Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-223

Proposal Title: Remote Sensing and Super-resolution Imaging of Microplastics

Project Manager Information

Name: Ardeshir Ebtehaj

Organization: U of MN - St. Anthony Falls Laboratory

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Project Basic Information

Project Summary: The research will collect samples of microplastics to establish relationships between physical and remote sensing characteristics of microplastics for cost effective monitoring of microplastics in Minnesota natural and engineered waters.

Funds Requested: $364,000

Proposed Project Completion: 2024-07-31

LCCMR Funding Category: Methods to Protect, Restore, and Enhance 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 and In the Future

Narrative

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

Plastic pollution of water resources is a growing worldwide problem and Minnesota is no exception. Global production of plastics has increased to more than 350 million metric tons per year. Plastics break down to smaller pieces called "microplastics". Humans and wildlife consume microplastics via water and food. Ingestion of microplastics by humans results in uptake and bioaccumulation of harmful chemicals, including known carcinogens (e.g., polychlorinated biphenyls [PCBs] and polycyclic aromatic hydrocarbons [PAHs]) as well as emerging contaminants such as pesticides, pharmaceuticals, and endocrine disrupting compounds. In addition, ingested microplastics cause digestive and reproductive problems, as well as death in fish, birds, and other animals. Microplastics may even harbor pathogenic bacteria. Recent research by the US Geological Survey and U of MN indicates that high concentrations of microplastics are potentially present in Minnesota waters. Little is known; however, about the spatial distribution and heterogeneity of microplastics in Minnesota waters.

To better understand and mitigate the effects of microplastics on public health and wildlife we first need to measure them in a regional scale. Modern techniques for cost effective detection and mapping of microplastics in surface waters are critically needed.

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.

The overarching goal of this proposed study is to advance our understanding of remote sensing properties of microplastics in surface waters. The objectives of the project are to:

- Characterize physical properties of microplastics in Minnesota natural and engineered waters.
- Conduct laboratory experiments to quantify remote sensing properties of microplastics in surface water.
- Develop/validate drone-based and in-situ remote sensing techniques for cost effective monitoring of microplastics in rivers and lakes.
- Disseminate the findings to stakeholders, legislators, and the public for strategic planning and awareness.

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?

This study will advance science to pave the ways for drone-based and satellite remote sensing and super-resolution in-situ imaging of microplastic particles. The results will lead to cost effective tools for mapping of microplastics in Minnesota waters and real-time monitoring of their concentration in inlets/outlets of wastewater treatment plants. The developed technology will inform decision makers for timely mitigation strategies and policy making to limit environmental and human health effects of related contamination in Minnesota.

Activities and Milestones

Activity 1: Sample and characterize physical properties of microplastics in Minnesota waters

Activity Budget: $64,000

Activity Description:
Remote sensing and physical properties of microplastics are tightly connected. Groups of samples from streams, rivers and lakes (30), storm water (10), and treated wastewater effluents (10) will be collected throughout Minnesota. The goal is collect a baseline dataset that enables us to study remote sensing properties of microplastics in laboratory (activity 2) based on the type and concentration of microplastics in different water bodies (i.e., rivers vs lakes). The sampling will be conducted during low and high runoff conditions over the first year to make sure that all potential types of microplastics are properly sampled as we hypothesis that their concentration and types vary seasonally based on changes in water transport mechanism and land use. Water samples will be analyzed to determine the type of microplastics as fragments, pellets/beads, lines/fibers or foams.

Activity Milestones:

Description	Completion Date
Water samples collected, analyzed for microplastic types and abundance	2021-09-30
Data analyzed and physical characteristics are determined based on the sampled groups	2022-01-31
Dissemination findings of Activity 1 via 1 open access journal publications	2022-05-31

Activity 2: Laboratory experiments to determine remote sensing properties of microplastics in water

Activity Budget: $200,000

Activity Description:
Microplastics of various types and concentration will be introduced into the outdoor reactors and experimental stream facilities at the Saint Anthony Falls Laboratory (SAFL) to resemble the boundary conditions and flow regimes of lakes and rivers, respectively. A new hyperspectral spectroradiometer will be purchased and installed over the reactors and the outdoor stream facilities to measure the far field remote sensing signals of microplastics from visible to near infrared wavelengths. The results will reveal connections between the remote sensing signals and concentration, size distribution and types of microplastics. In parallel an RGB camera (available at SAFL) with zoom-in lens in the near field will be deployed for super-resolution imaging of individual microplastic particles.

The former experiment will identify a few key wavelengths that can be used by commercial lightweight cameras on drones (e.g. MicaSens Altum, available with SAFL drone) to quantify and map microplastic type and abundance in the field. The latter experiment will serve as the ground truth for interpreting remote sensing signals, validation and in-situ measurements of microplastics with high degree of accuracy.

Activity Milestones:

Description	Completion Date
Collect samples of spectral properties of microplastic in the SAFL reactors and stream lab	2022-08-31
Develop high-resolution techniques for microplastic particle imaging	2023-03-31
Data analysis to inference spectral bandwidth for sensing of microplastics using drones	2023-04-30
Dissemination of Activity 2 findings via at least 2 open access journal publications	2023-09-30

Activity 3: Design, deploy and validate the developed remote sensing techniques in the field

Activity Budget: $100,000

Activity Description:

Based on the activities 1-2, we will design the remote and in-situ sensing platforms including both the hardware and data processing software to detect the type and estimate the concentration of microplastics. We test and validate the platforms in two stages. First, we conduct controlled experiments in the laboratory, knowing the concentration of microplastics released. Second, based on the data in activity 1, we will identify a watershed and key areas with high concentration of microplastics as well as a wastewater treatment plant to deploy the remote sensing platforms for data collection and validation in the field.

Activity Milestones:

Description	Completion Date
Hardware and software developments for the remote sensing platforms	2023-09-30
Deploying the platforms in the field	2024-05-31
Dissemination of Activity 3 findings via at least 2 open access journal publications	2024-07-31
Validation and analysis of the field data	2024-07-31

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Jiarong Hong	University of Minnesota	Dr Hong is an associate Professor of Mechanical Engineering. Dr. Hong will be responsible for developing in-situ imaging of microplastics in water.	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 be funded?

This project will provide a new and easily deployable tool for statewide remote sensing of microplastics in rivers and lakes and also pave the ways for future commercial technology developments for satellite remote sensing. The results provide capabilities to the state agencies to establish technology and guidelines to control and reduce microplastics at the sources, advance our storm water management systems and treatment plants to protect public from this emerging treat.

The project also pave the ways to target federally funded projects in near future such the one (https://nsf.gov/pubs/2020/nsf20050/nsf20050.jsp?org=NSF).

Project Manager and Organization Qualifications

Project Manager Name: Ardeshir Ebtehaj

Job Title: Assistant Professor

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

Department of Civil, Environmental, and Geo- Engineering, University of Minnesota
B.S., Civil Engineering, 1999, Iran University of Science and Technology, Tehran, Iran.
M.Sc., Environmental Engineering, 2001, Iran University of Science and Technology, Tehran, Iran.
M.Sc., Mathematics, 2012, University of Minnesota, Twin Cities, MN, United States.
Ph.D., Hydrology, 2013, University of Minnesota, Twin Cities, MN, United States.

Dr. Ebtehaj will be responsible will be responsible for overall project coordination and supervision of the study and development of the analytical models that relate extract remote sensing properties of microplastics in waters. He has been studying remote sensing of environment and water systems for ten years. As part of these studies, he has determined the global distribution of precipitation, soil moisture and flood inundation using NASA's satellites. He has published around thirty peer-reviewed papers and co-authored a book chapter on remote sensing of the environment in the handbook of environmental engineering in 2019. Dr. Ebtehaj is an associate editor of the Journal of Hydrometeorology, affiliate member of the University of Minnesota Institute on the Environment, and a member representative of the University of Minnesota in the University Centers for Atmospheric Research (UCAR). He is the recipient of an editor award from American Meteorological Society and a recipient of a NASA's Earth and Space Science Fellowship in 2014 and a NASA's new investigator (Early Career) award in 2018 for his contribution in remote sensing sciences.

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 (http://twin-cities.umn.edu/about-us). The laboratories and offices of the PI are in SAFL and contain the necessary fixed and movable equipment and facilities needed for the proposed studies.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	$ Amount
Personnel								
Ardeshir Ebtehaj		PI			27%	0.18		$34,935
Jiarong Hong		Co PI			27%	0.12		$27,171
Research Scientist		Research Scientist			24%	0.18		$15,266
Graduate Student		Graduate Student			44%	1.5		$152,410
Graduate Student		Graduate Student			44%	0.75		$76,205
Undergraduate Student		Undergraduate Student			0%	0.06		$10,000
							Sub Total	**$315,987**
Contracts and Services								
							Sub Total	**-**
Equipment, Tools, and Supplies								
	Equipment	A Spectroradiometer with spectral range 350-2500 nano-meter with resolution 2 to 8 nano-meter will be purchased to quantify remote sensing properties of microplastics in water. This budget line also covers two drift nets to collect microplastic debris typically with less than 300 µm.	To determine the key wavelengths needed for drone sensing using light weight cameras ALREADY available at SAFL.					$35,000
	Tools and Supplies	supplies	Nylon mesh sieves and mixed cellulose ester membrane filters. Mesh sieves and membrane filters will be used with a stereomicroscope to quantify and separate microplastic particulates and fibers. These materials will then be examined using a micro-attenuated total reflectance Fourier transform infrared spectrometer (micro ATR-					$6,500

			FTIR) to determine microplastic polymer type at SAFL.					
							Sub Total	**$41,500**
Capital Expenditures								
							Sub Total	**-**
Acquisitions and Stewardship								
							Sub Total	**-**
Travel In Minnesota								
	Miles/ Meals/ Lodging	Travel to sites for sampling of microplastics in rivers, lakes and wastewater treatment outlets. The cost covers using SAFL trucks and deploying the SAFL boats.	Sample microplastics in Minnesota waters and use them for laboratory experiments to determine their remote sensing properties.					$3,000
							Sub Total	**$3,000**
Travel Outside Minnesota								
							Sub Total	**-**
Printing and Publication								
	Publication	xx	xx					$3,513
							Sub Total	**$3,513**
Other Expenses								
							Sub Total	**-**
							Grand Total	**$364,000**

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	$139,062
			Non State Sub Total	**$139,062**
			Funds Total	**$139,062**

Attachments

Required Attachments

Visual Component

File: ad6e9dde-a37.pdf

Alternate Text for Visual Component

The graphics show samples of different types of microplastics in water, spectroradiometric experiments in outdoor stream facility at SAFL and drone-based remote sensing of microplastics over river and lakes.

Administrative Use

Does your project include restoration or acquisition of land rights?

No

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

Yes,

- Patent, Copyright, or Royalty Potential

Does your project include research?

Yes

Does the organization have a fiscal agent for this project?

Yes, Sponsored Projects Administration

Needs and Research Questions

1- Plastic pollution of water resources is a growing worldwide problem, and Minnesota is no exception.

2- To better understand and mitigate the effects of microplastics on public health and wildlife we first need to measure them cost effectively.

3- Remote sensing properties of microplastics in waters is not well understood.

Proposed Activities

1- Sample occurrence and types of microplastics in Minnesota waters to determine their physical properties.

2- Develop drone-based remote sensing and in-situ imaging tools for cost effective detection of microplastics in natural and engineered waters.

3- Design, deploy and validate the developed remote sensing techniques in the field.

Activities:

(1) Sample microplastics in the field.
(2) Determine remote sensing properties of microplastics in laboratory.
(3) Develop drone-based remote sensing and validate it in the field.