



Environment and Natural Resources Trust Fund

2022 Request for Proposal

General Information

Proposal ID: 2022-190

Proposal Title: Quantify air exposure levels of different demographic groups

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: We plan on evaluating indoor air quality and estimate pollution exposure levels of the population with low-cost air quality sensors. This proposal can advance environmental justice.

Funds Requested: \$360,000

Proposed Project Completion: June 30 2024

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?

Region(s): Metro

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

Region(s): Metro

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.

Overall, the outdoor air quality of Minnesota is healthy. However, indoor air quality is a rising concern for the state, especially during the COVID-19 pandemic. No comprehensive studies on indoor air quality have been conducted in Minnesota, thus we are proposing this project. People usually spend 90% of their time indoors, and the indoor air quality primarily determines exposure levels. It is still unclear 1) how is the indoor air quality in Minnesota? 2) what are the major sources of indoor pollutants, and 3) How indoor air pollution contributes to air pollution exposure levels. Major concerns regarding indoor air quality are gaseous pollutants, particulate matters (PM), and bioaerosols. All these pollutants are harmful to humans, especially for people with respiratory diseases. Gaseous pollutants include carbon monoxide (CO), ozone (O₃), nitrogen dioxide (NO₂), nitric oxide (NO), and volatile organic compounds (VOCs). PMs are micrometer-sized particles suspended in the air, such as dust suspended from carpet or pet furs. Bioaerosols are PMs with biomaterials, such as spores and droplets from sneezing. Some bioaerosols can spread respiratory diseases. Since every household and family differ greatly from another, a comprehensive study would be necessary for any conclusions to be generalized.

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 study will bring constructive additions to the Assessing Urban Air Quality (AUAQ) project run by the Minnesota Pollution Control Agency (MPCA) and funded by LCCMR. The AUAQ project deployed 44 low-cost air quality sensors to provide outdoor air quality data that highlighted the pollution trends across space and time. This study will conduct a comprehensive study regarding indoor air quality in Minneapolis–Saint Paul Metropolitan Area. From the data, we will estimate the air pollution exposure levels of different demographic groups with the effort of advancing environmental justice.

We will seek 30-50 volunteers to host low-cost sensors in their residential households for 1-3 months. The low-cost sensors will monitor hourly PM, CO, CO₂, O₃, NO, NO₂, and VOC concentrations. We will also collect PM and bioaerosols for laboratory analysis to identify major PM composition and microorganism species. With both indoor and outdoor data, we will compute the exposure level of different demographic groups.

This proposal emphasizes: 1) utilizes low-cost multi-pollutant sensors for indoor sampling, 2) includes both PM composition and bioaerosol samples, 3) estimates air pollution exposure levels with both indoor and outdoor.

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 will conduct a comprehensive study of indoor air quality in the Twin Cities area with low-cost sensors for exposure estimation. Outcomes are 1) Provides the MPCA and the Minnesota Department of Health (MDH) with data on indoor air quality, 2) Gives insights into the development of guidelines regarding indoor air pollution management, and 3) Pioneers the advancement of environmental justice. This effort is essential to reducing the health burden associated with air pollutants, which will substantially contribute to the better wellbeings of residents in the State of Minnesota.

Activities and Milestones

Activity 1: Design and calibrate sensing suites for indoor data collection

Activity Budget: \$200,000

Activity Description:

The indoor air quality study will recruit 30-50 volunteers from three counties (Hennepin, Anoka, and Ramsey, 10-15 from each county) to host sensing suites in their homes for 1-3 months. Diversities among volunteers in ages, occupations, and housing structures will be considered. Questionnaires will be distributed to volunteers about their daily activities, such as the times they stay indoors and outdoors and typical meal times, in order to supplement the quantitative data acquired from the sensors. Then we will assist volunteers to set up a sensing suite at their homes. The sensing suite includes three major components: a multi-pollutant low-cost sensor, a filter sampler, and a bioaerosol sampler. We will coordinate with the MPCA to pull ten low-cost sensors from the AUAQ project. These low-cost sensors will be calibrated with heating and cooking emissions. A home-made filter sampler will collect PM for composition analysis. A SPOT BioSampler (Aerosol Devices, Inc., CO, USA) and the polymerase chain reaction (PCR) method will be used to identify major indoor microorganism species. With 10 low-cost sensing devices, 5 filter samplers, and one SPOT BioSampler, we will coordinate the deployment schedule to ensure finishing the data collection within 1-1.5 years.

Activity Milestones:

Description	Completion Date
Indoor calibration of low-cost pollution sensors	December 31 2022
Build filter samplers with noise reduction enclosures	December 31 2022
Collect indoor air samples in 30-50 residential housings	December 31 2023

Activity 2: Analyze features of indoor environments and estimate air pollution exposure levels for different demographic groups

Activity Budget: \$160,000

Activity Description:

We can identify major indoor air pollutants, dominant PM composition, and primary indoor microorganism species with Activity 1 results. Such a comprehensive analysis can help identify indoor air pollution sources, whether major pollutions are from heating, cooking, outdoor traffic, or agricultural practices. Accordingly, preventive measures will be developed to mitigate indoor exposure, reducing the health burden associated with air pollutions. Then, we will summarize indoor air quality data collected from this project, collaborating with the outdoor air quality data published by the MPCA AUAQ project, as well as daily activities provided by volunteers through questionnaires. These inputs will be used in a Monte Carlo simulation to estimate air exposure levels among the population. The difference in pollution exposure between demographic groups will answer questions such as: How minors and elders affected differently by air pollution? How are different genders affected differently by air pollution? Do people in a specific neighborhood experience more severe air pollution? The answers to these questions are the basis for the advancement of environmental justice by investigating the consequences of unequal environmental conditions. The results can substantially benefit policymakers, state agencies (e.g., MPCA and MDH), and Minnesota residents.

Activity Milestones:

Description	Completion Date
Identify indoor air pollution characteristics	March 31 2024
Summarize typical trajectories of volunteers based on questionnaires	March 31 2024
Exposure estimation based on Monte Carlo Simulation	June 30 2024

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?

The high spatiotemporal resolution data provided by this study will be essential for epidemiological studies. This study will promote discussions and inspire new ideas regarding how we can efficiently mitigate indoor exposure levels to reduce health burdens, which is attractive to stakeholders. The outcome of the study will be favored by community outreach programs and mass communication. Funding agencies, such as the National Institutes of Health (NIH), the National Science Foundation (NSF), and the Centers for Disease Control and Prevention (CDC), will also be interested in this proposal.

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. She has joined the MPCA AUAQ project (previously funded by LCCMR), analyzing high spatiotemporal resolution outdoor air quality data in the Minnesota area. 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
Personnel								
PI		Project leader - 4 weeks summer salary			36.5%	0.16		\$24,423
Co-PI		Leadership, Research - 4 weeks summer salary			36.5%	0.16		\$39,979
2 Graduate Students		research			45%	2		\$232,765
2 undergraduate students		research			0%	0.76		\$13,631
							Sub Total	\$310,798
Contracts and Services								
University of Minnesota	Internal services or fees (uncommon)	Lab services - PM composition analysis, and microorganism characterization				-		\$20,000
							Sub Total	\$20,000
Equipment, Tools, and Supplies								
	Equipment	AQMESH sensor network and PM composition sampler rental fee	needed to collect samples					\$20,000
	Tools and Supplies	Lab supplies	sensor maintenance, instrumental supplies, calibration set up					\$6,202
							Sub Total	\$26,202
Capital Expenditures								
							Sub Total	-
Acquisitions and Stewardship								
							Sub Total	-

Travel In Minnesota								
	Miles/ Meals/ Lodging	approximately 5,357 miles	for sampling in various locations					\$3,000
							Sub Total	\$3,000
Travel Outside Minnesota								
							Sub Total	-
Printing and Publication								
							Sub Total	-
Other Expenses								
							Sub Total	-
							Grand Total	\$360,000

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: [5a31f769-631.docx](#)

Alternate Text for Visual Component

Schematic diagram of the proposed research activities....

Optional Attachments

Support Letter or Other

Title	File
Institutional Approval to Submit	73ba27ce-dab.pdf

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?

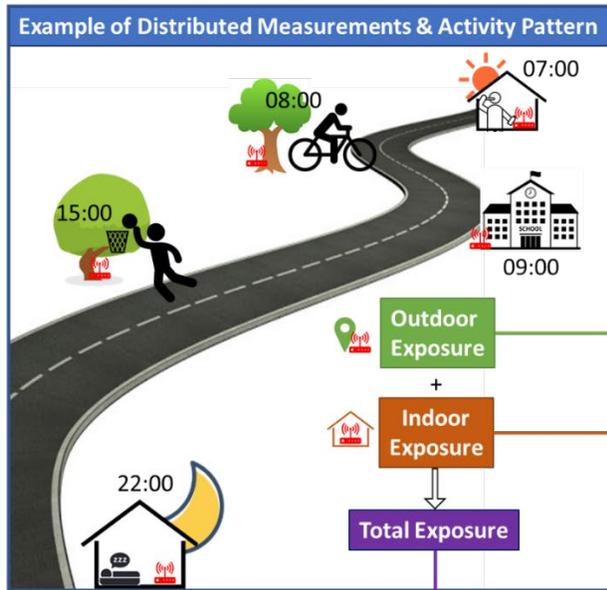
N/A

Does your project include original, hypothesis-driven research?

Yes

Does the organization have a fiscal agent for this project?

No



MPCA – Assessing Urban Air Quality Project

PM_{2.5} sensors and monitors

Project previously funded by LCCMR and maintained by MPCA. Deploying low-cost sensor to map urban air quality

Activity 1: Indoor Deployment

Low-cost Sensors	Aerosol Composition	Microorganism Species
Redistribute MPCA outdoor sensors for indoor purpose	Collect filter samples with noise reduction enclosed pump	Collect bioaerosol samples with the SPOT biosampler

Activity 2: Citizen Exposure Estimation

Environmental Justice	Preventive Guidelines
Estimate exposure variation among sub-population groups	Advocate preventive guidelines to reduce indoor exposure

Alternate Text for Visual Component

1) Schematic diagram of the proposed research activities.