

**Environment and Natural Resources Trust Fund
2020 Request for Proposals (RFP)**

Project Title:

ENRTF ID: 252-FH

Convert Solid Wastes to Protein Feed and Fertilizer

Category: H. Proposals seeking \$200,000 or less in funding

Sub-Category: F. Methods to Protect, Restore, and Enhance Land, Water, and Habitat

Total Project Budget: \$ 200,000

Proposed Project Time Period for the Funding Requested: June 30, 2023 (3 yrs)

Summary:

This project aims to use black soldier fly larvae to convert animal and food waste produced in Minnesota to \$7 billion worth protein-rich animal feed and organic fertilizer

Name: Min Addy

Sponsoring Organization: U of MN

Job Title: Prof.

Department: _____

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St. Paul MN 55108

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Location:

Region: Statewide

County Name: Statewide

City / Township: SAINT PAUL

Alternate Text for Visual:

With higher than 50% of feed conversion ratio, Black Soldier Fly Larvae can efficiently convert 25-million-wet-ton organic waste to 1.8-million-dry-ton feed and 1.3-million-dry-ton fertilizer

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



PROJECT TITLE: Convert solid wastes to protein feed and fertilizer

I. PROJECT STATEMENT

As one of the leading states in animal husbandry, Minnesota generates over \$3.2 billion/year in the dairy industry, and \$7.28 billion/year in the hog industry; Minnesota is also the #1 state in the nation for turkey production. However there are also various environmental impacts brought by these industrial activities. One of the most prominent issues is the huge amount of manures estimated at **25 million wet ton/yr**. Currently, most of the manure is still used for land application; less than 50% of nutrients applied to soil is assimilated by crops while ammonia emits into the atmosphere, and nitrate and phosphorus can easily leach into groundwater. In addition, it was estimated that one third of the produced food becomes wasted each year, which is equivalent to **1.34 million wet ton/yr of food waste in Minnesota**, and most of the food waste will end up in landfill. Environmentally responsible manure and food waste management practices can be very costly. On another side, the livestock industry is facing anticipated feed price increases that could potentially further narrow the economic return. **This project aims to use black soldier fly larvae (BSFL) to convert animal and food wastes to protein-rich feed and fertilizer.** It is estimated that if all the Minnesota organic wastes are converted to larvae biomass and fertilizer, **it can potentially produce 1.8 million dry ton animal feed and 1.3 million dry ton fertilizer, which is equivalent to \$6-7 billion/yr gross income to the state of Minnesota.** This project will develop and demonstrate the use of low cost BSFL technology to convert large amounts of waste into high value animal feed, and at the same time, generate organic fertilizers, thus preventing (or reducing levels of) contaminants from entering ground and surface waters.

Manure contains many pollutants like organic components, nitrogen, phosphorus, bacteria and other pathogens that can greatly impact water and air quality. Food waste, if not converted right away, will also decay and emit odor and pollute groundwater and air. Black soldier fly larvae are proven effective in reducing various organic wastes including chicken/swine/cattle manure, food waste, municipal waste and sewage sludge. The advantages of BSFL-based waste conversion are many, *for example, (1) it can be in different scales and adapt to various size of farms; (2) rapid larvae reproduction rates helps with fast waste reduction; (3) the larvae can treat a wide range of waste and can convert 50% dry mass to high-value protein with good animal palatability; (4) also it can eliminate house fly propagation; (5) it requires simple facilities and low energy input, and (6) it is easy to operate.* It was found that in addition to the 50% manure mass reduction, the concentration of other nutrients including Ca, Mg, S, Zn, Cu, Na, B in the larvae residue (treated manure) could also be reduced by 45-55%. Also, the antibiotic resistance in animal manure, which is a serious environmental issue because of the multi-drug resistance developed in naturally occurring bacteria, can be significantly reduced by the BSFL up to 95.0% in only 12-days of cultivation.

However, challenges still remain. BSFL commonly like warmth and dampness for their optimum growth; how to adapt the larvae in the northern climate can require a lot of engineering innovation. Also, larvae fed on manure have slower growth than those fed on a nutrient-balanced food waste. How to improve the waste conversion efficiency can be a difficult task. By mixing a second waste stream, such as food waste, into the larvae feed supply could further help treat the manure waste. Mechanizing the cultivation process can reduce labor costs and improve product consistency. Therefore the objectives of the proposed project will be: (1) to design and demonstrate a controlled cultivation system for food and manure waste conversion; (2) test and optimize the process with different or mixture of waste streams; (3) test larvae chemical and nutritional profile and waste residue as fertilizer.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: design a BSFL cultivation system for food and manure waste conversion.

The life cycle of BSF includes breeding, hatching, larvae, pupate, and adult stages. Each stage requires different cultivation conditions that have specific temperature, humidity, and light intensity requirements. The design will incorporate these constraints and develop a moderately sized system that can be demonstrated at an



**Environment and Natural Resources Trust Fund (ENRTF)
2020 Main Proposal Template**

animal farm.

ENRTF BUDGET: \$100,000

Outcome	Completion Date
1. <i>Design and construct a waste conversion system</i>	06/30/2021

Activity 2: Test the system and the quality of the larvae and waste residue

The system will be tested under northern climate conditions with different waste streams. The larvae development and feed conversion ratio will be monitored, and the cultivation process will be adjusted and optimized according to the different wastes being studied.

ENRTF BUDGET: \$50,000

Outcome	Completion Date
1. <i>Test and optimize the system with different or mixture waste streams</i>	06/30/2022
2. <i>Test the larvae chemical and nutritional profile and the waste residue as fertilizer</i>	06/30/2022

Activity 3: System demonstration

The system will be demonstrated at either UMN outreach center or a farm setting to the stakeholder. Because the system is very versatile and can be built for different scales, it is expected that through this project, the BSFL-based conversion technology can be adapted to various local farms or communities.

ENRTF BUDGET: \$50,000

Outcome	Completion Date
1. <i>Demonstrate the system at UMN outreach center or a farm setting at the stakeholder</i>	06/30/2023

III. PROJECT PARTNERS:

A. Project team:

Min Addy (BBE, UMN), Roger Ruan (BBE, UMN), Paul Chen (BBE, UMN)

B. Partners NOT receiving ENRTF funding

Name	Title	Affiliation	Role
Peter Forsman	Owner and President	Forsman Farms	Help with field testing

IV. LONG-TERM- IMPLEMENTATION AND FUNDING:

New scientific knowledge and experience on complete wastewater utilization processing will be acquired through this research, and the demonstration will raise significant interests from the public. We will seek industry partners and private, state, and federal funding to further develop and eventually commercialize the technology.

V. TIME LINE REQUIREMENTS:

This project is planned for 3 years beginning July 1, 2020 and ending June 30, 2023. Most of the first 24 months will be focused on system design and construction, and much of the last 12 months will be focused on development, evaluation, and demonstration of the proposed system.

Attachment A: Project Budget Spreadsheet
 Environment and Natural Resources Trust Fund
 M.L. 2020 Budget Spreadsheet



Legal Citation:
 Project Manager: Min Addy
 Project Title: Convert Solid Wastes to Protein Feed and Fertilizer
 Organization: University of Minnesota
 Project Budget: \$200,000
 Project Length and Completion Date: 3 years - June 30, 2023
 Today's Date: 4/11/19

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND BUDGET		Budget	Amount Spent	Balance
BUDGET ITEM				
Personnel (Wages and Benefits)		\$ 163,000	\$ -	\$ 163,000
Min Addy, PI, .16 FTE, 3 yrs, \$40,000, 73.5% salary/26.5% fringe - leading and managing lab and field testing projects, leading demonstration, supervising graduate student				
Roger Ruan, Co-PI, 0.04 FTE, \$33,000 3 years, 73.5% salary/26.5% fringe - leading lab and field testing project, demonstrations and supervising graduate student				
Paul Chen, Co-PI, 0.04 FTE, \$16,000, 73.5% salary/26.5% fringe, Leading lab and field testing project, demonstration, supervising graduate student				
Grad student, 0.25 FTE, \$74,000, 57.5% salary/42.5% fringe, conducting R&D, operations, demonstration, data analysis				
Professional/Technical/Service Contracts			\$ -	\$ -
Equipment/Tools/Supplies				
Supplies, instruments, non-capital equipment		\$ 30,000	\$ -	\$ 30,000
Capital Expenditures Over \$5,000				
		\$ -	\$ -	\$ -
Fee Title Acquisition				
		\$ -	\$ -	\$ -
Easement Acquisition				
		\$ -	\$ -	\$ -
Professional Services for Acquisition				
		\$ -	\$ -	\$ -
Printing				
		\$ -	\$ -	\$ -
Travel expenses in Minnesota				
Travel to collect samples in fields and demonstration site		\$ 3,000	\$ -	\$ 3,000
Other				
Chemical analysis, equipment calibration, repair and maintenance		\$ 4,000	\$ -	\$ 4,000
COLUMN TOTAL		\$ 200,000	\$ -	\$ 200,000
SOURCE AND USE OF OTHER FUNDS CONTRIBUTED TO THE PROJECT				
	Status (secured or pending)	Budget	Spent	Balance
Non-State:		\$ -	\$ -	\$ -
State:		\$ -	\$ -	\$ -
In kind: Unrecovered F&A		\$ 95,000	\$ -	\$ 95,000
Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS				
	Amount legally obligated but not yet spent	Budget	Spent	Balance
		\$ -	\$ -	\$ -

Total 25 million wet ton waste in MN:

- Hog manure
- Dairy manure
- Turkey litter
- Chicken poop



Wastes can be converted by Black Soldier Fly Larvae to high value added feed and fertilizer efficiently

1.8 million dry ton animal feed:

- Chicken feed
- Fish feed



1.34 million wet ton Food waste in MN



1.3 million dry ton fertilizer



Other organic solid waste, e.g., sludge



Black soldier fly larvae are very efficient for reducing various organic wastes including chicken/swine/dairy manure, food waste, municipal organic waste, and sewage sludge due to their rapid larvae reproduction rates. If all the animal waste and food waste produced in Minnesota are converted, it would potentially produce 1.8 million dry ton animal feed and 1.3 million dry ton fertilizer per year which is equivalent to \$6-7 billion/yr gross income.

Project Manager Qualifications and Organization Description

Dr. Min Addy, a Research Associate Professor in the Department of Bioproducts and Biosystems Engineering (BBE), University of Minnesota (UofM), will serve as the project manager of the proposed project. In the past ten years, Dr. Addy has been focusing on research on converting waste resources to renewable fuels, feed, and other valuable bioproducts. The processes she developed include waste to fuel conversion, anaerobic digestion, algae biofuel production, aquaponics and hydroponic for waste treatment and vegetable production, and microwave assisted biochar and biofuel production. Prof. Addy is an active researcher and involved in multiple LCCMR, USDA, DoD, DoE, Xcel Energy, and MnDrive funded projects. At the same time Dr. Addy has been managing the microalgae lab, thermochemical conversion lab at BBE, and a hydroponic growth facility at UofM Greenhouse. She also supervised over one hundred of under/graduate students, post-doctors, visiting scholars, and summer students and has published over 80 papers in refereed journals, and many meeting papers and reports, and holds 3 US patents.

As a member of the Center for Biorefining, a University of Minnesota research center, Professor Addy works closely with Professors Roger Ruan and Paul Chen, in coordination of the efforts and resources to conduct exploratory fundamental and applied research and provide education on bioenergy, biochemicals and biomaterials; stimulate collaboration among the University researchers, other public sector investigators, and private investigators involved in biobased production technology development; promote technology transfer to industries; and foster economic development in rural areas. The Center's research programs are founded by DOE, USDA, DOT, DOD, LCCMR, IREE, Xcel Energy, and other federal and state agencies, NGOs, and private companies. The Center is equipped with state-of-the-art analytical instruments, and processing facilities ranging from bench to pilot scale. In particular, they have the capability to develop various bioreactors for different purpose and the means to evaluate related processes.