National Institute of Environmental Health Sciences

The Environmental Health Science FEST

SENSORS AND TECHNOLOGIES FAIR

The EHS FEST Sensors and Technologies Fair is aimed at providing a great opportunity for sensor and technology developers funded by NIEHS and other agencies, to showcase their cutting-edge technologies and meet with leading scientists and end-users in exposure science, environmental epidemiology, community research and citizen science.

The event is divided into two sessions — the first session on Tuesday, December 6 includes a broad range of sensors and technologies capable of measuring physical, chemical, and biological targets in a variety of environmental matrices and online tools for research and education; the second session on Wednesday, December 7 emphasizes wearable technologies for personal environmental exposure monitoring.

Sensor Abstracts

Tuesday, December 6: 5:15 p.m. – 6:30 p.m.

1. National Priorities List Superfund Footprint Mapper: Site, Population, and Environmental Characteristics

Sandra Baptista, *Columbia University*
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Abstract:
The National Priorities List (NPL) Superfund Footprint Mapper: Site, Population and Environmental Characteristics is an interactive, online mapping tool created by scientists and staff at the Center for International Earth Science Information Network (CIESIN) as part of the Columbia University Superfund Research Program's (SRP) Research Translation Core. Its development was funded by NIEHS as a supplemental grant to the Columbia SRP. It provides researchers, regulators, and the general public with an innovative tool to better visualize and understand the characteristics of vulnerable populations, built and natural features, and environmental exposures near NPL Superfund sites. Its purpose is to help improve the evaluation of Superfund sites and more effectively address related environmental health concerns. Users can use the tool to explore data, create maps, and print or save the maps and data results obtained. The NPL Superfund site data used consist primarily of polygon shapefiles provided by ATSDR's Geographic Research, Analysis and Services Program with attribute data from the U.S. EPA Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) database. To more accurately estimate populations and their characteristics in proximity to these sites, U.S. Census Grids population data are utilized. The Mapper is built on the Esri Web Application Development Framework and gives users access to GIS capabilities and data through a Web browser.

Contributing Developers:
James Carcone, *Columbia University*
Tricia Chai-Onn, *Columbia University*
Annie Gerard, *Columbia University*
Kytt MacManus, *Columbia University*
Gregory Yetman, *Columbia University*

2. DERBI: A digital tool for reporting personal exposure results to participants

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Abstract:
Returning personal results to study participants, known as report-back, is increasingly recognized as ethical best practice in biomonitoring and personal exposure studies. Interviews in 10 studies show that report-back improves participant retention, supports learning, and motivates action. However, researchers often lack the time and expertise needed to produce high-quality reports and face difficult decisions when reporting chemicals with uncertain health effects, very high exposures, or to sensitive populations. To address practical barriers, we developed the Digital Exposure Report-Back Interface (DERBI) to automate critical but time-consuming tasks, such as producing individual summaries of notable results and graphs for each participant. Researchers also benefit from data visualization tools for exploring exposure patterns. DERBI reports include information about sources of exposure, health effects, exposure reduction tips, and study-wide findings. Many participants in the CDC Green Housing Study and the Child Health and Development Studies found the reports helpful, with some leveraging their results to obtain better healthcare and others making changes to their homes and habits to reduce exposures. CHDS participants who received individual results spent almost twice as long viewing their report as those who received only study-wide results. We are adapting DERBI for four new studies, including the first crowdsourced biomonitoring study: Detox Me Action Kit.

Contributing Developers:
Phil Brown, *Northeastern University*
Rachel Morello-Frosch, *University of California, Berkeley*
Herb Susmann, *Silent Spring Institute*
Katherine Boronow, *Silent Spring Institute*
Jennifer Ohayon, *Silent Spring Institute*
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3. RemRX

Alexis Carpenter, *AxNano*
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Abstract:
The EPA estimates that one out of every four Americans lives within three miles of a hazardous waste site. Over 450,000 brownfield sites are awaiting remediation and 1,280 sites on the National Priorities List. Potential Responsible Parties or the Superfund program are tasked with remediating these sites, but insufficient funding and a growing number of sites have led to significant delays. The U.S. remediation market has been growing steadily since 2009, averaging 2-3% increases per year, and the global environmental remediation technology market is forecasted to expand to $80.5 billion in 2019. There is significant societal need and market potential for innovative remediation technologies that decrease cost, increase efficacy, and shorten the remediation timeline. In Situ Chemical Oxidation (ISCO) is the fastest growing remediation technique as it is lower cost, more effective, and less disruptive than other methods. However, current ISCO methods require gaseous or liquid-form oxidizers that pose significant hazard to workers during transport and delivery and often require multiple injections to address rebounding and tailings. RemRX uses degradable polymers for controlled oxidant delivery and sustained treatment of contaminated water. Analogous to controlled release platforms used to improve the efficacy of therapeutics, RemRX utilizes currently approved chemical oxidants and provides a more efficient application method. In current development is a slow release formulation for In Situ Chemical Oxidation. RemRX is a tunable platform to address high and low levels of contamination, provides sustained release to eliminate rebounding and tailings, allows for reduced labor and equipment/infrastructure requirements throughout the remediation period, and is safer to transport and use.

Contributing Developers:
Charles Gause, *AxNano*
Colm Humphreys, *AxNano*
Stephanie Luster-Teasley, *North Carolina A&T*

4. Rutgers Electrostatic Passive Sampler (REPS): Development and Field Testing

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Abstract:
Passive sampling of airborne particles has multiple advantages over active sampling methods: no power is needed, low cost, usable over wide spatiotemporal scales, and amenable to the creation of massively distributed sampling networks. Here, we report on the development and field testing of a passive bioaerosol (airborne microorganism) sampler developed using parallel layers of a polarized, ferroelectric polymer (polyvinylidene fluoride, PVDF), or Rutgers Electrostatic Passive Sampler (REPS). PVDF has been permanently polarized by application of an external electric field and we have shown that it enhances electrostatic capture of microorganism-sized particles from 15 nm to 5000 nm. Four 10-day-long outdoor field test campaigns were conducted in highly varied environmental conditions (-2 to 33°C, 17 to 98% RH) to compare collection efficiencies of REPS to an active control sampler (Button Aerosol Samplers) and passive control samplers (PTFE settling filters and agar settling plates). Total bacteria and fungi were counted by Acridine Orange staining/microscopy each day for the Button Samplers and at the end of each field campaign for passive samplers. Culturable bacteria and fungi were determined daily by plating aliquots of extracted Button Sampler filter suspension and via agar settling plates, and at the end of campaigns for passive samplers. Compared to passive PTFE filters, REPS enhanced passive deposition of total microorganisms by 7-fold. REPS also collected 65% of the culturable bacteria that the active Button Samplers collected. Since the Button samplers operated at 4 L/min, REPS had an equivalent sampling flow rate of 2.6 L/min and 1.2 L/min for culturable bacteria, and total bacteria and fungi, respectively. These results suggest that REPS passively collects a similar number of microorganisms as an active sampler over long sampling durations, especially for culturable bacteria. This is most likely due to better preservation of culturability in the absence of a desiccating flow rate. These results suggest that our newly developed passive sampler is an effective bioaerosol sampling tool. Since the device is small (fits in a standard 50 mL centrifuge tube) and weighs ~ 50 g, it has a variety of potential applications, including sampling in flood damaged homes, monitoring aeroallergen patterns and assessing presence of airborne microorganism presence over wide spatial scales. Future tests will include indoor testing and development of a personal sampler prototype.

Contributing Developers:
Jennifer Therkorn, *Rutgers University/Johns Hopkins University Applied Physics Laboratory*
Jerry Scheinbeim, *Rutgers University*
Nirmala Thomas, *Rutgers University*

5. Non-invasive in vivo X-ray Fluorescence and Neutron Activation Analysis Technology to Quantify Metals in Human Tissue

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Abstract:
The broad applications of metals in industry, agriculture, and other fields have dramatically increased metal exposure to human population over the last several decades. Studies have linked metal exposures to various health effects and diseases. Many metals accumulate in bone. Metal concentration in bone provides unique information regarding long term chronic metal exposure, a pattern seen in most of the exposure scenarios. X-ray fluorescence (XRF) and Neutron activation analysis (NAA) are two powerful noninvasive techniques for in vivo quantification of metals. In our lab, two XRF systems and one NAA system were developed and validated to measure multiple metals, such as lead (Pb), strontium (Sr), manganese (Mn), aluminum (Al), sodium (Na), calcium (Ca), etc., in bone and/or toenail in vivo. One of the two XRF systems is a stationary system which consists of a low energy HPGe detector with four germanium crystals, four digital signal processing devices, and a Cd-109 radioisotope source. It has been used in environmental and occupational populations to measure Pb in bone for over 10 years and made significant contribution on our understanding of the health effects of cumulative Pb exposure. Recently, a study on childhood Pb poisoning was conducted using this system. A group of children diagnosed with Pb poison and corresponding controls were recruited for the study. The result shows that bone is a storage site for Pb in children and bone Pb is a valuable biomarker to assess cumulative exposure and to determine chelation efficacy for Pb poisoned children. The other XRF system is a newly developed portable system to measure Pb and Sr in bone, and Mn and mercury (Hg) in toenail. The portable system consists of a low-energy x-ray tube, a silicon-drifting detector, and well-constructed shielding. The latest detection limits for this system are 2.9 and 2.0 ppm (at 2 mm soft tissue thickness) for Pb and Sr in bone, and 2.1 and 0.4 ppm (micro g/g dry bone or toenail) for Mn and Hg in toenail. A validation study for this system is being conducted among an elderly population.
The newly developed NAA system consists of a DD neutron generator with optimized moderator/ reflector/ shielding assembly, a high purity germanium (HPGe) detector with 100% efficiency, and a digital signal processing device. It is used to detect metals in human hand bone. The latest detection limits for detection of Mn, Al, Na, and Ca in bone are 0.4, 8, 7, and 430 ppm respectively. The system is still being optimized to achieve lower detection limit for these and other metals. Recently, the system was used in an occupational study to investigate the association between cumulative Mn exposure and neurological functions. The results show significantly reduced cognitive and motor function with increased bone Mn among 60 Mn-exposed and control workers.

Contributing Developers:
Yingzi Liu, *Purdue University*
Aaron Specht, *Purdue University*
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Marc Weisskopf, *Harvard University*
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6. PROTECT's Electrochemical Reactor for Remediation of Contaminated Groundwater

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Abstract:
Our team is developing novel, sustainable, solar-powered and environmentally-friendly electrochemical technologies for remediation of contaminated groundwater. The technologies are based on the application of low level electric current through electrodes in reactors or wells in groundwater. Our innovative and easy-to-maintain systems are designed to utilize cost-effective electrodes through specified electrode arrangements and electric current control devices. Their performance is optimized to support the electrochemically-induced oxidation and/or reduction to simultaneously transform individual (e.g. trichloroethylene, TCE) and a mixture of contaminants (e.g., chromium, selenate, nitrate and arsenic). Major advantages of using these reactors for groundwater treatment are: 1) easy control of redox reactions rates in groundwater by adjusting electric current intensity, 2) the reactors do not require the addition of solutions or chemicals into groundwater, and 3) they can be driven by a renewable energy source. We will demonstrate a typical reactor we use for these applications. The reactor includes a set of electrodes connected to a power source and coupled with a pump for circulation of groundwater. The system is currently being tested in the field.

Contributing Developers:
Akram Alshawabkeh, *Northeastern University*
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April Gu, *Northeastern University*
Dorothy Vesper, *West Virginia University*

7. Passive Particle Monitor

Gretchen Gehrke, *Public Lab*
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Abstract:
This Passive Particle Monitor has been developed to provide an extremely low-cost, technologically accessible tool to monitor airborne particulate matter. The monitors can be deployed in the field for seven days, collecting particles on a glass depositional surface, which can then be analyzed using visible microscopy and open-source software programing designed to identify particle size and relative particle count. The purpose of the monitors is to assess average ambient particle concentrations, potentially discerning particle pollution hotspots of concern to communities. The hardware has been developed from the University of Iowa's outdoor adaptation of a particle monitor originally patented by the University of North Carolina, and consists of two plates, separated by approximately one inch, with exchangeable stubs and glass deposition slides inserting into the lower plate. Two versions have been designed, one entirely aluminum assembly and one entirely plastic (acrylic and ABS) assembly, which are currently being evaluated for their influence on particle deposition dynamics. The structures are designed to collect particles larger than 2.5 microns, but less than 10 microns in diameter. The analytical software program involves an automated ImageJ macro workflow that selects images collected from a visible microscope camera, such as with the open-source 3D-printed OpenFlexure Microscope developed at the University of Cambridge. The software program then calibrates the image scale, automates particle contrast, creates ideal spherical dimensions for particles, and then assesses the size of frequency of particles. This protocol provides particle size count concentrations, which can be transformed into an estimated particle concentration by mass for general comparison to state and federal particle air quality data. The extraordinarily low cost of the hardware components, the ease of monitoring, and the automation of the software analytical protocol make this passive particle monitor accessible to communities throughout the country who are interested in monitoring their ambient particulate matter. Passive particle monitors have been deployed in Public Lab communities in Chicago and rural Wisconsin in areas affected by windblown petroleum coke and industrial sand mining pollution. Further development includes co-location studies comparing the passive particle monitor with federal reference method dichotomous samplers to assess the accuracy and precision of the passive particle monitors and estimated particle count to mass conversions.

Contributing Developers:
Mathew Lippincott, *Public Lab*
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Amber Wise, *Chicago State University*
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8. FrackMap: Building a Geo-spatially Based Nexus of Research Publications and Perceptions Related to Hydrofracturing

Ann Backus, *Harvard University*
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Abstract:
The FrackMap originated as an NIEHS supplement project of the HSPH-NIEHS Center for Environmental Health and the UPENN Center of Excellence in Environmental Toxicology in collaboration with the Harvard Center for Geographic Analysis (CGA). The key-word process by which peer-reviewed and grey literature related to hydrofractured oil and gas wells was identified and vetted will be described along with the 11 research categories (such as waste water, air quality, health impacts) that define the map layers. A FrackMap demonstration will show the geo-spatial association of the individual research articles to individual wells or regions of unconventional drilling. Discussion about the potential of The FrackMap to enable researchers to pose new questions within and across layers (domains of research), to develop new collaborations, to spot new associations, and to discover research gaps will be welcome. Over 60,000 tweets related to perceptions of hydrofracturing, captured by the Harvard CGA's Geo-tweet Archive, were analyzed using the Nuance-R platform. The distribution of tweets across the U.S., and geo-located content (benefits/risks) and sentiment (positive/negative attitudes) topics will be presented. The temporal and spatial information embedded in tweets can be used to customize translation of the scientific research to improve public understanding of environmental and human health impacts, inform public policy, and support health parity and environmental justice.

Contributing Developers:
Nathalie de Marcellis-Warin, *Polytechnique Montreal, CIRANO, and Harvard University*
Thiery Warin, *Hautes Etudes Commerciales, Montreal, and Harvard University*

9. ARISense

Eben Cross, *Aerodyne Research, Inc.*
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Abstract:
Each ARISense system provides continuous, rapid (< 60s), time-stamped measurements of the following gas phase pollutant concentrations: carbon monoxide (CO), nitric oxide (NO), nitrogen dioxide (NO2), total oxidants (O3 + NO2) and carbon dioxide (CO2). The system also includes a low-cost optical particle counter which measures size-resolved particulate matter number concentrations (16 bins: 0.45 < dp < 17 um), yielding real-time, estimated particulate mass loadings for PM1, PM2.5, and PM10. In addition to the pollutant measurements, environmental parameters are also recorded by the device including wind speed, wind direction, barometric pressure, temperature, relative humidity, sound, and solar light intensity. The current system is housed in a weather-proof NEMA-rated enclosure (8.5 x 8.5 x 6 inches ~3 lbs.), powered by 120 V AC, and cloud-connected via a CAT-5 Ethernet cable. ARISense aims to address neighborhood-scale AQ measurement gaps that persists throughout much of the developed and developing world while also providing an accessible, open, transparent user-interface through which researchers and the general public can interact with their local AQ data. Reliable quantification of low-cost AQ sensor outputs is a primary focus of the ARISense R&D effort.

Contributing Developers:
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Ann Backus, *Harvard University*
Gary Adamkiewicz, *Harvard University*
Traci Brown, *Harvard University*

10. Non-Selective Passive Sampling Technology

Kelly O'Neal, *North Carolina State University*
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Abstract:
Environmental exposure to chemicals has been linked to serious human health problems. Understanding and managing the risks of chemicals requires accurate measurements of the identity, quantity and bioavailability of chemicals in the environment. We have developed a novel sampling technology to better assess the external organic chemical exposome in water, sediment, and soil and to allow the bioavailability of organic chemicals to be incorporated into risk analysis. Environmental exposure to chemicals is usually estimated from single time point measurements (grab samples) of a pre-defined list of target chemicals. However, there is often high temporal variability in exposure that renders grab samples unsuitable for estimating chronic exposure and there are many more chemicals beyond those of even the most exhaustive list of target chemicals. To help overcome this dual challenge to our current assessment of chemical exposure, we have developed a non-selective passive sampling device (nsPSD) that accumulates both polar and non-polar organic chemicals (log Kow range 0.2-8.0) that can be analyzed using both target chemical and non-target chemical methods. Our first generation nsPSD consists of a mixed phase polymer (proprietary formula) contained within a non-selective stainless steel screen and this device has been calibrated for over 700 organic chemicals. Our second generation device utilizes a novel polymer synthesis and deposition process (patent pending) that allows us to make a large sheet format nsPSD that results in unprecedented sensitivity for the simultaneous detection of both polar and non-polar organic chemicals. The most common application of these devices is measuring the bioavailable chronic exposure to organic chemicals in water, but the devices also can be used to measure the bioavailable concentration of chemicals in soil and sediment and can be used as a wearable device for measuring chemical exposure to individual humans.

Contributing Developers:
Damian Shea, *North Carolina State University*
Summer Xia, *North Carolina State University*
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11. Plasmonic Mercury Sensor

Jay James, *Picoyune*
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Abstract:
Mining and other industrial actions have contaminated thousands of sites in the United States with mercury, and many are in extremely remote and difficult to access locations. A surge in the use of mercury amalgam methods in artisanal gold mining is rapidly creating many more sites around the globe. Commercially available mercury monitors are often too complicated, unreliable, and expensive to operate in the field. These challenges have remained throughout decades of optimization and study of atomic absorption and atomic fluorescence spectroscopy. Plasmonic mercury detection offers fundamental advantages in portability and sensitivity over the existing methods. Our field deployable soil and sediment analyzer has the potential to eliminate delays and costs in mercury analysis. Rather than having to collect samples and wait for the results, investigators can generate immediate information on a site's mercury levels. Picoyune's Runabout is a portable mercury analyzer for solid and liquid samples. The system combines direct thermal sample decomposition with plasmonic mercury detection. The result is a hassle free tool capable of parts per trillion detection in the field. Plasmonic sensing is a robust and highly sensitive technique with unique advantages for mercury analysis. Gold nanoparticles have a resonant absorption in the visible that is sensitive to changes in size, composition, and surrounding index of refraction. By monitoring the visible light absorption of a gold nanoparticle film we can detect the adsorption of picogram masses of mercury. The film can be gently heated (>100 °C) and regenerated for repeated use (thousands of times). In the Runabout, the plasmonic sensor measures the mercury released from a thermal catalytic sample treatment directly. This is the ideal method for the field because it is a single step without the need for wet chemicals. Mercury monitoring costs hundreds of millions of dollars a year across diverse scientific, industrial, and regulatory groups. The fundamental issue these groups address is protecting human health, and the environment, from the risks of mercury pollution.

Contributing Developers:
Jeffrey Crosby, *Picoyune*
Donald Lucas, *Picoyune, Lawrence Berkeley National Laboratory*
Catherine Koshalnd, *University of California, Berkeley*

12. Participatory Online Communication and Engagement Tools for Environmental Health Science Data

Ilya Zaslavsky, *University of California, San Diego*
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Abstract:
Development of online tools for science communication, research translation and community engagement is in important component of the work at the Superfund Research Center (SRC) at the University of California, San Diego. New technologies developed at the San Diego Supercomputer Center's Spatial Information Systems Lab in partnership with the SRC and the Bioregional Center for Sustainability Science, Planning and Design, enable researchers to integrate information from health and environmental data sources, and share the data online as user-friendly interactive visualizations. The technologies include online mapping and scenario analysis, and a survey data analysis application called SuAVE (Survey Analysis via Visual Exploration). SuAVE presents an intuitive visual framework for the analysis of surveys and other collections, enabling custom searches, efficient exploration of subsets of data, and Google Maps-like navigation over a gallery of survey items. It combines visual, statistical and cartographic analyses, interfaces with R to compute statistical models, and enables comparison of distribution patterns and outliers. Users can publish their own surveys online, annotate patterns they discover, and share those annotations. Tools like SuAVE can help communicate scientific knowledge and develop insights through guided exploration of relationships between key environmental and health parameters, while engaging a broad audience in sharing their findings.

Contributing Developers:
Keith Pezzoli, *University of California, San Diego*
Thomas Whitenack, *University of California, San Diego*

13. OpenAQ Platform

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Abstract:
Air pollution is a public health crisis. Yet many scientific questions remain unanswered when it comes to the impact of air pollution on health in the most highly polluted environments. Official air quality data from approximately 60 countries are shared, in near real-time, publicly on the internet every day. These estimated 5-8 million data points generated each day are shared in disparate forms from one another and many are only temporary displayed on a website before being updated with new data. This makes the data difficult or impossible to access in real-time programmatically or retrospectively in any form. Also, researchers and citizen scientists lack a centralized platform on which to share data in a universal format. OpenAQ has opened up more than 21 million existing disparate, official and research-grade air quality data points in 25 countries through an open-source platform (https://openaq.org) so that communities around the world can use it to advance science, public engagement, and policy. We will present new open-source data exploration and visualization tools that allow the public, from scientists to journalists, to interact with this one-of-a-kind dataset. Also, we will share stories from Delhi to Ulaanbaatar of everyone from scientists to journalists using open air quality data to advance their fight against air inequality.

Contributing Developers:
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Daniel Silva, *Development Seed*
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14. Field Deployable Vapor Intrusion Monitor

Bikas Vaidya, *Lynntech*
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Abstract:
Monitoring of volatile organic compounds (VOCs) is important for health and environmental protection. Compared to traditional monitoring of VOCs by sample transfer to an off-site laboratory, there are many advantages to using portable monitoring devices for on-site testing. Unfortunately, on site testing and monitoring of VOCs is constrained by the limited capabilities of currently available portable devices. Lynntech has designed and developed an easy to operate portable VOC monitor that that can detect trace levels of the most frequently encountered toxic vapor intrusion contaminants like trichloroethylene (TCE) and tetrachloroethylene (PCE). Lynntech's approach is based on a novel sampling and detection cartridge (SDC) that when combined with commercially available, portable FTIR spectrometers, can detect VOCs at concentration levels useful for vapor intrusion monitoring. The SDC incorporates advances in the field of solid phase extraction and exploits a specialized polymer coated optical waveguide to pre-concentrate dilute VOCs from air and to exclude compounds that interfere with the analysis. There are numerous merits to this approach, including compact size/portability, near real time results, ease of automation, requirement of minimal expertise, and the reagent and solvent free operation. The portable VOC monitor was field tested at an EPA Superfund site. Lynntech employees performed the testing in parallel with EPA representatives that were there conducting scheduled air monitoring at the site. Out of the six houses in which the portable device was tested, it detected TCE in one and benzene in four of the houses. The concentrations of TCE and benzene measured by the device matched well with the results obtained by the EPA personnel using their standard method. The field testing at the EPA Superfund test site demonstrated that in addition to monitoring TCE and PCE, this device can be used for detection of benzene as well. Further laboratory testing has confirmed that this device can simultaneously detect ppb levels of TCE, PCE and other contaminants, such as benzene, toluene, ethyl benzene and xylenes.

Contributing Developers:
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15. ExpsomeDB

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Abstract:
In the biomedical research community the role of environmental factors on disease is still not very well understood. Part of the reason is that environmental factors can be so varied in that they can range from socioeconomic factors to environmental pollutants. This concept has been formalized with the term "exposome" which represents a human's exposure to all of these environmental factors.
This presents two challenges:

1) What are the elements of the exposome that are relevant for disease?
2) How can a researcher have access to this data?

In our work, we will discuss tools that we are building to enable researchers to answer these questions. In the era of "Big Data" many organizations are recognizing the value of their data and are in fact making it generally available. In theory it is possible for any researcher to access these data and do research, but data acquisition and processing can be limiting factors. Our goal is to make it easier for researchers to use exposome data by doing the aggregation ourselves and providing a common API for all of this data. We will discuss some of the varied data sources we plan to process (i.e. American Community Survey Data, NOAA, and EPA) and the design decisions we will make in order to make this useful for researchers. In particular, we have found GIS technologies to be very valuable as we aggregate so many disparate data sources. We will discuss the central role tools such as PostGIS have to play in order for this work to be possible.

Contributing Developers:
Chirag Patel, *Harvard University*
Chirag Lakhani, *Harvard University*
Shreyas Bhave, *University of California, Berkeley*
Rolando Acosta, *University of Puerto Rico, Humacao*

16. In Vitro Lung Cell Instrument

William Vizuete, *University of North Carolina, Chapel Hill*
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Abstract:
Our instrument is the only in vitro technology that permits realistic experiments with temporal resolution to capture the compositional changes of ambient particulate matter (PM). This novel instrument is a platform technology that can sample any air stream and use any biological tissue as the target for assessment of induced effects. The biological cells in the instrument are directly exposed to a complex air pollution mixture of gases and particles in their ambient state, without having to pre-collect or use solvents. This innovative instrument uses electrostatic charging on PM to efficiently deposit the particles directly onto cells at their air-liquid interface, thus simulating human exposure, but with increased accuracy and sensitivity compared with currently available methods. The charging has been shown to not harm living tissue, while the process of collecting and depositing particles onto the cells for toxicological measurements remains highly effective. Our instrument is innovative because sampling artifacts are vastly reduced compared to traditional toxicology techniques used for testing air pollution mixtures. In these techniques, PM is typically collected with filters before being re-suspended in a liquid medium and then placed on cells or instilled into animals. The relative ease-of-use of re-suspension makes it attractive, but likely underestimates or otherwise misrepresents the actual toxic potential of a PM sample for three key reasons. First, there is a near-total loss of volatile compounds during sample collection and re-suspension. Second, the PM suspended or dissolved in the media may not interact closely with the lipid/protein membrane of the cells, especially the highly-water soluble particles. And third, the re-suspension liquid can greatly reduce the total surface area of the PM due to particle agglomeration. In contrast, the Q-PM sample stream is not disturbed prior to the exposure process. Quite remarkably, virtually no adulteration of the sample occurs prior to, or during, cell exposure. Furthermore, the Q-PM is able to deposit significantly more mass per well plate than existing instruments. The Q-PM has a deposition efficiency of 47% and it samples at a volumetric flow rate that is 20 times larger than found in existing instruments. We are able to accomplish these large flows primarily due to the humidification and temperature controls that exist only in our technology, allowing us to capture more PM in less time. Since we are not placing the PM in liquid we have significantly more sensitivity. In our experiments we are able to detect toxicological marker responses that were 16 times lower than the dose required for a typical re-suspension exposure.

Contributing Developers:
Christopher Price, *Biodeptropnix LLC*
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Wednesday, December 7: 4:45 p.m. – 6:15 p.m.

17. Personal Ozone Monitor™ (POM™)

John Birks, *2B Technologies*
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Abstract:
We developed a small (4.0 x 3.0 x 1.5 inch), light weight (0.75 lb), low power (3 watts), battery-operated Personal Ozone Monitor™ (POM™) based on the well-established and highly accurate method of UV absorbance at 254 nm. High precision and accuracy of 1.5 ppb or better was achieved by folding the optical bench in a U shape to achieve the same path length as our much larger ozone monitors. In fast response mode, the POM reports a new measurement every 2 s. The instrument has a built-in GPS for logging positional coordinates along with ozone concentration and diagnostics. The internal data logger can store up to 8,192 lines of data, which can be downloaded to a personal computer via a USB port. The Personal Ozone Monitor is the smallest instrument ever designated as a U.S. EPA Federal Equivalent Method (FEM) for monitoring for compliance with the U.S. Clean Air Act. More than 140 POMs are now in use in a wide range of applications, including personal monitoring for safety in the ozone industry, leak testing, studies of human exposure to ozone, vertical profiling of the atmospheric using drones, and as an educational tool in the GO3 Treks project for K-12 students and citizen science monitoring.

Contributing Developers:
Craig Williford, *2B Technologies*
Peter Andersen, *2B Technologies*

18. MicroPEM Aerosol Exposure Monitoring Platform

Jonathan Thornburg, *RTI International*
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Abstract:
The MicroPEM™ technology provides particulate matter exposure data at the personal level in a low-burden package that can be worn by individuals to significantly enhance studies of public and occupational health. The National Research Council supports the application of personal exposure monitors to characterize exposure levels and patterns for correlation with acute and chronic health effects. Previous personal exposure sampling instruments can be burdensome thereby increasing the frequency and duration of time when the monitor is not worn according to the study protocol. These time periods contribute to exposure misclassification bias, defined as times when the exposure data are not representative of the person's exposure. The MicroPEM is designed to minimize the key aspects of exposure misclassification bias. The MicroPEM provides fully representative personal exposure characterizations by simultaneously defining the integrated exposure (filter based) as well as the patterns of exposure in real-time in a wearable low burden package weighing less than 240 grams. Selectable U.S. EPA particle cut-point definitions of PM2.5 or PM10 relate the collected data to targeted respiratory system deposition zones (deep lung or thoracic, respectively), allowing health-based associations to be studied against adverse disease outcomes. On board collection of quality control data and accelerometer motion allows straightforward validation of both wearing compliance for the collected samples and data, as well as enables estimates of respiratory ventilation and potential dose.

Contributing Developers:
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Ryan Chartier, *RTI International*
James Carlson, *RTI International*
Bradley Handziuk, *RTI International*
Phil Lawless, *RTI International*
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19. Modular Monitors for Particulates, Black Carbon, PAHs/VOCs and Bioaerosols for Public Health Studies

Jeffery Blair, *AethLabs*
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Abstract:
Together with our collaborator, the commercial manufacturer AethLabs, we are developing and validating a modular array of miniaturized air monitors for use as personal, mobile, residential, or fixed site ambient monitors in public health studies where exposure data is required. The array consists of several real-time monitors and an archive monitor for collection of integrated air samples for laboratory analyses. The real-time AethLabs microAeth monitors measure optically absorbent components of particulate matter using 5 wavelengths spanning UV - IR allowing composition identification including black carbon (e.g. from diesel), environmental tobacco smoke or environmental wood smoke. The instruments support the DualSpot loading compensation method which corrects for the optical loading effect and provides additional information about aerosol optical properties. An easy-to-exchange filter cartridge for automatic advancement of filter tape material enables unattended operation from weeks to a year, depending on the model and environmental factors. The cartridge tape provides a method for locally calibrating the optical data to be used for real-time estimations of particle associated PAHs. Data from third party monitors can be easily integrated into the data being recorded on any of the AethLabs monitors and uploaded to a study's server. The archive sampler is lightweight and very small (76mm W x 66mm H x 24mm D), very quiet (< 36 dB at 2 foot) and can automatically collect two air samples per deployment via automated valves that can be set up to be actuated due to location (e.g., leaving home) or time, allowing wide array of study designs. Size selective inlets allow either PM2.5 and/or PM10 and can be set up to collect two particulate matter filters or both particulate matter and semi-volatile VOCs/PAHs via an in line denuder. We are currently developing laboratory assays for bio-aerosols (airborne allergens and PCR-based microbial-assays), traditional filter based measurements (including gravimetric mass, metals, particle bound PAHs), and VOCs/semi-volatile PAHs. Tri-axial accelerometer and GPS chips are integrated into our personal real-time and archive monitors allowing determinations of location, wearing compliance and activity related parameters such as minute ventilation. Bluetooth, WiFi and/or serial connections allow all sensor data to be logged and sent to the study team on a daily basis. We gratefully acknowledge that the sensor development and validation was partially supported by grants from NIEHS (U01ES016110, R01ES020424, P30ES099089), and NIBIB (U01EB021983).

Contributing Developers:
Steven Blair, *AethLabs*
Steven Chillrud, *Columbia University*
Beizhan Yan, *Columbia University*
Matthew Perzanowski, *Columbia University*

20. Devices and Advanced Components for Fixed and Wearable Personal Exposure Monitoring of Ozone and Related Inhalation Hazards

Michael Carter, *KWJ Engineering, Inc*.
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Abstract:
Our company has spent several years developing and commercializing an ultra-small, ultralow power printed amperometric gas sensor that is compatible with the size and power requirements of modern applications in the Internet of Things, distributed sensing and mobile/wearable applications. As part of this program we are also developing new electrolyte materials and printed sensor designs to enhance performance (e.g., sensitivity, detection limit, environmental stability, etc.) of these sensors relative to current state-of-the-art. A second thrust has been the development of electronic hardware, firmware and smartphone apps to support the sensors in fixed site (home alarm) and wearable applications. We have identified and characterized a number of promising electrolytes which provide unprecedented performance for the amperometric sensor in measurement of ozone and related atmospheric pollutants. Also low power, small electronic platforms have been developed that can be used for fixed or wearable applications. This poster will present our recent efforts in the sensor and hardware development areas that are supported by NIEHS SBIR programs.

21. Personal Airborne Particulate Sampling Device

Joseph Caruso, *Wayne State University*
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Abstract:
Asthma is a chronic lung disorder characterized by airflow obstruction, bronchial hyper-responsiveness, and inflammation. Detroit's overall rate of asthma is 3 times higher than the state of Michigan's, and over 15% of the city's population will be affected by this disease in their lifetimes. Routine air monitoring indicates that Detroit ranks as one of the most polluted U.S. cities for particulate matter that is equal to or less than 2.5 µm in diameter (PM2.5), however, less is known about the bioactivity of individual particulate matter components. An average person inhales about 10,000 liters of air each day, at home, along commutes, while participating in outdoor activities, and during school or work. Most of the current literature utilizes modeling to estimate air pollution exposure, but this approach does not capture an individual's daily journey. Our main objective is to determine whether an inexpensive custom-built wearable personal air monitoring device can be used to determine asthma-related outcomes in a cohort of Detroit teenagers. An ideal personal air monitoring device would be small and wearable, have the ability to collect a wide range of allergens and toxicants, inexpensive such that a larger number of long-term field deployments can be performed without worry of equipment loss or damage, and have the accuracy and precision necessary for reliable exposure analysis. The personal airborne particulate sampling device we have developed meets these criteria. Some of its features include: footprint of a cellular phone and therefore small enough to wear on a belt loop or placed in a purse or backpack; it is designed to run 24 h per day for the duration of the study period; it collects PM material on 25 mm filters within swappable cartridges at 1-2 liters of air per minute; an airflow sensor compensates for obstructions to maintain continuous flow; and an accelerometer records active versus passive sample collection. This project incorporates the principles of participatory research, with teens having input into device and study design and the responsibility for data collection. The long term goal of this project is to work towards personalized preventative environmental health applications.

Contributing Developers:
Ao Yu, *Wayne State University*
Chin-An Tan, *Wayne State University*

22. Towards Point-of-Care Management of Chronic Respiratory Conditions: Electrochemical Sensing of Nitrite Content in Exhaled Breath Condensate Using Reduced Graphene Oxide

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Abstract:
We present a portable non-invasive approach for measuring indicators of inflammation and oxidative stress in the respiratory tract by quantifying a biomarker in exhaled breath condensate (EBC). We discuss fabrication and characterization of a miniaturized electrochemical sensor for detecting nitrite content in EBC using reduced graphene oxide. Nitrite content in EBC has been demonstrated to be a promising biomarker of inflammation in the respiratory tract, particularly in asthma. We utilized the unique properties of reduced Graphene Oxide (rGO) in that the material is resilient to corrosion while exhibiting rapid electron transfer with electrolytes allowing for highly sensitive electrochemical detection and minimal fouling. Our rGO sensor was housed in an electrochemical cell fabricated from Polydimethyl Siloxane (PDMS), which was necessary to analyze small EBC sample volumes. The sensor is capable of detecting nitrite at a low over-potential of 0.7 V with respect to Ag/AgCl reference electrode. We characterized the performance of the sensors using standard nitrite solutions in buffer, nitrite spiked into EBC, and also clinical EBC samples. The sensor demonstrated a sensitivity of 0.21 µA µM-1 cm-2 in the range of 20-100 µM and 0.1 µA µM-1 cm-2 in the range of 100-1000 µM nitrite concentration with a low detection limit of 830 nM in the EBC matrix. To benchmark our platform, we tested our sensors using seven pre-characterized clinical EBC samples with concentrations ranging between 0.14-6.5 µM. This enzyme-free and label-free method of detecting biomarkers in EBC can pave the way for development of portable breath analyzers for diagnosing and managing changes in respiratory inflammation and disease.

Contributing Developers:
Azam Gholizadeh, *Rutgers University*
Damien Voiry, *Rutgers University*
Andrew Gow, *Rutgers University*
Robert Laumbach, *Rutgers University*
Howard Kipen, *Rutgers University*
Manish Chhowalla, *Rutgers University*
Mehdi Javanmard, *Rutgers University*

23. AROMA TCE Analyzer

Bruce Richman, *Entanglement Technologies*
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Abstract:
The AROMA ultra-trace vapor analyzer is a new approach to the detection of volatile and semi-volatile chemicals at part-per-trillion concentrations in a compact portable instrument. The AROMA instrument combines Cavity Ringdown Spectroscopy with unique physical separation technologies to provide rapid, selective, sensitive detection. The AROMA platform has been field deployed to detect TCE for vapor intrusion, sewer pathway evaluation, soil gas studies, and benzene for mobile and fixed source detection. The present platform has a limit of detection for TCE at 20 pptv and for Benzene at 50 pptv in a 15 minute measurement. The optical foundation of the AROMA instrument promises extremely compact, robust, and stable instrument with performance to rival fixed laboratory analyses.

Contributing Developers:

Anthony Miller, *Entanglement Technologies*
Ricardo Viteri, *Entanglement Technologies*
Michael Armen, *Entanglement Technologies*

24. Wristband Chemical Sampler

Kim Anderson, *Oregon State University*
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Abstract:
An easily worn wristband that passively samples organic chemicals. Frequently asked questions are answered at: http://fses.oregonstate.edu/faq-page and technical attributes are described at: http://fses.oregonstate.edu/wb-technical.

Contributing Developer:
Steven O'Connell, *Oregon State University*

25. Science Take-Out: Environmental Health Education in a Bag!

Katrina Smith Korfmacher, *University of Rochester*
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Abstract:
In 2014, the COEC partnered with Science Take-Out on an NIEHS-funded Phase I STTR grant, "Science Take-Out Kits for Environmental Health Education" (1 R41 ES023706-01). This project developed a series of hands-on environmental health science kits for use in formal (middle/high school) and informal educational settings. Science Take-Out is a University of Rochester start-up company that was created in 2008 to disseminate educational materials developed by the UR's Life Sciences Learning Center. Science Take-Out kits are fully assembled "labs in bags" that require no teacher prep and no additional lab equipment. They provide teachers with a convenient and cost-effective way to infuse engaging hands-on wet lab and manipulative modeling activities into their existing curriculums. The COEC and Science Take-Out staff first generated 21 different environmental health kit ideas, and then used survey responses from 432 teachers to narrow these to a list of nine prototype kits based on important environmental health concepts, connections to teachers' existing curriculums, and relevance to students' lives. Each of these prototype kits was reviewed by a focus group of area secondary school teachers, whose feedback was used to refine the kits and select the top eight kits for pilot testing. Kit topics include: antimicrobials, pesticides, breast cancer, lead, lung disease, healthy homes, skin cancer, and water quality. Almost 700 teachers from throughout the U.S. volunteered to pilot test the kits; of these, 32 were selected to conduct pilot testing starting in February 2015. The pilot testing results were incorporated in the final editing of the new environmental health kits, which are now in production. At each stage of review, the COEC provided feedback on accessibility and community relevance of materials. Over the past year, we have worked with outreach programs around the country to pilot several of these kits in informal community education settings. STO and the COEC plan to continue to adapt these kits to produce versions appropriate for diverse community settings and audiences. STO-EH kits may be used to support citizen science initiatives by introducing participants to scientific concepts, technologies, and health issues related to their interests. This sensor session will provide an opportunity to interact with the STO kits and provide feedback on adaptation of the kits for various community groups.

Contributing Developers:
Dina Markowitz, *University of Rochester*
David Chang, *WEACT*

26. Low-Cost Personal Aerosol Sampler and Sensor System

Charles Henry, *Colorado State University*
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Abstract:
Wearable Air Sampling Technologies: The Ultrasonic Personal Aerosol Sampler (UPAS) is a time-integrated PM2.5 monitor that weighs 190g, emits under 40 dB of noise, and can operate continuously for 48 or 24 hr on a single battery charge at either 1 or 2 L/min of flow, respectively. The UPAS has been tested for pump and battery performance, flow accuracy, sampling efficiency, and validated through chamber and field tests against gold-standard reference methods for PM2.5. The UPAS cyclone inlet performed within 5% of the EPA federal reference method (FRM) for PM2.5. Chamber tests relative to the FRM sampler showed low bias (accuracy of 5.5 +/- 4.8% at one standard deviation), good precision (6.1% relative standard deviation among co-located devices), and high linearity across a broad range of PM2.5 concentrations (20-1000 ug/m3). The Automated Microenvironmental Air Sampler (AMAS) is similar in design to the UPAS but utilizes three filter channels with various location-activity sensors to assess personal exposure as a function of microenvironment. The goal of both sampler designs was to replace large, heavy, and relatively loud exposure assessment technology with quiet, wearable devices for use with children. Simple, Low-Cost Methods for Analyzing PM Composition: We have developed a series of microfluidic devices that can measure metals and oxidative reactivity of PM2.5 collected on air sampling filters. To measure metals, we have developed electrochemical paper-based analytic devices (ePADs). In these devices, electrodes are printed onto inexpensive paper substrates but are able to achieve detection limits of <1ppb (0.05ng/m3) for heavy metals like Pb and Cd. We can also adopt the chemistry used to measure other metals, including Cu, Ni, and Mn with detection limits ranging from 10-50 ppb (0.1-0.5 ng/m3). Measurements of PM have been validated against ICP-MS and showed no statistical difference in results even though the sensors cost <$1/test. We have also developed an electrochemical flow cell to measure aerosol oxidative reactivity using a variation of the dithiothreitol (DTT) assay. In the traditional DTT assay, PM reacts with reduced DTT to form the oxidized disulfide. To determine reactivity, the remaining reduced DTT is mixed with Ellman's reagent to generate a product that can be quantified using absorbance spectroscopy. The method is laborious, has limited time resolution, and cannot be used for on-line measurements. We have developed a method using a commercially available electrochemical cell that can measure DTT concentrations directly without additional reactions in a manner that is well suited for automated and/or real-time measurements. The measurement can be performed for filter samples or on-line measurements when coupled with a Particle-Into-Liquid-Sampler (PILS). The method was validated against the traditional spectroscopic method and found to give statistically similar results.

Contributing Developers:
John Volckens, *Colorado State University*
Casey Quinn, *Colorado State University*
Jaruwan Mettakoonpitak, *Colorado State University*
Daniel Miller-Lionberg, *Access Sensor Technologies*
Kevin Klunder, *Colorado State University*
Laurelle Turner, *Colorado State University*

27. Nanofiber Based VOC Sensor for Vapor Intrusion Applications

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Abstract:
Vapor intrusion (VI) refers to migration of volatile organic compound (VOC) vapors from underground sources into indoor air. Chlorinated VOCs such as dry cleaning and industrial degreasing solvents (e.g., trichloroethylene [TCE]; tetrachloroethylene [PCE]) are of particular concern because they are resistant to biodegradation and have high toxicity. Also recent studies suggest that short term concentration spikes can contribute significantly to long term exposure through the VI pathway. These concerns have created a need for cost-effective real-time monitoring of VOCs at VI sites, which is also reflected by a similar need for real-time outdoor air measurements of low concentration VOCs. Traditional methods (e.g., Method TO-15, passive methods) do not provide the temporal resolution for short-term monitoring, have relatively high costs, and do not provide real-time signaling when VOC levels rise indoors or outdoors. In this presentation we describe a low-cost, real-time VOC sensor recently developed by RTI that can detect chlorinated VOCs in air at the low concentrations of concern for cancer risk and developmental effects. The RTI VOC sensor has been demonstrated to be sensitive to both TCE and PCE down to sub-ppb levels (e.g., 0.03ppbv TCE) and has a fast response time (< 7 minutes) for both compounds. The relatively low cost of current prototype sensor (<$100 for the parts) and small dimension of the device (< 50g) makes it attractive and potentially suitable for large field applications at VI sites or for other environmental problems where air VOC concentrations are of concern. Side by side studies with TO-15 and passive samplers will be described for testing of this novel sensor, along with specific deployment plans for multiple real-time sensor use at large VI sites. Uses as an outdoor air measurement device will also be described.

Contributing Developers:
Robert Truesdale, *RTI International*
Chris Lutes, *CH2M Hill*
James Carlson, *RTI International*
Laura Haines, *RTI International*

28. Pocket-sized Device for Personal Exposure

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Abstract:
It is known that the environment we are exposed to can have a profound impact on our health. According to a report by the World Health Organization, environmental factors play a role in more than 80% of the diseases and contributing to nearly a quarter of all deaths worldwide. However, the interplays between environmental factors and exposure levels, exposure level and biological responses are still largely unknown. Some of the major challenges include 1) highly variable personal exposure levels to different pollutants, and 2) individual's genetic uniqueness and susceptibility to varying degrees of exposure levels and types of exposure. Environmental protection agencies have stationary monitoring stations providing data with rough spatial resolution, failing to capture individuals and settings specific (e.g. home, school, playgrounds) exposures. Many current portable technologies are large, expensive, and difficult to use. Our sensor addresses many of these challenges by providing a volatile organic compound monitoring solution to track personal exposure in a small (size of a deck of cards), affordable (cost of few hundred dollars with a replaceable sensor for $5), and user-friendly (cell phone interface) unit. We have demonstrated the reliability and performance of the device in multiple field applications including traffic pollutants, chemical plants air quality, fire overhaul, and home indoor air quality monitoring.

Contributing Developers:
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29. Mobile Environmental Exposure Personal Sensors (MEEPS)

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Abstract:
The objective of our NIH Grant is to develop real-time personal exposure sensor arrays to detect environmental airborne pollutants containing multiple stressors, and determine the causative relationship between exposure and respiratory health effects. Heterogeneous detectors comprising functionalized carbon nanotube (CNT) thin films deposited between interdigitated capacitive electrodes on common electronic substrates, such as FR-4 and glass, are being designed. The sensor board will be interfaced through a microcontroller and associated signal conditioning circuitry to a stand-alone LCD display, a laptop or a mobile device such as a smart phone. We plan to target the detection of ambient ozone in Phase 1, particulate matter (PM) and volatile organic compounds (VOCs) in Phase 2. CNT sensors offer sensitivity, compactness and fast response (e.g., less than 3 minutes for 100 ppm ammonia), and provide a versatile, extendable platform to incorporate accurate monitoring of several EPA criteria air pollutants, known to cause acute respiratory morbidity. The novelty of our approach lies in utilizing the unique electronic properties of single-walled nanotubes (SWNTs) and the tremendous potential to modulate their sensitivity using tailored chemical functionalization to adsorb specific molecules. The sensing element coated with SWNTs produces a positive (negative) electrical signal if the analyte under detection donates (accepts) electrons due to chemical reaction between the nanotubes at the film surface and the analyte. Secondly, instead of a conventional chemisresitor used in various nanomaterial-based sensors reported in literature, we utilize an interdigitated capacitor and measure the AC voltage (as opposed to DC) and characterize the detection event using two degrees of freedom. We believe that our patent-pending innovation will reduce the cross-sensitivity of the sensor. Phase 1 research develops an ozone exposure detector array, fabricated using two classes of nanosensors: (a) polybutadiene polymer-functionalized CNT thin-films, (b) CNT thin-films decorated with Pt or Pd metallic nanoparticles. Both offer maximum sensitivity to ozone while reducing cross-sensitivity to interferents such as NOx. We are currently prototyping the sensor array and associated electronics circuitry and calibrating the sensors in the laboratory under controlled gas flow conditions. We anticipate demonstration of salient features of the sensor functionality at the Conference, perhaps measuring either ambient ozone or ammonia using MEEPS and displaying relevant output on an LCD screen or a mobile phone. In Phase 2, pilot tests will be conducted on human volunteers to detect ambient ozone as a function of time over several days and determine causative relationships by measuring exhaled nitric oxide (eNO) concentration in the breath following the exposure.

Contributing Developers:
Elena Bekyarova, *Carbon Solutions Inc.*
Neil Hardy, *Georgia Institute of Technology*

30. Micro-Well Aerosol Collector for In-Situ Sample Analysis

Igor Novosselov, *University of Washington*
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Abstract:
Aerosol sampling and identification is vital for assessment and control of particulate matter pollution, airborne pathogens, allergens and toxins, and their effect on air quality, human health and climate change. In-situ analysis of chemical and biological airborne components of aerosol on a conventional filter is challenging due to dilute samples and not well-defined collection region. A micro-well aerosol collector is developed and evaluated for a collection of airborne PM in the 0.5-5 micron range. The design minimizes the particle collection area for in-situ optical analysis and provides increased limit of detection for liquid based assays due to the high concentration of the analyte in the elution/analysis volume. The design of the collector is guided by the computational fluid dynamics (CFD) modeling; it combines an aerodynamic concentrator inlet that focuses the aspirated aerosol into a narrow beam and a micro-well collector that minimizes particle scatter on the collection substrate. The optimization of the geometry and the operational conditions result in high concentration of collected particulate matter (PM) in the submillimeter region inside the micro-well. Collection efficiency experiments are performed in the aerosol chamber using fluorescence microspheres to determine the performance of the collector. The dependency of particle size and the sampling flow rate on the collection efficiency is investigated. Typical collection efficiencies in the micro-well are above 50 % for flow rates of 1 slpm. The sample can be eluted from the collector using a standard pipette, the elution volume of 10-20 microliters. The transparent collection substrate and the well-defined collection region independent of particle size allows for in-situ optical analysis of the collected PM.

Contributing Developers:
Jiayang He, *University of Washington*
Edmund Seto, *University of Washington*
J. Scott Meschke, *University of Washington*
Nicola Beck, *University of Washington*

31. Real-Time Methodology for Manganese Analysis in Blood and Water

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Abstract:
Analyses methods for manganese in blood and water are limited to high-cost laboratory technology. Current approaches for determining exposure require extensive labor, equipment and long turnaround times for results. Thus, our team has undertaken development of a rapid, point-of care, multi-analyte assessment for manganese and lead in both water and whole blood. A relatively swift, simultaneous assessment of heavy metal exposure, which ultimately reduces costs and turnaround times, would benefit pediatric public health nationally and internationally. Indeed, our long-term goal is to use sensors to move analysis from the laboratory to the clinical setting, providing results within minutes. We developed a sensor concept that integrates striping voltammetry electroanalytical technique with microfluidics, with detection limits in the low ug/L range. We conducted a pilot study to determine Mn in pond water from Burnet Woods, Cincinnati, OH, and well drinking water samples collected from different sites in Marietta, OH (which is home to a ferromanganese processing plant). Analyses were performed by diluting samples 2O into pH 5 using a pH 5.5, 1 M acetate buffer, and adding three spikes for the standard addition method. In these samples (n=7), the mean accuracy was 89.4% with mean precision of 97.2%, as compared with ICP-MS "gold standard" measurement by a reference lab. While we are still optimizing parameters for determination of Mn in whole blood, the preliminary results suggest that determination of <50 ug/L Mn is possible using hot-block digestion. In conclusion, we demonstrated determination of trace Mn in different matrices using an improved point-of-care electrochemical sensor. The performance of this simple, low-cost sensor is comparable with the conventional ICP-MS method for determination of Mn in water. Ultimately, we believe this sensor system could act as a simple, fast and low-cost alternative for point-of-care applications in local clinics or resource-limited settings.

Contributing Developers:
William Heineman, *University of Cincinnati*
Erin Haynes, *University of Cincinnati*

32. Validation of Environmental Sensors for Personal Monitoring and Citizen Science Studies

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Abstract:
Low-cost commercially available air quality sensors offer numerous opportunities for personal exposure and community-engaged Citizen Science studies. We present two systems: one which utilizes sensors for wearable applications and another which utilizes sensors for stationary field deployments. The wearable system utilizes low-cost PM counters, PM collection, and GPS to characterize personal exposures in space and time. We present data from a usability study that was utilized to refine the design of this wearable system. The stationary system consists of an Internet-connected platform that can read data from a variety of modular sensors, including PM sensors, VOC, and electrochemical traffic-related air pollution gas sensors. We describe our platform and three case studies based in California (Imperial County, Oakland, and San Diego) in which the system has been used in community-engaged research. In order to address sensor quality concerns, and the need to establish best-practices for deploying low-cost sensor technologies, in each of these field studies, the sensors were co-located and calibrated against regulatory reference instruments.

Contributing Developers:
Graeme Carvlin, *University of Washington*
Elena Austin, *University of Washington*
Jeffry Shirai, *University of Washington*

33. Personal Ultrafine Particle Counter

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Abstract:
Though ultrafine particles (UFP), those less than <0.1 micron contribute very little to overall mass, these particles can be very high in number and corresponding total surface area reaching several hundred thousand in number per cm3 in air. Furthermore, animal studies show that UFP administrated to the lung cause greater inflammatory response than do larger particles per given mass and have high size-specific deposition when inhaled. Largely escaping alveolar macrophage (compared to larger particles) UFP gain access to the pulmonary interstitium and circulatory system. UFP penetrate the upper airways and nasal olfactory nerve and cross the blood-brain barrier. In addition, studies show that UFP toxicity can be significantly enhanced when acting as adjuvants to gaseous co-pollutants and toxic metals. Thus, because of the toxicity of UFP, a NIH birth cohort study was undertaken by the founders examining the health effects of exposure to diesel exhaust particles of which 92% are UFP. This study revealed that higher exposures were associated with wheezing at age 1 and asthma at age 7. These and other findings were the impetus for the NIH recognizing the need for personal nanoparticle counter. The PUFP counters (C200 & C100) are water based condensation particle counters (CPC) that are relatively small ranging from 900-1500 cm3 (including rechargeable lithium polymer batteries) and weighing between 0.75-1kg. Battery operation is from 3.3-6 hours. These units are able to provide ongoing single particle count measurement from any geometrical position under sustained mobile conditions, high gravitational force (+4-gravitational acceleration), and can be turned upside down and jostled while maintaining pinpoint accuracy. The PUFP counters identify real-time (300msec+ 30%) and precise point sources of particle contamination from up to 200,000 particles/cc under complex and varied environmental sampling conditions. It stores data to a MicroSD card, and the sensors are GPS enabled, have wireless Bluetooth interface and are linked to Enmont EView software. The Enmont PUFP counters are differentiated from other sensors because of the patented (US8448657B2) proprietary technology in the design of an evaporation-condensation tube. Human, community and occupational testing: In order to test the ruggedness and sustainability of the PUFP counters, 25 children age 10 wore these at home and to and from school while walking or riding in buses and cars. The PUFP was found to be rugged and easy to operate under sustained use. Data will be presented also demonstrating how the PUFP can be used to measure air pollution corridors and “hot spots”; in cities as well as in occupational environments to measure peak levels of UFP.

Contributing Developers:
James Lockey, *Enmont LLC and the University of Cincinnati*
Grace LeMasters, *Enmont LLC and the University of Cincinnati*