Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-355

Proposal Title: Microplastics in Minnesota Water and Impact on Wildlife

Project Manager Information

Name: Lian Shen

Organization: U of MN - St. Anthony Falls Laboratory

Office Telephone: (612) 624-2022

Email: shen@umn.edu

Project Basic Information

Project Summary: We will conduct computer simulations and laboratory experiments to study microplastics pollution to investigate their transport in water columns and sedimentation at water bottoms, and their interactions with wildlife.

Funds Requested: $317,000

Proposed Project Completion: 2024-06-30

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.

Microplastic pollution in water has become an increasingly serious environmental problem in recent years. Being small in size, microplastics can easily escape waste water treatment systems and be consumed by fish accidentally, which further affect a wide range of wildlife in the ecosystem and ultimately human being. Research and news reports have shown the severity of microplastic pollution in Minnesota waters with their massive appearances in rivers and lakes, even in beers and tap water. When it comes to the study of microplastics, efforts have been made to collect their samples at the surface of rivers and lakes. However, the transport of microplastics under water and their sedimentation are rarely addressed in previous research, largely owing to the difficulties in conducting experiments in the water columns and at the bottoms of lakes and rivers. Considering the numerous wildlife threatened by the massive appearance of microplastics in Minnesota's water system, there is a critical need to study their transport and fate related to wildlife.

What is your proposed solution to the problem or opportunity discussed above? i.e. What are you seeking funding to do? You will be asked to expand on this in Activities and Milestones.

This proposed project will be a second step in research following the ENRTF project "Assess and Develop Strategies to Remove Microscopic Plastic-Particle Pollution from Minnesota Water Bodies" (M.L. 2018, Chp. 214, Art. 4, Sec. 2, Subd. 04b), in which Dr. Lian Shen is a co-investigator together with Dr. Filippo Coletti. In the on-going study, which is the first step in research, focuses are placed at a fundamental understanding of the motions of microplastic particles with a spherical shape at water surfaces. The knowledge gained from the present study will establish a scientific basis for the assessment and strategy development of microplastic pollution. For the next step, there is a critical need to study the transport and fate of microplastic particles of general geometries under water and near bottom, and their interactions with fish, which will be the focus of this proposed project. We will continue to use simulations on supercomputers and experiments using state-of the-art facilities. To study the impact on wildlife, representative fish in Minnesota waters will be modeled in our study. We will investigate a wide variety of scenarios that occur in Minnesota water system to quantify the impacts of microplastics.

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 outcome of this project will be the data and models of the motions and fate of microplastic particles encountered in Minnesota water bodies, in terms of: (1) Effects of particle shape. In existing studies in the literature, the particles are usually assumed to be spherical, which is often not the case in reality. (2) Motions and fate at water bottom. Compared with existing studies focusing on the water surfaces, knowledge on microplastic particles under water associated with the sedimentation processes is critically needed. (3) Impacts on widelife. The study on microplastic particles near fish will be of great value.

Activities and Milestones

Activity 1: Computer simulation of microplastics in Minnesota's water system

Activity Budget: $95,400

Activity Description:
Recent research shows that microplastics commonly seen in Minnesota lakes and rivers are fibers and fragments. Therefore, we will focus on fibers and fragments of different shapes and concentrations. We will also incorporate a number of representative river and lake topographies in Minnesota to our computer simulations. The simulation results will be validated using the experiment results obtained in Activity 2. The background flow simulation will also be validated using field measurement data of lakes and rivers in Minnesota. After the validation, microplastic particles of different type, shape and concentration will be systematically investigated in the simulation, and the transportation and sedimentation of the microplastics will be analyzed.

Activity Milestones:

Description	Completion Date
Dataset of base flow in rivers and lakes with validation	2022-06-30
Dataset of the motions of microplastic fibers and fragments of different shapes	2023-06-30
Establishment of a computer-based prediction tool for microplastic particles motions and fate	2023-12-31

Activity 2: Conduct field investigation and laboratory experiments to validate simulation model

Activity Budget: $126,200

Activity Description:
The Saint Anthony Falls Laboratory is a world-renowned laboratory equipped with state-of-the-art experiment facilities for environmental fluid flow studies. We will perform experiments for microplastic particles of a variety of representative shapes in the flumes in the lab. Moreover, the lab has an innovative Outdoor StreamLab, which can model natural water environment accurately. We will measure the velocity, rotation, and spatial centration distributions of microplastic fibers and fragments in flumes and in the Outdoor StreamLab. The dataset will be used to calibrate and validate the computer simulation results obtained in Activity 1.

Activity Milestones:

Description	Completion Date
Dataset on microplastic particles velocity and ambient flow velocity	2022-09-30
Dataset on microplastic particles rotation and its dependence on the particle shape	2023-03-31
Dataset on microplastic particles dispersion distance at water bottom	2023-09-30

Activity 3: Study microplastic particles interacting with fish in Minnesota's water system

Activity Budget: $95,400

Activity Description:
In this activity, we will perform the first-ever study on the motions of microplastic particles interacting fish. We will start the computer simulation with fish swimming motions. Fish body geometry and movement will be represented accurately in our computation. To consider the accident ingestion of microplastics, when a particle is near a fish's mouth area, its motion will be tracked. A great advantage of computer simulation based study is that the entire process

of microplastic particles entering the fish mouth can be recorded in detail in virtual reality. We will estimate the frequency of fish accidently eating microplastic particles. The results will be used to develop a model to quantify the number of microplastic particles consumed by fish.

Activity Milestones:

Description	Completion Date
Database of microplastic particle motions near fish	2023-12-31
Establishment of a model for the statistics of the intake of microplastic particles by fish	2024-06-30

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 be funded?

From this project, knowledge on the transport and sedimentation of microplastics of general shape in Minnesota rivers and lakes will be greatly enhanced, and their impacts on wildlife will be quantified. We will dissimilate the research results through reports, website, journal papers, and seminars. The information on the different types of microplastics in water column and at water bottom will serve as important resources with great reference values for developing strategies to migrate the impacts of microplastics on wildlife.

Project Manager and Organization Qualifications

Project Manager Name: Lian Shen

Job Title: Professor and Director

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

Lian Shen is the Director of the St. Anthony Falls Laboratory and a Professor in the Department of Mechanical Engineering at University of Minnesota, Twin Cities. He earned his Doctor of Science degree from Massachusetts Institute of Technology (MIT) in 2001. After three years of postdoctoral training at MIT, he joined the faculty of Johns Hopkins University in 2004. In 2012, he was recruited by University of Minnesota to join its faculty. Shen is a world expert on the study of environmental fluid flows and renewable energy. He is currently serving on the national committee of ASCE Environmental & Water Resources Institute on CFD Applications in Water and Wastewater Treatment. He is also on the editorial boards of three internal academic journals. Shen has organized several national and international conferences and symposiums.

Organization: U of MN - St. Anthony Falls Laboratory

Organization Description:

This project will be performed at the St. Anthony Falls Laboratory (SAFL, http://www.safl.umn.edu) at University of Minnesota. SAFL is an interdisciplinary fluid mechanics research and educational institution. It has 22 faculty members and 35 research and administrative staff members. SAFL is a world-renowned research laboratory specialized in environmental and engineering fluid mechanics. SAFL researchers have been performing many innovative environmental studies for the state of Minnesota. Some of the projects were/are funded by the Minnesota Environment and Natural Resources Trust Fund.

The proposed research leverages on the unique and advanced capability of measuring environmental flows at SAFL, which has 16,000 ft2 of research space dedicated to physical modeling and experimentation. The facility, which has recently been upgraded with a $16M renovation, has a wind tunnel and 15 general purpose flumes, tanks, and channels readily configurable to the needs of the projects. The SAFL wind tunnel is equipped with the ability to control and measure air velocity and temperature.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Project Manager		Oversee the whole project and lead the research planning and reporting			27%	0.12		$36,508
Postdoctoral Associate		Design and establish computational model and carry out computer simulations			20.2%	3		$193,799
Graduate Student Research Assistant		Perform experiments to validate the computational model			16.6%	0.75		$26,299
Undergraduate Student Assistant		Assist experiment data analysis and model validation			0%	0.75		$7,200
IT Staff		Assist computational model development			24%	0.6		$44,809
							Sub Total	**$308,615**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								
	Equipment	Cost of two velocimetry ($1,000 each), and data acquisition system ($2,000)	To conduct laboratory and field measurements for validating simulation results.					$4,000
	Tools and Supplies	Cost of materials for fabricating models to be tested in experiments.	To conduct laboratory and field measurements for validating simulation results.					$3,635
							Sub Total	**$7,635**
Capital Expenditures								
							Sub Total	**-**

Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	Field experiment	Miles and meals to conduct field experiments					$750
							Sub Total	**$750**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
							Sub Total	**-**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$317,000**

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	Unrecovered F&A	Support of SAFL facilities where research will be conducted.	Secured	$174,350
			Non State Sub Total	**$174,350**
			Funds Total	**$174,350**

Attachments

Required Attachments

Visual Component

File: c1c230e4-2fe.pdf

Alternate Text for Visual Component

Microplastics pollution in water bodies has become an increasingly serious environmental problem in Minnesota. Being small in size, microplastic particles can be taken in by fish accidentally. A wide range of wildlife in the ecosystem is affected. In this study, we will use computer simulation and experiment to investigate the motions and sedimentation of microplastic particles and their interaction with fish. Based on the research, a statistical model to predict the impact of microplastics on fish will be developed.

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Does your project have patent, royalties, or revenue potential?

No

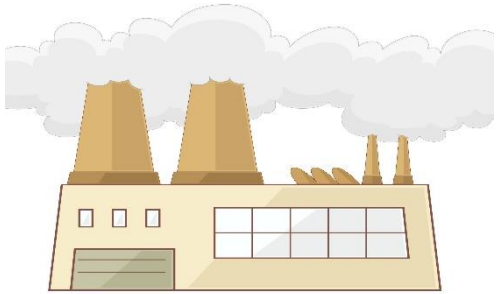
Does your project include research?

Yes

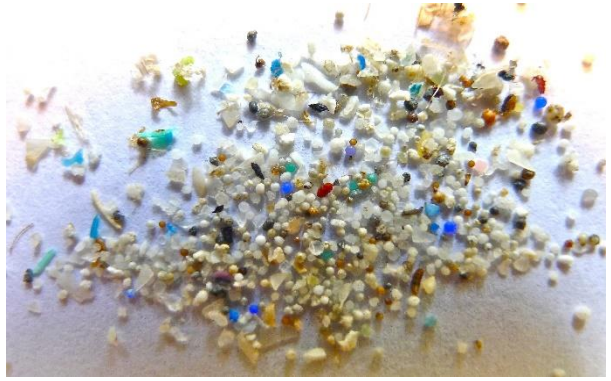
Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

Microplastics in Minnesota Water and Impact on Wildlife



Human activities have discharged a large amount of microplastics to rivers and lakes in Minnesota. There is a critically need to study the transportation and sedimentation of microplastics under water and their impact on wildlife.



Proposed research tasks

1. Study the transport and sedimentation of microplastics in Minnesota's water system by simulation and experiment.

2. Develop a statistical model to quantify the number of microplastics consumed by fish in different scenarios.