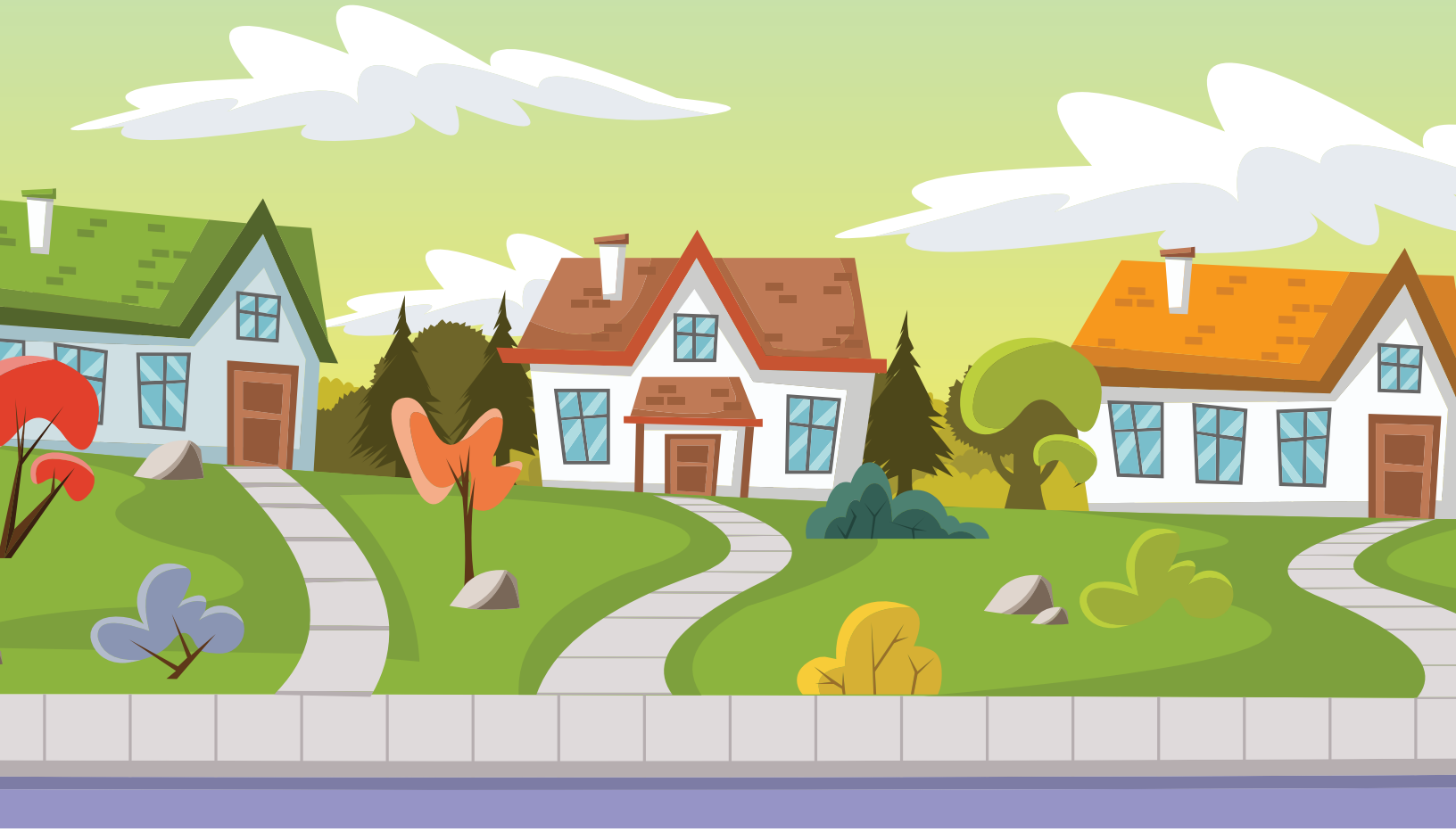
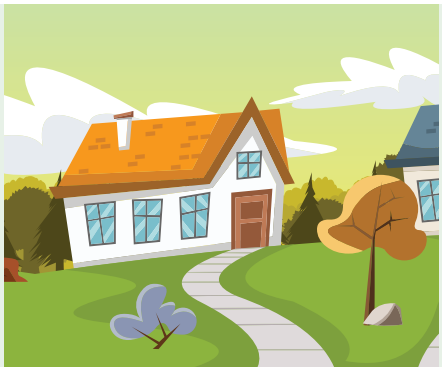
Preparing for Personal Air Sensors:
State and Local Air Quality Agencies on the Frontlines of Citizen Science



With their on-the-ground experience, proximity to the public, expert personnel, and ability to interpret current air quality information, state and local air agencies are uniquely situated to help address technological and communication issues surrounding the increased use of low-cost personal air sensors. The Association of Air Pollution Control Agencies (AAPCA) has worked closely with its member agencies, as well as the U.S. Environmental Protection Agency (EPA), over the last two years to better understand these sensors and develop tools to help facilitate proactive community engagement.

On the front lines. A number of recent developments underscore the public's interest in personal air sensors and the need for state and local air agencies to engage in these issues. These include:

- EPA, through its Offices of Air Quality Planning and Standards and Research and Development, has provided public information in the form of the Air Sensor Toolbox for Citizen Scientists, Researchers and Developers (https://www.epa.gov/air-sensor-toolbox) and Air Sensor Guidebook (https://cfpub.epa.gov/si/si_public_file_download.cfm?p_download_id=519616), as well as through challenges and prizes like the Wildland Fire Sensors Challenge (https://www.challenge.gov/challenge/wildland-fire-sensors-challenge/) and Smart City Air Challenge (https://www.challenge.gov/challenge/smart-city-air-challenge/).



Despite tremendous progress made in air pollution control in recent decades, AAPCA's April 2017 report noted disconnects between air quality data and public perception.

- Other EPA bodies, including the National Advisory Council for Environmental Policy and Technology ("Environmental Protection Belongs to the Public: A Vision for Citizen Science at EPA"; https://www.epa.gov/sites/production/files/2016-12/documents/nacept_cs_report_final_508_0.pdf)) and E-Enterprise for the Environment ("Advanced Monitoring Strategy and Implementation"; https://e-enterprisefortheenvironment.net/our-projects/advanced-monitoring-projects/advanced-monitoring/)), have provided advice on integrating personal air sensors into the work of EPA and co-regulators.
- The U.S. Congress has expressed its interest in sensor technology as well, with citizen science provisions of the American Innovation and Competitiveness Act signed into law earlier this year and the introduction of H.R.1355, the Crowd Sourcing of Environmental Data Act of 2017 (https://www.congress.gov/bill/115th-congress/house-bill/1355?q=%7B%22search%22%3A%5B%22air+monitor%22%5D%7D&r=4).
- State and local air agencies now regularly field calls from the public concerning readings from a wide array of personal air sensors.

AAPCA members have undertaken several initiatives to compare notes and develop strategies as they look to improve understanding and communication in the new world of personal air sensors. In 2016, AAPCA established a Personal Air Sensor Workgroup, which includes active participation from association committees focused on public outreach and information, ambient monitoring, and local government. In September 2016, the association held an extended topical session on personal air sensors during its Fall Business Meeting in Raleigh, NC. The session, *Preparing for Personal Air Sensors: Communication, Context, and Perspectives*, incorporated a broad spectrum of views from state and local air pollution control agencies, EPA, academics, and developers. Presentations covered public outreach programs, collocation studies, sensor development, and potential future avenues for using this technology (*Note*: Presentations are available online; http://www.csg.org/aapca_site/events/2016FallBusinessMeetingPresentations.aspx.)

Following the session and several in-depth workgroup discussions, AAPCA published a fact sheet, "Preparing for Personal Air Sensors: Definition, Opportunities, and Data Limitations." (http://www.csg.org/aapca_site/documents/AAPCAPersonalAirSensorFactSheet6-21-2017.pdf) Routinely updated, the fact sheet is a resource guide to defining personal air sensors, exploring opportunities for use, and recognizing data limitations.

Defining Personal Air Sensors

During the topical session and early workgroup discussions, the difficulty in defining personal air sensors was identified as a key communications issue. While the term "low-cost sensor" applies broadly to technology used for highly localized measurements, participants stressed the need to better contextualize personal air sensors in terms of the ambient air monitoring performed by air agencies.

The following consensus description was incorporated in the AAPCA fact sheet: "Low-cost and portable air sensors may have varying definitions. Personal air sensors may not meet the stringent standards established for monitors operated by state, local, or federal agencies and monitoring data used to inform compliance with National Ambient Air Quality Standards (NAAQS). An emerging technology, personal air sensors are sensing devices for air pollution that are designed to provide

short-term information regarding an individual's immediate environment. Quality assurance and quality control measures may not exist for personal air sensors or their data, and the result may be questionable data quality and a high variability between instruments."

Opportunities

Much of AAPCA agencies' work related to personal air sensors focuses on the opportunities presented by this type of citizen science. Low-cost, portable personal air sensors can have useful classroom and citizen science applications. Used properly, these tools can allow students and citizens to explore their local environment as well as learn about air quality and the Clean Air Act in the broader context of state, local, and national air pollution control efforts. For example, these sensors could be used in student-led research, efforts to engage communities in air quality awareness, or to help inform siting of regulatory monitors. As technology continues to improve, low-cost air sensors may be able to augment regulatory networks or detect pollution hotspots.

Personal air sensors could help educate the public on air quality trends. In August 2017, EPA released its air trends report, "Our Nations' Air: Status and Trends Through 2016," (https://gispub.epa.gov/air/trendsreport/2016/) highlighting trends also included in AAPCA's April 2017 report, "The Greatest Story Seldom Told: Profiles and Success Stories in Air Pollution Control" (http://www.csg.org/aapca_site/documents/GreatestStory4-17-17.pdf). Both reports demonstrate the tremendous progress made in the United States in virtually every measure of air pollution control over the last several decades, and rely on high-quality monitoring data from local, state, and federal environmental agencies.

Despite this progress, public opinion polls suggest that these improvements have gone under the radar for most Americans. The introduction to AAPCA's April 2017 report explored five key disconnects between air quality data and public perception, which present opportunities for expert air agencies. For example, between 2000 and present, between one-third and one-half of Americans polled annually by Gallup said they worry a great deal about pollution.[1] Over that same period, aggregate emissions from six common pollutants fell by more than 60 percent, air releases of toxic chemicals dropped more than half, and the carbon intensity of the economy went down by more than 25 percent. Greater public engagement could facilitate citizen understanding of air quality, and help focus energy and resources on the most pressing environmental issues.

Inquiries about personal air sensors, and increased public awareness as a result of these technologies, offer an opening for air agencies to provide important information to their constituents about monitoring technology, the Air Quality Index, and the basis for standards under the Clean Air Act. These agencies need to be able to move beyond technical descriptions of "parts per billion" or "micrograms per cubic meter," and create the capability to highlight case studies,

community involvement, and localized benefits. A 2004 study by Brody et al. examining local patterns of air quality perception in Texas, found that public views are not driven by actual air quality conditions but that "other factors such as a sense of place, neighborhood setting, source of pollution, and socioeconomic characteristics appear to shape perceptions."[2] The researchers suggest that "[p]olicymakers thus cannot rely on scientific data alone to drive a public decision-making process, but also must consider location-based factors, the specific make-up of the population, and the venues through which this population receives information on environmental conditions."

Limitations

The ability of air agencies to provide context to the public is particularly important in light of differing quality of air sensors currently available in the United States. Section 103 of the Clean Air Act directs EPA to "conduct a program of research, testing, and development of methods for sampling, measurement, monitoring, analysis, and modeling of air pollutants." In accordance with 40 CFR 53, EPA establishes "reference methods" or "equivalent methods" for criteria pollutants, stating that "each method is acceptable for use in state or local air quality surveillance systems." As of June 2017, two personal air sensors (the Personal Ozone Monitor and the Model 405 nm NO_2/NO/NO_x Monitor) have been designated as a Federal Equivalent Method (FEM), though a user would need to ensure that the instrument is used according to FEM protocol.[3]

On the other hand, laboratory and field testing suggests there are many low-cost sensors with quality that cannot compare to monitors used for regulatory purposes by air agencies. The South Coast Air Quality Management District's Air Quality Sensor Performance Evaluation Center (http://www.aqmd.gov/aq-spec/evaluations/summary), which "aims at being the testing center for low-cost air monitoring sensors to establish performance standards by which sensors are evaluated," has identified sensors measuring particulate matter, carbon monoxide, ozone, and nitrogen oxides that display a complete lack of correlation compared to regulatory monitors in field tests. Similarly, a North Carolina Department of Environmental Quality collocation study (http://www.csg.org/aapca_site/events/documents/Cherry-MonitoringSO2UsingSensorTechnology-9-21-2016.pdf) found a low-cost sulfur dioxide sensor showing levels of more than 150 parts per billion (ppb) at the same location where a regulatory monitor was reading less than 5 ppb.

In order to capture the differing quality of sensors, AAPCA's fact sheet lays out a number of potential limitations to data derived from personal air sensors. These include:

- Personal air sensors may not have established quality control and quality assurance measures and may not conform to quality assurance documents established by EPA or other regulatory bodies.
- Personal air sensors may have questionable data quality, and provide data that might not correlate with Federal Reference Method (FRM) or Federal Equivalent Method (FEM) monitors used for regulatory purposes.
- Personal air sensors may display air quality information differently than those data used by air agencies, including averaging time, units of measure, level, exposure, and method.
- While short-term measurements from personal air sensors might be for a second or minute, it is difficult to relate this data to the science of health effects of air pollution, where effects are evaluated based on an average of an hour or day of exposure.

In Memoriam: Steve M. Hays

A&WMA member **Steve M. Hays, P.E., CIH, FACEC, FAIHA**, founding partner and chairman emeritus of Gobbell Hays Partners (GHP) Environmental + Architecture firm, died in Nashville, TN, on September 28, 2017, after an extended illness.

An A&WMA member since 1991, Hays was a national leader in identifying and safely mitigating hazards related to asbestos, mold, and lead-based paints in buildings for more than 30 years, and was the co-author of two books: *Indoor Air Quality: Solutions and Strategies* and *Settled Asbestos Dust Sampling and Analysis*.

Appointed to the Board of the National Institute of Building Sciences by President Bill Clinton, he was a Fellow of the American Industrial Hygienists Association and the American Council of Engineering Companies. Among his many honors were the Mortimer M. Marshall Lifetime Achievement Award from the National Institute of Building Sciences (2013) and the Donald E. Cummings Memorial Award from the American Institute of Industrial Hygiene (2017).

Hays taught at Georgia Tech Research Institute and The Environmental Institute in Georgia and was a frequent guest lecturer at the University of California, Berkeley and Texas A & M University.

- Personal air sensors may not be operated in ambient conditions or by siting requirements in accordance with Title 40, Part 58 of the Code of Federal Regulations (CFR), Appendix E.
- Personal air sensors may have diminished accuracy from humidity, temperature, transitioning from indoors to outdoors (or vice versa), as well as cross sensitivities to other gases.
- Personal air sensors may not have the geographical information and documentation that are necessary to ensure consistent and comparable data.
- Personal air sensors need regular calibration and may be subject to drift and decreased sensitivity over time.
- Personal air sensors may have a high variability between instruments.

Air Agencies on the Frontlines

In a world of social media, the advancement of big data, and highly localized measurement technologies, it is more important than ever for state and local air agencies to develop proactive, credible avenues to communicate with the public about air quality. AAPCA and its members stand ready to help provide critical context, encourage educational opportunities, and recognize data limitations in a world of proliferating sensing technology. **em**

Jason Sloan is Policy and Membership Associate at Association of Air Pollution Control Agencies (AAPCA). **Sean Alteri** is Director at Kentucky Division for Air Quality and 2017 AAPCA President. **Stuart Spencer**, is Associate Director at Arkansas Department of Environmental Quality and 2018 AAPCA President.

The Association of Air Pollution Control Agencies

The Association of Air Pollution Control Agencies (**AAPCA**) is a national, non-profit, consensus-driven organization focused on assisting state and local air quality agencies and personnel with implementation and technical issues associated with the U.S. Clean Air Act. AAPCA represents more than 40 state and local air agencies, and senior officials from 20 state environmental agencies currently sit on the AAPCA Board of Directors. AAPCA is housed in Lexington, Kentucky as an affiliate of The Council of State Governments.

References

1. Gallup Inc. "Environment," March 2017; available at http://www.gallup.com/poll/1615/environment.aspx.
2. Brody, S.D.; Peck, B.M.; Highfield, W.E. Examining Localized Patterns of Air Quality Perception in Texas: A Spatial and Statistical Analysis; *Risk Analysis* **2004**, *24* (6), 1561-1574; available at http://research.arch.tamu.edu/media/cms_page_media/3391/RiskAnalysis_airq.pdf.
3. List of Designated Reference and Equivalent Methods; U.S. Environmental Protection Agency, June 16, 2017; available at https://www3.epa.gov/ttn/amtic/files/ambient/criteria/AMTIC_List_June _2017_update_6-19-2017.pdf