**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](https://water.unl.edu/article/animal-manure-management/nitrogen-dynamics), [phosphorus](https://water.unl.edu/article/animal-manure-management/phosphorous-dynamics), 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***](https://www.sciencedirect.com/topics/earth-and-planetary-sciences/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**

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| **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 animal farm. **ENRTF BUDGET: $100,000** |
| **Outcome** | **Completion Date** |
| *1. Design and construct a waste conversion system* | *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. Test and o*ptimize the system with different or mixture waste streams  | *06/30/2022* |
| *2. Test* the larvae chemical and nutritional profile and the waste residue as fertilizer | *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.

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| **ENRTF BUDGET: $50,000** |
| **Outcome** | **Completion Date** |
| *1. Demonstrate the system at UMN outreach center or a farm setting at the stakeholder* | *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**

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| **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 interest~~s~~ 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.