DESCRIPTION OF THE RESEARCH PROJECT FOR THE 2018 SUMMER RET SITE

Project 4: Air Quality Monitoring Near a Major Roadway

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Project Summary

What is the nature of the proposed RET project and the questions it answers.

The *big idea* for this project is the National Academy of Engineering Grand Challenge to "Restore and Improve Urban Infrastructure." There is growing interest from regulatory agencies to quantity ambient concentrations of air pollutants at the neighborhood level, which can be affected by major sources of air pollution such as transportation networks. Highways are vital for transport of goods. However, as they pass through communities, they emit air pollution, but the extent of these externalities at the neighborhood level are not well quantified. Cincinnati's location – its centrality and proximity to major metropolitan areas and a major waterway – makes the city an ideal location as an intermodal transportation hub. Cincinnati is the largest inland port in the country and 4th in the nation in total rail mileage and has the highest highway traffic volumes in the state of Ohio. Along with this growth, comes air pollution that are associated with numerous health effects in communities adjacent to highways. These communities are often comprised of economically disadvantaged and underrepresented sections of the general population. In Cincinnati, the Camp Washington neighborhood, which has the fourth lowest life expectancy in Cincinnati, of ~67 years (see **Figure 1**), adjacent to both a major highway and a major railyard. Therefore, agencies such as the Southwest Ohio Air Quality Agency (**SWOAQA**) are particularly interested understanding in air quality in this neighborhood. The central ***challenge*** or objective of this RET project is to develop a sampling protocol and implement a sampling plant to quantify ambient concentrations of fine particulate matter at fine spatial and temporal scales in a Cincinnati neighborhood that suffers from poor health outcomes and utilize geospatial data visualization tools to communicate results.

Fine particulate matter with an aerodynamic diameter less than or equal to 2.5 microns is referred to as $PM_{2.5}$. It is a complex mixture of organic and inorganic chemical species emitted directly into and also formed from atmospheric processing from precursor gases and can come from both anthropogenic and biogenic sources. Exposure to $PM_{2.5}$ has been associated with numerous poor health outcomes, including mortality and morbidity such as cardiovascular and respiratory health outcomes (Brook et al. 2010; Dockery et al. 1993; Laden et al. 2000; Mar et al. 2000; Peel et al. 2007; Peng et al. 2009; Puett et al. 2011; Sarnat et al. 2008; Schwartz et al. 2005; Stolzel et al. 2005; Zanobetti et al. 2009). An important constituent of $PM_{2.5}$, is black carbon (**BC**), of which major sources include mobiles sources and biomass burning.

Measuring emissions at the neighborhood scale is not a trivial task. However, recent advances in portable monitoring technology can be utilized to measure ambient air pollutant concentrations. This research will attempt to answer the following four ***guiding questions:***

1. What *in situ* air quality data needs to be collected to document harmful levels of pollutant exposure?
2. Considering recent advances in portable, lower-cost air monitoring equipment, what monitors/sensors should be deployed to generate real time data?
3. At fine spatial scales, what air quality monitoring will improve geospatial data visualization by better predicting spatial variations of $PM_{2.5}$ and black carbon (**BC**)?
4. What can we learn about the spatial variability of air pollution in Camp Washington?

Participating teachers will identify and utilize portable instruments to gather air pollution data (see **Figure 2**). As a control, they will also conduct background monitoring at several other neighborhoods sites not expected to be impacted by the highway. The main idea is to investigate how severely the major highway impacts the Camp Washington neighborhood. Teachers will learn data analytical simulation modeling techniques used to understand the spatiotemporal distribution of air pollution. At the end of the project, the teachers will have identified the locations in Camp Washington that experience the worst air quality.

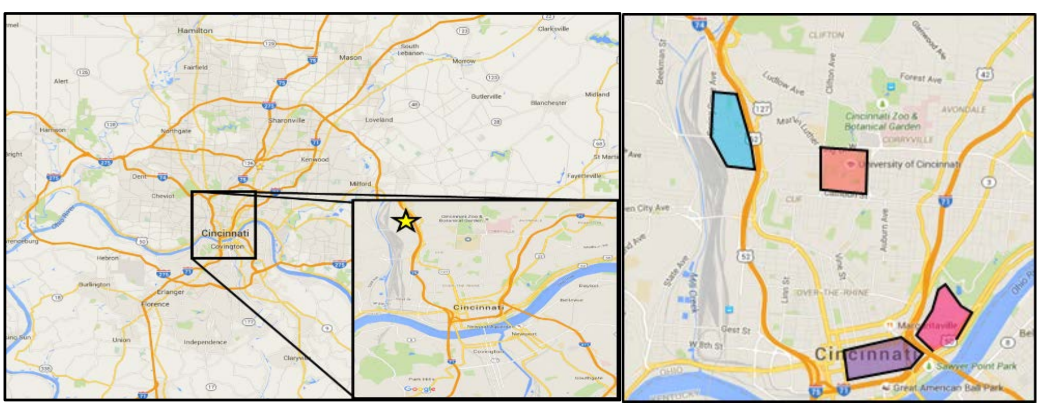

Figure 1: Cincinnati Metropolitan Area (Left) and Camp Washington Neighborhood (Right, Shaded In Light Blue) and Other Potential Neighborhood Sampling Locations (Right, Shaded Areas)

Figure 2: Portable Monitors Used for Air Pollution Measurements

What work needs to be conducted to achieve the objectives?

The work involves using portable air pollution monitors to measure fine particulate matter ($PM_{2.5}$), black carbon, and particle number concentration. We will utilize the following equipment:

- Dusttrak (TSI, Inc.) for measuring $PM_{2.5}$
- MicroAethalometer (AE51, Aethlabs, Inc.) for measuring black carbon
- GPS data using a smartphone app

The teachers will collect field data that will be utilized using GPS data along with air pollution data to create air pollution visualization in google maps and EPA data visualization software.

What research facilities will be used to conduct the research?

The work will be primarily conducted in the field at the Southwest Ohio Air Quality Agency's Near Roadway Site in the Camp Washington neighborhood. Work will also be conducted at other locations in Camp Washington.

What training will be provided in this project?

Training will be provided on: 1) using the Dusttrak and MicroAethalometer and a GPS smartphone app to collect air pollution and GPS data; 2) documenting, analyzing and reporting the field data collected; and 3) visualization of detailed spatiotemporal air pollution data using geospatial tools (e.g., google maps).

Research Timeline

The research tasks will be completed in 7 weeks, including the following activities that are specifically designated for the 2014 summer project:

Week 1: The teachers will be taking an Engineering Foundations course along with other groups of teachers involved in the summer project.

Week 2: The teachers will learn how to operate portable monitors. In addition, a field trip will be arranged to visit the Near Roadway site operated by SWOAQA (**Figure 2**).

Weeks 3-5: Field campaign using multiple portable monitoring stations in the Camp Washington neighborhood. A few of these days will be devoted to gathering data from neighborhoods not expected to be impacted by highways.

Week 6: The teachers will compile the results and knowledge gained from the above tasks and will be guided by the research mentors to develop an individual engineering design challenge activity to be incorporated in the classroom implementation plan proposed to take back the summer research experience back to their students. Specifically this engineering design challenge activity will be part of a comprehensive curricular unit for students to understand the basic concepts of correlation and source-receptor relationships as it pertains to air pollution.

Week 7: The teachers will prepare their final presentations and posters, and write their final reports and summaries.

Who will be the Industrial Advisor for this project?

In addition to coordinating the field trip, an industrial advisor, Ms. Anna Kelley of the Southwest Ohio Air Quality Agency, will serve as the Industrial Advisor for this project. She will participate in an *Industrial Advisors Panel Session* during the 2018 Summer RET Site to plan and schedule activities for teachers' students during the school year.

<u>Possible Ideas for Classroom Implementation</u>

Students will receive hands-on training to collect and analyze data. Critical to this process will be developing skills to create a sampling plan that is representative of dynamic spatial and temporal conditions. The students will then design a sampling protocol, deploy the instruments and gather data. A major challenge is that a particular spatial domain (e.g., neighborhood) cannot be sampled with full spatial and temporal resolution due to resource limitations. Therefore, the teachers will design an appropriate sampling plan that evaluates the tradeoffs between spatial versus temporal sampling (i.e., should one sample at multiple locations for short periods of time or should one focus on particular locations for longer periods of time?). This process will allow the teachers to engage in a challenge-based research project that will translate to classroom instruction. In addition, a math unit could be developed based on this real-world monitoring data. Students can analyze the data by performing basic statistics (e.g., average, maximum, minimum and standard deviation) of air pollutant concentrations, and compare difference in seasons, mornings, or afternoons, etc. An important part of this classroom experience will be to utilize data visualization techniques to communicate results. An example of a classroom project would be to design and build multiple low-cost $PM_{2.5}$ sensors that would be deployed. Students would analyze the gathered results for each monitor and compare results to understand the spatial variability of $PM_{2.5}$. One such analysis could be use MS Excel to plot concentrations at two locations and plot the trend line, with the idea that students gain a conceptual understanding of correlation.

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