Environment and Natural Resources Trust Fund
2015 Request for Proposals (RFP)

Project Title: **ENRTF ID:** **035-B**

Preventing Phosphorous from Entering Water Resources Through Draintiles

Category: B. Water Resources

Total Project Budget: $ 355,000

Proposed Project Time Period for the Funding Requested: 2 years, July 2015 - June 2017

Summary:

Draintile runoff discharges phosphorous and nitrogen into water resources. A new nanocomposite material made from biomass can adsorb this excess fertilizer for recycling back to agricultural lands.

Name: Kenneth Valentas

Sponsoring Organization: U of MN

Address: 1479 Gortner Ave, 140 Gortner Labs

St. Paul Mn 55108

Telephone Number: (763) 595-0365

Email valentas@umn.edu

Web Address

Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Cartoon showing removal of phosphorous from draintile discharge.

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

PROJECT TITLE: Preventing Phosphorous from Entering Water Resources Through Draintiles

I. Project Statement: We have a new way of protecting Minnesota's waters and fisheries from the excess fertilizer (phosphorous and nitrates) discharges of cities and farms. It involves a **new nanocomposite hydrochar** material made from waste biomass that preliminary experiments have shown to be **effective in adsorbing phosphorous and nitrogen from water, such as in draintiles**, and preventing them from entering water resources. This unique **hydrochar with "trapped" phosphorous and nitrogen can be recycled to the agricultural lands as a slow release soil amendment and fertilizer.** The net effect is keeping these unwanted nutrients out of the waters and at the same time reducing the overall fertilizer use through recycling by minimizing the loss of nutrients from leaching. Once phosphorous and nitrogen enter our water resources it is virtually impossible to remove them. The simple solution is to prevent them from entering the waterways. Denitrification bioreactors that utilize woodchips can remove some of the nitrates from drainage water but this is converted to nitrogen that has no value for recycling to the land. Phosphorous is often the limiting nutrient in aquatic ecosystems and the main culprit in eutrophication. To date, minimal progress has been made in reducing dissolved phosphorous losses from agricultural lands.

Overall Goal: We propose to take a significant step in minimizing phosphorous and possibly nitrate pollution through a novel mitigation process based on a magnesium oxide-hydrochar porous nanocomposite (engineered hydrochar), recently developed at the University of Minnesota, that removes phosphorous and possibly nitrates from draintile water and makes it available for recycling back to agricultural lands.

Outcomes.

(1) An effective and affordable engineered hydrochar filter for adsorbing phosphorous and possibly nitrates from water from drain-tiled land.

(2) An engineered hydrochar nanocomposite designed to adsorb phosphorous and nitrates from agricultural drainage water and have utility as a soil amendment that can be recycled to the agricultural land as a slow release fertilizer to reduce loss of nutrients through leaching.

Work Plan: We propose to:

- Design and construct a laboratory scale engineered hydrochar filter for use in removal of phosphorous and nitrates from drain-tile effluents.
- Determine the sorption/desorption efficiency of various engineered hydrochars and delineate critical design parameters for larger scale filters.
- Evaluate engineered hydrochars, made from several biomass sources, for effectiveness in adsorbing phosphorous and nitrates from soil leachates under various production conditions.
- Develop a quantitative long -term phosphorous management protocol based on experimentally determined sorption/decomposition properties of engineered hydrochars.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Make and evaluate engineered hydrochars for phosphorous sorption. **Budget: $ 155,000**

Determine efficacy of engineered hydrochars made from various biomass sources such as fermentation residues, dairy whey, manures, municipal sewage sludge and various activating metals such as magnesium and zirconium. The technology utilizes hydrothermal carbonization of biomass to make a hydrochar and subsequent heat treatment with an activating metal to increase porosity of the char.

Outcome	Completion Date
1. Make engineered hydrochars from various biomass sources and activating metals and	May 2016

evaluate phosphorous and nitrate sorption/desorption properties in laboratory.	
2. Optimize manufacturing parameters for best sorption/desorption properties.	Dec. 2016

Activity 2: Design and construct a laboratory scale engineered hydrochar filter to remove dissolved phosphorous and nitrates from drain-tile effluents and other runoff sources. **Budget: $ 95,000.**

Outcome	Completion Date
1. Identify filter support materials and configuration that maintains required hydraulic properties.	June 2016
2. Determine efficiency of filter at varying flow rates and phosphorous concentrations.	Jan 2017
3. Define critical design parameters for larger scale filter.	June 2017

Activity 3. Characterize phosphorous & nitrate sorption capacity of engineered hydrochars Budget: $ 55,000

Outcome	Completion Date
1. Determine sorption/desorption capacity at various phosphorous/nitrate concentrations and temperatures.	May 2016
2. Establish material strength (slaking potential) of various engineered hydrochars.	Aug 2016
3. Evaluate the kinetics of sorption/desorption as a basis for a field use protocol.	Nov. 2016

Activity 4: Develop protocol for utilizing engineered hydrochar filters in the field Budget $50,000

Outcome	Completion Date
1. Convert sorption/desorption data to protocol for use in the field	March 2017
2 Complete protocol handbook for use as a field application guide.	June 2017

III. PROJECT STRATEGY

A. Project Team/Partners

Project partners Receiving Funds:

- Dr. K.J. Valentas, Adj. Professor Biotechnology Institute, P.I. and process engineering expertise for manufacture of engineered hydrochars.
- Dr. Steve Heilmann, Research Associate, Expertise on hydrothermal carbonization technology.
- Four graduate students to support efforts of Valentas, Feyereisen, Spokas, and Lehman.

Project Partners Not Receiving Funds;

- Dr. Clarence Lehman, Dept. Ecology, Handbook for engineered hydrochar field use protocol.
- Dr. Gary Feyereisen, Dept. Soil, Water, Climate; USDA-ARS, Filtration of phosphorous from point sources.
- Dr. Kurt Spokas, Dept. Soil, Water, Climate; USDA-ARS, Phosphorous sorption/desorption of engineered hydrochars in soils.

B. Project Impact and Long-Term Strategy

Success on this project would be a significant positive step for the mitigation of phosphorous and possibly nitrate pollution of Minnesota's waters. The process for making the engineered hydrochars is expected to be patentable by the university and any royalties would be shared with the ENRTF. We also plan to cooperate with another project aimed at reducing pesticide residues, being submitted for LCCMR consideration this year (Wackett), if that project is funded. Future funding for development and ultimate commercialization would likely be a new start-up or collaboration with Minnesota companies such as 3M, Donaldson, Cargill, etc. who are active in water treatment and/or agriculture.

C. Timeline Requirements. This is a two- year project that involves small -scale field studies, green house growth trials and related studies. As such two growing seasons would be highly desirable.

2015 Detailed Project Budget

Project Title: Preventing Phosphorous from Entering Water Resources Through Draintiles

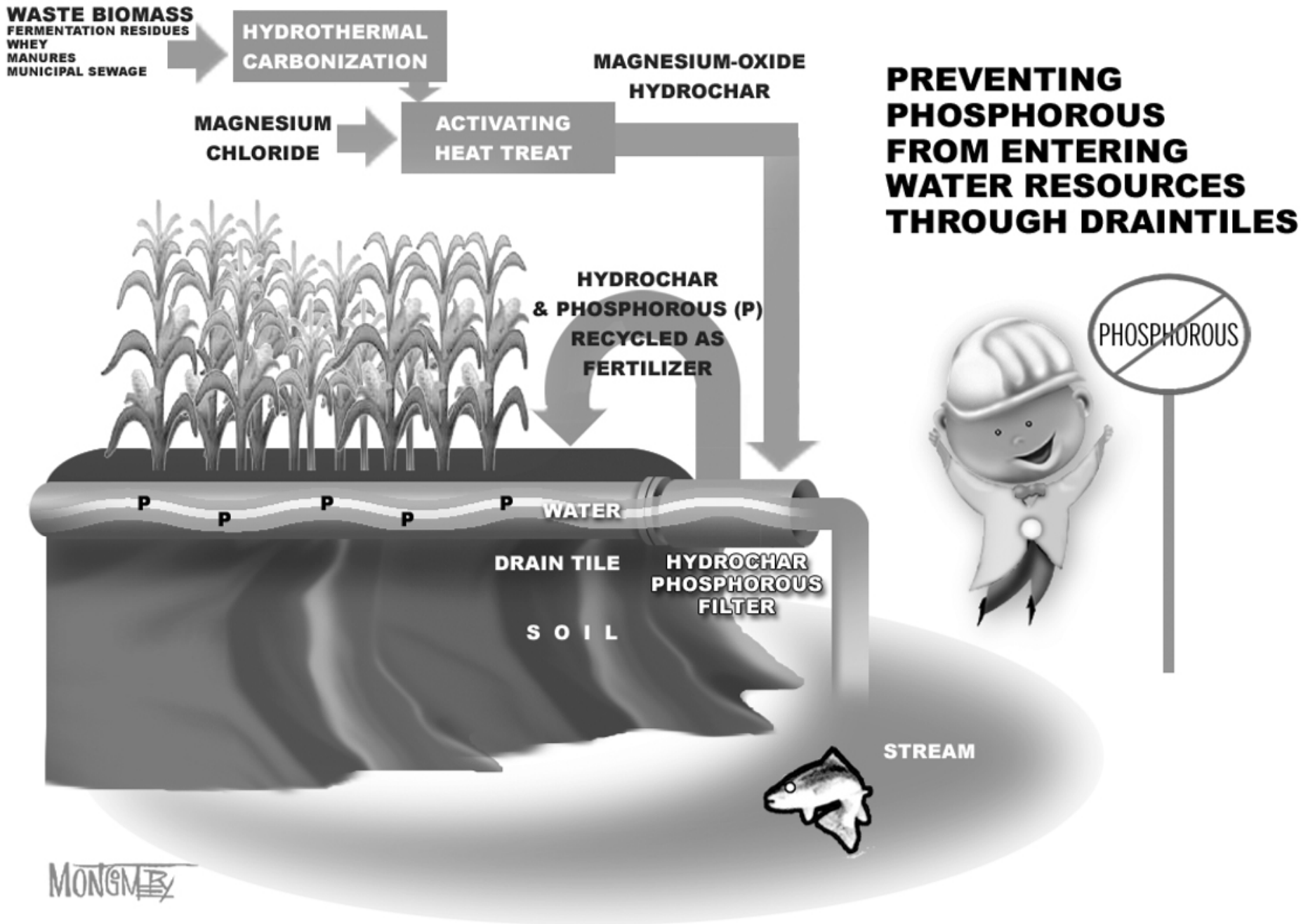
INSTRUCTIONS AND TEMPLATE (1 PAGE LIMIT)

IV. TOTAL ENRTF REQUEST BUDGET two(2) years

BUDGET ITEM	AMOUNT
Personnel: Ken Valentas, Adj. Professor, Biotechnology Institute, P.I., overall technical direction, supervise graduate students, 36% FTE, for 2 years, $75,000, 7.5% fringe, 92,5% salary. Valentas has a 50% unpaid appointment and is on soft money.	**$75,000**
Steven Heilmann, Research Associate, Supervise experiments on metal activated hydrochars, 25% FTE for one year , $23,000, 7.5% fringe, 92.5% salary	**$23,000**
Graduate student (to be named), conduct hydrothermal carbonization experiments and supervise various analytical tests, 100% FTE, for one year, 46% fringe, 54% salary	**$50,000**
Graduate Student/post doc (to be named) construct lab scale hydrochar filter and conduct tests, 100% FTE, $70,000 for 18 months, 46% fringe, 54% salary.	**70,000**
Graduate Student (to be named) conduct experiments on sorption/desorption properties of engineered hydrochars, 100% FTE for one year, $50,000, 46% Fringe, 54% salary.	**50,000**
Graduate student(to be named) develop protocol handbook and provide programming. 100%FTE for one year $50,000, 46% Fringe, 54% Salary	$ 50,000
Contracts: N/A.	$ -
Equipment/Tools/Supplies: Materials to construct hydrochar filter including metering pump, piping, fittings, valves and machining ($12,000); supplies including chemicals and filter bed medium ($5000)	$17,000
Acquisition (Fee Title or Permanent Easements): N/A	$ -
Travel: In State travel to obtain soil and water samples to support analysis and experiments.	$ 2,000
Additional Budget Items: Analytical tests for phosphorous, nitrates, ammonia, heavy metals, hydrochar porosity measurements, and SEM images of nanocomposite engineered hydrochars.	$ 18,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$355,000

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: *N/A*	N/A	*N/A*
Other State $ To Be Applied To Project During Project Period: *N/A*	N/A	*N/A*
In-kind Services To Be Applied To Project During Project Period: *F&A matching* *$355,500 - $108,000 (grad student fringe) * 52% = $128,700.*	$ 129,000	*Pending*
Funding History: Minnesota Corn Growers grant for $97,000 for period July 1, 2014 -June 30 2015. "Converting Condensed Distiller's Solubles (CDS) to Slow Release Fertilizers and Adsorbents for Phosphorous"	$97,000	Secured
Remaining $ From Current ENRTF Appropriation: *N/A*	N/A	*N/A*


WASTE BIOMASS
FERMENTATION RESIDUES
WHEY
MANURES
MUNICIPAL SEWAGE
HYDROTHERMAL CARBONIZATION
MAGNESIUM-OXIDE HYDROCHAR
MAGNESIUM CHLORIDE
ACTIVATING HEAT TREAT
HYDROCHAR & PHOSPHOROUS (P) RECYCLED AS FERTILIZER
P
P
P
P
P
WATER
DRAIN TILE
HYDROCHAR PHOSPHOROUS FILTER
S O I L
STREAM
PREVENTING PHOSPHOROUS FROM ENTERING WATER RESOURCES THROUGH DRAINTILES
PHOSPHOROUS
MONGMEY

Project Manager Qualifications

Kenneth Valentas is Adjunct Professor in the Biotechnology Institute (BTI) at the University of Minnesota. Previously he was Director of the BTI for 16 years and Associate Director for two years. Prior to joining BTI, Valentas was Sr. Vice President of Engineering at Pillsbury/Grand Met, and in total spent 24 years in industry at Sinclair Oil, General Mills and Pillsbury/Grand Met. He holds nine patents related to process engineering.

His PhD in Chemical Engineering is from the University of Minnesota under Regents Professor and former head Neal Amundson. Valentas is a recognized expert in process engineering and the author of two books on the subject. His research while at the BTI has focused on renewable energy with particular emphasis on thermochemical processing and hydrothermal carbonization (HTC) of biomass.

As Director of the BTI and Sr. Vice President of Engineering at Pillsbury, Valentas has gained particular expertise in managing teams of inter-disciplinary researchers and engineers in complex projects. The most recent pertinent experience relevant to this proposed project was his role as principal investigator and project manager for two state funded Biofuel Feasibility Studies (1,(2). A few pertinent peer reviewed publications are listed below (3), (4), (5)

Valentas will serve as *P.I.* and project manager to provide overall direction and coordinate cross-functional activities, write reports and make presentations as required.

(1) Valentas et al (2009) “White Earth Biofuels Feasibility Study”, 94pp., Funded by MNDA under Minnesota statute 48A.10.
(2) Valentas et al (2009), “Chisago, Isanti and Pine Counties Biofuels Feasibility Study”,90pp., Funded by MNDA under Minnesota Session Laws 2007 Chapter 45.

Copies of (1) and (2) are posted at www.bti.umn.edu

(3) Biomass & Bioenergy 2010, 34, 875-882; “Hydrothermal carbonization of microalgae”
(4) Applied Energy 2011, 88(10), 3286-3290; “Hydrothermal carbonization of microalgae. II. Fatty acid, char and algal nutrient products”
(5) Biomass & Bioenergy 2011, 35, 2526-2533; “Hydrothermal carbonization of distiller’s grains”

Organization Description

The University of Minnesota is the state’s main research and graduate teaching institution. Our university has been repeatedly ranked number-one in the nation for Ecology/Environment and Chemical Engineering, based on the citational influence of its scientific publications.