**PROJECT TITLE: Full utilization of concentrated livestock wastewaters**

**I. PROJECT STATEMENT**

Each year, Minnesota agricultural activities generate a huge amount of wastewaters, especially in the livestock production sector. There were about 24,000 registered feedlots in Minnesota. Take swine manure for example, on March 1, 2019, there are 8.7 million hogs/pigs on Minnesota farms, generating more than 5 million gallons of wastewater each day. Land applications and improper storage of livestock manure can contaminate surface water and groundwater. Animal manure is a valuable resource only if managed properly. This project is intended to address ***Priority B*** *titled**“Water Resources, 2II. Preventing or reducing levels of contaminants in ground and surface waters”* by taking a systems approach and assembling a suite of practical technologies being developed at the UMN Center for Biorefining to deliver ***multiple benefits*** including:

* Treating and utilizing concentrated wastewater for production of bioenergy, fertilizer, feeds, & foods;
* preventing nutrients and antibiotics from contaminating ground and surface waters
* reducing impacts of livestock farming on public health and quality of life
* bringing extra revenue to MN farmers

***Direct discharges of wastewater*** from large concentrated animal feeding operations into the water way ***are regulated*** under the Clean Water Act. ***Land application*** of raw or digested concentrated animal wastewater ***is inefficient due to nutrient runoff*** to the atmosphere, surface water, and groundwater, ***creating*** ***significant and urgent water and air pollution issues***.

This project is aimed to develop and demonstrate a system for complete treatment and utilization of concentrated animal wastewater. The proposed work is built on the promising preliminary results obtained from the previous scaled back LCCMR funded project. With the preliminary data from small scale systems, we are now ready to optimize, integrate, and demonstrate the processes and systems in pilot scale. The R&D work will overcome several ***technical challenges*** *in order to move the technology to the pilot demonstration stage*:

* Concentrated animal wastewater must be diluted 10-200 times for algae and vegetable cultivation. Adding so much fresh water to a wastewater treatment process does not seem intuitive and sustainable.
* Plant mostly absorb ions and not molecules. Therefore, molecules must be broken down.
* Use of animal manure for hydroponic cultivation raises concerns about pathogenic microorganisms that can cause diseases to vegetables and post safety risk to consumers.
* after hydroponic cultivation, the water may not be clean enough for discharge or for on-farm uses.

**The impacts of the project are broad and extendable.** The technology, if adopted by 20% of the swine capacity, can effectively reduce the potential of 380 million gallons of wastewater polluting our surface and ground water and use 19 million lbs, 13 million lbs, and 9.5 million lbs of nitrogen, phosphorus, and potassium fertilizers, respectively, for hydroponic production annually. The knowledge acquired and technology developed during the project will be disseminated through multiple channels and their application can go beyond swine manure to other animal wastes and municipal wastewaters.

**II. PROJECT ACTIVITIES AND OUTCOMES**

|  |  |  |
| --- | --- | --- |
| **Activity 1:** *Develop and optimize processes to reduce chemical oxygen demand and ammonia to desirable levels*  In this project, we will design and demonstrate a system consisting of ***novel and scientifically sound processes*** includingvacuum assisted thermophilic anaerobic digestion, biofilm based aerobic digestion, microalgae cultivation, biochar filtration, and hydroponic cultivation (*See a schematic diagram in visual presentation*). These processes have the potential to solve key issues in current anaerobic digestion and hydronic cultivation operations. The vacuum assisted thermophilic anaerobic digestion is designed to break down large organics, remove most ammonia and hydrogen sulfide (converted to solid fertilizers), inactivate pathogens, and generate biogas (converted to electricity). The biofilm aerobic digestion is designed to further break down molecules to ions, remove contaminants such as anti-biotics, and further reduce pathogens. The microalgae cultivation is included to further reduce remaining ammonia and nutrient concentration to levels suitable for hydroponic cultivation. The biochar filtration steps are designed to remove fine particles and bacteria and prepare the water for efficient algae and/or hydroponic cultivation. After hydroponic cultivation, water is filtered through biochar and recycled back to hydroponic system. Excess water can be discharged or used for farm operations such as animal house cleaning.  **ENRTF BUDGET: $275,000** | | |
| **Outcome** | **Completion Date** |
| *1. Develop and optimize vacuum assisted thermophilic anaerobic digestion and bio-film aerobic digestion processes* | *06/30/2021* |
| *2. Evaluate microalgae growth on vacuum assisted thermophilic anaerobic digestion and bio-film aerobic digestion treated water* | *12/31/2021* |
| *3. Develop and optimize* photocatalytic materials coupled with aerobic bacteria *for antibiotics removal and biochar filtration for particle removal* | *12/31/2022* |
| *4. Study hydroponic cultivation on the treated water* | *12/31/2023* |
| **Activity 2:** *Develop a demonstration system*  With the knowledge, experience, and optimized processes obtained from Activity 1, we will develop a small pilot scale system consisting of *vacuum assisted thermophilic anaerobic digestion, bio-film aerobic digestion*, photocatalytic materials coupled with aerobic bacteria, biochar filtration and hydroponic tray for comprehensive evaluation of the processes and demonstration of the technology to general public for education and outreach purpose. Stakeholders will be brought to the greenhouse facility at UMN where a demonstration of the technology will be conducted.  **ENRTF BUDGET: $270,000** | | |
| **Outcome** | **Completion Date** |
| *1. Scale-up parameters will be determined for the optimized process flow* | *03/31/2022* |
| *2. System design will be completed* | *06/30/2022* |
| *3. Individual units will be fabricated and assembled, and tested* | *12/31/2022* |
| *4. The system will be demonstrated on UMN outreach center or a farm setting to the stakeholders* | *06/30/2023* |

**III. PROJECT PARTNERS:**

**A. Project team:**

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

**B. Partners NOT receiving ENRTF funding**

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Title** | **Affiliation** | **Role** |
| Peter Forsman | Owner | Forsman Farms | Help withfield test and demonstration |
| John Snyder | President | Minnesga | Coordinate raw material and field test |

**IV. LONG-TERM- IMPLEMENTATION AND FUNDING:**

New scientific knowledge and experience on complete wastewater utilization process will be acquired through 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 process improvement and parameter optimization, and full understanding of the proposed process, and much of the second 12 months will be focused on development, evaluation, and demonstration of the proposed demonstration system.