Environment and Natural Resources Trust Fund

2023 Request for Proposal

General Information

Proposal ID: 2023-165

Proposal Title: Predicting and Preventing Microplastic Pollution in Minnesota Waters

Project Manager Information

Name: Boya Xiong

Organization: U of MN - St. Anthony Falls Laboratory

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Project Basic Information

Project Summary: We will study and model the generation of nano/microplastic from photoweathered bulk plastic of different types and offer strategies preventing fragmentation, enabling collection, and reducing plastic pollution in Minnesota's waterways

Funds Requested: $497,000

Proposed Project Completion: June 30, 2026

LCCMR Funding Category: Water Resources (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?

During the Project and In the Future

Narrative

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

Around 25% of plastic quickly turns into waste that is difficult to collect or recycle. Plastic pollution leaks into Minnesota's water where it can break down into very small particles (nano- and micro-size). These particles threaten Minnesota's water resources because: 1) microplastic can be eaten by aquatic organisms, and 2) microplastic releases/ adsorbs toxic contaminants. Citizens can also consume microplastics via eating or drinking plastic-tainted food or beverages. Looking forward, the quantity of microplastic in Minnesota's water is likely to double in 13 years due to 1) a recent collapse of international recycling markets; 2) a rapid growth trajectory of plastic production; and 3) surge in disposable plastic masks and waste due to COVID 19. Once they are in the ecosystem, microplastics are difficult to capture. It is thus imperative to understand the mechanisms of fragmentation from bulk plastic sources (bottles, fabrics, films, etc.) so we can know how much pollution is there and when and how to capture bulk plastic waste before it turns into microplastics. Plastic breakdown can depend on the type of plastic and the environmental conditions it is exposed to, such as sunlight, shear and abrasion from water, wind, and waves moving sediments in stream flows.

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.

We approach the problem in three steps: 1) understanding and modeling the formation of micro- and nano- plastic from bulk macro- plastic breakdown, e.g. bottles, cups, fibers, and bags, exposed to Minnesota weather in lakes and streams; 2) providing engineering solutions to intercept macro- plastic in fluvial environment based on their density and proclivity to be trapped in key areas of rivers, streams, and lakes; 3) engaging all age Minnesotans to crowdsource plastic pollution data combining waterway cleanups with a mobile app. The public engagement piece will provide data on the location and type of plastic found along waterways, will provide much needed cleanups, and will help to educate Minnesotans across all age groups on the fate of plastic in Minnesota's water.

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?

Microplastics represent an urgent and pervasive problem in Minnesota's environment. Our project will provide a range of solutions on understanding microplastic formation and collection of bulk plastic. Understanding how different plastic products contributing to microplastic formation can raise public awareness of reducing plastic use and provide new guideline for manufacturers to design sustainable plastics. Our educational component will mirror the progress in our understanding of microplastic formation in the environment and engage citizens in periodic clean up and collection operations. The outcome of this work is expected to reduce the impact of microplastic pollution in Minnesota's waterways and ecosystem.

Activities and Milestones

Activity 1: Understanding: How and how fast nano/microplastic generates from bulk photoweathered plastic under stream flow and waves

Activity Budget: $182,708

Activity Description:
Plastic that remains at the surfaces of water and soil are exposed to sunlight for a long time, which makes plastic brittle. Plastic can then fragment and be abraded by sediment and turbulent flows into nano/microplastics. We will first expose a variety of single-use plastics in a large-scale solar chamber to simulate Minnesota's sunlight. We will then measure the breakdown of photoweathered plastic in two lab-scale flow experiments that simulate 1) a stream flow with different flow rates and 2) a wavy lake shore at different wind speeds, with and without the presence of sediment loads. We will monitor how bulk plastic will reduce in mass, as nano/microplastics are generated and dispersed. This data will enable us to develop models that will predict how long bulk plastic can remain in the Minnesota environments before breaking down into microplastics. The model will be verified with experimental results in Outdoor StreamLab (OSL). The outcome of this activity allows us to know how quickly collection systems have to operate before breakdown plastics are too small to be captured. Manufacturers can learn from which plastic materials are more prone to pollute our environment to responsibly design future plastic products.

Activity Milestones:

Description	Completion Date
Photoweather a diversity of plastics in a solar chamber that simulates Minnesota's climate	December 31, 2023
Determine the rate of microplastic generation from bulk plastic by stream flows and sediment abrasion	December 31, 2024
Determine the rate of microplastic generation from bulk plastic by shore waves and sediment abrasion	December 31, 2024
Construct a model to predict microplastic generation and validate with Outdoor StreamLab experiments	June 30, 2025
Publication/dissemination of results	December 31, 2025

Activity 2: Solutions: How to reduce microplastic formation and improve macro- plastic collection

Activity Budget: $168,912

Activity Description:
Engineering solutions will be provided for both prevention and collection. The validated fragmentation model in activity 1 will inform us which plastics are more subject to fragmentation based on local weather, and thus are more likely to be microplastic sources. We will then investigate collection strategies based on the ability of plastic materials to float, settle, be trapped in vortical motions, as bubbles tend to do, or swirl out of vortices as sediments tend to do. We will test collecting strategies in stream flows, using the field-scale OSL at SAFL. By creating create an array of flow recirculation regions using porous grid or vegetation patches where macro- plastic and floating particles are expected to remain trapped to facilitate a periodic collection. Weathered bulk plastic particles of different size and density will be fed and tracked along OSL, opportunely modified to test both trap and collection. The outcome of this activity will inform how effectively bulk plastics can be trapped and collected before they become a source for releasing micro or nanoplastic that cannot be captured.

Activity Milestones:

Description	Completion Date
Design and test different flow recirculation collection spots using natural or artificial canopies	June 30, 2025
Quantify large plastic particle collection in meandering streams with or without flow recirculation areas	December 31, 2025
Publication/dissemination of results	June 30, 2026

Activity 3: Education and Broadening Participation: how to improve our ecosystem with an engaging citizen science

Activity Budget: $145,380

Activity Description:

Once nano/microplastic are diffused in our waterways, most cleanup activities have limited effectiveness. Thus, we need to intervene early and prevent pollution at its source. We could reduce use and advocate for better materials by informing citizens about the impact of their action towards plastic on the environment. More importantly, engaging citizens to collect plastic waste in our waterways and crowdsourcing the plastic pollution information in Minnesota will allow us to1) identify areas where plastics accumulate, 2) predict hotspots of microplastic pollution using our model, 3) develop solutions to collect plastic waste in Minnesota's waterway, 4) educate our citizens to reduce plastic use and littering. We aim to leverage an existing mobile app called Marine Debris Tracker to run a Minnesota state-wide campaign of volunteer cleanups through Minnesota's Adopt-A-River program (1-2 river reaches per year) and partnering with local stakeholders to collect plastic waste in Minnesota waterbodies. Citizens can report observed plastic pollution, but also provide the GPS location and the flow and weather conditions, which will be used by our model to predict local microplastic concentration. This last synergistic activity at a state level will broadly mitigate plastic pollution and its impact on Minnesota.

Activity Milestones:

Description	Completion Date
Inform citizens on the evolution of plastic waste in our environment through a project website	December 31, 2025
Organize strategic volunteer river and lake cleanups and crowdsource plastic data using a mobile app	June 30, 2026
Use the collected data to predict microplastic concentration in Minnesota	June 30, 2026
Engage with industry and other state agencies through a public seminar to disseminate results	June 30, 2026

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Michele Guala	University of Minnesota, Twin Cities, Department of Civil, Environmental and Geo-Engineering	Dr. Guala's research primarily focuses on experimental fluid dynamics, river morphodynamics, and particle turbulence interactions in geophysical flows. He is familiar with SAFL experimental facilities, including laboratory flumes and the SAFL Main Channel. Dr. Guala will supervise one PhD student to the segregation strategy and collector design of macroplastic	Yes
Jessica Kozarek	University of Minnesota, Saint Anthony Fall Lab	Jessica Kozarek has experience in the design of Outdoor SteamLab experiments, measuring complex flows and turbulence in meandering streams and flume experiments, and tracking the fate and transport of pollutants. Dr. Kozarek will oversee and organize the OSL experiments, river clean ups, and citizen science efforts.	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?

Plastic pollution and its effects on aquatic life and human health continues to be a major concern for Minnesota, in part, because there are few solutions once small plastic particles are dispersed in the environment. The results will be disseminated to industry, MPCA, practitioners, and other state agencies through a public seminar, designated website construction, open access publications, direct meetings, and conference presentations. If additional work is needed, Dr. Xiong will seek funding at National science Foundation and polymer industry partners.

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. Xiong is an assistant professor at the University of Minnesota in the Department of Civil, Environmental, and Geo-Engineering. Her research primarily focuses on advanced material and chemical analysis to understand polymer degradation, in particular how nano/ microplastics are generated from bulk plastic. She is also developing advanced mass spectrometry-based tools to identify degraded plastic chemicals that could potentially be toxic. Dr. Xiong will supervise one PhD student to laboratory scale plastic fragmentation experiments and conduct plastic analysis during degradation and counting and analyzing generated nano/microplastics. She will also oversee the overall project and the research team.

Organization: U of MN - St. Anthony Falls Laboratory

Organization Description:

The University of Minnesota is one of the largest, most comprehensive, and most prestigious public universities in the United States, leading research areas including water quality and material science (http://www1.umn.edu/twincities/01_about.php). The laboratories of the PI and/or core facilities at the University of Minnesota contain the entire essential fixed and moveable instrumentation needed for the proposed studies.

SAFL is an interdisciplinary fluid mechanics research facility of the College of Science and Engineering at the University of Minnesota. SAFL research focuses on environmental, energy, and health challenges. SAFL provides key instrumentation and expertise for the study of turbulence and sediment in rivers and streams, and for understanding interactions

between channels, waves, wind driven flows and pollutant dispersion. The experimental portion of this project is centered at SAFL because of the flumes, wave generation facilities, and data collection systems for high accuracy sensor positioning and sampling (http://www.safl.umn.edu/services/measurements). SAFL also has a sediment laboratory available for grain size analysis.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Project Manager		Dr. Xiong is an assistant professor at the University of Minnesota in the Department of Civil, Environmental, and Geo- Engineering. Her research primarily focuses on advanced material and chemical analysis to understand polymer degradation, in particular how nano/ microplastics are generated from bulk plastic. She is also developing advanced mass spectrometry-based tools to identify degraded plastic chemicals that could potentially be toxic. Dr. Xiong will supervise one PhD student to laboratory scale plastic fragmentation experiments and conduct plastic analysis during degradation and counting and analyzing generated nano/microplastics. She will also oversee the overall project and the research team.			33.5%	0.09		$14,300
Co-investigator		Dr. Guala's research primarily focuses on experimental fluid dynamics, river morphodynamics, and particle turbulence interactions in geophysical flows. He is familiar with SAFL experimental facilities, including laboratory flumes and the SAFL Main Channel. He also designed a small-scale laboratory flume with recirculation of sediment that will be easily implemented in activity 1 of the proposed plan. Dr. Guala will supervise one PhD student dedicated to the segregation strategy and collector design of macro- plastic particles in stream flows and will co-design laboratory scale plastic fragmentation experiments.			33.5%	0.6		$14,300
Co-investigator		Jessica Kozarek has experience in the design of OSL experiments, measuring complex flows and turbulence in meandering streams and flume experiments, and tracking the fate and transport of pollutants. Dr. Kozarek will oversee and organize			33.5%	0.6		$77,627

		the OSL experiments, river clean ups, and citizen science efforts.						
lab staff-1		Assist with lab scale flow device			33.5%	2		$8,010
lab staff-2		Assist with OSL operation			33.5%	2		$8,010
Graduate students-1		Perform laboratory scale plastic fragmentation experiments and conduct plastic analysis during degradation and counting and analyzing generated nano/microplastics			23.6%	1.5		$154,783
Graduate students-2		Perform experiments on segregation strategy and collector design of macro- plastic particles in stream flows and will co-design laboratory scale plastic fragmentation experiments.			23.6%	1.5		$154,783
Undergraduate researcher-1		Assist graduate student 2			0%	0.1		$8,000
Undergraduate researcher-2		Assist graduate student 2			0%	0.1		$8,000
							Sub Total	**$447,813**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								
	Tools and Supplies	OSL and SAFL supplies	Supplies, pumps, cameras, for operating OSL and lab scale flow device					$20,000
	Tools and Supplies	Polymer and microplastic analysis	Polymer sample, characterization, and instrument time for microplastic analysis					$14,687
	Tools and Supplies	Instrument maintenance	UV chamber supplies (light bulbs) to simulate Minnesota weather					$1,500
	Tools and Supplies	Laboratory Supplies	Chemicals, solvents, materials, and labware necessary to perform the experiments					$1,000
							Sub Total	**$37,187**
Capital Expenditures								
							Sub Total	**-**

Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	Attend volunteer cleanups	Organize activity 3					$4,000
	Conference Registration Miles/ Meals/ Lodging	Conference attendance by graduate students (2 conference for each student)	Disseminate results					$2,000
							Sub Total	**$6,000**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Publication	Open access journal fees	maximize dissemination of results of the project					$6,000
							Sub Total	**$6,000**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$497,000**

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				
			Non State Sub Total	**-**
			Funds Total	**-**

Attachments

Required Attachments

Visual Component

File: 99b714ae-f50.pdf

Alternate Text for Visual Component

Minnesota waterways are contaminated with bulk plastics and microplastics. We measure and develop models to predict how fast microplastics are forming from bulk plastics and design hydrology solutions to mitigate it. An mobile app will be used to organize citizen scientists to crowdsource plastic pollution data and river cleanup....

Optional Attachments

Support Letter or Other

Title	File
LOC 1078320 Xiong	1f0e1ecd-817.doc

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?

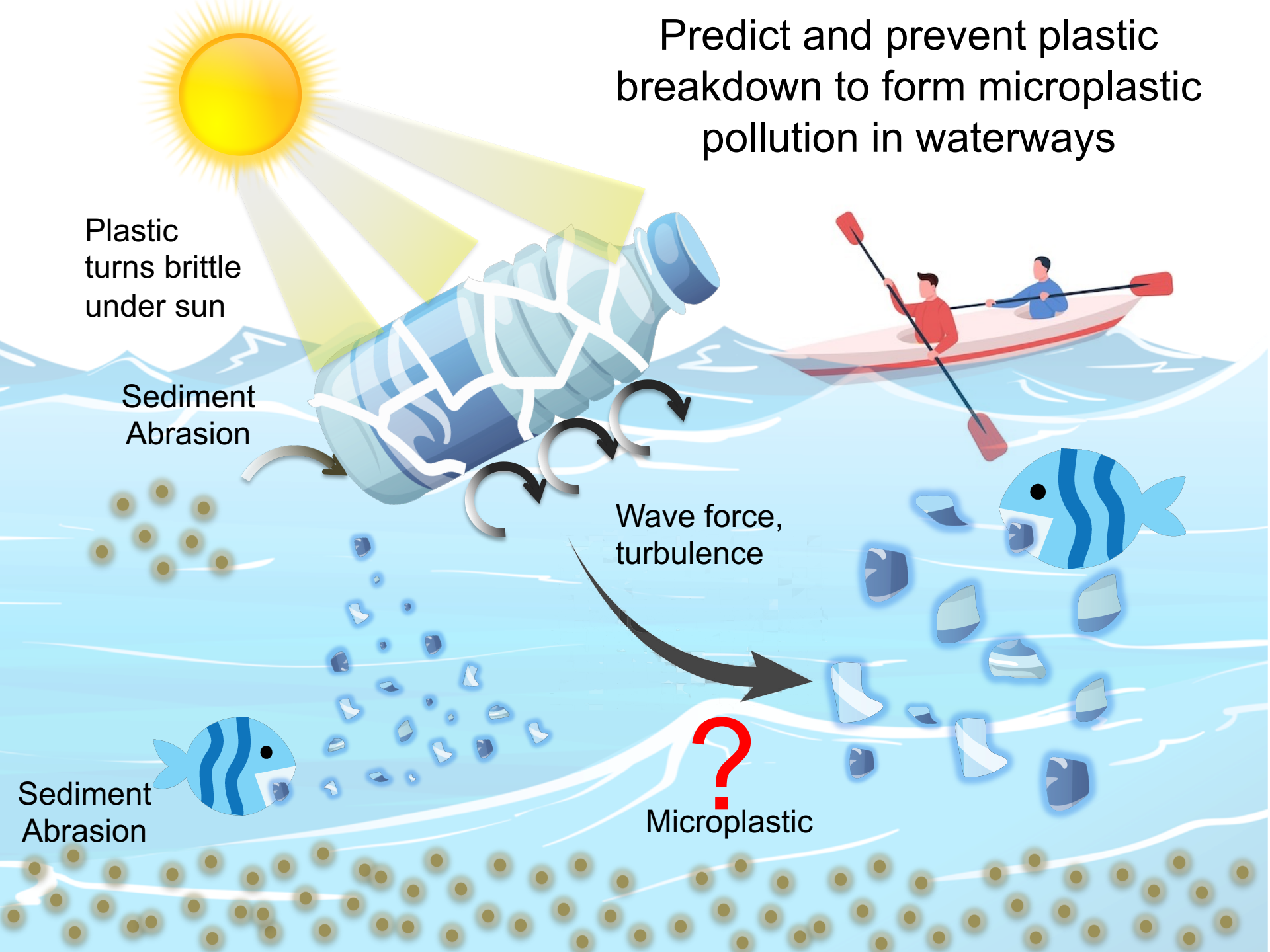
N/A

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration


Predict and prevent plastic breakdown to form microplastic pollution in waterways
Plastic turns brittle under sun
Sediment Abrasion
Wave force, turbulence
Sediment Abrasion
?
Microplastic