Environment and Natural Resources Trust Fund

2026 Request for Proposal

General Information

Proposal ID: 2026-046

Proposal Title: Eliminating Microplastics from Anaerobic Digestion to Prevent Pollution

Project Manager Information

Name: Lee Penn

Organization: U of MN - College of Science and Engineering

Office Telephone: (612) 626-4680

Email: rleepenn@umn.edu

Project Basic Information

Project Summary: This project optimizes anaerobic digestion to ensure that compostable plastics break down fully. By preventing microplastic pollution, it supports cleaner soils, water systems, and more sustainable waste management solutions.

ENRTF Funds Requested: $822,000

Proposed Project Completion: June 30, 2029

LCCMR Funding Category: Land (F)

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.

Plastic and microplastic pollution pose serious environmental and health risks. While bioplastics are often marketed as a solution, they only break down under specific conditions, such as the high temperatures of industrial composting facilities. In typical backyard or community compost piles, they do not fully decompose. Anaerobic digestion offers a promising way to manage bioplastic waste by breaking materials down into biogas and water. However, for this process to be truly effective, microplastics and other plastic debris must not persist in the remaining material. Additionally, materials added to anaerobic digesters frequently contain conventional plastics and microplastics, which do not readily degrade during anaerobic digestion. This proposal focuses on characterizing plastic and microplastics in anaerobic digestate and improving anaerobic digestion to ensure that no bioplastic fragments or microplastics remain in the final material. By optimizing this process, we can enhance the sustainability of bioplastics, and, by preventing release of microplastics from anaerobic digesters, contribute to cleaner soil and water systems.

**Additionally, the biogas produced can be captured and converted into electricity.

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 project has two primary aims: 1) isolation and quantification of microplastics from anaerobic digestate to better understand how much goes into digesters and how much comes out and 2) development of improved methods for the anaerobic digestion of sustainable polymers. Further, we aim to build partnerships with organizations (e.g., MPCA).

In part one, anaerobic digestates collected from various sources will be characterized for microplastics present. Non-plastic organic components of the digestates will be removed in a series of steps including wet-oxidation and organic solvent extraction. Sources include thermophilic anaerobic digesters located throughout the state of Minnesota, with different feedstock (agricultural waste, food waste, or activated sludge, for example). In part two, we will quantify the extent of bioplastic degradation in anaerobic digestion. Because bioplastics do not degrade well in the natural environment, it is important to understand how well they degrade in anaerobic digesters. Further, we will characterize the anaerobic digestate to understand which types of microbes lead to complete degradation of the bioplastics and understand whether the introduction of the bioplastics changes the microbial community in the digester. Finally, the project will focus on optimizing the anaerobic digestion of bioplastics to eliminate microplastics from the final digestate.

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?

Data will lead to improved anaerobic digestion conditions for sustainable plastics. Outside of those conditions, these plastic particles don't degrade readily. Under industrial anaerobic conditions -- they do, but microplastics and plastic debris can remain, potentially leading to release of such debris into the environment. This project will lead to conditions that eliminate remaining microplastics and other plastic debris. The methods developed could be deployed by stakeholders throughout the state, such as waste and watewater treatment and resources recovery managers and anaerobic digestion industries. Sustainable waste management of plastics will contribute to cleaner soil and water systems.

Activities and Milestones

Activity 1: Develop method to separate and quantify microplastics from digestate.

Activity Budget: $225,000

Activity Description:
Anaerobic digestates collected from various sources will be characterized for microplastics present. Non-plastic organic components of the digestates will be removed in a series of steps including wet-oxidation and organic solvent extraction. Upon extraction, the microplastics will be identified and counted using optical and Fourier Transform Infrared Spectroscopy (FTIR) microscopy. Recovery studies with standard microplastics will be performed to verify the efficiency of the extraction in addition to identifying if the extraction processes cause degradation to the plastic materials themselves. Standard plastics used will be both non-degradable petroleum-based plastics and commercially available biodegradable plastics.

Activity Milestones:

Description	Approximate Completion Date
Develop method to separate and quantify microplastics in digestate	December 31, 2026
Separation of bioplastic from anaerobic digestate	June 30, 2027
Characterization of plastics in digestate from active anaerobic digesters in Minnesota	December 31, 2027

Activity 2: Quantify microplastics after anaerobic digestion of specific bioplastics

Activity Budget: $300,000

Activity Description:
We will quantify degradation of plastics by anaerobic digestion. Anaerobic digestion experiments will be conducted with different types of bioplastic provided by 3M, with inoculum-only blanks, cellulose-based positive controls,and polystyrene and polyethylene as negative controls. Digestates from various Minnesota sources will be used as inoculum. Experiments will be conducted in triplicate. Each trial will use 1000 g of inoculum with 15–100 g of test plastic in 2-L Erlenmeyer flasks connected to gas bags. Flasks will be incubated at 37°C ± 2°C (mesophilic) or 52°C ± 2°C (thermophilic) for 3–30 days. The production of biogas (CH4, CO2) will be monitored to quantify the biodegradation rate of the bioplastics.

Plastic degradation will be assessed using weight loss and characterized by electron microscopy, FTIR, gel permeation chromatography, differential scanning calorimetry, and other methods. Plastics will be separated from digestate using wet peroxide oxidation methods as described by the National Oceanic and Atmospheric Administration. The composition of microorganisms will be characterized with DNA sequencing approaches to identify the microorganisms responsible for degrading the bioplastics and how the microbial communities in the digestor respond to exposure to plastics. Findings will inform strategies to improve anaerobic digestion for plastic waste management.

Activity Milestones:

Description	Approximate Completion Date
Perform Anaerobic Digestion of Bioplastic Samples and Quantify Plastic Debris Remaining	June 30, 2028
Peroform Microbial Analysis	December 31, 2028

Activity 3: Optimize Anaerobic Digestion of Bioplastics

Activity Budget: $297,000

Activity Description:

We will characterize the efficacy of changing the anaerobic digestion conditions and/or applying pretreatments to improve the degradation of plastics. Experiments will focus on quantifying the rate and extent of degradation of cellulose-based positive controls, PS- and PE-based negative controls, and test samples from 3M as a function of changing conditions (e.g., inoculum source, temperature, pretreatment). Pretreatments will include coating with solutions containing enzymes with demonstrated activity towards enhancing the adhesion of microbes on the target plastics. Anaerobic digestion experiments will be conducted using the methods described in Activity 2, and plastic degradation and microbial communities during the degradation will be assessed.

As with activity two, the remaining plastic debris will be quantified. In addition, microbial ecology studies will use DNA sequencing to identify plastic-degrading bacteria and whether the microbial community changes with conditions or pretreatments. Findings will inform strategies to improve AD for plastic waste management.

Activity Milestones:

Description	Approximate Completion Date
Parallel reactors with different inoculums	December 31, 2028
Parallel Reactors with Varying Pretreatments	December 31, 2028
Microbial Characterization of Best Performing Conditions	June 30, 2029

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Melissa Maurer-Jones	UMN - Duluth	Co-Project Manager	Yes
Naba Kalita	UMN - Duluth Natural Resources Research Institute	Co-Project Manager	Yes
Chan Lan Chun	UMN-Duluth	Co-Project Manager	Yes
Eric Singsaas	UMN - Duluth Natural Resources Research Institute	Co-Project Manager	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 work be funded?

The project has two primary aims: 1) isolation of microplastics from anaerobic digestate to better understand how much goes into digesters and how much comes out, and 2) development of improved methods for the anaerobic digestion of sustainable polymers. The details of methods, including effective and ineffective methods, will be publicly available. We aim to build partnerships with organizations such as state agencies (e.g., MPCA and MDA), municipalities (e.g., wastewater treatments, resources recovery centers) , anaerobic digestion industries and so forth. Further, the results will be published in peer-reviewed journals and presented at regional conferences.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Microplastics: Transporters Of Contaminants In Minnesota Waters	M.L. 2021, First Special Session, Chp. 6, Art. 5, Sec. 2, Subd. 04c	$425,000

Project Manager and Organization Qualifications

Project Manager Name: Lee Penn

Job Title: Professor

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

Dr. Penn has been at the University of Minnesota (UMN) since 2001 and has extensive experience engaging in collaborative work. Dr. Penn is faculty in the Chemistry Department at UMN and an expert in studying how both natural and anthropogenic materials change under environmentally relevant conditions. Dr. Penn has extensive experience with field sampling, materials characterization, and design and implementation of both batch and column reactors. Dr. Penn has an extensive publication record on topics related to environmental remediation, geochemistry, and microplastics.

Professor Penn and members of the Penn research group have extensive materials characterization experience with methods like electron microscopy and vibrational spectroscopy particularly relevant to this work. The group also studies the degradation of microplastics and the uptake of persistent organic pollutants by traditional and sustainable polymers.

The group also collects samples from field sites and separates microplastics from other materials found in those samples. The group is well positioned for success with the proposed work.

Organization: U of MN - College of Science and Engineering

Organization Description:
The University of Minnesota College of Science and Engineering brings together the University's programs in engineering, physical sciences, mathematics and computer science into one college. Because of this unique structure, the college is uniquely positioned to provide the vision, leadership, and intellectual capital that underwrite interdisciplinary progress in the 21st Century. The college is ranked among the top academic programs in the country. The college includes 12 academic departments offering a wide range of degree programs at the baccalaureate, master's, and doctoral levels.

Researchers within the College of Science and Engineering are on the leading edge of finding ways to solve some of the world's greatest problems by developing new forms of environment-friendly energy and products, new medical devices, digital and electronic technologies, and a strong national infrastructure. The college has collaborations with the University of Minnesota’s world-renowned medical school, locally-based companies such as 3M and Medtronic, as well as universities around the globe.

Partnerships with the private sector nurture the work of College of Science and Engineering faculty and students. Input from leading companies helps shape the college's curriculum, ensuring that students' skills match industry needs. In return, the college offers a wealth of resources to help businesses succeed.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Professor R Lee Penn - Twin Cities		Project Manager			37%	0.18		$52,625
Professor Chan Lan Chun - NRRI		Co-project manager			37%	0.18		$36,718
Research Scientist Naba Kalita - NRRI		Co-project manager			37%	0.51		$65,241
Research Group Leader Eric Singsaas - NRRI		Co-project Manger			37%	0.24		$55,363
Professor Melissa Maurer-Jones - Duluth		Co-project Manager			37%	0.18		$33,814
Graduate Research Assistant UMN-Twin Cities (Beginning)		Researcher			23.2%	0.25		$21,315
Graduate Research Assistant - UMN - Duluth		Researcher			23.2%	0.82		$62,866
Undergraduate Research Assistants - Duluth		Research Assistants			0%	0.38		$12,572
Graduate Research Assistant UMN-Twin		Researcher			23.2%	1.26		$111,100

Cities (Advanced)								
Env Genomics Scientist (R5) - NRRI		Researcher			37%	0.12		$13,432
Tech (Temp/Casual) - NRRI		Tech			7.4%	0.03		$1,506
Tech (Bargaining Unit) - NRRI		Tech			32.3%	0.03		$2,855
Undergraduate Research Assistants - NRRI		Research Assistants			0%	1.5		$53,468
Graduate Research Assistant - NRRI		Researcher			23.2%	0.82		$61,648
							Sub Total	**$584,523**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								
	Tools and Supplies	Lab Supplies - Twin Cities	General laboratory supplies (e.g., glassware, tubing, chemicals, plastic standards, sample preparation materials, sample holders, microscopy supplies, etc...) used to complete the work scope					$20,263
	Equipment	Non-capitalized equipment - Twin Cities	Non-cap equipment (small scale anaerobic digester for twin cities lab, to run in parallel with larger anaerobic digesters at the NRRI) needed to meet the aims of the project					$5,000
	Tools and Supplies	Lab Supplies - Duluth	General chemical supplies used to complete the work scope including purchase of enzymes, cell culture					$5,492

			chemicals (e.g., salts, yeast extracts) and supplies (culture tubes, well plates), solvents, gloves, replacement glassware.					
	Tools and Supplies	Lab & Medical Supplies - NRRI	Specialized glasswares, tubings, gas washing bottles, calibration gases for gas chromatography and tedlar bags are essential for maintaining a sterile environment, which is critical for the health and efficiency of the anaerobic digestion process. It also allows for precise control over experimental conditions, which is vital for completion of the project aims.					$35,000
	Tools and Supplies	Lab & Medical Supplies - NRRI	Laboratory Supplies: Plasticwares, chemicals, and molecular agents for DNA extraction and metagenomic analysis					$16,000
							Sub Total	**$81,755**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Other	Various Allowable Travel Costs - Airfare, Lodging, Registration, Ground Transportation, and Meal Per Diem - NRRI	In-person meetings, scientific presentations at regional conferences, personnel travel for full team lab meetings and access to equipment across locations)					$9,000
							Sub Total	**$9,000**
Travel Outside Minnesota								

	Other	Various Allowable Travel Costs - Airfare, Lodging, Registration, Ground Transportation, and Meal Per Diem - Twin Cities	Domestic travel to formally present project findings	X				$12,425
							Sub Total	**$12,425**
Printing and Publication								
	Publication	Research Publications	Publication of research findings related to this project					$5,000
							Sub Total	**$5,000**
Other Expenses								
		Lab Services - Twin Cities	Purchase of equipment time (e.g., FTIR spectroscopy, electron microscopy, and other methods to characterize plastics) and lab services related to completing the project work scope					$23,297
		Tuition - Twin Cities	Cover the tuition portion of the Grad RA appointments					$16,931
		Repairs & Maintenance - Twin Cities	Repair and maintenance of equipment to ensure continued use of lab hardware that benefit the aims of this project					$9,313
		General Operating Services - Duluth	General services needed to complete the work scope that includes but is not limited to analysis costs using materials characterization tools such as DSC, SEM, TGA, and FTIR.					$3,000
		Tuition - Duluth	Cover the tuition portion of the Grad RA appointments					$27,003
		General Operating Services - NRRI	The budget for General Operating Services is designed to support the day-to-day activities of NRRI related to the successful completion of the project aims. This includes funding for shipping samples between sites.					$5,000
		Lab & Medical Services - NRRI	UMN Genomic Center: Library preparation and AVITI Freestyle sequencing for metagenomic analysis ($4000 for Y1, $5,500 for Y2, $3,000 for Y3)					$12,500

		Lab & Medical Services - NRRI	Contract Services: (GC-MS equipment time) -This equipment is crucial for detailed chemical analysis of anaerobic digestion byproducts. It will provide valuable data on the composition of by-products formed, which is essential for optimizing processes and identifying potential applications, which will help in completion of project aims.					$3,000
		Tuition - NRRI	Cover the tuition portion of the Grad RA appointments					$29,253
							Sub Total	**$129,297**
							Grand Total	**$822,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Travel Outside Minnesota	Other	Various Allowable Travel Costs - Airfare, Lodging, Registration, Ground Transportation, and Meal Per Diem - Twin Cities	Travel to formally present project findings

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	**-**
Non-State				
In-Kind	University of Minnesota Operating Funding	Indirect costs (Facilities & Administration) - Twin Cities	Pending	$140,583
In-Kind	University of Minnesota Duluth Operating Funding	Indirect costs (Facilities & Administration) - Duluth	Pending	$63,582
In-Kind	University of Minnesota Duluth Operating Funding	Indirect costs (Facilities & Administration) - NRRI	Pending	$200,195
In-Kind	University of Minnesota Operating Funding	1% of key personnel salary & fringe	Pending	$9,223
			Non State Sub Total	**$413,583**
			Funds Total	**$413,583**

Total Project Cost: $1,235,583

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: e5089db1-570.docx

Alternate Text for Visual Component

Left: Three common sources of microplastics: households, industries, and landfilles. Center: Schematic of an anaerobic digestion system with biogas collection and conversion to electricity. Right: Three common uses of digestate: animal bedding, agricultural application, and land restoration.
The project goal is to eliminate microplastics from the anaerobic digestate produced....

Supplemental Attachments

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

Title	File
Board Letter Authorizing Submission 2026-046	5a4e3a6f-0db.pdf
3M Letter of Support for 2026-046	cbc6d7e7-148.pdf
RamWash Recycling and Energy Letter of Support for 2026-046	a1b3b193-ddf.pdf
Amp Americas Letter of Support for 2026-046	fb5d649f-776.pdf
Metropolitan Council Letter of Support for 2026-046	64b93f6d-3a4.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?

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?

No

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:

Andrew Carlson (University of Minnesota - Twin Cities), Megan Gorder (Natural Resources Research Institute), Michael Jacob (University of Minnesota - Duluth)

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