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

Project Title: **ENRTF ID: 064-B**

Vegetated Filter Strips as Optimized Water Purification Systems

Category: B. Water Resources

Total Project Budget: $ 278,744

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

Summary:

Plant-soil amendments will be evaluated to determine which combination creates a soil microbial community in vegetated filter strips that enhances the loss of nitrates, sediments, polycyclic aromatic hydrocarbons, and nanoparticles.

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Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Pictorial overview of proposed work.

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

PROJECT TITLE: Vegetated Filter Strips as Optimized Water Purification Systems

I. PROJECT STATEMENT

Water from various anthropogenic land uses contain chemicals from excess nutrients and sediments to strong carcinogens like polycyclic aromatic hydrocarbons (PAHs) and more recently to emerging contaminants such as pharmaceuticals and nanoparticles. When these runoff waters are forced through a vegetated filter strips (VFS), the soil-plant-microbe community that interacts with the pollutants in the water greatly reduces sediment, nutrient and some chemical loading into the adjacent waterbody. There has been variation in the performance of VFS as water purification systems; thus it is critical to examine VFSs as a system to understand and optimize the components of a VFS that result in optimum improvement in water quality. The objective of the current study is to examine the interaction between soil amendments, plant species, and the resulting microbial community to optimize not only sediment and nutrient removal, but also removal of organic chemicals flowing from anthropogenic land uses.

Anthropogenically impacted environments have become the norm in Minnesota, and beyond. Through industrialization, chemical usage has dramatically increased resulting in decreased pristine environments. Protecting surface waters from pollution by chemicals, microorganisms, and other pollutants that degrade water quality is of significance to Minnesota as we have 12,000 lakes, more than 104,000 miles of streams and 9.3 million acres of wetlands all of which are likely impaired. Statewide, the DNR has a proposal with Governor Mark Dayton to designate 125,000 acres of land adjacent to waterways in the state as filter strips. The design for these filter strips is focused on the removal of phosphorus, nitrate, and sediments from water. While removal of these chemicals is important, if the vegetated filter strips can be designed to address not only these chemicals, but also other chemicals such as polycyclic aromatic hydrocarbons (PAHs), and nanoparticles, water quality will be improved to a greater extent. Few studies have focused on the soil microbial communities resulting from the interaction between plant species, soil amendments, and the impacts these pieces functioning together have on pollutants.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1*:* Greenhouse and field studies to screen plant species-soil amendment-microbial community treatments for their ability to remove polycyclic aromatic hydrocarbons (PAHs), nanoparticles, nitrates, and sediments.	**Budget: $278,744**

Description: The focus of this project is the identification of plant species-soil amendment combinations that optimize the removal of PAHs, nanoparticles, nitrates and sediments as water passed through the soil profile. Thus, plant species previous shown to be effective in VFSs (*Festuca arundinacea, Sorghastrum nutans, Bouteloua dactyloides, Panicum virgatum* and *Iris prismatica)* and widely accepted in the anthropogenic landscape will be examined in combination with soil amendments designed to increase retention of organic compounds in the VFS (peat, biochar, and a combination of peat and biochar). Approximately 1 month after the plant-soil amendment treatments have been established in columns; water containing PAHs, titanium nanoparticles, nitrates, and excess dissolved sediments will be added to the top of the column. Water draining through the column will be collected and analyzed for PAHs (via gas chromatography), nanoparticles (via scanning electron microscopy), nitrates (via UV-VIS spectrophotometry), and sediments (via mass per volume of water). All treatments will be replicated 4 times. This experiment will proceed for 6 months' time; after 6 months have passed soil samples will be taken from the columns and will be subjected to PLFA analysis to evaluate the microbial community structure and function within each of the columns. Information obtained from this phase of the study will inform treatments that will be selected for a field study in which high performing

combinations of plant species and soil amendments will be evaluated for their effectiveness in reducing PAHs, nanoparticles, nitrates, and sediments in a field setting. Based on the activity mentioned above, we will select a subset of plant species-soil amendment-microbial community treatments for evaluation in the field. The top 4 performing treatments from the greenhouse study will be evaluated for their efficacy in reducing pollution of surface waters in a field setting. This will be done in a highly engineered system to ensure that all variables can be controlled including rainfall, slope, and porosity of the soil itself. This will ensure we will be evaluating the interaction between the plant species and soil amendment and their efficacy on contaminant removal. In both experiments, target compounds will be spiked into an appropriate volume of distilled water and pre and post-treatment of the water will be analyzed using the methods mentioned in activity 1.

Outcome	Completion Date	Budget
1. Collection of water samples and performance of analytical procedures for greenhouse (PAHs, nanoparticles, nitrates, and sediments)	*August 2017*	*$77,353*
2. Collection of water samples and performance of analytical procedures for field (PAHs, nanoparticles, nitrates, and sediments)	*August 2019*	*$191,391*
3. Collaboration with UM Extension to produce Extension Bulletin and have information meetings	*August 2019*	*$10,000*

III. PROJECT STRATEGY

A. Project Team/Partners

K. Walker, Ph.D. *is currently an Assistant Professor of Agronomy at the University of Minnesota Crookston. She has numerous publications in areas including cultural practices on endophyte expression in turf, turfgrass management, nitrogen fertilization effects on aboveground responses and soil nitrogen losses from turfgrass, reducing sediment and nutrient runoff losses during turfgrass establishment and Creeping bentgrass fairway divot recovery.* ***B. Dingmann, Ph.D.*** *is currently an Associate Professor of Biology at the University of Minnesota Crookston. He has several publications related to the proposed research methodology. His contribution to the research will involve undergraduate conducted projects within the overall project parameters evaluating the microbial community structure and function.*

B. Project Impact and Long-Term Strategy

It is crucial for our society to minimize water use, protect water quality, and reduce greenhouse gas emissions as we move forward. UMC is known throughout the state of Minnesota as a campus who focuses on sustainability issues through undergraduate student projects. However, this project has the potential to put UMC on the national and international page in regards to environmentally focused research. Findings of the research will be disseminated through extension publications and peer reviewed publications which will reach audiences locally and internationally. We are seeking funding to perform a greenhouse trial followed by a minimum of two years of field research necessary for meaningful results.

C. Timeline Requirements

The proposed activity is a multi-phase project. The first 6 months of the study would be a greenhouse trial and the second phase of the project is a 2 year field study using the results of the greenhouse trial to inform the experimental treatments used.

2016 Detailed Project Budget

Project Title: Vegetated Filter Strips as Optimized Water Purification Systems

IV. TOTAL ENRTF REQUEST BUDGET: Three years

BUDGET ITEM *(See "Guidance on Allowable Expenses", p. 13)*	**AMOUNT**
Personnel:	
K. Nannnega; K. Walker, B. Dingmann (1 month summary salary; 33.7% benefits) for year 1, 2, and 3	80,220
1 Technician (3 months summary salary; 27.4% benefits for all three years)	28,414
2 Undergraduate Students (6 months salary; 7.7% benefits for all three years)	74,442
Professional/Technical/Service Contracts:	
Phospholipid Fatty Acid Analysis by University of Minnesota Twin Cities	38,016
Scanning Electron Micrograph Time by University of North Dakota	33,060
Equipment/Tools/Supplies:	
Lab Supplies: chemicals, tools, bottles, gloves, metal boxes, wood, seed, fertilizer, columns, peat, biochar, glass jugs, nanoparticles, PAHs, solvents, gases, standards, GC vials, enzymes, extension bulletins	23,033
Acquisition (Fee Title or Permanent Easements):	NA
Travel:	
Rental of vehicle to be used during field season for all 3 years including gasoline, etc… (2,000 miles)	1,559
Additional Budget Items:	NA
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 278,744

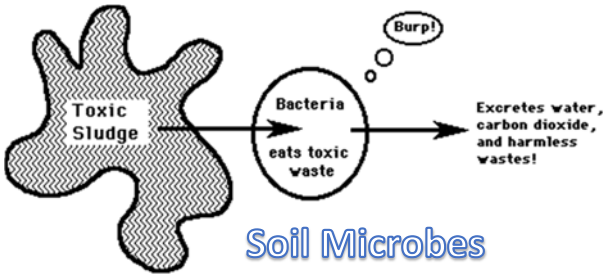
V. OTHER FUNDS *(This entire section must be filled out. Do not delete rows. Indicate "N/A" if row is not applicable.)*

SOURCE OF FUNDS	**AMOUNT**	**Status**
Other Non-State $ To Be Applied To Project During Project Period: *I*	NA	
Other State $ To Be Applied To Project During Project Period:	NA	
In-kind Services To Be Applied To Project During Project Period: *Salary of K. Nannenga, K. Walker, and B. Dingmann over 3 years; 1 month each in each of 3 years.*	$ 36,000	*Secured*
Funding History:	NA	
Remaining $ From Current ENRTF Appropriation:	NA	

Vegetated Filter Strips can enhance removal of pollutants from waters

Credit: Bryan Yoon

Each plant species and organic amendment has different abilities to remove contaminants and purify water



Benefits:

Decreased nutrient, sediment, and pollutant loading into surface waters.

Improved Water Quality for recreation use (swimming, fishing, habitat quality)

Project Manager Qualifications

Katy Wren Nannenga, Ph.D. ***K. Nannenga, Ph.D.*** *is currently an Assistant Professor of Biology and Environmental Sciences at the University of Minnesota Crookston. She has numerous publications in areas including vegetative filter strips in golf courses; greenhouse gas emissions from soils, nitrogen mineralization, and phytoremediation.* Her previous position was as a Research Soil Scientists with the USDA ARS National Soil Dynamics Laboratory where she evaluated greenhouse gas fluxes from agricultural soils. Her post-doctoral fellow was done at The Environmental Institute at the University of Massachusetts-Amherst where she worked with John Clark utilizing vegetative filter strips to mitigate pesticide losses from golf courses. She received a Ph.D. from Purdue University in December 2005 in environmental soil science with the Department of Agronomy, and a B.S. degree from the University of North Dakota in May 2001 in Biology. Her research interests lie in the area of greenhouse gas emissions from soils, nitrogen mineralization, phytoremediation, or using plants to enhance the loss or pollutants from the environment. Her dissertation was titled dewatering and remediation of contaminated dredged sediments. For her dissertation she focused on evaluating plants for their ability to dewater supersaturated sediments with the idea that the removal of water would enhance the aerobic degradation of many of the pollutants found in the sediments. In addition, she evaluated the effect plants had on the loss of polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) from sediments.

Organizational Description

The University of Minnesota Crookston (UMC) is one of the 5 coordinate campuses of the University of Minnesota system. UMC is an undergraduate only University with just under 1000 on-campus undergraduate students with 32 on-campus majors and 14 on-line majors. The PI is housed in the Department of Math, Science, and Technology and advises students majoring in Biology and Environmental Sciences; and the Co-PI is housed in the Department of Agriculture and Natural Resources and advises students majoring in Agronomy and Turfgrass Management. The proposed work will be done with the assistance of undergraduate students primarily majoring in Agronomy, Biology, Environmental Sciences, and Natural Resources. The laboratory space needed for these studies is housed on the University of Minnesota Crookston campus and has all of the necessary equipment to conduct the proposed activities. In addition, UMC has greenhouse and growth chamber space that would be available for the greenhouse trials proposed in the second activity.