Environment and Natural Resources Trust Fund
2018 Request for Proposals (RFP)

Project Title: **ENRTF ID: 034-B**

Removing Plastic Particle Pollution from Minnesota Water Bodies

Category: B. Water Resources

Total Project Budget: $ 388,557

Proposed Project Time Period for the Funding Requested: 3 years, July 2018 to June 2021

Summary:

The objective of the present proposal is to assess and provide remedy to the urgent problem of microscopic plastic particles polluting water bodies in Minnesota.

Name: Filippo Coletti

Sponsoring Organization: U of MN

Address: 110 Union St SE

Minneapolis MN 55455

Telephone Number: (650) 289-8216

Email fcoletti@umn.edu

Web Address

Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Schematic illustrating micro-plastics entering the aquatic ecosystem, and diagram of the proposed actions

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

PROJECT TITLE: REMOVING PLASTIC PARTICLE POLLUTION FROM MINNESOTA WATER BODIES

I. PROJECT STATEMENT

The objective of the present proposal is to tackle the urgent problem of **microscopic plastic particles** polluting water bodies in Minnesota. Our **goals** are to: 1) **track** the motion of these increasingly abundant pollutants, (2) **locate** the areas of rivers and lakes where they accumulate, and (3) **remove** them effectively and inexpensively.

Scientific reports indicate that the Great Lakes, including **Lake Superior, and the basin of rivers in Minnesota are polluted with billions of tiny pieces of plastic**, and a **2016 report from the Friends of the Mississippi River found high concentration of micro-plastics in the river's sediment in Minnesota**. These consists of mm-sized micro-beads and micro-fibers used for cleaning and personal care products or shed from clothing, which slip through the water treatment plants. These particles act like **toxic sponges** for harmful substances and **vector of invasive species** that enter the aquatic food chain, with **severe consequences for ecosystem and population**.

Micro-plastics are insidious because they come in various shapes and sizes, may agglomerate in larger flocks, and behave differently in streaming water versus still water. Because of these complexities, today it is unknown how far they travel in the waterways, how much they float or sink, and ultimately where they end up. Therefore **there is no established method to limit micro-plastic impact once they enter the water system**.

Using expertise and the unique resources at the St. Anthony Falls Laboratory, we will collect data through laboratory and field measurements, to **quantify the abundance, monitor the dispersion, and forecast the pathway** of the 10 most common types of plastic particles in 5 Minnesota rivers (including the **Mississippi** and **Eagle Creek**) and 5 Minnesota lakes (including **Lake Superior** and **Lake Calhoun**). We will so identify the **most dangerous particles** accumulating in the most ecologically sensitive areas. We will then demonstrate how the accurate prediction of where micro-plastics accumulate allows us to **remove them** effectively and inexpensively using **conveniently positioned mesh nets**.

A key component of our program will be the **outreach to the citizens of Minnesota**: we will launch a program where volunteers (bikers, backpackers, kayakers) send samples and email pictures from the water bodies encountered on their explorations. Coupling the information with experimental findings, we will create an **online map of plastic pollution in Minnesota waters**, to be used in educational/training activities statewide.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Collect experimental data on plastic particle dispersion and accumulation in Minnesota rivers and lakes **Budget: $150,200**

We will measure how 10 types of micro-plastics (micro-beads and micro-fibers) travel, float, and/or settle in stagnant and streaming water. At the laboratory level, large flumes and water tanks at the St. Anthony Falls Laboratory will be used, reproducing conditions occurring in natural water bodies and allowing for **well-controlled experiments**. In the field, we will record the abundance and motion of micro-particles in **5 lakes and 5 river segments**. We will use a network of cameras placed at multiple stations, and collect samples using fine mesh nets placed near the camera locations. We will so **identify the locations most likely to get polluted**.

Outcome	Completion Date
1. Collect data on horizontal and vertical velocities of 10 types of micro-plastics in streaming and still water conditions	January 2019
2. Assess concentration, pathway, and accumulation of micro-plastics in 5 Minnesota rivers	June 2019
3. Assess concentration, pathway, and accumulation of micro-plastics in 5 Minnesota lakes	June 2020
4. Identify and list locations most vulnerable to micro-particle pollution	June 2021

Activity 2: Demonstrate accurate prediction of micro-plastic dispersion and effective removal of micro-plastics **Budget: $112,438**

The experimental data collected in Activity #1 will inform and validate a **predictive tool** that forecasts the concentration and pathways of micro-plastics in real-time. Such tool will also exploit readily available

information including local wind speed and morphometry of the water bodies. The resulting **pollution map** will be used to strategically place and orient the mesh nets at the most effective locations, providing a **simple and low-cost method of removing the micro-particles**.

Outcome	Completion Date
1. Develop predictive tool for pathway and accumulation of micro-plastics in Minnesota rivers and lakes	January 2021
2. Demonstrate accuracy of plastic pollution map, by removing micro-particles using mesh nets located at most critical locations	June 2021

Activity 3: Engage and educate citizens in the action against plastic water pollution **Budget: $125,919**

Our capability of collecting data will be greatly expanded by **enlisting Minnesota citizen scientists**, who can provide samples from the bodies of water they visit or live by. Moreover, we will develop a **free mobile app** that anyone can use to send images and videos, from which quantify concentration and accumulation of micro-plastics at the time and location the message was sent. The wealth of data will be combined into an **Internet-based and publicly accessible map** of the plastic pollution in Minnesota rivers and lakes. This will represent a resource for schools and community associations who volunteer to keep our aquatic system healthy and clean.

Outcome	Completion Date
1. Assess public awareness and establish focus groups for engaging citizen scientists	June 2019
2. Develop mobile app for reporting on water plastic pollution	June 2020
3. Establish Internet-based map of plastic pollution in Minnesota	June 2021

III. PROJECT STRATEGY

A. Project Team/Partners

The team consists of Filippo Coletti (Assistant Professor of Aerospace Engineering & Mechanics and member of the St. Anthony Falls Laboratory) as the Project Manager, and Lian Shen (Associate Professor of Mechanical Engineering and Associate Director for Research at St. Anthony Falls Laboratory). We will seek collaboration with state and federal agencies in Minnesota. In previous efforts on aquatic pollution studies, we have had interactions with Mr. Dan Breneman at Minnesota Pollution Control Agency, Mr. Lawrence DiDomenico of the Coast Guard Marine Safety Unit at Duluth, and Prof. Jay Austin at the Large Lakes Observatory. We will work to continue these interactions to exchange data and provide mitigation guidelines.

B. Project Impact and Long-Term Strategy

The amount **of plastic waste in lakes and rivers is projected to grow rapidly**, driven by the rise in plastics consumption (ca. 9% per year). Recently the United Nations has called micro-plastics in water “an emerging issue of international concern.” New federal and state legislation has banned the sale of certain products containing micro-beads, but thousands of tons of micro-plastic pollution are already in our waters, and will take **thousands of years to biodegrade**. The scientific and societal outcomes of the proposed projects will be a powerful weapon to reduce plastic water pollution, in that it will **inform state agencies on where and how to remove the most harmful micro-plastics from our waters.** The collected data will be shared with federal and state agencies through a **user-friendly web interface**, providing guidelines to wisely allocate resources to remove the pollution and **mitigate the ecologic impacts**. Additionally, we will hold virtual workshops to help agency members familiarize with the tools developed in this project. The research findings will be disseminated through presentations, workshops, and local media outlets, and will be leveraged in **educational efforts** including the SAFL outreach program towards middle school students from Native American tribes in northern Minnesota. The information will be used to **inform consumers' choice, support legislative action, and influence corporate responsibility**, ultimately preserving the aquatic ecosystem and population of Minnesota**.**

C. Timeline Requirements

This project is planned for 3 years beginning on July 1 2018 and ending on June 30 2021.

2018 Detailed Project Budget

Project Title: Removing plastic particle pollution from Minnesota water bodies

IV. TOTAL ENRTF REQUEST BUDGET: 3 years

BUDGET ITEM	AMOUNT
Personnel:	$ 380,057
Dr. Filippo Coletti, PI, 1 month summer salary (11% FTE), 75% salary, 25% benefits, ($46,004)	
Dr. Lian Shen, co-PI, 0.5 month summer salary (5% FTE), 75% salary, 25% benefits, ($25,732)	
SAFL technician, (15% FTE), 79% salary, 21% benefits, ($25,675)	
Graduate Research Assistant (Activity #1 and #2, Aerospace Engineering & Mechanics Dept.) (50% FTE), 59% salary, 41% benefits, ($141,323)	
Graduate Research Assistant (Activity #2 and #3, Mechanical Engineering) (50% FTE), 59% salary, 41% benefits, ($141,323)	
Equipment/Tools/Supplies:	
Ten cameras for field experiments ($500 each)	$ 5,000
Fine mesh netting for collecting particles in field experiments	$ 500
Travel: Mileage, lodging, and meals for travel to and between the field measurements sites and the university based on the university compensation policy	$ 3,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	**$ 388,557**

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period:	N/A	
Other State $ To Be Applied To Project During Project Period:	N/A	
In-kind Services To Be Applied To Project During Project Period: The University of Minnesota does not charge the State of Minnesota its typical overhead rate of 54% of the total modified direct costs (graduate tuition and equipment are excluded).	$ 158,295	*Secured*
Funding History:	N/A	
Remaining $ From Current ENRTF Appropriation:	N/A	

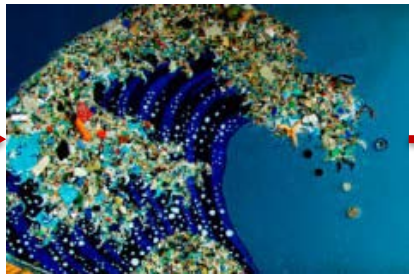
REMOVING PLASTIC PARTICLE POLLUTION FROM MINNESOTA WATER BODIES

THE PROBLEM

Plastic particles enter our waterways …

… small enough to escape waste treatment …

… and contaminate rivers and lakes …

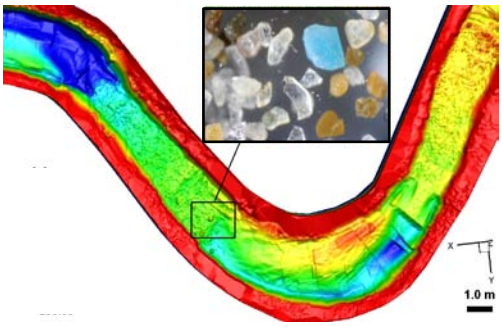


… including the world largest freshwater ecosystem …

… and harming Minnesota wildlife (and population!)

THE PROPOSAL

Monitor and forecast particle pathway…



…and remove them efficiently…

…engaging citizen scientists

PROJECT MANAGER QUALIFICATIONS

The proposed research will be lead by Filippo Coletti, Assistant Professor of Aerospace Engineering and Mechanics at the University of Minnesota, who will be in charge of the experimental studies. Coletti obtained his bachelor's and master's degrees in Mechanical Engineering at the University of Perugia (Italy) in 2005, and a research master in Fluid Dynamics at the von Karman Institute (Belgium) in 2006. He performed his doctoral studies at the von Karman Institute and at the University of Stuttgart (Germany), where he obtained his Ph.D. in Aerospace Engineering in 2010. From 2011 to 2013 he was postdoctoral fellow at Stanford University, before joining the U of M in 2014. Shortly after he became a member of the St. Anthony Falls Laboratory (SAFL), where he conducts research in environmental fluid mechanics, focusing on the transport of solid particles in the environment. Coletti uses advanced imaging techniques both in the laboratory and in the field, where he is part of a team that investigates settling speed of hydrometeors. He also conducts research in health-related processes such as transport of contaminants in the human respiratory system, and he is a member of the graduate faculty in the Biomedical Engineering Department at the University of Minnesota. His research is funded by federal agencies including the National Science Foundation (NSF) and the National Institute of Health (NIH), as well as by major companies including 3M and Boston Scientific. Coletti has published 60 refereed journal articles and conference papers on transport phenomena and experimental fluid mechanics. A list of his recent honors include the CAREER Award from the National Science Foundation (2015-2019), the Non-Tenured Faculty Award from The 3M Company (2015-2018), and the Best Paper Award from the ASME Wind Energy Committee (2014).

The modeling component of the proposed research will be directed by Lian Shen. Shen is the Associate Director for Research of St. Anthony Falls Laboratory and the Benjamin Mayhugh Associate Professor of Mechanical Engineering at the University of Minnesota. He is leading SAFL's computational fluid dynamics (CFD) group, which has developed high-fidelity simulation algorithms for modeling highly complex turbulent hydrodynamics and particle transport problems in real-world environments. Shen earned his bachelor's degree in mechanics from University of Science and Technology of China in 1993 and his doctoral degree in fluid mechanics from Massachusetts Institute of Technology in 2001. Prior to coming to the University of Minnesota, he was at the faculty in Department of Civil Engineering at the Johns Hopkins University (2004-2012). Being a world-expert on CFD, Shen has been active in professional societies, including American Society of Civil Engineering (ASCE) and American Geophysical Union (AGU), and is a member of the ASCE Environmental & Water Resources Institute (EWRI) task committee on CFD Applications in Water and Wastewater Treatment. He is on the editorial boards of the International Journal of Computational Methods and the Ocean Systems Engineering journal.

ORGANIZATION DESCRIPTION

The proposed research will be conducted at the St. Anthony Falls Laboratory, University of Minnesota. The laboratory is particularly experienced in conducting and analyzing field measurements of water quality in lakes, rivers, and reservoirs. Unique flume facilities are available for experimental research, including: a 84 m long water channel running at 8,500 liters/sec, provided with wave generator, glass walls for observation, and automated carriages for traversing the imaging system; several other instrumented flumes running at ranges of 20 to 170 liters/sec; scaled-down river delta basins with automated mechanisms for wave generation and tidal cycles; and the Outdoor Stream Lab, a premier research facility developed by SAFL and the National Center for Earth-surface Dynamics (NCED) at the University of Minnesota, that allows for outdoor hydrological and ecological field-scale experiments under controlled conditions. Automated data collection, sampling protocols, wireless data transfer and display over the Internet have been developed for several state and federal funding agencies at the laboratory. SAFL has also top-notch computing capabilities that allow for high performance parallel processing linked by high speed connections.