Environment and Natural Resources Trust Fund
2016 Request for Proposals (RFP)

Project Title: **ENRTF ID: 068-B**

Minnesota Resources to Remove Pollutants and Enhance Crop Production

Category: B. Water Resources

Total Project Budget: $ 505,833

Proposed Project Time Period for the Funding Requested: 3 years, July 2016 to June 2019

Summary:

We will use reed-sedge peat, a Minnesota natural resource, to prevent nitrogen and phosphorus run-off from agricultural drainage and use the recovered peat as a fertilizer for enhanced crop production.

Name: Michael Sadowsky

Sponsoring Organization: U of MN

Address: 1479 Gortner Ave, 140 Gortner Labs

St. Paul MN 55108

Telephone Number: (612) 624-2706

Email sadowsky@umn.edu

Web Address http://www.mississippi-metagenome-project.umn.edu/

Location

Region: SE

County Name: Dodge, Rice

City / Township: Claremount and Dundas

Alternate Text for Visual:

Flow diagram of proposed process of nutrient removal and crop protection

_____ Funding Priorities _____ Multiple Benefits _____ Outcomes _____ Knowledge Base

_____ Extent of Impact _____ Innovation _____ Scientific/Tech Basis _____ Urgency

_____ Capacity Readiness _____ Leverage _____ TOTAL _____%

PROJECT TITLE: Minnesota Resources to Remove Pollutants and Enhance Crop Production

I. PROJECT STATEMENT

In Minnesota, subsurface drainage is a major pathway for transporting contaminants from land to surface waters, which has a significant environmental impact. Loss of nutrients from agricultural drainage to waterways has been of major concern due to human health issues and is a large contributor to oxygen deficiency in aquatic systems. For protection and restoration of the MN's water resources, it is essential to reduce the level of these contaminants in subsurface drainage in a cost-effective manner. We propose the use one of Minnesota's natural resource, reed-sedge peat, to prevent run-off and recover nutrients (nitrogen and phosphorus) from drainage water. This project will utilize engineered peat (hardened granular media coated with phosphorus-scavenging microorganisms) as a medium for sorbing nutrients from water. The nutrients recovered by the peat can be reapplied to agricultural land as valuable fertilizer for enhancement of crop production.

Minnesota has over ~ 7 million acres of peatlands, more than any of the lower 48 States. Reed-sedge peat, an organic formed from the incomplete anaerobic decomposing of plant matter, has an effective adsorption capacity for a variety of contaminants and has been used as a carrier for application of microbes (*e.g* rhizobia) to agricultural fields. In this proposal, we aim to enhance removal performance of soluble phosphate from drainage tile water by integrating an engineered peat with microorganisms that contain a phosphate binding protein. The microorganisms act as "bags of protein" to trap phosphate inside of cells. Moreover, the potential utility of peat materials in trapping nutrients will be evaluated as slow release fertilizer and soil amendment. This process provides several benefits: including better protection against nutrient leaching and run-off and recovery of nutrients that are in limited supply and cause algal blooms in waterways and a dead zone is the Gulf of Mexico. This project will develop this mitigation technology via both bench- and pilot-scale experiments and evaluate its effectiveness on two southeastern MN agricultural fields (in Claremont in Dodge county and Dundas in Rice County). The application can be flexible and effective depending upon seasonality of drainage and timing of field operations and may be combined with current practices to prevent nutrients from entering water resource. The project develops sustainable strategies to enhance the effectiveness of agricultural practices by mitigating off-site movement of contaminants and by enhancing crop production in Minnesota.

These studies will put Minnesota at the forefront of this important area of environmental research. Project outcomes will provide more insight into increasing the efficacy of contaminant removal strategies for agricultural practices, with the ultimate goal of improving water quality and enhancing important economic activities. We also believe that one of the best approaches to protect and restore water resources in Minnesota is to engage the public through exhibits at the Science Museum of Minnesota and the Bell Museum of Natural History.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Determine nutrient sorption capacity of engineered peat with phosphorus-scavenging microorganisms **Budget: $108,700**

The engineered peat will be coated with non-reproducing, immobilized, *E. coli* cells overexpressing phosphate binding proteins that act as phosphorus scavengers. These "dead" cells act as "bags of proteins" to trap soluble phosphorus inside of cells, as was previously done for atrazine. This protein has a very high affinity and specificity for phosphate. Prior to incorporation onto engineered peat, these bacteria will be killed by glutaraldehyde fixation treatment. This renders the cells non-viable but they still contain active enzymes. Bacteria needed for this process will be produced at the Biological Resource Center of the University of Minnesota, with up to 500L fermentation capacity. We will characterize the efficacy of the engineered peat and the peat with phosphorus-scavenging microorganisms in adsorbing phosphorus and nitrate from agricultural drainage (soil leachates) under various conditions. Moreover, the phosphate-binding protein incorporated with the engineered peat will be monitored before and after sorption of nutrient using Western blotting and Phosphorus analyses.

Outcome	Completion Date
1. Construct the engineered peat with phosphorus-scavenging microorganisms	December, 2016
2. Determine the nutrient sorption/desorption efficiency of the engineered peat and the peat coated with phosphorus-scavenging microorganisms in various conditions	June, 2017

3. Delineate critical design parameters for larger-scale filters using sorption capacity	June, 2017

Activity 2: Evaluate the effectiveness of engineered peat with phosphorus-scavenging microorganisms in agricultural fields **Budget: $229,000**

Based on the findings of activity 1, we will design and construct larger scale biofilters with engineered peat and phosphorus-scavenging microorganism and evaluate their performance of nutrient recovery from drainage water through pilot-scale laboratory and field experiments. Our field experiments will be conducted in two locations in MN: Claremont in Dodge county and Dundas in Rice County for load reduction of nitrate and phosphorus in agricultural drainage under various production conditions. We will monitor nutrients and physiochemical parameters of influent and effluent in biofilters using sensors and continuous water sampling. Additionally, potential key functional microbial activities involved in N and P cycling will be also examined using quantitative polymerase chain reaction, and other molecular biology techniques.

Outcome	Completion Date
1. Construct larger scale filter with engineered peat with P-scavenging microbes	April, 2017
2. Determine the nutrient recovery efficiency of the biofilter through pilot-scale experiments	April, 2018
3. Determine the nutrient recovery efficiency of the biofilter in field in various growth conditions	June, 2019

Activity 3: Evaluate the utility of the trapped nutrient onto peat as slow-release fertilizer **Budget: $88,133**

We will collect the peat materials following biofilter operation, release their nutrients via mild chemical treatment and characterized their nutrient contents and chemical forms. The N and P released from biofilter material will be measured through column extraction method and evaluated as fertilizers for plant growth in growth chamber/green houses and in the field.

Outcome	Completion Date
1. Characterize the content and forms of nutrient trapped in biofilter	January 31, 2018
2. Determine N and P release from after-use biofilter materials as slow-release fertilizer	June 30, 2019

Activity 4: Project data dissemination **Budget: $80,000**

We will disseminate our results through personal presentations to state agencies, fact sheets, a dedicated web site, and in papers published in professional journals. Moreover, we will develop a practical-oriented document to help landowners and professionals in the field to understand, manage, and monitor their biofilter for subsurface drainage. We will also develop public displays at two museums (the SMM and The Bell Museum of Natural History) to reach a large number of adults and children for water conservation.

Outcome	Completion Date
1. Production of public exhibits and dedicated web site.	December 31, 2018
2. Dissemination of project data and results via seminars, and workshops	June 30, 2019

III. PROJECT STRATEGY

A. Project Team/Partners

The project will be carried out under the direction of Drs. Michael Sadowsky, Chan Lan Chun, and Mikael Elias. Funded project partners will include Peggy Jones of American Peat Technology, LLC, Pat Hamilton of the Science Museum of Minnesota, and Susan Weller, Bell Museum Director. We will also collaborate with Barb Peichel at MPCA, Heidi Peterson at MDA, and Mike Berndt at MNDNR for dissemination activities.

B. Project Impact and Long-Term Strategy

The outcomes of the project will provide sustainable strategies to enhance the effectiveness of agricultural practices by mitigating off-site movement of phosphorus and nitrogen contaminants and by enhancing crop production in Minnesota. Additional funding for more long term and more extensive operation will be obtained from the USDA, water treatment and/or agriculture industries and foundations.

C. Timeline Requirements

The project will be completed over a period of 36 months, including two-year laboratory experiment and one complete field seasons (March-November in 2019), but the impact will last for many more years.

2016 Detailed Project Budget

Project Title: *Use of Minnesota Resources to Remove Pollutants and Enhance Crop Production*

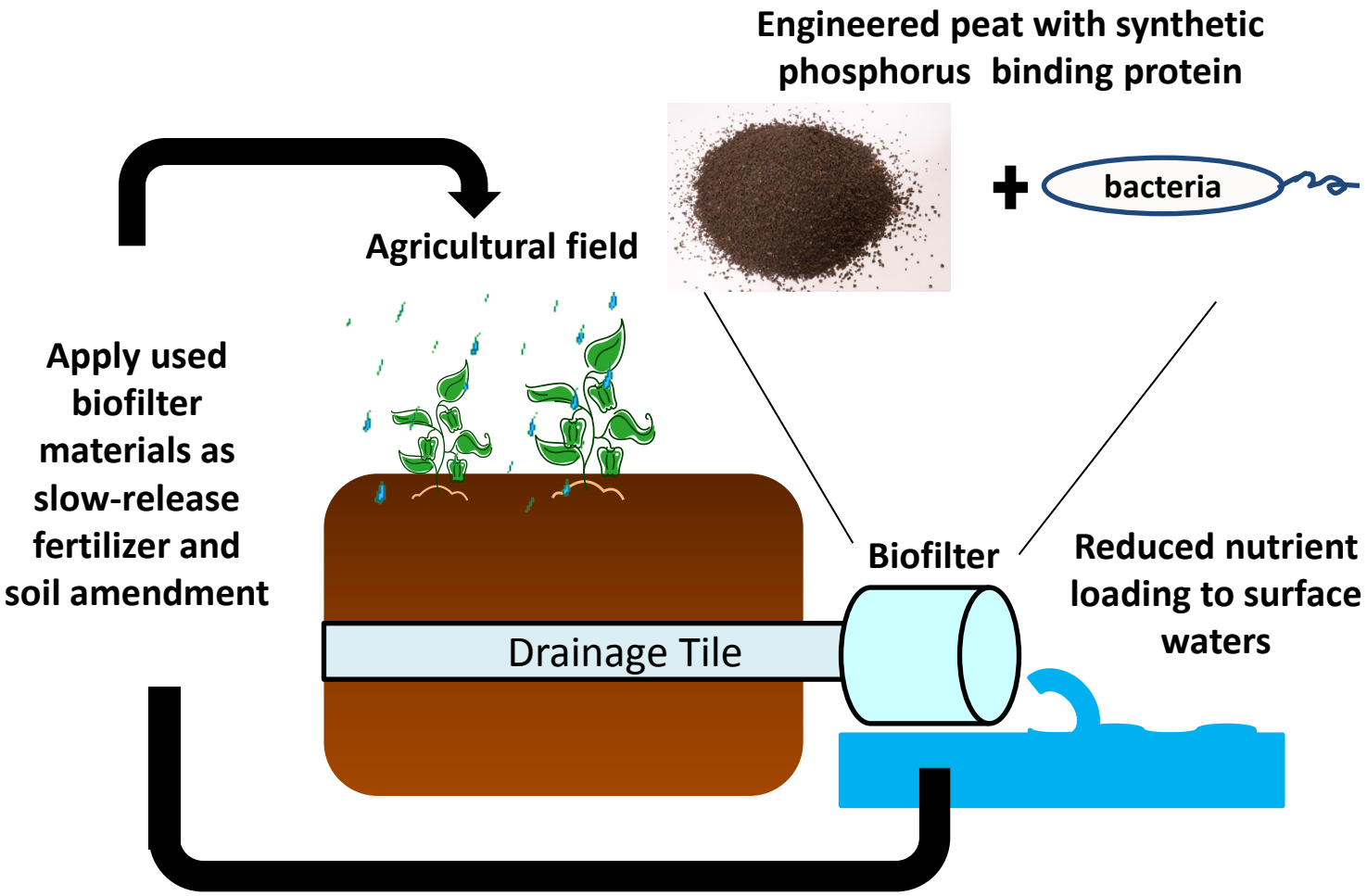
IV. TOTAL ENRTF REQUEST BUDGET *3* **years**

BUDGET ITEM	AMOUNT
Personnel:	
Research Associate (20% time, 34% fringe, 3 years, 1 person)	$ 37,536
Postdoctoral Associate (100% time, 22% fringe, 3 years, 1 person)	$ 152,145
Graduate Student (50% time, GRA tution and benefits, 3 years, 1 person)	$ 115,500
Technician (20% time, 36% fringe, 3 years, 1 person)	$ 42,152
Contract:	
Exhibit at Science Museum of Minnesota and Bell Museum (staff time and materials)	$ 80,000
Travel:	
In-state Travel for 24 samplings per year × 1 years @3000 mi × $0.50/mi	$ 1,500
Conferences	
Equipment/Tools/Supplies:	
Equipments for sample collection and nutrient monitoring	$ 15,000
Peat and laboratory supplies: $20,000/year × 3 years	$ 60,000
Publication	$ 2,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 505,833

V. OTHER FUNDS *(This entire section must be filled out. Do not delete rows. Indicate "N/A" if row is not applicable.)*

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ To Be Applied To Project During Project Period:	$ -	
Other State $ To Be Applied To Project During Project Period:	$ -	
In-kind Services To Be Applied To Project During Project Period: *In-kind Services To Be Applied To Project During Project Period: In kind services will be provided by the BMBB Department and BioTechnology Institute to cover indirect costs associated with managing the research project and providing administrative support to researchers*	$ 244,294	
Funding History: LCCMR project, Mississippi Water Quality – Deeper Look, Broader Impacts will be leverage to this project (July 2011-December 2014).	$ 555,700	
Remaining $ From Current ENRTF Appropriation:	$ -	

Minnesota Resources to Remove Pollutants and Enhance Crop Production



Project Manager Qualifications and Organization Description:

Project Manager: Dr. Michael J. Sadowsky

Title: McKnight University Professor and Director BioTechnology Institute

Affiliation: University of Minnesota, Department of Soil, Water and Climate, and BioTechnology Institute

The UMN Biotechnology Institute (BTI) provides advanced research, training, and university-industry interactions in biological process technology, and other areas of biotechnology research. Faculty in the BTI have broad expertise in: Biocatalysis, Metabolic engineering/microbial physiology, Population dynamics, Molecular biology, Proteomics and focused expertise in defined areas such as bioremediation, biomaterials, biosensors, and bioinformatics.

Education:
Ph.D., 1983. University of Hawaii, Honolulu, Hawaii. Major: Microbiology
M.S., 1979. University of Wisconsin-Oshkosh, Wisconsin. Major: Microbiology
B.S, 1977. University of Wisconsin-Madison, Wisconsin. Major: Bacteriology

Professional Experience:

- Director BioTechnology Institute, University of Minnesota, St. Paul, Minnesota, 2009 - present.
- Co-Director, Microbial and Plant Genomics Institute, University. of Minnesota, 2006-2009.
- Distinguished McKnight University Professor: Department of Soil, Water, & Climate, and
- BioTechnology Institute, University of Minnesota, St. Paul, Minnesota, 04/04 - present.
- Professor: Department of Soil, Water, and Climate and Department of Microbiology
- University of Minnesota, St. Paul, Minnesota, 07/96 – 04/04.
- Associate Professor: Departments of Soil Science and Microbiology
- University of Minnesota, St. Paul, Minnesota, 07/93 - 6/96.
- Assistant Professor: Departments of Soil Science and Microbiology
- University of Minnesota, St. Paul, Minnesota, 06/89 - 6/93.
- Microbiologist: U.S. Department of Agriculture-ARS; Beltsville, Maryland, 01/86 - 05/89.

Dr. Sadowsky will have chief management responsibilities for overseeing the proposed project. He will be responsible for working with Drs. Chun and Elias, and project partners, to ensure that project goals, results and timelines are met. He will also be responsible for working with the graduate student and postdoctoral associate at UMN, staff at the museums and partners at MN DNR. Dr. Sadowsky is an environmental microbiologist with 33 years research experience in the analysis and use of microorganisms in environmental settings. Dr. Sadowsky's laboratory studies the distribution and diversity of microorganisms in aquatic and soil environments and uses genetic, genomic, and biotechnology tools to examine how microorganism become established in new environments. He is currently Director of the BioTechnology Institute, and is involved in teaching microbial ecology and metagenomic courses at the University and Lake Itasca.
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