Environment and Natural Resources Trust Fund
2014 Request for Proposals (RFP)

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Project Title:

Protecting Bacteria from Contaminants to Preserve Water Quality

Category: B. Water Resources

Total Project Budget: $ 279,000

Proposed Project Time Period for the Funding Requested: 3 Years, July 2014 - June 2017

Other Non-State Funds: $ 0

Summary:

Treatment plants use bacteria to degrade pollutants. Man-made chemicals including perfluorinated chemicals that enter treatment plants harm bacteria. If we can protect bacteria, we can better protect water quality.

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Sponsoring Organization: U of MN

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Location

Region: Statewide

County Name: Statewide

City / Township:

MP: 0613-2-067-proposa
Budget: 0613-2-067-bud
Qual: 0613-2-067-qualifi
Map: 0613-2-067-map-N
Resolution:
List:

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

Environment and Natural Resources Trust Fund (ENRTF)
2014 Main Proposal
Project Title: Protecting bacteria from contaminants to preserve water quality

I. PROJECT STATEMENT

In this proposal we will study how perfluorinated compounds and co-contaminants impact the bacteria that we depend on to protect water quality. In short, through this research we will determine:

- Which perfluorinated chemicals are most harmful when in mixtures?
- Which co-contaminants are most harmful when present with perfluorinated chemicals?
- At what perfluorinated chemical or co-contaminant concentrations do problems occur?
- Are certain bacteria more resistant to these chemicals, and if so, how?

By answering these questions, we should be able to make engineering and policy decisions to ensure that our wastewater treatment plants and landfills continue to function as they should.

Background

Humans depend on bacteria to cycle nutrients and carbon. In doing so, bacteria perform critical ecological functions that enable life to exist. We also harness bacteria for use in engineered systems such as wastewater treatment plants and landfills. In fact, it is through the activity of **bacteria** in engineered systems that we are able to **protect Minnesota's surface water** from excess nitrogen pollution, **decompose solid waste**, and **treat wastewater** so that its discharge is cleaner and therefore better supports fish and aquatic life.

Unfortunately, the environments **where these critical bacteria live** are also environments **filled with a complex "soup" of chemicals**. The chemicals present in personal care products, medicines, and the products we buy, such as clothing and packaging, are eventually found in wastewater, solid waste, and the wastewater-derived biosolids that are applied to agricultural land. **These chemicals can negatively affect bacterial function**, and can be particularly damaging when present in mixtures. One common class of chemicals that are present throughout the environment in Minnesota are perfluorinated chemicals; based on other research, we hypothesize that **perfluorinated chemicals can cause other co-contaminants to be more toxic to bacteria**.

As stated above, the **proposed research** will study **how bacterial function** (the removal of harmful nitrogen- and carbon-containing compounds in engineered systems that model wastewater treatment plants and landfills) is **affected** when bacteria are **exposed to** a mixture of **perfluorinated chemicals** in the presence and absence of **other co-contaminants**, much as one would observe in wastewater treatment plants or landfills. This research will help us understand **why/when critical bacterial functions such as nitrogen cycling and carbon decomposition are lost** as a result of chemical exposure. It will also help us understand **which bacteria are more resistant** to such harmful affects **and why**. In much the same way that we protect ourselves from the cold by wearing a coat, bacteria can protect themselves from harmful environmental assaults by developing a protective outer layer (or "coat"). How this type of "coat" affects bacterial function and resistance to the negative impacts of perfluorinated chemicals and other co-contaminants will be determined **with the goal of developing engineered methods to protect critical bacterial functions**.

II. DESCRIPTION OF PROJECT ACTIVITIES

Activity 1: Understanding how and why perfluorinated chemicals alter bacterial function (nitrogen cycling and carbon decomposition) alone or in mixtures with a co-contaminant **Budget: $186,000**

Two different types of microorganisms, one critical for nitrogen cycling ("nitrifiers") and one critical for carbon cycling ("methanogens"), will be exposed to several perfluorinated chemicals alone and present in mixtures with a model pesticide (the co-contaminant). Bacteria with different levels of protection (i.e., different types and thicknesses of "coats") will also be studied. The toxicity of the chemicals will be assessed over a range of concentrations and exposure conditions to answer the following questions:

- Which perfluorinated chemicals are most harmful when in mixtures?
- At what perfluorinated chemical or co-contaminant concentrations to problems occur?
- Are certain bacteria more resistant, and if so, how?

Outcome	Completion Date
1. In cultures of nitrogen-cycling bacteria, determine which perfluorinated chemicals are most harmful, alone and in mixtures, and at what concentrations	*06/30/2015*
2. In cultures of carbon-cycling bacteria, determine which perfluorinated chemicals are most harmful, alone and in mixtures, and at what concentrations	*06/30/2016*
3. Determine whether certain common bacterial traits (different types and thicknesses of protective "coats") make bacteria more resistant to this type of toxicity	*01/31/2017*

Activity 2: Understanding the chemical properties of co-contaminants that make them more harmful to bacterial function (nitrogen cycling and carbon decomposition) in the presence of perfluorinated chemicals **Budget: $93,000**

We will determine whether certain chemical properties of co-contaminants, when present in mixtures with perfluorinated chemicals, can be used to predict harm to bacterial function. Again, two different types of microorganisms, one critical for nitrogen cycling and one critical for carbon cycling, will be exposed to a range of co-contaminants specifically chosen for their chemical properties. The co-contaminant exposure will occur at different concentrations alone (to act as a control), and in mixtures containing perfluorinated chemicals. The effect of chemical exposure on bacterial function will be determined as a function of critical co-contaminant chemical properties to answer the following question:

- Which co-contaminants are most harmful when present with perfluorinated chemicals?

Outcome	Completion Date
1. In cultures of nitrogen-cycling bacteria, determine how co-contaminant chemistry affects bacterial function when present in mixtures containing perfluorinated chemicals	*03/31/2016*
2. In cultures of carbon-cycling bacteria, determine how co-contaminant chemistry affects bacterial function when present in mixtures containing perfluorinated chemicals	*03/31/2017*

III. PROJECT STRATEGY

A. Project Team/Partners

The project team consists of the Principal Investigator (PI) Paige Novak (University of Minnesota) and co-PI Dr. Matt Simcik (UMN). Novak is an expert on microbial systems and Simcik is an expert on the analysis of trace chemicals, including perfluorinated chemicals. The PI and co-PI will work together on all aspects of the research.

B. Timeline Requirements

The proposed project will be completed in the allotted three-year period

C. Long-Term Strategy and Future Funding Needs

The proposed research fits into a larger research agenda centered at the University of Minnesota that is focused on the problem of Contaminants of Emerging Concern. When taken together, this research and other complementary current and prior research in this area will provide a more complete picture of how to safeguard our environment through engineering different types of treatment systems (systems that encourage the development of protective bacterial "coats" for example). In particular, an emphasis on understanding threats to water quality in Minnesota can help us to then engineer better treatment methods to promote cleaner water and therefore healthier fish and aquatic ecosystems.

2014 Detailed Project Budget

Project Title: Protecting bacteria from contaminants to preserve water quality

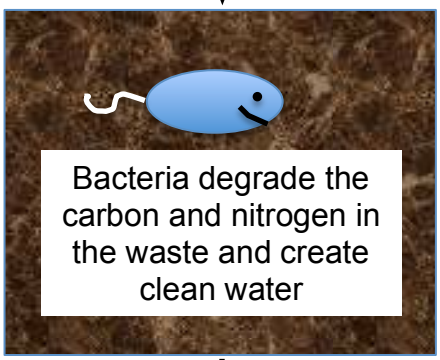
IV. TOTAL ENRTF REQUEST BUDGET 3 years

BUDGET ITEM	AMOUNT
Personnel: Novak (PI, 8% time per year for three years, salary 75% of cost, fringe benefits 25% of cost). Project supervision, provide guidance on the experimental set-up and microbial culturing.	$ 53,000
Personnel: Simcik (PI, 10% time per year for three years, salary 75% of cost, fringe benefits 25% of cost). Project supervision, guidance on the analysis methods.	$ 35,500
Personnel: Graduate student (50% time per year for three years, 57% salary, 33% tuition, 10% fringe benefits). Conducting laboratory experiments, performing analysis, and imaging studies.	$ 131,500
Personnel: Undergraduate student (13 weeks (i.e., summer), full time per year for three years). Assisting with analysis and laboratory experiments.	$ 15,500
Equipment/Tools/Supplies: Laboratory supplies including, but not limited to: chemicals for experiments (PFCs and co-contaminants), bacterial cultures, oxygen probes, analysis needs such as standards, gas tanks, needles, septa, supplies for bacterial imaging (fluorescent antibodies, chemicals), consumables such as gloves and solvents ($8,500/yr). Additional funds budgeted for equipment repair and maintenance ($6,000), and imaging and image analysis ($10,000).	$ 43,500
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 279,000

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ Being Applied to Project During Project Period: none	$ -	
Other State $ Being Applied to Project During Project Period: none	$ -	
In-kind Services During Project Period: Novak and Simcik will provide unpaid time to the project (including 1% cost-share each). Because the project is overhead-free, laboratory space, electricity, and other overhead costs are provided in kind. The University of Minnesota overhead rate is 52%.	$ 116,000	
Remaining $ from Current ENRTF Appropriation (if applicable): no prior projects directly related to proposed project	$ -	
Funding History: Preliminary research in this area has been supported by a seed grant from the University of Minnesota (The Office of the Vice President for Research at the University of	$ 33,366	

Waste (containing nitrogen and carbon)



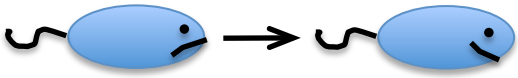
Clean water

The benefit of bacteria

Waste (containing nitrogen and carbon), and manmade chemical mixtures

Dirty water

The problem



Determine why bacteria are harmed by chemical mixtures so that it can be prevented

Our proposed project

Project Manager Qualifications and Organization Description

Paige J. Novak
Professor, Environmental Engineering, Department of Civil Engineering and Resident Fellow of the Institute on the Environment, University of Minnesota

B.S., Chemical Engineering, 1992, The University of Virginia, Charlottesville, VA.
M.S., Environmental Engineering, 1994, The University of Iowa, Iowa City, IA.
Ph.D., Environmental Engineering, 1997, The University of Iowa, Iowa City, IA.

Dr. Paige Novak and Dr. Simcik will share overall project coordination. Dr. Novak will direct the efforts on microbial cultivation and experimentation. She is an expert in applied environmental microbiology and has been studying the fate and biological transformation of micropollutants for over ten years. Recent work has focused on the effects of the micropollutants triclosan and perfluorooctane sulfonate (PFOS) on microbial community function and structure. Dr. Novak was the 2007 recipient of the Paul L. Busch Award (Water Environment Research Foundation) for her research on industrial phytoestrogens, the 2013 Bill Boyle Educator of the Year Award (Central States Water Environment Association), and the 2011 Samuel Arnold Greeley Award (American Society of Civil Engineers). She, Dr. Heiko Schoenfuss, and Dr. William Arnold will complete an LCCMR-funded project on the fate and effects of phytoestrogens in the environment. Four to five manuscripts will be (or have been) submitted for publication from this work.

Dr. Matt Simcik (University of Minnesota)
Associate Professor, Environmental Health Sciences, School of Public Health, University of Minnesota

B.S., Chemistry, 1992, Michigan State University
M.S., Civil Engineering, 1994, University of Minnesota
Ph.D., Environmental Sciences, 1998, Rutgers, The State University of New Jersey

Dr. Simcik is an expert in environmental chemistry. He will direct the analysis of perfluorinated compounds (PFCs) and co-contaminant analysis. He has been analyzing trace organic contaminants in various environmental media for 20 years, including PFCs for the past 10 years.

Organization Description
The University of Minnesota is one of the largest, most comprehensive, and most prestigious public universities in the United States (http://www1.umn.edu/twincities/01_about.php). The laboratories and offices of the PI and co-PIs contain all of the necessary fixed and moveable equipment and facilities needed for the proposed studies.