EPA

sciencematters

July 2018

Innovations in Air Quality Monitoring

Table of Contents

Tracking Emissions Using New Fenceline Monitoring Technology

New cost-effective approaches to measuring air pollutants at the fenceline or in communities near industrial facilities can help identify and control air pollution that may drift across property lines. The benefits include reduced operational expenses for companies and improved air quality. Over the past five years, EPA researchers have been developing low-cost and portable Next Generation Emission Measurement technologies that can be deployed next to an industrial complex for emissions testing. The research is being conducted in collaboration with industry, states, and communities.

"The long-term goal of this research is to modernize approaches to source management for certain sectors so we can do a better job of protecting the environment and save companies money," says Eben Thoma, lead investigator at EPA.

Companies can manage air pollutants that are emitted from smokestacks or tailpipes using existing measurement and control technologies. In contrast, "fugitive emissions" escape from some industrial processes or equipment leaks in facilities such as refineries, chemical plants, and energy production operations. The fugitive pollutants are difficult to identify, measure, and track, and can include many different volatile organic compounds (VOCs).

For neighborhoods and communities living close to industry, emissions may be a concern to health and wellbeing. The release of VOCs can lead to ozone formation, and many of the compounds are hazardous air pollutants that can contribute to harmful health effects.

One measurement technology developed by EPA that has shown promise is called the SPod, a solar-powered sensor system that is portable, lower-cost, and can be placed at a facility's fenceline. The instrument detects and locates plumes of air pollutants, including VOCs, that are being emitted.

"The SPod is a simple sensor," Thoma explains. "Its job is to protect the fenceline by detecting whether VOC emissions are present and providing wind and concentration data to help identify the source and speed repair of emissions if required."

"The SPod is a simple sensor. Its job is to protect the fenceline by detecting whether VOC emissions are present and providing wind and concentration data to help identify the source and speed repair of emissions if required."

The SPod is an open-source design that has been shown in field studies to provide useful emission detection information. EPA has shared the design with dozens of interested early adopters to encourage improvements and commercialization.

"We have shared the SPod design with anyone interested," says Thoma. "We did not patent the technology because we want to spur innovation in the marketplace."

Three early SPod-like prototypes, developed by interested parties, are being evaluated by Thoma and his colleagues at EPA's research laboratories in Research Triangle Park, N.C. The devices are being compared to the Agency's research SPod, as well as more sophisticated and expensive measurement instruments. They plan to evaluate the prototypes in field studies as well.

Researchers are also in the early stage of testing a new mobile version of the SPod that can be used on a truck or moved around inside an industrial facility instead of placed around the perimeter of a facility.

Taking the SPod concept another step forward, EPA researcher Ingrid George is developing the VOC Emissions Tracker (VET), a lower-cost emission measurement system that can be easily deployed in the field to help detect VOC emissions and locate their sources.

The VET combines three advanced VOC measurement technologies:

- the SPod to detect and locate VOC plumes,
- a miniaturized, field-deployable automated gas chromatograph used to monitor a specific VOC pollutant of concern,
- and a canister triggering system that can collect whole air samples when a plume has been detected.

The samples can be sent to the lab for analysis for a wide range of VOCs, to further identify their sources.

For a pilot study in Dallas, Tex., the VET has been customized to measure xylene, a VOC, to assist EPA and Texas with determining the source or sources that may be contributing to elevated levels of the pollutant in the city. Xylene contributes to the formation of ozone and is a hazardous air pollutant. The tracker is undergoing testing and will be deployed in Dallas later this year for its first field demonstration.

"I think the VET system could be a very useful tool to understand different sources of VOC emissions, help industry reduce their cost of locating and repairing leaks, and improve air quality in communities in the area," says George.

The new emissions measurement technology being developed and tested at EPA is providing new solutions to complex air quality problems that exist in some parts of the country.

SPod air sensor device.

Eben Thoma and Ingrid George work on fenceline air monitoring instruments at a lab in N.C.

Advancing Air Quality Measurement Capabilities for Transportation Activities

Researchers at EPA are working to investigate local air pollution in three neighborhoods in Kansas City, Kans., to better understand how the many transportation activities in the area and other conditions like weather impact air quality. Their collaboration with residents and other stakeholders is called the Kansas City Transportation and Local-Scale Air Quality Study (KC-TRAQS).

The study launched in fall 2017 when EPA researchers began collecting air quality data in the neighborhoods of Turner, Argentine and Armourdale using a variety of stationary and mobile measurement equipment, including:

- an instrumented electric vehicle equipped to take high-time resolution (one-second) measurements and allow for increased spatial coverage across the study area,
- portable and lower-cost monitors equipped with sensors in six locations for changes in meteorology, like wind direction and temperature, and for continuous readings in the community,
- stationary samplers placed in five locations throughout southeast Wyandotte County.

The instruments measure fine particle pollution known as $PM_{2.5}$, and black carbon, a component of $PM_{2.5}$, which can impact lung and heart health. The stationary samplers will collect particulate matter on filters over a 24-hour period; filters will then be sent to the EPA laboratory for further analysis.

“One of our main goals for this project is to better understand the extent of air pollution in the community such as along a street, a park or other locations where people live, work and play,” says Sue Kimbrough, technical lead for the study.

The study will help to raise awareness of air quality issues in the community and advance the monitoring technologies for use by other communities with similar air quality concerns related to transportation.

Citizen scientists in the communities are taking part in the study by using AirMappers. These lunchbox-size monitors developed by EPA enable residents and students to collect local air quality data by carrying or attaching the devices to a bicycle while walking or biking around the study area. AirMappers include rechargeable battery power, a global positioning system, and particle and carbon dioxide sensors.

Researchers will share results with neighborhood leaders, state and local government officials, air quality planners, the railway company, and other stakeholders to support decisions to improve air quality in the community. Findings will be published in the peer-review literature.

KC-TRAQS is funded by EPA’s Office of Research and Development. Monitoring and measuring analysis is for research only and is not a health-based assessment and/or is not intended for regulatory purposes.

Visit the study page: www.epa.gov/air-research/kansas-city-transportation-and-local-scale-air-quality-study

Above, Air monitoring vehicle. Right, Sue Kimbrough shows equipment to local students.

EPA Scientists Collaborate with States to Protect Long Island Sound Air Quality

Expansive views of land across water, gulls cawing, water lapping on the rocks: this is Long Island Sound. Despite its close proximity to New York City and other major urban areas, a diverse array of aquatic and terrestrial homes dot the narrow land that stretches out toward the Atlantic Ocean.

The unique geography of Long Island Sound presents an interesting challenge for scientists. For example, the cooler surrounding waters trap regional air pollutants above the water. As temperatures rise, the breeze pulls this pollution inland. This leads to high ground-level ozone concentrations along the shorelines of New York, Connecticut, and Rhode Island. Although ozone levels have decreased in recent years, they still persistently exceed National Ambient Air Quality Standards (NAAQS).

EPA scientists are collaborating in a multi-agency field study from June to September 2018 to better understand the complex interaction of emissions, chemistry, and meteorological factors contributing to these high ozone levels along the Long Island Sound shorelines. The Long Island Sound Tropospheric Ozone Study (LISTOS) includes researchers from state and federal agencies and academia with expertise in collecting aircraft, satellite, and ground-based air quality measurements.

The study will provide valuable data and resources to state air quality managers as they develop strategies to control ozone pollution, and reduce and eliminate NAAQS non-attainment areas.

As part of the study, EPA scientists are using a variety of advanced instruments at sites surrounding Long Island Sound to measure compounds such as nitrogen dioxide, formaldehyde, and carbon monoxide, which react in the atmosphere in the presence of sunlight to form ozone.

"As our instruments continue to advance, EPA is learning about ozone formation near the ground and aloft."

Other compounds, including carbon dioxide, sulfur dioxide, and particulate matter, are being measured to better understand emission sources.

"As our instruments continue to advance, EPA is learning more about ozone formation near the ground and aloft," says Jim Szykman, who leads EPA's work on the project. "Ultimately this enables states to have a better sense of how to most effectively protect people and the environment from harmful ozone levels."

Specific instruments being used include:

- Sensor pods that measure carbon dioxide and provide a better understanding of emission activity near dense urban areas;
- Advanced chemistry instruments that measure formaldehyde, nitrogen oxides, and ozone at the surface to better understand ground-level ozone chemistry;
- Ceilometers, which send pulses of light up through the atmosphere to help scientists analyze backscatter from aerosols and identify how pollutants are mixing in the atmosphere;
- Spectrometers that focus on the large-scale transport of ozone precursors (primarily nitrogen dioxide and formaldehyde) and will be used to validate and evaluate urban-scale measurements from the TROPOspheric Monitoring Instrument, a satellite instrument on board the European Space Agency Sentinel-5 Precursor satellite launched in fall 2017.

David Williams installs a spectrometer at the U.S. Fish and Wildlife Service Outer Island, Conn. site.

By using various instruments to measure ozone precursors on both the ground and in the atmosphere, researchers can determine the height at which precursors are mixing and the ease at which pollutants might move across a region.

In addition to EPA's ground and satellite work, the University of Maryland and NASA are flying aircraft fitted with instruments that measure nitrogen dioxide and formaldehyde in the atmosphere. University of Maryland will fly its aircraft over the study area when there is a high-ozone episode during the research months, and NASA will use its aircraft throughout the summer to gather data to better understand ozone formation and nitrogen dioxide emissions.

Setup of instrumentation and data collection for this study began in June and will continue through September 2018. A workshop is planned for early 2019 to discuss LISTOS and its initial findings.

The Northeast States for Coordinated Air Use Management (NESCAUM) is organizing the study, with additional funding from New York State Energy Research and Development Authority and National Fish and Wildlife Foundation to support the participation of the University of Maryland, College Park; University at Albany-State University of New York; Stony Brook University; and City College of New York. Funding and support are provided by many other partners.

"Air pollution in the New York City area and over Long Island Sound is complex and dynamic on a daily basis," says Paul Miller, Chief Scientist at NESCAUM. "The LISTOS effort is helping address a difficult public health problem that affects over 20 million people living in the region."

Air Sensor Toolbox for Citizen Scientists

The availability of lower-cost and portable air sensor monitors has spurred interest by communities and citizen groups in learning about their local air quality. EPA has developed the Air Sensor Toolbox for Citizen Scientists to provide information and guidance on using air sensor technology and conducting air monitoring projects.

- Learn how to select and use air sensors.
- Find out what your sensor readings mean.
- Learn what EPA is doing to advance air sensor technology.
- Access air sensor resources and learn about funding opportunities.

Visit the Air Sensor Toolbox: www.epa.gov/air-sensor-toolbox

Amanda Kaufman and Teri Conner evaluate air sensor technology at EPA lab in N.C.

Take a Look Inside the Toolbox

These and other resources are available on the online Air Sensor Toolbox.

Air Sensor Guidebook Provides Monitoring How-To

The Air Sensor Guidebook is a comprehensive resource for anyone interested in monitoring local air quality. Topics covered include information on air pollutants and uses for air sensors, what to look for in a sensor, how to collect useful data using sensors, sensor performance guidance, and maintaining your sensing device.

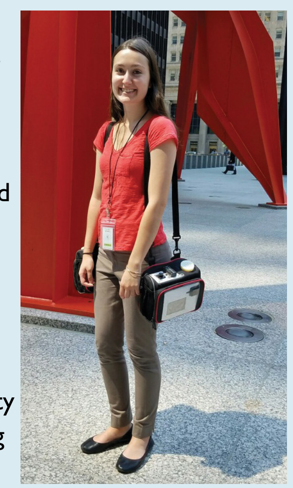
Air Sensor Guidebook: www.epa.gov/air-sensor-toolbox/how-use-air-sensors-air-sensor-guidebook

Guide and Analysis Tool for Community-led Monitoring

EPA has developed a guide and analysis tool for citizen scientists interested in air quality monitoring to evaluate the performance of lower-cost air sensors and interpret the data collected. While EPA developed the resources to be suitable for citizen scientists and communities, they are also useful to the broader air sensor user community, both experts and non-experts.

Guide and Analysis Tool: www.epa.gov/air-research/instruction-guide-and-macro-analysis-tool-community-led-air-monitoring

Mapping Air Data Using RETIGO



Real Time Geospatial Data Viewer (RETIGO) is a free, web-based tool developed by EPA that can be used to explore environmental data that you have collected either stationary or in motion (e.g., air quality sensors added to a bike). It is designed to reduce technical barriers to visualize collected air quality data or other data, enabling users to explore geospatial data over time and space.

RETIGO: www.epa.gov/hesc/real-time-geospatial-data-viewer-retigo

Air Sensor Performance Evaluations

Emerging air quality sensors have a wide appeal to professional researchers, community groups, students, and citizen scientists alike because they are lower in cost, compact, portable, and provide real-time air quality data. Since this technology is still under development, little information exists on the quality of data that these sensors produce. To help those interested in using sensors as part of air monitoring projects, EPA researchers evaluate sensors for how well they measure air pollutants and how easy they are to use.

Air Sensor Evaluations: www.epa.gov/air-sensor-toolbox/evaluation-emerging-air-pollution-sensor-performance

How to Build and Operate a Village Green Air Monitoring Station

The Village Green Project has successfully demonstrated the capabilities of new real-time monitoring technology for residents and citizen scientists to learn about local air quality. The project involved the development of a solar-powered, park-bench style air monitoring station that includes miniaturized air sensors and other instruments that provide information on local air quality and meteorological conditions.

Through partnerships with cities and other organizations, EPA installed stations in eight cities across the United States for use by the public. The stations are lower in cost and require less maintenance, but they are not off-the-shelf products that can be purchased. The system requires technical skills to build and some experience in air quality monitoring.

Researchers developed a manual and training video on how to construct, operate and maintain a Village Green station.

Village Green Project: www.epa.gov/air-research/village-green-project

Simulating Oil Spill Burns to Improve Clean Up and Protect Air Quality

The practice of burning oil spills has been a fast and relatively safe way to reduce the impact on water quality and marine life. Of concern, however, is the formation of soot-laden smoke and oily residues resulting from incomplete combustion of oil. Burning oil can produce thick black plumes that disperse downwind as they rise into the atmosphere, potentially impacting air quality. Once the fires are out, oily residues in the water can cause environmental damage.

EPA experts are joining the U.S. Department of Interior's Bureau of Safety and Environmental Enforcement (BSEE) to investigate ways to improve oil burn procedures that can lead to more efficient burning and, thus, less emissions and residue. But improving burning practices in water is a challenging endeavor.

Several new exploratory methods are being tested by BSEE at the U.S. Army Corps of Engineers Cold Regions Research and Engineering Laboratory in New Hampshire. The lab has a 60-foot- long concrete basin for fresh and saltwater investigations. Researchers are testing new methods to reduce air emissions and oily residues using different types of materials during a burn, such as carbon fiber, and different systems for keeping water separate from the oil during burning.

EPA's air emissions and combustion researchers are participating in the study to offer their expertise in measuring air pollutants and residues from oil spills. They are providing sophisticated, real-time air emission sensors for soot monitoring and residue characterization. Two novel sensor packages developed by EPA will collect air quality measurements to determine how efficiently the fire burns when the new mitigation methods are used. If emissions decline, that indicates more complete combustion and less environmental impact.

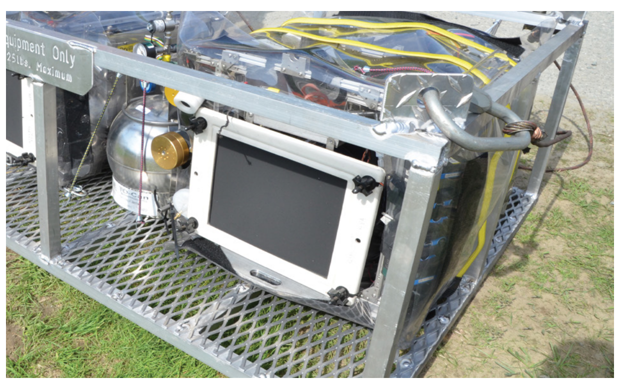
"There are a lot of unanswered questions about the environmental impact of burning as a clean-up procedure," says Brian Gullett, lead investigator of the research team conducting the air emissions study. "It is important to have data in hand so the next time there is an oil spill, the most appropriate measures can be taken to remediate the problem."

Once the oil in the water basin is ignited, the air sensor instruments are lowered into the plume using a crane.

> *"There are a lot of unanswered questions about the environmental impact of burning as a clean-up procedure. It is important to have data in hand so the next time there is an oil spill, the most appropriate measures can be taken to remediate the problem."*

Continuous real-time data is collected, along with samples collected on filters and specialized absorbents that can be taken to the lab for analysis. EPA researchers also collect residue samples for testing. The instrument system measures coarse and fine particulate matter, carbon monoxide, carbon dioxide, black carbon, volatile and semi-volatile organic compounds, and polycyclic aromatic hydrocarbons. The combined system is unique for its ability to comprehensively measure a wide range of combustion pollutants.

Study results can help to develop recommendations for best burning practices during oil spill responses. The emissions and residue data collected can be used to predict quantities of oil during future oil spills and used in atmospheric models to predict downwind worker exposure or shore population exposure levels.



Above, customized real-time air sensor instruments ready to be lifted into plume by a crane. Right, study underway at the U.S. Army Corps of Engineers Lab in N.H.

EPA Grants Help Communities Monitor Air Pollution

Reducing air pollution levels takes the effort of theentire community. At least that's the opinion of Catherine Karr, a professor at the University of Washington (UW), and principal investigator of an air pollution study in the lower Yakima Valley in Washington State.

This agricultural valley has historically experienced high levels of fine particulate matter ($PM_{2.5}$), a common air pollutant, especially in the winter during cold stagnant air periods. Important sources of $PM_{2.5}$ include residential wood-burning heaters or agricultural burning. Long-term exposure to $PM_{2.5}$ can cause respiratory and cardiovascular illness and lead to decreased lung function, irregular heartbeat, atherosclerosis (narrowing of the arteries,) and premature death.

Dr. Karr's air pollution study is funded by the Air Pollution Monitoring in Communities grant from EPA's Science to Achieve Results (STAR) Program. The grants awarded to six universities and research institutions across the country are providing researchers with the opportunity to investigate emerging air monitoring technology and to work with communities to address air quality problems. While low-cost and portable air sensor technology is becoming readily available to the public, there is limited knowledge on how communities and individuals are using the technology, the accuracy of the data they produce, how the sensors perform over time, and what is needed to help inform future sensor use.

To evaluate the use of low-cost air pollution sensors by communities, research scientists at the UW are partnering with Heritage University where students reflect the diversity of the community, including Yakama Nation, Native Americans of other tribes, and Latino immigrant families.

As part of the study, researchers teach the students how to use low-cost air pollution sensors to monitor air quality. The university students then work with local high school students to conduct citizen science projects to investigate PM2.5 exposure--and exposure to wood smoke in particular--in their communities. They learn about air quality issues and share what they learn with their families, tribal elders, and others in their community, helping to increase community awareness of air pollution issues and air sensor technologies.

"Students are a good bridge to the community at large," says Karr. "Not only do they help us by collecting data, but we can also provide an opportunity for them to explore some related fields, see science in action and get to know the scientists."

The researchers are working with many groups including the Air Quality Section of the Yakama Nation Environmental Management Program, education leaders and other community organizations to identify potential solutions for reducing fine particle pollution. This collaboration helps incorporate many perspectives into the project and ensures that the results will be meaningful to the decision-makers.

"It's so important to have these conversations where everybody feels their perspective is respected and understood," says Karr. "Building that relationship and trust with a community is critical to being able to improve local air quality."

Across the country, another grantee at Carnegie Mellon University (CMU) is working with residents in Pittsburgh, Pa., a city that has struggled with exposure to air pollution for many years. In 2017, an American Lung Association study ranked the area encompassing Pittsburgh and the surrounding areas as eighth highest in a list of 200 metropolitan areas in the country for long-term soot pollution.

R. Subramanian, a research scientist at CMU's mechanical engineering department and the principal investigator for this project, has provided communities in Pittsburgh with real-time affordable multi-pollutant (RAMP) air quality monitors to measure local pollutant levels. The monitors have been distributed throughout the city, with some hosted at the homes of local citizens. CMU researchers have a series of goals, one of which is examining whether communities are empowered to take action when they have information about air quality from sensors and air pollution maps that show risks of exposure. Researchers are also looking to evaluate the accuracy and reliability of these low-cost sensors.

RAMP monitors installed in Pittsburgh measure common air pollutants, including PM2.5, ozone, carbon monoxide, nitrogen dioxide, and sulfur dioxide, all of which can impact human health.

"We have air scientists, social scientists, community organizations, public-private partnerships, and of course, the people of Pittsburgh who have hosted the RAMPs and have been very engaged about air pollution issues," says Subramanian. "I think that level of collaboration is more of what's needed to bring about meaningful lasting change."

To learn more about the STAR Air Pollution Monitoring for Communities grants and access publications, visit:

www.epa.gov/air-research/air-pollution-monitoring-communities-grants

Workshop Focuses on Air Sensor Performance

The EPA convened a workshop on June 25-26, 2018, in Research Triangle Park, N.C., titled: Air Sensors 2018: Deliberating Performance Targets to gather information on the state of air quality sensor technologies; learn how they are used to meet a wide range of monitoring needs; and obtain stakeholders' perspectives on non-regulatory performance targets for fine particulate matter ($PM_{2.5}$) and (O_3) ozone sensor devices.

The workshop was conducted in collaboration with the Environmental Council of the States (ECOS), and with the assistance of numerous national and international air quality experts.

A summary of the main outcomes and findings of the workshop is expected to be published in fall 2018 and made available on the EPA's Air Sensor Toolbox website, along with the workshop presentations.

EPA continues its extensive collaboration with stakeholders to develop non-regulatory air quality sensor performance targets and to evaluate the feasibility of an independent, voluntary, third-party certification program. The workshop is a major step toward developing consistent performance targets that promote data quality.

Learn more at: www.epa.gov/air-sensor-toolbox

July 2018

United States Environmental Protection Agency
Office of Research and Development (8101R)
Washington, DC 20460