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

Project Title: ENRTF ID: 248-FH
Concentrating Animal Waste for Solid Fertilizer Production
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 vrs)
Summary:
The proposal aims to develop an efficient and low-cost animal waste treatment process to concentrate the waste into solid fertilizers and separate the liquid for vegetables and microalgae production
Name: Min Addy
Sponsoring Organization: U of MN
Job Title: Prof.
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Web Address:
Location:
Region: Statewide
County Name: Statewide

City / Township:

Alternate Text for Visual:

25-million-ton animal waste can be concentrated to 3-million-dry-ton solid fertilizer. The separated liquid can be used for vegetable and microalgae production. The total gross income is estimated over \$1.6-billion/yr.

Funding Priorities Multiple Benefits	OutcomesKnowledge Base
Extent of Impact Innovation	_Scientific/Tech Basis Urgency
Capacity ReadinessLeverage	TOTAL%



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, 211. 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 directly with >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 μ m 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

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.

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

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.

Attachment A: Project Budget Spreadsheet Environment and Natural Resources Trust Fund M.L. 2020 Budget Spreadsheet Legal Citation: Project Manager: Min Addy Project Title: Concentrating Animal Waste for Solid Fertilizer Production 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
Min Addy, PI, .16 FTE, 3 yrs, \$40,000, 73,5% salary/26.5% fringe - leading and m	anaging lab and field					
testing project, leading demontration, supervising graduate student						
Roger Ruan, Co-PI, 0.04 FTE, \$33,000 3 years, 73.5% salary/26,5% fringe - leadin	ng lab and field					
testing project, demonstration, supervising graduate student						
Paul Chen, Co-PI, 0.04 FTE, \$16,000, 73.5% salary/26.5% fringe - leading lab and	I field testing project,					
demonstration, supervising graduate student						
Grad student, 0.5 FTE, \$74,000, 57.5% salary/42.5% fringe, conducting R&D, op	erations,					
demontration, data anaylsis						
Professional/Technical/Service Contracts						
				\$-	\$	-
Equipment/Tools/Supplies						
Supplies, instruments, non-capital equipment		\$	30,000	\$-	\$	30,000
Capital Expenditures Over \$5,000						
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Printing		Ŷ		Ŷ	Ŷ	
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Travel expenses in Minnesota				,		
Travel to collect samples in fields and demonstration site			3,000	\$-	\$	3,000
Other						
Chemical analysis, equipment calibration, maintenance and repairs			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	В	alance
Non-State:		\$	-	\$-	\$	-
State:		\$	-	\$-	\$	-
In kind: Unrecovered F&A	Secured	\$	95,000	\$-	\$	95,000
Other ENRTF APPROPRIATIONS AWARDED IN THE LAST SIX YEARS	Amount legally obligated but not yet spent	I	Budget	Spent	В	alance
		\$	-	\$ -	\$	-



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.