Speck Sensor
A Direct-to-Consumer Indoor Particulate Matter Monitor

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Air quality is a growing concern in the 21st century.
Fine Particles ($\text{PM}_{2.5}$)

- Human Hair: 50-70 micrometers
- Coarse Dust: ≤ 10 micrometers
- Fine Particles ($\text{PM}_{2.5}$): ≤ 2.5 micrometers
Health Impact

Coarse Dust
PM$_{2.5}$
Indoor Fine Particles Sources

Indoor Sources

Activity Sources

Outdoor Sources

Source: Google Images
Source: Google Images
Source: Shenango Channel
The Speck monitors fine particle concentration levels in your home, and empowers you to understand and take control of your air quality.
Improving Your Air Quality

- Establish a baseline
- Identify hot spots
- Investigate sources
- Experiment

Become an ‘air quality detective’ and collectively troubleshoot with friends/community

Open/Close Windows

Get an Air Purifier
My Speck Data

Tuesday 23 June 2015

Wednesday 24 June 2015

Particles Per Liter (particles/L)
My Speck Data

My air quality was worst during cooking/meal times!
Search for Better Air Quality

Solution:
Turn off microwave vent + Install window exhaust fan + Open basement door 😊
Can Speck use empower citizens to take action for better air quality?
Our Approach

1. Placed Specks in CLP locations across Pittsburgh
2. Invited library patrons to fill out surveys before and after Speck use in their homes
Study Participants

Reporting on 25 people who completed both the pre and post surveys:

• Average age was 45 (SD=14.2)
• 74.0% have a college degree or higher
• 60.0% have an annual income of $51k or higher
• 38.5% have children under the age of 18 living at home
• Majority have NO adults over the age of 65 living at home
• 12% report having a respiratory illness
Increased knowledge of indoor air quality
Better identification of health risks
Higher perceived personal risk
Greater confidence in ability to take action if indoor air quality is poor
Why did I check out the Speck?

Well, we have a kid who is new, so we wanted to check the levels in the house. We have a nephew who suffers terribly from, you know, he's about 3, and it's either an asthma or an allergy, and he has just gotten on breathing treatments, and it's just...it's terrifying to watch him go through it, so you know, we were always kind of wondering.

- Participant 4
What discoveries did I make?

It actually was really surprising because we know we get that good aroma of bacon and we thought that was a sense like the only thing, like the smell of cooking, was the only thing being released. – Participant 2

We found. I don’t know if you want to know about this or not, but through the speck we found when we run [the] vacuum there is a jump. So imagine that; in the sucking up of all of that stuff it all leads to sending, dispersing it all throughout...whatever it happens to be on the carpet things that have settled. – Participant 4
What did I do?

So that was kind of the first time that we had that AHA moment...Um, so we are better about running, like, the ventilations system, the fan. We have one above the stove and one that exits out. We are better about doing that…Brushing the dogs so that they're not producing a lot of dander. – Participant 2

We try to change out our filters in our furnace and our air conditioner, you know try to do that on a yearly basis. Yeah, so that's kind of, that's probably like the only thing that we actually go out of our way to do in terms of air, keeping the air clean. - Participant 4
Spreading the word

From what we’ve learned from our house I’ve tried to tell my sister about my nephew. These like, running the vacuum and cooking and, you know, things like that. Even to offer, they light a fire pit outside, to even say, maybe you should get one of those like propane jobs. You know, it's not as fun, but I feel like that would be cleaner than burning wood, you know, and like I said, some of the wood I think they are burning isn't of the best quality anyway, but I've tried to...Some of the things we have learned just by seeing them, would like to try to pass on. – Participant 4
Summary and next steps

• Initial findings suggest indoor air quality monitor CAN help people learn about risk, and help them take steps to reduce risk
• Put Specks in libraries across the country
• Continue evaluation
Thank You!
The Speck monitors fine particle concentration levels in your home, and empowers you to understand and take control of your air quality.
<table>
<thead>
<tr>
<th>Particle Counts (ppL)</th>
<th>Estimated Mass (μg/m³)</th>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>8001 - 16000</td>
<td>321 - 640</td>
<td>Very High</td>
<td>This level of particles is unsafe and warrants more serious long-term health effects if sustained.</td>
</tr>
<tr>
<td>4001 - 8000</td>
<td>161 - 320</td>
<td>High</td>
<td>Air pollution levels are dangerous and everyone may experience coughing, itchy eyes or other symptoms. This level of particles may significantly trigger asthma and allergy symptoms. Work to decrease values as soon as possible or consider wearing a mask.</td>
</tr>
<tr>
<td>2001 - 4000</td>
<td>81 - 160</td>
<td>Elevated</td>
<td>Air pollution is unacceptably high and problematic for all persons due to significant particulate loading in the air. Brief exposures to this level often occur from cleaning, such as vacuuming a carpet. If this level is sustained during the nighttime, consider investing in an air filter for the bedroom.</td>
</tr>
<tr>
<td>1001 - 2000</td>
<td>41 - 80</td>
<td>Slightly Elevated</td>
<td>Air quality is problematic for vulnerable populations (elderly, respiro-compromised individuals or children). This level of pollution warrants taking steps to try to reduce: turn on your kitchen hood vent; consider opening or closing a window as appropriate, etc.</td>
</tr>
<tr>
<td>501 - 1000</td>
<td>21 - 40</td>
<td>Moderate</td>
<td>Air quality poses a slightly elevated risk of asthma, allergy and arrhythmia symptoms. Frequently seen moderate level of particulates are often caused by human behavior (cooking, candle burning, etc.).</td>
</tr>
<tr>
<td>0 - 500</td>
<td>0 - 20</td>
<td>Good</td>
<td>Air quality is considered good and there is little risk of particulates causing harm to your health.</td>
</tr>
</tbody>
</table>
Steps Toward Improving Your Air

Indoor pollutant levels can rise up to 100 times higher than outdoor levels. Between work, school, and home, we spend up to 90% of our lives indoors. Indoor air quality is affected by pollutants generated both inside and outside of our homes. Common sources can include burning kerosene, wood or oil, smoking tobacco products, releases from household cleaners, pesticides, building materials, and radon. According to World Health Organization, 4.3 million people a year die from the exposure to household air pollution. The good news is that you can use Speck to monitor trends at home, school, or work and start taking action towards clean air.

If you are seeing high Speck readings, here are some steps you can take to ensure you are working to fight indoor fine particles and pollution:

- Wash pillows, furniture (did you know you should vacuum furniture?), or plush toys frequently in hot water with gentle detergent.
- Limit window opening during periods of high pollen counts in outdoor air or when the weather is extremely hot.
- Wipe surfaces with a damp cloth to remove dust, and wear a filter mask to ensure you are not inhaling dust.
- Vacuum often, and do so with HEPA bags and filters with fine particle filtration. Be sure to do this when those with asthma are out.
- To reduce the use of volatile organic products, use simple cleaning products such as soap, vinegar, or baking soda, and reduce the use of pesticides or paint that contains VOCs.
- Eliminate smoke and combustion acts or appliances (i.e. candles, the act of pan frying).
- Filter outdoor air using a high performance filter in a circulation air system. To reduce indoor fine particles, use HEPA stand-alone fans or duct filters.
- Tighten the house/building envelope to reduce the amount of outdoor pollution that makes its way indoors.
Fine Particles

Fine particles (PM$_{2.5}$) are invisible pollutants that can be harmful to your health. There may be several sources of PM$_{2.5}$ inside your home. Monitoring these particles can help identify ways to improve your indoor air quality and breathe easier.

What are fine particles?
Fine Particulate Matter or PM$_{2.5}$ refers to particles of matter suspended in the air that are 2.5 micrometers in diameter or smaller. That’s 30 times smaller than the diameter of a single human hair!

What are the health effects of fine particles?
Fine particles have been identified by the Environmental Protection Agency and the American Lung Association as an air pollutant that can be very harmful to your health. Inhaling PM$_{2.5}$ can cause coughing or wheezing. Exposure over extended periods of time can contribute to or worsen illnesses such as asthma, heart disease, chronic bronchitis, emphysema and pneumonia.

How can fine particles affect me?
Coarse particles that are between 2.5 and 10 micrometers in size are generally trapped by hairs and mucus in the nose and throat, but never make it as far as your lungs. Fine particles, on the other hand, are dangerous because they are small enough to penetrate deep into the lungs, blocking the air sacs where oxygen enters the bloodstream. While particulates are generally not toxic, airborne toxic chemicals can attach to PM$_{2.5}$ and enter your bloodstream. Fine particulate pollution can also have environmental impacts including soil and water contamination.
Indoor sources of fine particles

Below are a few examples of indoor air pollutants that generate fine particulate matter.

- **Gas and Oil Heating**
  These can sometimes release particulates. Pay attention to where furnace vents are or if you have an oil heater. For example, in one case where the oil heater vented below the window of a child’s bedroom, pollution levels were elevated compared to the rest of the house.

- **Forced-Air Heating & Air Conditioning**
  These systems can be major sources of air pollution if the ductwork is dirty, or if there are no filters in the system to filter out particles as they move large volumes of air throughout the house. On the other hand, with proper HEPA filters in place, a forced-air system can significantly clean indoor air.

- **Fireplace**
  Try to make sure the fireplace is well ventilated, and avoid burning if drafts are coming down the chimney.

- **Furniture**
  Sitting down on dusty chairs, pillows, or beds can free trapped dust.

- **Wood-burning stoves**
  Although wood-burning stoves can be a more economical way to heat your home, they can greatly increase indoor pollution levels because of the toxins contained in wood smoke.
Activity sources of fine particles

Below are a few examples of activities that generate fine particulate matter.

- **Cooking**
  Preparing food, especially frying or using skillets, can cause particulates to be released into the air. Oily or burnt foods can produce large plumes. What’s more, you will find different cooking oils behave differently according to their smoke point. Click here to see a chart which includes the smoke points for various cooking oils. Extra light olive oil is a good high-temperature oil choice, but extra virgin olive oil generates smoke at much lower temperatures, and butter and peanut oil have even lower smoke points. In particular, cooking without using a hood that exhausts the air out of the house is often a major source of indoor air pollution.

- **Vacuuming and Dusting**
  These actions release dust from furniture, walls, and shelves and can cause large spikes in particulate counts. Vacuums of different models behave extraordinarily differently, with some vacuums dirtying the air significantly, while other vacuums have such good HEPA filters that using them actually cleans the air significantly!

- **Second-Hand Smoke**
  Smoking inside the home or near windows and doors will cause particulate counts to rise. Many are surprised to see that smoking outdoors, on the porch, can increase particulate counts inside the house, even in a child's bedroom one floor away to the rear of the house!

- **Incense and Candles**
  Smoke, especially after extinguishing, is a trade-off for using these items.

- **Grills and Barbecues**
  Try to cook outside away from windows, or close them when cooking is occurring. Again, the exact position of the barbecue from the house and the wind direction matters greatly in whether the barbecue pollutes the house or not.

- **Home Renovations**
  Any major work can free a variable amount of dust and dirt from old walls, floors, and ceilings. Be careful doing work in old houses where asbestos or soot may be present.

- **Showers, humidifiers, and boiling water**
  Increased humidity will increase the size of particles through hydrosopic growth, which will cause a measurable increase in particle density. These increases, while not strictly as bad as other forms of heightened pollution, aggravate conditions such as allergies and asthma.
Speck readings that you may encounter

Below are examples of types of historical graphs you may see on the Speck - the shape of these data plots can help you figure out the sources of particulates.

• **Brief spikes**
  If an event lasts for only a few hours and is not periodic, it may indicate a single release of particulates from something like cooking, or an idling vehicle near your home.

• **Sustained changes**
  If the average particulate reading increases or decreases and remains this way for more than a day, something may have changed inside your home or outside with regard to ambient air quality.

• **Periodic changes**
  If the same signal shape shows up every day at the same time, consider traffic patterns, forced air systems, nearby factory or power plant activity, or daily habits that may be causing repeat events.
General strategies to improve your indoor air quality

• **Add a HEPA air purifier**

  HEPA purifiers can drastically reduce the amount of particles in a closed space. Be sure to size the purifier appropriately to the space it is intended for, and change the filter regularly. Information on recommended room sizes and filter replacement is typically included on the filter packaging. Make sure that doors to the room with the purifier are closed when it is in use to preserve the cleaned air! Keep in mind that HEPA purifiers are generally more effective than ionic purifiers (with no filter). Also, HEPA purifiers do not generate ozone emissions that can be harmful to breathe.

• **Clean regularly**

  Open windows, vacuum, and remove dust from any frequently occupied space. This will keep particulate matter from repeatedly being disturbed and re-settling. When vacuuming, use a vacuum with a built-in HEPA filter so that you are not blowing particulates from the carpet or floor back into the air. Also remember to change this HEPA filter regularly, even though some vacuums neglect to mention this necessity.

• **Open or close windows**

  See how the Speck responds to opening or closing different windows. Whether this helps or hurts may depend on the time of day and wind conditions, so watch carefully!

• **Change cooking oils and techniques**

  When possible, try to find cooking oils that generate fewer fine particles (oils that have a higher smoke point are good candidates). Also, always use the range hood to ventilate the kitchen, or open windows and aim a fan to direct particulates outside. Make sure the range hood is exhausting outside and not just back into the kitchen!

• **Join organizations and communities that care about air quality**

  Join those who are petitioning for cleaner air and let your voice be heard. Cleaner air is possible through changes in community, industry, and legislature. The Breathe Project, SWPA-EHP, GASP and CWA are great groups to start with.
Experiments to test your ideas for ways to improve the air you breathe

Below are a few examples of mini explorations you can run at home to investigate ways to reduce your fine particulate concentration levels.

- **Bedroom**
  Are you waking up with allergies or red eyes? Are your children coughing at night but not during the day? You can make several material changes that may help improve the air quality in bedrooms. If the Speck reading is increasing when your kids get in bed, try hypoallergenic dust covers on their pillows, mattress and/or comforter. Bedding can collect dust, mold spores and other allergens; hypoallergenic covers stop these sources of pollution from dispersing into the air when you disturb the bed. Consider an inexpensive HEPA purifier, meant for a small room, but be sure to shut the doors to the room, as these filters only clean a small space effectively. Run the Speck and see if the air quality clearly improves, and monitor coughing or allergic reactions to determine whether they improve as well.

- **Kitchen**
  Investigate your kitchen ventilation hood to see if it effectively moves particulates outside or just recycles them back into the kitchen. If you are seeing poor air quality readings for long periods after/during meals, try leaving the hood on for much longer (if it vents outside). Try cooking at lower temperatures, use high-temperature-burning oils (such as extra light olive oil), or try steaming instead of frying. Start the hood even before the oil is hot, to start making the air flow correctly. Experiment with when and how high to run the hood fan to get the best air quality.

- **Cleaning**
  Vacuum instead of dusting. Try using a vacuum with a HEPA filter that actually cleans the air. Also, rather than dusting surfaces like fireplace mantles, use the handheld extension on the vacuum to suck up the dust rather than just spreading it into the air.

- **HVAC**
  Replace the HEPA filter if you have a forced-air system. If your filter is missing or expired, you may notice that the air quality does not get better when the forced-air turns on.

- **Large living spaces**
  If you have large spaces with bad air quality, like a dining room or living room that you often use, consider a HEPA purifier meant for continuous use and large flow rates from a reputable brand. There are many reviews available online to help you choose the best purifier for your home.
Other resources to help you improve your air quality

Below are a few links to external resources that can help as you investigate ways to reduce levels of fine particulates in your home.

- Fixing Stove Hoods To Keep Pollution Out Of The Kitchen
- EPA FAQs on Fine Particles (PM$_{2.5}$)
- Smoke Point Reference
Will Kay ➤ Speck Sensor
January 17 · 📁

I checked one of those out from the Carnegie Library. Learning a lot already about what affects air quality. Apparently Speck doesn't like when I cook bacon.

Speck Sensor was mentioned in a post.

CMU CREATE Lab
December 7, 2015 · 📁

As the Speck Sensor enters libraries, find out how you could win a free one!

Specks in Pittsburgh Public Libraries!

Speck air quality monitors are now available in 14 different Carnegie Library of Pittsburgh locations! Speck is an air quality monitor that detects fine…

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