only used for the N2O monitoring for this project and follow-up research.					$132,600
	Tools and Supplies	N2O and O2 microsensors	Measure the concentration of water-dissolved N2O and O2					$5,200
	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	**$151,800**
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					$4,000
							Sub Total	**$4,000**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$335,000**

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				
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	$111,300
			State Sub Total	**$111,300**
Non-State				
			Non State Sub Total	**-**
			Funds Total	**$111,300**

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....

Optional Attachments

Support Letter, Photos, Media, Other

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

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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

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 design, construction, or renovation of a building, trail, campground, or other capital asset costing $10,000 or more?

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?

No