**PROJECT TITLE:** Removingairborne contaminants from animal production facilities

**I. PROJECT STATEMENT**

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 such as *Salmonella*, *Streptococcus,* and avian influenza virus, and odorous and acid rain causing chemicals such as ammonia and hydrogen sulfide. This project will be focused on the development and evaluation of innovative non-thermal plasma-based technologies and their use in reducing or eliminating airborne biological and chemical contaminants from animal production facilities. The successful development of the proposed technology is expected to help protect human and animal health and reduce greenhouse emissions. The project addresses ***Priority*** *E: Air Quality, Climate Change, and Renewable Energy*.

***Avian influenza virus (AIV) or bird flu*** caused by 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 estimated $647.2 million in economic damage and affected over 2,500 jobs. Some AIV strains can cause infections in humans, with mortality rates of 50% among infected individuals in some outbreaks. Cases of human infection with AIVs have been reported globally although it is quite rare in the US. US Centers for Disease Control and Prevention speculates that poultry facilities could spread bird flu to humans through a number of pathways (See visual attachment). ***Other airborne pathogens*** in poultry barns and hog farms, which have potential to harm humans, include *Salmonella*, *Staphylococcus*, *Streptococcus*, *Mucor*, *A. niger*, *Scopulariopsis*, and many others.

Controlling ***nuisance odors*** from animal facilities such as ammonia and hydrogen sulfide (H2S) is another major area of 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.

This project is built on our expertise and experience in developing ozone and non-thermal plasma (NTP) processes for AI virus inactivation, odor reduction, and hazardous emission control. These techniques are based on non-thermal plasma physics and chemistry and are proven methods of microbial control and hazardous gaseous decomposition. A plasma is electrically energized matter in a gaseous state, and is generated by passing gases through electric fields. Plasma particles consist of species that are extremely reactive, and therefore can attack or react with problematic chemical compounds on contact. These species are very strong oxidizers that can rapidly decompose other inorganic and organic compounds mainly in two ways: chemical (free radical-promoted) attack and direct electron impact.

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 AI virus viability, decomposition of ammonia, H2S, and removal of small particles will be evaluated. Furthermore, the economic, environmental, and health impacts will be analyzed.

**Impacts**: Minnesota is a leading poultry producer. It raised about 240 million turkeys in 2018 and the number of all layers on hand during January 2019 was 11.1million. 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. By removing hazardous airborne biological and chemical contaminants, the health of humans, animals, and the environment will be protected.

**II. PROJECT ACTIVITIES AND OUTCOMES**

|  |
| --- |
| **Activity 1:** *Design, fabricate, and test an NTP treatment unit for destruction and removal of airborne contaminants in animal production facilities* We will first use our current lab NTP treatment apparatus to develop and optimize the process. Additional NTP reactor configurations will be tested. An optimal configuration, a set of optimized processing parameters, and scale-up parameters will be determined for the proposed prototype treatment unit for this study. Enhancement of airborne contaminant removal using electrostatic precipitation will be examined and the result will be used to determine if an electrostatic precipitation device will be implemented into the prototype unit. 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.**ENRTF BUDGET: $285,000** |
| **Outcome** | **Completion Date** |
| *1. Key processing variables will be identified and quantified and basic biological and chemical contaminates removal mechanisms will be delineated*  | *06/30/2021* |
| *2. Removal efficiency, air quality data, and energy efficiency will be evaluated*  | *12/31/2021* |
| *3. An preliminary optimized system and process flow diagram will be delivered* | *12/31/2022* |
| **Activity 2:** *Assess potential positive environmental, health, and economic impacts of the strategy* 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. **ENRTF BUDGET: $300,000** |
| **Outcome** | **Completion Date** |
| *1. Scale-up parameters will be determined for the optimized process flow* | *03/31/2022* |
| *2. Field test/demonstration system design will be completed* | *06/30/2022* |
| *3. Field test/demonstration system will be fabricated and tested in lab and on fields* | *12/31/2022* |
| *4. The field test/demonstration system will be demonstrated in* WCROC *to the stakeholders* | *06/30/2023* |

**III. PROJECT PARTNERS:**

**A. Project team:**

The project team consists of process and system engineers, veterinary medicine professionals, extension professionals: Roger Ruan (Bioproducts & biosystems Engineering or BBE, UMN), Yuying Liang (Veterinay Medicine, UMN), Paul Chen (BBE, UMN), Kevin Janni (BBE, Extension, UMN), and Sally Noll (Animal Science, Extension, UMN)

**B. Partners NOT receiving ENRTF funding**

|  |  |  |  |
| --- | --- | --- | --- |
| **Name** | **Title** | **Affiliation** | **Role** |
| Peter Forsman | Owner | Forsman Farms | Help with field demonstration |
| John Snyder | President | Minnesga | Help with pilot system development  |

**IV. LONG-TERM- IMPLEMENTATION AND FUNDING:**

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.

**V. TIME LINE REQUIREMENTS:**

This project is planned for 3 years beginning July 1, 2020 and ending June 30, 2023. Most of the first 18 months will be focused on process improvement and parameter optimization, and full understanding of the proposed process, and much of the second 18 months will be focused on development, evaluation, and demonstration of the proposed demonstration system.