

**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

**Office Telephone:** (612) 625-1712

**Email:** ruanx001@umn.edu

## **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 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 arts analytical instruments, and processing facilities ranging from bench to pilot scale.

## **Budget Summary**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Category / Name** | **Subcategory or Type** | **Description** | **Purpose** | **Gen. Ineli gible** | **% Bene fits** | **# FTE** | **Class ified 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 Maintenence | 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** |

### **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](https://lccmrprojectmgmt.leg.mn/media/map/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](https://lccmrprojectmgmt.leg.mn/media/attachments/25599099-d7c.pdf) |
| UMN financial audit report | [78d40f43-62e.pdf](https://lccmrprojectmgmt.leg.mn/media/attachments/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