Environment and Natural Resources Trust Fund
2012-2013 Request for Proposals (RFP)

Project Title: **ENRTF ID:** **149-I**

Stopping Phosphorous from Entering Water Resources and Fisheries

Topic Area: I. Water Resources

Total Project Budget: $ 398,000

Proposed Project Time Period for the Funding Requested: 2 yrs, July 2013 - June 2015

Other Non-State Funds: $ 0

Summary:

Phosphorous from treatment plants, feedlots and agriculture fertilize algae that threaten our water resources. Thermal treatment by Hydrothermal Carbonization will remove phosphorous from these sources allowing its recycle to agriculture.

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Sponsoring Organization: U of MN

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Location

Region: Statewide

County Name: Chisago

City / Township:

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

PROJECT TITLE: Stopping Phosphorous from entering Water resources and Fisheries

I. PROJECT STATEMENT: Minnesota's water resources and fisheries are being threatened by phosphorous in the effluent from treatment facilities, and runoff from feedlots and agriculture. **We propose to take a significant step in stopping phosphorous pollution through a novel mitigation process (Hydrothermal Carbonization - HTC), recently developed at the University of Minnesota, which removes phosphorous and makes it available for recycling. This process subjects dilute slurries (1-10% solids) to a temperature of 200^{0}C at elevated pressure for about 30 minutes. This results in a solid carbonaceous coal-like char (called hydrochar) that binds the phosphorous and is easily separable from the sterile, pathogen free, de-odorized effluent.**

Importance: Phosphorous is essential for life, but our use far exceeds what is actually required and the excess is being flushed or drains away into our waters. There it acts as an **unwanted fertilizer** leading to eutrophication and greatly accelerates the growth rate of algae and other aquatic plants, and a depletion of oxygen **(hypoxia) that contributes to the decline of fisheries**. Once the phosphorous enters the water it is virtually impossible to remove it. This is a man made problem. The simple solution is to **stop phosphorous before it enters the water- ways.** The EPA recognizes this and has indicated that permissible levels of phosphorous emission from waste treatment plants will soon be cut in half. Other entry points for excess phosphorous are draining of wetlands for agricultural purposes and feedlot operations. **Preliminary experiments with the Hydrothermal Carbonization technology show that phosphorous can be reduced by as much as 90%** in waste treatment effluent and swine manure. Based on this, we believe that **this can potentially stop phosphorous pollution** in an economical and beneficial manner.

Goals

- **Demonstrate the feasibility of utilizing Hydrothermal Carbonization technology to prevent phosphorous from entering our water resources by trapping in hydro char.**
- **Recycle "trapped" phosphorous in hydro char for agricultural fertilizer uses.**
- **Demonstrate the efficacy of the hydro char as a filter for removing phosphorous runoff from agricultural tile drain water.**

Outcomes

- **Sufficient justification for investment in a demonstration pilot operation for treatment of human sanitary waste and/or animal waste.**
- **An effective phosphorous filter for tile drained land.**

Work Plan: We will work with municipal sewage waste provided by our collaborator, Chisago Lakes sewage treatment facility, to establish efficacy of the process and to generate sufficient quantity of the phosphorous adsorbing hydro char to test phosphorous recovery schemes and regeneration capacity. Hydro char will also be evaluated in a collaborative effort with the USDA-ARS Soil & Water Management Research Unit at the University of Minnesota to construct a model filtration system for phosphorous adsorption from agricultural tile drain water. We will process swine, cattle and poultry manures. Adsorption of heavy metals such as lead, nickel, chromium and copper, found in waste treatment effluent, will be measured. Heat and material balances and economic evaluations will be performed for all applications.

II. DESCRIPTION OF PROJECT ACTIVITIES

Activity 1: Establish efficacy of Hydrothermal Carbonization for removing phosphorous from waste treatment effluent. Perform experiments and laboratory tests with sewage treatment effluent provided by Chisago Lakes sewage treatment plant. Determine energy and chemical cost savings and economic benefit of recycling phosphorous as a fertilizer. Budget: $ 210,000.

Outcome	Completion Date
1. Optimum process conditions for removal of phosphorous (P)	*December 2013*
2. Determine savings in energy and chemical costs due to phosphorous removal	*April 2014*
3. Determine capital savings due to HTC process to meet new EPA (P) regulations	*June 2014*
4. Establish economic benefit of recovering and recycling phosphorous	*Sept. 2014*
5. Cost estimate for demonstration pilot waste treatment facility	*Oct. 2014*

Activity 2. Test the Hydrothermal carbonization process on swine, cattle and poultry manures for phosphorous capture and other benefits. Ascertain functional relationship between catalysts and retention of phosphorous. Determine if process removes antibiotics and hormones. Budget: $ 90,000

Outcome	Completion Date
1. Determine relationship between catalyst and phosphorous removal levels	*Feb. 2014*
2. Assess efficacy of HTC process for removal of antibiotics and hormones	*Feb. 2015*
3. Conduct anaerobic digestion tests on HTC filtrate.	*June 2015*

Activity 3: In a collaborative effort with the USDA-ARS Soil & Water management unit at the U of Minn., hydro char will be evaluated as a phosphorous adsorption medium for agricultural drain tile water. This involves construction of an apparatus and testing for efficacy. Budget: $ 98,000

Outcome	Completion Date
1. Build and evaluate model hydro char phosphorous filter for agricultural runoff	August 2014
2. Establish regeneration capacity of hydro char for phosphorous capture	Jan.2015

III. PROJECT STRATEGY

A. Project Team/Partners

U. of Mn.Faculty and staff members are Dr. Ken Valentas, Adj. Professor, Biotechnology Institute, as P.I. and project manager to provide overall direction and coordinate cross-functional activities. Dr. Steve Heilmann*, Research Associate, Biotechnology Institute, responsible for supervising and conducting HTC experiments and hydro char modifications, Graduate student*(to be named), Gary Feyereisen**, USDA-ARS Soil & Water management unit, U of Mn., to build and evaluate model filter system based on hydro char for phosphorous removal in drain tile applications. Research technician* (to be named) to assist in filter testing. Some services will be contracted with engineering consultants*. The Chisago Lakes Sewage treatment facility will provide sewage samples, routine analytical tests and technical counsel**.*

* Valentas, Heilmann, Grad. Student and Technician will receive funds; ** Feyereisen will not receive funds

B. Timeline Requirements

We anticipate two years of funding *since we expect since the Hydrothermal carbonization tests and field filtration tests will require two cycles/seasons to complete.*

C. Long-Term Strategy and Future Funding Needs: *Successful conclusion of this project will provide the basis for two future outcomes. (1)* **Investment in a demonstration pilot operation for treatment of human and/or animal waste (**Public/private investment) **(2) A potential business venture to produce and market a hydro char phosphorous filtration system for agriculture drain tile water.**

2012-2013 Detailed Project Budget

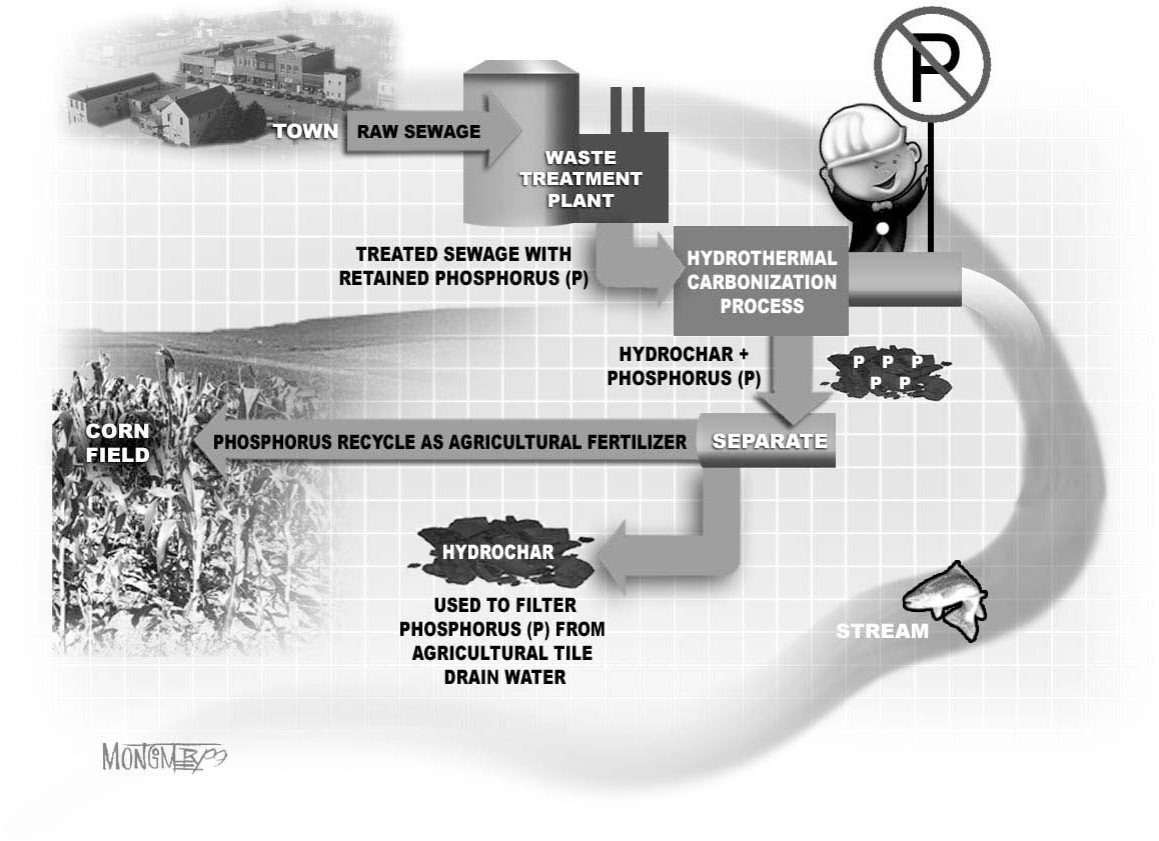
LCCMR Proposal 2012: ***Stopping phosphorous from entering water resources and fisheries***

IV. TOTAL ENRTF REQUEST BUDGET 2 years

BUDGET ITEM *(See list of Eligible and Non-Eligible Costs, p. 11)*	**$**
Personnel:Ken Valentas, Adjunct Professor, Project manager, P.I. @36% FTE for 2 years, $75,600, 7.4% Fringe, 92.6% Salary.	$75,600
Steve Heilmann, Research Associate, **Supervise and conduct experiments, @ 54% FTE for 2 years, $86.400, 7.4% Fringe, 92.6% salary**.	$86,400
Graduate student or Post Doc. (to be named), conduct experiments and generally assist in testing and sample preparation., @100% FTE for 2 years, $80,000, 46% Fringe, 54% salary	$80,000
Research Assistant, (to be named), construct model hydro char filter and conduct lab and field trials, 100% FET for 18 months, $80,000, 33% Fringe, 67% Salary	$80,000
Contracts: Sanitary engineering consultant, Janski Consulting, LLC (this consultant works with Chisago Lakes sewage treatment plant and we collaborate with them)	$4,000.00
Engineering process & design consultant for capital cost estimating. (to be named)	$6,000
Equipment/Tools/Supplies: 12 channel feed metering pump for hydro char filtration studies	$3,200.00
Supplies for filter construction and experiments:Filter column pipes, fittings,depth control, valves, tubing and machining ($7100); Analysis of reactive &total phosphorous ($4400);Chemicals for sorption studies ($2000); filter bed media ($2500).	$15,800.00
Equipment modifications; Reactor body and stirring mechanism ($16,000), Induction heating apparatus ($8000); chemicals for HTC experiments; ($2000)	$26,000.00
Travel: Instate travel to waste treatment facilities and feedlots and the like	$3,000.00
Additional Budget Items: Analytical tests for phosphorous, nickel, cadmium, chromim, lead, carbon content, nitrogen and other sbstances present in the hydro char and filtrate. Includes tests associated with hydro char regeneration experiments. Approximately 350 tests at average cost of $50 per test	$18,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	
	$ 398,000

V. OTHER FUNDS

SOURCE OF FUNDS		
Other Non-State $ Being Applied to Project During Project Period: *Indicate any additional non-state cash dollars to be spent on the project during the funding period. For each individual sum, list out the source of the funds, the amount, and indicate whether the funds are secured or pending approval.*	**AMOUNT**	**Status**
Other State $ Being Applied to Project During Project Period: *Indicate any additional state cash dollars (e.g. bonding, other grants) to be spent on the project during the funding period. For each individual sum, list out the source of the funds, the amount, and indicate whether the funds are secured or pending approval.*	$ -	*Indicate: Secured or Pending*
In-kind Services During Project Period: USDA-ARS will provide the following: Salaries for technician and scientist ($25,200), Equipment and supplies (5,500)	$30,700	*pending*
Remaining $ from Current ENRTF Appropriation (if applicable): *Specify dollar and year of appropriation from any current ENRTF appropriation for any directly related project of the project manager or organization that remains unspect or not yet legally obligated at the time of proposal submission. Be as specific as possible. Describe the status of funds in the right-most column.*	$ -	
Funding History: *Indicate funding secured prior to July 1, 2013, for activities directly relevant to this specific funding request. State specific source(s) of funds.*	$ -	*Indicate: Unspent? Not Legally Obligated? Other?*
	$30,700	


TOWN
RAW SEWAGE
WASTE TREATMENT PLANT
TREATED SEWAGE WITH RETAINED PHOSPHORUS (P)
HYDROTHERMAL CARBONIZATION PROCESS
HYDROCHAR + PHOSPHORUS (P)
P P P P P
CORN FIELD
PHOSPHORUS RECYCLE AS AGRICULTURAL FERTILIZER
SEPARATE
HYDROCHAR
USED TO FILTER PHOSPHORUS (P) FROM AGRICULTURAL TILE DRAIN WATER
STREAM

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 eight 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.