**PROJECT TITLE: Concentrating Animal Waste for Solid Fertilizer Production**

**I. PROJECT STATEMENT**

Minnesota is a leading farming state, generating over **25 million wet ton animal waste** each year. The current practice is directly land spreading manure. However, the nutrient loss can be up to 50%, especially for nitrogen fertilizer, due to ammonia escaping into the atmosphere and nitrate leaching into underground water. Animal farms, especially small to mid-size animal producers, are struggling to find economically acceptable technologies to treat their manure wastewater to meet the discharge requirements. There are increasing interests and efforts in treatment through complete utilization approaches but not without challenges.

This project addresses *“Water Resources, 2II. Preventing or reducing levels of contaminants in ground and surface waters”* through developing and demonstrating innovative and practical technologies. In this proposed project, ***we aim to develop*** ***a series of efficient and low-cost animal* *waste treatment processes*** ***to (1) separate the solid (include soluble and insoluble solid) from the liquid, (2) dry the solids by solar energy and use the solid as slow release fertilizer, and (3) adapt the liquid for hydroponic and microalgae cultivation without diluting with freshwater.*** If all the wastes in Minnesota is converted, the potential fertilizer yield is about **3 million ton/yr** which is equivalent to **$1.6 billion/yr** gross income. Since the system isn’t limited by scale and can be easily scaled up, it can fit for various size of farms.

In the past we have demonstrated that the animal wastewater could be used for hydroponic cultivation directlywith >200 time’s freshwater dilution and the growth results were comparable to the optimum control group. The challenge was that the nutrient profile does not adequately match the nutrients needed by plants, the solid remained in the wastewater potentially causes root degradation, and the water cannot be recycled due to high levels of accumulated salt and unwanted organic components. This is also a challenge for the current hydroponic industry. Separating solids from the liquid is a way to concentrate nutrients and on the other hand reduce nutrient level in the liquid by as much as 50-70%. Since small particles in manure are in size of 4-9 µm and difficult to be separated by filtration alone. Therefore more effective separation process should be implemented. The separated solids containing nutrients are more suitable for land application, but it still contains 95% moisture. A drying process is needed to make the solid into valuable organic fertilizer. The purified liquid, which contains most of the inorganic nutrients, is more suitable for hydroponic plant and microalgae cultivation due to reduced turbidity and impurities.

**II. PROJECT ACTIVITIES AND OUTCOMES**

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| **Activity 1:** *Develop and optimize processes to* separate solid and liquid and keep the nutrient in the liquid to a *desirable level*  Filtration, electrochemical flocculation combined with membrane technology, and biochar adsorption will be investigated for their capability and effect on the solid and liquid separation. Several soil compatible and porous materials, e.g. perlite, sand, diatom earth, clay (either in individual format or combined format) will be tested for soluble and insoluble particles removal efficiency. Since many particles are positively charged, electrochemical flocculation combined with membrane should be effective for the soluble organic and pigments removal. Biochar will be used for multiple purposes. At the initial treatment, based on the different pore size of the char, it can be used for insoluble particle removal, also the soluble organic compound and inorganic ions removal. At this point, the majority of N, P should be loaded on to the biochar. Second, at the hydroponic cultivation stage, the biochar will be used for maintaining the water quality in the system by removing accumulated salt and unwanted compounds.  **ENRTF BUDGET: $100,000** | | |
| **Outcome** | **Completion Date** |
| *1. Evaluate several material, e.g. perlite, sand, diatom earth, clay for their filtration effect* | *06/30/2021* |
| *2. Evaluate electrochemical flocculation combined with membrane for solid separation* | *12/31/2021* |
| *3. Evaluate biochar for particle and nutrient remove efficiency* | *12/31/2022* |
| *4. Develop and optimized a process for the manure solid and liquid separation* | *12/31/2023* |
| **Activity 2:** *Develop a* solar drying system for solid fertilizer production  After the solid been separated by the filtering media, it will be dried by solar energy or directly applied to soil. The biochar can be dried along with other solid using a solar drying system where the water evaporated can also be ammonia rich condensate that can be used for the hydroponic cultivation. Biochar has strong ability to absorb solar energy and Minnesota has 4.5 kWh/m2·day solar energy equivalent to evaporating 7 L water/m2·day, which is highly economical and sustainable for a farm operation. The dried solid can be sold as slow-release fertilizer.  **ENRTF BUDGET: $50,000** | | |
| **Outcome** | **Completion Date** |
| *1. Develop a* solar drying system for solid fertilizer production | *03/31/2022* |
| *2. Demonstrated the system at UMN outreach center or a farm setting to the stakeholders* | *06/30/2023* |

**Activity 3:**Hydroponic system for liquid nutrient removal

The liquid from solid/liquid separation process will still contain certain amount of nutrient. With minor modification and nutrient balance, this liquid should be suitable for hydroponic cultivation. Plants and algae are efficient in removing N, P and beneficial metals, e.g. Ca, Mg, Fe, K and Na. Different plants will be selected for targeting removal of different nutrient and metals. Treated water will remain in the system, and the evaporation and transpiration will be balanced by the inputting water. Biochar will be used to remove any accumulated salt and organic compounds and restore the water quality to an acceptable level. Finally, the overall mass balance and economic analysis will be conducted to evaluate the technology viability.

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| **ENRTF BUDGET: $50,000** | | |
| **Outcome** | **Completion Date** |
| *1. Develop an algae and hydroponic system for wastewater utilization* | *03/31/2022* |
| *2. Demonstrate the system at UMN outreach center or a farm setting to the stakeholders* | *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 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.