Environment and Natural Resources Trust Fund
2020 Request for Proposals (RFP)

Project Title: **ENRTF ID: 071-B**

Microplastics: Occurrence, Toxins, and Detection with Drones

Category: B. Water Resources

Sub-Category:

Total Project Budget: $ 450,000

Proposed Project Time Period for the Funding Requested: June 30, 2023 (3 yrs)

Summary:

A baseline survey of microplastic occurrence and toxicity in Minnesota waters will be conducted to establish relationships with watershed attributes and develop cost effective remote sensing tools.

Name: Ardeshir Ebtehaj

Sponsoring Organization: U of MN

Job Title: Assistant Professor

Department: Civil, Environmental and Geo- Engineering

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Location:

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

The map demonstrates the proposed sampling strategy, laboratory experiments and remote sensing technology for quantifying the types and pathways of microplastics and adhered toxic chemicals in Minnesota waters.

_____ Funding Priorities	_____ Multiple Benefits	_____ Outcomes	_____ Knowledge Base
_____ Extent of Impact	_____ Innovation	_____ Scientific/Tech Basis	_____ Urgency
_____ Capacity Readiness	_____ Leverage	_____ TOTAL	_____%

PROJECT TITLE: Microplastics: Occurrence, Toxins, and Detection with Drones

I. PROJECT STATEMENT

Microplastic pollution of water resources is a worldwide problem, and Minnesota is no exception. Humans and wildlife consume microplastics via water and food, but the distribution of microplastics and their health effects on people and ecosystems have yet to be determined in Minnesota. Cost effective techniques to quantify the occurrence, transport, and fate of microplastics, including the chemical pollutants they carry, in Minnesota waters are urgently needed.

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 amount and types of microplastic released, the spatial distribution of microplastics, and the type and concentration of chemicals associated with microplastics in Minnesota waters. This study will quantify the occurrence and concentration of microplastics and provide new insights into the pathways by which toxic chemicals are carried by microplastics into Minnesota's aquatic environments and drinking water systems. This project will also lead to technology development for cost effective *drone-based sensing of microplastics***.** The objectives of the project are to:

- Quantify microplastics in Minnesota's natural and engineered waters,
- Develop a relationship between watershed characteristics and microplastic type/abundance,
- Identify toxic chemicals absorbed and transported by microplastics,
- Develop and validate a drone-based remote sensing technique for quantifying microplastics in lakes and rivers, and
- Disseminate the findings to stakeholders, legislators, and the public for strategic planning and awareness.

There is no comprehensive assessment of the occurrence of microplastics or the pollutants associated with them in Minnesota waters. A technique to rapidly and broadly detect microplastics is critically needed. *The results of this work will allow identification of the sources of microplastics and inform potential mitigation strategies to limit environmental and human health effects of related contamination in Minnesota.*

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Frequencies, types, concentrations and toxicity of microplastics in natural and engineered waters — **ENRTF Budget: $152,000**

Samples from streams, rivers and lakes (60), storm water (20), and treated wastewater effluents (20) will be collected throughout Minnesota to provide a baseline survey of the occurrence, types and concentration of microplastics. Half of the samples will be analyzed to study the adhered chemicals. The sampling will be conducted during low and high runoff conditions over the first year to quantify seasonal changes in concentration of microplastics. Water samples will be analyzed to determine the type of microplastics as fragments, pellets/beads, lines/fibers or foams for all samples. For the streams, rivers and lakes, data on watershed attributes (land cover, population density, agricultural developments, wastewater effluent, storm water input locations) will be compiled and used to establish the relationship between the occurrence and type of microplastics and watershed attributes. This will allow identification and prediction of the areas most vulnerable to microplastic pollution.

Outcome	Completion Date
1. *Water samples collected, analyzed for microplastic types and abundance*	2/31/2020
2. Data analyzed and statistical relationships established based on watershed variables	6/31/2020
3. Dissemination findings of Activity 1 via at least 2 open access journal publications	1/30/2021

Activity 2: Assess the contaminants absorbed and transported by microplastics **ENRTF Budget: $156,500**

The source and type of microplastic will affect the contaminants it carries. For example, PAHs and pesticides are likely to be associated with microplastics from urban runoff, whereas those in wastewater may carry various emerging contaminants, including endocrine disruptors. Different plastic materials (e.g., plastic strips in a metal cage) will be deployed in wastewater effluents and streams to assess how plastic material affects contaminant uptake. Specific indicator chemicals (high volume use pesticides, pharmaceuticals) or target chemicals of specific concern (PCBs, PAHs) will be quantified. These chemicals will also be quantified in the microplastics collected in Activity 1. In the laboratory, release rates from pre-loaded microplastics will be used to assess the potential for long range facilitated transport of contaminants by microplastics.

Outcome	Completion Date
1. *Verification of methods for extracting contaminants from microplastics*	06/30/21
2. Deployment of plastics in wastewater, urban and rural streams	09/30/22
3. Quantification of contaminants in deployed and collected microplastics	03/30/23
4. Assessment of contaminant release from microplastics	03/30/23
5. Dissemination of Activity 2 findings via at least 2 open access journal publications	6/30/2023

Activity 3: Develop drone-based remote sensing tools to detect microplastics in surface waters **ENRTF Budget: $141,500**

Timely detection and monitoring the movement of microplastics in surface waters requires a cost-effective monitoring technology. We propose a drone-based remote sensing technology. Microplastics of various materials will be introduced into the outdoor reactors and experimental stream facilities as the Saint Anthony Falls Laboratory (SAFL) to develop a drone sensing technique. To that end, a new hyperspectral spectroradiometer needs to be purchased and installed over the bioreactors and the outdoor stream facilities to determine key wavelengths that can be used by commercial lightweight cameras (e.g. MicaSens Altum, available with SAFL drone) to quantify microplastic type and abundance in the field.

Outcome	Completion Date
1. *Collect samples of spectral properties of water with different concentration of microplastic*	06/01/22
2. Data analysis to inference spectral bandwidth for sensing of microplastics using drones	01/01/22
3. Conduct field scale validation of the tool using the existing SAFL drone (LCCMR funded)	06/01/23
4. Dissemination of Activity 3 findings via at least 2 open access journal publications	06/01/23

III. PROJECT PARTNERS:

A. Partners receiving ENRTF funding

Name	Title	Affiliation	Role
William Arnold	Professor	U of MN, CEGE	Co-investigator
Miki Hondzo	Professor	U of MN, CEGE	Co-investigator

IV. LONG-TERM- IMPLEMENTATION AND FUNDING: This project will provide a baseline assessment of the occurrence and toxicity of microplastics in Minnesota waters impacted by humans, establish relationship between the microplastic levels and watershed natural and urban attributes and lead to cost effective technologies for drone-based monitoring of microplastics. This work will provide methods to the state agencies, if needed, for establishing 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.

V. TIME LINE REQUIREMENTS: The project will be completed in a three-year period. The sample collection and method development for analyzing occurrence of microplastics, extracting the adhered toxic substances and understanding the electromagnetic properties of microplastics in water all require attention to detail and replication.

Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: Ardeshir Ebtehaj
Project Title: Microplastics: Occurrence, Toxins, and Detection with Drones
Organization: University of Minnesota
Project Budget: $450,000
Project Length and Completion Date: 3 years, June 30, 2023
Today's Date: March 15, 2019

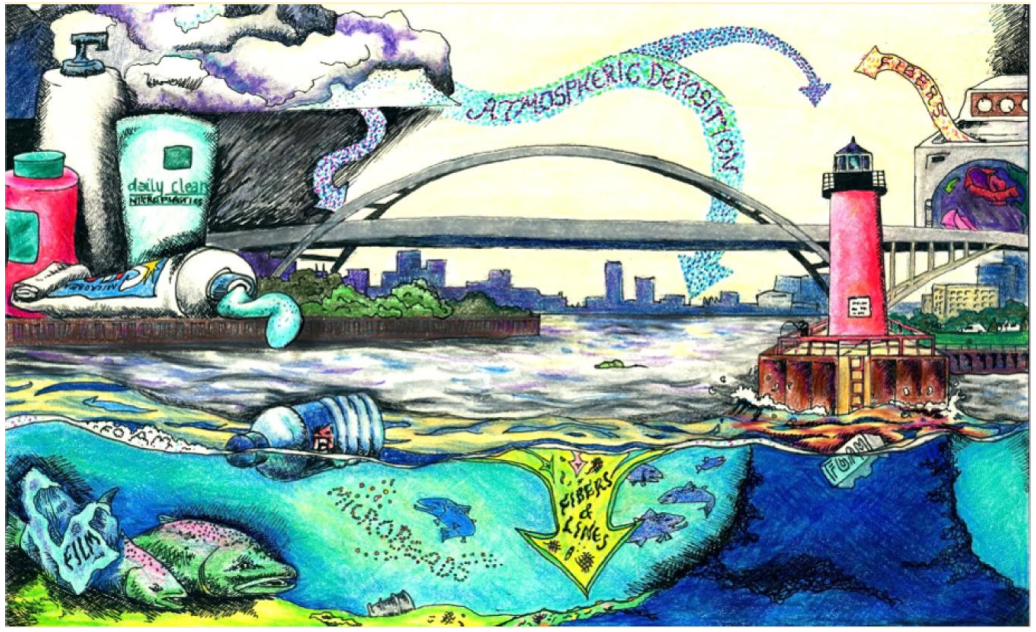
ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$ 379,000	$ -	$ 379,000
Ardeshir Ebtehaj, Project Manager (74% salary, 26% fringe benefits). 6% FTE for years 1 - 3. Overall project coordination, Lead Task 1 and Task 3studies, $31,900			
William Arnold, co-Project Manager (74% salary, 26% fringe benefits). 4% FTE for years 1 - 3. co-lead Task 1 studies,Lead Task 2 studies. $35,400			
Miki Hondzo, co-Project Manager (74% salary, 26% fringe benefits). 2% FTE for years 1 - 3. co-lead Task 1 studies, co-lead Task 3 studiesLead Task 2. $15,900			
Graduate student Research assistant 1, Perform microplastic collection and quantification in Task 1, assist with sample collection for Task 2, model development and data anaysis in Task 3 (56% salary, 44% fringe benefits) 50% FTE for years 1 &2, 25% for Year 3. $132,750			
Graduate student Research assistant 2, Assist with microplastic collection and quantification in Task 1, identify plastic materials in Task 1, quantify contaminant uptake and release in Task 2, quantify target pollutants in Task 2 (56% salary, 44% fringe benefits) 25% FTE for year 1, 50% for Years 2& 3. $132,750			
Research Scientist, Assist with assembly, testing, deployment of trawls for microplastic collection, Assist with drone assembly, testing, measurements, 4% FTE in Years 2 & 3 ($15,000)			
Undergraduate researcher. Assist with sample collection in summers Year 1 -3 (100% salary), 25% FTE $15,300			
Professional/Technical/Service Contracts			
	$ -	$ -	$ -
Equipment/Tools/Supplies			
Laboratory supplies - glassware, solvents, sample mounting/prepartion kits, salts, laboratory safety supplies, analytical standards, plastic materials	$ 13,000	$ -	$ 13,000
Analytical instrument time to identify microplastic composition (50 samples)	$ 9,000	$ -	$ 9,000
Analytical instrumen time to quantify target emerging contaminants	$ 10,000	$ -	$ 10,000
Trawls to collect microplastics (two at $4000 each)	$ 8,000	$ -	$ 8,000
Capital Expenditures Over $5,000			
Spectroradiometric camera for drone measurements	$ 22,000	$ -	$ 22,000
Fee Title Acquisition			
	$ -	$ -	$ -
Easement Acquisition			
	$ -	$ -	$ -
Professional Services for Acquisition			
	$ -	$ -	$ -
Printing			
	$ -	$ -	$ -
Travel expenses in Minnesota			
Mileage, hotel, and meal expenses associated with travel to sampling locations. Costs will be based on U of MN travel policies.	$ 3,000	$ -	$ 3,000
Other			
Open access publication fees to allow papers to be available immediately	$ 6,000	$ -	$ 6,000
COLUMN TOTAL	$ 450,000	$ -	$ 450,000

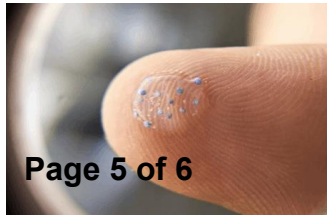
SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind: Because the project is overhead free, laboratory space, electricty, and other facilities/adminstrative costs (54% of direct costs excluding permanent equipment and graduate student tuition benefits) are provided in-kind.	secured	$ 180,000	$ -	$ 180,000

Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	Amount legally obligated but not yet spent	Budget	Spent	Balance
None directly related to this project		$ -	$ -	$ -

Microplastic pollution of water resources is a worldwide problem, and Minnesota is no exception.

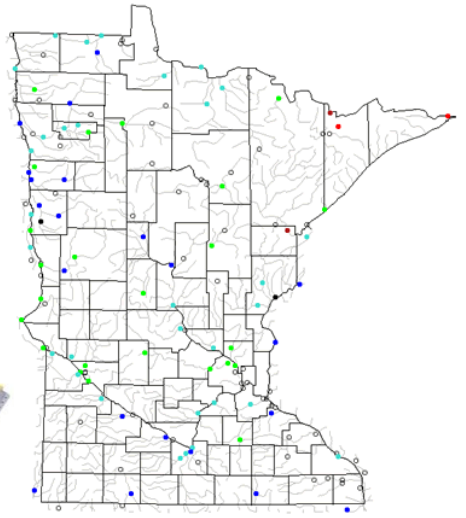
Sources, occurrence, toxicity, transport and fate of microplastics are unknown in Minnesota waters





Proposed Activities

1- Sample occurrence and types of microplastics in Minnesota waters to provide a baseline survey.



2- Assess the concentration and types of the absorbed contaminants through laboratory experiments

3- Develop drone-based remote sensing tools for cost effective detection of microplastics in Minnesota waters.

Project Manager Qualifications and Organization Description

Ardeshir Ebtehaj, Assistant Professor
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 the MP levels to watershed attributes and remote sensing component of the project. 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 over twenty peer-reviewed papers on remote sensing of the Environment and co-authored a book chapter on remote sensing of environmental variables and fluxes 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 of the graduate study committee in Water Resources Science at the University of Minnesota. He was a NASA's Earth and Space Science Fellow in 2014 and won a NASA's new investigator (Early Career) award in 2018 for his contribution in remote sensing sciences.

Qualifications of the Collaborators

William A. Arnold, Distinguished McKnight University and Joseph T. and Rose S. Ling Professor and Associate Head, Department of Civil, Environmental, and Geo- Engineering, University of Minnesota
B.S., Chemical Engineering, 1994, Massachusetts Institute of Technology, Cambridge, MA.
M.S., Chemical Engineering, 1995, Yale University, New Haven, CT.
Ph.D., Environmental Engineering, 1999, The Johns Hopkins University, Baltimore, MD.
Dr. William Arnold will be responsible for overall project supervision for analyzing microplastic contaminants, field and laboratory samplings and development of analytical methods and protocols. He has been studying the fate of pharmaceutical and pesticide compounds in aquatic environments for sixteen years. As part of these studies, he has determined the transformation rates and identified reaction products of numerous compounds. Recent work has focused on the hydrolysis and photolysis of neonicotinoid insecticides. He has published over twenty peer-reviewed papers on pesticide and pharmaceutical fate since 2003, and he is the co-author of a textbook on water chemistry published in 2011. Dr. Arnold is a Resident Fellow of the University of Minnesota Institute on the Environment, an Associate Fellow of the Minnesota Supercomputing Institute, and a member of the graduate faculty in Water Resources Science. He won the *Arcadis/Association of Environmental Engineering and Science Professors Frontier in Research Award* in 2012 and the University of Minnesota College of Science and Engineering *George W. Taylor Award for Distinguished Research* in 2011.

Miki Hondzo, James L. Record Professor
Department of Civil, Environmental, and Geo- Engineering, University of Minnesota
B.S., Civil Engineering, 1983, University of Sarajevo, Bosnia and Hercegovina
M.Sc., Surface Water Hydrology, 1988, Free University of Brussels, Belgium
Ph.D., Civil Engineering, 1992, University of Minnesota, Twin Cities, MN, United States
Dr. Hondzo will be responsible for development and guidance of the detection of microplastics under field and outdoor laboratory conditions using the proposed drone technology. He has been studding ecological fluid mechanics, and water quality and transport processes in lakes, rivers, and watersheds in the past 20 years. Dr. Hondzo is an Associate Editor of the journal of Environmental Fluid Mechanics.

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 contain the necessary fixed and moveable equipment and facilities needed for the proposed studies.