What You're Breathing, Right Now

You encounter many types of air over the day. This technology tells you everything about it

Yale

SUSTAINABILITY

Perhaps you're aware of the air quality right outside your home. But that's one data point. What's the air inside your home when you wake up? Or on the mornings when you burn your toast? Perhaps you took a side street on the way to work, instead of the usual main road — how does that change things?

These are the microenvironments you encounter throughout the day. Getting a clear account of the quality of all these microenvironments — from one room to the next — would give us a much more thorough look at the air we're each breathing from day to day, even hour to hour.

Drew Gentner, associate professor of chemical & environmental engineering and forestry & environmental studies, is currently at work on that now with a study that looks at the interiors of homes, workplaces, and vehicles, and out on the streets of Baltimore, Md. In collaboration with researchers at Johns Hopkins University, his lab has set up a stationary air quality monitoring network that will measure more than 50 sites throughout the city, and enlisted 100 people for the study to wear portable air monitors, each for several days.

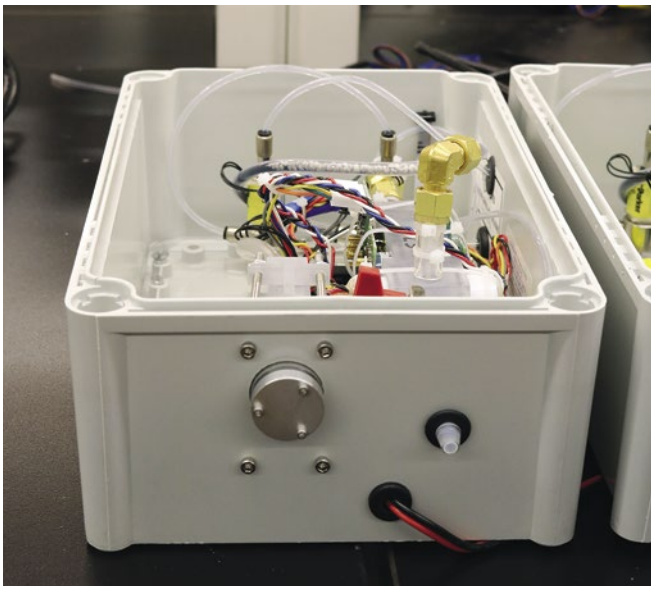
Continued →

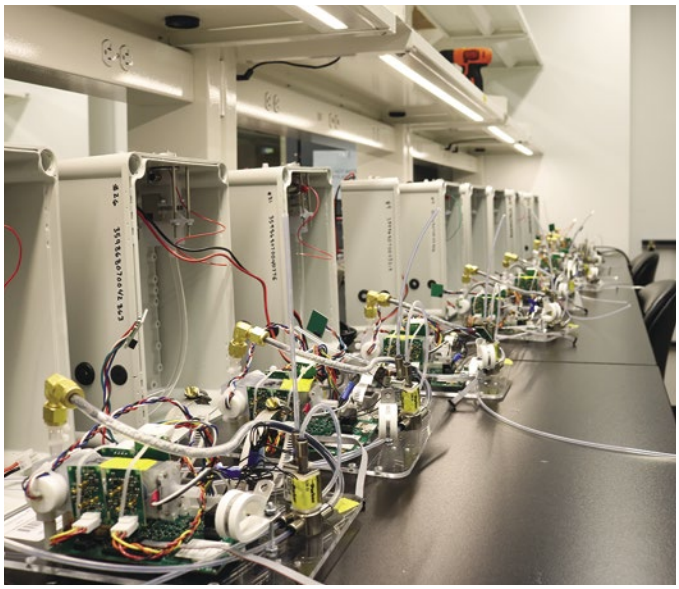
"On any given day, a person is going to different locations — in your home, your car, your office, and different shops," Gentner said. "Outside of the scientific goals of understanding the spatial temporal heterogeneity of exposure to air pollutants, we want to provide people the tools they need to make informed decisions and better personal choices. That's one of the things we're interested in: How do people's personal choices affect air pollution?"

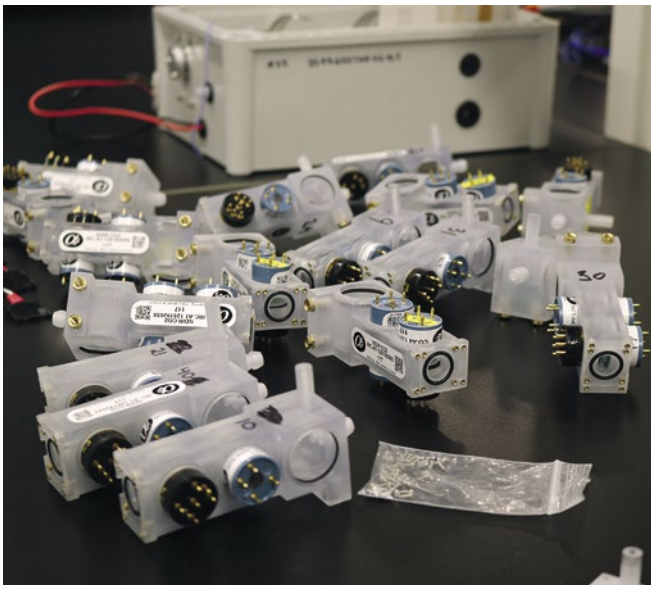
Below: *By deploying both wearable and stationary air sensors, Gentner hopes to learn how the data collected differs from one another. The sensors can detect matter as small as 2.5 micrometers in diameter — the size determined to pose serious health effects.*

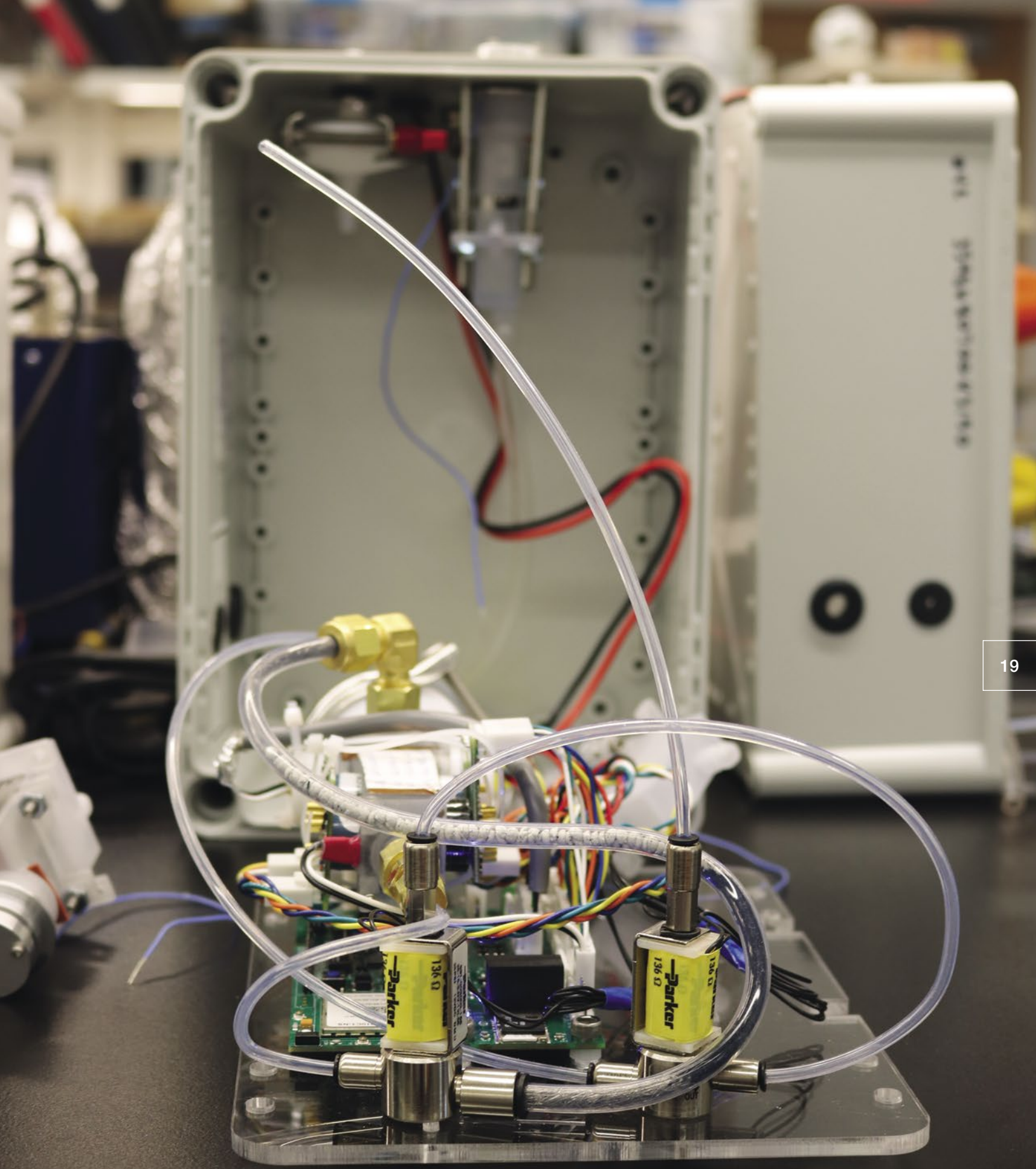
Larger cities often have a few stationary sensors to collect air quality data. Gentner's project, though, will provide something much more thorough than the single-point measurements that make up many air reports. It's an idea that technology has caught up with, as the cost of making sensors has decreased even as they become more accurate. The project is part of the Solutions for Energy, Air, Climate, and Health (SEARCH) Center, created by the U.S. Environmental Protection Agency (EPA) with a five-year, $10 million grant. Only one of three centers funded by the EPA, it's designed to study the relationships between air quality, energy policy, climate change, and public health. Michelle

Continued →









The inner workings of a stationary air quality monitor. The researchers have installed 50 monitors across Baltimore.

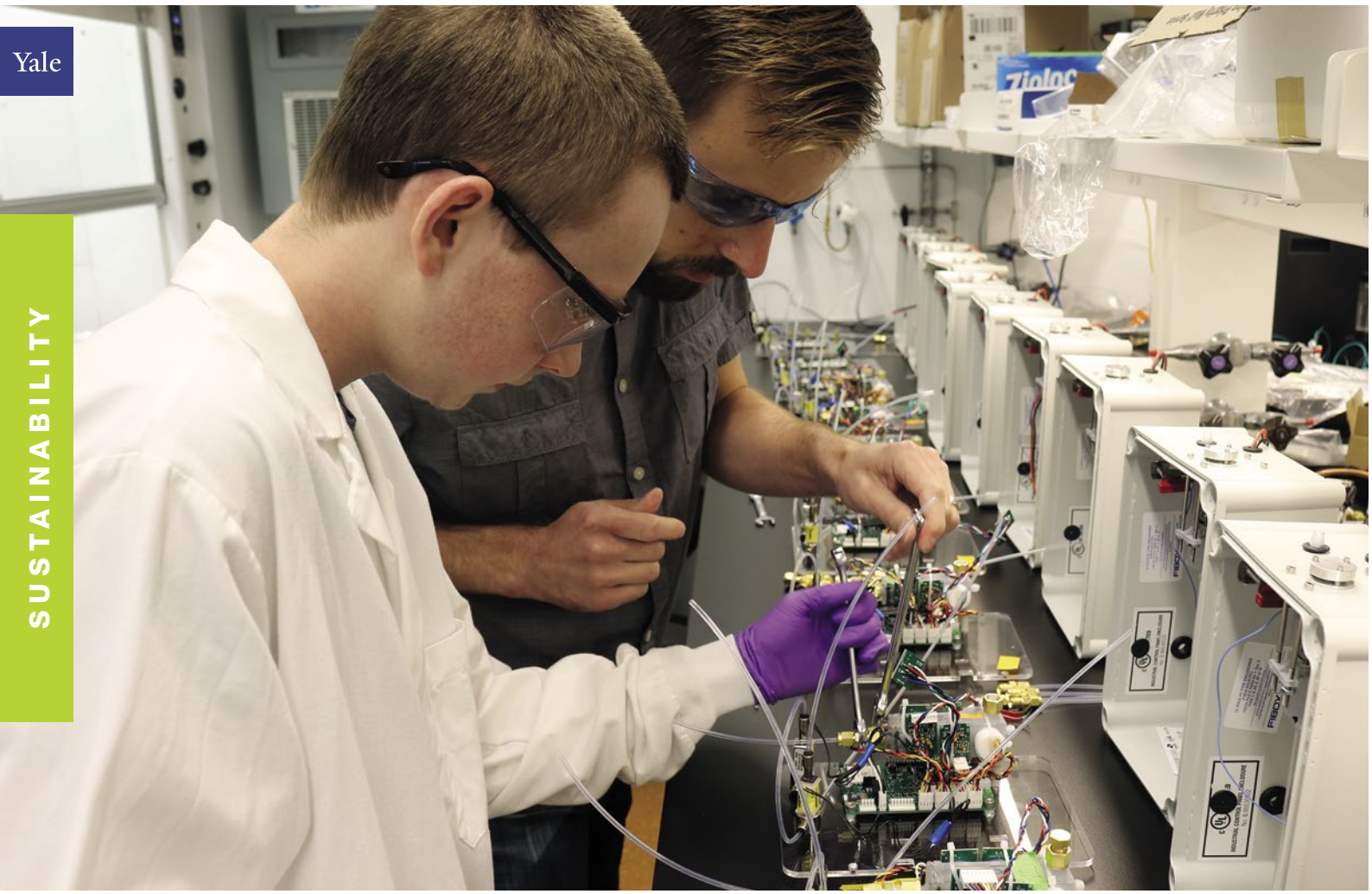
Bell, the Mary E. Pinchot Professor of Environmental Health at the Yale School of Forestry & Environmental Studies and Chemical & Environmental Engineering, serves as the director of the multidisciplinary research center. Yale, Johns Hopkins University and other institutions serve as partners.

One thing the researchers are particularly interested to see is how the data collected by the wearable air sensors differs from the stationary ones placed throughout the city. Two people could live in the same apartment building and work in the same office building, but the air they breathe could be very different depending in part on how they get to work, whether it's by car, bicycle or walking. Baltimore has a program that allows residents to share city-owned scooters; Gentner's lab hopes that some of study's volunteers will take part in it — that's one more data point.

"I think the person-to-person variations are going to be pretty fascinating," Gentner said, adding that this is especially true for indoor environments. "We've done all sorts of tests and regulations on outdoor air pollution for years, and that's brought down particle concentration outdoors. One thing that's outside these regulations has been indoor air quality. No matter how well we do things outside, concentrations indoors could be higher by orders of magnitude."

On average, people spend about 80% of their time indoors, and everything from the aerosol from cooked food to the emissions from a stove plays a role in the air quality.

Below: *Gentner and a student researcher put the finishing touches on a stationary air sensor.*



Above: *Only the finest air quality for Handsome Dan, as he models the newest air sensor prototype.*

Things as simple as being aware of how long your stove is on, or opening the windows more can make a big difference. Getting the right ventilation your home, he said, is among the most significant changes people can make to improve indoor air quality.

Gentner began working on the sensors a few years ago, when his lab and a group of undergraduate students developed the first prototypes. Developing a new technology is rarely a quick or easy process. The study requires that the monitors they developed are sensitive enough to detect such gases as carbon monoxide and nitrogen dioxide, as well as dust, soot, and any other microscopic elements that make up the atmosphere's particulate matter. Specifically, they want them to be able to detect matter as small as 2.5 micrometers in diameter — about 30 times smaller than the diameter of the average human hair, and the size that's been determined to pose particularly serious health effects.

On top of that, they also had to make the portable sensors comfortable enough for users to wear. Colby Buehler, a graduate student in Gentner's lab, has been working on the EPA project since he came to Yale a little over a year ago. He notes that it has involved building several prototypes before reaching the current solutions. One company, for instance, stopped manufacturing a sensor, so the lab had to adjust to changes in the available components.

"There's a lot of troubleshooting and testing because the sensor industry is developing so rapidly and quality control needs to be high," Buehler said, pointing to several sensors on a counter in Gentner's lab, several with notes taped to them identifying monitors at various stages in the quality control process.

The portable sensors are a little larger than a mobile phone and are attached to a battery that can be stored in a regular bag, purse, or backpack. The shoulder mounted system is fairly light, but the subjects each wear them for all their waking hours four days in a row (while sleeping, the sensors stay in the room with them), so they need to be as easy to wear as possible.

"It's gone through a couple design changes," Buehler said. "We looked at other wearable technologies as models, and we knew we wanted something that wouldn't need its own backpack" — which has been a complaint about past personal exposure monitoring studies that the Yale team sought to overcome.

They knew that it should be mounted to the shoulder to get the sensors close to the user's breathing zone and accurate data of their personal

Continued →

exposure, but designing something to comfortably fit took some careful engineering design. Eventually, they settled on a form-fitting design with a customizable attachment system, which did the trick. There were also some valuable feedback from early testers, so Buehler and the team readjusted the design to make a more user-friendly product.

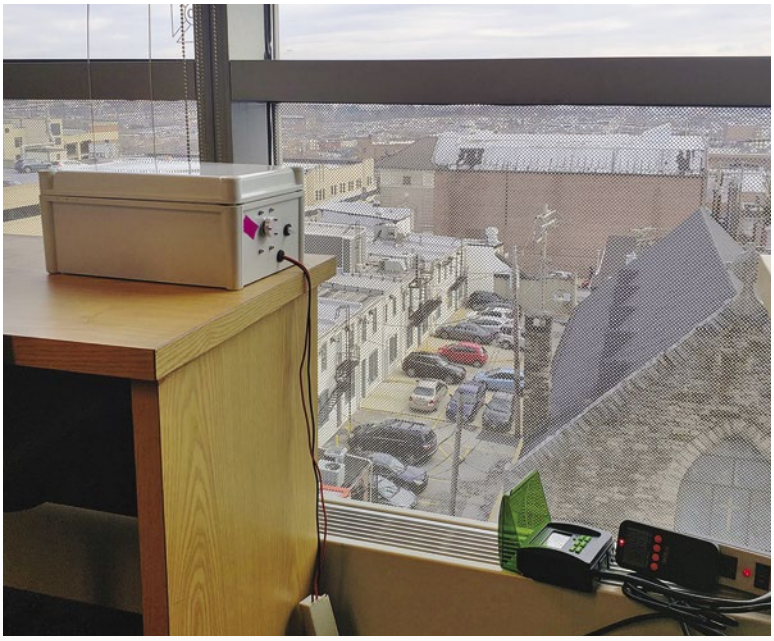
Misti Zamora, a postdoctoral fellow at Johns Hopkins, has been busy finding places for the stationary sensors and volunteers for the portable ones.

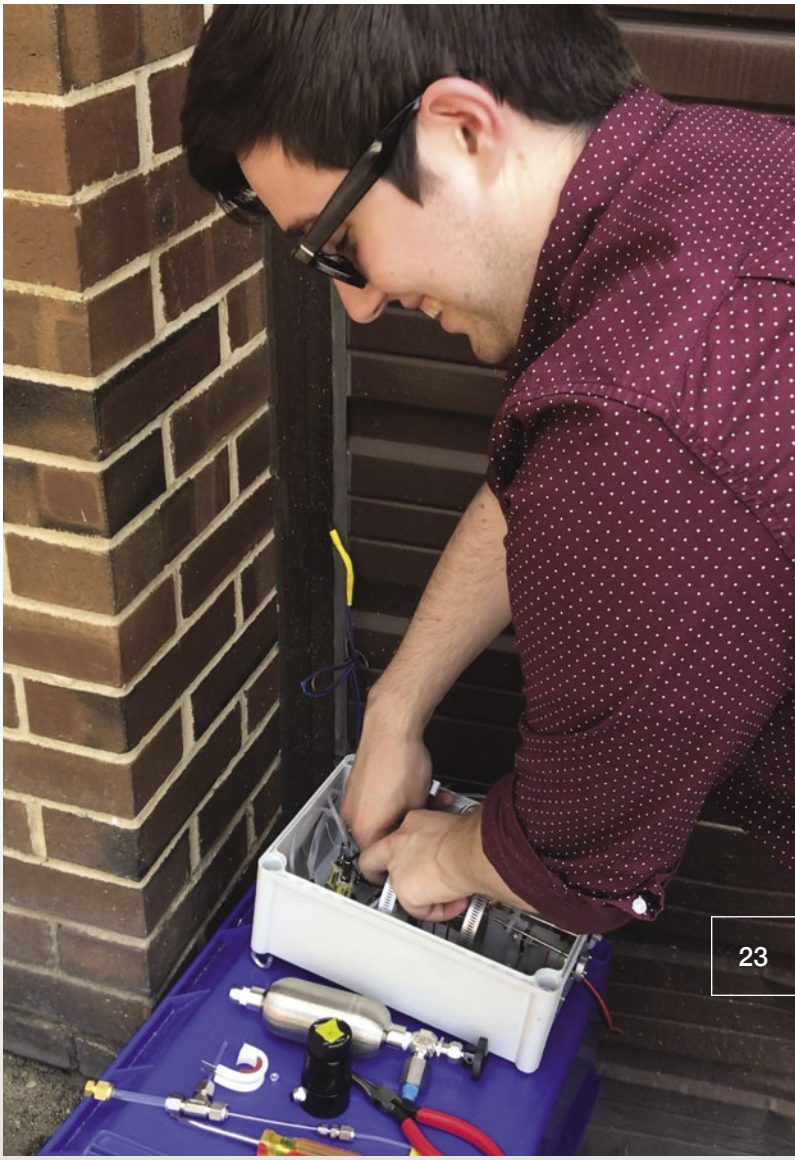
"We spent a lot of time finding good sites — some at libraries, some at people's homes and some at parks and things like that," said Zamora, who works in the lab of Kirstin Koehler, an associate professor in the Johns Hopkins Bloomberg School of Public Health. "We've been working a lot with the communities because they're letting us host them in their areas — they obviously have an interest about air quality in their neighborhoods."

Zamora noted that Baltimore is a good city for this kind of study. It has a diverse population and geography, and like a lot of cities, has its share of air quality issues. She often wonders herself about the quality of her own microenvironments throughout the day.

"From where I work, it's three-quarters of a mile away, and I think about what that means as to my actual exposure, especially since I go outside a lot," she said. "But let's say you don't go outside much — you stay inside and play computer games all day. How much outdoor air are you actually breathing? This study will give us a lot of insight into personal exposures vs. regional exposures — both of which are important for different reasons. And we can look at these and compare them side-by-side."

It's an issue that a lot of people wonder about, apparently. Not only have communities been helpful in hosting the stationary sensors in their neighborhood, the researchers even had to turn away people volunteering to wear the personal sensors due to an excess of sign-ups.





Left & Middle: *The stationary sensors are placed both indoors and outdoors to understand the quality of the diverse microenvironments people experience throughout the day.*

Right: *Colby Beuhler, a graduate student in Gentner's lab, prepares to install a stationary monitor.*

"I've been kind of surprised at how excited people are about this, I thought it was going to be hard to find people to host these things for us, but now we have more than we need," she said. "I sometimes think that we just do our science and people aren't as excited about it as we are, but really, they are."

Users of the technology are limited to those enlisted in the study, but it could become more widely available. Gentner's work on this air pollution monitoring technology includes a partnership with HKF Technology, a Delaware-based company developing technology for improving air quality. Ken Hu, CEO of the company, is working with Yale and Gentner on commercializing the technology – potentially allowing consumers to determine the air quality of their own microenvironments.

This, Gentner said, could empower people to take it on themselves to improve the air that they breathe each day.

"We can't regulate every microenvironment, and agencies can't regulate people's exposure to air pollution in their homes beyond certain guidelines," he said. "But people can take measures to reduce that exposure by making better choices."

This article was developed under Assistance Agreement No.RD835871 awarded by the U.S. Environmental Protection Agency to Yale University. It has not been formally reviewed by EPA. The views expressed in this document are solely those of the author and do not necessarily reflect those of the Agency. EPA does not endorse any products or commercial services mentioned in this publication.