Environment and Natural Resources Trust Fund

2025 Request for Proposal

General Information

Proposal ID: 2025-141

Proposal Title: Biochar to Monitor and Remediate Microplastics

Project Manager Information

Name: Lee Penn

Organization: U of MN - College of Science and Engineering

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Project Basic Information

Project Summary: Microplastics are ubiquitous. We propose to develop a biochar-based method to monitor and sequester microplastics in Minnesota waters.

ENRTF Funds Requested: $546,000

Proposed Project Completion: June 30, 2028

LCCMR Funding Category: Methods to Protect or Restore Land, Water, and Habitat (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?

During the Project

Narrative

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

Microplastics are tiny pieces of plastics that have broken off bigger plastic objects (e.g., clothing, bags) or were intentionally added to products (e.g., plastic manufacturing nurdles). Microplastics pose a major threat to our environment. Organisms both on land and in water ingest microplastics, which can severely disrupt digestion and, in extreme cases, lead to death. In addition, microplastics have the capacity to absorb contaminants such as plasticizers, pesticides, and drug molecules, which means they can serve as carriers for transporting and reservoirs for these pollutants within the environment. Consequently, organisms that consume microplastics can be inadvertently exposed to these harmful substances.

We propose to develop a method for both monitoring and sequestering microplastics in Minnesota Waters with biochar. Biochar is relatively cheap to make and has myriad other benefits, including potential for use in carbon sequestration and treatment of water contaminated with dissolved pollutants. We hypothesize that the properties of biochar will mean that we can monitor microplastics through favorable interactions between biochar and microplastics. In addition, amending biochar with iron-bearing mineral phases could improve the uptake of microplastics by biochar. We will perform both lab-based experiments and field experiments and design and field-test a pilot scale system.

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.

Our team proposes to develop a method to both monitor and remediate microplastics in Minnesota waters.

We propose to do this by:

- Identifying what biochar properties lead to the best uptake of microplastic particles from water
- Identifying whether, and, if so, how, iron-bearing minerals improve efficacy of uptake of microplastics
- Quantifying and identifying microplastics taken up by biochar
- Collecting and characterizing microplastics collected from Minnesota waters using established methods to ground-truth what we learn from the above three activities.

Major Results Expected:

1. New method for monitoring and sequestering microplastics from Minnesota waters
2. Pilot system for testing in the lab using water collected from the field
3. Pilot system for testing in the field

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 team will perform lab-based experiments to identify which biochar properties lead to the best uptake of microplastic particles from water. The team will design and test a pilot biochar-based system for monitoring and remediating microplastics in water. The results from this project will enable the State of Minnesota to develop better approaches to monitoring and remediating microplastic contaminated waters. In addition, the team will give open scientific presentations and publish scientific papers addressing the above objectives.

Activities and Milestones

Activity 1: Lab Studies to Identify Which Biochar Properties Provide the Best Affinity for Microplastic Particles

Activity Budget: $300,000

Activity Description:
We will prepare a series of biochar samples using methods established by the MN Biochar Initiative. We hypothesize that iron-bearing phases will improve uptake of microplastics by biochar. Thus, we will amend a subset of those biochar samples with iron-bearing mineral phases. Then, we will prepare batch reactors containing water spiked with microplastic particles with known size, size distribution, and composition and labeled with a fluorescent dye. The amount of microplastic taken up by the biochar will be quantified by quantifying the microplastic remaining in the water. Columns will be packed with the most promising subset of biochar samples, and the influent will be spiked with the same fluorescent microplastic particles. The effluent will be monitored for the breakthrough of microplastic particles. Results will enable the identification of biochar properties that enable effective removal of microplastic particles from the water. The biochar will be harvested and analyzed for microplastic loading using known analytical methods (pyrolysis with gas chromatography) and examined using electron microscopy.

Activity Milestones:

Description	Approximate Completion Date
Prepare biochar samples with a variety of properties	June 30, 2026
Determine affinity of biochar for microplastics in batch reactors	December 31, 2026
Quantify retention of microplastics by a column packed with the various biochar samples	June 30, 2027
Characterize microplastics sequestered by biochar materials	December 31, 2027

Activity 2: Ground-truthing with Environmental Water Samples and Designing Pilot Scale System

Activity Budget: $246,000

Activity Description:
At least five Minnesota waters will be sampled, and a portion of those samples will be filtered for in order to quantify microplastics and natural particles using previously established methods (based on results from a previous project). A portion of each water sample will be combined with the biochars identified as most effective during Activity 1 in batch reactors, and the partitioning of microplastics between the water and the biochar determined. This will test for potential interference effects due to the presence of components of natural water (e.g., dissolved organic matter). Biochar identified as most effective in the batch reactors will be used to pack columns, and the water samples will be used as influent and the effluent monitored for breakthrough of microplastic (and other) particles and chemical species. Results from these activities will enable the design of a pilot system for testing first in the lab and then in the field.

We will focus on at least five field sites for testing, including three sites within close distance to the St Paul campus to facilitate frequent monitoring (both natural and human-made ponds/wetlands that receive stormwater input).

Activity Milestones:

Description	Approximate Completion Date
Quantifying microplastics in lakes using filtration methods	March 31, 2026
Characterizing partitioning of microplastics between natural water samples and biochar	December 31, 2027
Characterizing breakthrough of microplastics through columns packed with biochar	December 31, 2027
Design and testing of pilot system	June 30, 2028

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Matt Simcik	University of Minnesota - Twin Cities School of Public Health	Dr. Simcik is in the Division of Environmental Health Sciences in the School of Public Health. He is an expert in the fate and transport of organic contaminants in the environment. Dr. Simcik will supervise the lab manager and graduate assistants both in experimental and field work.	Yes
Melissa Maurer-Jones	University of Minnesota - Duluth	Dr. Maurer-Jones is faculty in Chemistry and Biochemistry at UMN-Duluth and will supervise and mentor graduate students at UMN and UMD. She will help coordinate characterization of microplastics from field sites and co-lead field sampling and field experiments. Dr. Maurer-Jones will supervise graduate assistants in both experimental and field work.	Yes
Emilie Snell-Rood	University of Minnesota - Twin Cities College of Biological Sciences	Dr. Snell-Rood will help coordinate field tests of microplastics monitoring via an existing collaboration with the Minneapolis-St. Paul Metropolitan Area Long Term Ecological Research program; existing field sites include several wetlands and stormwater ponds within close distance of the UMN St Paul campus. Dr. Snell-Rood will supervise graduate assistants.	Yes
Giniw (Colin Eagle)	Leech Lake Tribal College	Giniw will lend his expertise in the collection and characterization of microplastics to coordinate and implement field sampling and testing and supervise and mentor undergraduate students at Leech Lake Tribal College. Giniw will recruit undergraduate students for summer positions focused on fieldwork.	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?

Results from this project will enable the State of Minnesota to develop better approaches to monitoring and remediating microplastic contaminated waters. The results of this project will enable managers of Minnesota's water resources and legislators to better address the issue of environmental contamination. Results will inform next steps, including the design and testing of an apparatus for roadside monitoring of microplastics suspended in the air. The biochars most effective for monitoring and remediating microplastics in water might also prove useful in monitoring microplastics generated via traffic, and the team would seek funding through MnDOT and other funding sources.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Protecting Minnesota Waters by Removing Contaminants from Wastewater	M.L. 2019, First Special Session, Chp. 4, Art. 2, Sec. 2, Subd. 04g	$250,000
Microplastics: Transporters Of Contaminants In Minnesota Waters	M.L. 2021, First Special Session, Chp. 6, Art. 5, Sec. 2, Subd. 04c	$425,000
Pollinator Plantings and the Redistribution of Soil Toxins	M.L. 2022, , Chp. 94, Art. , Sec. 2, Subd. 08e	$610,000
Karner Blue Butterfly Insurance Population Establishment in Minnesota	M.L. 2023, , Chp. 60, Art. 2, Sec. 2, Subd. 08b	$405,000

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 Dr. Lee Penn will be primary project manager. Dr. Lee Penn has a research group of five graduate students and two undergraduate students and collaborates with numerous other research groups on topics related to the environment and pollution in water. Dr. Penn has established, productive collaborations with Drs. Maurer-Jones, Simcik, and Snell-Rood. The collaboration with Giniw is growing out of initial contact with Leech Lake Tribal College from a couple years ago.

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 (also graduate faculty in Water Resource Science and Earth Sciences) and an expert in studying how both natural and anthropogenic materials change under environmental conditions. Dr. Penn has experience synthesizing and characterizing biochar. 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.

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								
Lab Manager		Manage PI lab operations			27.1%	0.24		$17,736
Principal Investigator Penn		Project Manager			37.1%	0.3		$84,917
Co-Principal Investigator Simick		Supervise graduate student;lead sample collection in the field; evaluate data and design experiments.			37.1%	0.27		$72,026
Graduate Research Assistant (Beginner)		Design and execute experiments and sample collection; prepare and characterize biochar; characterize lab and field samples, .			37.1%	1.5		$148,043
Undergraduate Researcher - summer position		Co-advised and working in close collaboration with members of each PI's research group; Design and execute experiments and sample collection; Prepare and characterize biochar materials.			0%	3		$24,000
Co-Principal Investigator Giniw		Supervise undergraduate student; lead sample collection in the field; evaluate data and design experiments.			29%	0.36		$25,367
Co-Principal Investigator Snell-Rood		Supervise graduate student; coordinate and co-lead sample collection in the field; evaluate data and design experiments. Funding is for years 2 and 3 of the project.			37.1%	0.1		$32,317
Co-Principal Investigator Maurer-Jones		Supervise graduate student;lead sample collection in the field; evaluate data and design experiments.			37.1%	0.3		$45,735
Undergraduate Researchers at UMD		Co-advised and working in close collaboration with members of each PI's research group; Design and execute experiments and sample collection; Prepare and characterize biochar materials.			0%	0.75		$15,000
							Sub Total	**$465,141**
Contracts and Services								
University of Minnesota - Twin Cities	Internal services or	User fees for instrumentation (microscopy and spectroscopy for polymer characterization) at the				0		$9,000

Characterization Facility	fees (uncommon)	University of Minnestoa - College of Science and Engineering's Characterization Facility.						
Natural Resources Research Institute	Professional or Technical Service Contract	Fees to pay for biochar characterization using total pore size characterization and other methods.				0		$15,000
UMN Chemical Instrumentation Facility	Internal services or fees (uncommon)	Fees associated with training on and use of instrumentation that will facilitate identification of microplastics collected from lab and field samples of water.				-		$5,000
							Sub Total	**$29,000**
Equipment, Tools, and Supplies								
	Tools and Supplies	Supplies for preparation of small batches of biocar for initial testing	Gases, chemicals, biomass, and vessels for preparation of biochar with different properties - small batches.					$5,000
	Tools and Supplies	Supplies for preparation of large batches of biochar for field testing	Gases, chemicals, biomass, and vessels for prepration of biochar with properties identified as promising from activity one - larger batches.					$5,000
	Tools and Supplies	Standard Microplastic Samples	Standard microplastic samples for in-lab testing of efficacy of uptake by biochar in batch and column experiments					$2,359
	Tools and Supplies	Chemical Supplies	salts, water purification cartridges, glass containers					$10,000
	Tools and Supplies	Filters	Filters for removal of microplastics from experimental and natural waters for comparison to materials collected by biochar materials. This will be an essential comparison.					$12,000
	Tools and Supplies	Chemicals (dyes, salts, buffers, and related)	Supplies for identifying microplastic particles in experimental and field water samples					$2,500
	Tools and Supplies	Supplies for construction of lab-based column system (including pumps, column materials, tubing, and connectors)	These supplies will enable testing of biochar using a flow-through reactor with control over the chemistry of the influent and collection of the effluent.					$5,000

	Tools and Supplies	Supplies for building pilot system for field testing, including materials to contain biochar and facilitate collection	This will enable in-field testing of our pilot system					$5,000
							Sub Total	**$46,859**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	Travel to/from field site	Travel to/from field sites for sample collection; travel to/from University of Minnestoa - Duluth and Cass Lake MN for collaborative meetings, sample collection, sample characterization, and team meetings. In addition, funds are included for local conferences.					$5,000
							Sub Total	**$5,000**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$546,000**

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	University of Minnesota	The principal and co-principal investigators will also devote 1% time per year in-kind .	Potential	$26,422
In-Kind	University of Minnesota	In-kind Overhead for administrative and operational expenses that will support the research described within this application.	Potential	$328,369
			Non State Sub Total	**$354,791**
			Funds Total	**$354,791**

Total Project Cost: $900,791

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: 7793c152-db6.pdf

Alternate Text for Visual Component

Microplastics are ubiquitous. The schematic shown here highlights some of the ways in which microplastics enter water. We propose to use biochar as a material for monitoring and remediating microplastic contaminated water....

Supplemental Attachments

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

Title	File
University of Minnesota letter of endorsement	ac81d619-f36.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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?

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, Victoria Troxler, Christina Doherty (all at the University of Minnesota -- Twin Cities)