Environment and Natural Resources Trust Fund
2016 Request for Proposals (RFP)

Project Title: **ENRTF ID: 147-E**

Revolutionizing Ammonia Emission Reduction/Nutrient Recovery from Manure

Category: E. Air Quality, Climate Change, and Renewable Energy

Total Project Budget: $ 558,539

Proposed Project Time Period for the Funding Requested: 3 years, July 2016 to June 2019

Summary:

This project develops a revolutionary technology to reduce 70% ammonia emission from animal manure during storage and land application and recover the nutrients (70% N and 90% P) as fertilizer

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Sponsoring Organization: U of MN

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Location

Region: Statewide

County Name: Statewide

City / Township:

Alternate Text for Visual:

Revolutionizing emission reduction and nutrient recovery for animal manure by synthesized nano-scale zeolite from coal fly ash

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

Project Title: Revolutionizing Ammonia Emission Reduction/Nutrient Recovery from Manure

I. PROJECT STATEMENT

In Minnesota, ammonia emission from dairy and swine manure during both storage and land application accounts for 53.5% of the total emission resulting from all human activities. This is not only a big loss of the nutrient value of manure, but also a major cause for environmental deterioration and human health problems such as 1) decreased water quality resulting from harmful algal blooms; 2) vegetation or ecosystem changes due to higher concentration of nitrogen; 3) climatic changes associated with increases in nitrous oxide (N2O); 4) soil acidification through nitrification and leaching; 5) respiratory diseases caused by exposure to high ammonia loaded fine particulate aerosols (PM2.5); and 6) nitrate contamination of drinking water. Lack of effective technologies to properly treat the manure continues to make the situation worse. Therefore, in order for the animal industry to continue to grow while protecting the environment at the same time, cost effective removal and recovery of nutrients from manure becomes vital for pollution control and environmental sustainability.

The goal of this research is to provide Minnesota swine and dairy producers with a novel technique to minimize the negative impact of animal manure on the environment, and produce a renewable fertilizer at the same time, so their growth can be sustained over the long haul. This goal will be accomplished by developing a new mineral called "zeolite" (at nano-scale) from a waste material, i.e., fly ash generated from coal burning power plants, that can effectively reduce/recover ammonia nitrogen and phosphorus contained in swine and dairy manure, thus reducing ammonia emission, which is a greenhouse gas (GHG), from animal operations. The potential benefits can be summarized in the following using swine manure as an example:

- Recover manure N by 70% (97 million lbs from a total of 138.7 million lbs based on 4.75 million pigs)
- Reduce ammonia emission by 70%
- Recover phosphorus by 90% (78 million lbs)
- Save producers $31.6 million for N fertilizer for 900,000 acres corn/soybean rotation fields per year (commercial anhydrous ammonia price: $717/ton)
- If dairy manure is included, money savings and environmental benefit will be much more significant

The specific goals of this project include:

- Developing the hydrothermal reaction process to produce the zeolite with high absorption capacity from coal fly ash, and determining the process parameters and their impact on the quality of the product;
- Examining the effectiveness of the produced zeolite in simultaneously removing N and P in animal manure to produce a fertilizer product;
- Scaling up the hydrothermal system for pilot scale production of zeolite; and
- Demonstrating a prototype zeolite reactor at the UMN Southern Research & Outreach Center (SROC) to promote the new technology.

II. PROJECT ACTIVITIES AND OUTCOMES

Activity 1: Nano-scale zeolite production process development from coal fly ash **Budget: $126,000**

The objective of this activity is to study methods and conditions to generate zeolite coated with nano-particles, understand the process parameters involved in the formation of zeolite and their impact on the quality of the product. A hydrothermal reactor for zeolite production will be developed and the optimum condition (temperature, alkalinity, reaction time, and liquid/substrate ratio) for producing zeolite will also be determined. The chemical and physico-chemical characteristics of fly ash and the zeolite product will be examined.

Outcome	Completion Date
1. Raw fly ash and produced zeolite characterization	*12/31/2016*
2. Nano-coated zeolite production and the optimum reaction condition determination (temperature, alkalinity, reaction time, and liquid/substrate ratio)	*03/31/2017*

Activity 2: Nutrient recovery efficiency examination **Budget: $109,000**

In this activity we will examine the N and P removal efficiency and capacity using the produced nano-coated zeolite. Swine and dairy manure will be characterized. Batch studies with three replicates will be used to study the effect of sorption time and dosage of the produced zeolite on ammonium N and P removal efficiency.

Outcome	Completion Date
1. The best sorption time and the optimum dosage of zeolite addition to recover N and P in swine and dairy manure determined	*12/31/2017*
2. Percent reduction in ammonia emission and N and P recovery by zeolite determined	*12/31/2017*

Activity 3: Scaling-up and operation of the hydrothermal reactor **Budget: $189,000**

A pilot-scale hydrothermal reactor will be constructed at the UMN SROC at Waseca, MN to mass produce zeolites. The operation of the scaled-up reactor will be evaluated and the operational parameters will be optimized based on the production rate and absorption efficiency of the zeolite products.

Outcome	Completion Date
1. Design, analysis, and construction of the scale-up hydrothermal reactor for producing the nano-scale zeolite finished	*3/31/2018*
2. Operation and parameters optimized	*9/31/2018*

Activity 4: Application and onsite evaluation and demonstration **Budget: $134,539**

A scale-up prototype application and onsite evaluation will be executed. The mass volume of zeolites will be produced and the removal efficiency will be evaluated at the UMN SROC swine facilities at Waseca, MN. The costs and benefits of constructing and operating the onsite system will be calculated and analyzed.

Outcome	Completion Date
1. Pilot-scale onsite application setup and demonstration at SROC finished and removal efficiencies of N and P from swine and dairy manure determined	*12/31/2018*
2. Operating system evaluation and cost estimation accomplished	*6/30/2019*

III. PROJECT STRATEGY

A. Project Team/Partners

The team includes Dr. Xiao Wu (Research Associate, Project Manager) and Professor Gregg Johnson (Co-PM), both from the University of Minnesota SROC. Dr. Wu will be overseeing the project including the development and evaluation of the proposed system, and will be receiving funds on behalf of the University of Minnesota. Dr. Johnson will help organize activities for technology and information dissemination among farmers in Minnesota, with no fund requested. Besides, a postdoc researcher specialized in thermal bioprocessing techniques will execute the research activities including the design and testing of the hydrothermal reactor, and a research engineer will be responsible for construction and operation of the scale-up reactor.

B. Project Impact and Long-Term Strategy

The outcomes of the project will provide swine and dairy producers with a novel technique to minimize ammonia emission from animal manure by 70% and produce a renewable fertilizer equivalent to $31.6 million per year. The economic and environmental benefit will be demonstrated by not only creating a nutrient rich fertilizer for agronomic utilization, but greatly reducing the commercial fertilizer loads to the cropland to avoid potential nutrients runoffs and gaseous ammonia emissions, which, upon completion of this project, will immediately reduce the carbon footprint of animal operations and achieve sustainable growth of the animal industries in the State.

C. Timeline Requirements

The project will be completed in 3 years, with one and half years for lab-scale study and the remaining one and half years for scale-up study and on-site implementation and evaluation as well as cost estimation.

2016 Detailed Project Budget

Project Title: Revolutionizing Ammonia Emission Reduction/Nutrient Recovery from Manure

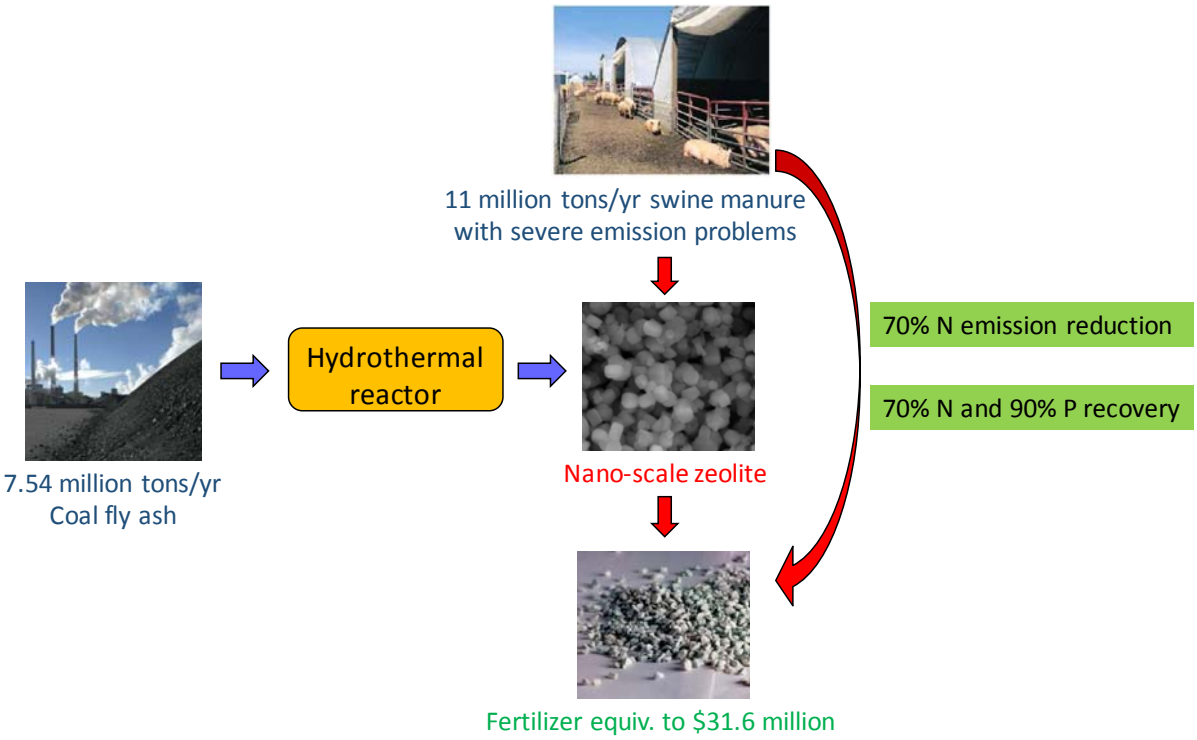
IV. TOTAL ENRTF REQUEST BUDGET 3 years

BUDGET ITEM	AMOUNT
Personnel:	
Xiao Wu, Project Manager (75% salary, 25% benefits); 0.5 FTE (50% time on this project) for year 1, 1 FTE for year 2 and 1 FTE for year 3	$ 245,098
1 postdoc (80% salary, 20% benefits); 1 FTE for year 1 and 1 FTE for year 2	$ 101,041
1 Research Engineer (75% salary, 25% benefits); 1 FTE for year 2 and 1 FTE for year 3	$ 148,400
Professional/Technical/Service Contracts:	
Construction service firm TBD; Installing pilot-scale hydrothermal reactor and nano-zeolite absorption reactor: materials: $7,000; construction and installation: $10,000; miscellaneous supplies: $3,000	$ 20,000
Equipment/Tools/Supplies:	
supplies for constructing lab-scale reactors including hydrothermal reacotor for nano-zeolite generation: $5,000, manure treatment reactor with all the control systems including reactor bodies, pumps, mixers, etc.:$5,000	$ 10,000
Sample analysis ($50/sample x 500 samples) , chemical reagents, lab supplies including gloves and glasswares: $5,000	$ 30,000
Travel:	
in-state travel from Waseca to Owatonna Coal plant to collect fly ash samples and run experiments for two people including meals and lodging during the three year period (estimated $200/trip x 20 trips).	$ 4,000
TOTAL ENVIRONMENT AND NATURAL RESOURCES TRUST FUND $ REQUEST =	$ 558,539

V. OTHER FUNDS

SOURCE OF FUNDS	AMOUNT	Status
Other Non-State $ Being Applied to Project During Project Period: N/A	$ -	
Other State $ Being Applied to Project During Project Period: N/A	$ -	
In-kind Services During Project Period: 0.2 FTE Technician for helping purchasing research materials, designing research reactors, trouble-shooting potential problems of the reactor system, field sampling, routine maintenance of lab conditions and management of lab supplies, etc.	$ 10,000	secured
Remaining $ from Current ENRTF Appropriation (if applicable): N/A	$ -	
Funding History: N/A	$ -	

Scheme of the proposed system:
Revolutionizing nitrogen emission reduction and nutrient recovery for animal manure by synthesized nano-scale zeolite from coal fly ash



Project manager qualifications:

Xiao Wu, Ph.D., Research Associate, Southern Research and Outreach Center, the University of Minnesota. Dr. Wu has many years of experience in conducting research in agricultural waste management and treatment system, emission control and using agricultural wastes as substrates to produce bioenergy and other value-added products. In the last 5 years, she has published over 20 papers in refereed journals in the subject area and made numerous presentations and talks across the nation and around the world. Dr. Wu is in charge of a 1,500 sqft laboratory for Renewable Energy and Environmental Engineering research, equipped with all the necessary lab facilities for the proposed project. She will be mainly responsible for developing and evaluating each unit in the proposed treatment technology, as well as the complete system in terms of nano-zeolite production and nutrients recovery into fertilizer. She will also be in charge of all the experiments to be conducted at the Southern Research and Outreach Center at Waseca, Minnesota, and reporting of the project outcomes to LCCMR.

Organizational description:

The University of Minnesota is the flagship in higher education in Minnesota and is an 1862 land grant institution in the US. The University of Minnesota, founded in the belief that all people are enriched by understanding, is dedicated to the advancement of learning and the search for truth; to the sharing of this knowledge through education for a diverse community; and to the application of this knowledge to benefit the people of the state, the nation, and the world.

University of Minnesota Southern Research and Outreach Center located in Waseca, MN is a scientific community whose mission is to conduct innovative basic and applied research for broad dissemination and education in the areas of agricultural production, human health, renewable energy and the environment, and provide extension service and research-based educational information to our clientele about crop production, animal nutrition, horticulture and animal manure treatment and utilization techniques. 926 acres are dedicated to research, outreach and extension activities. The unique location of SROC enables it to deliver research based information and transfer the knowledge to stakeholders in a more direct and efficient way.