



Environment and Natural Resources Trust Fund

2021 Request for Proposal

General Information

Proposal ID: 2021-351

Proposal Title: Disinfect Airborne-Pathogens and Contaminants in Animal Production Facilities

Project Manager Information

Name: Roger Ruan

Organization: U of MN - College of Food, Agricultural and Natural Resource Sciences

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Project Basic Information

Project Summary: Develop a non-thermal plasma (NTP) based process to disinfect airborne contaminants including pathogens in animal production facilities and thus reduce health hazards and improve wellbeing of animals.

Funds Requested: \$754,000

Proposed Project Completion: 2024-06-30

LCCMR Funding Category: Air Quality, Climate Change, and Renewable Energy (E)

Project Location

What is the best scale for describing where your work will take place?

Statewide

What is the best scale to describe the area impacted by your work?

Statewide

When will the work impact occur?

During the Project and In the Future

Narrative

Describe the opportunity or problem your proposal seeks to address. Include any relevant background information.

Minnesota is a leading livestock producing state. Livestock and its products account for about half of the state's farm income. A major concern with livestock farming is the airborne pollutants including pathogenic microorganisms, e.g. avian influenza viruses, and odorous chemicals, e.g. ammonia and hydrogen sulfide.

Bird flu caused by Avian influenza virus (AIV) is incredibly disruptive to the regional poultry industry due to massive culling of infected birds, and restrictions placed on poultry meat exports. In 2015 a regional outbreak in Minnesota resulted in an economic loss of estimated \$647.2 million and affected over 2,500 jobs. Although quite rare in the US, some AIV strains can cause infections in humans, with mortality rates of 50% in some outbreaks reported globally. Other airborne pathogens in poultry barns and hog farms, which have potential to harm humans, include Salmonella, Staphylococcus, Streptococcus, Mucor, and many others.

Nuisance odors from animal facilities is another major concern. Odor-related issues range from mild complaints from neighboring communities to lawsuits resulting in costly stoppages in farming operations. Minnesota, as a leading producer of eggs and turkeys as well as hogs, must find a solution to these economic, environment, and health problems.

What is your proposed solution to the problem or opportunity discussed above? i.e. What are you seeking funding to do? You will be asked to expand on this in Activities and Milestones.

This project addresses Priority E: Air Quality, Climate Change, and Renewable Energy. This project will be focused on the development and evaluation of innovative non-thermal plasma (NTP) processes and their use in reducing or eliminating airborne biological and chemical contaminants from animal production facilities. A plasma is electrically energized matter in a gaseous state, and is generated by passing gases through electric fields. A plasma consists of species that are extremely reactive, and they can react with problematic microbial organisms and chemical compounds on contact mainly in two ways: chemical (free radical-promoted) attack and direct electron impact. Our past research has demonstrated the effectiveness of NTP on virus. However, it remains unclear how bacteria and odorous compounds emitted from poultry facilities react to NTP. In this project, we will develop an NTP treatment unit for air sanitization and odor control in poultry facilities. While the core technology is NTP, other techniques such as electrostatic precipitation will be employed to improve effectiveness and efficiency. The effect of the treatment on AIV viability, decomposition of ammonia, H₂S, and removal of small particles will be evaluated. Furthermore, the economic, environmental, and health impacts will be analyzed.

What are the specific project outcomes as they relate to the public purpose of protection, conservation, preservation, and enhancement of the state's natural resources?

The successful development of the proposed technology is expected to help protect human and animal health and by removing hazardous airborne biological and chemical contaminants from poultry facilities. The knowledge acquired and technology developed may be extended beyond poultry industry. With more than 24,000 registered feedlots in Minnesota, the proposed technology has a great potential to make a huge impact on controlling and reducing airborne pollutants in Minnesota livestock farms.

Activities and Milestones

Activity 1: Design, fabricate, and test an NTP treatment unit for destruction and removal of airborne contaminants in animal production facilities

Activity Budget: \$400,000

Activity Description:

We will first use our current lab NTP treatment apparatus to develop and optimize the process. Additional promising NTP reactor configurations will be tested. For instances, the feasibility of enhancing airborne contaminant removal by using electrostatic precipitation will be examined. Also will be investigated is the incorporation of photocatalysis, such as using modified TiO₂, which could be promoted under NTP conditions and therefore improve the effectiveness of the overall process. An optimal configuration, a set of optimized processing parameters, and scale-up parameters will be determined to guide the development of a prototype treatment unit that will fit the requirement of a demonstration farm facility. The destruction and removal of key airborne contaminants, i.e., selected pathogens (AI virus, Salmonella) and odorous compounds (ammonia, H₂S) will be evaluated when the unit is initially tested in labs.

Activity Milestones:

Description	Completion Date
Key processing variables will be identified and quantified and basic contaminates removal mechanisms delineated	2022-06-30
Removal efficiency, air quality data, and energy efficiency will be evaluated	2023-12-31
An preliminary optimized system and process flow diagram will be delivered	2023-12-31

Activity 2: Assess potential positive environmental, health, and economic impacts of the strategy

Activity Budget: \$354,000

Activity Description:

After testing and study of the prototype unit in lab setting, the unit will be taken to a poultry barn in Rosemount Research and Outreach Center for field testing and demonstration. Data on destruction and removal of airborne contaminants, treatment capacity, energy consumption, and operation costs will be collected and analyzed. The environmental, health, and economic impacts of the strategy will be assessed under different scenarios. Stakeholders will be brought to the demo site to view the system and operation.

Activity Milestones:

Description	Completion Date
Scale-up parameters will be determined for the optimized process flow	2023-03-31
Field test/demonstration system design will be completed	2023-06-30
Field test/demonstration system will be fabricated and tested in lab and on fields	2023-12-31
The field test/demonstration system will be demonstrated in WCROC to the stakeholders	2024-06-30

Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Yanling Cheng	University of Minnesota	co-PI	No
Paul Chen	University of Minnesota	co-PI	Yes

Long-Term Implementation and Funding

Describe how the results will be implemented and how any ongoing effort will be funded. If not already addressed as part of the project, how will findings, results, and products developed be implemented after project completion? If additional work is needed, how will this be funded?

New scientific knowledge and experience on NTP based process for removal of airborne contaminants from poultry barns will be acquired through research, and the operation and demonstration on farm will raise significant interests from the stakeholders. We will seek industry partners and private, state, and federal funding to further develop and eventually commercialize the technology.

Other ENRTF Appropriations Awarded in the Last Six Years

Name	Appropriation	Amount Awarded
Demonstrating Innovative Technologies to Fully Utilize Wastewater Resources	M.L. 2014, Chp. 226, Sec. 2, Subd. 08c	\$1,000,000
Development of Innovative Sensor Technologies for Water Monitoring	M.L. 2016, Chp. 186, Sec. 2, Subd. 04j	\$509,000

Project Manager and Organization Qualifications

Project Manager Name: Roger Ruan

Job Title: Professor

Provide description of the project manager's qualifications to manage the proposed project.

Dr. Roger Ruan, Professor and Director, Center for Biorefining and Department of Bioproducts and Biosystems Engineering, University of Minnesota, Fellow of ASABE and Fellow of IFT, is the project manager of the proposed project. Dr. Ruan's research focuses on renewable energy technologies, solid and liquid waste treatment and utilization, and environmental engineering. Specifically, he has conducted research and published his findings in the areas of municipal, agricultural, and industrial wastewater treatment and utilization through novel anaerobic digestion, microalgae cultivation, and hydroponic cultivation, biomass and solid wastes (including plastics) gasification and pyrolysis, airborne pathogen disinfection, catalysis, non-thermal plasma, ammonia synthesis, etc. He is a top-cited author in the area of agricultural and biological sciences with an h-index of 63, i10-index of 255, and over 15,400 citations, and has received over 180 projects totaling over \$45 million in various funding for research, including major funding from USDA, DOE, DOT, DOD, LCCMR, and industries. He was the project manager of several earlier LCCMR funded projects which resulted in the issuance of a US patent and licensing of a technology. Therefore he has the technical expertise and project management experience to ensure the execution of proposed projects.

Organization: U of MN - College of Food, Agriculture and Natural Resource Sciences

Organization Description:

The Center for Biorefining is a University of Minnesota research center and help coordinate the University efforts and

resources to conduct exploratory fundamental and applied research; 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 funded 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 arts analytical instruments, and processing facilities ranging from bench to pilot scale.

Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
Personnel								
Roger Ruan		PI			36.5%	0.12		\$24,328
Graduate Research Assistant		Research Assistant			45%	1.5		\$150,933
Paul Chen		Co-PI			36.5%	0.48		\$64,621
Graduate Research Assistant		Research Assistant			45%	1.5		\$150,933
Post Doc		Researcher			25.4%	3		\$193,799
							Sub Total	\$584,614
Contracts and Services								
							Sub Total	-
Equipment, Tools, and Supplies								
	Equipment	Components for fabrication of experimental apparatus and small demonstration system, including NTP reactors, power supplies, control circuit, nebulizer, compressor, sampler, catalyst reactor, vacuum pumps, enclosure, fans, flow control, temperature sensor, etc.	To fabricate experimental apparatus and small system for running experiments, conducting performance analysis, and demonstration					\$150,000
	Tools and Supplies	Materials and lab supplies including chemicals for analysis, photocatalysts, consumable supplies for analytical instruments, microorganisms, culture media, glassware, etc.	For running experiments and operating the systems.					\$13,386
							Sub Total	\$163,386
Capital Expenditures								
							Sub Total	-

Acquisitions and Stewardship								
							Sub Total	-
Travel In Minnesota								
							Sub Total	-
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
							Sub Total	-
Other Expenses								
		Repairs and Maintenance	Repairs and Maintenance of analytical instruments					\$6,000
							Sub Total	\$6,000
							Grand Total	\$754,000

Classified Staff or Generally Ineligible Expenses

Category/Name	Subcategory or Type	Description	Justification Ineligible Expense or Classified Staff Request
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Non ENRTF Funds

Category	Specific Source	Use	Status	Amount
State				
			State Sub Total	-
Non-State				
			Non State Sub Total	-
			Funds Total	-

Attachments

Required Attachments

Visual Component

File: [f6a08578-0dd.pdf](#)

Alternate Text for Visual Component

- 1) pathways for pathogens and chemical hazards to impact farm animals and farmers
- 2) our approach to sanitizing air in animal facilities

Optional Attachments

Support Letter or Other

Title	File
UMN authorization letter	25599099-d7c.pdf
UMN financial audit report	78d40f43-62e.pdf

Administrative Use

Does your project include restoration or acquisition of land rights?

No

Does your project have patent, royalties, or revenue potential?

Yes,

- Patent, Copyright, or Royalty Potential

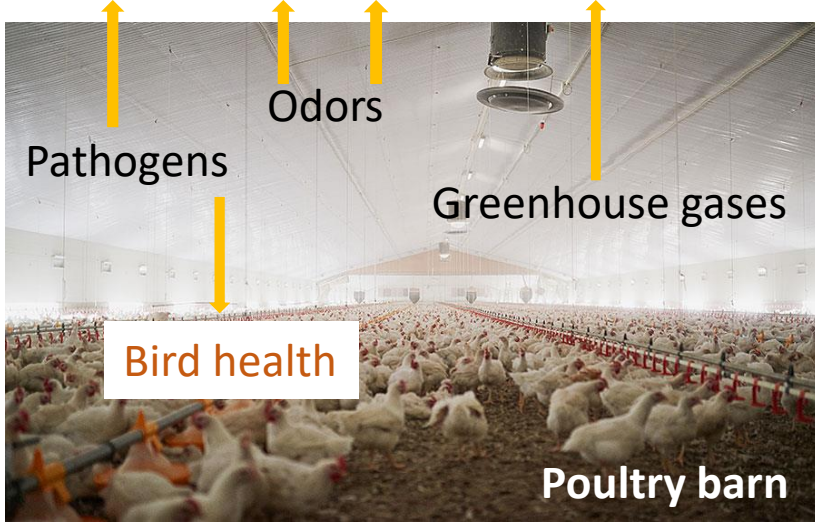
Does your project include research?

Yes

Does the organization have a fiscal agent for this project?

No

Human health Environmental impact

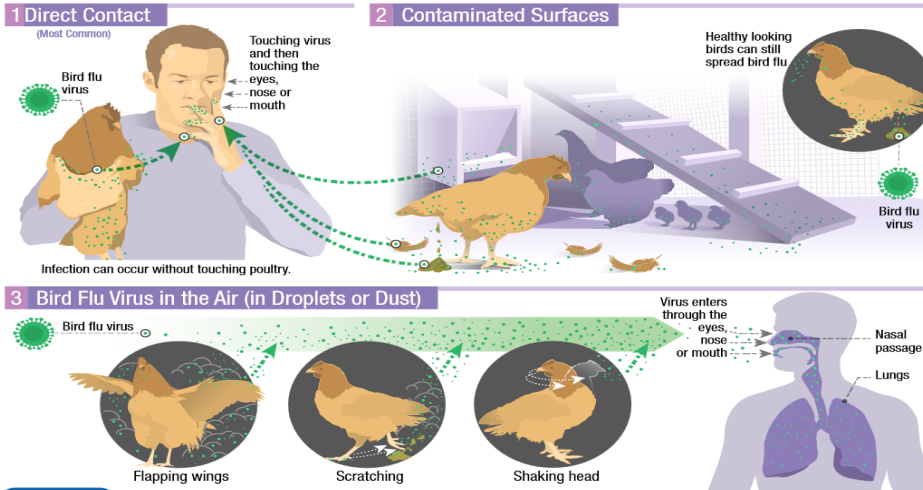


What can the gases (ammonia, hydrogen sulfide, methane, NOx, SOx) from animal manures do to human and the environment?

- Nuisance odors
- Contribute to the formation of secondary particulate matter (PM2.5) and tropospheric ozone, which are harmful to human health and the climate
- Harmful to animals too.

How Infected Backyard Poultry Could Spread Bird Flu to People

Human Infections with Bird Flu Viruses Rare But Possible

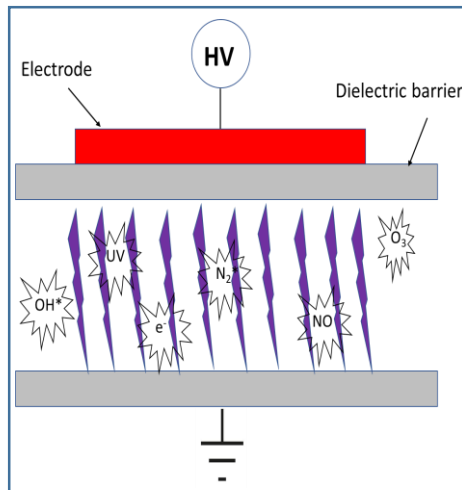


← Pathogens originated from animal facilities such as avian influenza virus Other airborne pathogens in poultry barns and hog farms, which have potential to harm humans



www.cdc.gov/flu/avianflu/avian-in-humans.htm

Dirty air
Pathogens
& Gases



Sanitized air

↑ Non-thermal plasma (NTP) reactor for AIV inactivation being developed at UMN