Today's Date: 12 Feb 2020

Date of Next Status Update Report: 31 January 2021

Date of Work Plan Approval:

Project Completion Date: 30 June 2023

Does this submission include an amendment request? _NO_

PROJECT TITLE: Microplastics as Transporters of Contaminants of Concern in Minnesota Waters

Project Manager: R Lee Penn

Organization: University of Minnesota – Twin Cities

College, Department, or Division: Chemistry

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Location: Statewide

Total Project Budget: $425,000

Amount Spent: $0

Balance: $425,000

Legal Citation: M.L. 2020, Chp. xx, Sec. xx, Subd. xx

Appropriation Language:

I. PROJECT STATEMENT:

Plastic pollution is a growing environmental problem, and **microplastics** are tiny pieces of plastics that have broken off bigger plastic objects (e.g., clothing, bags, containers) or were added to products (e.g., microbeads). Microplastics pose a major threat to our environment. ***We propose to study how microplastics can serve as vehicles to transport contaminants of concern (COCs) within the environment***.

Microplastics are problematic for three reasons. First, organisms, on land and in water, eat microplastics, and those microplastics can severely disrupt digestion, sometimes even resulting in death. Second, microplastics can absorb contaminants (i.e. plasticizers, pesticides, drug molecules). This makes microplastics potential vehicles for transporting contaminants within the environment and delivering contaminants to organisms that eat those microplastics. Third, microplastics may act as reservoirs for many **contaminants of concern** (COCs) in the environment, including pesticides and plasticizers. There are two important types of COCs to consider: molecules used in the fabrication of plastics (e.g., plasticizer) and molecules absorbed from the plastic product's surroundings (e.g., pesticides or herbicides). How much and which COCs are carried by microplastics in water has not been studied in the environment, and not at all in Minnesota.

Here, we propose to examine how microplastics change the fate and transport of COCs in Minnesota waters. We propose to do this by:

- Determining how much and which COCs are taken up by several types of common microplastics
- Determining how microplastics continue to break down, how they settle out from water, and how uptake and release of COCs changes as a result of breaking down
- Modeling the fate and transport of COCs, in order to learn how things change with microplastics present
- Collecting and characterizing microplastics collected from Minnesota waters to ground-truth what we learn from the above three activities.

Major Results Expected:

1. Determination of how much and which COCs are taken up by common microplastics.
2. Improved understanding of how microplastics change the fate and transport of COCs in Minnesota Waters, which will lead to better predictions about environmental impact.

Deliverables: The team will give open scientific presentations and publish scientific papers addressing the above objectives. In addition, the results from this project will enable the State of Minnesota to better predict the impact of environmental contamination with chemicals and microplastics and develop better approaches to prevention and remediation.

II. OVERALL PROJECT STATUS UPDATES:

First Update 31 January 2021

Second Update 31 July 2021

Third Update 31 January 2022

Fourth Update 31 July 2022

Fifth Update 31 January 2023

III. PROJECT ACTIVITIES AND OUTCOMES:

Activity 1: Lab Studies to Determine Fate and Transport of COCs by Microplastics

Description: We will perform batch experiments combining select COCs and common types of microplastics. We will measure how much of the COCs partitions (i.e., is absorbed) into the microplastic particles. Target COCs will include plasticizers used to make plastics (e.g., per- and polyfluoroalkyl substances (PFAS), polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and current-use organochlorine pesticides. Target microplastics will include fibers of polyester, Rayon, Nylon, polyurethane, and polyethylene terephthalate (fleece) and will include standards as well as plastic materials collected from the field. Fibers will be introduced to glass containers of aqueous solutions with known amounts of COCs, allowed to equilibrate for 24 hours on a wrist-action shaker, filtered, and analyzed for COCs in both the water and microplastic particles. Partition coefficients, which are a quantitative description of how much of each COC is taken up by a particular plastic, will be calculated. Finally, microplastic particles will be examined using microscopy before and after experiments and will include characterization of the presence (or absence) of biofilms by using live/dead cell visualization using fluorescence microscopy combined with organic carbon measurements.

Many COCs are “removed” from water through settling and subsequent burial in sediments. The settling behavior of naturally occurring particles is already well known. However, microplastics have different shapes, densities, and surface chemistry. These properties affect how quickly a particle settles and is buried in the sediments of an aquatic system (e.g., lake or river). Therefore, we investigate the settling properties of microplastics in natural waters. We will perform column experiments. A glass column will be filled with a suspension of microplastic particles, both standards and aged particles, in water. Because particles scatter light, we will use small lasers to detect particles at specified heights along the column. This procedure will enable us to measure the settling rate of the particles. We will perform these experiments with microplastic particles before and after exposure to COCs and/or agitation with sand grains.

These results will be used in a model designed to predict the fate and transport of COCs associated with microplastics.

With the reduction in funding rate, a slightly reduced number of batch experiments (ca. 5% fewer) are proposed.

ENRTF BUDGET: $306,000

Outcome	Completion Date
1. Environmental sampling and characterization	*June 2023*
2. Model validation	*June 2023*

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Third Update 31 January 2022

Fourth Update 31 July 2022

Fifth Update 31 January 2023

Final Report between project end (June 30) and August 15, 2023

Activity 2: Ground-truthing with Environmental Samples

Description: Twenty Minnesota waters (rivers and lakes) will be sampled and filtered for both microplastics and natural particles. Both the filters and filtrates will be analyzed for COCs and microplastics. Initial determination of the amount of microplastics in a field sample will use light microscopy after dying with Nile Red, which does not dye the naturally occurring particles (e.g., small sediment particles or organisms) and only dyes the plastics red. The microplastic particles will be further characterized in order to identify the polymer (e.g., polyurethane, polyethylene terephthalate, etc…). Results from the field samples will be compared to the predictions resulting from activity one.

Although the recommended funding rate is lower than our original request, we propose to prioritize this activity so that the scope remains unchanged.

ENRTF BUDGET: $119,000

Outcome	Completion Date
1. Environmental sampling and characterization	*June 2023*
2. Model validation	*June 2023*

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Fourth Update 31 July 2022

Fifth Update 31 January 2023

Final Report between project end (June 30) and August 15, 2023

IV. DISSEMINATION:

Description: The team will give open scientific presentations at both local and national meetings and publish scientific papers addressing the above objectives. We will also prepare a webpage to convey results to the public.

The Minnesota Environment and Natural Resources Trust Fund (ENRTF) will be acknowledged through use of the trust fund logo or attribution language on project print and electronic media, publications, signage, and other communications per the ENRTF Acknowledgement Guidelines.

First Update 31 January 2021

Second Update 31 July 2021

Third Update 31 January 2022

Fourth Update 31 July 2022

Fifth Update 31 January 2023

Final Report between project end (June 30) and August 15, 2023

V. ADDITIONAL BUDGET INFORMATION:

A. Personnel and Capital Expenditures

Explanation of Capital Expenditures Greater Than $5,000: N/A

Explanation of Use of Classified Staff: N/A

Total Number of Full-time Equivalents (FTE) Directly Funded with this ENRTF Appropriation:

Enter Total Estimated Personnel Hours for entire duration of project: 7,326	Divide total personnel hours by 2,080 hours in 1 yr = TOTAL FTE: 3.5

Total Number of Full-time Equivalents (FTE) Estimated to Be Funded through Contracts with this ENRTF Appropriation:

Enter Total Estimated Contract Personnel Hours for entire duration of project: 0	Divide total contract hours by 2,080 hours in 1 yr = TOTAL FTE: 0

VI. PROJECT PARTNERS:

A. Partners outside of project manager's organization receiving ENRTF funding - None
B. Partners outside of project manager's organization NOT receiving ENRTF funding
   1. Prof. Melissa Mauer Jones from the University of Minnesota – Duluth (UMD) is studying how microplastic particles form from larger pieces of plastic. We will partner with her research group in using microplastic particles generated in her experiments as standards and test samples in our batch and column experiments described in activity 1.
   2. Prof. Melinda Neville from the Earth Systems Science department at Leech Lake Tribal College is studying microplastics from surface waters and sediments collected from MN lakes (e.g., Bemidji and Andrusia). We will work with her research group on best practices for sample collection and share samples.

VII. LONG-TERM- IMPLEMENTATION AND FUNDING:

Results from this project will enable the State of Minnesota to better predict the impact of environmental contamination with chemicals and microplastics and develop better approaches to prevention and remediation. The results of this project will enable managers of Minnesota's water resources and legislators to better address the issue of environmental contamination.

VIII. REPORTING REQUIREMENTS:

- Project status update reports will be submitted 31 January and 31 July for each year of the project
- A final report and associated products will be submitted between June 30 and August 15, 2023.

IX. SEE ADDITIONAL WORK PLAN COMPONENTS:

A. Budget Spreadsheet

B. Visual Component or Map

C. Parcel List Spreadsheet

D. Acquisition, Easements, and Restoration Requirements

E. Research Addendum

Attachment A: Project Budget Spreadsheet
Environment and Natural Resources Trust Fund
M.L. 2020 Budget Spreadsheet
Legal Citation:
Project Manager: R. Lee Penn
Project Title: Microplastics: Transporters of Contaminants in Minnesota Waters
Organization: University of Minnesota
Project Budget: 448,630
Project Length and Completion Date: 3 years; complete June 2023
Today's Date: 12 Feb 2020

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET	Budget	Amount Spent	Balance
BUDGET ITEM			
Personnel (Wages and Benefits)	$ 375,739	$ -	$ 375,739
R. Lee Penn (PI): $42227 (8.7% effort all three years). Fringe is 34.2% of salary. Supervise graduate student; perform electron microscopy on samples; co-lead sample collection in the field; evaluate data and design experiments.			
Matt F. Simcik (Co-PI): $42,660 (8.7% effort all three years). Fringe is 34.2% of salary. Supervise graduate student;lead sample collection in the field; evaluate data and design experiments.			
Lab Manager: $13,796 (8% effort all three years) Fringe is 28.4% of salary			
Grad RA 1: $139,272 (50% effort all three years, fringe is 17.7% of salary plus tuition at $15,522/year). Co-advised and working in close collaboration with members of each PI's research group; Design and execute experiments and sample collection; characterize standard and field samples of polymer fibers.			
Grad RA 1: $137,784 (50% effort all three years, fringe is 17.7% of salary plus tuition at $15,522/year). Co-advised and working in close collaboration with members of each PI's research group; Design and execute experiments and sample collection; quantify absorption of contaminants in standard and field samples of polymers.			
Technical Services:			
User fees for instrumentation (microscopy and spectroscopy for polymer characterization) at the University of Minnestoa - College of Science and Engineering's Characterization Facility ($3k/yr)	$ 9,000	$ -	$ 9,000
Equipment/Tools/Supplies			
Model contaminant compounds	$ 4,000		$ 4,000
General chemical supplies (salts, water purification cartridges, glass containers)	$ 10,000		$ 10,000
Filters for removal of microplastics from experimental and natural waters	$ 12,000		$ 12,000
Two wrist action shakers	$ 8,000		$ 8,000
Supplies for settling experiments (long glass column, six small lasers for light scattering measurements)	$ 3,261		$ 3,261
Supplies for Materials Characterization (microscopy and spectroscopy for polymer characterization before and after use in batch experiments and for characterization of samples collected from the field; glass storage containers ($100), fine tweezers ($100), slides for light and fluorescence microscopy ($100), electron microscopy sample stubs ($500), fluorescence dyes ($500), cotton gloves for handling ($100), crystal substrates for FTIR analysis ($400).	$ 2,000	$ -	$ 2,000
Travel expenses in Minnesota			
Travel to/from field sites for sample collection; travel to/from University of Minnestoa - Duluth for collaborative meetings, sample collection, and experiments	$ 1,000	$ -	$ 1,000
COLUMN TOTAL	$ 425,000	$ -	$ 425,000

SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT	Status (secured or pending)	Budget	Spent	Balance
Non-State:		$ -	$ -	$ -
State:		$ -	$ -	$ -
In kind:	secured	$ 191,969	$ -	$ 191,969
The investigators will also devote 1% time per year in kind ($1,507).				
Because the project is overhead free, laboratory space, electricty, and other facilities/adminstrative costs (54% of direct costs excluding permanent equipment and graduate student academic year fringe benefits) are provided in-kind				

Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	Amount legally obligated but not yet spent	Budget	Spent	Balance
Protecting bacteria from contaminants to preserve water quality		$ 279,000	$ 279,000	$ -
Solar Cell Materials from Sulfur and Common Metals (M.L. 2014)		$ 494,000	$ 494,000	
Protecting Minnesota Waters by Removing Contaminants from Wastewater		$ 250,000	$ -	$ 250,000