PFAS as emerging unregulated contaminants

Jane Hoppin, ScD
NC State University
Per- and Polyfluoroalkyl Substances (PFAS)

Resistant to:
- Water
- Stains
- UV radiation

Used in consumer products since the 1950s:
- Surfactants, lubricants, adhesives
- Carpet, upholstery, clothing
- Car interiors
- Food packaging
- Nonstick cookware
- Cleaning products
- Personal care products
- Fire-fighting foam

Chemical Properties Lead to:
- Persistence and bioaccumulation
- Water solubility and water contamination
- Ubiquitous in indoor environment and blood
- Transport around globe in ocean currents and atmosphere
A Global Problem

Contamination Sites
EPA Tap Water Detection

Source: https://www.ewg.org/interactive-maps/2017_pfa/

Ronneby, Sweden 2013
Xu et al. 2021

Veneto Region, Italy 2013-7
Ingelido et al. 2020

>10,000 ng/L PFAS in drinking water
Two PFAS have been widely studied → “Legacy Compounds”

Perfluorooctanoic acid (PFOA / C8)

Common uses:
Goretex, Teflon

Perfluorooctane sulfonate (PFOS)

Common uses:
Firefighting, stain repellent
Guidance on PFAS Exposure, Testing, and Clinical Follow-Up

July 2022

https://www.nationalacademies.org/our-work/guidance-on-pfas-testing-and-health-outcomes
Health Effects of PFAS: Conclusions

Sufficient evidence of an association
• Decreased antibody response (in adults and children)
• Dyslipidemia (in adults and children)
• Decreased infant and fetal growth
• Increased risk of kidney cancer (in adults)

Limited suggestive evidence of an association
• Increased risk of breast cancer (in adults)
• Increased risk of testicular cancer (in adults)
• Liver enzyme alterations (in adults and children)
• Increased risk of pregnancy-induced hypertension (gestational hypertension and preeclampsia)
• Thyroid disease and dysfunction (in adults)
• Increased risk of ulcerative colitis (in adults)
Recommendation 5-3: Clinicians should use serum or plasma concentrations of the sum of PFAS* to inform clinical care of exposed patients, using the following guidelines for interpretation:

- Adverse health effects related to PFAS exposure are not expected at less than 2 nanograms per milliliter (ng/mL).
- There is a potential for adverse effects, especially in sensitive populations, between 2 and 20 ng/mL.
- There is an increased risk of adverse effects above 20 ng/mL.

*Simple additive sum of MeFOSAA, PFHxS, PFOA (linear and branched isomers), PFDA, PFUnDA, PFOS (linear and branched isomers), and PFNA in serum or plasma. Caution is warranted when using capillary blood measurements as levels may differ from serum or plasma levels.
GenX Exposure Study

Started in response to community concerns
Designed to answer the community questions:
  - What is GenX?
  - Is it in me?
  - Does it have health effects?

Partners
  - CHHE (NC State, ECU)
  - Cape Fear River Watch
  - New Hanover County Health Department
Cape Fear River Basin, North Carolina

- Deep River
- Haw River
- Wilmington
- Fayetteville
- Pittsboro

Largest watershed in NC
Supplies ~1.5M people with drinking water

 fluorochemical manufacturing

GenX Exposure Study
PFAS in River AND Drinking Water

Detlef Knappe, NCSU
Mark Strynar, USEPA
Andy Lindstrom, USEPA
Chemours: GenX polluting the Cape Fear since 1980

By Adam Wagner and Tim Buckland GateHouse Media

Wilmington-area officials demand answers, action during invitation-only meeting with company

WILMINGTON -- A former DuPont plant has been discharging an unregulated toxic chemical into the Cape Fear River since 1980, company officials revealed Thursday at a meeting with local and state officials.
GenX concentrations after fluorochemical manufacturer announced on 6/21/2017 that it stopped discharging GenX.
Responding to Community Concerns

People want to know:
- Am I exposed?
- Is the chemical in my body?
- What are the health effects?

Challenges at the time:
- What chemicals to look for?
- No analytical standards
- No half life information
- Little or no toxicology data
- No comparison populations
Study Design

Wilmington residents on Cape Fear Public Utility Authority water, ages 6 and older

344 total
44 provided samples 6 months apart
(Nov 2017, May 2018)

Collect blood and drinking water
Analyze for GenX and other PFAS
Analyzed for lipids, thyroid hormones, and comprehensive metabolic panel
Measured BMI

Report back results to community, individuals
PFAS Serum Results

We detected 7 PFAS in the blood of almost everyone in Wilmington

Three brand new PFAS
  - Nafion byproduct 2
  - PFO4DA
  - PFO5DoA
  - Also: PFO3DoA, NVHOS, Hydro-Eve

Legacy PFAS
  - PFOA
  - PFOS
  - PFNA
  - PFHxS

We did not detect GenX in anyone.

Kotlarz et al, Env Health Perspect 2020
Three long chain fluoroethers in Wilmington blood

1. Nafion byproduct 2 (99%)

2. PFO4DA (98%)

3. PFO5DoA (87%)
How much was found?

Blood concentration (ng/mL)

Nafion byproduct 2

PFO4DA
Elevated legacy PFAS in Wilmington

White is NHANES 2015-1016
Green is Wilmington 2017
Elevated body burden in Wilmington relative to US population

Median blood concentration (ng/mL)

Wilmington adults, 2017

∑20 PFAS (27.4 ng/mL)
∑10 fluoroethers (6.3 ng/mL or 23%)

US population, NHANES 2015-2016

∑8 PFAS (8.27 ng/mL)
Blood concentrations of fluoroethers decreased after six months

Median blood concentration for 44 participants (ng/mL)

Half life estimates (days)
- PFO4DA: ~120 days
- Nafion byproduct 2: ~300 days

Published half lives (days)
- PFHxA: 32 days
- PFHpA: 62 days
- PFOA: 840 days
- PFOS: 1241 days
If GenX is not in your blood, what does it mean?

GenX has a very short biological half-life (~3 days)
What we measure in the body represents recent exposure
It does not mean that there’s no risk from past exposures.

To understand long term health effects, we need to estimate past exposure using information on water levels, water consumption, for the 40 years that these chemicals were discharged to the river.
We looked for GenX, but we found

New PFAS in the blood of all Wilmington residents, 5-11 months after discharge to the river stopped

Residents in this community had elevated levels of all legacy PFAS
  Drinking water levels of PFOA predict this blood level.
  No information about what potential peak exposures levels might have been.

~25% of PFAS in blood was related to the new chemicals

We could not measure and quantify all new chemicals, so this is an underestimate.
PFAS levels in Cape Fear River water (ng/L) in 2015

Adapted from Zhang et al., ES&T Letters, 2019
Evaluating PFAS Exposure

Some PFAS are biologically persistent (legacy)
  Biomarkers are good integrated measures on long term exposure
  Half-life ranging from 2-7 years

Fluoroethers have short half lives
  3 days for GenX
  ~1 year for Nafion byproduct 2
  Biomarkers may be poor measures of long term exposure
  May need to reconstruct exposure history

All exposures happen together. Difficult to disentangle individual chemicals
Acknowledgements

GenX Study Team
   Jane Hoppin, Nadine Kotlarz, Detlef Knappe, Claire Critchley, Katy May, Michael Cuffney,
   Julia Kaplan, Dylan Wallis, Morgan Lennon, Rob Smart, Grace Campbell, Marisa
   Incremona, Adrien Wilkie, Charlie Reed, Gracie Miller

   David Collier, Suzanne Lea, Jamie DeWitt, Melissa Johnson
   Andy Lindstrom, Mark Strynar, Theresa Guillette, James McCord

Community Partners
   Kemp Burdette, Dana Sargent, Deborah Maxwell, Amanda Boomershine, Veronica Carter,
   Jonelle Kimborough, Phillip Tarte

Funders
   NIEHS, UNC Policy Collaboratory

Study participants, community volunteers, and everyone who has helped us
along the way