Environment and Natural Resources Trust Fund

2027 Request for Proposal

General Information

Proposal ID: 2027-467

Proposal Title: Optimizing Benefits of Polymer-Coated Fertilizers on Minnesota Land

Project Manager Information

Name: Boya Xiong

Organization: U of MN - College of Science and Engineering

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Project Basic Information

Project Summary: Strategies to optimize the agronomic, environmental, and economic performances of conventional and biodegradable polymer-coated fertilizers will be developed by assessing the potential release of microplastics into Minnesota's agricultural land.

ENRTF Funds Requested: $549,000

Proposed Project Completion: June 30, 2030

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?

During the Project and In the Future

Narrative

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

Polymer-coated fertilizers (PCFs) are currently sold and applied on around a million acres of sandy soil for corn and potato growth in Minnesota. Our previous studies have shown that PCFs can increase crop yield while reducing nitrogen pollution in Minnesota's crop and soil systems. However, a potential and unresolved environmental concern is whether the PCFs introduce harmful microplastics to Minnesota's land. A lab study showed that the PCFs are cracked during fertilizer slow release, contributing to their breakdown into microplastics by soil abrasion. Microplastics released can move in the soil column, be taken up by crops entering our food, and/or be flushed into tile-drainage, entering surrounding water. Therefore, microplastics from polymer-coated fertilizer may pose potential threats to soil, ecological, and human health. Thus, we need to know 1) the size and concentration of microplastics release from PCF application on croplands, some of which are connected with tile-drainage; 2) to what degree the released microplastic will accumulate in soil, migrate to tile-drainage, and/or be taken up by crop, 3) whether biodegradable PCFs release more or less microplastics compared to conventional products, 4) whether the risk of microplastics, if any, can outweigh the agronomic and N reduction benefit.

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.

Because PCFs are continually applied to Minnesota's agricultural land, information about their breakdown into microplastics is critical. We propose to quantify microplastic release from several commercial products applied to corn and potato plots at the University of Minnesota Research and Outreach Centers in Becker and Waseca over two years. We will determine the levels of microplastics and distribution in Minnesota's agricultural land and surrounding water due to the application of PCFs. We will test different sites with and without tile drainage, and with a range of soil textures, so we can determine how different farm practices and geological settings can influence microplastic migration to the surrounding environment. We will determine whether microplastics are taken up by potato and corn plants, and potential movements from roots to leaves, so we can assess whether we will ingest plastics via consuming food crops. Furthermore, we will compare both conventional products and products marked as biodegradable to determine whether the emerging biodegradable ones release less microplastics. The collected information will be used for a life cycle assessment model comparing the risks of microplastics to the agronomic and N reduction benefits, informing strategies to minimize the negative impacts of these products on Minnesota's agricultural land.

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?

Understanding the loading, transport, and fate of microplastics derived from polymer-coated fertilizers (PCFs) in Minnesota agricultural land will generate outcomes that directly protect and conserve the state's land resources. The project will quantify microplastic release and movement to soils and nearby surface waters, enabling assessment of potential risks to aquatic ecosystems and drinking water sources. It will also evaluate whether microplastics are taken up by crops, informing potential human and livestock exposure through food consumption. Finally, the project will compare conventional and biodegradable PCFs and provide science-based recommendations on lower-risk fertilizer options to reduce environmental contamination while maintaining agricultural productivity.

Activities and Milestones

Activity 1: Quantify polymer-coated fertilizer released microplastics in soil and tile-drainage

Activity Budget: $314,611

Activity Description:
Polymer-coated fertilizer (PCFs) consists of a flexible and micro-thin polymer membrane encapsulating nitrogen granules. Water taken up by the membrane can dissolve the granule but can also swell and crack the membrane, releasing microplastics. Additionally, sunlight, soil abrasion, and machinery forces could tear apart the soft membrane into microplastics. Biodegradable PCFs can be degraded by microorganisms and might release microplastics faster than conventional types. We know that microplastics can reside in soil, or travel vertically, or be flushed into nearby water via tile-drains, negatively impacting soil health and water quality. Thus, we will assess the release of microplastics from conventional and biodegradable PCFs on experimental corn and potato production fields with and without tile-drains. Different soil textures could impact the transport of microplastics and will be studied. Fertilizers will be applied at a previously determined rate that generates the best environmental benefits (e.g., N loss reduction), expanding two growing seasons in 2027 and 2028. Following the fertilizer application, soil and tile-drain water samples will be collected and analyzed for microplastics using a combined micro-Raman spectroscopy and pyrolysis gas chromatography mass spectrometry. We will also sample sites with PCFs applied 2-10 years ago to evaluate microplastic release beyond two years.

Activity Milestones:

Description	Approximate Completion Date
Finalize fertilizer product list and verify polymer composition of original products	October 31, 2027
Optimize extraction and analytical methods using micro-Raman and py-GCMS	June 30, 2028
Determine baseline concentration of microplastics in the studied sites	June 30, 2028
Determine concentration of microplastics in sites applied with fertilizers 2-10 years ago	June 30, 2029
Apply fertilizer products to and maintain study sites	October 31, 2029
Determine microplastics released from fertilizers in soil and tile-drain sample	June 30, 2030
Manuscript preparation and submission	June 30, 2030

Activity 2: Quantify polymer-coated fertilizer-derived microplastics in crop tissue.

Activity Budget: $157,306

Activity Description:
Microplastics found in agricultural soils have been shown to be taken up by plants and crops, presenting a potential animal and human health risk associated with the ingestion of food contaminated with microplastics. The health effects are beyond just the microplastic particles themselves, but also their associated chemicals (e.g., PFAS, pesticides) and potential pathogens. Thus, it is important to understand if and how the released microplastics can be taken up by crops, especially potatoes, as a root vegetable. We will compare the concentration of polymers in the root, stem, and leaves of potato and corn, harvested by the end of each growing season, using the pyrolysis gas chromatography mass spectrometry method. We will determine the extent of microplastic contamination from PCFs in our food systems. To determine their agronomic and environmental benefits, we will also measure and compare the nitrogen use efficiency by the crop, residual nitrogen in the soil, and crop yield in response to different fertilizer treatments. The data will be used to determine the tradeoff between environmental benefits (N loss reduction) and damage (microplastic release) of the PCFs.

Activity Milestones:

Description	Approximate Completion Date
Optimize analytical methods to analyze polymer in crops	December 31, 2028
Determine concentration of microplastic polymer in crops	December 31, 2029
Determine agronomic and environmental benefits	December 31, 2029
Manuscript publications	June 30, 2030

Activity 3: Holistically assessing the environmental risks and benefits of polymer-coated fertilizers, considering microplastics

Activity Budget: $77,083

Activity Description:
Using information on the release and migration of microplastics from and agronomic and nitrogen management benefits of PCFs obtained from Activities 1 and 2, we will leverage an existing life cycle assessment model for sustainable agriculture technology to perform gate-to-gate analysis. Specifically, we will compare the potential ecotoxicity and human health risks of released microplastics to the environmental benefits of N loss reduction (e.g., reduction in global warming potential and eutrophication potential). Using this information, we will inform whether the release of microplastics will outweigh the benefit of N loss reduction, or will inform how much less microplastic release is acceptable for future biodegradable PCF products. Input from stakeholders, industrial manufacturers, and farmers will be sought to maximize the potential impact of the recommendations and the extent of Minnesota's agricultural land resilience.

Activity Milestones:

Description	Approximate Completion Date
life cycle assessment model development	June 30, 2029
Gate-to-gate LCA analysis of different products	December 31, 2029
Recommendations and communication with stakeholders	March 31, 2030
Manuscript/report publication	June 30, 2030

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Boya Xiong, Ph.D.	University of Minnesota, Twin Cities, Department of Civil, Environmental, and Geo-Engineering	PI, supervising and leading the entire project.	Yes
Fabian Fernandez	University of Minnesota, Twin Cities, Department of Soil, Water, and Climate	Co-PI. Supervise the application of polymer-coated fertilizer in the experimental crop field.	Yes
Carl Rosen	University of Minnesota, Twin Cities, Department of Soil, Water, and Climate	Co-PI, supervise field experiments of the application of polymer-coated fertilizer	No

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.
For each of the activities, results will be disseminated by peer-reviewed publications in archival journals. Data will also be archived in the open-access data repository for the University of Minnesota. Results will also be communicated to the stakeholders through the Minnesota Extension Nutrient Management Group and other avenues. Co-PIs Fernandez and Rosen are members of the Nutrient Management Group that regularly post video, blogs, and podcasts with extension content to a broad reach to stakeholders across Minnesota. We will also present our findings at the flagship Minnesota Nutrient Management and Nitrogen Conferences, with over 400 attendees annually, including farmers, crop consultants, the agriculture industry, and state agencies that directly and indirectly impact 11.9 million acres of Minnesota's farmland. Co-PIs Fernandez and Rosen also have a close working relationship with MPCA and MDA, and we will incorporate agencies' inputs into our study design and disseminate our outcomes. Co-PI Rosen has published a large review study with the MPCA on strategies to reduce N and P pollution in Minnesota. PI Xiong has established regular communication with personnel from the Water Quality Standards Unit of the Minnesota Pollution Control Agency (MPCA). They are the only personnel at the state level who are actively involved in sampling and measuring the scope of microplastic contamination in Minnesota's water and are involved in developing regulatory guidelines from their data. They will unofficially support the technical aspects of this project and leverage the data generated from this project for risk assessment and to develop guidelines for drinking water in the karst region. Lastly, results from the project will also be presented at scientific conferences, including national conferences. The Environment and Natural Resources Trust Fund will be acknowledged through use of the trust fund logo or attribution language on project print and electronic media, publications, signage, and presentations.

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 will be implemented through engaging stakeholders via the UMN Extension Nutrient Management Group and beyond. Co-PIs Fernandez and Rosen are active members who regularly produce videos, blogs, and podcasts reaching statewide stakeholders. Findings will also be presented at the Minnesota Nutrient Management and Nitrogen Conferences, with over 400 annual attendees, including farmers, industry representatives, and state agencies influencing 11.9 million acres of farmland. The team maintains strong collaborations with the MPCA and MDA, incorporating agency input and disseminating results. Data and models will be publicly available through the UMN Data Repository, with additional funding pursued to support long-term.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Impact of Microplastics on Wastewater Treatment in Minnesota	M.L. 2025, First Special Session, Chp. 1, Art. 2, Sec. 2, Subd. 04u	$506,000

Project Manager and Organization Qualifications

Project Manager Name: Boya Xiong

Job Title: Assistant Professor

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

Dr. Boya Xiong is a McKnight Land-Grant assistant professor in the Department of Civil, Environmental, and Geo-Engineering at the University of Minnesota. She obtained her PhD from Penn State University in 2018 and was a postdoc at MIT until 2020. She has 11 years of experience in studying the fate and degradation of emerging contaminants derived from polymer chemicals and plastic wastes, and the design of membrane filtration for water and wastewater treatment. She has 36 manuscripts published in high-impact peer-reviewed journals, including Nature, on these topics. She has extensive expertise in all the analytical techniques used for quantifying and identifying microplastics in water samples. Her group at the University of Minnesota developed various novel tools using atomic force microscopy (AFM) for understanding the key processes that generate nano- and micro-sized plastics from bulk plastic degradation. Via an ongoing ENTRF-funded work (as a co-PI), her team developed micro-Raman spectroscopy and nano-infared spectroscopy based detection methods to quantify microplastics in municipal wastewater and vulnerable groundwater in Minnesota. Dr. Xiong will lead the microplastic sample analysis of the collected soil, water, and plant samples.

Organization: U of MN - College of Science and Engineering

Organization Description:

The University of Minnesota (UMN) is one of the largest, most comprehensive, and most prestigious public universities in the United States. The College of Science and Engineering at the University of Minnesota is ranked among the top engineering and science 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, designing new medical devices, improving digital and electronic technologies, and developing a strong national infrastructure. The College of Science and Engineering also offers students a rigorous, world-class education tailored to their interests and goals. The Department of Civil, Environmental, and Geo- Engineering (CEGE) at UMN is known for its pioneering work in analytical, computational, and experimental methods. We practice research excellence grounded in rigorous fundamentals for wide-ranging applications. The

laboratories in CEGE and centralized research facilities have all of the necessary space and equipment to perform the proposed work.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Dr. Boya Xiong/principal investigator		Principal Investigator; Leading and supervising the project. Responsible for microplastic sampling and analysis, grad student advising, publication, and outreach			36.6%	0.06		$52,130
Undergraduate student (UMN)		Students will assist with sampling and microplastic analysis			0%	0.08		$8,075
Staff Thor Sellie		This researcher will assist with plots and field experiments and daily maintenance.			32.3%	0.66		$67,776
Graduate student research assistant		Students will work on sampling and microplastic analysis			24.2%	1.65		$220,196
Staff Matthew McNearney		This researcher will assist with plots and field experiments and daily maintenance.			32.3%	0.66		$58,658
Researcher 6		This researcher will assist in collecting crop and soil samples for crop yield and N use efficiency data.			36.6%	0.3		$28,589
Co-PI: Dr. Fabian Fernandez		Oversee the field experimental setup, sampling, analysis related to crop and soil N.			36.6%	0.3		$29,576
							Sub Total	**$465,000**
Contracts and Services								
Lab services	Internal services or fees (uncommon)	Characterization facility Raman spectroscopy and AFTR-FTIR at UMN Minneapolis campus; N analysis of soil.				0		$42,000
							Sub Total	**$42,000**
Equipment, Tools, and Supplies								
	Tools and Supplies	Laboratory and field work supplies for the collection of water samples, microplastic analysis, and soil and water sampling (no single item will exceed $5,000)	These supplies will be used to complete application of fertilizer on soil plots and the analyses of microplastics.					$18,000

							Sub Total	**$18,000**
Capital Equipment								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	Cost to cover field trips to plot setup, maintenance, and collect samples for microplastic analyses. Budgeted for two people on each trip. Meals each trip, including lunch and dinner for two people, are included. Each trip would be 140 or 100 miles, depending on the location.	Up to six field trips each year and 18 total. These field trips will be used to collect all samples that will be analyzed. Monies for food for two people to support the sample collection.					$12,000
	Conference Registration Miles/ Meals/ Lodging	Attend the in state conference each year in year 2 and 3 once each year in Mankato (160 miles each trip) for two person.	To attend the Minnesota Nutrient Management and Nitrogen Conferences					$4,000
							Sub Total	**$16,000**
Travel Outside Minnesota								
	Conference Registration Miles/ Meals/ Lodging	two travels of project PI and one graduate student to outside MN conference (e.g. Association of Environmental Engineering and Science Professors (AEESP) Research and Education Conference or Gordon Research Conference, Environmental Science Water	To give formal presentation on project findings and identify further collaboration and secure federal funding	X				$8,000
							Sub Total	**$8,000**
Printing and Publication								
							Sub Total	**-**
Other Expenses								

							Sub Total	**-**
							Grand Total	**$549,000**

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
Travel Outside Minnesota	Conference Registration Miles/Meals/Lodging	two travels of project PI and one graduate student to outside MN conference (e.g. Association of Environmental Engineering and Science Professors (AEESP) Research and Education Conference or Gordon Research Conference, Environmental Science Water	To give a formal presentation on project findings and identify further collaboration, and secure federal funding. Such collaboration could lead to more advanced risk assessment for microplastic pollution in Minnesota from fertilizers and inform strategies to minimize the effect while still achieving nutrient loss reduction.

Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	**-**
Non-State				
In-Kind	No funds required	Dr. Gilbertson will support work on activity 3. No monies will be required for this work.	Secured	-
			Non State Sub Total	**-**
			Funds Total	**-**

Total Project Cost: $549,000

This amount accurately reflects total project cost?

Yes

Attachments

Required Attachments

Visual Component

File: b648026e-09c.pdf

Alternate Text for Visual Component

Polymer-coated fertilizer can break down into microplastics that may enter crop, water, and soil. Tradeoff between N loss reduction and microplastic risks should be evaluated to identify nutrient management strategies that do not cause additional harm to soil, ecosystem, human health, and land resilience....

Supplemental Attachments

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

Title	File
SPA letter	c4ad7ab1-ba4.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?

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:

Boya Xiong

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