3rd Annual PFAS Meeting Program

June 15-17th, 2022

Wilmington, NC

Table of Contents

Introduction

Join us for the 3rd National PFAS Conference this June in the coastal town of Wilmington, NC. This community is part of the Cape Fear River Watershed in which GenX-contaminated drinking water was first detected. This conference series is uniquely designed to exchange information, provide support to PFAS-affected communities, and facilitate engagement across diverse sectors involved with PFAS to accelerate the protection of health and the environment. (Information and recorded sessions from the previous meetings can be found **here**).

At This Conference, We Will…

- Highlight local community perspectives and global impacts of PFAS
- Continue collaborative conversations that integrate cutting-edge scientific discoveries with the complex social and political contexts of affected communities that are often marginalized and underserved
- Identify the best methods to share findings and ensure ongoing communication between researchers, PFAS sectors, and affected communities
- Share information and resources that respond to needs identified by affected communities and other diverse PFAS sectors
- Strengthen existing and establish new collaborations between researchers, communities, and political and public sectors to encourage coordinated and solution-based approaches that will prevent future PFAS contamination and exposure-related health risks

Code of Conduct

We are committed to fostering a culture of diverse and inclusive excellence in which persons of all identities and from all backgrounds feel welcomed, supported, and encouraged to engage in the free and open exchange of ideas. Our dedication to excellence means that attendees at this event can expect to experience a safe environment free of discrimination and harassment. Behaviors that do not uphold the highest standards of integrity and professional ethics are contrary to our mission and values. Sexual harassment, other forms of harassment, or sexual assault will not be tolerated. Individuals violating this policy are subject to immediate removal from the event. Any violations of this policy should be reported here.

NSF/NIH Conference Programs Codes of Conduct

COVID-19 Guidelines

We will monitor and follow all federal, state, and local guidelines related to the COVID-19 pandemic. In consideration of the latest public health guidelines and research related to COVID-19, those attending the conference in person are encouraged to be fully vaccinated against COVID-19. In the interest of safety, we encourage attendees to wear masks. We will provide some masks for those who need them and we encourage you to bring your own.

Recording

Please respect the work of our speakers. Many are sharing pre-published information and do not wish for their data to be recorded. If a speaker has a red sticker on their name badge, they have indicated their presentation cannot be recorded. As we have done in the past, the conference will record presentations of those speakers who give us permission. We will notify attendees when those recordings are available to view

Hosts and Sponsors Recognition

Hosted by the NC State Center for Environmental and Health Effects of PFAS (Superfund) and Cape Fear Community College:

Center for Environmental and Health Effects of PFAS
NC STATE | ECU

CAPE FEAR COMMUNITY COLLEGE

We would also like to take a moment to acknowledge our sponsors:

Break Sponsorship

North Carolina Collaboratory
University of North Carolina, Chapel Hill

Great Lakes PFAS Action Network

Meal Sponsorship

Environmental Working Group

Waters Corporation

SCIEX

Eurofins Environmental Testing

Special Event Sponsorship

NMS Labs

Additional Sponsorship

Center for Human Health and the Environment
NC State University

National Institute of Environmental Health Sciences
National Institute of Health

Conference Agenda

Day 1: Wednesday June 15, 2022

8:00 - 9:00	**Registration and Breakfast**
9:00 - 9:10	**Welcome Remarks**
	Carolyn Mattingly, NC State, NC
9:10 - 9:40	**Keynote: Strategic Roadmap and Infrastructure Bill Update**
	Radhika Fox, U.S. EPA Office of Water
9:40 - 10:30	**Introduction to Environmental Justice, PFAS and North Carolina**
	Courtney Woods, University of North Carolina - Chapel Hill, NC Emily Donovan, Clean Cape Fear, NC Vaughn Hagerty, former investigative reporter, NC
10:30 - 10:45	**Coffee Break**
10:45 - 11:15	**The North Carolina Story, Part 1: Scientific Discovery and Community Response**
	Chair: Emily Donovan, Clean Cape Fear, NC Katie Bryant, Clean Haw River, NC Ken Waldroup, Cape Fear Public Utility Authority, NC Detlef Knappe, NC State, NC
11:15 - 11:30	**Q&A with Discovery and Community Response Speakers**
11:30 - 12:00	**The North Carolina Story, Part 2: Foundational and Ongoing Scientific Discovery**
	Chair: Katlyn May, NC State, NC Jane Hoppin, NC State, NC Heather Stapleton, Duke University, NC Geoff Gisler, Southern Environmental Law Center, NC
12:00 - 12:15	**Q&A with Foundational and Ongoing Discovery Speakers**
12:15 - 1:15	**Lunch and Group Photo**

1:15 - 1:45 **Environmental Justice**

Chair: Alissa Codner, Whitman College, WA
Matthew Tejada, U.S. Environmental Protection Agency, DC
Linda Shosie, Environmental Justice Task Force, AZ
Cheryl Cail, South Carolina Indian Affairs Commission, Idle No More Committee, SC

1:45 - 2:00 **Q&A with Environmental Justice Speakers**

2:00 - 2:30 **Keynote: Perils of PFAS**

Chair: Sue Fenton, National Institute of Environmental Health Sciences, NC
Linda Birnbaum, National Institute of Environmental Health Sciences, NC (Scientist Emeritus and Former Director)

2:30 - 3:00 **PFAS Policy Challenges**

Loreen Hackett, PfoaProject, NY
Sarah Doll, Safer States, OR
Rob Bilott, Taft Stettinius & Hollister LLP, KY

3:00 - 3:15 **Q&A with Speakers from Overview and Policy Challenges**

3:15 - 3:45 **Coffee Break and Poster Session**

3:45 - 4:30 **Blood Testing and Medical Monitoring**

Chair: Andrea Amico, Testing for Pease, NH
Sandy Wynn-Stelt, Great Lakes PFAS Action Network, MI
Laurel Schaider, Silent Spring Institute, MA
Courtney Carignan, Michigan State University, MI
Elizabeth Friedman, Children's Mercy Hospital, Region 7 Pediatric Environmental Health Specialty Unit, MO

4:30 - 5:00 **Q&A with Blood Testing and Medical Monitoring Speakers**

5:00 - 6:00 **Poster Session (5:00-5:30 odd numbered, 5:30-6:00 even numbered) and Cocktail Hour**

6:00 - 7:00 **Dinner and Award Reception**

Day 2: Thursday June 16, 2022

8:00-9:00	**Breakfast**
9:00 - 9:30	**Fertility, Maternal, Infant and Child Health Outcomes** **Chair: Jane Hoppin, NC State, NC** Emily Marpe, Hoosick Falls, NY Sue Fenton, National Institute of Environmental Health Sciences, NC
9:30 - 9:45	**Q&A with Fertility, Maternal, Infant and Child Health Outcomes Speakers**
9:45 - 10:15	**Breastfeeding and PFAS** **Chair: Jane Hoppin, NC State, NC** Judy LaKind, LaKind Associates, MD Megan Romano, Dartmouth University, NH
10:15 - 10:30	**Q&A with Breastfeeding and PFAS Speakers**
10:30 - 11:00	**Coffee Break and Posters (odd numbered)**
11:00 - 11:30	**Long-Term Health Effects: Immune System** **Chair: Carolyn Mattingly, NC State, NC** Jamie DeWitt, East Carolina University, NC Philippe Grandjean, Harvard University, MA
11:30 - 11:45	**Q&A with Immune Speakers**
11:45 - 12:15	**Long-Term Health Effects: Cancer** **Chair: Carolyn Mattingly, NC State, NC** Stel Bailey, Fight For Zero, National PFAS Contamination Coalition, FL Kyle Steenland, Emory University, GA
12:15 - 12:30	**Q&A with Cancer Speakers**
12:30 - 1:30	**Lunch**
1:30 - 2:00	**Dietary Exposure Pathways: Fish and Game** **Chair: Courtney Carignan, Michigan State University, MI** Troy Techlin, Saginaw Chippewa Indian Tribe, MI Anna Robuck, Icahn School of Medicine, Mount Sinai, NY

Jon Petali, New Hampshire Department of Environmental Services, NH

2:00 - 2:15 **Q&A with Fish and Game Speakers**

2:15 - 3:00 **Dietary Exposure Pathways: Produce and Livestock**

Chair: Courtney Carignan, Michigan State University, MI
Fred Stone, Stoneridge Farm, ME
Sarah Lupton, U.S. Department of Agriculture, ND
Chris Higgins, Colorado School of Mines, CO
Owen Duckworth, NC State, NC

3:00 - 3:15 **Q&A with Produce and Livestock Speakers**

3:15 - 3:45 **Coffee Break and Posters (even numbered)**

3:45 - 4:15 **Overlooked Exposure Pathways: Occupational**

Chair: Detlef Knappe, NC State, NC
Denise Trabbic-Pointer, Sierra Club, MI
Kevin Ferrara, Air Force Veteran, Agile Fire Service Organization, PA
Jason Burns, Fall River Fire Department, MA

4:15 - 4:30 **Q&A with Occupational Pathway Speakers**

4:30 - 5:00 **Overlooked Exposure Pathways: Residential**

Chair: Detlef Knappe, NC State, NC
Graham Peaslee, University of Notre Dame, IN
Rainer Lohmann, University of Rhode Island, RI
Michael Pjetraj, North Carolina Department of Environmental Quality, NC

5:00 - 5:15 **Q&A with Residential Pathway Speakers**

5:15 - 5:45 **Cocktail Hour**

5:45 - 7:00 **Dinner and "No Defense" Documentary Screening**

7:00 - 7:30 **No Defense Panel Discussion**

Andrea Amico, Testing for Pease, NH
Craig Minor, Retired United States Air Force, OH
Anthony Spaniola, Great Lakes PFAS Action Network, MI

Day 3: Friday June 17, 2022

8:00-9:00	**Breakfast**
9:00 - 9:30	**Progress and Challenges in Remediation Technology: Water Treatment Technologies** **Chair: Rainer Lohmann, University of Rhode Island, RI** Andrea Amico, Testing for Pease, NH Detlef Knappe, NC State, NC Max Krause, U.S. Environmental Protection Agency, OH
9:30 - 9:45	**Q&A with Water Treatment Speakers**
9:45 - 10:15	**Progress and Challenges in Remediation Technology: Disposal** **Chair: Rainer Lohmann, University of Rhode Island, RI** Sonya Lunder, Sierra Club, CO Patrick MacRoy, Environmental Health Strategy Center, ME Jose Aguayo, Center for Health, Environment & Justice, VA
10:15 - 10:30	**Q&A with Disposal Speakers**
10:30 - 10:45	**Coffee Break**
10:45 - 11:15	**Broken Policy & Proposed Solutions: Evaluating Chemical Safety and Management at the U.S. Federal Level** **Chair: Laurel Schaider, Silent Spring Institute, MA** Denise Keehner, U.S. Environmental Protection Agency, DC Kathryn Alcantar, Center for Environmental Health, CA John Reeder, Environmental Working Group, DC
11:15 - 11:30	**Q&A with Evaluating Chemical Safety and Management at the U.S. Federal Level Speakers**
11:30 - 12:00	**Broken Policy & Proposed Solutions: Protecting Food Supplies and Creating Safer Products** **Chair: Laurel Schaider, Silent Spring Institute, MA** Tom Neltner, Environmental Defense Fund, MD Arlene Blum, Green Science Policy Institute, CA Xenia Trier, European Environment Agency, Denmark
12:00 - 12:15	**Q&A with Protecting Food Supplies and Creating Safer Products Speakers**

12:15 - 1:15 **Lunch**

1:15 - 2:45 **Breakout Working Session**

Organizer: Courtney Carignan, Michigan State University, MI

PFAS Pollution: Causes and Solutions - Led by Arlene Blum (Green Science Policy Institute) and Rob Bilott (Taft Stettinius & Hollister LLP)

This workshop will explore the history of chemical producers continuing contamination and harm as well as polluter responsibility for the cost of health problems and clean up. Attendees will be engaged in discussion of how to hold polluters responsible and prevent further PFAS contamination.

Issues in PFAS Disposal and Destruction - Led by Sonya Lunder (Sierra Club), Denise Trabbic-Pointer (Sierra Club), and Stephen Colby Brown (Sierra Club)

This workshop will discuss ways that current technologies to store or destroy PFAS waste are limited and incomplete as well as local, state and national strategies to achieve our goal of waste containment and destruction. Attendees will be engaged to share questions about waste and to brainstorm better management options for wastes generated at specific sites.

Next Steps to Address PFAS in the Fire Service - Led by Miriam Calkins (National Institute for Occupational Safety and Health) and Racquel Segall (International Association of Fire Fighters)

This workshop will discuss experience, resources, and priorities to reduce PFAS exposure in firefighters as well as to identify priority areas where approaches are needed. Attendees will be engaged in brainstorming, problem solving, and information sharing in a full group setting. Topics of discussion may include training and education materials, resources for AFFF disposal, current practices to reduce exposure, communication on PFAS serum concentrations, and prioritizing concerns.

Forming Community-NGO Partnerships - Led by Sandy Wynn-Stelt and Tony Spaniola (Great Lakes PFAS Action Network)

This workshop will highlight the Great Lakes PFAS Action Network as an example of how partnerships between PFAS-impacted communities can combine the voices and stories of community members with the skills and resources of non-profit groups to benefit local communities and support policy changes. Attendees will be engaged in small group discussions of specific steps needed to develop a clear and successful working relationship between community members and existing groups.

Promoting PFAS Awareness and Access to Patient Care - Led by Elizabeth Friedman (Pediatric Environmental Health Specialty Unit) and Courtney Carignan (Michigan State University)

This workshop will feature presentations from community members Ayesha Khan and Andrea Amico on their experiences with clinicians and actions they've taken to address some of those challenges, such as clinician training and legislation for insurance coverage of blood testing. Attendees will engage in discussing barriers encountered in their communities and strategies to address those challenges.

Promoting Public Health from PFAS - Led by Brittany Jacobs (U.S. EPA)

This workshop will provide an overview of how some of the PFAS Roadmap actions, across EPA programs, can address public health for PFAS. Attendees will be engaged in discussion.

2:45 - 3:00 **Closing Remarks**

Emily Donovan, Clean Cape Fear, NC

3:00 - 5:00 **Learning and Engagement Field Trip**

Organizing Committee

Andrea Amico, Testing for Pease

Sylvia Broude, Community Action Works

Phil Brown, Northeastern University

Kemp Burdette, Cape Fear River Watch

Grace Campbell, NC State

Courtney Carignan, Michigan State University

Veronica Carter, NC Coastal Federation/Env. Justice and Equity Advisory Board

Alissa Cordner, Whitman College, PFAS Project Lab at Northeastern

Deborah Dicks Maxwell, NAACP/Cape Fear River Watch

Emily Donovan, Clean Cape Fear

Sue Fenton, National Toxicology Program/National Institute of Environmental Health Sciences

Philippe Grandjean, Harvard University

Hope Grosse, BuxMont Coalition for Safer Water

Denise Hall, NC State

Ashley Higgs Hammell, Community Action Works

Jane Hoppin, NC State

Detlef Knappe, NC State

Rainer Lohmann, University of Rhode Island

Carolyn Mattingly, NC State

Katlyn May, NC State

Laurel Schaider, Silent Spring Institute

Speakers

Jose Aguayo
Center for Health, Environment & Justice (CHEJ), VA
Jose Luis Aguayo is the Senior Science Associate for the Center for Health, Environment & Justice (CHEJ). He holds a bachelor's degree in biology and a master's degree in public health. Before CHEJ, Jose worked for Eastern Research Group as a contractor for the US Environmental Protection Agency (EPA), providing research and data analysis to the Safety and Sustainability Division. He also worked at the Environmental Working Group (EWG), researching toxic ingredients in food and personal care products. Jose's current focus is on providing technical assistance to environmental justice (EJ) communities and advancing other EJ initiatives

Kathryn Alcantar
Center for Environmental Health (CEH), CA
Kathryn Alcantar leads the CEH's policy team, providing strategic direction and building partnerships with cross-sector allies to advance policy work at the state and federal level. She also serves on the Executive Committee, Network Council, and as co-lead of the Policy and Legal Hub of the Cancer Free Economy Network, helping to uplift CEH's policy goals at the national level and galvanizing the 60-member network to accelerate progress towards a healthy, regenerative economy. From 2009 – 2017, Kathryn served as CEH's California Policy Director as well as Director of Californians for a Healthy and Green Economy (CHANGE) Coalition where she helped to build strong alliances with environmental justice, environmental health, labor, and worker advocates, health professionals and sustainable business allies to advance right-to-know policies on flame retardants in furniture, chemicals in cleaning, salon and beauty products as well as helped to defend Proposition 65. For 25 years, Kathryn has been working in the field of environmental health and justice while working at multiple organizations including the California Department of Public Health, Hispanic Foundation of Silicon Valley, WE ACT for Environmental Justice, Latino Issues Forum, Greenlining Institute and the U.S. EPA, Region 9. She is an alumna of the San Francisco Foundation's Multicultural Leadership Program and the Environmental Leadership Program. She holds a double master's degree (MPA/MPH) in Environmental Policy and Public Health from Columbia University and a bachelor's in Civil and Environmental Engineering from University of California (UC)- Berkeley.

Andrea Amico
Testing for Pease, NH
Andrea Amico is a co-founder of the Testing for Pease community action group. She started advocating for more answers and action for the Pease community impacted by PFAS water contamination at the former Pease Air Force Base in Portsmouth, NH in 2014 after learning her husband and two small children were impacted by highly contaminated drinking water. She is passionate about raising awareness of PFAS water contamination, providing education to impacted communities, lowering standards for PFAS in drinking water, and collaborating with

others on all aspects of PFAS (communities, physicians, legislators, researchers, government agencies, etc) to achieve the common goal of reducing PFAS exposure through drinking water.

Stel Bailey

Fight For Zero, National PFAS Contamination Coalition, FL

Stel Bailey is the Chief Executive Director of Fight For Zero, a leader in the National PFAS Contamination Coalition, and a recognized environmental health advocate who has worked as an assistant environmentalist collecting samples and gathering critical data. Bailey's life took an unthinkable turn in 2013 when her father, brother, the family dog, uncle, and herself were diagnosed with cancer and no family history. She learned of harmful chemicals that were in their Florida water. Her powerful testimony of overcoming illness and losing her family to environmentally caused diseases has given her an influential platform to educate and inspire others to care more about the ecosystem.

Rob Bilott

Taft Stettinius & Hollister LLP, KY

Rob Bilott is a partner in the Cincinnati and Northern Kentucky offices of the law firm, Taft Stettinius & Hollister LLP, where he has practiced in the Environmental and Litigation Practice Groups for over 31 years. During that time, Bilott has handled and led some of the most novel and complex cases in the country involving damage from exposure to per- and polyfluoroalkyl substances (“PFAS”), including the first individual, class action, mass tort, and multi-district litigation proceedings involving PFAS, recovering over $1 billion for clients impacted by the chemicals. In 2017, Bilott received the Right Livelihood Award, known as the “Alternative Nobel Prize,” for his decades of work on behalf of those injured by PFAS chemical contamination. He is the author of the book, “Exposure: Poisoned Water, Corporate Greed, and One Lawyer’s Twenty-Year Battle Against DuPont,” and his story is the inspiration for the 2019 motion picture, “Dark Waters,” starring Mark Ruffalo as Bilott. His story and work is also featured in the documentary, “The Devil We Know.” Bilott is a 1987 graduate of New College in Sarasota, Florida and a 1990 graduate of the Ohio State University Moritz College of Law. Bilott also serves on the Boards of Less Cancer and Green Umbrella and is frequently invited to provide keynote lectures and talks at law schools, universities, colleges, communities, and other organizations all over the world. He is a fellow in the Right Livelihood College, a Lecturer at the Yale School of Public Health, Department of Environmental Health Sciences, and an Honorary Professor at the National University of Cordoba in Argentina. He also received Honorary Doctorate Degrees from both Ohio State University and New College.

Linda Birnbaum

Scientist Emeritus and Former Director, National Institute of Environmental Health Sciences (NIEHS), NC

Dr. Linda Birnbaum, Ph.D., D.A.B.T., A.T.S., is the former Director of NIEHS of the National Institutes of Health, and the National Toxicology Program (NTP). As a board-certified toxicologist, Birnbaum served as a federal scientist for 40 years. Prior to her appointment as NIEHS and NTP Director in 2009, she spent 19 years at the US EPA where she directed the largest division focusing on environmental health research. Birnbaum has received many awards and recognitions, including the North Carolina Award in Science, election to the Institute of Medicine of the National Academies, one of the highest honors in the fields of medicine and health and to the Collegium Ramazzini, an independent, international academy of internationally renowned experts in the fields of occupational and environmental health. She is an active member of the scientific community. She was vice president of the International Union of Toxicology, the umbrella organization for toxicology societies in more than 50 countries, and former president of the Society of Toxicology, the largest professional organization of toxicologists in the world. She is the author of more than 1000 peer-reviewed publications, book chapters, abstracts, and reports. Birnbaum's own research focuses on the pharmacokinetic behavior of environmental chemicals, mechanisms of action of toxicants including endocrine disruption, and linking real-world exposures to health effects. A native of New Jersey, Birnbaum received her MS and PhD in microbiology from the University of Illinois at Urbana-Champaign.

Arlene Blum
Green Science Policy Institute, CA
Dr. Arlene Blum, PhD, is a biophysical chemist, author, mountaineer, and executive director of the Green Science Policy Institute and a Research Associate in Chemistry at UC Berkeley. Blum and the Institute's scientific research and policy work with government and business has contributed to preventing the use of PFAS, flame retardants and other harmful chemicals in consumer products and building materials worldwide. She is the author of Annapurna: A Woman's Place and Breaking Trail: A Climbing Life. See www.greensciencepolicy.org and www.arleneblum.com.

Katie Bryant
Clean Haw River, NC
Katie L. Bryant is a former microbiologist with a focus in academic biomedical research, vaccine manufacturing, and quality assurance. She moved to Pittsboro, North Carolina in 2011 as a military spouse, where she started her family and later learned the truth behind Pittsboro's secret water crisis. Immersing herself into citizen activism, she became the chair of the Pittsboro Water Quality Task Force from 2019 to 2020, and after continued inaction within the local government, co-founded Clean Haw River alongside fellow Biologist, Dr. Jessica Merricks. Since, she has been on a growing mission to bring awareness, understanding, and action to Pittsboro's drinking water crisis.

Jason Burns
Fall River Fire Department
Jason Burns has been a career firefighter in Fall River, MA since 2006. He served as President of their union for eight years and was recently elected as District Vice President of the Professional Firefighters of Massachusetts. He is also Executive Director of the Last Call Foundation, a non-profit that provides funding, education, and research to advance the safety needs of the firefighting community. He is married to Elizabeth and is the father to five beautiful daughters,Taylor, Madison, Samantha, Abigail, and Emersyn.

Cheryl Cail

South Carolina Indian Affairs Commission, Idle No More Committee, SC

Cheryl Cail is a small business owner who lives in Myrtle Beach, South Carolina. She is the Associate Director for the South Carolina Low Country, North Coast with American Rivers organization. She is also the Vice Chief of the Waccamaw Indian People, and the Chairperson for SC Idle No More, a committee under the SC Indian Affairs Commission, which promotes Indigenous ways of knowing, rooted in the holistic approach, to protect water, air, land, and all creation for future generations. Cheryl has been a water protector since 2016, elevating inclusion of indigenous people in the role of conservation and preservation. In early 2019, after Cheryl's son was diagnosed with testicular cancer, she became aware of PFAS contamination in the groundwater at the former Myrtle Beach Airforce Base from Aqueous Film Forming Foam (AFFF). She joined the National PFAS Contamination Coalition Grassroots team and later in 2020, she joined the Leadership team. She manages the Facebook education page, Clean Water SC and continues to educate others about the harmful impacts of PFAS to the ecosystem. Her advocacy work has primarily been focused on contamination at Department of Defense sites and its impact to the rivers and EJ communities.

Courtney Carignan

Michigan State University, MI

Dr. Courtney Carignan, PhD, is an exposure scientist and environmental epidemiologist at Michigan State University with a joint appointment in the Departments of Food Science & Human Nutrition and Pharmacology & Toxicology. Her research helps protect reproductive and child health by investigating exposure to contaminants in food, water, consumer and personal care products. She conducts biomonitoring and health studies for a wide range of populations, including preconception and birth cohorts, communities exposed to contaminated drinking water, and those with occupational exposures.

Miriam Calkins

National Institute for Occupational Safety and Health (NIOSH)

Dr. Miriam Calkins, PhD, is a Research Industrial Hygienist with NIOSH. She is the Director for the Exposure Assessment Core in the Fire Fighter Cancer Cohort Study (FFCCS) and the Project Officer for a feasibility study of PFAS exposure and health indicators in occupational settings. She completed her doctorate in Occupational and Environmental Hygiene as well as her master's in Exposure Science, at the University of Washington in Seattle. Calkins also holds a Graduate Certificate in Climate Science from the University of Washington. Currently, Her research focuses on PFAS; comprehensive exposure assessments for firefighters during fire response, training, and investigations; and occupational heat exposure. Additional research interests include heat stress and traumatic injury in construction and agricultural occupations as well as optimization of monitoring strategies for application to research and practice.

Stephen Colby Brown

Sierra Club

Dr. Stephen Colby Brown, PhD, has contributed to projects at Smith Kline Beckman, Glaxo, Glaxo-Wellcome, Parke-Davis, Pfizer, and Esperion Therapeutics in most therapeutic areas. He has worked with the Sierra club as part of the Grassroots Network PFAS Action Team since 2015. He received his PhD in Pharmaceutical Chemistry from UCSF. He was elected as a AAAS Fellow in 2001.

Jamie DeWitt
East Carolina University, NC
Dr. Jamie DeWitt, PhD, is a Professor in the Department of Pharmacology & Toxicology of the Brody School of Medicine at East Carolina University (ECU). Her laboratory's research program focuses on functional effects of environmental chemicals on the immune system and its interactions with the nervous system during development and adulthood. With respect to PFAS, DeWitt has published numerous primary research articles and review articles, book chapters, and edited a book on their toxicity. She has served as an external reviewer of PFAS documents for the US EPA, the US National Toxicology Program, and the US Agency for Toxic Substances and Disease Registry. She also was a member of the International Agency for Research on Cancer working group for the assessment of the carcinogenicity of PFOA. Her laboratory is currently assessing the immunotoxicity of emerging PFAS that are of concern in NC through funding from the NC Policy Collaboratory and in her role as an Investigator with the NC State's NIEHS-funded Superfund Research Center for Environmental and Health Effects of PFAS.

Sarah Doll
Safer States, OR
Sarah is the National Director of Safer States, which provides support and strategic guidance to advocates and the space for national collaboration and coordination. Doll uses her unique strategic and collaboration skills to leverage collective state and local action to secure policy protections and create pressure for market transformation to reduce the threat of harmful chemicals in our daily lives. She has over 20 years of experience managing successful environmental health campaigns. Prior to Safer States, Sarah worked for the Oregon Environmental Council, the City of Portland, and on Capitol Hill.

Emily Donovan
Clean Cape Fear, NC
Emily Donovan is co-founder of Clean Cape Fear, a grassroots community group, which formed in 2017 after learning DuPont/Chemours contaminated North Carolina's drinking water supply for over 40 years. She has testified before Congress twice and participated in a Washington Post Live panel discussion with actor, Mark Ruffalo, and lawyer, Rob Bilott. She helped organize and host two screenings of the movie, Dark Waters, featuring special guest, Mark Ruffalo--both events resulted in NC's Attorney General suing DuPont/Chemours and NC's General Assembly filing a historic number of PFAS-related bills. She helped secure reverse osmosis filling stations in 49 local public schools impacted by PFAS contamination. She is a member of the leadership team for the National PFAS Contamination Coalition, an active member of the organizing committee for this conference and sits on various community advisory boards and coalitions working to address PFAS contamination.

Owen Duckworth
NC State, NC

Dr. Owen Duckworth, PhD, is a Professor of Soil and Environmental Chemistry in Crop and Soil Sciences at NC State University. He has a BS in Chemistry and Geology from the College of William and Mary, an MS in Environmental Sciences and Engineering from the University of North Carolina at Chapel Hill, and a PhD in Applied Sciences and Engineering from Harvard University. His research focuses on the biogeochemical processes that control the fate, transport, speciation, and bioavailability of nutrients and contaminants in soil and water. Understanding these processes at the fundamental level is essential to solving critical modern societal problems, including managing, and remediating polluted sites and improving nutrient uptake by crops or other plants. Duckworth's lab utilizes a wide variety of chemical, microbiological, analytical, spectroscopic, and field-based approaches to study biogeochemistry at molecular to field-scale, and collaborates national and internationally with chemists, biochemists, microbiologists, plant scientists, soil scientists, engineers, nutritionists, and public health professionals.

Suzanne Fenton
NIEHS, NC
Dr. Suzanne "Sue" Fenton, PhD, is a senior scientist specializing in Reproductive Endocrinology in the Division of the National Toxicology Program at NIEHS. Her laboratory has expertise in discovery of chemicals or environmental factors contributing to mammary gland developmental defects or cancer, pregnancy-related disease, and persistent adverse health effects in developmentally exposed offspring. She has received several NIH and EPA-based awards for her research on perfluorinated chemicals and endocrine disruptors.

Kevin Ferrara
US Air Force (USAF) Veteran, Agile Fire Service Organization, PA
Kevin Ferrara provides administrative leadership and management consultation on identifying, developing, implementing, and maintaining strategies and techniques critical to operate and sustain career and volunteer fire protection and emergency service organizations. While serving in the USAF, Ferrara received and provided in-depth training while attaining higher education and professional credentials that supported his senior fire officer roles at military installations around the world as well as receiving accolades from national and international governmental and fire service organizations. He was directly responsible for developing several USAF programs, policies, and budgets that improved support operations; most notably an Emergency Response Capability (ERC) assessment tool still used by the USAF today. Ferrara delivers agile fire protection and emergency service consultation to career, volunteer, and administrative organizations around the world. In addition to consulting, he hosts AFSO21's Weekend Wrap-up Podcast, discussing firefighter health and safety issues including occupational cancer and PFAS exposure among firefighters.

Radhika Fox
US Environmental Protection Agency (EPA) Office of Water
Radhika Fox is the Assistant Administrator for the U.S. Environmental Protection Agency's Office of Water. The Office of Water works to ensure that drinking water is safe, wastewater is safely returned to the environment, and surface waters are properly managed and

protected. Prior to joining EPA, Fox served as Chief Executive Officer for the US Water Alliance, Director for policy and government affairs for the San Francisco Public Utilities Commission, and the Federal Policy Director at PolicyLink. She has used her 20+ years of experience to address the most salient water issues facing the nation—including climate change, affordability, equity, governance, innovative finance, and the evolution of the One Water movement. Fox holds a BA from Columbia University and a master's in City and Regional Planning from the University of California at Berkeley where she was a Department of Housing and Urban Development Community Development Fellow.

Elizabeth Friedman
Children's Mercy Hospital, Region 7 Pediatric Environmental Health Specialty Unit, KS
Dr. Elizabeth Friedman, MD, is an environmental physician with extensive training in pediatrics, internal medicine, preventive medicine, and occupational and environmental medicine, as well as public health. She works as the Region 7 Mid-America PEHSU director, a primary care physician, and as the Medical Director of the environmental health program at Children's Mercy Hospital in Kansas City, MO.

Geoff Gisler
Southern Environmental Law Center (SELC), NC
Geoff Gisler is a senior attorney in the Chapel Hill office of the SELC. He leads the organization's Clean Water Program, which focuses on keeping PFAS and other industrial chemicals out of drinking water. Gisler led SELC's representation of Cape Fear River Watch in litigation against The Chemours Company and the North Carolina Department of Environmental Quality following the discovery of the company's PFAS discharges and negotiated the consent order that is responsible for ongoing remediation at Chemours' facility.

Philippe Grandjean
Harvard University, MA
Dr. Philippe Grandjean, DMSc, MD, is a physician and environmental epidemiologist, who specializes in the effects of environmental chemicals on human health. Current studies focus on adverse effects associated with developmental exposure to environmental chemicals, especially the perfluorinated alkylates. His studies provided documentation for new and lowered European Union limits for exposure to these compounds. He is a professor of environmental medicine at the University of Southern Denmark and an Adjunct Professor at Harvard University and at the University of Rhode Island. In June 2022, he is attending the annual meeting of the International Society for Children's Health and the Environment (ISCHE), where he is receiving an award for successfully combining research with advocacy for children's environmental health.

Loreen Hackett
PfoaProject, NY
Loreen Hackett has been advocating for contaminated families in Hoosick Falls, NY since their severe PFOA contamination was announced in 2015 and led to the issuance of the first National Priorities List Federal Superfund Site for PFOA, as well as additional state sites. In June 2016, she created #PfoaProjectNY, which has expanded worldwide, and continues to share all things

PFAS. Hackett was the first Co-Chair of the Hoosick Falls Community Participation Working Group (CPWG) established for the superfund sites and is on the CAP committee for their Centers for Disease Control (CDC)-awarded site study in collaboration with University of Albany. She is on the leadership committee of the National PFAS Contamination Coalition (NPCC). She presented on the public panel representing EPA Region 2 for the CDC-funded National Academies of Sciences, Engineering, and Medicine panel for physician guidance on PFAS. She is an allied member of the JustGreen Partnership. She has attended and submitted testimony in two Congressional hearings in DC, various NY state hearings, and continues working with elected officials on both the state and federal levels on bills regulating PFAS, introducing the PFAS Accountability Act with Senator Kirsten Gillibrand as well as collaborating with numerous environmental organizations. She is also a cancer survivor, linked to PFAS exposure, and has a primary interest in PFAS-related health effects.

Vaughn Hagerty
Former investigative reporter, NC
Vaughn Hagerty spent more than 25 years as a journalist and wrote the first news article about the presence of GenX and other PFAS from Chemours in the drinking water of hundreds of thousands of Southeastern North Carolina residents.

Chris Higgins
Colorado school of Mines, CO
Dr. Christopher P. Higgins, PhD, is an environmental chemist at the Colorado School of Mines. Higgins received his AB in Chemistry from Harvard University, and graduate degrees in Civil and Environmental Engineering from Stanford University. He joined the Colorado School of Mines in 2009, attaining the title of Professor in 2019. His research focuses on the movement of contaminants in the environment. In particular, he studies chemical fate and transport in natural and engineered systems, with a focus on poly- and perfluoroalkyl substances (PFAS). Higgins has authored more than 120 peer-reviewed publications. His research has been supported by NSF, NIH, EPA, USDA, and the DoD.

Jane Hoppin
NC State, NC
Jane Hoppin, ScD, is an environmental epidemiologist who is leading the GenX Exposure Study in North Carolina. She is a professor at NC State and Director of the NIEHS-funded P30 Center, the Center for Human Health and the Environment (CHHE), and an Investigator with NC State's NIEHS-funded Superfund Center for Environmental and Health Effects of PFAS. She has published over 200 scientific papers focusing on how chemicals in the environment influence human health. She is currently a member of the National Academies of Sciences, Medicine, and Engineering panel on the "Guidance on PFAS Testing and Health Outcomes." In Feb 2022, she received the James E. Holshouser Award for Public Service from the UNC Board of Governors.

Brittany Jacobs
U.S. EPA

Brittany Jacobs is a Biologist in the Health and Ecological Criteria Division in the Office of Science and Technology, Office of Water at the US EPA. She joined EPA as a Presidential Management Fellow in August 2016 after completing her PhD in Cell and Molecular Biology from the University of Wisconsin-Madison. Jacobs has worked on projects supporting Safe Drinking Water Act actions and Clean Water Act actions, most notably the GenX chemicals toxicity assessment finalized in 2021 and the updated toxicity assessments for PFOA and PFOS sent for external peer review in 2021.

Denise Keehner
US EPA, DC
Denise Keehner is the Director of the Office of Pollution Prevention and Toxics at US EPA HQ. Prior to taking this position in April 2022, Keehner was an Assistant Secretary at the Maryland Department of the Environment (MDE), leading MDE's PFAS-related efforts and efforts to incorporate Environmental Justice into MDE permitting and compliance monitoring programs. She led MDE's Wetlands and Waterways Program for four years prior to moving into the Assistant Secretary position. In 2013 Keehner retired from the US EPA as the Director of the Office of Wetlands, Oceans and Watersheds after 35 years of federal service, which spanned positions in the Office of Water, Office of Solid Waste, Office of Pesticide Programs, and the Office of Pollution Prevention and Toxics. She returned to the US EPA in April of 2022 to help the agency achieve the great promise of the new Toxic Substance Control Act (TSCA) to effectively and efficiently assess and address the risks to human health and the environment posed by industrial chemicals. She has a degree in Biology from the University of Maryland.

Matt Klasen
US EPA, DC
Matt Klasen serves as the Manager of EPA's Council on PFAS, a cross-agency group of EPA policy and technical leaders created by EPA Administrator, Michael Regan, to develop and implement the Agency's PFAS strategy. Klasen joined the PFAS Council in October 2021 after serving for five years in EPA's Office of Congressional and Intergovernmental Relations as the Congressional lead for EPA's drinking water, water finance, and PFAS activities. He began his EPA career as a Presidential Management Fellow in 2007, and has served in EPA's Office of Environmental Information, Office of Water, Office of the Administrator, and Office of Ground Water and Drinking Water, as well as in EPA Region 9 (San Francisco), at the Council on Environmental Quality, and at the Environmental Council of the States (ECOS). He has a BA in Environmental Studies and Political Science from Washington University in St. Louis and an MPA in Environmental Science and Policy from Columbia University.

Detlef Knappe
NC State, NC
Dr. Detlef Knappe, PhD, is the S. James Ellen Distinguished Professor of Civil, Construction, and Environmental Engineering at NC State University. He joined the NC State faculty in 1996 after receiving a PhD degree in Environmental Engineering from the University of Illinois at Urbana-Champaign. Knappe's research interests broadly encompass drinking water quality and treatment. He is a member of the NC Secretaries' Science Advisory Board, a Trustee for the

Water Science and Research Division of the American Water Works Association, and is Deputy Director of NC State's NIEHS-funded Superfund Center for Environmental and Health Effects of PFAS.

Max Krause
US EPA, OH
Dr, Max Krause received his PhD in Environmental Engineering from the University of Florida in 2016. Upon completing his dissertation in solid and hazardous waste management, he joined the US Environmental Protection Agency's Office of Research & Development, where he has been for six years. His current research focuses on waste characterization and landfill emissions. Krause was part of the EPA's PFAS Innovative Treatment Team, which evaluated multiple technologies for effective PFAS destruction. He continues to investigate hydrothermal technologies on different PFAS-containing wastes.

Judy LaKind
LaKind Associates, MD
Dr. Judy LaKind, PhD, President of LaKind Associates, and Adjunct Associate Professor in the Department of Epidemiology and Public Health, University of Maryland School of Medicine, has expertise in exposure science, assessment of human health risks, biomonitoring, scientific/technical analysis for regulatory support, and systematic reviews. She is the former president of the International Society of Exposure Science. LaKind serves on the editorial boards of the Journal of Toxicology and Environmental Health and Environment International. She received her PhD from the Johns Hopkins University (JHU) in environmental engineering, her MS from The University of Wisconsin, Madison in geology and her BA from JHU in geology.

Rainer Lohmann
University of Rhode Island (URI), RI
Dr. Rainer Lohmann, PhD, is a Professor at the University of Rhode Island's Graduate School of Oceanography. He has a degree in Chemical Engineering and Doctorate in Environmental Science. He is Director of the URI-led NIEHS-funded Superfund Research Program Center on the Sources, Transport, Exposure and Effects of PFAS (STEEP). His research focuses on the detection, fate, and transport of anthropogenic pollutants in the environment, often relying on passive samplers in the process.

Sonya Lunder
Sierra Club, CO
Sonya Lunder (she/her) is the Senior Toxics Policy Advisor for the Sierra Club nationally. She supports Sierra Club's federal and state and local policy campaigns to address the harmful and ongoing use of toxic chemicals, with a growing focus on waste issues. Sonya has a master's degree in Public Health from the University of California, Berkeley. Sonya lives and works in Colorado.

Sara Lupton
United States Department of Agriculture, ND

Dr. Sara Lupton, PhD, is currently a Research Chemist with the Animal Metabolism-Agricultural Chemicals Research Unit at the Edward T. Schafer Agricultural Research Center in Fargo, ND within the United States Department of Agriculture-Agricultural Research Service. Lupton received her BS in Chemistry in 2005 from Northland College in Ashland, WI, and her PhD in Environmental Analytical Chemistry in 2010 from University at Buffalo, State University of New York in Buffalo, NY. She is the ARS lead scientist for the USDA's Dioxin Survey conducted every five years in beef, pork, and poultry. Her other research includes absorption, distribution, metabolism, and excretion (ADME) studies of animal drugs and environmental contaminants in lab and food animals, in vitro metabolism of environmental contaminants, and investigation of environmental contaminant sources (feed, water, housing, etc.) that contribute to residue levels in food animals. Lupton has conducted research on PFAS compounds in food animals for over 10 years.

Patrick MacRoy
Environmental Health Strategy Center, ME
Patrick is the Deputy Director of Defend Our Health, where he provides day-to-day management of its operations and ensures its programs meet their ambitious goals. Since working with Fred Stone to first tell his story of how PFAS contaminated his dairy in early 2019, Patrick has led Defend's work to secure health protective policies related to the chemicals in Maine, including first-in-the-nation products regulations and testing for farm fields. Prior to joining Defend Our Health in December of 2016, Patrick held senior leadership roles in both government and nonprofit organizations. His past professional experience includes serving as the Executive Director of the Alliance for Healthy Homes, a national advocacy organization focused on eliminating health hazards in housing. Under his direction, the Alliance advanced congressional action and regulations to protect families from formaldehyde, lead, radon, toxics in fragrances, and other chemicals in homes, while launching innovative partnerships to help local partners and contractors comply with federal laws in renovation requirements. He previously worked as an epidemiologist with the State of Rhode Island and as an epidemiologist and director of the City of Chicago's lead poisoning prevention program. Patrick earned a master's in environmental studies and a bachelor's in Public Policy, both from Brown University. Outside of work, he is an avid long-distance motorcyclist (IBA #48186) and aspiring snowmobiler.

Emily Marpe
Hoosick Falls, NY
Emily Marpe is a mother who turned to activism after learning her private well was polluted with PFAS. As part of her all-consuming quest to protect her family and community, she formed a concerned-citizens group, ran for public office, and traveled to Washington, DC, to lobby federal lawmakers, in one case even testifying before Congress. She also helped organize a class-action lawsuit, which was recently settled for $23.5 million and will establish a medical-monitoring program for residents of Petersburgh, NY. Her driving inspiration is her

children who, through no fault of their own, are growing up with forever chemicals in their bodies.

Craig Minor
Craig Minor is Mitchell Minor's dad and husband to Carrie Minor (40 Years). He is co-author of "Overwhelmed, A Civilian Casualty of Cold War Poison; Mitchell's Memoir." Craig is a retired United States Air Force Lieutenant Colonel, Senior Acquisition Manager, NT39A Instructor Research Pilot, and B-52G Aircraft Commander with a Juris Doctor in Law, master's in Business Administration in Finance, and Bachelor of Science in Chemistry.

Tom Neltner
Environmental Defense Fund (EDF), MD
Tom Neltner is the Environmental Defense Fund's Senior Director for Safer Chemicals. He and his colleagues lead EDF's efforts to remove or minimize hazardous chemicals from products and the marketplace through cross-cutting policy initiatives. His primary focus is on food additive safety and reducing exposure to lead in our homes and communities. He is a chemical engineer and attorney with experience in chemical safety issues in the workplace, the environment, the home, consumer products, and food.

Graham Peaslee
University of Notre Dame, IN
Dr. Graham Peaslee, PhD, is a professor of physics at the University of Notre Dame. He leads an active research group in the area of applied nuclear science where he brings established nuclear measurement techniques to pressing environmental issues. His interests include detection of total fluorine as a surrogate for PFAS (per- and polyfluorinated alkyl substances), but also rapid screening of materials for heavy metals and other chemicals of concern. He has more than 230 peer-reviewed publications in basic and applied research, most led by student co-authors.

Jon Petali
New Hampshire Department of Environmental Services, NH
Dr. Jonathan Petali, PhD, is the toxicologist for the New Hampshire Department of Environmental Services. He supports human health and ecological risk assessments for a variety of chemical contaminants, including PFAS, and has a special interest in risk communication around emerging contaminants. He holds a PhD in Environmental Toxicology from the University of Nebraska Medical Center, and BS in Biological Sciences from Wright State University.

Michael Pjetraj
NC Department of Environmental Quality, NC
Michael Pjetraj is the Deputy Director for the Division of Air Quality (DAQ). He has been with the DAQ since 1995 and has worked in the Raleigh Regional Office and the Central Office as an environmental engineer. He also served as the Stationary Source Compliance Branch Supervisor in the Central Office for eight years. Prior to joining the DAQ, he worked for a source

testing/consulting company. Pjetraj earned an engineering degree from NC State University. He is a licensed Professional Engineer in North Carolina and is also a NC Certified Public Manager. He serves on the Board of Directors for the Air and Waste Management Association Research Triangle Park Chapter.

John Reeder
Environmental Working Group, DC
Before joining EWG, John Reeder was an executive in residence at American University's School of Public Affairs, where he taught American government and environmental policy. Previously he served at the EPA as deputy chief of staff, and held several senior executive positions, including director of congressional affairs and director of environmental cleanup at federal Superfund sites. Reeder worked along Senate committee staff on two special assignments to Capitol Hill to help negotiate agricultural and environmental legislative reforms. He graduated from the University of Minnesota with a bachelor's degree in agriculture and applied economics and a master's degree from the Humphrey School of Public Affairs. He is a recipient of the EPA Administrator's Gold Medal Award and the US Army's Commendation Award for overseas active duty in the military.

Anna Robuck
Icahn School of Medicine, Mount Sinai
Dr. Anna Ruth Robuck, PhD, is an environmental chemist and oceanographer studying chemical and plastic pollution as a research fellow in the Department of Environmental Medicine and Public Health at the Icahn School of Medicine at Mount Sinai. Her research focuses on the detection and characterization of legacy PFAS, novel PFAS, plastics, and plastic-derived chemicals in humans, wildlife, fish, and water using high resolution mass spectrometry and advanced data handling techniques. She earned a PhD in Chemical Oceanography from the University of Rhode Island Graduate School of Oceanography, as part of the STEEP Superfund Research Program. Robuck also holds a BS in Marine Biology and Chemistry, and an MSc in Marine Science and Geographic Information System, both from the University of North Carolina Wilmington.

Megan E. Romano
Dartmouth University, NH
Dr. Megan Romano, PhD, is an environmental and perinatal epidemiologist and an associate professor of epidemiology at the Dartmouth Geisel School of Medicine. Her work investigating the influence of PFAS on breastfeeding duration and childhood obesity has influenced drinking water guidance across several states in the US. Her research broadly investigates the influence of exposure to environmental endocrine disrupting chemicals found in food, water, and consumer products on maternal and child health, with a current focus on the influence of PFAS on complications of pregnancy, lactation, and human milk composition. Romano is also engaged in multiple translational research efforts in the state of New Hampshire to support communities impacted by environmental contamination.

Laurel Schaider

Silent Spring Institute, MA

Dr. Laurel Schaider, PhD, is a Senior Scientist at Silent Spring Institute, where she leads the Institute's water quality research on highly fluorinated chemicals (PFASs) and other contaminants of emerging concern. Her research focuses on characterizing PFAS exposures from drinking water, understanding health effects associated with PFASs, identifying other sources of PFAS exposure such as food packaging, investigating socioeconomic disparities in exposures to drinking water contaminants, and working with communities to develop research studies and resources to address their concerns. She is the principal investigator for the PFAS-REACH (PFAS Research, Education, and Action for Community Health) study, a researcher-community partnership that is evaluating PFAS exposures and immune system effects in children in communities with PFAS water contamination and developing an online resource center for PFAS-affected communities. Schaider earned her MS and PhD in Environmental Engineering at the University of California, Berkeley, and an SB in Environmental Engineering Science from MIT.

Racquel Segall

International Association of Fire Fighters (IAFF)

Racquel Segall is the Deputy Director for Occupational Health and Medicine at the IAFF. She oversees research, education, cancer partnerships and technical assistance for health and safety topics that impact our members.

Linda Shosie

Environmental Justice Task Force, AZ

Linda Shosie is an environmental justice (EJ) leader and human rights activist FOR safe, clean, healthy, and sustainable environments for over ten years. She is the Owner and Founder of the EJ Task Force- organization, which was formed a little over five years ago when she became aware of PFAS contamination in the groundwater and drinking water supply at the DM Air Force Installations because of the use and disposal of PFAS-containing Fire Fighting Foams. In 2007 Linda had to face a mother's worst nightmare. When her 19-year-old child Tianna died of a rare autoimmune related disease that Linda believes was caused by community-wide exposure to numerous toxic chemicals that contain PFAS. She joined the National PFAS Contamination Coalition Leadership Team in 2017. In 2018 she brought the EPA Administrator, Mr. Steve Cook, to tour her community to show the agency how legacy PFAS pollution impacts communities of color and disadvantaged communities with the goal of raising public awareness about the PFAS crisis in the Tucson Airport Superfund Site area. Since Linda joined the NPCC she has met regularly with EPA, including Radhika Fox and Matthew Tejada, DOD, and other federal agencies as well as the White House Council on Environmental Quality and National Academies of Sciences, Engineering, and Medicine. She provides stakeholder input concerning the PFAS crisis and regulations to protect children and prevent future contamination. Linda is also a member of the Citizens Science Advisory Board.

Tony Spaniola

Great Lakes PFAS Action Network

Anthony Spaniola is an attorney, impacted citizen and national PFAS advocate. His family's lake home in Oscoda, Michigan is in the “zone of concern” for PFAS contamination from the former Wurtsmith Air Force Base, the first reported US military PFAS site in the world and the source of five separate public health warnings for the Oscoda community. Drawing on his personal, professional and policy experience, Spaniola has worked with community leaders, scientists, NGO’s, and government officials at all levels on various PFAS projects. He is a co-founder and co-chair of the Great Lakes PFAS Action Network and a co-founder of the Need Our Water (NOW) community action group in Oscoda. He also serves on the Leadership Team of the National PFAS Contamination Coalition. Among his projects, Spaniola served as a consultant to Pulitzer Prize winning journalist Sara Ganim on her critically acclaimed PFAS documentary, “No Defense: The U.S. Military’s War On Water.” He has delivered PFAS presentations at academic and other venues across the country and was the only non-scientist community member to serve as a panelist at the National Academy of Sciences Inaugural PFAS Workshop in 2019 in Washington, DC. In 2021, he testified in Congress about the Department of Defense's PFAS response before the US Senate Homeland Security and Governmental Affairs Committee. Spaniola's PFAS work is informed, in part, by his experience working with his state legislator father on the front lines of Michigan's polybrominated biphenyl contamination crisis in the 1970s. In the wake of that crisis, he initiated legislation (enacted as Michigan Public Act 82 of 1984) creating the Michigan Cancer Registry. Spaniola is a founding partner in the commercial law firm of Ufer, Spaniola & Frost, P.C. in Troy, Michigan. He holds an undergraduate degree in government from Harvard and a juris doctorate from the University of Michigan Law School.

Heather Stapleton
Duke University, NC
Dr. Heather Stapleton, PhD, is an environmental chemist and exposure scientist in the Nicholas School of the Environment at Duke University. Her research interests focus on identification of halogenated and organophosphate chemicals in consumer products and building materials and estimation of human exposure, particularly in vulnerable populations such as pregnant women and children. Her laboratory specializes in analysis of environmental and biological tissues for organic contaminants to support environmental health research.

Kyle Steenland
Emory University, GA
Dr. Kyle Steenland, PhD, is a Professor in the Department of Environmental Health at Rollins School of Public Health at Emory University. He is an epidemiologist. Before coming to Emory in 2002, he worked at the National Institute for Occupational Health in Cincinnati. From 2005 to 2012 he was a member of the three person C8 Science Panel conducting studies in the mid-Ohio valley, where Dupont had used PFOA to make Teflon, which resulted in contaminated groundwater and drinking water around the plant. The C8 Science Panel conducted a number of studies in the area to determine whether PFOA was likely to have caused any adverse health effects in the exposed population. The Science Panel concluded that six health outcomes were probably linked to PFOA, including two cancers, kidney and testicular cancers.

Fred Stone
Stoneridge Farm, ME
Fred Stone is co-owner of Stoneridge Farms, Inc. along with his wife Laura Stone. Stoneridge is a dairy farm located in Arundel, Maine. Stone, a third-generation dairy farmer, and Laura are operating a dairy farm that has been in existence since 1914. They purchased the farm from Stone's parents in 1977.

Troy Techlin
Saginaw Chippewa Indian Tribe, MI
Troy Techlin is the Environmental Manager for the Saginaw Chippewa Indian Tribe of Michigan. He oversees the environmental and natural resource programs for the Tribe. He has been the lead for all PFAS issues for the Tribe. He attended the National PFAS summit in DC and organized a listening session with the US EPA for the Tribe and local partners about community concerns about PFAS.

Matthew Tejada
US EPA, DC
Dr. Matthew S. Tejada, PhD, joined the EPA in March of 2013 as a career senior executive and director of the Office of Environmental Justice. As director, Matthew leads the Environmental Justice Program's cross-cutting work throughout the EPA and across activities with other federal agencies, states, Tribes, local governments, and other stakeholders. Before his career at EPA, Tejada spent over five years as executive director of the environmental justice advocacy Air Alliance Houston in the Houston and Texas Gulf Coast area. He received his master's and doctoral degrees from the University of Oxford where he was a member of St. Antony's College and a BA in English from the University of Texas at Austin, then served two years in the Peace Corps. Tejada is a native of Ft. Worth, Texas, lives with his wife Andrea in Silver Spring, Maryland and is the proud father of Nia Tejada.

Denise Trabbic-Pointer
Sierra Club, MI
Denise Trabbic-Pointer is a 2nd generation DuPonter. She retired in January 2019, after 42 years with DuPont and a spin-off company, Axalta Coating Systems, as their Global Environmental Competency Leader. She is a Chemical Engineer with a BS and MS in Hazardous Materials Management by education and a health and environmental manager by career. Since May 2019, she has worked with the Sierra Club – Michigan Chapter, as a Toxics & Remediation Specialist.

Xenia Trier
European Environment Agency (EEA), Denmark
Dr. Xenia Trier, PhD, joined the EEA in 2016 where she works at the science-policy interface on the risk governance of chemicals and provides input to the EU processes on the EU chemicals Strategy for Sustainability (CSS), which includes PFAS. Other topics of interest include managing classes of chemicals, non-essential uses, safe and sustainable design (SSBD), early

warning systems, chemicals in the circular economy, indicators of chemical pollution, mixtures, and monitoring and data management (IPCHEM). Before joining the EEA, Trier worked as an analytical chemist in a commercial compliance laboratory, and at the Danish National Food Institute (DTU), conducting research, enforcement and providing advice on organic pollutants in air, soil, water, food contact materials and human blood at national and EU level. Since 2006, she has worked on PFAS, including completing her PhD on polyfluorinated surfactants in paper and board food contact materials (2007-2011) and publishing on both analytical and science-policy aspects of PFAS.

Ken Waldroup
Cape Fear Public Utility Authority (CFPUA), NC
Kenneth Waldroup is Executive Director of CFPUA, the primary water and wastewater provider in Wilmington and New Hanover County. Mr. Waldroup has more than 29 years of experience in the water industry and was an assistant director at the City of Raleigh Public Utilities Department (Raleigh Water) prior to joining CFPUA in June 2021. A licensed professional engineer, Waldroup has a bachelor's degree in nuclear engineering from NC State University and a master's in public administration from NC Central University. Waldroup is a former member of the NC Environmental Management Commission and was the 2020-21 chair of the North Carolina Section of the American Water Works Association & the North Carolina Member Association of the Water Environment Federation.

Courtney Woods
University of NC - Chapel Hill, NC
Dr. Courtney Woods, PhD, is an Associate Professor of Environmental Sciences and Engineering at the Gillings School of Global Public Health at UNC Chapel Hill. As an environmental health scientist, she employs community-driven, mixed methods research approaches to assess hazards exposure and risk perception. Specific areas of interest include community impacts from industrial animal agriculture and solid waste facilities and rural water quality. Woods leads the Environmental Justice Action Research Clinic (EJ Clinic), which provides action-oriented research and technical assistance to communities facing existing and imminent environmental hazards. She also leads the Environmental Health Solutions MPH concentration at Gillings and serves as one of three co-leads for the Health Equity, Social Justice, and Human Rights MPH concentration.

Sandy Wynn-Stelt
Great Lakes PFAS Action Network, MI
Sandy is a master's–level Psychologist and Board-Certified Behavior Analyst who lives in Belmont Michigan. She has a small private practice that works with adults with intellectual disabilities and Autism Spectrum Disorder. In 2017 she learned that the well water in her community has been contaminated with PFAS and related compounds at some of the highest levels found in drinking water by Wolverine Worldwide. Since that time, she has spoken with several state and local legislators, the Michigan Attorney General and has testified in Washington DC at hearings on PFAS contamination. She currently participates in the local Wolverine Community Advisory Committee where she is on the leadership team as well as on

the MPART (Michigan PFAS Action Response Team) and the National PFAS Contamination Coalition. She also participates in the Michigan Department of Health and Human Services Health Study as a stakeholder for both the state PFAS study and the Agency for Toxic Substances and Disease Registry Multisite PFAS Study.

Poster Abstracts

Categories

- **Exposure Pathways (Posters 1-16)**
- **Risk Assessment (Poster 17)**
- **Remediation (Posters 18-25)**
- **PFAS Chemistry (Posters 26-28)**
- **Fate and Transport (Poster 29)**
- **Managing PFAS Waste (Posters 30-31)**
- **Epidemiology (Posters 32-37)**
- **Developmental and Reproductive Toxicology (Posters 38-44)**
- **Immune Toxicology (Posters 45-47)**
- **Health Effects (Posters 48-50)**
- **Medical Screening Guidance and Clinician Training (Poster 51)**
- **Environmental Justice, Risk Communication, and Community Engagement (Posters 52-60)**

Exposure Pathways

1. **Development of a community facing webtool to estimate blood PFAS levels from contaminated drinking water: Validation and Implementation**

Meghan T. Lynch, Abt Associates; Claire R. Lay, Abt Associates; Sara Sokolinski, Abt Associates; Adriana Antezana, Abt Associates; Carleen Ghio, Abt Associates; Brad Firlie, Abt Associates; Rachel Rogers, Center for Disease Control; Weihsueh Chiu, Center for Disease Control and Texas A&M University

Tools to estimate potential body burden associated with drinking PFAS-contaminated water are useful for public health assessment of exposed communities. We created a suite of one-compartment pharmacokinetic models using historical water concentrations and individual life-history information to estimate perfluorooctanoic acid (PFOA), perfluorooctanesulfonic acid (PFOS), perfluorononanoic acid (PFNA), and perfluorohexanesulfonate (PFHxS) serum concentrations resulting from drinking water exposures. Our model incorporates background exposure and drinking water exposure for all ages and sexes. For adults who have born children, the model estimates clearance through birth and breastfeeding. For children, the model estimates gestational exposure as well as exposure through breast milk, and/or formula. We used data from the ATSDR exposure assessments to validate the model and found it to be generally accurate within 1 order of magnitude. This presentation will include an overview of the model structure, the validation results and will demonstrate a user-friendly in-browser web estimator which implements our model. The web estimator outputs central estimates of blood PFAS with measures of uncertainty in relation to the levels found in the general U.S (United States). population. We anticipate this estimator will have utility in communications and public outreach for communities with elevated water concentrations of these four PFAS. The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention or ATSDR.

2. PFAS Identified In Wilmington NC Sea Foam via an Untargeted Approach Using High Resolution Mass Spectrometry

Rebecca A. Weed, North Carolina State University; Emily Donovan, Clean Cape Fear; Drake Phelps, Clean Cape Fear and North Carolina State University; Grace Campbell, North Carolina State University; Katlyn May, North Carolina State University; Erin Baker, North Carolina State University; Jeffrey R. Enders, North Carolina State University

Per- and polyfluoroalkyl substances (PFAS) are ubiquitous in the environment and exposure to these contaminants has been linked with negative health impacts. There are many potential routes of exposure to these compounds but an unconventional exposure source could be PFAS contaminated sea foam. Natural sea foam is produced from decomposing plant and algae material and has a brown/off white color with an earthy smell. PFAS contaminated sea foam is bright white, can be sticky and piles up on the beach in large amounts. Citizens of Wilmington, North Carolina, started noticing increasing amounts of sea foam on their beaches that had a bright white color. Wilmington is also near the river delta for North Carolina's largest river system, the Cape Fear River, which has been previously found to be contaminated with several PFAS, notably GenX, PFOS and PFOA. A small sampling campaign was conducted by local community groups in and around Wilmington, North Carolina to collect sea foam in order to determine if it was contaminated with PFAS. Six samples were collected by scooping sea foam into a 1 liter HDPE bottle. The foam samples were extracted using solid phase extraction (SPE) with a weak anion exchange (WAX) column to remove interferents and concentrate the PFAS. The samples were analyzed using an untargeted method on a high resolution Thermo Scientific Orbitrap Exploris 240 mass spectrometer coupled to a Thermo Scientific Vanquish LC system. The resulting data was interrogated in Compound Discover© against multiple databases: EPA CompTox PFAS database, ChemSpider, mzCloud, & Environmental and Food Safety (EFS) compound database. This resulting list was sorted based on three confidence levels: confirmed structure, probable structure, & tentative/putative candidate. These levels were based on the following criteria: exact mass, mass defect, isotope pattern, adduct observations, retention time match, and fragmentation match to a library or in-house standard. There were multiple "confirmed structure" hits including Hydro-Eve, GenX, Nafion by product 2, PFO4DA & PFO5DoA. Due to several of the detected compounds being known contaminants in the Cape Fear River system, it suggests that the increase of sea foam along the beaches in this area could be connected to contamination from upstream sources.

3. **ATSDR's Exposure Assessment of Per- and Polyfluoroalkyl Substances (PFAS) in Massachusetts, West Virginia, Delaware, and Washington**

Brad Goodwin, Agency for Toxic Substances and Disease Registry; Rachel Rogers, National Center for Environmental Health and Agency for Toxic Substances and Disease Registry; Peter Kowalski, Agency for Toxic Substances and Disease Registry; Karen Scruton, Agency for Toxic Substances and Disease Registry; William Jones, Agency for Toxic Substances and Disease Registry; and Ana Pomales, Agency for Toxic Substances and Disease Registry

The Agency for Toxic Substances and Disease Registry (ATSDR) conducted PFAS exposure assessments (EAs) in 10 communities that were known to have PFAS in their drinking water and are near current or former military bases. This poster presentation focuses on four EAs that were initiated in 2019: Hampden County, MA; Berkeley County, WV; New Castle County, DE; and Spokane County, WA. In each community, ATSDR recruited participants from a sampling frame based on a high likelihood of ingesting PFAS-contaminated drinking water. ATSDR collected serum and urine samples from participants and collected dust and tap water samples in a subset of participating homes. Participants were surveyed about factors that could affect their serum PFAS levels. In all four communities, the PFAS contamination of the drinking water supply was mitigated prior to the start of each EA. The Centers for Disease Control and Prevention's Environmental Health Laboratory measured serum PFAS levels for seven PFAS. The geometric mean PFAS serum levels for each EA were compared to levels measured in the 2015-2016 National Health and Nutrition Examination Survey (NHANES). In the Hampden County, MA; New Castle County, DE; and Spokane County, WA communities, the age-adjusted serum geometric means of PFHxS, PFOA, and PFOS exceeded the respective NHANES values. In Berkeley County, WV, only the age-adjusted geometric mean for PFHxS exceeded the NHANES value. Common factors, e.g., age, length of residency, gender, associated with PFAS levels in each community and recommendations for reducing exposure will be presented.

The findings and conclusions in this presentation have not been formally disseminated by the Agency for Toxic Substances and Disease Registry and should not be construed to represent any agency determination or policy.

4. **Public Health and Toxicity Assessment of Per- and Polyfluoroalkyl (PFAS) Mixtures**

Moiz Mumtaz, David Mellard, Rachel Rogers, Karen Scruton, Greg Ulirsch, Jill Dyken; Agency for Toxic Substances and Disease Registry

Environmental exposures are complex, multi-route, multi-source, and often involve chemical mixtures. Per- and polyfluoroalkyl substances (PFAS) are multi-system toxicants ubiquitous in our environment, and exposures to them are no exception. To assist with its public health assessment process, the Agency for Toxic Substances and Disease Registry derives minimal risk levels (MRLs) for chemicals based on available animal and human toxicity data. An MRL is an estimate of daily human exposure to a hazardous substance that is likely to be without an appreciable risk of adverse noncancer health effects over a specified route and duration of

exposure. MRLs are often used to derive comparison values for initial screening of contaminants in the environment. Contaminants that exceed the comparison values are subjected to further evaluation for their potential to result in harmful exposures.
For mixtures toxicity assessment, the 2018 ATSDR Mixtures Framework recommends a data-driven 3-tiered approach. Applying the hazard index (HI) method, we evaluated possible developmental and other health effects from ingestion of PFAS mixtures in water. This included 42 private drinking wells surrounding a facility using an aqueous film-forming foam (area 1) and 2,745 wells surrounding a plastics manufacturing facility (area 2). Perfluorooctanesulfonic acid (PFOS) was the major contaminant in area 1 wells, while perfluorooctanoic acid (PFOA) was the major contaminant in area 2 wells. Multiple PFAS were detected in most wells analyzed, including PFAS which could not be included in mixtures analyses due to a lack of toxicity data. However, a majority were below screening levels and didn't undergo further toxicity analysis.

For area 1, 40 wells had detectable levels of PFAS. ATSDR applied the public health assessment and mixtures methods described above to make a health determination on only 10 of those wells (5 presented a risk of harmful effects and 5 presented unlikely risk). ATSDR could not make a health determination for the remaining 30 wells because of the lack of toxicity data on all mixture components.

ATSDR's evaluation of area 2 was more general due to the large number of wells having detectable levels of PFAS. Using its standard methods, ATSDR determined that 237 of the wells presented a risk of harmful effects to sensitive age groups, and 22 wells presented risk to all age groups. However, over half of the wells evaluated had detections of other PFAS that had no toxicity data and therefore could not be included in the mixtures evaluation.

At both areas evaluated, actions have been taken to reduce PFAS exposure from private wells above the applicable federal or state guidelines. Residents potentially exposed to high levels of PFAS have been advised to discuss their exposures with health care providers and to consider reducing their exposure to consumer products that contain PFAS.

These examples suggest that more comprehensive assessments could be achieved with enhanced data collection, better understanding of PFAS mechanisms of toxicity, increased toxicity testing, and development of MRLs or other health guidance values for additional PFAS.

"The findings and conclusions in this abstract are those of the author(s) and do not necessarily represent the official position of the Centers for Disease Control and Prevention/the Agency for Toxic Substances and Disease Registry."

5. The effects of parity on per-and polyfluoroalkyl substance concentrations in newborn dried bloodspots

Jordan McAdam, Laura Jones, Thomas O'Grady, Erin Bell; UAlbany School of Public Health

Per-and polyfluoroalkyl substances (PFAS) are of concern in public health due to widespread exposure through use of PFAS-containing products, contaminated foods, or drinking water. Although it has been suggested as a determinant of PFAS exposure concentrations in mothers, the role of parity is not well characterized when estimating infant exposure. Most previous studies consider parity as a confounder rather than a predictor of exposure. This study examines the relationship of parity and infant concentrations of perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA). We included 2482 mother-infant dyads from the Upstate KIDS Study--including 1948 singletons and 533 randomly selected twins--specifically from pairs where infants had dried bloodspot (DBS) collected shortly after birth and analyzed for PFAS quantification. We used linear regression [PFOS model point estimate (95% CI) 2.29 (2.16, 2.42); PFOA model point estimate (95% CI) 1.54 (1.44, 1.63)] to assess the associations of parity and geometric mean PFOS and PFOA concentrations, adjusting for maternal education, maternal age, and maternal race. Measured infant concentrations of PFAS were comparable to those reported in previous literature. PFOS concentration estimates declined with increasing parity, with the largest percent change between 1 and 2 previous births. Infant PFOA concentrations declined with increasing parity but increased after 3 previous live births; this could be due to decreased power with increasing parity. Findings suggest that PFOS and PFOA may have different biological half-lives and transfer patterns to the fetus based on parity. Future studies should include a greater number of maternal participants with varying parity.

6. **Perfluoroalkyl substance (PFAS) concentrations in plasma and skin of dairy cattle after life-time exposures to contaminated water and feed: Associated trends with age and lactation.**

Sara J. Lupton, United States Drug Administration; Edward T. Schafer, United States Drug Administration; David J. Smith, United States Drug Administration; Eric Scholljegerdes, New Mexico State University; Shanna Ivey, New Mexico State University; Abigail W. Snyder, United States Drug Administration; Emilio Esteban, United States Drug Administration; John J. Johnston, United States Drug Administration

A US herd of approximately 5,000 dairy cattle was discovered to have life-time exposures to feed and water contaminated with perfluoroalkyl substances (PFAS) originating from the legacy use of aqueous film forming foam (AFFF). Perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) were the major PFAS compounds in water sources; however, perfluorobutanoic acid (PFBA), perfluorohexanoic acid (PFHxA), perfluoroheptanoic acid (PFHpA), perfluorononanoic acid (PFNA), perfluoro butane sulfonate (PFBS), perfluoro hexane sulfonate (PFHxS), and perfluoro heptane sulfonate (PFHpS) were also present in water and analyzed for the study. On-farm plasma and skin (ear notch) samples were taken from a cohort of 164 dairy cattle ranging in age from < 6 months to ~7-8 years old. The cohort included heifers, lactating cows, and dry cows. Dairy heifers ranging in age from < 6 months to 12-14 months had plasma concentrations of summed PFAS carboxylic acids averaging 0.6 ± 0.6 ng/mL (mean ± SD); the summed sulfonate concentration in the same cohort averaged 105.3 ± 35.3 ng/mL. Sulfonate concentrations trended upward with age of heifer. Lactating and dry cows ranged from 2 to 8 years old with summed carboxylic acid concentrations in plasma of dry cows averaging 0.3 ± 0.3 ng/mL while lactating cows averaged 1.5 ± 0.9 ng/mL. Summed sulfonate concentrations in plasma of dry cows were 170.7 ± 54.1 ng/mL while the lactating cows averaged 197.3 ± 76.0 ng/mL. Overall, PFHxS, PFHpS, and PFOS were present in the highest concentrations in plasma. Generally, the PFHxS concentrations in plasma for heifers, lactating cows, and dry cows were higher than the average PFOS concentration in those cohort groups. In ear notch samples, PFHxS, PFHpS, and PFOS were the dominant PFAS' present, however, the average PFOS concentration was generally higher than that of PFHxS. The concentrations of PFHpS and PFOS in ear notches of heifers tended to accumulate with the age, however a significant ($P < 0.05$) effect of lactation status (dry vs lactating) on total sulfonate concentration in skin was noted where dry cows had higher concentrations than lactating cows. These data support the concept that PFAS tissue depots occur and that tissue depots may serve as releasable reservoirs of PFAS. On a population basis, summed PFAS concentrations in plasma averaged 160.8 ± 63.5 ng/mL across all 164 animals at the time of sampling. Analysis of all samples against estimated age, suggests that steady state of summed PFAS sulfonates occurred after about 2 years of exposure.

7. Presumptive Contamination: A New Approach to PFAS Contamination Based on Likely Sources

Derrick Salvatore, Northeastern University; Kira Mok, Northeastern University; Grace Poudrier, Northeastern University; Phil Brown, Northeastern University; Linda Birnbaum, National Institute of Environmental Health Sciences; Gretta Goldenman, Milieu Consulting; Sharyle Patton, Commonweal Health and Environment Program; Maddy Poehlin, PFAS Project Lab; Julia Varshovsky, Northeastern University; Alissa Cordner, Whitman College

While research and regulatory attention to per- and polyfluoroalkyl substances (PFAS) has increased exponentially in recent years, data about the scale of PFAS releases and resulting contamination in the United States are uneven and incomplete . Given existing knowledge about sources of PFAS contamination, we posit that in the absence of testing data, PFAS contamination can be presumed around three types of facilities: 1) fluorinated aqueous film-forming foam (AFFF) discharge sites, 2) certain industrial facilities, and 3) sites related to PFAS-containing waste. Our model integrates available geocoded, nationwide datasets into a single analysis of presumptive contamination sites in the United States. We used this model to create a publicly-available map of 57,813 sites of presumptive PFAS contamination in the United States, in collaboration with the PFAS-REACH study.

- Fluorinated AFFF discharge sites: Military sites have routinely discharged AFFF as part of training, testing, and firefighting operations since 1967. Of the 687 Department of Defense (DOD) installations with known or suspected releases of PFAS, none have begun a cleanup phase, while numerous other military installations remain unassessed. We identified 3,493 Military Sites using the DOD's Military Installations, Ranges, and Training Areas and Formerly Used Defense Sites datasets. We also identified 519 airports certified for AFFF use under Title 14 CFR Part 139, which requires regular AFFF testing and discharging. PFAS contamination should also be expected at fire suppression locations where fluorinated AFFF was deployed, including fires from airplane and rail crashes and at oil and gas facilities. We identified 401 railroad crash sites with documented fires. (Nationwide, geolocated datasets are not available for other categories of AFFF release sites.).

- Certain industrial facilities: Researchers, state agencies, and the EPA have all used North American Industry Classification System (NAICS) codes to identify industrial facilities suspected of using PFAS, although approaches vary. Our method synthesizes previous approaches to develop a consistent set of 38 NAICS codes that are likely sources of PFAS contamination. We identified 49,145 facilities whose primary NAICS code is linked to PFAS use.
- Sites related to PFAS-containing waste: PFAS are often present in wastewater entering wastewater treatment plants (WWTPs), resulting in contaminated effluent and sludge. Typical wastewater treatment methods cannot break down terminal PFAS, and PFAS have been found in water systems near WWTPs due to chemical transformations of precursor chemicals. Using the Clean Watershed Needs Survey, we identified 4,255 major WWTPs where contamination is expected. (Nationwide, geolocated datasets are not available for hydraulic fracturing sites, sewage sludge application sites, and other sites linked to PFAS waste.)

This model presents a conceptual argument for presumptive contamination and a methodological approach that clearly identifies locations where PFAS contamination is likely. In the absence of PFAS testing data, this approach can be used to prioritize investigative testing and remediation resources. Our analysis contributes to increasing knowledge of PFAS contamination. and builds on prior research identifying suspected industrial PFAS dischargers and state-based studies that use PFAS testing data to identify suspected categories of contamination.

8. Challenges in estimating exposure to perfluoroalkyl substances in food through the biosolids pathway

Ankita Bhattacharya, Michigan State University; Sarah Choyke, Colorado School of Mines; Juliane Brown, Colorado School of Mines; PingPing Meng, North Carolina State University; Geoff Rhodes, Michigan State University; Detlef Knappe, North Carolina State University; Hui Li, Michigan State University; Christopher P. Higgins, Colorado School of Mines; Courtney Carignan, Michigan State University

Food safety concerns have been raised regarding elevated concentrations of poly- and perfluoroalkyl substances (PFASs) in the soil of agricultural fields. In Michigan, this includes several farms that have received biosolids from wastewater treatment plants (WWTP) contaminated by influent from the metal plating industry as well as waste from paper mills that have been land applied. PFAS uptake into food crops is influenced by concentrations and mixtures of PFASs, plant species and compartment(s), soil organic carbon, and other soil characteristics, as well as growth conditions. These factors pose a challenge for state and federal agencies assessing risk of foods grown in a field with PFAS-impacted soils. Therefore, we investigated uncertainty associated by first estimating PFAS levels in corn kernels using soil concentrations and bioaccumulation factors (BAFs) from soil to crops and then comparing to measured concentrations from a contaminated field. Estimated concentrations of PFOS in corn kernels ranged from 0 to 8313 ng/kg, with some estimated daily intakes exceeding benchmark values. We analyzed PFASs in corn kernels collected from a field with elevated concentrations of PFOS (12 to 496 ng/g) and other PFASs using LC-MS/MS. None of the investigated PFASs were identified above the limit of detection in the corn kernels. Our findings indicate that site-specific evaluations can greatly reduce uncertainty in exposure and risk assessment. Future studies should also investigate uptake into the corn stalk and leaf, which may be more likely to take up PFASs than the kernels and are consumed by livestock. We encountered many challenges conducting this pilot study and caution readers not to draw any broad conclusions from our findings about the safety of biosolid contaminated fields.

9. Fate and Disposition of PFAS in Broiler Chickens During a 6 Week Exposure Period

Abigail W. Snyder, David J. Smith, Sara J. Lupton, Edward T. Schafer; United States Department of Agriculture

Per- and poly-fluorinated alkyl substances (PFAS) consist of over 4000 different chemical entities used as surfactants in a host of industrial and consumer products. PFAS contaminants have been measured in chickens, pigs, goats, and cattle and detected across the food web. Additionally, concentrations of PFAS have been measured in poultry products during market basket surveys, and studies exposing poultry to acute doses of PFAS have shown accumulation and translocation of PFAS. However, there are few data describing the fate and disposition of PFAS in poultry during lifetime exposures to environmental levels of PFAS in water. Therefore, the fate and disposition of a suite of 25 PFAS compounds was determined in broiler chickens during 6 weeks of exposure to drinking water containing each compound at 100 ng/L. Fifty-six straight run broiler chicks, distributed equally among 4 pens, were provided water containing 100 ng/L of 13 perfluorocarboxcylic acids (4 – 18 carbons) and 12 perfluorosulfonates (4 – 13 carbons) starting at 2 days of age to maturation (market weight) at 6 weeks. A control pen contained 11 birds which received PFAS-free water. Two birds from each pen were sacrificed each week (8 treated and 2 controls at weeks 1-4) except for weeks 5 and 6, then 3 birds from each treated pen were harvested (not including control pen). Tissues collected at harvest included blood (plasma), liver, bile, kidney, breast and thigh muscle, fat, reproductive tract, small intestine, large intestine, ceca, pancreas, and gizzard including proventriculus and crop, brain, heart, lung, skin, and spleen. All samples are being analyzed via in-lab validated methods by ultra-performance liquid chromatography – tandem mass spectrometry (UPLC-MS/MS) with matrix matched curves and QA/QC procedures. Summed carboxylic acid data for plasma through weeks 1 and 2 are 728.3 ng/L and 1,613.3 ng/L, respectively. Of the 13 acids analyzed, perfluorooctanoic acid (PFOA) and perfluorononanoic acid (PFNA) were the only two acids quantifiable in week 1. Week 2 had quantifiable levels for PFOA, PFNA, perfluorodecanoic acid (PFDA), and perfluoroundecanoic acid (PFUdA). PFOA and PFNS remained the highest concentrations through the first two weeks. The summed sulfonate concentrations for weeks 1 and 2 in plasma were 2,271.1 ng/L and 3,710.4 ng/L, respectively. There were 5 quantifiable sulfonates in week 1, perfluorohexane (PFHxS), perfluoroheptane (PFHpS), and perfluorooctane (linear and two branched; PFOS, 3Me-PFOS, 6Me-PFOS). In week 2, there were two additional quantifiable sulfonates, perfluoropentane (PFPeS) and perfluorononane (PFNS). Plasma and edible tissue (muscle, liver, skin, and gizzard) samples continue to be extracted and analyzed.

10. Novel Perfluoroalkyl Ether Acids in Homegrown Produce from a PFAS-Impacted Community in North Carolina

Sarangi Joseph, Owen W. Duckworth, and Detlef R.U. Knappe; North Carolina State University

In the Cape Fear River basin of North Carolina, novel perfluoroalkyl ether acids (PFEAs) such as hexafluoropropylene oxide-dimer acid (HFPO-DA, commonly known as GenX) are receiving attention because they are widely detected in private wells and public water systems. Apart from drinking water, diet can be an important exposure route. In PFAS-impacted communities, homegrown fruits and vegetables may take up PFAS from contaminated irrigation water and/or soil, but the uptake of PFEAs and other per- and polyfluoroalkyl substances (PFASs) into local produce remains unclear. Extraction methods for the determination of PFAS in food have been developed for some traditionally studied perfluoroalkyl acids (PFAAs), but methods for novel PFEAs are lacking. In this study, an extraction and clean-up method was developed for the quantification of 45 PFASs, including 13 PFEAs, and the method was applied to conduct survey produce grown in backyard gardens near Fayetteville Works, a fluorochemical manufacturing plant near Fayetteville, NC.
We extracted and analyzed 47 samples (harvested between 2013 to 2019, including berries, tomatoes, apples, peaches, grapes, pecans, okras, squashes, corn, etc.) from five field sites within a PFAS-impacted community. We are analyzing samples by using liquid chromatography−tandem mass spectrometry (LC−MS/MS). Data obtained to date suggest that elevated PFEAs were detected with concentrations ranging from 0.05 to 12.4 ng/g wet weight in twelve blueberry and blackberry samples (collected between 2015 and 2019). Perfluoro-2-methoxypropanoic acid (PMPA), perfluorodioxahexanoic acid (PFO2HxA) and perfluoromethoxyacetic acid (PFMOAA) were the dominant PFEAs. These results suggest that produce grown in PFAS-impacted communities can be an important exposure route.

11. The PFAS UNITEDD Michigan Study: PFAS Exposure via Drinking Water and Local Diet for a Paper Mill Impacted Community

Rachel Bauer, Michigan State University; Ankita Bhattacharya, Michigan State University; Ying Guo, Michigan State University; Heather Stapleton, Duke University; Christopher Higgins, Colorado School of Mines; Sarah Choyke, Colorado School of Mines; John Adgate, University of Colorado; Courtney Carignan, Michigan State University

PFAS contaminated drinking water has been identified across Michigan and the U.S. In 2018, a state-wide drinking water monitoring program identified PFOA + PFOS in the public drinking water system of a small community at concentrations over 1,000 ppt. The source of contamination was linked to a landfill where papermaking and associated paper-manufacturing waste was disposed. The public drinking water source was switched to a cleaner nearby water system and a private well monitoring program was undertaken. Those with elevated PFAS concentrations have been provided with water filters or bottled water. Due to concerns about the potential for plant uptake and bioaccumulation in livestock, residents were advised not to eat foods grown or produced at home or to take protective measures such as installing raised gardening beds. As the necessity and effectiveness of these interventions are not well understood, we conducted a biomonitoring study to improve understanding of the uptake of PFASs into local foods from contaminated soil and water and to assess relative exposure from drinking water, diet, and the indoor environment. We enrolled 129 participants from 92 homes from 2020 to 2021 and collected water, food and soil, and air and dust samples from 42, 24, and 32 homes, respectively. We also collected blood samples and wristbands from 100 and 87 participants, respectively. Overall study findings and individual water, food and soil, and blood results are being shared with participants.

12. Evaluating Performance Trade-offs between PFAS and PFAS-free Turnout Gears in New and Aged Conditions.

Nur-Us-Shafa Mazumder, R. Bryan Ormond; North Carolina State University

The term ‘firefighter’ and ‘cancer’ have become so intertwined in the past decade that they are now nearly inseparable. A new focus for research in this area is on per- and polyfluoroalkyl substances (PFAS) in addition to the typical chemicals (i.e., polyaromatic hydrocarbons (PAHs), phthalates, phenols) that firefighters encountered during the firefighting. The PFAS chemicals are found in aqueous film-forming foam (AFFF) that is used to extinguish the fire that involves flammable gas or liquid. In addition, the turnout gears worn by the firefighter to ensure heat and chemical protection are manufactured with fluorine-based water and oil repellent chemicals. Therefore, a new concern has been raised that firefighters are being exposed to PFAS chemicals from the turnout gear itself. In this research, turnout composites of different constructions and repellent finishes will be subjected to cycles of ultra-violet light, thermal exposures and laundering to realistically age the materials. Following the ageing process, the materials will be thoroughly evaluated for trade-offs that may exist between fluorinated and non-fluorinated repellent finishes. The initial evaluations will include the ability to resist water and oil, thermal protection from heat, and impact of radiant load on total heat loss. This study focuses on the assessment of the protection performance of PFAS and PFAS free contamination resistance turnout composites. Findings of this research will fill significant knowledge gaps related to the different contamination resistance and their impacts on both protective and comfort performances. In addition, this research will also give us better understanding if any PFAS is coming-off from the turnout gear in new and aged conditions. The research findings will allow firefighters to conduct their own assessments of risk associated with potential trade-offs.

13. Release of gas phase PFAS from paper-based food packaging and municipal solid waste under simulated landfill conditions

Yuemei Ye, North Carolina State University; Ivan A. Titaley, Oregon State University; Florentino de la Cruz, North Carolina State University; Morton A. Barlaz, North Carolina State University; Jennifer A. Field, Oregon State University

Landfills receive a wide range of products that contain PFAS including, for example, carpet, food packaging materials and textiles. The presence of per-and polyfluoroalkyl substances (PFAS) in the leachate generated at landfills that contain municipal solid waste (MSW) is well documented. In contrast to leachate, there is no published information on the presence of PFAS in landfill gas although elevated PFAS has been reported in the ambient air at three landfills.

The objective of this research is to measure the release of PFAS during the anaerobic decomposition of a variety of single use food packaging materials. Initially, 40 samples of various food packaging materials were collected and screened using Particle-Induced Gamma Ray Emission (PIGE). Eleven of the 40 samples showed a total fluorine concentration above 500 ppm, including various microwave popcorn bags, paper plates & clamshell containers, some of which are labeled as eco-friendly. The 11 samples that showed high total F were then subject to a methanol extraction and HPLC-MS analysis. 6:2 FTOH at greater than 1.5 ng/g was confirmed in all 11 samples. To evaluate gaseous PFAS release, these 11 samples are being tested in reactors operated under anaerobic conditions and designed to simulate the high solids environment of a landfill. Each test material will be inoculated with a PFAS-free culture. Gas samples are collected by allowing gas to pass through a sorbent tube and then to a gas collection bag so that the volume of gas passing through the tube is known. Gas and leachate samples will be collected every one to two weeks to evaluate the extent to which the presence of PFAS is released to the gas phase. In preliminary work with one material, quantifiable 6:2 FTOH was observed by collecting 300 mL of the gas produced from the anaerobic biodegradation of the test material.

14. Crop Uptake and Bioaccumulation of PFAS from Irrigation Waters

Sarah Doydora, North Carolina State University; Pingping Meng, North Carolina State University; Yue Zhi, Formerly with North Carolina State University; Steve Broome, Formerly with North Carolina State University; Owen Duckworth, North Carolina State University; Detlef Knappe, North Carolina State University

Per- and polyfluoroalkyl substances (PFAS) are a group of persistent synthetic fluorinated organic compounds that are widespread due to their presence in diverse manufactured products. These chemicals have been detected in agricultural produce, with different plants and PFAS accumulating to different extents. However, limited work has been conducted to understand the uptake of perfluoroalkyl ether acids (PFEA) on different plants. This study aimed to assess the bioaccumulation of PFEA in food plants and compare their bioconcentration and translocation factors for legacy PFAS compounds. Radish and lettuce were grown in potted Norfolk sandy loam soils under greenhouse conditions and were irrigated with legacy PFAS- and PFEA-contaminated water until maturity. The plants were harvested, and their shoots, roots and, tubers (if present) were separated. Soils and soil pore water were also sampled to allow to determine how PFAS are transported though the water-plant-soil system.

15. Do Product Labels Predict the Presence of PFAS in Consumer Items Used by Children and Teens?

Kathryn Rodgers, Silent Spring Institute; Christopher Swartz, Silent Spring Institute; James Occhialini, Alpha Analytical; Philip Bassignani, Alpha Analytical; Michelle McCurdy, Galbraith Laboratories; Laurel Schaider, Silent Spring Institute

PFAS are persistent and toxic chemicals used to impart water- and stain-resistance in many consumer products used by children. Since PFAS are typically not listed on product labels, we evaluated whether information on product labels can be used by consumers to select children's products without PFAS. We selected 93 children's items across three product types (furnishings, apparel, bedding) and five labeling groups representing different combinations of water- or stain-resistance and "green" (including green certifications and nontoxic language) assurances. We screened products for total fluorine (F) and analyzed a subset (n=61) for 36 extractable PFAS and a smaller subset (n=30) for PFAS precursors using the Total Oxidizable Precursor assay. Products advertised as water- and/or stain-resistant had more frequent detections and higher concentrations of total F than those without such claims, and targeted extractable PFAS were detected only in water- and/or stain-resistant products. Precursor concentrations typically exceeded pre-oxidation concentrations. Among products advertised as water- and/or stain-resistant, detection frequencies and concentrations of target PFAS were similar regardless of "green" assurances. This study illustrates many non-essential uses of PFAS in products used by children and suggests that while water- and stain-resistant assurances can identify products likely to contain PFAS, current green assurances and certifications do not indicate absence of PFAS.

16. PFAS Biomonitoring in Children and Adolescents

Laura M Labay and Barry K Logan; NMS Labs

The EPA notes that emerging research is identifying evidence of adverse health outcomes related to PFAS exposure including endocrine, developmental, reproductive, and carcinogenic effects. They also note that additional health effects are difficult to ascertain without empirical evidence of exposure, which inevitably requires testing of both exposed and unexposed populations. Testing of environmental concentrations of key PFAS chemicals in soil, water and food indicate only the potential for exposure, while testing serum or plasma from exposed individuals provides a measure of the amounts of PFAS chemicals that enter and are retained in the body. PFAS testing is a complex analytical challenge, due to the low concentrations of PFAS chemicals in the human body, trace concentrations in laboratory supplies and reagents, and the chemical similarity of the compounds identified by the CDC as being most relevant to human health. We present PFAS plasma and serum concentrations in a pediatric population by age group, using a robust validated testing procedure.

Serum/plasma PFAS concentrations in a cohort of children (2 to 12 years; n=26) and adolescents (13 to 19 years; n=194) were assessed over an approximately two-year period (Jan 2020 to April 2022) to determine which PFAS chemicals were most frequently identified in these age groups and their concentrations. Toxicological testing was performed at NMS Labs (Horsham, PA) by LC-MS/MS and included PFBS, PFHpA, PFHxS, PFNA, PFOA, and PFOS in the analytical scope. There are many factors that can impact the reliability of results including pre-analytical and analytical steps such as the sample collection containers utilized, their storage prior to analysis, method sensitivity, and precision and accuracy of the assay. Following the removal of one outlier in the children group, positive findings were evaluated.

Exposure history or the reason for the PFAS analysis request (e.g., epidemiological study, biomonitoring following exposure, etc.) was unavailable for these patients. Even with this limitation, however, the data reveal information about PFAS exposure patterns. First, all PFAS chemicals tested were detected in both children and adolescents with PFHxS, PFNA, PFOS, and PFOA being found with the greatest frequency. Second, mean concentrations in children were greater for five PFAS compounds as compared to adolescents indicating that one variable affecting PFAS body burden is age. Overall, PFAS testing quality impacts study findings and conclusions, and any method should be critically challenged and evaluated to ensure it is appropriate for study needs.

Risk Assessment

17. Current Status of an Update to ATSDR's Toxicological Profile for Perfluoroalkyls

Brittany N. Szafran, Melanie C. Buser; Agency for Toxic Substances and Disease Registry

The Agency for Toxic Substances and Disease Registry (ATSDR) develops toxicological profiles (TPs) under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980. The TPs serve as a compilation of available toxicological and epidemiological information on a given hazardous substance. As part of TP development, minimal risk levels (MRLs) are derived when sufficient data exists. MRLs are estimates of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse non-cancer health effects over a specified route and duration of exposure. These substance-specific guidelines are intended to serve as screening levels to identify exposures that warrant further evaluation. ATSDR released the final version of the TP for Perfluoroalkyls (PFAS) in May 2021, which discussed information on 12 PFAS and contained intermediate-duration oral MRLs for perfluorooctanoic acid, perfluorooctane sulfonic acid, perfluorohexane sulfonic acid, and perfluorononanoic acid. This version of the profile contained information on literature published through May 2020. An update to the Perfluoroalkyls TP is currently in development. This update will incorporate more recent literature and reassess the four MRLs that were previously derived. As part of this update, ATSDR is exploring the possibility of MRL development for additional perfluoroalkyls. Currently, the profile is undergoing review by experts within ATSDR. Once the profile has undergone an inter-agency review, an independent peer review, and agency clearance, it will be released for a 90-day public comment period. ATSDR is aiming to release the TP for public comment in this calendar year, barring any setbacks or delays in the review process.

The findings and conclusions in this presentation have not been formally disseminated by The Agency for Toxic Substances and Disease Registry and should not be construed to represent any agency determination or policy.

Remediation

18. PFAS Removal using VSEP

Mark Galimberti

We conducted a pilot test for an American waste and environmental services company in North America that operates a waste treatment facility. The facility accepts and treats a wastewater contaminated with firefighting foam, some fine suspended solids, and other contaminants. The compounds in the wastewater that are of highest concern are a collection of polyfluoronated compounds (PFOS). The VSEP would treat the effluent so that the permeate could be discharged while the VSEP concentrate would be solidified in a landfill. We tested both NF and RO membranes.

19. Ionic Fluorogels: a platform technology for PFAS remediation from water

Irene M. Manning, Nick Guan Pin Chew, Haley P. Macdonald, Orlando Coronell, Frank A. Leibfarth; University of North Carolina - Chapel Hill

Per- and polyfluoroalkyl substances (PFAS) are small molecules used widely in industrial processes, consumer products, and fire-fighting foams. They contaminate waters worldwide and are associated with adverse human health effects, necessitating effective remediation strategies. Motivated by the limitations of current technologies, we identified two design parameters native to anionic PFAS, fluorophilicity and ion exchange, which we hypothesized could be synergistically leveraged for selective PFAS sorption. The synthesis of systematic libraries of Ionic Fluorogels with varied compositions of fluorous and electrostatic components led to the identification of optimized resins demonstrating selective, rapid removal of anionic PFAS, facile regeneration, and promising removal of PFAS in flow-through packed beds. Careful choice of the fluorinated matrix enabled chemical stability and avoided PFAS production and leaching. Leveraging these design principles enabled further materials development and optimization toward multikilogram-scale synthesis for pilot-scale implementation.

20. Progress in the Development of Rapid Field-Compatible PFAS sensors

Laura Grace, Alexis Carpenter, Wesley Storm, AxNano

There has been a rapid increase in interest on the environmental impacts of per-and polyfluoroalkyl substances (PFAS). These species, otherwise known as “forever chemicals”, are the subject of remediation and monitoring efforts in both the private and public sectors. This has created a need for a field-compatible PFAS sensor that can accurately and rapidly detect PFAS in complex matrices.
Currently, the gold standard method for PFAS analysis typically involves sending samples off-site and results can take days to weeks to be delivered. There has been difficulty developing

field-compatible sensors that can detect low concentrations of PFAS in water and provide results rapidly (same day or less).

To gain a clearer understanding of the specific needs of parties that could benefit from a rapid field-compatible PFAS sensor, AxNano has developed relationships with government and industry stakeholders and will present the scope of the market that has been discovered. Along with this, the technical challenges in developing a PFAS sensor will be presented, along with strategies that AxNano and other researchers are exploring to address these challenges.

21. Thermal Reactivation of Spent Granular Activated Carbon (GAC) Containing Per- and Polyfluoroalkyl Substances (PFAS)

Stefanie Starr, North Carolina State University

Thermal reactivation of spent granular activated carbon (GAC) is a management strategy that permits GAC reuse. The fate of per- and polyfluoroalkyl substances (PFAS) during thermal reactivation of spent GAC from PFAS remediation sites is poorly understood. This study aims to identify conditions that effectively mineralize PFAS during thermal reactivation of PFAS-laden GAC. Thermogravimetric analysis (TGA) experiments with pure PFAS in acid and salt forms as well as PFAS/base (NaOH, Ca(OH)2) and PFAS/salt (NaCl, CaCl2) mixtures were conducted to determine the thermal stability of nine PFAS. Off-gas from the TGA experiments was collected with impingers to trap gaseous compounds soluble in basic water and SUMMA canisters to capture volatile and semi-volatile PFAS that pass through the impingers. Impinger solutions and TGA pan residues were analyzed for fluoride using an ion selective electrode. Targeted PFAS analysis of the impinger solutions was performed with liquid chromatography-mass spectrometry. Results to date show that thermolysis of all tested PFAS was complete at temperatures used to reactivate GAC. In both absence and presence of a base or salt, salt forms of PFAS were more persistent than acid forms, and perfluoroalkyl sulfonates were more persistent than perfluoroalkyl carboxylates. Total fluorine recovery in the absence of a base or salt and in the presence of a salt was <10%. In the presence of Ca(OH)2 and NaOH, total fluorine recoveries increased to >50% with increasing Ca/F and Na/F molar ratios for PFOS salt. Results show that the addition of a base enhances mineralization of some PFAS.

22. Removal of per- and polyfluoroalkyl substances (PFAS) by anion exchange resins: Effects of PFAS structure and background water matrix constituents

Lan Cheng, Detlef Knappe; North Carolina State University

Per- and polyfluoroalkyl substances (PFAS) are persistent organic contaminants with adverse environmental and public health effects. Concerns about the presence of PFAS in drinking water have led to a demand for effective PFAS removal technologies. Anion exchange (AIX) is a readily implementable water treatment method that can remove many PFAS, including fluoroethers, such as GenX. In this research, the removal of 23 PFAS, including legacy PFAS and fluoroethers with three to nine fluorinated carbons, was investigated using rapid small-scale column tests (RSSCTs). Research objectives were to (1) investigate how PFAS structure affects the PFAS uptake capacity of AIX resins, (2) quantify how PFAS influent concentration affects PFAS removal, and (3) assess how background water matrix constituents (e.g., dissolved organic carbon, major anions) affect PFAS removal.

The PFAS removal effectiveness of AIX resins was strongly associated with PFAS structure. In a given PFAS class, such as the perfluoroalkyl carboxylic acids, the uptake capacity of AIX resins increased with increasing PFAS chain length. Furthermore, percent PFAS removal by two AIX resins was independent of PFAS influent concentrations in the range of 30 - 300 ng/L. The uptake capacity of AIX resins for individual PFAS was quantified using partition coefficients (KAIX), which ranged from 24 to >1900 L/g. Based on PFAS structural features, we developed a quantitative structure-property relationship that can be used to describe the affinity of PFAS to AIX resins. With this method, we found the relative contributions of the moieties -CF2-, -O-, -SO3, -COOH, -CH2, -CHF, and >CF-CF3 to KAIX to be 1: 0.34: 3.87: 0: -1.96: 0: 1.68. Regarding background water matrix constituents, KAIX decreased with increasing total organic carbon (TOC) concentration. Nitrate also adversely impacted PFAS removal, while chloride, sulfate, and bicarbonate at concentrations up to 3 meq/L had negligible effects on KAIX. The data were used to develop a multiple linear regression model to predict KAIX from PFAS structural fragments and background water matrix constituents. This research will support the design of future AIX treatment processes in the context of remediation and drinking water treatment.

23. Performance of resins and activated carbon in removing precursors PFAS using pilot scale study

Rominder Suri, Temple University; Mark E. Fuller, Aptim Federal Services; Erica R. McKenzie, Temple University

Per- and polyfluoroalkyl substances (PFAS) have been ubiquitously found in the environment, including groundwater, and perfluoroalkyl acids (PFAA) are commonly monitored. Many studies also found precursors of PFAA (pre-PFAA), including cationic and zwitterionic PFAS that can degrade to PFAA, in soils and in groundwater. The use of anion exchange resins and activated carbon have been explored for a decade for treating PFAS-contaminated water, but their ability to remove pre-PFAA is largely untested. In this study, pilot-scale columns were used to compare the performance of activated carbon (Calgon F400) versus three anion exchange resins: PFA694E (gel, strong base), A592E (macroporous, strong base), and USA21107 (macroporous, weak base). The pilot-scale column was setup in a municipal drinking water treatment facility in Pennsylvania. The total oxidizable precursor (TOP) assay was used to quantify the concentration of pre-PFAA. In the untreated groundwater, the pre-PFAA concentration was ~ 0.35 μg/L (0.27-0.37 μg/L), and the PFAA concentration was ~1.7 μg/L. Generally, the anion exchange resins and activated carbon removed some pre-PFAA, but performance varied, with the following rank order (from greatest least removal): F400 > USA21107 > A592E > PFA694E. It is important to acknowledge that the pilot-scale column was operated under relevant use-cases, and that flow rates were specific to the media: F400 was 6 bed volumes (BV)/hr;

USA21107 and A592E were 16 BV/hr; and PFA694E was 60 BV/hr. F400, with a lower flow rate, was monitored at a 50% port and ~ 0.1 μg/L precursors were consistently observed throughout the initial 5000 BV of pilot-scale testing. Interestingly, the ~ 0.1 μg/L precursors were observed in all samples, and there was no sign of breakthrough over time (i.e., the concentration of pre-PFAA did not increase). The pre-PFAA removal efficiency of USA21107 was better than the removal efficiency by A592E; these resins had the same flow rate, so a direct comparison of performance is possible. At 14000 BV, the effluent pre-PFAA concentration from USA21107 and A592E was ~0.2 μg/L and ~0.25 μg/L, respectively. While the effluent concentrations were similar, the effluent pre-PFAA breakthrough profiles differed. USA21107 had a consistent effluent concentration (~0.2 μg/L), which did not respond to changes in influent pre-PFAA concentrations. By contrast, A592E initially removed ~93% of pre-PFAA, but then exhibited rapid breakthrough of precursors, and exhibited only limited removal (~5 -18%) from 2600 BV through 13400 BV. The resin PFA694E (60 BV/hr) was sampled from a 25% port and the pre-PFAA concentration fluctuated greatly, with high removal efficiency at initial run and at 20000 BV (~70% removal), but negligible removal at other BVs. Efforts are ongoing to better understand the unexpected breakthrough curve profiles and longer-term performance for each media. Ongoing work includes TOP data forensics and high-resolution mass spectrometry suspect screening, considering positive and negative mode electrospray ionization. Understanding pre-PFAA removal is important to a holistic assessment of media performance and PFAS drinking water exposure.

24. Advanced Polymer and Polymer Nanocomposite Sorbents for Water Remediation

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Decades of use of per- and polyfluoroalkyl substances (PFAS) in a multitude of consumer and industry-based products have led to a devastating amount of soil and water contamination. The chemical and thermal stability of PFAS have proved them to be an especially daunting challenge from an environmental remediation standpoint. Presently, the only full-scale water treatment separates via sorption and uses non-selective materials such as activated carbon (AC) or mineral media which are extremely difficult and/or costly to regenerate. Developing effective and renewable remediation technologies that lead to clean and safe drinking water sources are therefore a vital part of current research efforts. Research focused on selective sorption is becoming a more practical route for capture and removal from contaminated water systems.

This work seeks to develop and assess various polymer and polymer nanocomposite sorbents that have affinity for PFAS compounds, such as perfluorooctanoic acid (PFOA) and perfluorosulfonic acid (PFOS). Two routes of sorption were explored: (1) contaminant binding and removal via magnetic decantation of functionalized polymer nanocomposites; (2) contaminant binding through flocculation with functionalized thermo-responsive polymers.

Polymers were synthesized via free radical polymerization reactions with (1) amine functionalized cationic monomers with crosslinker N,N'-methylenebisacrylamide (NMBA) (2) N-isopropylacrylamide (NIPAAm) and various cationic and/or fluorinated comonomers.

In some instances, nanocomposite systems were created with the inclusion of magnetic nanoparticles during the synthesis process. In addition to magnetic separation, the magnetic nanoparticles enable remote activation using an alternating field that can be used as a novel approach to regenerate the sorbents. Two types of binding systems and removal were examined depending on polymer structure (i.e., crosslinked or linear). Binding studies were conducted by subjecting controlled amounts of each sorbent (e.g., 2.5 mg/ml) to aqueous solutions with various PFAS concentrations for up to 24 h at room temperature for crosslinked systems and 1 h at 50 ºC for linear systems. Cationic crosslinked polymers showed high affinity for PFOA (>80%) and PFOS (>90%) across a range of aqueous pH (4 – 10). Linear polymers that included both cationic and fluorinated monomers showed improved flocculation and contaminant removal as compared to those systems with isolated functionality. Both routes of treatment show promising results for future application as water remediation materials.

25. Current and future PFAS discharge from groundwater to streams near a fluorochemical manufacturing facility in North Carolina

Craig R. Jensen, North Carolina State University; David P. Genereux, North Carolina State University; Detlef R.U. Knappe, North Carolina State University; D. Kip Solomon, University of Utah; Troy E. Gilmore, University of Nebraska - Lincoln

Widespread PFAS contamination of groundwater has been detected in the area surrounding the Fayetteville Works facility near Fayetteville, NC. This groundwater discharges to tributaries of the Cape Fear River, an important drinking water source for communities downstream of Fayetteville Works. It is therefore important that the flux of PFAS from groundwater to stream water be quantified. In October 2020, groundwater samples were collected at the groundwater-surface water interface via temporary piezometers in tributary streambeds using a point sampling approach. Samples were collected at 20 points in the streambeds of Kirks Mill Creek, Willis Creek, Mines Creek, and Georgia Branch. Groundwater samples were analyzed for 37 different PFAS. At each point, groundwater flux to the stream was estimated using a falling head test to measure hydraulic conductivity and a piezomanometer to measure vertical head gradient. In total, 17 PFAS were detected, with 5 PFAS appearing in all groundwater samples. Perfluoromethoxypropanoic acid (PMPA) and GenX were the most prevalent PFAS, with average concentrations of 524 and 234 ng/L respectively. The total quantified PFAS flux from groundwater to stream water ranged from 0.2 to 8.0 mg m-2 d-1.

Given the importance of groundwater as a drinking water source in the area, current work is aimed at quantifying how PFAS discharge from groundwater to streams is likely to change in coming years. To answer this question, the SF6 and 3H/3He age-dating methods were used to estimate the age of each groundwater sample. A preliminary transit time distribution (TTD) of groundwater discharging to the streams near the Fayetteville Works facility was created using these data, with groundwater ages ranging from zero to 39 years old. Ongoing work is exploring the relationship between PFAS concentration and groundwater age, with the goal of forecasting future PFAS export from groundwater to stream water in coming years using convolution modeling.

PFAS Chemistry

26. Development and Demonstration of Volatile and Semi-Volatile Per- and Polyfluoroalkyl Substances (PFAS) GC-MS Methods on Select NIST Reference Materials

Alix E. Rodowa, Jessica L. Reiner; National Institute of Standards and Technology

Per- and polyfluoroalkyl substances (PFAS) are contaminants of concern, and have been observed in consumer products, consumer byproducts (e.g., dust, wastewater, and landfill leachate), and environmental compartments including humans and biota. As a result, routine monitoring methods, method development, and commercial analysis of these compounds have become more widely available. Current commercial methods typically target ionic, less volatile PFAS by liquid chromatography tandem mass spectrometry (LC-MS/MS). However, volatile and semi-volatile analytes are not commonly included despite the fact that volatile and ionic PFAS are known to co-occur as a result of manufacturing processes. Further, volatile PFAS are commonly excluded due to their poor sensitivity by LC-MS/MS and a lack of materials available to validate analytical methods (e.g., Standard Reference Materials (SRMs) and analytical standards). To fill this data gap, multiple instrumental methods for twelve volatile and semi-volatile PFAS including 4:2, 5:2s, 6:2, 7:2s, 8:2, and 10:2 fluorotelomer alcohols, 8:2 and 10:2 perfluoralkyl acrylates and perfluoroalkyl acetates, and methyl- and ethylperfluoroctanesulfonamide, have been developed for electrospray ionization gas-chromatography mass spectrometry (EI GC-MS). To demonstrate the efficacy of the methodology two Standard Reference Materials (SRMs) from NIST, SRM 2585 Organic Contaminants in House Dust and SRM 2781 Domestic Sludge were selected for quantitative evaluation of GC amenable PFAS. Each of these materials represents a different analytical compartment, and both materials have reported concentrations of ionic PFAS by LC-MS/MS on their Certificates of Analysis. The observed volatile PFAS concentrations in the selected SRMs are subsequently evaluated across instrumentation and across acquisition modes to evaluate accuracy and precision. These volatile PFAS measurements add value to the volatile PFAS knowledge-base and provide needed methodological, analytical validation materials.

27. Validation studies of EPA Method 537.1 for Monitoring Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS) in Drinking Water Using UHPLC with a Triple Quadrupole Mass Spectrometer.

Jason Weisenseel, Principal Field Applications Scientist; Michael T Costanzo, MSMS Sales Specialist

Per- and polyfluoroalkyl substances (PFAS) are a group of man-made chemicals that have been used in a wide variety of industries around the world since the 1950s. Applications include food packaging, various household products, fire suppression foams, and water repellent clothing. This class of chemicals are incredibly stable so they are persistent and accumulate in the environment. Growing health concerns regarding PFASs and their prevalence in consumer goods and the environment indicates a critical need to monitor levels of PFAS in the environment. EPA Method 537.1 is currently one of the standard methods for analysis of PFASs in drinking water to measure 18 PFAS compounds at low parts per trillion levels. This presentation will focus on validation of EPA Method 537.1 using the PerkinElmer QSight LC-MS/MS and future work on EPA Methods 533 and 1633.

28. Development and Optimization of Extraction Method for Per- and Polyfluoroalkyl Substances from Firefighter Turnout Materials

Andrew Hall, North Carolina State University; R. Bryan Ormond, North Carolina State University

Per- and Polyfuoroalkyl Substances (PFAS) are used in aqueous film forming foams and water repellents in turnout gear which may be the source of elevated levels of PFAS found in the blood serum of firefighters. To study firefighters exposure to water repellents, fabric samples are extracted to collect samples. Most PFAS quantification methods are intended for water samples so a method needs to be developed targeted towards extractions. Fabrics were initially doped with a known quantity of PFAS and extracted with methanol in a Buchi Speedextractor to collect all treatments on the fabric. A method used for water samples was used as a starting point that involved solid phase extraction (SPE) and evaporation. The combination of high solvent volume and sediments collected resulted in SPE being unsuitable. To improve SPE, speedextractor samples were either vortexed and supernatant used in SPE or evaporated to reduce the amount of solvent volume. High performance liquid chromatography triple-quadrupole mass spectrometer (HPLC-QqQ) will be performed to determine the amount of PFAS lost in each process.

Preliminary results show that several PFAS compounds are detected from turnout treatment extractions using HPLC-QqQ. To accurately quantify and to improve sample preparation, a process prior to SPE will be selected. By optimizing the sample preparation, throughput is improved allowing for additional samples to be prepared. There is interest in testing fluorinated and non-fluorinated treated turnout gear to determine what is the exposure level firefighters have with PFAS. Additionally, other factors such as abrasion and weathering can be assessed for changes in PFAS levels.

Fate and Transport

29. PFAS in Publicly Owned Treatment Works Facilities in New Hampshire and Implications on Groundwater

Jennifer Harfmann, Stephen Roy; New Hampshire Department of Environmental Services

Nearly half of residents in New Hampshire rely on groundwater as a source of drinking water, and as such discharging treated wastewater to the ground or groundwater requires a discharge permit under the state's groundwater discharge program. Twenty percent of the facilities that hold a groundwater discharge permit in New Hampshire are publicly owned treatment works (POTWs). Following adoption of PFAS standards in 2016, mandatory groundwater quality sampling for PFAS at these discharge sites indicates that PFAS have been detected in the groundwater at all POTWs holding a groundwater discharge permit, and groundwater quality standards were exceeded at more than 60% of them. Since POTWs are receptors of wastewater from a diversity of industrial, commercial, and domestic sources, analyzing PFAS signatures at POTWs can inform source identification efforts in the state in order to minimize and/or eliminate PFAS discharge to groundwater.

Managing PFAS Waste

30. Managing PFAS Waste

Tim Whitehouse

Background: PFAS contamination is widespread and growing in the United States. According to the Environmental Working Group (EWG), the number of U.S. communities confirmed to be contaminated with PFAS continues to grow at an alarming rate. As of August 2021, the EWG had mapped water systems in 2,854 locations in 50 states and two territories contaminated with PFAS.

Despite this, there are no federal laws or regulations that govern the management of waste containing PFAS. This means that facilities handling PFAS waste, machinery, containers, transport vehicles, and disposal facilities all are potential sources of PFAS contamination. Determining a safe method for disposal of PFAS waste is a complex issue due to their solubility, environmental mobility, and persistence. A key cause for concern in managing waste containing PFAS as there is no known way to safely dispose or destroy PFAS.

Waste containing PFAS disposed of in landfills poses a threat to human health and the environment. For example, toxic PFAS can leach from landfills and severely pollute groundwater, the primary source of drinking water for one-third of the nation. Incineration of waste containing PFAS expels them into our environment and threatens our clean air and public health. Throughout the United States, communities and farmers are finding that biosolids used as fertilizer are contaminating their soils, water, produce, eggs, milk, and meat with PFAS.

Methods and Data: Our poster will identify and visually explain the strengths and weaknesses of the current federal system for managing PFAS waste. It will show a map of EPA data PEER received through a Freedom of Information Act (FOIA) request on PFAS transfers voluntarily identified in hazardous waste e-manifests and state waste code searches. The map has information on the generation, storage, and disposal of almost 14 million kilograms (about 30,864,680 lbs.) of waste contaminated with PFAS between July 2018 and August 2021. Our poster will also show a map of an EPA data set with information on some 120,000 industrial facilities that “may be handling” PFAS that PEER obtained from EPA through FOIA. These maps will display how the federal government has no handle on the management and disposal of waste contaminated with PFAS.

Conclusion: We conclude the framework that will best ensure the safe management of waste containing PFAS must include three elements: (1) PFAS are regulated as a class; (2) PFAS are used only for essential purposes; and (3) PFAS wastes are managed from the moment of generation to final disposal (often referred to as “cradle-to-grave”) under the federal Resource Conservation Recovery Act. We also conclude that The Environmental Protection Agency’s failure to address the cradle-to-grave management of waste contaminated with PFAS means the problems associated with PFAS contamination will grow exponentially worse over time, imposing tremendous financial, health, and environmental costs on society, while allowing those who created the problem to avoid or minimize their financial responsibility for the harm caused by this waste.

31. Ten bad things done with “forever chemical” waste

Sonya Lunder and Denise Trabbic-Pointer; Sierra Club

EPA is moving slowly to regulate at least four chemicals, PFOS, PFOA, PFBS and GenX as Hazardous Substances, but the process will take several years. In the meantime most types of disposal for PFAS chemicals are virtually unregulated. The persistence and mobility of PFAS chemicals poses an incredible challenge for waste managers. Yet, there is very little tracking of the movement of PFAS waste. Landfills and deep wells aren’t necessarily designed to be secure for the length of time that PFAS will persist. The chemicals’ intense thermal stability and reactivity means that they may not be fully destroyed in incinerators. PFAS are flushed into wastewater, and waste sludge is spread on land, perpetuating the cycling of PFAS in the environment. Too often locally-unwanted land uses, like dumps, incinerators and injection wells are located in historically “red lined” communities, on Tribal lands, or other sacrifice zones. Therefore as money is earmarked to clean up PFAS contaminated water and soil, it is essential that we trace the path of PFAS wastes and ensure that they are safely contained and/or destroyed instead of transferring risks to other people and places. We’ve gleaned through the sparse data on the movement of PFAS wastes to identify the 10 most concerning methods for securing PFAS waste:

- Burn PFAS-based industrial fire fighting foams in hazardous waste incinerators. Between 2019-2021 the U.S. military sent more than 2 million gallons of PFOS-based foams to incinerate in East Liverpool, and other states.
- Concentrate PFAS waste from sewage sludge and spread it on agricultural lands. The state of Maine and Minnesota have both tracked contaminated crops, meat and dairy products in fields where biosolids have been applied as a fertilizer.
- Explode it! US Ecology in Beatty, Nevada used “open detonation” to dispose of 18,155 kilograms of PFAS containing waste.
- Remove PFAS from surface water using reverse osmosis treatment but discharge the polluted wastewater back into the Cape Fear River.
- Send PFAS-based fire fighting foams to be used as “fuel” at incinerators that make energy, aluminum or cement. A cement plant in Indiana reports burning at least 12,000 pounds of PFAS waste in 2020.
- “Regenerate” used carbon filters by heating them to release PFAS into the air, without monitoring destruction. Evoqua has one of its regeneration facilities on Colorado River Tribes lands in Arizona.

- Export foreign waste to the United States where rules are weaker. For several years Chemours shipped its GenX waste from the Netherlands back to North Carolina for disposal.
- Dump PFAS down the drain. Only a handful of states set limits on PFAS discharges into the wastewater system.
- Bury it in a local landfill. PFAS are detected in ground and surface water or liquid leachate at most historic and active landfills.
- Inject liquid wastes into deep wells. Nearly 250,000 kilograms of PFAS-containing waste were sent to Deer Park Texas for deep well injection.

Epidemiology

32. Individual and mixture effects of perfluoroalkyl substances on liver function biomarkers in the Canadian Health Measures Survey

Michael M Borghese, Chun Lei Liang, James Owen, Mandy Fisher; Environmental Health Science and Research Bureau, Health Canada

Background
Perfluoroalkyl substances can disrupt hepatic metabolism and may be associated with liver function biomarkers. We examined individual and mixture effects of PFAS on liver function biomarkers in a representative sample of Canadian adults. We explored the potential for effect modification by sex and body mass index, as well as by physical activity level which may attenuate the deleterious effect of PFAS on metabolic disorders.

Methods
We analyzed data from participants aged 20-74 from several cycles of the Canadian Health Measures Survey (n= 1957 to 4657). We used linear regression to examine associations between plasma concentrations of PFOA, PFOS, PFHxS, PFNA, PFDA, and PFUDA on serum concentrations of aspartate aminotransferase (AST), gamma-glutamyltransferase (GGT), alkaline phosphatase (ALP), alanine aminotransferase (ALT) and bilirubin. We used quantile g-computation to estimate the mixture effect of a simultaneous, one-quartile change in PFAS concentrations.

Results
Each doubling of PFOA, PFOS, PFHxS, or PFNA concentrations was associated with higher AST, GGT, and ALP concentrations. We did not observe consistent associations with PFDA and PFUDA or for ALT and bilirubin. Each doubling of PFOA concentrations was associated with 16.5% (95%CI: 10.4, 23.0) higher GGT concentrations among adults not meeting Canada's physical activity guidelines vs. 6.6% (95%CI: -1.6, 15.5) among those meeting these guidelines. Sex and BMI also modified some associations, though to a lesser extent. In quantile g-computation models, each simultaneous one-quartile increase in the PFAS mixture was positively associated with AST, GGT, and ALP (range = 2.8% to 9.7%).

Conclusion
Higher plasma concentrations of PFOA, PFOS, PFHxS, and PFNA – both individually and as a mixture – were associated with higher serum concentrations of liver function biomarkers. We show, for the first time, that higher levels of physical activity appear to be protective against the hepatotoxic effects of PFOA. This work contributes to a growing body of evidence supporting the hepatotoxic effects of PFAS.

33. Characterizing Global Serum PFAS Concentrations

Julia Kaplan, Morgan Lennon, Stacie Reckling, Helena Mitasova, Jane Hoppin; North Carolina State University

Background: Per- and polyfluoroalkyl substances (PFAS) are persistent and ubiquitous in the environment. Concentrations of these chemicals vary by time and geographic area, but there has been no formal aggregation of PFAS blood levels globally over time.

Methods: To create a database of global blood PFAS levels, we conducted PubMed searches between May 2019-March 2022 using a structured ontology. Search terms included long-form and abbreviated chemical and group names (e.g., perfluorooctanoic acid (PFOA), per-fluoroalkyl substances (PFAS)), and sample media (e.g., serum). Review articles; meta-analyses; animal studies; sample media not including blood, serum, or plasma; and articles not in English were excluded, as well as those only using NHANES data. Data were either manually extracted from the articles or obtained from The Comparative Toxicogenomics Database (CTD). Articles were categorized by data collection location, population (e.g., adults, children, pregnant women/birth cohorts, communities exposed to contaminated water), sample size, number of detected PFAS, specific PFAS detected, PFAS concentrations, sampling media (whole blood/serum/plasma), and exposure source. Summary statistics were calculated and compared to US population data from the National Health and Nutrition Examination Survey (NHANES) 1999-2000 and 2011-2012 cycles.

Results: We have identified 1,186 articles published between 1993-March 2022 meeting our inclusion criteria and have extracted data from 272 (23%). PFOA (97%) and perfluorooctanesulfonic acid (PFOS) (94%) were the most studied PFAS although many studies reported additional legacy PFAS such as perfluorohexanesulfonic acid (PFHxS) (70%). Of the studies where PFOA was measured, 165 (61%) articles included unique sample populations and were used in further analyses. Diverse populations from 26 countries and territories were represented, with the highest number of studies located in China. From blood collected between 1959-2019, published PFOA concentration measures of central tendency (eg., mean, median) ranged from 0.1-1636.0 ng/mL (Interquartile Range (IQR): 1.8-5.8), with the highest concentration associated with an occupationally exposed population. The median serum PFOA in samples collected from 2011-2019 was 3.0 ng/mL (IQR: 1.7-6.6) compared to the NHANES US population estimate of 2.1 ng/mL (IQR: 1.5-3.0) in 2011-2012; suggesting that the literature as a whole is consistent with population based data for PFOA.

Conclusions: While not currently aggregated, the published scientific literature provides an opportunity to assess the levels of PFAS over time and geographic region. In this preliminary analysis of PFOA levels from 165 published papers, we observed a wide range of PFOA levels in studies from 26 countries around the world. Ultimately, we plan to make this information accessible to researchers, community groups, and public health officials to allow better understanding of PFAS exposure.

34. Prediction of GenX concentration on silicone wristbands as method to measure PFAS in contaminated groundwater community

Claire E. Critchley, North Carolina State University; *Nadine Kotlarz,* North Carolina State University; *Heather M. Stapleton, Duke University; Detlef Knappe,* North Carolina State University; *Michael Cuffney,* North Carolina State University; *Jane A. Hoppin,* North Carolina State University

Introduction

Per- and poly-fluoroalkyl substances (PFAS) that were emitted into the air from a chemical manufacturing facility in Fayetteville, North Carolina, contaminated water of over 5,000 private wells. Silicone wristbands have previously been used as a method of measuring passive environmental exposure to other chemicals. The GenX Exposure Study, designed to assess GenX and other PFAS exposures in residents of the Cape Fear River Basin, NC, utilized silicone wristbands to determine if PFAS were present in Fayetteville participants' ambient environment.

Methods

We recruited 90 GenX Exposure Study participants to wear pre-cleaned silicone wristbands for five consecutive days in February 2019. Wristbands were analyzed for 20 PFAS by liquid chromatography-tandem mass spectrometry (LC-MS/MS). Method reporting limits (MRL) ranged from 0.36 pg/g (GenX) to 8350 pg/g (PFBS). GenX had the highest detection rate and was the focus of this analysis. Exposure data were collected via questionnaire; tap and well water samples were analyzed for PFAS by LC/MS-MS. We used non-parametric tests to evaluate environmental and demographic predictors of wristband GenX concentration. Using these tests, we created multivariate linear regression models to evaluate the relationship between wristband GenX and tap and well water GenX concentrations. GenX concentrations were log transformed in both wristbands and water to increase normality. Due to small sample size, comparable models were developed by keeping variables meeting a 0.2 p-value cut-off in either tap or well models. We adjusted for race, working outside of the home, current cooking and drinking water source, use of water treatment, and number of carpeted rooms in the home.

Results

Wristband participants were 57% female and 83% white; 11 children were included. Nine PFAS were detected on wristbands, with GenX (89%) as the most frequently detected. PFNA and PFOS were also frequently detected (>50%). PFOA, PFBA, PFDA, 6:2 PFS, PFHxA, and PFHxS were detected less frequently (<30%). Median wristband GenX concentration was 10.88 pg/g (IQR 4.11-24.55). GenX levels did not vary by demographic characteristics but did vary based on water use and household variables (ex. number of carpeted rooms). The multiple linear regression model for tap water explained 47% of the variance in wristband GenX concentration, and the well water model explained 44%. Tap and well water GenX concentrations have a positive association with wristband GenX concentrations. In evaluation of behaviors related to GenX levels, we observed use of bottled water or water treatment, had higher levels of GenX in wristbands, likely due to interaction with higher levels of GenX in well water through washing or bathing.

Conclusion
GenX was detected on wristbands worn by residents near a chemical manufacturing facility. Wristband GenX concentration was predicted by water GenX concentration, household, and water use variables in a multiple linear regression model. These results suggest GenX was present on the skin of study participants in the Fayetteville area, probably as the result of contact with contaminated water used for washing and bathing. Currently, we do not have evidence that PFAS migrate across skin barriers at the concentrations detected.

35. PFAS in well water and blood serum from private well owners residing near a fluorochemical manufacturing facility in North Carolina

Nadine Kotlarz, North Carolina State University; Claire Critchley, North Carolina State University; David Collier, East Carolina University; Suzanne Lea, East Carolina University; Detlef Knappe, North Carolina State University; Jane Hoppin, North Carolina State University

Atmospheric deposition of PFAS emitted by the Fayetteville Works facility near Fayetteville, North Carolina (NC), has resulted in widespread groundwater contamination in the surrounding area. In February 2019, we enrolled 153 people from 85 homes and measured PFAS in well water and serum samples. People were recruited based on previously measured GenX well water concentration; approximately 40% had GenX in well water above the NC provisional health goal of 140 ng/L. Of the 24 PFAS we analyzed for, 10 were perfluoroalkyl ether acids (PFEAs) that come uniquely from Fayetteville Works and 14 were PFAS with multiple possible sources.

Four short-chain (≤6 carbons in chain) PFEAs were detected in >75% of wells. PMPA was most frequently detected (n=73 wells; 87%) and had the highest median concentration (342 ng/L, interquartile range [IQR] 143-748 ng/L), followed by GenX (85%, median: 107 ng/L, IQR: 13-261 ng/L), PEPA (82%, median: 81 ng/L, IQR: 12 - 179 ng/L), and PFO2HxA (77%, median: 107 ng/L, IQR: 8-221 ng/L). PMPA, GenX and PEPA were not detected in any blood samples, not even from the 24 participants who reported continuing to drink well water up until the date of specimen collection. While blood is generally considered a gold standard for assessing exposure to PFAS, it may not be appropriate for characterizing exposure to PFEAs with short biological half-lives.

Two long-chain PFEAs were detected in >30% of serum samples. Nafion byproduct 2, a C7 sulfonic acid, was detected in 56% of serum samples (median: 0.1 ng/mL, IQR: non-detect [ND] - 0.7 ng/mL). Nafion byproduct 2 was also frequently detected across wells (73%; median: 14 ng/L, IQR: ND – 30 ng/L). We examined the relationship between Nafion byproduct 2 levels in well water and levels in serum using multivariable linear regression modeling. We also assessed age, history of working at Fayetteville Works, years lived in the area surrounding Fayetteville Works, direction and distance of private well from Fayetteville Works, and consumption of bottled water. Nafion byproduct 2 levels in serum were significantly associated with a history of working at Fayetteville Works ($p < 0.001$) and associated with Nafion byproduct 2 levels in well water ($p = 0.06$). PFO5DoA, another long-chain PFEA, was detected in Fayetteville blood (35%). Most people who had detectable PFO5DoA in blood did not have detectable PFO5DoA in well water.

Six legacy PFAS (PFHxS, PFOA, PFHpS, PFOS, PFNA, PFDA) were detected in the serum of most (>90%) participants. The median serum PFOA concentration across adults (3.1 ng/mL, IQR: 1.9-4.3 ng/mL) was approximately double the median for the US population (1.4 ng/mL). The median PFOS blood level in adults (9.9 ng/mL, IQR: 5.1-13.9 ng/mL) was about three-fold higher than the US median (3.0 ng/mL). While these PFAS were detected in blood, PFOA and PFOS were infrequently detected in wells (37% and 24%, respectively).

Our results suggest there are variable levels of exposure to PFEAs from Fayetteville Works in the private well community surrounding the facility. There is also elevated exposure to legacy PFAS not uniquely associated with Fayetteville Works.

36. Predictors of per- and polyfluoroalkyl substances (PFAS) serum concentrations in residents of Wilmington, North Carolina (NC): The GenX Exposure Study

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Background/Aim: In June 2017 the Wilmington, NC, public became aware of GenX, a per- and polyfluoroalkyl substance (PFAS), in the lower Cape Fear River – Wilmington's primary source of drinking water. Community concern about GenX and other PFAS in the drinking water led to the development of the GenX Exposure Study. A primary objective of the study was to evaluate what factors predict PFAS levels in the blood of people in this community.

Methods: We recruited participants from Wilmington whose drinking water was sourced from the Cape Fear River. During November 2017 and May 2018, participants provided a blood sample and completed a questionnaire that gathered information on characteristics that may influence PFAS exposure. Seven of the 20 PFAS analyzed in serum samples were detected in >75% of participants; four legacy compounds (PFOA, PFOS, PFNA, PFHxS) and three fluoroethers (Nafion byproduct 2, PFO4DA, PFO5DoA). For each of these PFAS, we built linear models to evaluate predictors of serum levels. We used the same base model for each PFAS, which included five variables: years lived in Lower Cape Fear Region (LCFR), years lived outside the LCFR, race/ethnicity, gender, and enrollment date. We divided other possible predictors into three domains (demographics/lifestyle/general health; water usage; food and other PFAS sources) and performed bivariate statistics to determine which domain-specific variables were associated with serum PFAS levels. The domain-specific variables that met our p-value cutoff ($p<0.2$) were moved forward into multivariable models. We built full models using the base model variables plus selected domain-specific variables that could differ by PFAS.

Results: Our analysis included 335 participants, aged 6 and older, who had complete exposure and possible predictive variable data. Most participants were adults (84%), non-Hispanic white (77%), female (63%), and enrolled in November 2017 (90%). From our base models, years lived in the LCFR had almost two times the concentration per nanograms per milliliter (ng/mL) unit increase of PFAS serum levels than years lived outside the LCFR. For example, PFOS had beta coefficients of 0.27 ng/mL (95% confidence interval: 0.21, 0.32) for years lived in the LCFR and 0.13 ng/mL (95% CI: 0.09, 0.18) for years lived outside the LCFR. Males were found to have higher levels across all PFAS compared to females [e.g., PFOS: 3.24 ng/mL (95% CI: 1.62, 4.87), Nafion byproduct 2: 0.14 ng/mL (95% CI: -0.35, 0.64)]. Non-Hispanic Black participants compared to non-Hispanic white participants had lower levels for all PFAS [e.g., PFOA: -1.56 ng/mL (95% CI: -3.09, -0.04), PFO4DA: -1.47 ng/mL (95% CI: -4.1, 1.16)], except PFOS 3.92 ng/mL (95% CI: -0.07, 7.92).

Conclusions: Years lived in the Lower Cape Fear Region was an important predictor of an individual's PFAS serum levels for all seven PFAS evaluated. In this small cross-sectional study comprised of Wilmington residents with a likely common source of PFAS contamination from drinking water, our base models predicted 5-34% of the variance in serum PFAS levels and full models (base + domain-specific variables) predicted 20-38% of the variance in PFAS serum levels.

37. Perfluoroalkyl substances, blood lipids and Apolipoproteins in lipoprotein subspecies, and the Risk of Coronary Heart Disease: A case-control study

Lu Zhu, Yang Hu, Jeremy Furtado, Philippe Grandjean, Frank Sacks, Eric Rimm, Qi Sun; Harvard University

Background
Per- and polyfluoroalkyl substances (PFASs) are toxic and persistent artificial environmental pollutants that induce adverse effect on human metabolic system. The association of PFASs with blood lipids, lipoproteins and apolipoproteins, and coronary heart disease (CHD) risk are inconsistent in previous studies. The aim of current study is to examine the potential association between plasma PFASs, blood lipoproteins and their subspecies defined by apolipoproteins, and whether PFASs are associated with CVD risk.

Methods
A case-control study was conducted in 100 men and 102 women aged 45-70 years. We leveraged 101 participants from HPFS and NHS who were initially free of cardiovascular disease and developed a fatal or non-fatal myocardial infarction during follow-up, and randomly matched controls in a 1:1 ratio for age, smoking status, and date of blood draw. Seven plasma PFASs measurements were examined at baseline, including iperfluorohexane sulfonic acid (PFHxS), perfluorooctanoic acid (PFOA), total perfluorooctane sulfonic acid (PFOS), branched PFOS (brPFOS), linear PFOS (nPFOS), perfluorononanoic acid (PFNA), and perfluorodecanoic acid (PFDA), with all mean CVs <20%. Pearson correlation was applied to study the relationship

between PFASs, lipoproteins and subspecies; Conditional logistic regression model was conducted to test the association between PFASs and CHD risk; a mediating effect model was used to assess how blood lipids and apolipoprotein subspecies mediate the association between PFASs and CHD risk.

Results

For lipids and subspecies with ApoC-III, we observed non-significant inverse associations between PFASs and the subspecies of HDL, LDL and VLDL that contain only ApoC-III. A significant negative association between PFOS and ApoC-I concentration of LDL with ApoC-III (r=-0.26, p=0.007), and a significant positive association between PFHxS and ApoE concentration of LDL with ApoC-III (r=0.23, p=0.01) were observed. For those without ApoC-III, the directions of most significant associations are positive. Strong correlations were demonstrated between PFOA and LDL with ApoC-II (r=0.23, p=0.01), between PFNA, PFDA and HDL with ApoE (r=0.37, p=0.00004; r=0.20, p=0.03, respectively). In addition, elevated PFOS concentrations were associated with higher relative risk of CHD (HR=1.04, p=0.02), especially for branched PFOS (HR=1.18, p=0.003), and these association were largely dose dependent (PFOS: p for linearity = 0.009; brPFOS: 0.0007). Mediation analysis illustrated no mediating effect regarding blood lipids and apolipoprotein subspecies on the association of interest, except for HDL on the association between PFOS, nPFOS and CHD risk (%mediated=25%, p=0.03; %mediated=36%, p=0.03, separately).

Conclusions

Our results suggest that most plasma PFASs are more likely to be positively associated with blood lipoproteins and their subspecies without ApoC-III and negatively associated with those with ApoC-III, and there is a linear positive dose-response relationship between PFOS and CHD risk.

Developmental and Reproductive Toxicology

38. Select Perfluoroalkyl Substances Induce Platinum Resistance in Monolayer Ovarian Cancer Cultures

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Per- and poly-fluoroalkyl substances (PFAS) are ubiquitous in our everyday environments and have been implicated in altered ovarian function. While this is true, their role in disease progression and therapy response in ovarian cancer has seldom been explored. In some North Carolina drinking water, a mixture of PFAS containing perfluorooctanoic acid (PFOA), perfluoroheptanoic acid (PFHpA) and perfluoropentanoic acid (PFPA) is present. In order to examine the effects of individual PFAS and mixtures on ovarian cancer cell viability, NIH:OVCAR-3 human ovarian cancer cells were exposed to PFOA, PFHpA, PFPA, or combinations of the agents at concentrations ranging from 0-2.25μM for 48 hours, including a 1-hour serum-free pulse to ensure cell exposure. Results showed that at all concentrations of both individual agents and mixtures, cytotoxicity did not exceed 10%. In fact, cells exposed to mixtures sometimes demonstrated increased cell viability compared to those exposed to the vehicle control, suggesting a potentially proliferative effect of PFAS mixtures. To determine the contribution of these chemicals to platinum resistance in monolayer ovarian cancer cultures, NIH:OVCAR-3 cells were exposed as described to individual PFAS at 500nM and 2μM or mixtures at 2μM (2 PFAS mixture) and 2.25μM (3 PFAS mixture) prior to exposure to 0-400μM carboplatin for 48 hours. Results showed that in NIH:OVCAR-3 cells, exposure to 2μM PFHpA increased cell viability compared to the vehicle control at 50μM and 200μM carboplatin while 2μM PFPA increased cell viability compared to the vehicle control at 50μM, 100μM, and 200μM carboplatin. After exposure to PFAS mixtures, the combination of 1μM PFHpA and 1μM PFPA increased cell viability after treatment with 400μM carboplatin compared to the vehicle control. Other mixtures, such as 750nM PFOA + 750nM PFHpA + 750nM PFPA trended towards significance after exposure to 200μM carboplatin, although further experiments are needed to explore this relationship. Increased cell viability in PFAS-exposed ovarian cancer cells compared to controls indicates that certain North Carolina-based PFAS and PFAS mixtures in drinking water may induce resistance to platinum-based chemotherapy in monolayer ovarian cancer cultures. This is the first study of its kind to examine the association between individual PFAS or PFAS mixtures and in vitro toxic response to a chemotherapeutic agent.

39. Evaluating maternal exposure to an environmental per and polyfluoroalkyl substances (PFAS) mixture during pregnancy: adverse maternal and fetoplacental effects in a New Zealand White (NZW) rabbit model

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Mixtures of per- and polyfluoroalkyl substances (PFAS) are often found in drinking water, and serum PFAS are detected in up to 99% of the population. However, very little is known about how exposure to PFAS mixtures affects maternal and fetal health. We investigated maternal, fetal, and placental outcomes after preconceptional and gestational exposure to an environmentally relevant PFAS mixture in a New Zealand White (NZW) rabbit model. Dams were exposed via drinking water to control (no detectable PFAS) or a PFAS mixture drinking for 32 days. The mixture was formulated with PFAS to resemble levels measured in tap water from Pittsboro, NC (10 PFAS compounds; total PFAS load = 758.6 ng/L). Dams were bred on day 7 and sacrificed on gestational day 25. Maternal, fetal, and placental outcomes were evaluated at necropsy. Thyroid hormones were measured in maternal serum and kit blood. Placental gene expression was evaluated by RNAseq and qPCR. PFAS exposure resulted in higher body weight (p=0.01), liver (p=0.01) and kidney (p=0.01) weights, blood pressure (p=0.05), and BUN:CRE ratio (p=0.04) in dams, along with microscopic changes in renal cortices. Fetal weight, measures, and histopathology were unchanged, but a significant interaction between dose and sex was detected in the fetal: placental weight ratio (p=0.036). Placental macroscopic changes were present in PFAS-exposed dams. Dam serum showed lower T4 and a higher T3:T4 ratio, although not statistically significant. RNAseq revealed that 11 of the 14 differentially expressed genes (adj. p< 0.1) are involved in placentation or pregnancy complications. Overall, we report adverse maternal and placental effects of an environmentally-relevant PFAS mixture in vivo. Exposure elicited weight gain and signs of hypertension, renal injury, and a sex-specific changes in placental response. Our results indicate PFAS exposure can shift biologically relevant expression of genes involved in placentation and preeclampsia.

40. Developmental toxicity of PFAS in zebrafish larvae

Matthew Farrell, North Carolina State University; Jeffrey Enders, North Carolina State University; Antonio Planchart, North Carolina State University

Per- and polyfluoroalkyl substances (PFAS) are ubiquitous environmental contaminants used in manufacturing and numerous commercial products. Some PFAS have been connected to harmful health effects, but to this point the number of different PFAS chemicals being produced and released into the environment has greatly outpaced the scientific community's ability to study them. This has emphasized the importance of establishing which structural characteristics of PFAS are responsible for toxic effects, so that models can be established to predict harmful chemicals. This study seeks to relate carbon chain lengths, functional acid groups, and ether linkages of PFAS with acute toxicity. Zebrafish embryos were aqueously exposed to seventeen individual PFAS over the course of five days and then examined for signs of developmental toxicity. Increased carbon chain length and sulfonic acid functional groups were found to positively correlate with mortality and several indicators of developmental toxicity, including spinal malformation, swim bladder non-inflation, and yolk sac / pericardial edema. Inclusion of

ether linkages showed negative correlation with these same phenotypes. This study reinforces the links between key PFAS chemical characteristics and toxicity by examining a wide range of structurally similar PFAS under identical conditions.

41. Neurobehavioral consequences of embryonic PFOA or PFOS exposure in the developing zebrafish

Andrew B Hawkey, Mikayla Mead, Anas Gondal, Sarabesh Natarajan, Edward D. Levin; Duke University

Per- and poly-fluoroalkyl substances (PFAS) are widely used flame retardants and industrial additives of increasing concern as environmental toxicants. Aquatic ecosystems and drinking water are particularly vulnerable to PFAS contamination, and detection of these compounds in water is increasingly common across much of the US. However, PFAS includes many varying compounds which may differ in their toxic potential, including their developmental and neurotoxicity. In the present study, zebrafish embryos were exposed to vehicle (0.1% DMSO) or a range of concentrations of two representative PFAS, PFOA (0.1-100uM) and PFOS (0.01-1uM) from 5 hr-5 days post-fertilization (dpf). This was followed by neurobehavioral testing at larval (6dpf), adolescent (~3 months) and adult (6-7 months) time points. These dose ranges were subthreshold for producing increased mortality or dysmorphogenesis. PFOA was tolerated at 100x the concentration tolerated for PFOS among embryonic/larval fish. In larval zebrafish, embryonic PFOA exposure caused specific increases in larval motility in the dark (100uM), while much lower doses of PFOS interfered with light-dark modulation of motility (0.1-1uM). In adolescence, embryonic PFOA (100 uM) exposure caused enhanced anxiety-like diving behavior in the novel tank (100uM), but had no effects in the tap startle test. By adulthood, all effects observed in adolescence in PFOA treated fish attenuated. In contrast, much lower concentrations of PFOS caused reductions in the diving response (0.1uM), coinciding with a loss of locomotor increases across the novel tank session (0.1-1uM). Lower dose PFOS exposure (0.01 uM) caused reduced startle responses in the tap test. By adulthood, the only observed effect was a reduction in novel tank activity with the lowest dose exposure (0.01uM). Additional analysis of social and fear-like avoidance responses in adulthood are ongoing. The current findings suggest that PFOA and PFOS have differential adverse effects across early development, with lower tolerability for PFOS relative to PFOA and compound-specific neurotoxic effects. Research was supported from the Duke University Superfund Research Center ES010356.

42. Perfluorooctanoic Acid Decreases Proliferation in Human Endometrial Stromal Cells

Mackenzie J. Dickson, Suzanne E. Fenton, Francesco J. DeMayo; National Institute of Environmental Health Sciences

Per- and polyfluorinated substances (PFAS) are a large class of ubiquitous chemical compounds that persist in the environment. Exposure can occur through consuming contaminated water or food or using products that contain PFAS. Previous work has associated

higher levels of perfluorooctanoic acid (PFOA) with decreased fertility in women, including a longer time to pregnancy and an increased risk of miscarriage. Within the uterus, decidualization of stromal cells is a critical step for successful implantation and pregnancy establishment. We hypothesized that PFOA alters the endometrial stromal proliferation and decidualization and contributes to PFAS induced subfertility. Immortalized human endometrial stromal cells (HESC) were plated at 1.5 x 105 cells/mL or 7.5 x 104 cells/mL and treated for 48 or 72 hours respectively, with PFOA in tenfold concentrations ranging from 0.01 to 1 mM or vehicle in reduced serum medium. After incubation, cell viability was quantified by the colorimetric assay for WST8, an indicator of mitochondrial activity. After 48 hours, 1 mM of PFOA was toxic to cells. Cells appeared morphologically dead and there was 100% decrease in cell number compared to vehicle. However, the cells exposed to 100 µM of PFOA or less morphologically appeared similar to vehicle, but the cell number was reduced on average by 77%. There was no difference in cell proliferation between the doses of PFOA ranging from 0.01 - 100 µM. The results were similar for exposure of HESC to PFOA for 72 h, and cell proliferation was reduced compared to vehicle independent of dose. In conclusion, exposure of PFOA alters the proliferation of immortalized human endometrial stromal cells in vitro. These alterations found in endometrial stromal cell proliferation and viability could contribute to the inability of women with PFOA exposure to establish a viable pregnancy. Additional experiments to induce decidualization in vitro are being conducted to analyze the interaction of PFOA and steroid hormones. Further, these experiments will be repeated in primary endometrial stromal cells isolated from biopsies to validate these findings.

43. The Neurobehavioral Effects of Perinatal PFAS Exposure through Drinking Water

Melissa Marchese, Tianyi Zhu, Andrew Hawkey, Katherine Wang, Edward Levin, Liping Feng; Duke University School of Medicine

Per- and polyfluoroalkyl substances (PFAS) are persistent organic pollutants that have become globally ubiquitous in the environment and in humans. One local population facing disproportionate PFAS exposure risk through their drinking water was Pittsboro, NC residents. In utero PFAS exposure is associated with an array of long-term health effects; however, the mechanism of toxicity is poorly understood. The aim of this study is to determine the causal relationship between in utero PFAS mixture exposure and cognitive deficits, emotional dysfunction, and behavioral dysregulation in rats. Using animal models, this study addresses the neurodevelopmental effects of gestational exposure to clearly defined PFAS concentrations seen in Pittsboro's drinking water and a 5,000-fold concentration as the positive control. To quantitatively assess toxicity, animal subjects exposed to PFAS-laden drinking water during fetal development underwent a battery of assessments from an established behavioral testing framework. Dams exposed to the high-dose mixture yielded smaller litters on average. Offspring in the low-dose group of environmental relevance demonstrated significantly smaller weights ($p<0.05$) and smaller anogenital distances on average just prior to weaning (PND 21). In the behavioral battery, low and high-dose-exposed rats made fewer attempts to explore different arms of the elevated plus maze, indicating a heightened anxiety response. In the figure-8 maze, males in the high-dose group displayed hyperactivity compared to the other groups. These findings suggest that maternal PFAS exposure may be able to cause diminished fertility, small pup size, increased anxiety, and hyperactivity in rats. However, continued investigation is necessary to obtain sufficient statistical power.

44. PFAS Exchange: An online resource center for educating and empowering PFAS-impacted communities

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Across the U.S. and around the world, a growing number of communities are discovering PFAS contamination of water supplies and local environments. The PFAS-REACH (Research, Education, and Action for Community Health) Study, a collaboration among researchers and community partners, developed an online resource center – the PFAS Exchange – to address the needs of PFAS-impacted communities.

The PFAS Exchange provides a range of tools and resources, including:

- An innovative online data interpretation tool, What's My Exposure, for helping community members understand and contextualize results of PFAS testing in blood and drinking water. This tool was created using research-based approaches for report-back of chemical test results developed by Silent Spring Institute.

- The Connecting Communities map, with state-specific information about community groups, known and suspected contamination sites, health studies, and state-level action on addressing PFAS. The map, built using the ArgGIS Experience platform, includes information from the Northeastern University Contamination Site Tracker.

- A Resources page with fact sheets and other resources to address questions and needs commonly expressed by PFAS-impacted communities. These address topics such as: medical monitoring, blood testing, water treatment, immune system effects including vaccine response, and exposure reduction.

The PFAS Exchange is available at: www.pfas-exchange.org.

44B. Effects of hexafluoropropylene oxide dimer acid (GenX) exposure on neurological behaviors and reproduction in Caenorhabditis elegans

M. Storm Cash, East Carolina University

Per- and polyfluoroalkyl substances (PFAS) are commercially manufactured chemicals known for widespread usage in different industries. Past research indicating health effects and bioaccumulation in humans and the environment has resulted in the banning and withdrawal of some PFAS. GenX (hexafluoropropylene oxide dimer acid (HFPO-DA)) is a short-chained replacement for a long-chained PFAS, but little research has been conducted on potential health impacts of GenX to justify its growing prominence. In this study, we used the model organism Caenorhabditis elegans (C. elegans) to investigate the impact of GenX exposure on neurological behaviors, reproduction, and their mechanisms. Age-synchronized C. elegans were dosed with a range of environmentally relevant concentrations from 14 to 71,000 ng/L of GenX and assessed at different posttreatment time periods. Our findings suggest that exposure to GenX increases various neurological activities of C. elegans, including pharyngeal pumping rate and head thrashing rates, especially at low dosage levels. Exposure to GenX also caused increased production of offspring in a dose-specific manner with increased germ cell counts in various gonadal regions, including oocytes and sperms. Gene expression analysis indicated a general gene expression suppression following GenX exposure; some oxidative stress-related and oogenesis and spermatogenesis related genes were significantly suppressed. The testing into mitochondrial toxicity potential is ongoing. These results align with past research on PFOA eliciting excitatory responses in C. elegans and certain vertebrate species and also provide new insights into GenX toxicity.

Immune Toxicology

45. Quantifying the impact of PFOA Exposure on B cell development and antibody production

Krystal Taylor, East Carolina University; Tracey Woodlief, North Carolina State University; Jamie DeWitt, East Carolina University

Over 12,000 synthetic chemicals have been identified as per- and polyfluoroalkyl substances (PFAS). Many are used in non-stick cooking ware, medical garments, and food packaging. PFAS are environmentally and biologically persistent, and some have demonstrated toxicity, including cancer, effects on reproduction and development, endocrine disruption, and immune dysfunction. Suppression of T-cell dependent antibody responses (TDAR) has been observed in epidemiological and experimental animal studies of legacy PFAS. Molecular mechanisms of PFAS-induced immunosuppression remain elusive, leading our lab to focus on B cell subclasses, enumerating B cells as they transform from naïve B cells to memory B cells and antibody-secreting plasma cells. Adult male and female C57BL/6 mice were given the long-chain legacy PFAS, perfluorooctanoic acid (PFOA; 0 or 7.5mg/kg) via gavage for 15 days, a time sufficient for suppression of the TDAR. In a second experiment, male and female C57BL/6 mice were given a short-chain PFAS, perflurorohexanoic acid (PFHxA; 0, .0.5, 5 or 50 mg/kg/day) via gavage for 30 days. Separate groups of animals were injected with antigens to elicit the TDAR. One day after dosing ended, spleens were prepared to determine B cell populations via a flow cytometric panel to identify B cell subsets. Flow cytometric analysis revealed that memory B cells or plasmablast cell subclasses are likely impacted by PFOA and PFHxA exposure. Our data indicates overall B cell numbers are not affected by exposure. Still, changes in the numbers of B cell subsets suggest that the ability of B cells to differentiate is impacted. Currently, we are developing ex vivo naive B cell protocols that model T cell-dependent activation. These assays will determine if naïve B cell activation and differentiation are targeted by PFAS exposure.

46. Comparing the Respiratory Burst In Vivo, In Vitro, and Ex Vivo After Exposure to Per- and Polyfluoroalkyl Substances

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The United States Environmental Protection Agency currently estimates that there are more than 12,000 per- and polyfluoroalkyl substances (PFASs), which are used to produce non-stick cookware, food contact materials, hydro- and oleophobic textiles, and more. Due to their unique chemistry, they are ubiquitous and persistent in the environment, making exposure to PFASs commonplace. It is estimated that 98% of Americans have detectable serum levels of multiple PFASs. These compounds have also been detected in wildlife, illustrating their wide-reaching impact. It is well established that these compounds are immunotoxic; however, previous research has focused largely on the effects of PFASs on the adaptive immune system, leaving a knowledge gap on what is known about the effects of these compounds on the innate immune system. To bridge this gap, we utilized an in vivo larval zebrafish model, an in vitro human neutrophil-like cell culture model, and primary neutrophils exposed to PFASs ex vivo to investigate innate immune function after exposure to environmentally relevant PFASs. The respiratory burst was measured as a functional readout of innate immune function. Neutrophils induce microbicidal reactive oxygen species through the respiratory burst to defend the host against pathogens. Data show that some PFASs are capable of inhibiting the respiratory burst in vivo, in vitro, and ex vivo. Potency was similar among the model systems, indicating potential evolutionary conservation. Current studies are exploring whether exposure to PFASs confers susceptibility to infectious disease, and what mechanisms may be responsible for this immunosuppressive phenotype.

47. How Do Per- And Polyfluoroalkyl Substances (PFAS) Affect Macrophage Function?

Ashley Connors, Jeffrey A. Yoder; North Carolina State University

Immune function can be impaired by environmental contaminants. One class of chemicals recently shown to interfere with the immune systems is per- and polyfluoroalkyl substances (PFAS). Earlier work focused on impacts on the adaptive immune system, though disruptions to the innate immune system have also been identified. These studies indicate that PFAS exposure can influence the numbers of innate immune cells, cellular signaling, and functional endpoints. For example, we reported that certain PFAS can reduce the oxidative burst in vivo in larval zebrafish (Danio rerio), in vitro in a human neutrophil-like cell line, and ex vivo in primary human neutrophils. To complement these neutrophil studies, we are evaluating how macrophages are affected by a 2-day (in vitro) and 4-day (in vivo) exposure to ten different PFAS. In cytotoxicity studies with macrophage-like THP-1 cells, we found no changes in cell viability at or below exposures to 80 μM PFAS. We are currently investigating how phagocytosis is affected during PFAS exposures using both zebrafish larvae and THP-1 cells: macrophage populations derived from zebrafish and THP-1 cells will be challenged with fluorescent heat-killed E. coli. Phagocytic index and number will be measured with flow cytometry. Based on these functional assays, we will select 2-3 specific PFASs for studies that will elucidate currently unknown molecular mechanisms of PFAS immunotoxicity. To this end, we will conduct transcriptomic analyses on PFAS-exposed macrophage-like THP-1 cells to identify differentially expressed gene networks. Understanding how PFAS affect innate immunity will help us better understand how PFAS exposure can alter an organism’s ability to resist pathogens in its environment as well as cancer.

Health Effects

48. An experimental pipeline to quantify increased invasiveness potentials of PFAS exposure on 3D breast tumor models

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The chemical stability of per- and polyfluoroalkyl substances (PFAS) make them ideal coatings for consumer goods. The chemical stability of PFAS and the scarcity of biological processes capable of breaking carbon-fluorine bonds is responsible for their significant environmental and bioaccumulation. Perfluorooctanesulfonic acid (PFOS) and perfluorooctanoic acid (PFOA) are ubiquitous in the blood serum of individuals around the world despite their limited use in many countries, with serum half-lives that ensure tissues and organs are continuously exposed to these substances for periods of years. Epidemiological studies have linked PFAS exposure to tumorigenesis and correlated exposure to increased occurrences of breast, liver, pancreatic, and testicular cancer. Libraries of next-generation PFAS molecules incorporating ether and ester linkages are replacing legacy substances such as PFOS and PFOA, despite limited toxicological data on these molecules and their metabolites. To determine the role of PFAS in the promotion of tumor growth and invasiveness, we developed a pipeline that evaluates hormone-sensitive and insensitive breast cancers in monolayer and 3D culture (tissue-like) formats. This work highlights our preliminary results, evaluating short-term (48 hours) and prolonged (several weeks) exposure to PFOS, PFOA, and several other PFAS molecules with concentrations ranging from 0.1 – 10,000 ppb. Specifically, we evaluated the ability of these substances to promote the epithelial to mesenchymal transition (EMT) and increase the invasiveness of these cells. Using quantitative molecular-based readouts, we link EMT-related changes at the gene-level signatures to increased invasion of breast cells from 3D tissue-like environments. Our results highlight the differential responses of cells to these PFAS molecules, with PFOA inducing a strong EMT gene signature in MCF7 (ER+ breast carcinoma cell line) but limited increases in invasion. Although, PFOA induced a limited change in EMT gene expression but a significant increase in M231 (triple negative, fibroblast-like breast carcinoma cell line) invasion.

49. Cytotoxicity Evaluation of Individual and Combined Exposures to PFAS and PAHs Contaminants

Fatema Tuj Jahura, Jessica Gluck, R. Bryan Ormond, Kiran Mumtaz; North Carolina State University

Firefighters are continuously exposed to many chemical agents on the fireground, including volatile organic compounds, polycyclic aromatic hydrocarbons (PAHs) in the fire smoke, and per- and polyfluoroalkyl substances (PFAS) in fire extinguishers. Also, a new concern has been raised regarding firefighters' exposure to PFASs through turnout gear. Several studies have linked PFAS to certain types of cancer, and some of the PAHs are probable or known carcinogens. However, the combined effects and toxicological interactions of PAHs and PFAS have remained largely unknown even though firefighters are rarely exposed to a single chemical. The study aims to investigate the individual and combined cytotoxicity of the several PAHs and PFAS found in human blood serum. In this pilot study, PAHs and PFAS samples with various concentrations will be exposed to two different types of cells, mouse embryonic fibroblasts and pluripotent stem cells (hiPSC). Cells will be evaluated for viability using both a Live/Dead assay and AlamarBlue to evaluate proliferation via cellular metabolic activity at multiple time points up to 7 days. The results from the study will provide preliminary data to establish a baseline cytotoxicity profile to enable us to evaluate the potential of tumor generation due to PFAS in the future. In addition, the data will provide an insight into the mixture effects of chemicals that may allow better PFAS exposure-related health risk assessment.

50. Exposure of Hyperlipidemic Mice to a Mixture of Legacy, Alternative, and Emerging Per- and Polyfluoroalkyl Substances (PFAS) Modulates Cholesterol Metabolism

Katherine Roth, Zhao Yang, Manisha Agarwal, Wanqing Liu, Michael Petriello; Wayne State University

Per- and polyfluoroalkyl substances (PFAS) are a class of ubiquitous synthetic chemicals used in a variety of consumer and industrial products for their surfactant properties. PFAS have been measured in the environment as well as circulating in humans across the globe. Epidemiological studies have associated exposure to PFAS with dyslipidemia, along with related diseases such as steatosis and cardiometabolic disorders. However, most mechanistic studies focus on singular PFAS exposure as opposed to mixtures containing legacy, alternative, and emerging subtypes. Our studies aim to investigate mechanisms linking exposure to a PFAS mixture with alterations in lipid metabolism, notably increased circulating cholesterol, and the development of cardiovascular diseases, such as atherosclerosis. To begin these studies, male and female Ldlr KO mice were fed a low-fat atherogenic diet and exposed to drinking water containing a mixture of 5 PFAS representing legacy, alternative, and emerging subtypes (i.e., PFOA, PFOS, PFNA, PFHxS, and GenX), each at a concentration of 2mg/L, for 7 weeks. Exposure to the PFAS water increased circulating cholesterol in both male and female mice after 7 weeks compared to vehicle water. To start investigating mechanisms leading to increased circulating cholesterol levels, we first examined PFAS-induced effects on the conversion of cholesterol to bile acids. However, hepatic transcriptional regulation of two major enzymes in the classic and alternative pathways of cholesterol conversion to bile acids (Cyp7a1 and Cyp27a1) were not significantly affected by PFAS exposure. LC-MS was then used to determine if there were alterations in bile acid transport and excretion by measuring bile acid levels in the plasma and feces of the Ldlr KO mice. These analyses revealed that bile acid levels increased in the plasma of male and female mice exposed to PFAS. However, in the feces, the levels of excreted bile acids were found to be decreased in the PFAS-exposed mice compared to the vehicle mice, suggesting lowered excretion as a mechanism for increased circulating cholesterol. Hepatic and ileal protein levels of bile acid transporters were also measured. In the liver, protein levels of the hepatic uptake transporter NTCP was increased in the PFAS-exposed mice, especially in the males. In males, the ileal uptake transporter ASBT was increased in the PFAS-exposed mice compared to vehicle, which could be a mechanism for decreased bile acid excretion due to increased reuptake. Interestingly, at 7 weeks, hepatic Slc10a1 (encoding NTCP) was transcriptionally downregulated and ileal Slc10a2 (encoding ASBT) was not significantly affected in the PFAS-exposed mice compared to vehicle. Finally, since the gut microbiota are critical mediators of sterol and bile acid formation, we also examined changes using 16s rRNA sequencing and observed altered diversity and genera associated with the production of secondary bile acids (e.g., clostridium) in male PFAS-exposed mice. Overall, exposure of hyperlipidemic mice to a PFAS mixture resulted in increased circulating cholesterol levels along with alterations in bile acid transport through the enterohepatic circulation, bile acid excretion, and the bile acid-gut microbiota axis.

Medical Screening Guidance and Clinician Training

51. Translating Research to Action with Improved Medical Screening Guidance and Clinician Training for PFAS-impacted Communities

Courtney Carignan, Michigan State University; Phil Brown, Northeastern University; Alan Ducatman, West Virginia University; Elizabeth Friedman, Children's Mercy Kansas City; Jamie DeWitt, East Carolina University; Tony Fletcher, London School of Hygiene and Tropical Medicine; Martha Powers, Northeastern University; Andrea Amico, Testing for Pease; Maia Fitzstevens, Silent Spring Institute; Shaina Kasper, Community Action Works; Cheryl Osimo, Massachusetts Breast Cancer Coalition; Ayesha Khan, Nantucket PFAS Action Group; Jaime Honkawa, Nantucket PFAS Action Group; Lydia Silber, Nantucket PFAS Action Group; Laurel Schaider, Silent Spring Institute

PFAS-REACH (Research, Education, and Action for Community Health) is an NIEHS-funded Research to Action project that supports communities impacted by PFAS contaminated drinking water. Affected community members and their clinicians have identified improved medical screening as a high priority need. An advisory team of scientists, clinicians, and community members developed PFAS medical screening guidance documents for residents of PFAS-impacted communities and their clinicians. Science-based suggestions about medical screening for adults and children include suggestions for medical screening of health outcomes linked to PFAS exposure, potentially useful clinical laboratory testing, as well as discussion points that patients can use to encourage two-way conversations with their doctor. We also developed a CME training for clinicians with support from the EPA/CDC-funded Pediatric Environmental Health Specialty Units (PEHSU). These actionable resources help protect children's health and support impacted communities to reduce their PFAS exposure and mitigate related health risks.

Environmental Justice, Risk Communication, and Community Engagement

52. Environmental Justice (EJ) For All

Linda Shosie, EJ Task Force

I come from Tucson, Arizona, I have been an environmental justice organizer and human rights activist fighting for the Human Rights to the Enjoyment of a Safe, Clean, Healthy and Sustainable Environments for over ten years. I am part of the NPCC- representing the Citizens of the State of Arizona who are disproportionately impacted by PFAS water pollution. I live in the Heart of one of the largest Southern Arizona's DOD- militaries (Federal Facilities) Installations in the Country. I am the owner and founder of the EJ Task Force Organization which was formed nearly five years ago when we found out that the DOD- was discharging large quantities of PFAS-Containing Firefighting Foams into our community arroyos, sewages, drinking water and groundwater supplies since 1970's. Due to these practices, PFAS has contaminated groundwater and drinking water, surface waters across our region. Last year, Tucson Water was forced to shut down some of their production wells at the Tucson Airport Remediation Plant (TARP) Wastewater Treatment Facility. After a state's investigation found PFAS detections at 70,000 ppt. It will take billions more rate payer dollars to get it back in service.

Since 1940's these military industries have been contaminating our cities public water systems and it just keeps happening and they keep getting away with it and without being held accountability for the cleanup costs by the government. Our community has continually seen higher cancer rate clusters, birth defects, and increase auto immune disease related health disparities that have gone unaddressed, downplayed by our state and county health departments. Many mothers like myself have witnessed the deaths of our children. Myself, and my children, have experienced our own health struggles which I will share with you on the presentation.

I joined the 2022 PFAS Conference Subcommittee EJ Panel, because I wanted to meet the EJ people deeply rooted in the NC- SC areas. So, I can educate attendees on what is meant by EJ For All, and the true definition of Environment. My focus is going to be on telling attendees my personal story, of the health struggles myself and my family and neighbors have incurred resulting from community-wide exposures to toxic chemicals PFAS. I will take attendees on a tour and show them around my community so they can see firsthand how EJ communities and disadvantaged communities are disproportionately impacted by PFAS when compared to the people living in the white neighborhoods in the foothills. Here in Tucson, AZ- you will see how Latino people in the central Tucson area are more exposed to PFAS.

53. Exploring People's Perceptions of and Motivations for Participating in Research Studies

Grace Campbell, North Carolina State University; Charlie Reed, North Carolina State University; Suzanne Lea, Eastern Carolina University; Omar Diaz, Eastern Carolina University; Mary Grace Miller, North Carolina State University; Katlyn May, North Carolina State University

In 2016, GenX and other per- and polyfluoroalkyl substances (PFAS) were discovered in the drinking water of residents from Wilmington (at the base of the Cape Fear River Basin, North Carolina). Since then, elevated levels of PFAS have been discovered throughout the Cape Fear River Basin. In 2017, the GenX Exposure Study began with the goal of understanding exposure and potential health effects of PFAS throughout the Basin. From November 2020 to November 2021, the Study has recruited almost 1,000 participants. While the Study has successfully recruited a large number of people, the participants are not fully representative of the larger communities' or region's demographics. In the first round of sampling between 2017-2019, 54.93% of the cohort was above the age of 50 and 81.29% white, which is not representative of the demographics of the Cape Fear River Basin, North Carolina.

In January 2021, the Study began a qualitative research project to better understand why this is, exploring what makes people hesitant and, likewise, what makes people willing to participate in research studies related to human and environmental health. This research project uses interviews with key informants, or individuals with key characteristics which make them most knowledgeable on the topic of interest. Participants are recruited through snowball sampling to better reach populations who have our key characteristics of interest. These interviews will generate robust qualitative data about the perceptions of health studies, and will inform future communication, recruitment, retention, dissemination, and engagement efforts in PFAS-impacted communities.

54. The Superfund Research Program: Engaging with Communities and Communicating Risks of PFAS Exposure

Sara M. Amolegbe, Brittany A. Trottier, Michelle L. Heacock, Heather F. Henry, Danielle J. Carlin, William A. Suk; National Institute of Environmental Health Sciences

The National Institute of Environmental Health Sciences (NIEHS) Superfund Research Program (SRP) is a network of multi-disciplinary scientists combining expertise in biomedical, environmental science and engineering, community engagement, and data management to provide practical, scientific solutions for pressing public health issues. SRP researchers study health effects of exposure to hazardous substances, including per- and poly-fluoroalkyl substances (PFAS), and investigate effective, sustainable ways to mitigate or prevent exposures through a nationwide grantee network. They also work closely with affected communities to develop innovative strategies to communicate potential health risks and empower individuals to reduce their exposures and protect their health.

To address concerns related to PFAS, SRP grantees are tailoring communication strategies and facilitating knowledge exchange between scientists and local communities to improve health and lower health disparities. SRP grantees engage with community members, regulatory partners, and lawmakers by sharing research results and educational resources that can be used to inform ways to reduce exposure to PFAS and improve health. They have hosted town halls, created community resource websites and fact sheets, developed videos, and shared findings via podcasts. SRP researchers have also communicated results of PFAS testing and conducted interviews and focus groups with participants to learn more about their communication preferences to further customize reports. Additionally, SRP-funded research is being used to help inform new methods for dealing with PFAS in the environment as well as recommendations for health protective standards for PFAS.

A unique aspect of the SRP is the University-based multi-project center concept, where health scientists and engineers working in transdisciplinary teams contribute their diverse expertise to address the center's research focus. The multidisciplinary SRP Center concept provides a framework for research teams to rapidly respond and apply knowledge and expertise to understand and reduce environmental threats. This poster will provide examples of successful research and health communication strategies by SRP grantees to understand the health effects, mitigate environmental exposures, or reduce the toxicity of PFAS. It will also describe how SRP grantees have engaged with communities and tailored risk communication strategies to educate communities of PFAS risks.

55. Sociodemographic Determinants of PFAS Contamination in United States Community Water Supplies: An Analysis of Sampling Data from 11 States

Laurel A. Schaider, Silent Spring Institute; Elsie M. Sunderland, Harvard University

Many studies show marginalized communities are disproportionately exposed to air pollution. However, relatively few studies have considered disparities in water quality, including exposures to per- and polyfluoroalkyl substances (PFAS). Here, we evaluate whether Community Water Systems (CWS) serving greater proportions of minority and low-income individuals have higher likelihoods of detecting PFAS and exceeding Maximum Contaminant Levels (MCL). We compiled drinking water PFAS concentration data from 11 states with statewide monitoring data and ancillary data on sociodemographics, CWS characteristics, and PFAS sources. We examined associations between PFAS concentrations in drinking water and sociodemographics at various spatial units for 4,698 CWS (serving 62.2 million people) using multivariate logistic regressions. CWS serving 20.8 million people (33%) had detectable concentrations (>5 ng/L) of at least one of five PFAS and those serving 16 million people (26%) exceeded the lowest state-level MCL for several PFAS. CWS with detectable PFAS levels and MCL exceedances served greater proportions of Hispanic and Black residents than those without. At the county-level, a percentage point increase in the proportion of Hispanic residents served by a CWS was associated with a 4-6% increase in the odds of detecting PFAS. Results for individual state-level relationships were more mixed, although systems serving greater proportions of Hispanic residents in five states had increased odds of detecting several PFAS. Our findings suggest that CWS serving communities with greater proportions of Hispanic and non-Hispanic Black residents may be at increased likelihood of detecting PFAS, including detection at levels above regulatory thresholds. These disparities are concerning and warrant consideration when planning remediation and treatment for sites contaminated with PFAS.

56. Strategies and Best Practices to Communicate Fish Consumption Advisories and Associated Health Risks in the Lower Cape Fear River

Elizabeth Shapiro Garza, Duke University; Samuel Cohen, Duke University; Martin Dietz, Duke University; Chiara Klein, Duke University; Katie Taylor, Duke University; Steven Yang, Duke University; Mozghon Rajaee, Oakland University; Abigail Joyce, Duke University

The Lower Cape Fear River is a highly polluted waterway. The N.C. Department of Health and Human Services has issued fish consumption advisories for legacy pollutants such as mercury, other metals and PCBs, but not for the PFAS compounds that have been detected in the Cape Fear River and within the river's fish. While state advisories may be set for PFAS compounds in the future, there is an urgent need to communicate the potentially cumulative health risks from consuming these multiple contaminants in wild caught fish, particularly to more vulnerable populations.

Since 2016, the Duke University Superfund Research Center's Community Engagement Core has worked with community partners in the Lower Cape Fear River Basin to increase knowledge of current fish consumption advisories and to encourage safer choices when preparing and eating fish caught from the river. This coalition of community partners conducted research on fish consumption patterns and the most effective messaging and channels of communication to inform and elicit safer choices. Research included household and bankside surveys, focus groups and key actor interviews. The results were then used to inform the development of culturally appropriate materials and targeted outreach campaigns. Through this work we have also learned valuable lessons that can inform future efforts to communicate about risks of eating PFAS-contaminated fish.

We found that people are eating fish from the Lower Cape Fear River and that many are subsistence consumers who depend on wild caught fish as an affordable source of protein. In a survey of households in low-income neighborhoods, 44% ate fish from the river, 28% had children that received free or reduced-price lunches at school, and 19% received SNAP benefits. We also found that nearly 60% of bankside fishers are eating what they catch, and nearly half share with other people, including more vulnerable groups such as children and women of child-bearing age.

Our research also found that, because many people depend on wild caught fish as a food source and/or an important cultural and recreational activity, guidance discouraging eating any fish from the river will be ineffective. This indicates that messaging should instead encourage alternative behavior changes that can limit risk. In the survey of bankside fishers, half of respondents said they "definitely will not" stop eating fish from the river, but that they were willing to eat fewer large fish, filet fish, buy fish from a market, and try other actions that can reduce health risks.

Consistent with other research, we found that messaging is most effective when communicated through a combination of videos or graphics and simple text accessible to people of low literacy and with translations to the base languages of fish consumers. We also found that the most effective channels of communication include fish license offices, regulatory bulletins, bait and tackle shops, and trusted sources of nutritional education, such a public health departments and cooperative extension.

This research and the resulting outreach campaign have generated valuable lessons that can inform future strategies to communicate about the risks of eating PFAS-contaminated fish.

57. Official health communications are failing PFAS-contaminated communities

Alan Ducatman, West Virginia University; Jonas LaPier, Green Science Policy Institute; Rebecca Fuoco, Green Science Policy Institute; Jamie C. Dewitt, East Carolina University

Public health and environmental health agencies provide official, publicly available information about toxic chemicals. Accounting for the risk of needlessly alarming readers while helpfully providing useful information is known to be a difficult mission. Residents of the most heavily impacted communities and their healthcare providers rely on official agency webpages and fact sheets to understand risks and to weigh potential interventions. We reviewed official agency communications intended for the exposed population and for clinicians who care for them and summarized representative information. We also characterized evidence for a selected list of health outcomes associated with PFAS exposure, for comparison purposes. We found that official health communications rarely differentiate between high exposure communities such as those with contaminated water supplies or exposed workers, compared to the risks of PFAS contamination that affect humans worldwide. Most official health communications do not realistically distinguish levels of evidence for specific health outcomes and choose to present uncertainty as if it pertains equally to all outcomes. Common obfuscations that are hard for patients and clinicians to parse are “may” and “some studies” type statements that do not distinguish between the ample evidence for outcomes such as lipid, liver, and immune toxicity, versus differing levels of evidence for a wider range of outcomes. Few official health communications provide examples of useful interventions or helpful clinician-patient discussions and decisions in the face of prominent levels of internal PFAS contamination. For example, one health communication provides an example of two ways to dismiss or refute concerns of the exposed patient, without a parallel discussion of what can be done productively about decreasing risk. This document provides an example of deflecting concern by noting that the patient may have other risks for outcomes that can be caused by PFAS exposure. A limited number of communications provide useful templates for improved discussions and patient-clinician engagement. Populations with high PFAS exposure need health communications responsive to legitimate concerns about increased risk and reasonable desire to participate in risk reduction. Currently available health communications do not address the needs of this population. Common shortcomings include failure to consider the needs of high exposure populations, failure to distinguish levels of evidence combined with ambiguous statements about outcomes, statements about evidence that poorly represent the current scientific knowledge, and failure to even address the common reason for the patient visit, which is risk reduction. Bland “may cause” and “some studies” statements give the sponsoring agency the advantage of never being fully wrong and provide little assistance to patients or clinicians. We also note the public health inappropriateness of a focus on comorbid risk factors as a reason to dismiss legitimate concerns when a focus on sensitive populations and patient-clinician partnership would be expected and helpful. We focus on a small group of more useful public communications that provide useful templates for recrafting currently available public messages.

58. Research, Communication, & Engagement to Reduce Firefighter Exposure to Per- and Polyfluoroalkyl Substances

Ayesha Khan, Nantucket PFAS Action Group; Jaime Honkawa, Nantucket PFAS Action Group; Lydia Silber, Nantucket PFAS Action Group; Graham Peaslee, Notre Dame College; Ankita Bhattacharya, Michigan State University; Amulya Vankayalapati, Michigan State University; Courtney Carignan, Michigan State University

While it is understood that aqueous film forming foam (AFFF) is a source of occupational exposure to PFAS for firefighters, there is little awareness in the firefighter community and also concerns that firefighter turnout gear may be an additional exposure pathway. Therefore, we have developed materials to help educate firefighters about PFAS and ways to limit exposure to this toxic class of chemicals. We are also conducting research to better understand exposure from turnout gear and help firefighters pursue safer alternatives. Project partners include the Nantucket Fire Department, the Fall River Fire Department, the Hyannis Fire Department, Last Call Foundation, Community Action Works, Clean Water Action, and Public Employees for Environmental Responsibility. Our poster will share our educational materials for firefighters and translate current information about PFAS in turnout gear.

59. PFAS Stakeholder Engagement in North Carolina

Tatiana Proksch, Megan Franklin, Jethro SSengonzi, Savanna Smith; SciPolPack

Per- and polyfluoroalkyl substances (PFAS) are a large class of substances that contain at least one perfluoroalkyl moiety. These “forever chemicals” bioaccumulate in the environment and humans and have been linked to liver damage and immunodeficiency. A significant amount of research has gone into finding more about these health concerns, as well as using testing to track the spread of PFAS and comparing different classes of PFAS. Research is important to develop and publish minimal risk levels for PFAS using data from epidemiologic and toxicologic literature, however, this type of research takes time and cannot help humans who are currently at risk. The Science Policy Pack is a group of STEM graduate students at NC State that are in a unique position to connect students and members of the public to experts and policymakers who study PFAS. This poster will discuss the main stakeholders in North Carolina, primarily who they are, why they care, and what are they doing to help. We have spoken to several experts in academia, advocacy, and the government to better understand what needs to be done and how they can be helped. These discussions are important to facilitate communication between these entities to work towards their common goals.

60. PFAS Central: Sharing Notable PFAS News, Scientific Papers, Policy & Events

Seth Rojello Fernandez, Green Science Policy Institute; Anna Soehl, Green Science Policy Institute; Lydia Jahl, Green Science Policy Institute; Rebecca Fuoco, Green Science Policy Institute; Arlene Blum, Green Science Policy Institute and UC Berkeley

After decades of human exposure and harm, PFAS are finally in the spotlight. The past five years have seen an increase in research, media coverage, and political action on these forever chemicals. To better share this avalanche of new information, the Green Science Policy Institute partnered with the Social Science Environmental Health Research Institute at Northeastern University to create PFASCentral.org. PFAS Central is updated weekly with the latest curated news articles, peer-reviewed scientific articles, policy, events, job listings, and consumer information. PFAS Central is also home to the PFAS-Free Products list and the PFAS Data Hub. The PFAS-Free Products page, initiated in response to requests from members of PFAS-contaminated communities, maintains an up-to-date list of products without PFAS, including outdoor gear, apparel, shoes, cosmetics and personal care products, baby products, foodware, furniture, carpets and rugs, textiles, and more. The Data Hub contains links to over 75 databases from around the world. PFAS Central currently gets an average of 6,000 visitors per month and continues to grow. Please visit PFASCentral.org

61. Songbird Farm: A PFAS Impacted Farm

Adam Nordell

My name is Adam Nordell, my wife and I run an organic vegetable and grain farm called Songbird Farm in Unity, ME. After seven years living and farming on our land in Unity, we learned this past winter that our farm was impacted by historic sludge spreading. Private testing revealed severe contamination of our soil, drinking/irrigation water and blood serum. Most of our soils test between 250 and 450 ppb for the sum of six chemicals, most of which is PFOS. Our well tested at 8030 ppt for the sum of six, around 6000 ppt of which is PFOA. Our blood levels match and surpass the levels experienced by employees of Dupont and 3M. Some of our produce tested positive for the chemicals as well. Though the state and federal governments have so far failed to offer any regulation or guidance on acceptable levels of PFAS in produce, any detectable levels were incredibly distressing to us. We quickly shut down all production on our farm and informed our wholesale and retail customers what we knew, what we didn't know, and our plan to investigate whether our farm remained a safe and viable operation.

In some ways, the timing of our discovery was fortunate. Led by farmer Fred Stone, environmental non profit Defend Our Health and state senators Bill Pluecker and Stacey Brenner, Maine has spent the past two legislative sessions grappling with its sludge spreading history, and the impact of sludge on its agricultural soils, surface & ground water, wild fish and game. Building on this strong momentum shortly after our own discovery, we had the opportunity to testify on bills LD 1911 and 1875, which respectively seek to end sludge spreading on ag lands and clean up industrial and waste water treatment effluent spilling into our rivers. I believe our testimony and the media focus on our farm helped to build towards the strong and sometimes unanimous support the bills received on their way to getting signed this Spring.

Soon after our own discovery and public announcement, four other young farming families in our area discovered contamination issue in their own land and water. We were able to coordinate with these farms to push the policy conversation forward, organizing our voices in support of LD 1875 and 1911 and advocating for the creation of a safety net for impacted farmers and other impacted Maine residents. We held press meetings, had meetings with the non-profit community, with state legislators and Gov. Janet Mills. We organized with our farmer peers, customers and other supporters by phone, email and social media and helped mobilize significant vocal support for what became LD 2013 and provided an initial $60 million to deal with the many expensive impacts of PFAS on Maine farmland, domestic wells, and human health.

Our farm remains shut down. Since the passage of these three bills, I have been doing short term contract work helping the non-profit community with service outreach to PFAS impacted farms. It looks like I am about to sign on as an employee with Defend Our Health, helping organize with impacted communities in Maine to support the implementation of the three PFAS bills, and push for further support for dealing with the effects of these long lasting pollutants in our state.

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