What's in Your AIR? And Why Should You Care?

Air Pollution Affects the Health of You and Your Family

At Piera Systems we often get asked, why should I care about air quality? People who ask this are usually healthy, live where air quality is good and don't view air pollution as an existential threat. However, the quality of the air you breath is directly linked to your health, longevity and quality of life. In much the same way that the food you consume affects your health, so does the air you breathe. We watch what we eat, why not watch the air outdoors and indoors? What if you could measure it, identify when it's becoming unhealthy, identify the source and take action to improve it? At Piera we provide accurate, real-time data at low cost on particulate matter, the source of most air pollution using the Piera-1 Intelligent Particle Sensor.

The UN's Environment Program (UNEP) lists five reasons why you should care, the first being that polluted air is creating a health emergency. According to the World Bank, air pollution costs the global economy more than US $5 trillion every year in welfare costs and $225 billion in lost income. The WHO has found that air pollution causes more than 7.0 million deaths per year with 91 % of the world's population living where air quality exceeds WHO guidelines of 10 ug/m3 (mass concentration). The cause of this health crisis is particulate matter from industrial emissions, motor vehicles, domestic combustion, smoking/ vaping etc. Particulate matter of size PM2.5 um (microns) and smaller is the primary cause. Until now there has been no real-time, accurate, affordable method for measuring air quality < 2.5 um. These particles are so small they penetrate the skin directly and enter the bloodstream, and the more toxic ones can be fatal. Scientific American recently reported on a link between air Quality and Alzheimer's. Covid-19 caused by the novel Coronavirus is ~.125 microns. Researchers in Italy have identified a potential relationship between PM pollution and Covid-19 infection spread in Italy.

> "In conclusion, the rapid COVID-19 infection spread observed in selected regions of Northern Italy is supposed be related to PM10 pollution due to airborne particles able to serve as carrier of pathogens. As already highlighted in previous studies, it is recommended to take into account PM10 contribution and make policymakers aware of the need to take direct actions for pollution control."

Covid-19 has created a 'tipping point' that will force us to not only address the pandemic but drive social, economic, environmental and political change. According to a Pew Research poll most surveyed countries, including the US, say global climate change is a major threat. Getting accurate data about PM is key to enforcement, improvement and slowing climate change. Covid-19 has also exposed a weakness in the role of the EPA, they don't monitor, enforce and improve indoor air quality.

The Role of the EPA

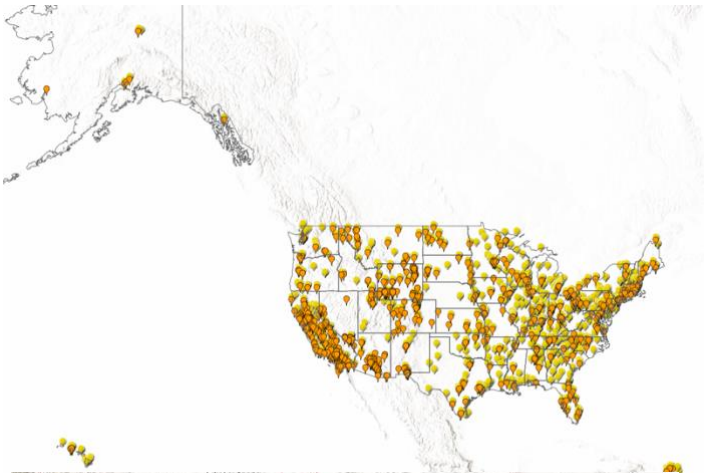
Most of us are aware of the Environmental Protection Agency and assume they are addressing air quality issues. Their mandate is to monitor, report and enforce air quality guidelines for outdoors, not indoors. The EPA is also subject to economic, political and scientific constraints as well. Let's look at how we got to this point…

The Clean Air Act of 1970 created the testing infrastructure and enforcement mechanisms to improve air quality in the US. Signed by Richard Nixon, it brought together a hodgepodge of state regulations and gave enforcement authority to the newly formed EPA. The Act's passage grew out of the first Earth Day, April 22, 1970. Since 1970, the act has seen multiple amendments, with California leading the way in measuring, enforcing and improving air quality. EPA scientists have been researching, producing findings and developing technology vital to our understanding of air pollution for decades.

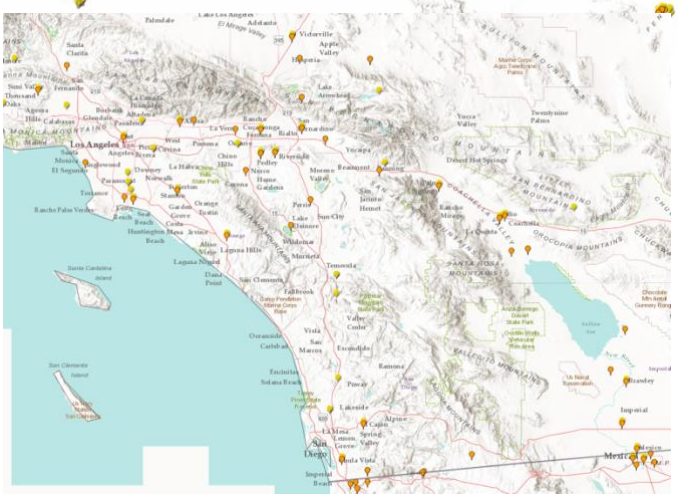
Air Quality Index		
AQI Category and Color	**Index Value**	**Description of Air Quality**
Good Green	0 to 50	Air quality is satisfactory, and air pollution poses little or no risk.
Moderate Yellow	51 to 100	Air quality is acceptable. However, there may be a risk for some people, particularly those who are unusually sensitive to air pollution.
Unhealthy for Sensitive Groups Orange	101 to 150	Members of sensitive groups may experience health effects. The general public is less likely to be affected.
Unhealthy Red	151 to 200	Some members of the general public may experience health effects; members of sensitive groups may experience more serious health effects.
Very Unhealthy Purple	201 to 300	Health alert: The risk of health effects is increased for everyone.
Hazardous Maroon	301 and higher	Health warning of emergency conditions: everyone is more likely to be affected.

This is the table the EPA uses to report air quality, the index value is ug/m3 or mass concentration. This simple chart and single metric are easy to understand, easy to measure and effective in enforcement. It is not however the full picture. MC is the sum of particulate matter of various sizes and quantities especially what is called fine (<2.5 um) and ultra-fine (<1.0) PM.

In 1997, the EPA issued new Air Quality Standards for Particulate Matter and in 1998 developed a method for measuring Fine PM (PM2.5). The EPA operates a nationwide air monitoring network (SLAMS) to measure six primary air pollutants: carbon monoxide, lead, sulfur dioxide, ozone, nitrogen dioxide, and particulate matter (PM_{10} and $PM_{2.5}$).



Here is a map of the active (~5k) stations that measure PM2.5 10. Seems like a lot of stations, and it is, but the scale is 600 miles/inch. Now let's zoom in on the densest region, Southern California.



This is the Coachella Valley, 60 miles east of LA. The scale here is 20 miles to the inch. Not much coverage, but more than most of the US. So, what's the air like where you live? What if there is a fire or polluter that affects your air? It's not likely the EPA will detect this for some time and then only if it reaches one of their

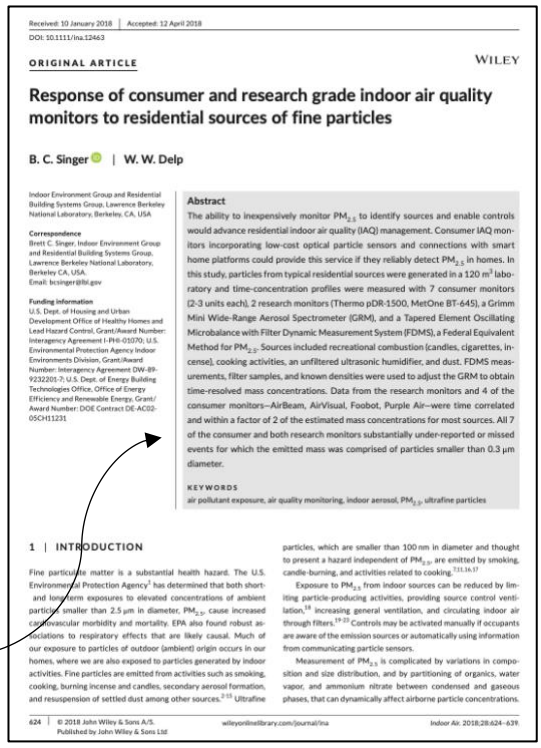
stations. You might ask why aren't there more SLAMS? Well, they are expensive, costing hundreds of thousands of dollars to deploy, maintain and extract the data, analyze and act on it.

The EPA would like to improve resolution with 'spatial data' and is monitoring advancements in air sensor monitoring technology in order to provide new lower-cost devices to help air quality managers, communities and citizens with understanding air quality. EPA researchers are at the forefront of the development and evaluation of air sensor monitors and conduct workshops to assess advances in lower cost sensors. The EPA has an Air Sensor Toolbox if you want to find out more. However here is one critical point, the EPA only cares about outdoor air quality, not the air in your home, office, restaurant, public space or where you spend most of your time.

Indoor Air Quality: A More Negative Impact to Your Health

Indoor air quality has been under increased scrutiny for some time now by consumers, researchers, and regulatory bodies. The ingress of bad outdoor air together with the introduction of other PM by residents (smoking, cooking, chemicals, etc.) has created a need for better monitoring in real-time and the use of air purifiers, smart HVAC systems, scrubbers, filters, etc. to clean the air. With Covid-19, the need to monitor and improve is dramatically higher. The threat is highest indoors due to the concentration of the virus, its spread through the air and it's residual presence without good, fresh air flow. Indoor air quality is not in the EPA's charter, but some excellent research has been done by a number of government labs.

Lawrence Berkeley National Laboratory has an Indoor Environment Group and Residential Building Systems Group. In 2018 they conducted research into indoor air quality monitors ability to detect sources of fine particles. This report discusses exhaustive testing for a wide range of PM created in a typical household including; dust, cigarettes, incense, candles, gas, and by cooking (toast, bacon, pizza, oil, pancakes, etc.). They controlled the conditions in their lab, measured them with expensive instruments (~$25k) and compared them to a number of air quality monitors which use existing optical PM sensors (Not Piera-1). From the abstract…



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Response of consumer and research grade indoor air quality monitors to residential sources of fine particles

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Abstract

The ability to inexpensively monitor $PM_{2.5}$ to identify sources and enable controls would advance residential indoor air quality (IAQ) management. Consumer IAQ monitors incorporating low-cost optical particle sensors and connections with smart home platforms could provide this service if they reliably detect $PM_{2.5}$ in homes. In this study, particles from typical residential sources were generated in a 120 m^3 laboratory and time-concentration profiles were measured with 7 consumer monitors (2-3 units each), 2 research monitors (Thermo pDR-1500, MetOne BT-645), a Grimm Mini Wide-Range Aerosol Spectrometer (GRM), and a Tapered Element Oscillating Microbalance with Filter Dynamic Measurement System (FDMS), a Federal Equivalent Method for $PM_{2.5}$. Sources included recreational combustion (candles, cigarettes, incense), cooking activities, an unfiltered ultrasonic humidifier, and dust. FDMS measurements, filter samples, and known densities were used to adjust the GRM to obtain time-resolved mass concentrations. Data from the research monitors and 4 of the consumer monitors—AirBeam, AirVisual, Foobot, Purple Air—were time correlated and within a factor of 2 of the estimated mass concentrations for most sources. All 7 of the consumer and both research monitors substantially under-reported or missed events for which the emitted mass was comprised of particles smaller than 0.3 μm diameter.

KEYWORDS
air pollutant exposure, air quality monitoring, indoor aerosol, $PM_{2.5}$, ultrafine particles

1 | INTRODUCTION

Fine particulate matter is a substantial health hazard. The U.S. Environmental Protection Agency[1] has determined that both short- and long-term exposures to elevated concentrations of ambient particles smaller than 2.5 μm in diameter, $PM_{2.5}$, cause increased cardiovascular morbidity and mortality. EPA also found robust associations to respiratory effects that are likely causal. Much of our exposure to particles of outdoor (ambient) origin occurs in our homes, where we are also exposed to particles generated by indoor activities. Fine particles are emitted from activities such as smoking, cooking, burning incense and candles, secondary aerosol formation, and resuspension of settled dust among other sources.[2-15] Ultrafine particles, which are smaller than 100 nm in diameter and thought to present a hazard independent of $PM_{2.5}$, are emitted by smoking, candle-burning, and activities related to cooking.[7,11,16,17]

Exposure to $PM_{2.5}$ from indoor sources can be reduced by limiting particle-producing activities, providing source control ventilation,[18] increasing general ventilation, and circulating indoor air through filters.[19-23] Controls may be activated manually if occupants are aware of the emission sources or automatically using information from communicating particle sensors.

Measurement of $PM_{2.5}$ is complicated by variations in composition and size distribution, and by partitioning of organics, water vapor, and ammonium nitrate between condensed and gaseous phases, that can dynamically affect airborne particle concentrations.

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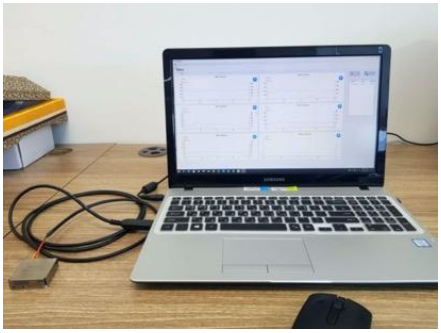
Many of the sources of PM emits particles smaller than PM2.5 and none of the monitors was capable of measuring < PM0.3 um. With Covid-19 at ~.125, one can see an urgent need for identifying PM in sizes from 0.1-0.3 um. So why hasn't someone invented an accurate, low-cost sensor that can measure the full range of PM from 0.1 um – 10 um both indoors and outdoors per the EPA's requirements? Enter Piera Systems and the Piera-1 Intelligent Particle Sensor.

Piera Systems Intelligent Particle Sensor: Piera-1

Piera-1 uses a breakthrough approach for detecting and measuring the quantity and size of particles suspended in air. Unlike existing PM sensors that are inaccurate, low in resolution and slow, Piera-1 has superior

accuracy, can detect smaller particles (PM0.1-PM10) and counts them in real time with low power consumption. Piera-1 uses a patented, photon-counting custom ASIC to deliver a highly sensitive optoelectronic particulate sensor. Piera-1 can be programmed to detect a wide range of particle sizes allowing for a single sensor to be used in many applications. For the first time, applications can be developed that take advantage of low cost, accurate, detailed, real-time data about PM. Machine Learning/AI and algorithms can be used to classify this data. An example is Piera Systems vape/smoke detector, **Canāree,** that can identify and discriminate between cigarette and vape smoke, calculate its mass concentration, dissipation, etc. The Piera-1 Evaluation Kit is available for developers to conduct their own testing, certification and integration into their products. Piera-1's ability to count individual particles, size and distribution for PM <0.1-2.5 um is unique. Piera-1 can be programmed to 'zoom in' and focus on specific sizes such as PM0.1-0.3, the size of viruses such as Covid-19 and influenza. Detection can lead to adjustments in climate control systems, filtering, using fresh air and other approaches to remove the PM.



"What's in your AIR" is more than a marketing slogan, it's critical to staying healthy and slowing global warming. Accurate, real-time information from low cost sensors like Piera-1 integrated into air quality monitors, air purifiers, HVAC systems, automobiles and numerous digital health applications can address this threat. If you are developing a product that would benefit from complete, accurate real-time data about PM, contact us.