



# Environment and Natural Resources Trust Fund

## 2022 Request for Proposal

### General Information

**Proposal ID:** 2022-252

**Proposal Title:** Quantify indoor air quality improvement with air purifiers

### Project Manager Information

**Name:** Jiayu Li

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

**Office Telephone:** (612) 624-1761

**Email:** lijiayu@umn.edu

### Project Basic Information

**Project Summary:** This proposal will characterize various air purifiers to examine how they can improve indoor air quality and ventilation conditions.

**Funds Requested:** \$518,000

**Proposed Project Completion:** June 30 2025

**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.**

Indoor air quality is a rising concern, especially during the COVID-19 pandemic. Some situations wearing masks and social distancing are safe but inconvenient, such as crowded workspaces, dentistry, and restaurants. Improving indoor air quality is essential to reduce residents' exposure to air pollutants, reducing the spread of contagious airborne diseases, such as COVID and other current and future epidemics.

Air purifiers are an efficient and economical option to improve indoor air quality, as they can stand-alone or be integrated into existing ventilation systems. Various air purifiers can accelerate air pollutants' removal through filtration, photocatalytic, ultraviolet (UV), and nonthermal plasma. Air purifiers' impact is equivalent to ventilation improvement, as air pollutants decay faster under good ventilation conditions. However, such an improvement has not been quantified in real-life scenarios.

This proposal will quantify how air purifiers can improve indoor ventilation rates. By sampling 10-15 commercial buildings, we expect to draw general conclusions to questions such as 1) when an air purifier is needed? 2) How many air purifiers are sufficient? 3) Are air purifiers equally effective to all types of air pollutants?

### **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. Indoor air quality is an emerging concern amid the pandemic. It remains untested how air purifiers can improve the air quality in real-life scenarios. This proposal will 1) evaluate the performance of air purifiers and 2) establish an empirical model to predict the improvement of deploying air purifiers.

The improvement of deploying air purifiers will be quantified through ventilation rates. A higher ventilation rate indicates a better ventilation condition with faster removal of indoor air pollutants. Deploying air purifiers can accelerate the removal of indoor air pollutants, equivalent to improving ventilation conditions. This study will test air purifiers operating on various working principles. The existing ventilation conditions of 10-15 commercial housings will be examined. Then, we will test how much improvement can be achieved by deploying air purifiers. Finally, an empirical model will be established to predict the improvement of deploying air purifiers. This research will inspire preventive guidelines to ensure indoor air safety.

### **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?**

This project's major outcomes will be: 1) a comprehensive evaluation of indoor air quality in Minnesota businesses, 2) an empirical model to predict air quality improvement with air purifiers, and 3) preventive guidelines to improve indoor air quality. By evaluating air purifiers' performance, this research can ease the concern of disease transmission in public spaces and businesses. The general public, especially seniors and children, will benefit from well-ventilated, safer spaces. After the pandemic, this proposal's outcomes will continue to benefit people in extreme outdoor air pollution events, flu season, and future disease outbreaks.

## Activities and Milestones

### Activity 1: Test existing ventilation systems and various air purifiers

**Activity Budget:** \$300,000

#### Activity Description:

Previous studies usually test air purifiers in lab settings with specific types of air pollutants. The proposed study will test air purifiers with multiple air pollutants in real-life scenarios. We will seek 10-15 voluntary business owners or industrial collaborators to test 1) existing ventilation systems and 2) the performance of air purifiers. We will deploy 3-5 low-cost multi-pollutant air quality sensors at different locations to evaluate ventilation conditions. Ventilation rates can be calculated based on the decay curve of particulate matters (PM) and gaseous pollutants. Bioaerosols, pathogen-containing particles or droplets, will also be sampled as background. Then, air purifiers operating on different working principles (e.g., filtration, photocatalytic, UV, nonthermal plasma, and pulse low-temperature microwave technologies) will be deployed in the space. Ventilation rates will be re-calculated based on the decay curve of air pollutants, and bioaerosols will be re-sampled to be compared with the background concentrations. An increasing ventilation rate and a decreasing bioaerosol concentration represent an improved ventilation condition.

#### Activity Milestones:

Description	Completion Date
Develop protocols to measure ventilation rates	December 31 2022
Calibrate low-cost air quality sensors for field measurements	June 30 2023
Sample 10-15 commercial buildings to evaluate the improvement of air purifiers	December 31 2024

### Activity 2: Establish empirical models to predict air purifiers' impact on ventilation conditions

**Activity Budget:** \$218,000

#### Activity Description:

In this task, we will try to quantify air purifiers' influences through 1) an empirical model and 2) simulations. Factors influencing ventilation conditions will be identified from Activity 1 results, such as room dimensions, occupancy levels, indoor activities, and air purifiers. The association between ventilation rates and these factors will be established through an empirical model. Thus, by knowing some basic information about an enclosed space, we can predict how much improvement can be made by deploying an air purifier. We can also estimate how many air purifiers are required to reach the expected ventilation rates. The empirical models established by experimental results will be further validated by computational fluid dynamics (CFD) simulations. The field campaign can only measure limited samples, but CFD can simulate infinite scenarios. Field campaign results can constrain CFD simulations. With intensive simulation, we expect more general and informative conclusions. We can also simulate the release and trajectory of pathogen-containing particles, analyzing the variation of exposure risks within an enclosed space. Conclusions from this task can benefit ventilation design and improvement for improving indoor air quality.

#### Activity Milestones:

Description	Completion Date
Establish empirical models from experimental results	June 30 2024
Simulate various indoor ventilation conditions with CFD simulations	December 31 2024
Advocate guidelines to improve indoor ventilations	June 30 2025

## Project Partners and Collaborators

Name	Organization	Role	Receiving Funds
Roger Ruan	University of Minnesota	Dr. Roger Ruan, Professor and Director, Center for Biorefining and Department of Bioproducts and Biosystems Engineering, University of Minnesota. Dr. Ruan's research focuses on renewable energy technologies, solid and liquid waste treatment and utilization, and environmental engineering. Dr. Ruan and Li will coordinate the sampler design and sample collection.	Yes
Monika Vadali	Minnesota Pollution Control Agency	Monika Vadali from the Minnesota Pollution Control Agency (MPCA) leads the Assessing Urban Air Quality project that was previously funded by the LCCMR. Her project deployed 44 low-cost multi-pollutant AQMESH sensors in Twin Cities. Monika and Li will distribute AQMESH sensors. Besides, she will also share historical AQMESH data.	Yes
Kathy Raleigh	Minnesota Department of Health	Kathy Raleigh is from the Minnesota Department of Health (MDH). She is an expert on indoor air quality and has been involved in various projects characterizing the health impact of air pollutants. In this proposal, she will assist with indoor air quality analysis from the perspective of public health.	No

## 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?**

This study addresses both practical and scientific gaps to answer an essential question: how we can ensure safe indoor environments. This research will assist in reopening amid pandemic, flu season, nursing homes, and other scenarios. We will quantify how much improvement air purifiers can bring to existing ventilation systems. Preventive guidelines will be promoted regarding indoor air quality, which will benefit business owners, workers, and the general public. The outcome of the study will be favored by community outreach programs and mass communication.

## Project Manager and Organization Qualifications

**Project Manager Name:** Jiayu Li

**Job Title:** Assistant Professor

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

Dr. Jiayu Li, Assistant Professor for Department of Bioproducts and Biosystems Engineering, University of Minnesota, is the project manager of the proposed project. Jiayu's research focuses on low-cost air quality sensors and bioaerosols. She has characterized multiple air quality sensors, including particulate matter sensors and multiple gaseous sensors. Her previous work used these sensors to map urban air quality with high spatiotemporal resolution. Jiayu has also worked with various bioaerosol samplers and has published several papers characterizing bioaerosols in hospitals. Her background and experience fit well in this project.

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

**Organization Description:**

The College of Food, Agricultural and Natural Resource Sciences (CFANS) is one of seventeen colleges and professional schools at the University of Minnesota. CFANS comprises six divisions, twelve academic units, 10 research and outreach centers throughout Minnesota. CFANS is devoted to create a world that will feed our growing population while sustaining the natural resources upon which we depend. CFANS' vision is to advance Minnesota as a global leader in food, agriculture, and natural resources through extraordinary education, science-based solutions, and dynamic public engagement that nourishes people and enhances the environment in which we live. Funding for CFANS' cutting-edge

research comes from partners of all sizes and specialties. In the 2020 fiscal year, 413 sponsored project awards from 195 distinct funders were received by CFANS.

## Budget Summary

Category / Name	Subcategory or Type	Description	Purpose	Gen. Ineligible	% Benefits	# FTE	Classified Staff?	\$ Amount
<b>Personnel</b>								
PI		Lead investigation, supervise, analyze - 4 weeks summer salary			36.5%	0.24		\$37,002
Co-PI		Leadership, research, supervision - 4 weeks summer salary			36.5%	0.24		\$60,570
2 graduate students		research, analysis			45%	3		\$301,902
2 undergraduate students		research			0%	1.14		\$20,652
							<b>Sub Total</b>	<b>\$420,126</b>
<b>Contracts and Services</b>								
University of Minnesota	Internal services or fees (uncommon)	Lab services - microorganism speciation				-		\$30,000
							<b>Sub Total</b>	<b>\$30,000</b>
<b>Equipment, Tools, and Supplies</b>								
	Equipment	sensor	design and calibration					\$50,000
	Tools and Supplies	Lab supplies	sensor maintenance, instrumental supplies, calibration set up					\$8,874
							<b>Sub Total</b>	<b>\$58,874</b>
<b>Capital Expenditures</b>								
							<b>Sub Total</b>	<b>-</b>
<b>Acquisitions and Stewardship</b>								

							<b>Sub Total</b>	-
<b>Travel In Minnesota</b>								
	Miles/ Meals/ Lodging	approximately 5,040 miles	sampling					\$9,000
							<b>Sub Total</b>	<b>\$9,000</b>
<b>Travel Outside Minnesota</b>								
							<b>Sub Total</b>	-
<b>Printing and Publication</b>								
							<b>Sub Total</b>	-
<b>Other Expenses</b>								
							<b>Sub Total</b>	-
							<b>Grand Total</b>	<b>\$518,000</b>

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: [56f537f7-dc2.docx](#)

#### *Alternate Text for Visual Component*

- 1) Examples of candidate air purifiers operating on various working principles
- 2) Schematic diagram of the proposed study...

### Optional Attachments

#### *Support Letter or Other*

Title	File
Institutional Approval to Apply	<a href="#">643ff755-e91.pdf</a>

## Administrative Use

**Does your project include restoration or acquisition of land rights?**

No

**Does your project have potential for royalties, copyrights, patents, or sale of products and assets?**

No

**Do you understand and acknowledge IP and revenue-return and sharing requirements in 116P.10?**

N/A

**Do you wish to request reinvestment of any revenues into your project instead of returning revenue to the ENRTF?**

N/A

**Does your project include original, hypothesis-driven research?**

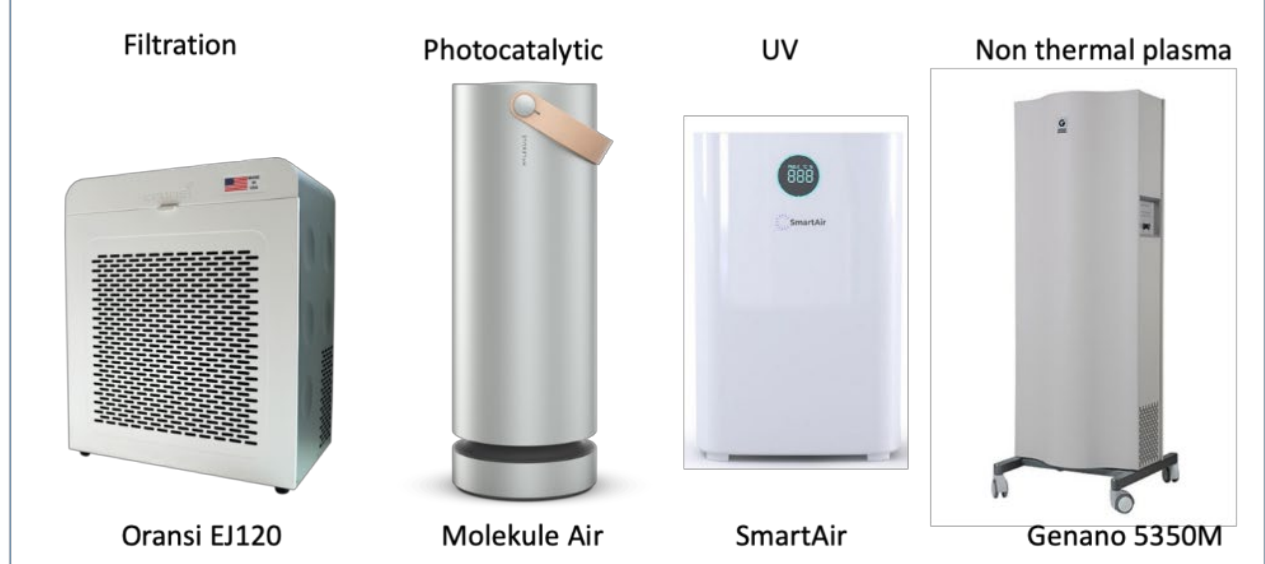
Yes

**Does the organization have a fiscal agent for this project?**

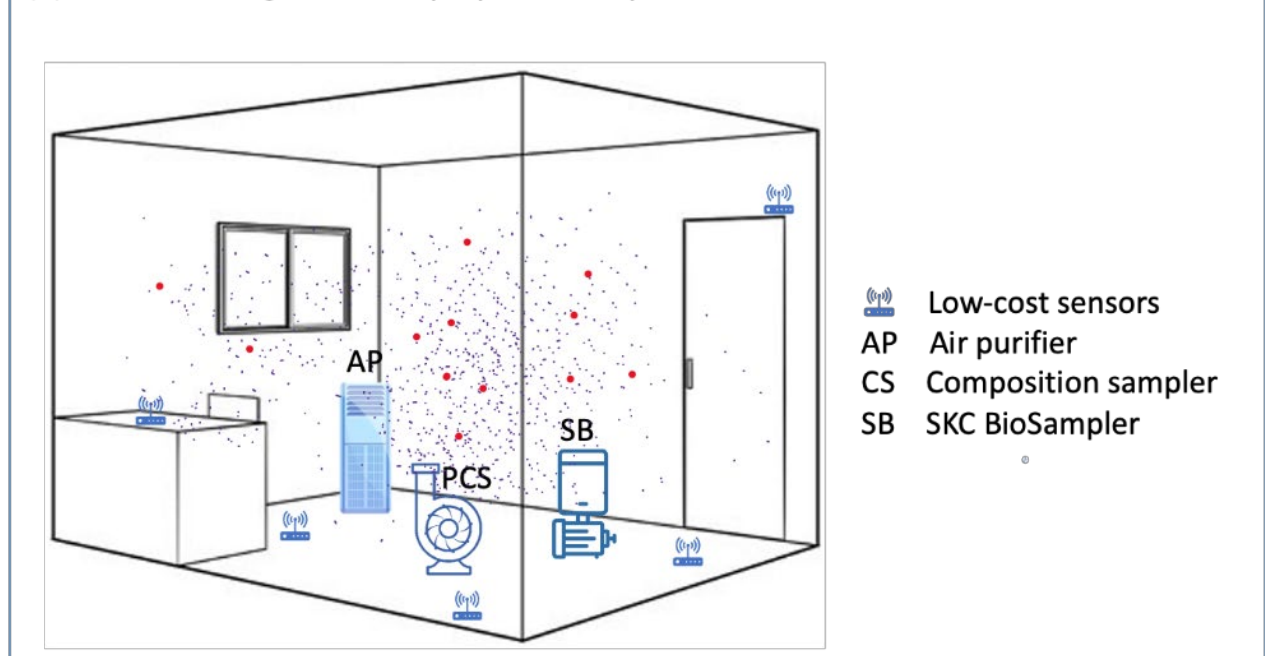
No

## Visual Component

### (1) Examples of candidate air purifiers operating on various working principles



### (2) Schematic diagram of the proposed study



### Alternate Text for Visual Component

- 1) Examples of candidate air purifiers operating on various working principles
- 2) Schematic diagram of the proposed study

