Environment and Natural Resources Trust Fund
2017 Request for Proposals (RFP)

Project Title: **ENRTF ID: 053-B**

Enhancing Septic Tank Performance by Temperature Control

Category: B. Water Resources

Total Project Budget: $ 397,000

Proposed Project Time Period for the Funding Requested: 3 years, July 2017 - June 2020

Summary:

This project will study the temperature control methods and their effects on the septic tank performance in microbial degradation of organic solids and utilization of carbon, nitrogen and phosphorus.

Name: Bo Hu

Sponsoring Organization: U of MN

Address: 1390 Eckles Ave

St. Paul MN 55108

Telephone Number: (612) 625-4215

Email bhu@umn.edu

Web Address

Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Powerpoint slide to explain the proposed research activities

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

PROJECT TITLE: Enhancing Septic Tank Performance by Temperature Control

I. PROJECT STATEMENT

This project will test temperature control approaches in order to improve the septic tank performance. Subsurface sewage treatment system, or commonly known as septic tank system, is an integral part of sewage treatment systems. USEPA estimates that septic system handles sewage (individual or community level scales) from about 20-25% of US households, and this number is increasing due to the development in areas difficult to access to centralized wastewater treatment systems. It is estimated that 10% to 20% of septic systems malfunction, resulting in pollution of surface and ground water. The malfunction can be a result of lack of maintenance and inadequate regulation, but the increasing waste load from household, for instance, more installation of food waste disposers (requiring 50% increase of tank capacity when installed), poses a threat to system fail. The increased organic strength and solids, especially use of some types of toilet papers, can also create difficulties in organic degradation, causing poor performance of septic systems.

Septic system treats sewage by solids settling and microbial sludge degradation in tanks, followed by nutrients and chemicals adsorptive removal through sand filtration systems. In Minnesota, temperature in well-installed septic tanks at 1-6 feet underground is estimated to be stabilized between 50-60 ^{o}F (or 10-16 ^{o}C), and microbial activities are usually very low at this temperature range, which may limit the degradation of solids. Insulation is a common practice for preventing septic pipes from frozen in winter, but it is usually being done in a way that only covers the top of a tank. This practice does not prevent heat loss from septic tank as heat radiates from wastewater to walls and then to soils, even though water used in households is generally warm and heat can also be released from microbial activities.

It is proposed in this study that septic temperature can be appropriately controlled at a suitable range for microbial activities through better tank insulation and/or heating. By increasing tank temperature, the overall septic performance will be enhanced as a result of better microbial degradation of solids and utilization of carbon, nitrogen, and phosphorus. This preferred condition of higher temperature will especially be helpful in dealing with the increased sewage strength due to food waste disposal, and will accelerate the degradation of recalcitrant solids in sludge like fibers from toilet papers and some common medication drugs. This study will evaluate the effect of temperature in the lab study on sewage treatment performance and solids degradation, with or without food waste and toilet paper inclusion. The study will also evaluate the change of temperature profile in the real household septic tanks when insulation and heating are provided.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Lab study of interactions of different organic waste in septic degradation **Budget: $124,000**

Lab study will first focus on the interactions of different organic waste in septic degradation at different temperature levels, and the organic waste here includes food waste, different types of toilet papers, and common antibiotic drugs. Food waste is expected to significantly increase the organic loading of the septic tank, and may negatively affect the water quality of septic effluent. The antibiotic drugs may inhibit or eliminate some species of bacteria and may slow the organic degradation rate. Including food waste into the septic system may increase the degradation rate of toilet papers and antibiotic drugs, especially at high temperature levels, and the combined effects might even be positive to the water quality of septic effluent. Small-scale septic tanks (0.5L) will be used to test in the batch operation.

Outcome	Completion Date
1. Evaluate simulated septic tank performance with food waste addition	*Sep 30, 2017*
2. Evaluate simulated septic tank performance with different toilet paper addition	*March 31, 2018*
3. Evaluate simulated septic tank performance with antibiotic addition	*June 30, 2018*

Activity 2: Lab simulation of temperature controlled prototype septic tanks **Budget: $145,000**

Prototype reactors (5 to 10 gallons) will be constructed to simulate the septic systems in the continuous operation. Household wastewater with typical loading of food waste, toilet papers, and antibiotic drugs will be used to study the temperature effects on the organic degradation. With the increase of temperature, the effluent quality, mainly represented by strength of total suspended solids (TSS), COD (total, colloidal, and soluble), biochemical oxygen demands (BOD), total nitrogen (TN) and total phosphorus (TP), may accordingly improve. The sludge accumulation rate, represented by final concentration of mixed liquor suspended solids (MLSS) and mixed liquor volatile suspended solids (MLVSS) may also be lowered by higher temperatures.

Outcome	Completion Date
1. Prepare prototype septic tanks	*Sep 30, 2018*
2. Evaluate septic tank performance at different temperature levels	*March 31, 2020*

Activity 3: Temperature management on newly installed septic tanks **Budget: $128,000**

This activity aims to assess the temperature change with insulation or heated conditions in real septic tanks circumstances. Construction companies will be connected and sites will be selected within 60 miles from the UMN campus to facilitate the logistics of the experiment, and sites are preferred to being clustered at the same community. Three conditions, including the control, well-insulated, and heated, will be implemented for septic tanks. The insulation will be done on all-wall, and the heating will be done with a predetermined level of power consumption. Each condition will be triplicated. Temperatures of the sludge, influent, supernatant, effluent, tank walls, and soil above, below, and around septic tanks, will be monitored for a year, covering summer and winter seasons. With the temperature information collected, heat transfer models can be developed to calculate the heat loss from tank to soil, or the other way around, at different seasons of a year. Water will be sampled for analysis at the end of treatment. Combined with the lab simulation experiment, septic performance with insulation and heating can be predicted through the development of heat transfer models.

Outcome	Completion Date
1. Select site for septic tanks installation and monitoring	*June 30, 2018*
2. Monitor temperatures of nine septic tanks and develop septic tank heat transfer models	*June 30, 2020*

III. PROJECT STRATEGY

A. Project Team/Partners

Dr. Bo Hu, an associate Professor of the Department of Bioproducts and Biosystems Engineering. He will manage the research activities for this project. He directed an earlier LCCMR project on novel septic tank development for nutrient and energy capture. Dr. Hongjian Lin, Research Associate in the Department of Bioproducts and Biosystems Engineering, will take charge of the lab simulation experiment. He conducted an earlier LCCMR project on novel septic tank development for nutrient and energy capture. Dr. Carlos Zamalloa, Research Associate in the Department of Bioproducts and Biosystems Engineering, will work on lab simulation and on-site experiments. Dr. Sara Heger, Extension Specialist at Water Resource Center will assist in the site selection for ST installation and monitor, and will be in charge of project outreach and extension.

B. Project Impact and Long-Term Strategy

The successful implementation of the project will produce an alternative and more effective septic tank system for onsite sewage treatment. The proposed work will test the hypothesis that increasing temperature will generate better septic effluent quality, reduce solids/sludge accumulation, and the proposed work will develop a novel operating mode of septic tanks with insulation and/or heating. With those performance confirmed, the knowledge will be ready to be transferred to industrial and environmental settings, MN septic tank industry for tank manufacturing, and MPCA legislature and enforcement.

C. Timeline Requirements:

We are planning to finish both lab and field study within three years.

2017 Detailed Project Budget

Project Title: *Enhancing Septic Tank Performance by Temperature Control*

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

BUDGET ITEM *(See "Guidance on Allowable Expenses", p. 13)*	**AMOUNT**
Personnel:	$ 336,000
Project director, Bo Hu will be paid to manage the project, design the experiments and write the project report. The payment will cover his one month summer salary and fringe benefits. 75.32% of payment will be the salary and 24.68% will be the fringe benefits.	$ 39,950
Postdoc researcher, Dr. Hongjian Lin will be paid to execute the activities and provide technical expertise. 85% of time enployment will be covered for this position by the project for three years. 75.32% of payment will be the salary and 24.68% will be the fringe benefits.	$ 157,258
Postdoc researcher, Dr. Carlos Zamalloa will be paid 50% to execute the activities and provide technical expertise. 50% of time employment will be covered for this position by the project for three years. The budget includes 82.30% for the salary and 17.70% for the fringe benefits.	$ 88,686
Septic system extension specialist , Dr. Sara Heger will be paid to provide practical field research experience relating to septic systems in MN, locate new construction sites, facilitate the onsite design and provide extension on the application of the research. Two month appointment will be paid with the project, including 75.32% for the salary and 24.68% for the fringe.	$ 50,106
Professional/Technical/Service Contracts:	$ 10,000
Professional service is needed to provide chemical analysis for some parameters we cannot measure in our lab, for instance, the antibiotic concentrations in the septic effluent.	$ 10,000
Equipment/Tools/Supplies:	$ 48,000
Two prototype septic tank reactors will be constructed to simulate the septic operation in the continuous mode.	$ 5,000
We will select nine septic systems for our onsite evaluations. Home owners at each site will be paid with $500 for their participation (Sum $4,500). Each septic tank is budgeted for $1000 to install a	$ 24,000
Supply and chemicals to be used to work on the experiments in the lab and field	$ 19,000
Travel:	$ 3,000
Travel to the home sites with septic tanks we will ask to install. Ten travels are planned per each project year and $100 is budeged per travel per year.	$ 3,000
Additional Budget Items:	$ -
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST	$ 397,000

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

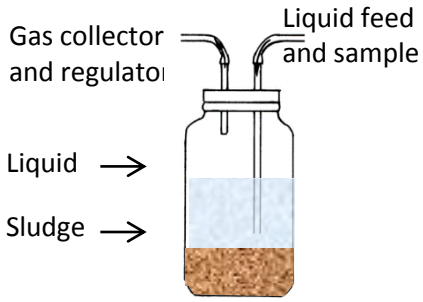
SOURCE OF FUNDS	**AMOUNT**	**Status**
Other Non-State $ To Be Applied To Project During Project Period:	$ -	
Other State $ To Be Applied To Project During Project Period:	$ -	
In-kind Services To Be Applied To Project During Project Period: *Unrecovered F&A*	$ 206,000	*Secured*
Funding History:	$ -	
Remaining $ From Current ENRTF Appropriation:	$ -	

Enhancing Septic Tank Performance by Temperature Control

Bo Hu, Hongjian Lin, Carlos Zamalloa, and Sara Heger, University of Minnesota

Activity 1: Lab study of interactions of different organic waste in septic degradation

Simulated septic tanks

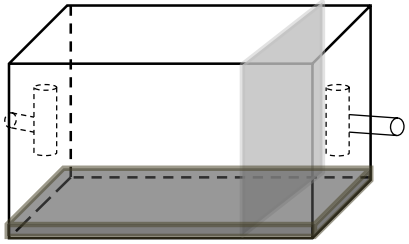


Treatments:
Temperature: 5, 15, 25, and 35 °C
Food waste disposal: up to 60% of COD increase
Toilet paper: up to 60% of COD increase
Antibiotics: different levels addition to sewage

Responses:
Water quality, gas production and composition, and solids degradation

Operating stages in a cycle of a simulated tank:
Feed with corresponding wastewater
Settle and react for 3.5 days
Decant the supernatant
Feed
Next cycle

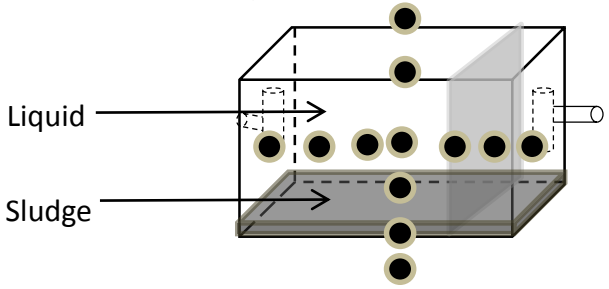
Activity 2: Lab simulation of temperature controlled prototype septic tanks



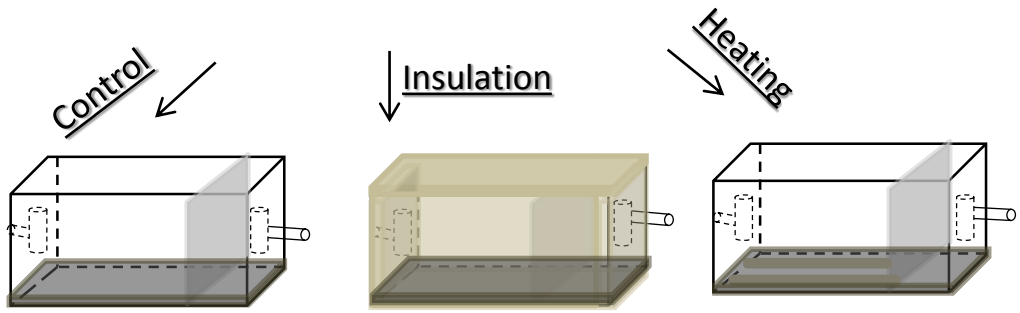
Lab prototype test:
5-10 gal prototype
Temperature controlled at 15, 25, and 35 °C, respectively
Feed with synthetic sewage

Prototype monitored for:
Water quality: total solids, total suspended solids, chemical oxygen demands (total, colloidal, and soluble), etc.
Sludge accumulation rate: visual inspection of sludge depth, mixed liquor suspended solids, and mixed liquor volatile suspended solids

Activity 3: Temperature management on newly installed septic tanks



Points for thermocouple installation (repeat for each tank)



Project Manager Qualifications

The research team will include Dr. Bo Hu, Dr. Hongjian Lin, Dr. Carlos Zamalloa from the Department of Bioproducts and Biosystems Engineering, and Dr. Sara Heger, the extension specialist at the Water Resource Center, University of Minnesota.

With regard to technical expertise, **Dr. Bo Hu** is an Associate Professor at the Department of Bioproducts and Biosystems Engineering and also a joint faculty member at Biotechnology Institute of UMN. With over 10 years of active research experience specifically in biomass utilization, fermentative conversion, and molecular biology, he has led projects on microbial oil production from waste materials via mixotrophic microalgae and oleaginous fungal fermentation, and projects to develop the modified anaerobic digestion system for biohydrogen production and its microbial community change by using 16s rDNA based microbial analysis. Hu's team at UMN has set up several standard procedures such as 16s rDNA fingerprint screening for microbial species in the wastewater treatment facilities, ITS sequences to identify oleaginous fungal species; and several conversion platforms such as pelletized fungal fermentation, solid and hemi- SolidSF to accumulate oil from lignocellulosic materials. His research ideas have been funded by many programs, especially local funding agencies such as MN Pork Board, IOWA Pork Board, MN Rapid Agricultural Response Program, LCCMR, etc. to tackle regional issues.

Dr. Hu's lab is located at BAE 320B, adjacent to Dr. Hu's office. The lab space is around 1000 sqft and it is equipped with two laminar flow hoods and one clean bench. The lab has all the necessary equipment and facilities for this project, including a refrigerated shaker, two open air shakers, one incubation shaker, two incubators, one fermentation bioreactor, GC-FID-TCD, HPLC, IC, PCR thermal cycler, several electrophoresis, centrifuge, and ovens. The research group can also utilize facilities and equipment at the **Biotechnology Resource Center** (BRC), on a pay-per-sample base. BRC is a 4,000 square-foot laboratory/pilot plant facility with state-of-the-art equipment for research and development in fermentation, animal cell culture technology, molecular biology, protein expression, and separation of a wide range of biological molecules.

Organization Description

Dr. Bo Hu joined the faculty at Department of Bioproducts and Biosystems Engineering of UMN in August 2009. As the core department of UMN to tackle Agricultural engineering and environmental engineering issues, Bioproducts and Biosystems Engineering Department has very dynamic research activities and numerous excellent scientific researchers have received grant supports from LCCMR program. The collaborative partner Sara Heger works with the Onsite Sewage Treatment Program at the Water Resource Center of UMN. The program seeks to protect public health and the environment by improving wastewater treatment through research-based education and outreach for homeowners, small communities, professionals and policy-makers. UMN Sponsored Projects Administration (SPA) will be the entity authorized by the Board of Regents to manage the project agreements with LCCMR program.