Program on Occupational Health and Safety Education on Emerging Technologies - Mid Atlantic Partnership (POccETMAP)

1R25ES033038-01 – Funded by NIEHS; Dates: 9/1/2021 – 8/31/2026

Johns Hopkins University, Gurumurthy Ramachandran, Principal Investigator

University of Maryland, Amir Sapkota, Co-Investigator

George Mason University, Anna Pollack, Co-Investigator

Old Dominion University, James Blando, Co-Investigator

The program's ***objective*** for the proposed funding period is to develop a comprehensive set of web-based educational modules in OHS, with emphasis on applications in emerging technologies, emerging contaminants, and disaster preparedness.

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Key Personnel

Detection Technologies

Peter DeCarlo
Associate Professor,
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Carsten Prasse,
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Vulnerable Occupational Populations

Anna Pollack,
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Exposure assessment and mitigation

Meghan Davis,
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James Blando,
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Disaster Preparedness

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Dan Barnett,
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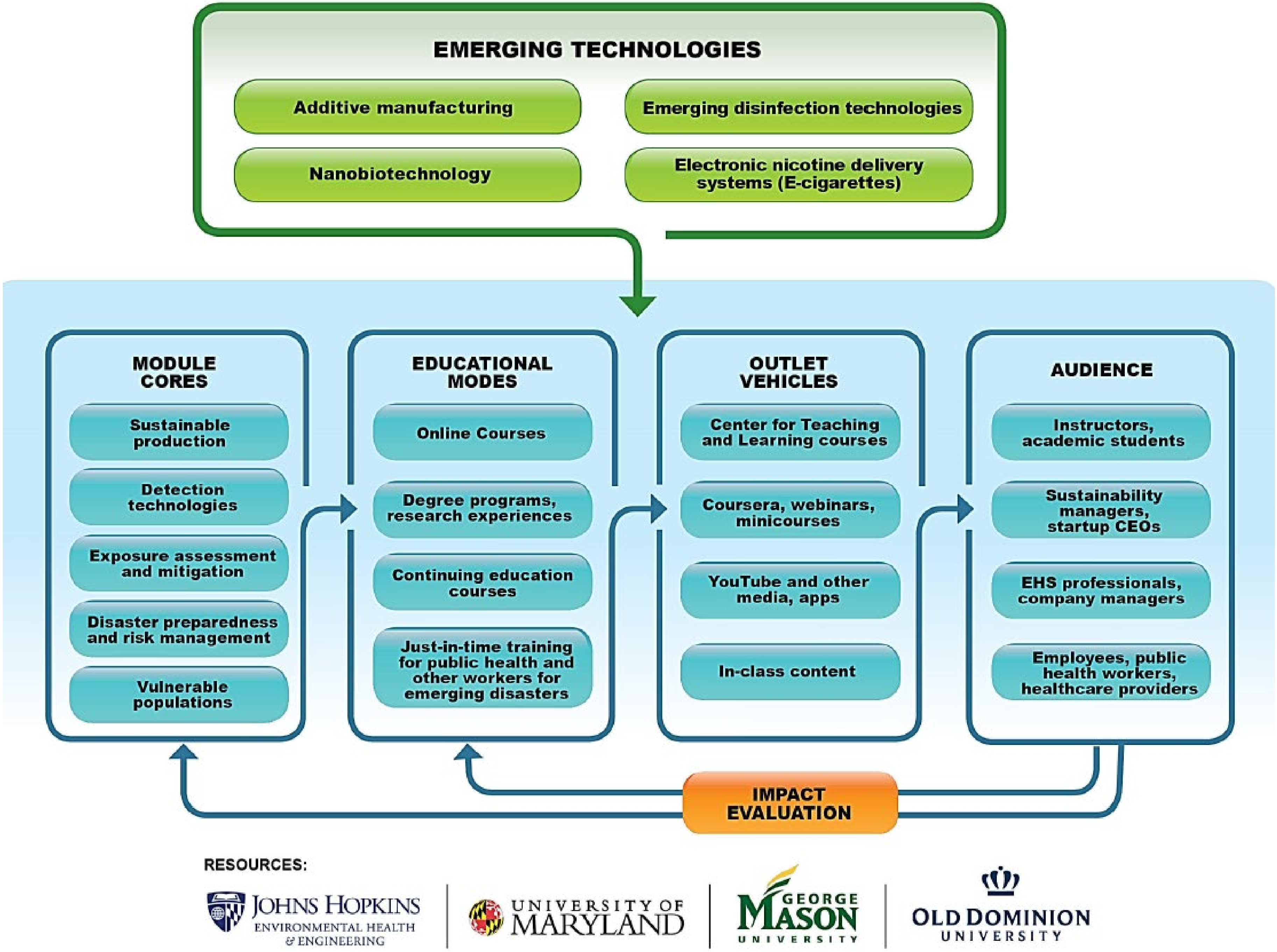
Professor, JHU

Sustainable Production

Ana Rule, Assistant
Professor, JHU

G. Ramachandran,
Professor, JHU


EMERGING TECHNOLOGIES
Additive manufacturing
Emerging disinfection technologies
Nanobiotechnology
Electronic nicotine delivery systems (E-cigarettes)
MODULE CORES
Sustainable production
Detection technologies
Exposure assessment and mitigation
Disaster preparedness and risk management
Vulnerable populations
EDUCATIONAL MODES
Online Courses
Degree programs, research experiences
Continuing education courses
Just-in-time training for public health and other workers for emerging disasters
OUTLET VEHICLES
Center for Teaching and Learning courses
Coursera, webinars, minicourses
YouTube and other media, apps
In-class content
AUDIENCE
Instructors, academic students
Sustainability managers, startup CEOs
EHS professionals, company managers
Employees, public health workers, healthcare providers
IMPACT EVALUATION
RESOURCES:
JOHNS HOPKINS ENVIRONMENTAL HEALTH & ENGINEERING
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GEORGE MASON UNIVERSITY
OLD DOMINION UNIVERSITY

Specific Aim 1

- Develop **five online cores** for professional training of OHS specialists, engineers, scientists, technicians, and instructors in the areas of
  (a) **Detection Technologies** for emerging contaminants;
  (b) **Exposure assessment and mitigation** strategies;
  (c) **Disaster preparedness** and risk management;
  (d) **Vulnerable occupational populations; and**
  (e) **Sustainable production** and product stewardship of emerging technologies.

Each core will contain 10 web-based modules. Each module will consist of a set of short learning objectives that can each be completed in about one hour.
Total = 50 modules in 5 years.

POccETMAP YouTube Channel

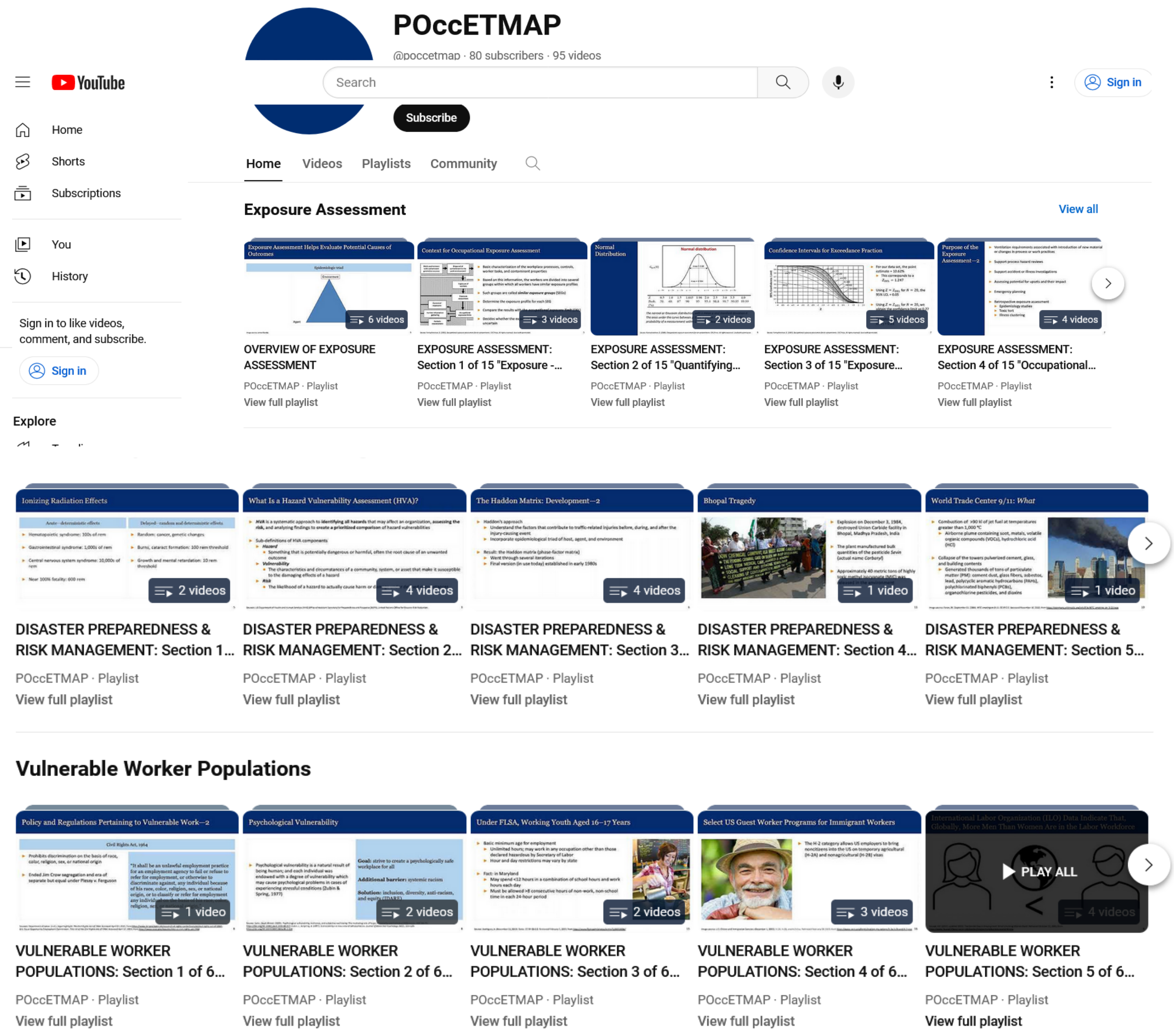
POccETMAP
Program on Occupational health and safety education on Emerging Technologies – Mid Atlantic Partnership

https://www.youtube.com/@poccetmap

81 subscribers

Module Area	Number of Videos	Views (as of 4/26/2024)
Exposure Assessment	71	2392
Disaster Preparedness	13	2549
Vulnerable Populations	13	177
Detection Technologies	5	90

Video times range from 10-25 minutes



Non-Target Analysis

Non-Target Analysis

- What makes NTA challenging
  1. The chemicals are not included in established libraries or databases
  2. Presence of the chemical in the sample is not known *a priori*
- Analytical approaches to elucidate the chemical space:

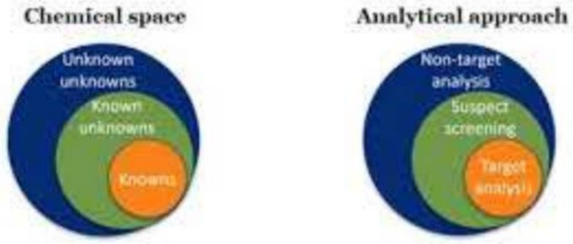


Image source: Carsten Prasse

Applications of Non-Target Analysis

Example: Chemical Exposures of Hairdressers—3

Level 1 Annotation	DTXSID	Neutral formula	Neutral exact mass	Median peak area ratio
Methylparaben	DTXSID4022529	$C_8H_8O_3$	152.04734	6.30
Capsaicin	DTXSID9020241	$C_{18}H_{27}NO_3$	305.19909	3.46
2-Naphthol	DTXSID5027061	$C_{10}H_8O$	144.05751	3.16
Ethylparaben	DTXSID9022528	$C_9H_{10}O_3$	166.06299	2.28
Propylparaben	DTXSID4022527	$C_{10}H_{12}O_3$	180.07864	2.00

Level 2 Annotation	DTXSID	Neutral formula	Neutral exact mass	Median peak area ratio
Oleamide	DTXSID6027137	$C_{18}H_{35}NO$	281.27186	2.05
Eicosapentaenoic acid	DTXSID9041023	$C_{20}H_{30}O_2$	302.22458	1.92
Isoquinoline	DTXSID2047644	C9H7N	129.05785	1.85

- Among the compounds detected, only five could be confirmed using commercially available reference standards (Level 1), while the identity of three additional compounds was tentatively identified with high confidence based on online database matches (Level 2)
- **The identity of the majority of detected compounds remains unknown**

Decontamination Techniques

Disinfection or Decontamination Technologies

- Disinfection technologies: processes and technologies that inactivate, remove, or kill microbes
- Examples:
  - Germicidal ultraviolet radiation (GUV or UV)
  - Hydrogen peroxide vapor systems
  - Steam sterilization and other temperature/pressure-based methods (e.g., pasteurization)
  - Water disinfection technologies
    - Physical and chemical processes (filtration, adsorption, coagulation, precipitation)
    - Photochemical processes (UV-A, UV-C, solar)
    - Electrochemical oxidation

Source: [illegible] (2021). A review on disinfection technologies for controlling the antibiotic resistance spread. *Science of the Total Environment*, [illegible]

Uncertainty Analysis

Uncertainty and Acceptability—1

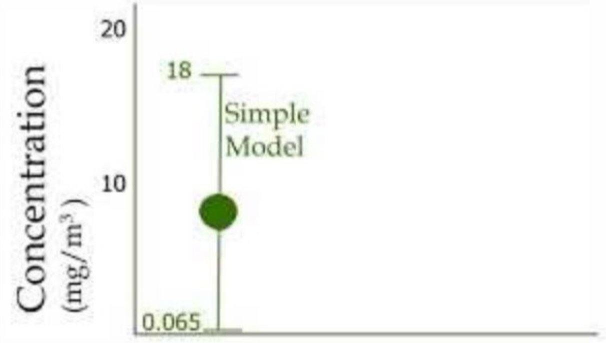


Image source: Created by G. Ramachandran

Specific Aim 2

- **Use the modules in the online cores to:**

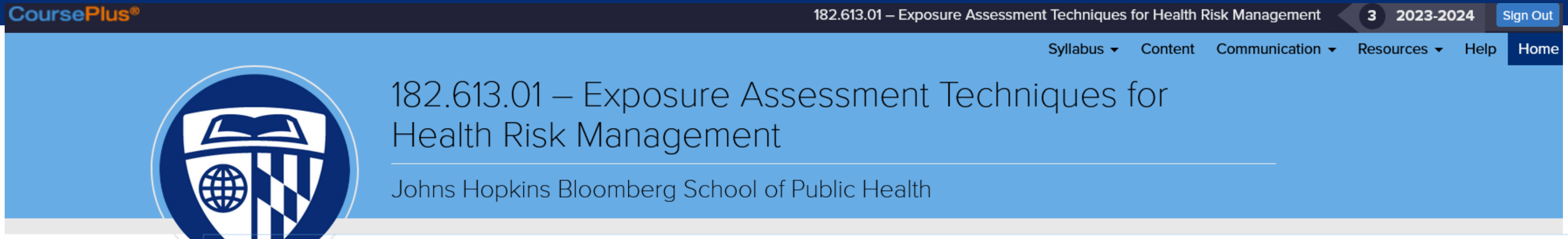
(a) Enrich the OHS curricula by offering blended learning courses that emphasize applications of OHS principles to the study of emerging technologies**;**

(b) Develop a new Online Master's program in Product Stewardship and sustainable production of emerging technologies;

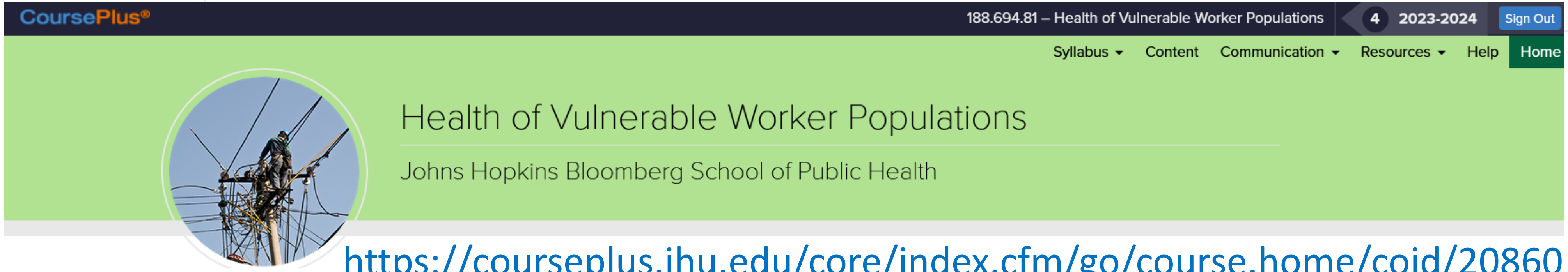
(c) Use the modules to provide **just-in-time training** in disaster preparedness **for frontline workers** in local and state departments of health and healthcare workers;

(d) Create **continuing education** courses for professionals and instructors in OHS applicable to emerging technologies and **outreach** to workers.

Enriching Curricula:
Incorporating POccETMAP Materials into JHU Courses



https://courseplus.jhu.edu/core/index.cfm/go/course.home/coid/20521/



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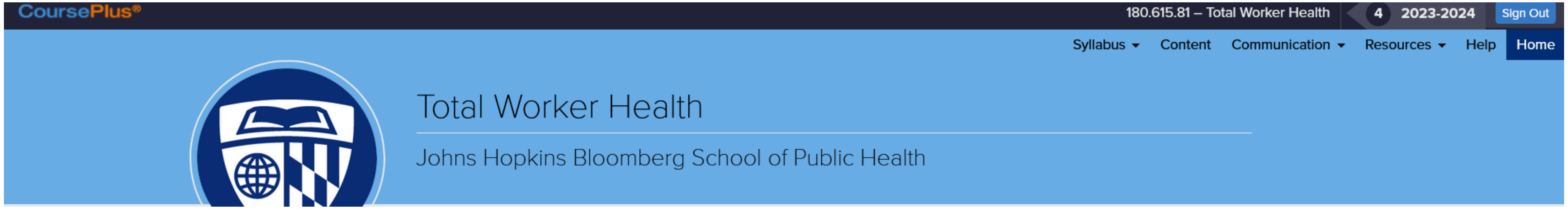
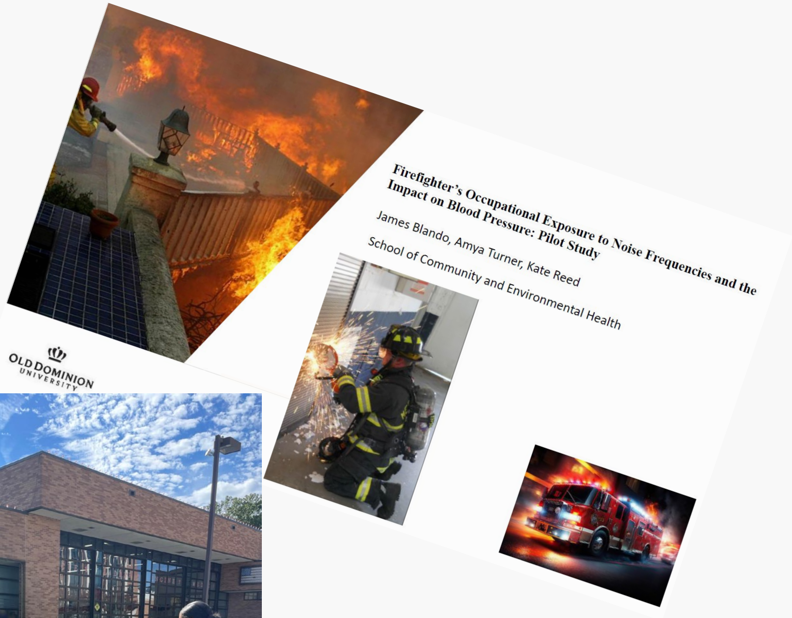


https://courseplus.jhu.edu/core/index.cfm/go/course.home/coid/20832/

Enriching Curricula: Old Dominion University

- May 11 – 25th, 2024, Jim Blando traveling to Kyrgyzstan for Fulbright Specialist Project to work with the International School of Medicine and the Ministry of Health – will demonstrate POccETMAP utility to collaborators and encourage use and program incorporation
- POccETMAP modules utilized in MPHO 632 Environmental and Occupational Risk Assessment course, especially the modules on Exposure Assessment Overview and module on Exposure Management (taught each year, roughly 20 students per semester)
- Currently developing module on exposure to physical agents – noise; undergraduate (Amya Turner) and MPH student (Kate Reed) involved in development and utilized knowledge to conduct noise surveys among firefighters
  - Students also conducting research on noise effects among firefighters

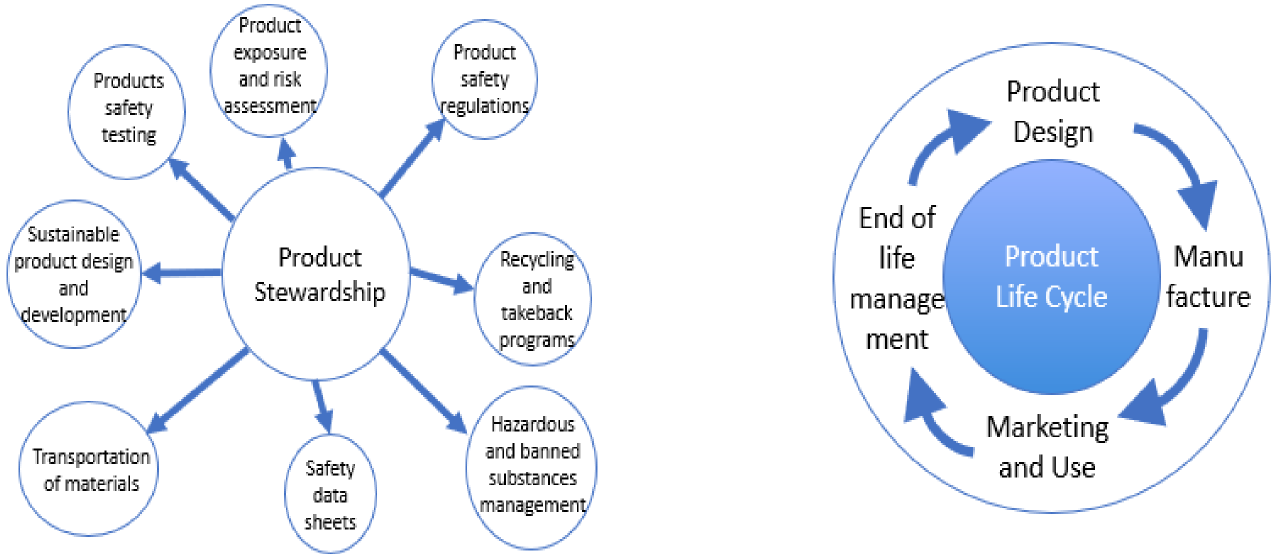


Amya Turner collecting noise measures for inclusion in Module on physical agents – noise exposure

Product Stewardship Certificate

- Responsible management of the health, safety, and environmental aspects of raw materials, intermediate, and consumer products throughout their life cycle and across the value chain in order to prevent or minimize negative impacts and maximize value

Product Life Cycle Model



Product stewardship requires that a company manage its products from their inception to disposal (cradle to grave).

Health, safety, and environmental protection should be an integral part of the design, purchasing, manufacture, distribution, use, recycling, and disposal of products

Outline of Program

- Entirely online, 18 term credit program.
- Designed for junior, mid-level, and executive-level professionals (non-degree students) desiring to expand their knowledge of product stewardship to advance their careers.
- Backgrounds including environmental health, regulatory compliance, industrial hygiene, occupational health and safety, sustainability, engineering, chemistry, toxicology, product development, supply chain, and law.
- Also open to masters and doctoral degree students and post-doctoral trainees at JHSPH and WSE.

Program Requirements

No.	Course Title	Credits	Online Term
N/A	Introduction to Online Learning	0	1, 2, 3, 4, S
550.860	Academic & Research Ethics at JHSPH	0	Any

Two of these three EP courses

No.	Course Title	Credits	Online Term	Areas
317.600	Introduction to the Risk Sciences and Public Policy	4 cr (term)	3	Risk Assessment
EN 535.662	Energy and Environment (online)	3 cr semester (4.5 term cr)	Fall Semester	Life Cycle Analysis
EN 575.736.	Designing for Sustainability: Applying a Decision Framework (online)	3 cr semester (4.5 cr)	Fall Semester	Sustainability
EN 575.623	Industrial Processes and Pollution Prevention (online)	3 cr semester (EP) (4.5 cr)	Fall Semester	Manufacturing/Engineering principles
180.628	Intro. to Environmental & Occupational Health Law	4 cr (term)	4	Environmental Law
187.640	Toxicology 21: Scientific Foundations	1 cr	2	Regulatory Toxicology

Potential courses for MS Program

Technical Competency	Courses
Basic Sciences (Prerequisites)	Chemistry, organic chemistry, physics, biology, anatomy, physiology, statistics, mathematics
Toxicology:	PH.187.610 Public Health Toxicology (4 cr) or EN.575.619 Principles of Toxicology, Risk Assessment & Management (online)
Environmental Chemistry	EN.575.744 Environmental Chemistry
Exposure Assessment and Control	PH.182.613 Exposure Assessment Techniques for Health Risk Management (3 cr)
Risk Assessment	PH.317.600 Introduction to the Risk Sciences and Public Policy (4 cr)
Sustainability	575.736. Designing for Sustainability: Applying a Decision Framework
Product Safety testing	EN.575.619 Principles of Toxicology, Risk Assessment & Management
Hazardous waste management	EN.570.691 Hazardous Waste Engineering and Management

Regulatory Competency	Courses
Environmental Law	Intro. to Environmental & Occupational Health Law (4 cr) 575.435 - Environmental Law for Engineers and Scientists
Regulatory Toxicology	Toxicology 21: Scientific Foundations (1 cr)

Professional Competency	Courses
Economics/Public policy	575 . 411 - Economic Foundations for Public Decision Making
Financial Management	575 . 710 - Financing Environmental Projects
Risk Management	PH.317.610 Risk Policy, Management and Communication (3 cr)

Electives

575 . 711 - Climate Change and Global Environmental Sustainability
188.682. A Built Environment for A Healthy and Sustainable Future.
575 . 733 - Energy Planning and the Environment
575.723. Sustainable Development and Next Generation Buildings
420.610. Sustainable Business
575 . 408 - Optimization Methods for Public Decision Making
575 . 411 - Economic Foundations for Public Decision Making
575 . 423 - Industrial Processes and Pollution Prevention
575 . 435 - Environmental Law for Engineers and Scientists
575 . 437 - Environmental Impact Assessment
310.708. - Sustainable Finance and Impact Investing
575 . 759 - Environmental Policy Analysis
615 . 448 - Alternate Energy Technology

CE Credit for OSH Professionals

Training primarily targeted to:

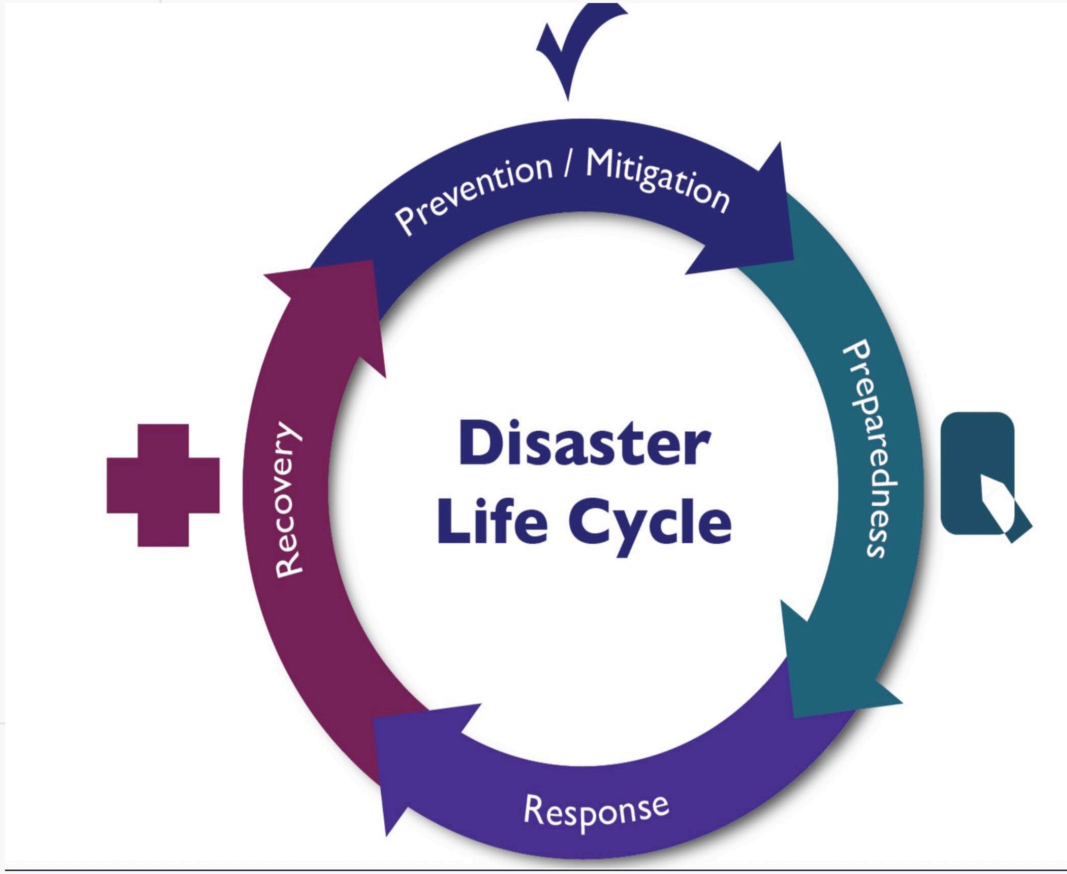
- Physicians, Physician Assistants, Nurses, Nurse Practitioners, Industrial Hygienists (7 credentials), Safety Professionals (10 credentials) and Hazardous Materials Management/ Dangerous Goods Transportation Professionals (12 credentials).
- Modules are free
- Registration though CoursePlus on Hopkins website which will administer quiz, evaluation and provide CE certificates.

Outreach to Vulnerable Worker Populations

- Katrina Randolph, who started her salon 22 years ago, is a member of Health Advocates In-Reach and Research (HAIR), a program that engages barbershops and beauty salons in Baltimore City.
- She was recruited for a study of chemical exposures from hair salon products and processes, led by Dr. Lesliam Quirós-Alcalá, that **measured the levels of certain chemicals in the air of the salon and in the stylists' urine**.
- In general, women have greater exposure to these chemicals because they use more personal care products than men do. **Women of color, who use more types and greater quantities of hair care products, may be even more highly exposed.**
- Environmental justice should be embedded in exposure science.

POccETMAP – Disaster Preparedness & Risk Management Trainings (Amir Sapkota and Daniel Barnett)

- Deliberate Events Involving Chemical Agents: *Acute Outcomes*
- Deliberate Events Involving Chemical Agents: Chronic *Outcomes*
- Biological Agents and Radiological Agents
- National Incident Management System & Incident Command System
- Disaster Preparedness and Risk Management
- Hazard Vulnerability Assessment for Public Health Emergencies and Disasters
- The Haddon Matrix and Public Health Emergencies and Disasters



Specific Aim 3

- **Create laboratory and field-based research experiences** for undergraduate, masters, and doctoral students in OHS relating to emerging technologies and contaminants that will orient them for advanced studies in these topics and nurture the next generation of researchers and professionals in these areas, as well as provide synergies with activities of the NIOSH-funded JHU ERC.

Research Experience 1 (Ethylene Oxide Monitoring)

Ethylene oxide (EtO) is a hazardous air pollutant

- Formula: C_2H_4O, MW: 44.05 g mol^{-1}
  - Produced via catalytic oxidation of C_2H_4
  - 1:10,000 cancer risk for lifetime exposure is 11 pptv
- Industrially produced chemical for:
  - Sterilization and fumigation
    - >50% of all medical devices in U.S.
    - Spice and tree nut fumigation
  - Primary chemical feedstock for:
    - Ethylene glycol production (production/processing
    - used to make polyethylene fibers and antifreeze

New EPA rules for facilities using or producing EtO

Final Amendments to Air Toxics Standards for Ethylene Oxide Commercial Sterilization Facilities
FACT SHEET

- On March 14, 2024, the U.S. Enviro
(EPA) announced final amendment
for ethylene oxide (EtO) emitted fr
facilities, also called commercial ste

Quick Facts

- This action will result in

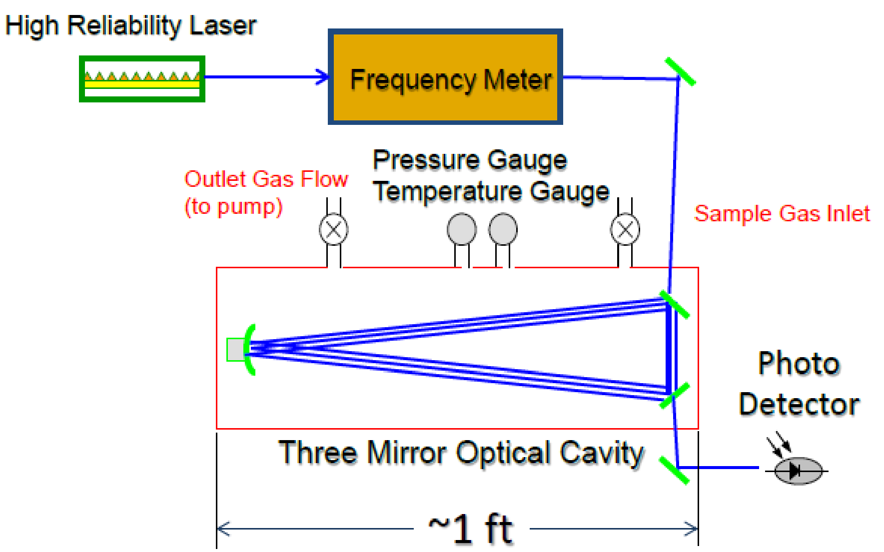
Final Rule to Strengthen Standards for Synthetic Organic Chemical Plants and Polymers and Resins Plants

April 9, 2024, the U.S. Environmental Protection Agency (EPA) announced a set of final rules that will significantly reduce emissions of toxic air pollution from chemical plants, including the potent air toxics ethylene oxide (EtO) and chloroprene. The reductions dramatically reduce the number of people with elevated air toxics-related cancer risks in communities surrounding the plants that use those two chemicals, especially communities historically overburdened by air toxics pollution.

Cavity Ringdown Spectroscopy

- Light is absorbed at special frequencies specific to each molecule.
- At these special frequencies, the greater the distance the light travels through the sample the greater the total absorption.

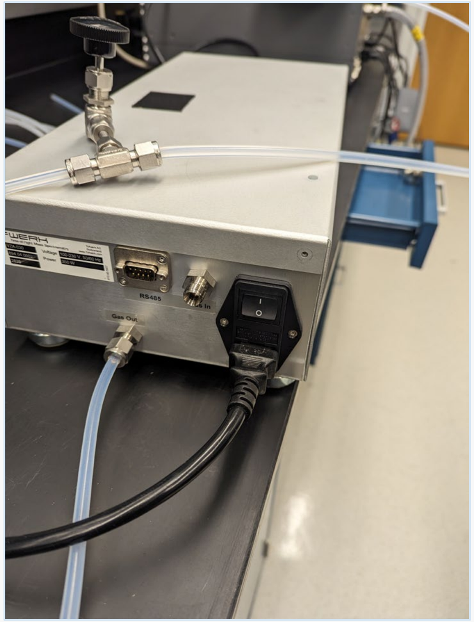
CRDS's optical cavity transforms 45,000 ft (8.5 miles) into 22,500 round trips in a ~1 ft long sample cell.



Resulting in parts-per-billion sensitivity

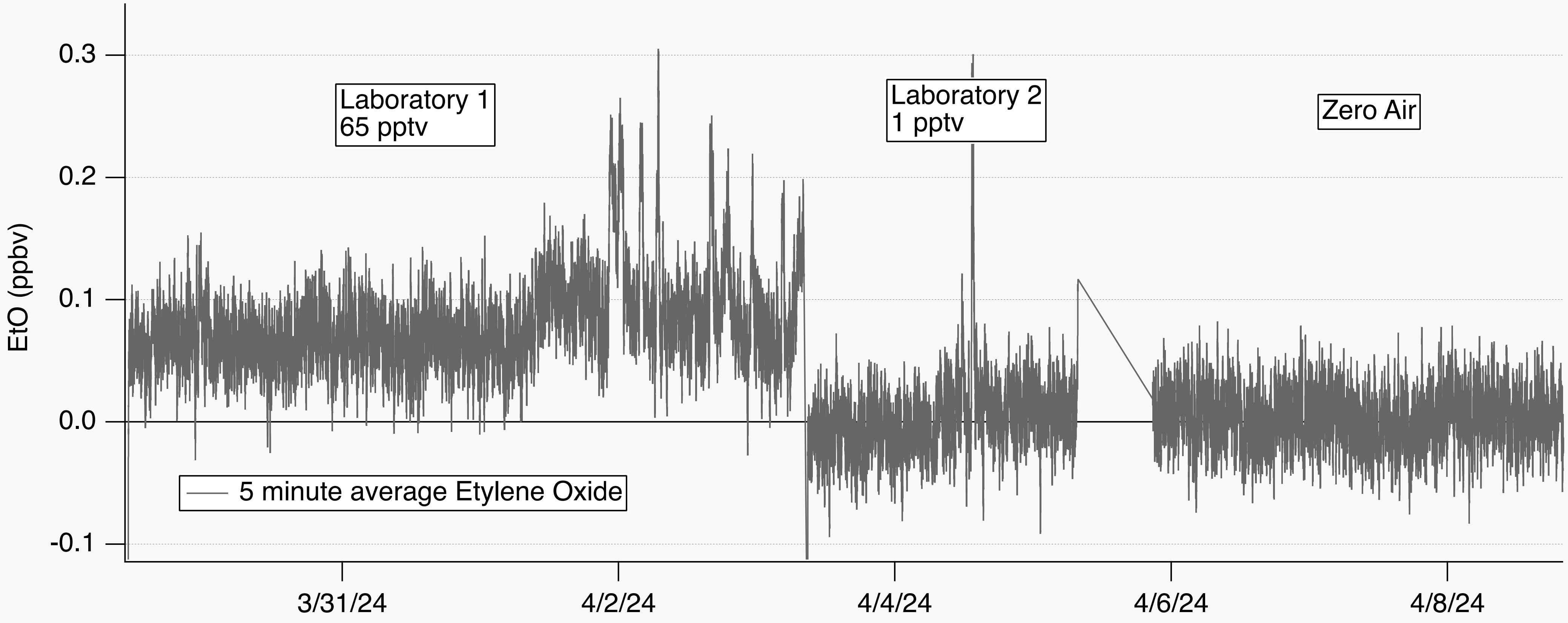
Using Picarro Cavity Ringdown Spectroscopy Instrument

Instrument to measure low levels of EtO set up next to hood where sterilization takes place



Zero Air Generator
For baseline determination

Lab worker exposures in Labs 1 (with sterilizer) and 2 (without sterilizer)

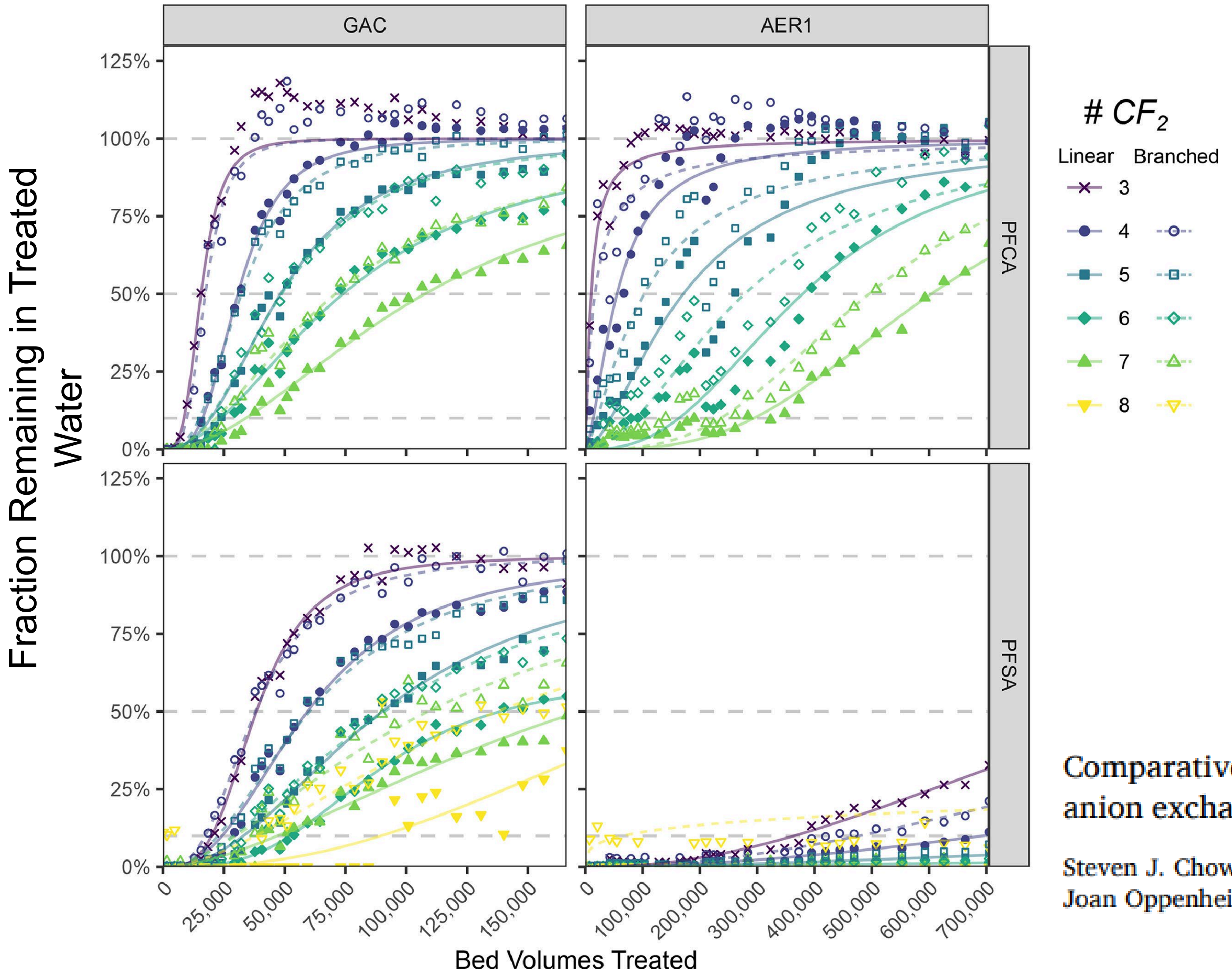


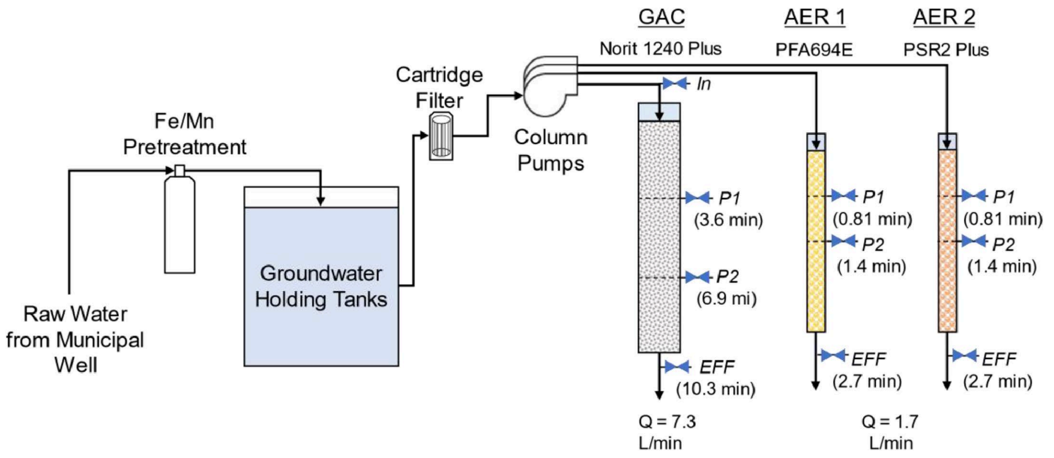
- Preliminary measurement data suggests elevated levels of Ethylene oxide present in laboratory 1 where medical sterilization occurs compared to laboratory 2.

Research Experience 2 (Treatment of PFAS in groundwater)

Pilot treatment of PFAS contaminated groundwater

Evaluation of anion exchange (AER) and granular activated carbon (GAC)





Water Research
Volume 226, 1 November 2022, 119198

Comparative investigation of PFAS adsorption onto activated carbon and anion exchange resins during long-term operation of a pilot treatment plant

Steven J. Chow [a], Henry C. Croll [b], Nadezda Ojeda [a], Jamie Klamerus [c], Ryan Capelle [c], Joan Oppenheimer [d], Joseph G. Jacangelo [a,e], Kellogg J. Schwab [a,*], Carsten Prasse [a,*]

Research Experience 3 (Peroxy-acetic acid exposures to healthcare workers)

Peracetic Acid Case Study

Disinfectants

Glutaraldehyde – dermatitis and occupational asthma
Ortho-phthalaldehydes (OPA)
Bleach
Hydrogen Peroxide / Acetic Acid
Peracetic Acid (w/ hydrogen peroxide/acetic acid)

Basic Characterization - Background

- Disinfectants:
  - Concentrated form
    - PAA < 40% (general use, <15%)
    - Hydrogen Peroxide (HP): <30%
    - Acetic Acid: <10%
  - Dilution for Use:
    - PAA < 0.5%
    - HP <1%
    - Acetic Acid <1%
- Health Effects:
  - Skin Irritation (concentrated form)
  - Eye Irritation (burning eyes)
  - Upper Respiratory Irritation
  - Occupational Asthma(?) – at least one case

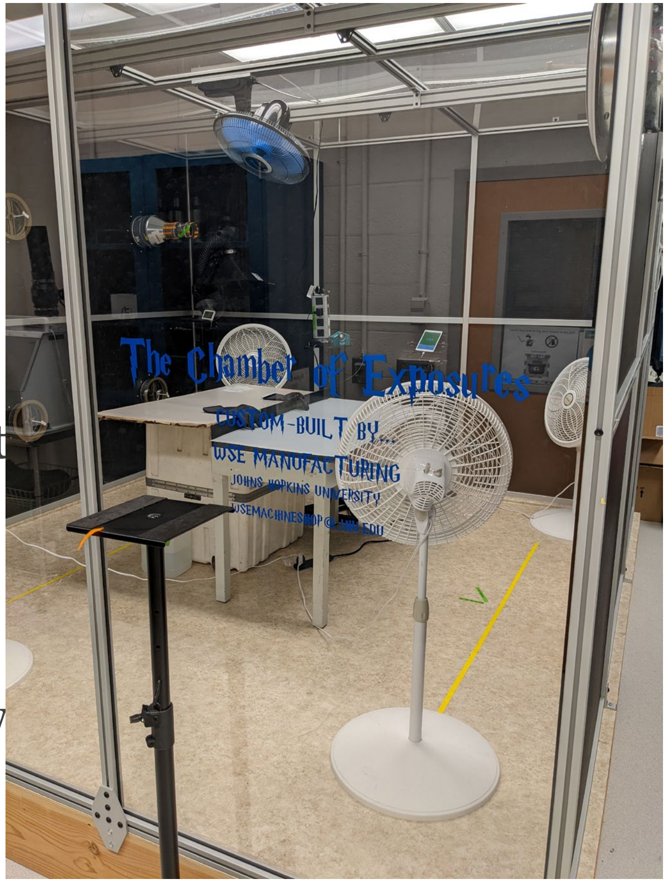
Sampling Methods

- Table recreated from NIOSH presentation by Dr. Kevin Dunn, CIH

Method	Chemical Measurement	Manufacturer	Range	LOD
Direct Reading Methods	PortaSens II	Analytical Technology, Inc.	0 -2 ppm 0-20ppm	0.05 ppm 0.1 ppm
	SafeCide Portable Monitoring	ChemDAQ, Inc.	0-3ppm	0.01 ppm
	4000 Series Compact Portable Analyzer	Interscan Corp.	0-5 ppm 0-50 ppm	0.05 ppm 0.5ppm
Analytical Laboratory Methods	Impinger (colorimetric)	CHEMetrics, Inc.	0-1.6 ppm (per 15 L)	0.016 ppm
	Impinger (Hecht liquid analysis)	Reagents purchased directly	0.02 – 16.2 ppm (per 15 L)	0.003 ppm 0.013 ppm
	Sorbent tubes (Hecht)	SKC, Inc.	At least 0.47 ppm (per 15 L)	0.005 ppm

Highly-Controlled Exposure Scenarios

- Wiping Scenarios performed in a highly-controlled Exposure Chamber
- Wiping: 6 Wipes / 15 minutes
- ChemDAQ Meter
  - Front Lapel, or
  - Stand @ Shoulder Height
- Respirator
  - 3M Combination Cartridge (OV/Acid))
  - Floor Fans (4x) set to low
    - Well-Mixed Room Model
- ACH: 2 – 8 ACH



Modeling Information – Well-Mixed Room

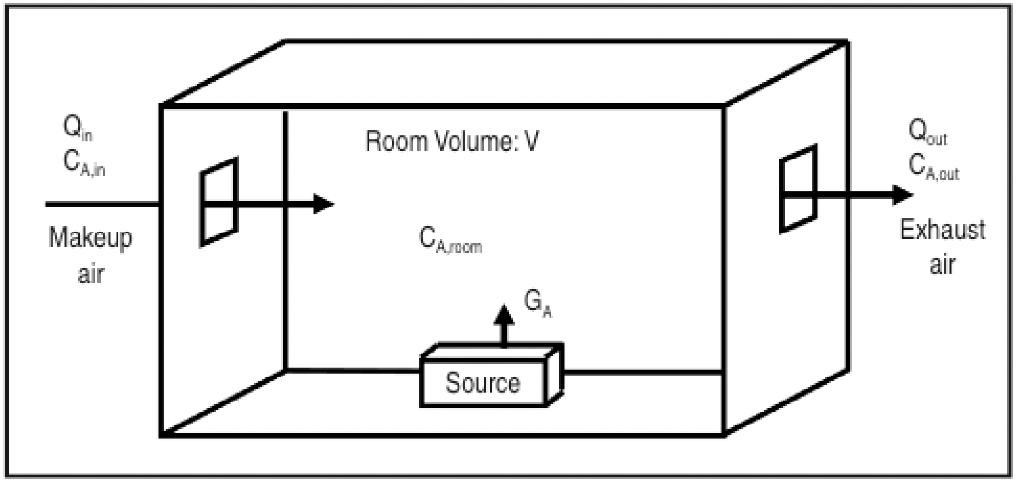
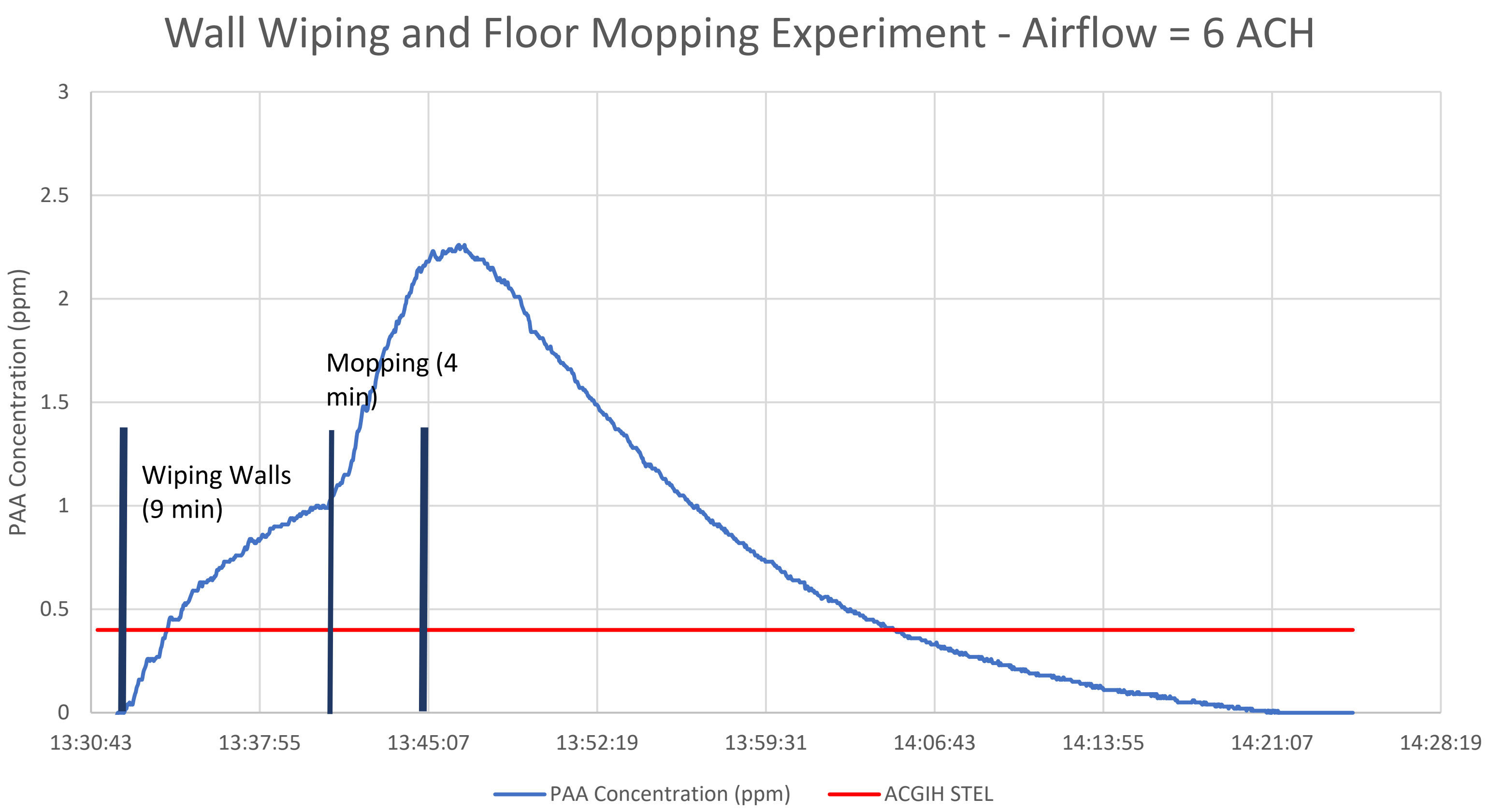


Figure 4.1 — Conceptual Model of the Well Mixed Box.

$$C(t) = \frac{G_{n(t)} + C_{in} * Q}{Q + k_L * V} * \left[1 - e^{\left(-\frac{Q+k_L*V}{V}*t\right)}\right] + C_0 * e^{\left(-\frac{Q+k_L*V}{V}*t\right)}$$

Results



Wall Wiping and Floor Mopping Experiment - Airflow = 6 ACH
PAA Concentration (ppm)
3
2.5
2
1.5
1
0.5
0
13:30:43
13:37:55
13:45:07
13:52:19
13:59:31
14:06:43
14:13:55
14:21:07
14:28:19
Wiping Walls (9 min)
Mopping (4 min)
PAA Concentration (ppm)
ACGIH STEL

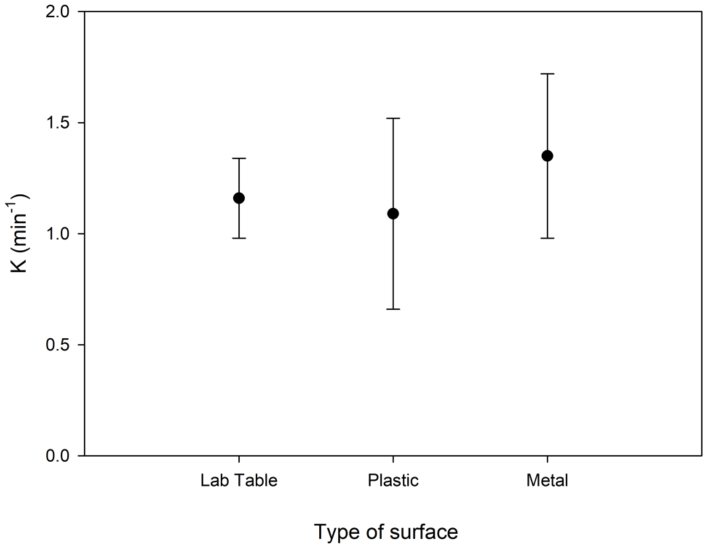
Modeling – Evaporation Constant

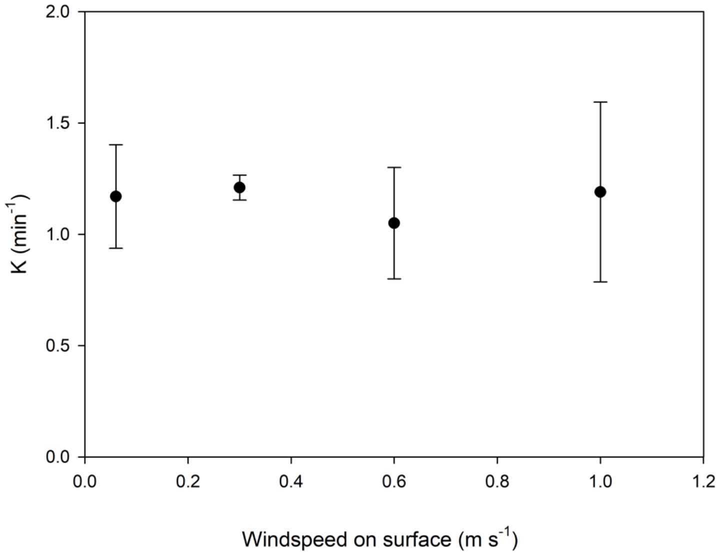
$$G(t) = M_0 * k * e^{-kt}$$

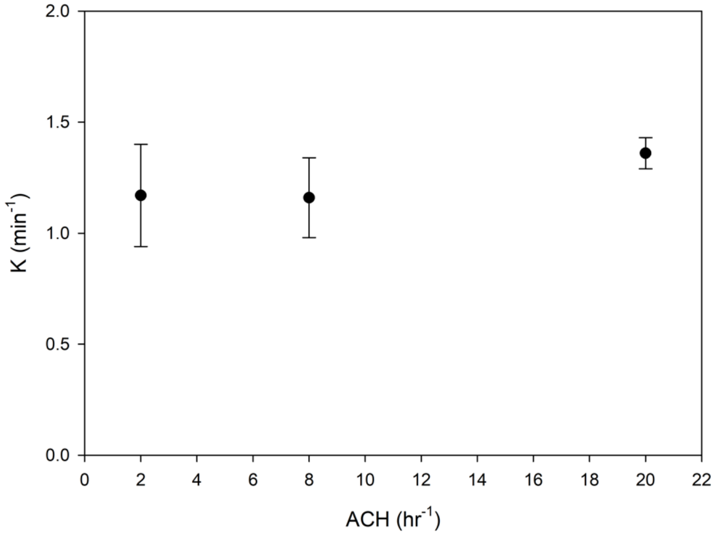
- **Surface (Roughness):**

Wind Speed

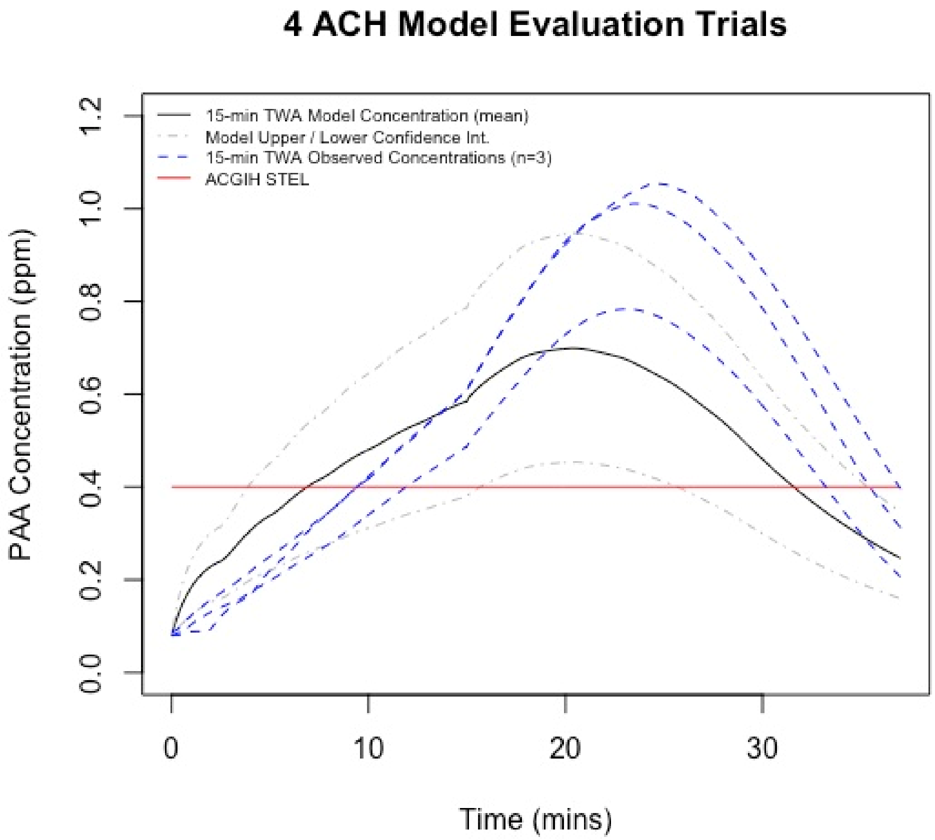
Q (ACH)

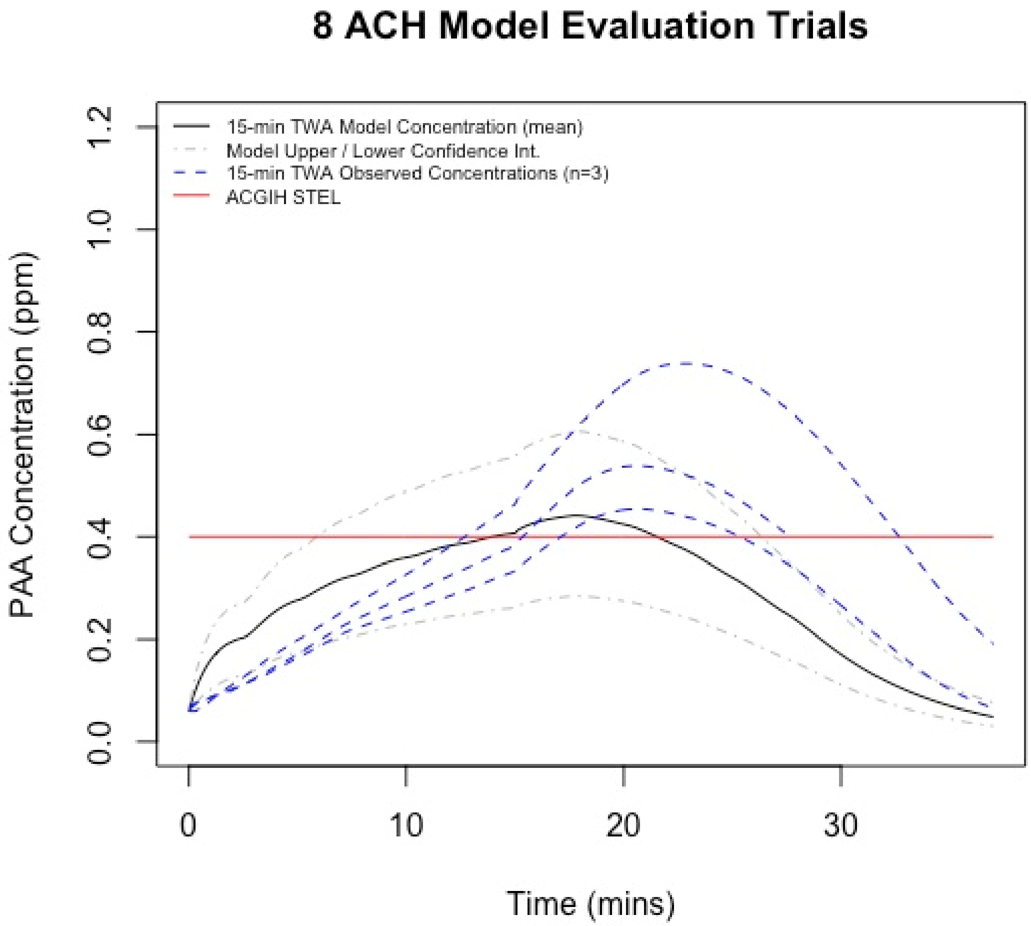






Model Comparison to 6-Wipe Scenarios





Research Experience 3 (Electronic cigarette toxicity)

Rapid Market Change

~2004
1st generation
Cig-a-likes

2nd G
Pens
(2010)

3rd gen.
MODS (~2010)

4th gen
PODS (~2015)

5th gen
D-pods
(2019)

Liquid

Coil

Battery

disposables

Closed systems

Open systems

Closed systems

Marketed mostly to smokers

Marketed mostly to young non-smokers

https://www.fda.gov/tobaccoproducts/labeling/productsingredientscomponents/ucm456610.htm
https://en.wikipedia.org/wiki/Construction_of_electronic_cigarettes#/media/File:Parts_of_an_Electronic_cigarette.png

Chemicals of concern found in all e-cig aerosols

- Nicotine (addictive, CV and Neurotoxic effects)
- Aldehydes (airway constriction, damage airway cell lining)
- PAH (carcinogenic; reproductive, kidney and liver damage)
- Endotoxins / B-glucans (asthma exacerbation)
- Metals (Carcinogenic, Neurotoxic, Cardiotoxic)

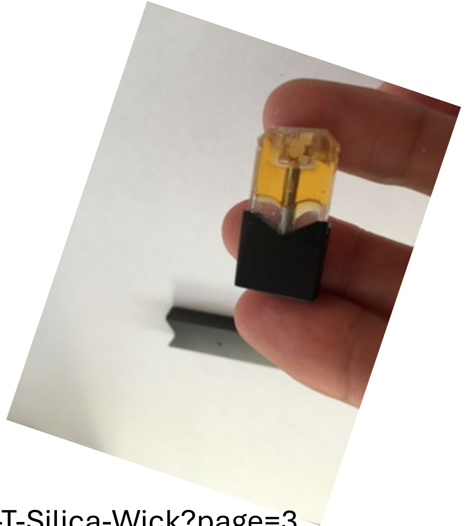
Chem Res Toxicol. 2021 Oct 18;34(10):2216-2226. doi: 10.1021/acs.chemrestox.1c00253. Epub 2021 Oct 5.

Characterizing the Chemical Landscape in Commercial E-Cigarette Liquids and Aerosols by Liquid Chromatography–High-Resolution Mass Spectrometry

Mina W Tehrani [1], Matthew N Newmeyer [1], Ana M Rule [1], Carsten Prasse [1] [2]

Why focus on metals?

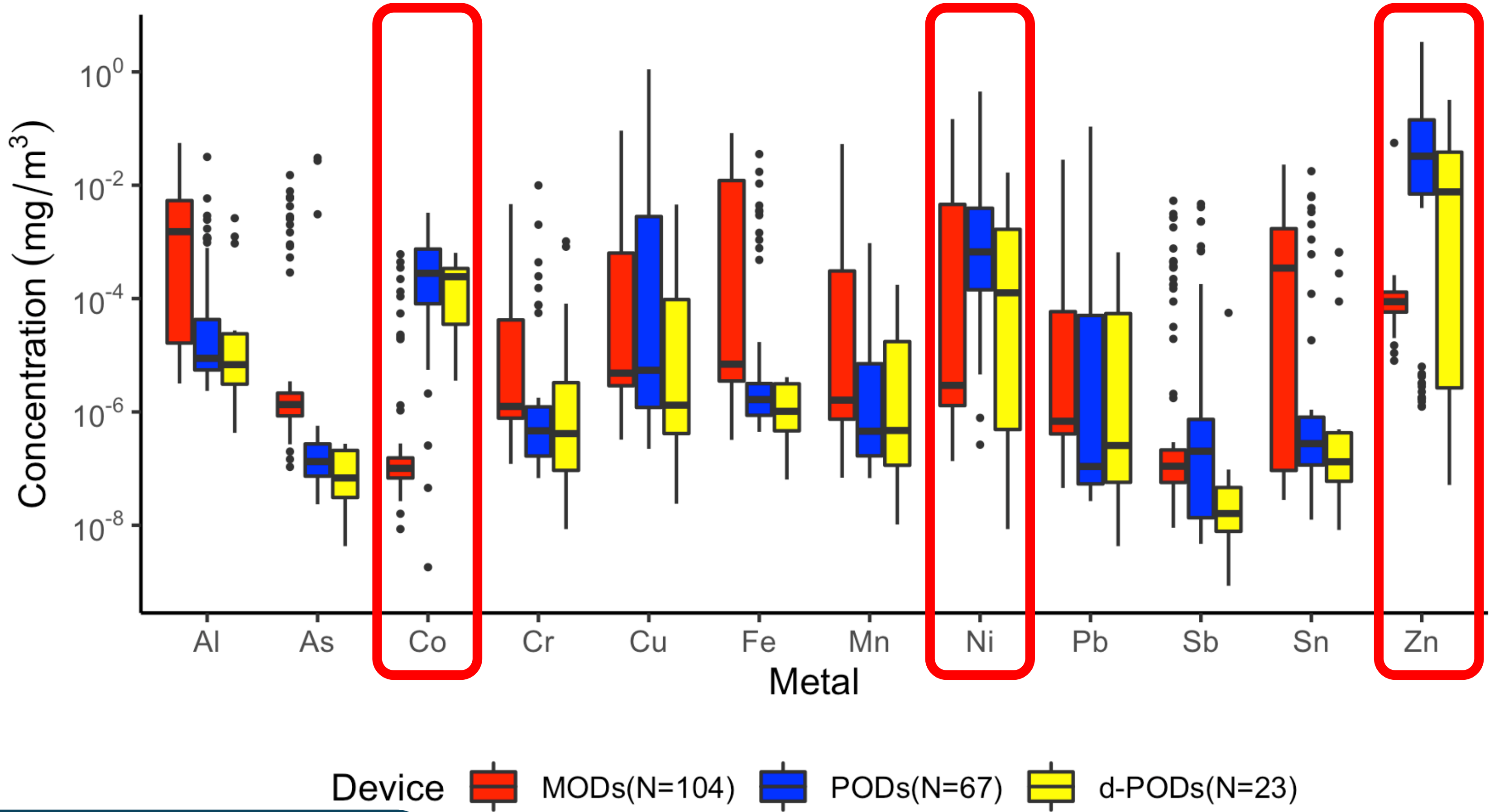
- Liquid is in contact with metal heating coil
- Common heating coil alloys:
  - Nichrome: **nickel-chromium** alloy (80/20 %)
  - Kanthal: Iron-**chromium**-aluminum alloy
  - Stainless steel: **chromium** (min10.5%)-**nickel-manganese**-carbon alloy
- Both Ni and Cr are inhalation carcinogens



https://ukvapers.org/Thread-What-is-In-Your-Hand-Right-Now-Part-2?page=113

https://ukvapers.org/Thread-AGA-T-Silica-Wick?page=3

Metals in aerosols by device type (n = 194)




Environmental Health Perspectives

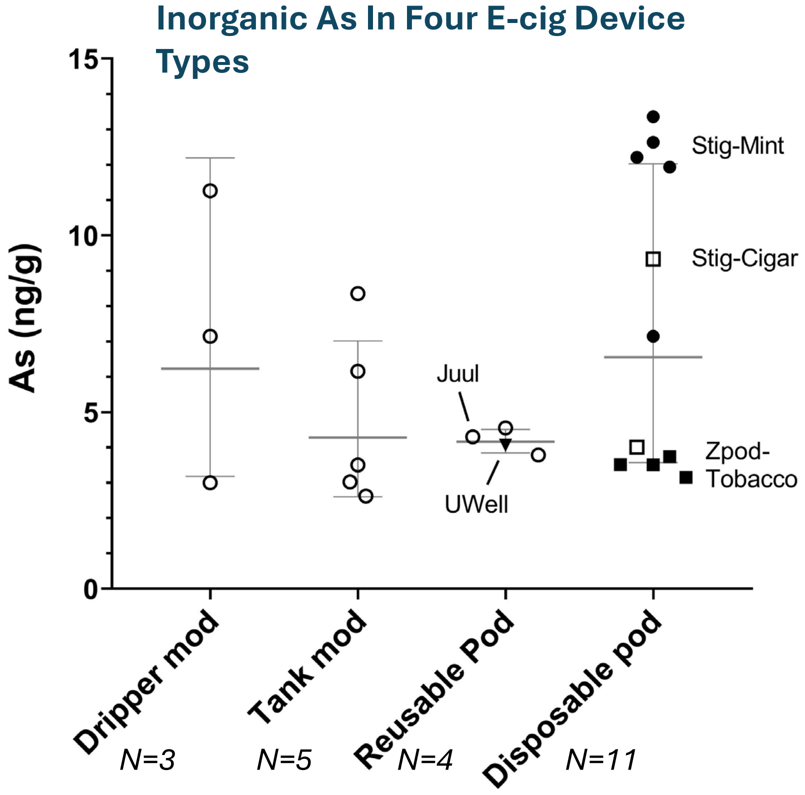
TML version of this article
ɔi.org/10.1289/EHP11921.

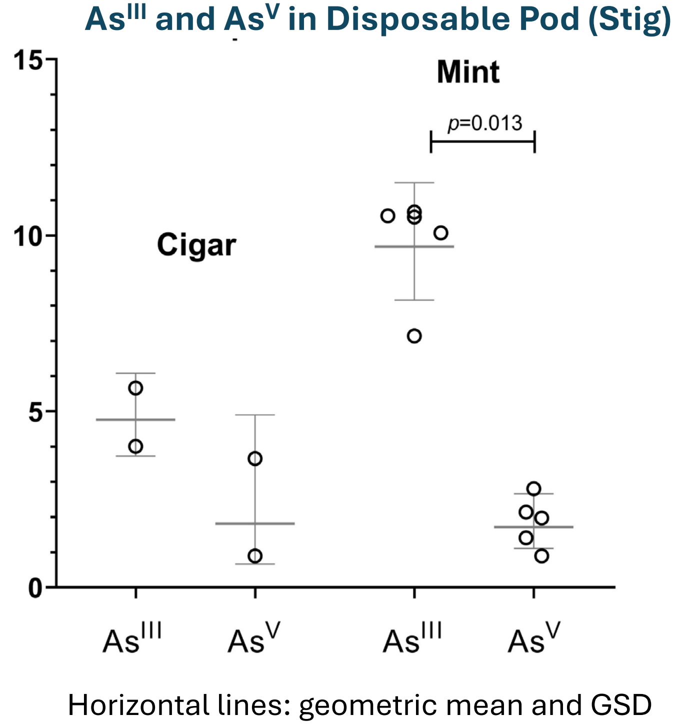
Metal Concentrations in E-Cigarette Aerosol Samples: A Comparison by Device Type and Flavor

Angela Aherrera,[1,2] Joyce Jy Lin,[1] Rui Chen,[1] Mina Tehrani,[1] Andrew Schultze,[3] Aryan Borole,[1] Stefan Tanda,[4] Walter Goessler,[4] and Ana M. Rule[1]

Co and Ni concentrations were higher in PODs and d-PODs.

Inorganic Arsenic (As) In E-Cigarette Aerosols





As speciation in 23 samples with masses >25 mg and the highest total As content.

- Species greatly impacts As toxicity
- Inorganic As, especially As^{III}, is more toxic than organic As

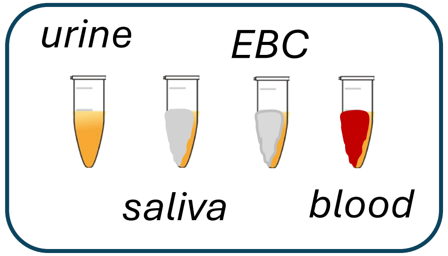
Tehrani et al. J Environ Expo Assess 2023 DOI:10.20517/jeea.2023.03

FINDINGS

- Among the individual products analyzed, i-arsenic levels ranged from 0.017 – 1.8 μg/m^3
- California EPA (CalEPA) set a chronic inhalation reference exposure level (REL) of 0.015 μg/m^3
- Highest levels in some of the new disposable pod products
  - Significantly higher levels of the more toxic As^{III} than As^{V}

Metals in biospecimens from EMIT participants

- Cross-sectional study in 4 waves
  - Wave 1 (2015): 50 MOD users *
  - Wave 2 (2017): 50 vapers, 50 non-vaper controls
  - Wave 3 (2018-22): 24 POD, 17 MOD, 17 dual, 9 smkers, 30 ctrls
  - Wave 4 (2023-24): (Aherrera K99): 53 vapers (d-POD), 36 non-vapers

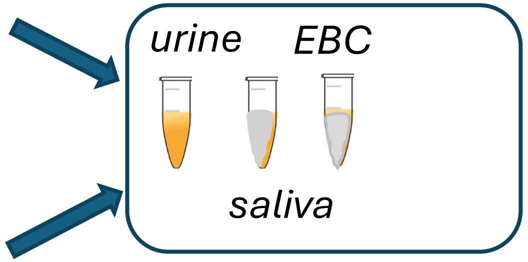


EBC = Exhaled Breath Condensate

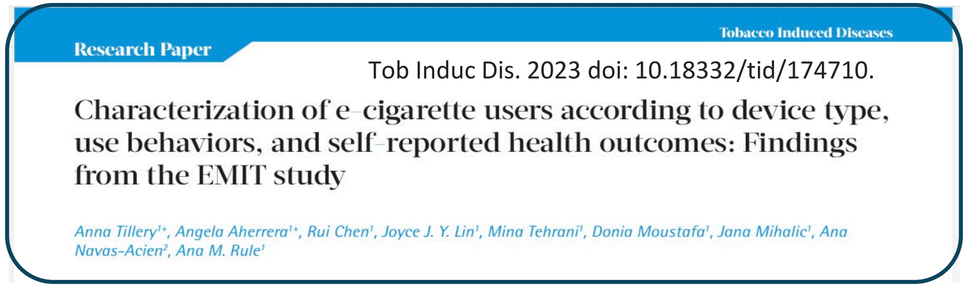
Collected from each participant:

- *Dispenser liquid**
- *Tank (after vaping)**
- *Aerosol*

- *E-cigarette use / behaviors*
- *Other metal sources*



EBC = Exhaled Breath Condensate



Research Paper — Tobacco Induced Diseases

Tob Induc Dis. 2023 doi: 10.18332/tid/174710.

Characterization of e-cigarette users according to device type, use behaviors, and self-reported health outcomes: Findings from the EMIT study

Anna Tillery[1*], Angela Aherrera[1*], Rui Chen[1], Joyce J. Y. Lin[1], Mina Tehrani[1], Donia Moustafa[1], Jana Mihalic[1], Ana Navas-Acien[2], Ana M. Rule[1]

Thank you!