Environment and Natural Resources Trust Fund

2026 Request for Proposal

General Information

Proposal ID: 2026-398

Proposal Title: Removing Microplastics from Minnesota Waters

Project Manager Information

Name: Mikael Elias

Organization: U of MN - College of Biological Sciences

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Project Basic Information

Project Summary: Microplastics contaminate water, soils and Humans in Minnesota and beyond. This project leverages the characterization and AI-guided enzyme engineering to optimize microplastic degradation for scalable implementation to clean drinking water.

ENRTF Funds Requested: $598,000

Proposed Project Completion: June 30, 2029

LCCMR Funding Category: Water (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?

In the Future

Narrative

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

Microplastics contamination is an emerging, pressing environmental and public health concern in Minnesota and worldwide. Microscopic plastic debris (0.1 – 5 millimeters (mm)) are for example detected in soils, rivers and in the Great lakes, which thousands of communities rely on for freshwater. In fact, a study found that 81% of tap water samples (and even beer samples or food) contained microplastic particles that originate from the breakdown of large plastics and propagate via the water distribution system. Unfortunately, while standard water treatment processes remove a significant portion of them (70 to 90%), a substantial amount of microplastics remain in drinking waters and the environmental, enough to affect wildlife and humans, microplastics can for example be detected in the human brain. Minnesota's state agencies recognize the issue and an interagency workgroup is performing risk assessments. However, no established remediation technology exists to specifically degrade and completely remove microplastics in water. Therefore, innovative solutions are much needed to protect our wildlife, aquatic ecosystem, and the health of Minnesotans.

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.

Special proteins, namely enzymes, are capable of performing chemical reactions. Natural enzymes were identified and are able to degrade different types of plastics into much smaller products. Unfortunately, these biological molecules are not readily suitable for use in water filtration systems or other bioremediation methods. They lack activity against specific plastics, stability, and their functionalization into usable materials is needed. We will take a three-pronged approach to advance the bioremediation of microplastics. First, we will identify, produce and characterize new enzymes that are capable of degrading plastic polymers such as cutinases, PETase and laccases to determine if these candidates are suitable for formulation into materials. Second, we will engineer existing, known enzymes and newly identified ones to improve their stability (including environmental stability), activity levels, and operational activity at pH, temperature and in condition compatible with water treatment. Third, we will engage with stakeholders, including water treatment plants and the Metropolitan Council, the Minnesota DNR, the Minnesota Pollution Control Agency and the MN Department of Health to build the best strategy for the future implementation of such technology in water treatment plants.

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?

We expect to have optimized enzyme formulations that degrade microplastics and with potential for integration into municipal water treatment processes or as an upgrade to consumer water filters. The proposed integrated approach that includes AI-optimized enzymes and formulation will fill in a gap to overcome the current limits of microplastics degradation. This project amplifies Minnesota's current efforts to curb plastic pollution. If successfully implemented, this technology would result in cleaner water for Minnesotans and fully aligns with the Minnesota Environment and Natural Resources Trust Fund's missions.

Activities and Milestones

Activity 1: Identification and Characterization of Novel Microplastics-Degrading Enzymes

Activity Budget: $292,880

Activity Description:
We will identify through bioinformatics searches novel plastic degrading enzymes (namely cutinases, esterases, oxidases), particularly from extremophiles for their high stability. We will also identify new candidates from environmental samples from 2 plastic-polluted sites (e.g. water and sediment near wastewater discharge, landfills in Minnesota). Environmental DNA will be sequenced using shotgun metagenomic sequencing and > 50 candidates will be identified for their potential microplastics degrading ability. These genes will be cloned, and the corresponding enzymes will be produced (>5), and characterized enzymatically and thermal stability. This will include activity against model substrates such as PET film pieces, polyethylene micro-pellets under controlled conditions. We will select the 2-3 most promising candidates for further characterization, including the determination of their optimal operating conditions (pH, salinity) and efficacy in water samples, including Minnesota surface and tap water samples with added microplastics. Structural characterization will be performed on these lead candidates to decipher their mechanisms and guide optimization efforts.

Activity Milestones:

Description	Approximate Completion Date
Identify >50 candidate genes with high potential microplastic-degrading activity	June 30, 2027
Production and characterization of >5 novel microplastic-degrading enzymes	June 30, 2028
Characterization of 2-3 lead enzymes, including in water treatment conditions	October 31, 2028

Activity 2: Optimizing Microplastics-Degrading Enzymes

Activity Budget: $292,880

Activity Description:
Plastic degrading enzymes with the best properties will be optimized structure-guided algorithms and machine learning models to increase their stability, longevity and activity against specific types of microplastics found in drinking waters (polyethylene, polyvinyl chloride, polyethylene terephthalate). Dozens of variants for each enzyme will be created and tested in medium-throughput assays for improved plastic degradation. The goal is to obtain variants with at least 2× the activity or 2× the half-life (stability) compared to their starting versions. These variants will subsequently be immobilized on filtration media, such as alginate beads and immobilized on membranes such as PVDF or polypropylene membranes that are commonly used for water filtration. Notably, this immobilization step is likely to increase the stability and durability of these enzymes. The created biomaterials will then be tested in simulated water treatment systems, with microplastics containing water. The ability of the biomaterials to reduce microplastics particles will be determined, along with particle count and mass, the time required for degradation, the filtration capacity of the system, the number of cycles that it can sustain, including in cold water (~10 °C) that would represent Minnesota groundwaters. The goal is to achieve >90% reduction in microplastics concentration in the treated water.

Activity Milestones:

Description	Approximate Completion Date
Engineer and improve plastic-degrading enzymes (>2-times)	January 31, 2029
Functionalize the best enzymes into biomaterials	April 30, 2029
Create biomaterials that can remove >90% of microplastics from water	June 30, 2029

Activity 3: Stakeholder Engagement and Field Trial Pathway

Activity Budget: $12,240

Activity Description:

In this activity, the goal will be to engage with water treatment plants, regulators and industry partners to prepare for pilot-scale studies. We will meet and collect input from the Minnesota Department of Health (MDH) and Pollution Control Agency (MPCA) to ensure our approach aligns with drinking water safety regulations. Early engagement with the regulators is essential to adequately guide optimal experimental design and strategy. Municipal and industry partnerships will be sought to design out pilot experiments and integrate the enzyme technology into existing processes (enzymes beads in sad filtration, or enzyme-coated membranes). Minnesota-based companies such as 3M and Pentair and their filtration division will be consulted. With stakeholder input, the goal is to develop a detailed pilot plant implementation plan of these novel filtration technologies, including a safety/risk assessment.

Activity Milestones:

Description	Approximate Completion Date
Discuss regulatory aspects with MDH/EPA	January 31, 2028
Obtain letters of collaboration from water treatment plants / tech company	February 28, 2028
Complete a pilot testing protocol	June 30, 2029

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?

One implementation strategy is to integrate the developed technology into existing filtration systems across Minnesota. For example, this enzyme technology could be added as a polishing step in water treatment plants. Another avenue is to integrate it to personal and household filter systems. Such as technology could be further modified to remediate food, soil, stormwater or waste water effluents. Support for a clear commercialization strategy will be sought from federal agencies such as the NSF (e.g. SBIR grants) and successful pilot-scale testing would allow to establish productive public-private partnership where a Minnesota company licenses the technology for product development.

Project Manager and Organization Qualifications

Project Manager Name: Mikael Elias

Job Title: Associate Professor

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

Mikael Elias holds a Ph.D. in structural enzymology from Université Aix-Marseille (France) and completed his postdoctoral training at the Weizmann Institute of Science (Israel) as a Marie Curie Fellow, specializing in protein evolution and engineering. Since 2014, he is an Associate Professor in the Biochemistry, Molecular Biology and Biophysics department, where he runs a productive laboratory that studies the structure, function, and evolution of proteins and enzymes, with applications in microbiology, human health, and crop and environmental protection. This project builds on his recognized expertise (>75 research articles, 6 patents), including in protein engineering. He currently runs several projects where proteins are improved for applications such as bioremediation or replacing current, toxic technology with eco-friendly ones. In addition to leading a research laboratory, his past experience as co-founder and former CEO of an enzyme biotechnology company (now acquired) provided him with the network, experience and tools to direct translational research, engage stakeholders and execute this project.

Organization: U of MN - College of Biological Sciences

Organization Description:

The University of Minnesota is a public land-grant research university. The PI's lab is hosted in the University of Minnesota Biotechnology Institute. This interdisciplinary Institute is located on the Saint Paul campus and hosts a wide range of faculty and labs that apply different aspects of biological, geological and material sciences to address societal challenges. This unique structure creates a cutting-edge, highly collaborative environment to conduct challenging projects that necessitate a wide range of expertise. At the Institute, the PI also has access to extensive lab space to support the proposed research, as well as comprehensive General Administration, Human Resources and accounting to ensure proper project management.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Project PI		Oversee and manage research for this grant.			36.6%	0.24		$60,985
Lab Researcher		Complete and oversee research to advance the bioremediation of microplastics.			36.6%	3		$261,775
Assistant lab researcher		Assist researcher in their research to advance the bioremediation of microplastics.			74.11%	3		$196,000
							Sub Total	**$518,760**
Contracts and Services								
							Sub Total	-
Equipment, Tools, and Supplies								
	Tools and Supplies	Chemicals, flasks, pipettes, disposable plasticware, for example test tubes and petri plates, molecular biology reagents and kits. Also includes supplies for protein purification (e.g. chromatography colums), characterization supplies such as substrates, mass spectrometry, NMR and ITC usage, and crystallization supplies as well as shipping costs to send samples for structural analysis at national labs. Supplies for functionalization of enzymes on membranes and beads, and bioreactor systems to evaluate filtration performance.	Producing and optimizing enzymes for lab testing, as well as routine lab supplies and DNA sequencing.					$69,000
							Sub Total	**$69,000**
Capital Expenditures								
							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-

Travel In Minnesota								
	Miles/ Meals/ Lodging	Trips to visit stakeholders during the 3 year period of the project.	This will cover travel costs and accomodations to meet and discuss research with stakeholders.					$2,240
							Sub Total	**$2,240**
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
	Publication	Open-access publication fee	This allows everyone to access the research without the need to pay a subscription to the publisher.					$5,000
							Sub Total	**$5,000**
Other Expenses								
		Repairs and Maintenence	These funds will be used to cover repairs associated with the use of our research instruments for this project.					$3,000
							Sub Total	**$3,000**
							Grand Total	**$598,000**

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	Indirect costs for this proposal though not allowed, are listed as in-kind contribution of 54% MTDC which is the Federally Negotiated rate with the U of M. The indirect is proportionate to the awarded funds at a rate of 54% so if the award is reduced the F&A would be reduced.	To pay for facility and administrative expenses for this project.	Secured	$291,971
			Non State Sub Total	**$291,971**
			Funds Total	**$291,971**

Total Project Cost: $889,971

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: c9d20cbd-164.pdf

Alternate Text for Visual Component

Enhanced Enzymes Can Break Down Microplastics Contaminants....

Supplemental Attachments

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

Title	File
SPA approval letter	32b102c2-3bd.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Do you understand that travel expenses are only approved if they 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 understand the UMN Policy on travel applies.

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

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

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

Provide the name(s) and organization(s) of additional individuals assisting in the completion of this proposal:

Lori Nicol and Amy Angel, University of Minnesota

Do you understand that a named service contract does not constitute a funder-designated subrecipient or approval of a sole-source contract? In other words, a service contract entity is only approved if it has been selected according to the contracting rules identified in state law and policy for organizations that receive ENRTF funds through direct appropriations, or in the DNR's reimbursement manual for non-state organizations. These rules may include competitive bidding and prevailing wage requirements

N/A