Emerging Per- and Polyfluoroalkyl Substances: The North Carolina Experience

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Outline

• Timeline of GenX response and scope of issue
• Public health responses
• Challenges and data gaps
• Ongoing and future activities
Wilmington, North Carolina
Timeline of Response to GenX in Drinking Water

• June 2017
  – News coverage brings GenX to the forefront
  – N.C. DHHS contacted by local health departments
What is GenX?

• Replacement chemical for PFOA
• Perfluoroalkyl Ether Carboxylic Acid (PFECA)
• Manufactured since 2009
• Byproduct of other manufacturing processes since ~1980
Scope of Problem – Surface water sourced public water

- Hundreds of thousands public water customers affected by GenX and other PFAS in Cape Fear River

Sun et al 2016
Timeline of Response to GenX in Drinking Water

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  − N.C. DHHS issues initial drinking water assessment
  − Chemours stops discharge of GenX to Cape Fear River

• July 2017
  − N.C. DHHS updates assessment and issues a provisional health goal of 140 ng/L (ppt)

• August 2017
  − GenX detected in monitoring wells on-site

• September 2017
  − Private well sampling near the facility begins
Scope of Problem – Groundwater sourced private wells

- Hundreds of parcels with private wells near the facility potentially impacted by GenX and other PFAS

- Phase 1 & 2 GenX results
  - **Blue**: ND
  - **Green**: 11-100 ng/L
  - **Yellow**: 101-140 ng/L
  - **Orange**: 141-420 ng/L
  - **Red**: >420 ng/L
Scope of Problem – Groundwater sourced private wells

- Sampling will continue until full extent of contamination is determined
  - Dark blue: phase 1
  - Orange: phase 2
  - Light blue/yellow: phase 3
  - Fuchsia: phase 4
Scope of Problem – Other Compounds

(a) Raw water
Pre-ozone effluent
Settled water
Settled-ozone effluent
BAC effluent
Finished water

Concentration of traditional PFASs at a WTP in Community C (ng/L)

- PFPPrPrA
- PFBA
- PFPeA
- PFHxA
- PFHpA
- PFOA
- PFNA
- PFDA
- PFBS
- PFHS
- PFOS

Sun et al 2016
Scope of Problem – Other Compounds

Sun et al 2016
PFAS Associated with the Cape Fear River (1 of 2)

Monoether PFECAs
Strynar et al., 2015

PFMOAA
CAS: 876-15-3

Precursor-Acyl Fluoride

Vinyl Ether

PFMODh
CAS: 977-76-7

PEPA
CAS: 19739-98-2

PEVE
CAS: 13482-42-2

Structural Isomer

PFECA-Fi
CAS: 88989-09-5

PMVE
CAS: 13987-98-6

PMVE
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Precursor-Acyl Fluoride

Vinyl Ether

PFECA-A
CAS: 88989-09-5

PFDi
CAS: 19739-98-2

PFVE
CAS: 13482-42-2

Related Substance

HFP-DA ammonium salt
CAS: 50037-00-5

HFP-DA
CAS: 9232-20-5

PPVE
CAS: 28124-04-8

Structural Isomer

PFECA-C
CAS: 50033-38-8

HFPO-DA
CAS: 12352-21-9

HFPODAF
CAS: 13580-00-6

Strynar et al., 2015
# PFAS Associated with the Cape Fear River (2 of 2)

<table>
<thead>
<tr>
<th>Polyether PFECAs</th>
<th>PFESAs</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strynar et al., 2015</strong></td>
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</tr>
<tr>
<td><img src="image1" alt="PFOS1h-A" /></td>
<td><img src="image2" alt="PFESA BP1" /></td>
</tr>
<tr>
<td><img src="image3" alt="PFOS2h-A-F" /></td>
<td><img src="image4" alt="PFESA NP2" /></td>
</tr>
<tr>
<td><img src="image5" alt="PFOS3A" /></td>
<td><img src="image6" alt="PFESA BP3" /></td>
</tr>
<tr>
<td><img src="image7" alt="PFOS3A-F" /></td>
<td><img src="image8" alt="PFESA NP1" /></td>
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<tr>
<td><img src="image9" alt="PFOS4A" /></td>
<td><img src="image10" alt="PFESA BP2" /></td>
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<tr>
<td><img src="image11" alt="PFOS4A-F" /></td>
<td><img src="image12" alt="PFESA NP2" /></td>
</tr>
<tr>
<td><img src="image13" alt="PFOS5DA" /></td>
<td><img src="image14" alt="PFESA BP4" /></td>
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<tr>
<td><img src="image15" alt="PFOS5DA-F" /></td>
<td><img src="image16" alt="PFESA NP3" /></td>
</tr>
</tbody>
</table>

## Other

- **McCord and Strynar, 2018**

- ![HFPO](image17)
- ![Hydro EVE](image18)
- ![NVHOS](image19)
- ![HFPO-DA de carbonyl](image20)
- ![HFPO-TA de carbonyl](image21)
- ![E1](image22)
- ![E2](image23)

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*Strynar et al., 2015; McCord and Strynar, 2018*
PFAS Levels: Before and After Discharge Stopped
Public Health Role – Drinking Water

• For private drinking water wells, PH provides
  − Information about the contaminant
  − Recommendations for use or treatment options
  − Recommendations for repeat sampling

• Guidance on public water supplies provided if requested from DEQ or local authorities
  − Assistance with health risk evaluations, use recommendations
Usual Sources for Health-Based Guidance

1. National regulatory standards (EPA)
2. State Standards (DEQ/Environmental Management Commission)
3. National health advisories or other health values (EPA, CDC)
4. Other governmental guidance
   - Standards from other states or countries
   - World Health Organization, European Union values
5. If guidance not available from 1–4, can consider establishing state-specific health goal
What is a Health Goal?

- Level of contamination below which no adverse health effects would be expected over a lifetime of exposure
- Calculated based on the most vulnerable population
- Non-regulatory, non-enforceable
- Change as new information becomes available
Health Goal: Data Types and Requirements

• Must have sufficient health-related information
  – Animal studies *(required)*
  – Epidemiologic studies
  – Other laboratory studies

• Some health-related information not in public domain

• Health-related information often lacking for emerging compounds
### Repeated Oral Dose Studies ≥28 Days Submitted by Registrant

<table>
<thead>
<tr>
<th>Study</th>
<th>Lowest NOAEL (mg/kg/day)</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>28-day study in rats</td>
<td>30 (male)</td>
<td>Highest dose tested</td>
</tr>
<tr>
<td>28-day study in mice</td>
<td>0.1 (male)</td>
<td>Adverse effects in the liver</td>
</tr>
<tr>
<td>90-day study in rats</td>
<td>10 (male)</td>
<td>Regenerative anemia</td>
</tr>
<tr>
<td>90-day study in mice</td>
<td>0.5 (both sexes)</td>
<td>Indicators of liver toxicity</td>
</tr>
<tr>
<td>Chronic toxicity / oncogenicity study in rats (2 years)</td>
<td>1 (male)</td>
<td>Adverse effects in the liver; increases in certain tumors</td>
</tr>
<tr>
<td>Reproduction / Developmental screen in mice</td>
<td>0.1 (F0 male) 0.5 (offspring)</td>
<td>Adverse effects in the liver; body weight decreases in offspring</td>
</tr>
<tr>
<td>Prenatal and Developmental study in rats</td>
<td>10 (maternal and fetal)</td>
<td>Early delivery and lower fetal weights</td>
</tr>
</tbody>
</table>
GenX Provisional Drinking Water Health Goal: 140ppt

- Recommend not using well water for drinking, cooking, or preparing baby formula if exceeds 140ppt
- Can continue to use well water for bathing, washing dishes and laundry
  - Per CDC, only a very small amount can get into the body through the skin
  - Little exposure expected during swimming, bathing, or showering
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• October 2017
  – External Science Advisory Board begins review of health goal

• October 2018
  – Board approves current health goal

• November 2018
  – EPA draft RfD released
Other Public Health Actions

Summary of Selected Cancer Rates for Bladen, Brunswick, New Hanover and Pender Counties, 1996–2015, and Comparison to Statewide Rates

Background and Summary
This summary was prepared to answer questions about cancer rates in four counties that have arisen during the ongoing investigation of GenX and other PFAS. The primary purpose of this summary is to provide information about causes and potential associations, which will be further explored and conclusions can be drawn about the information described here.

Bladen, Brunswick, Cumberland, New Hanover and Pender Counties and North Carolina

Summary

What is the purpose of this report?

Biological sampling for GenX and other Per- and Polyfluoroalkyl Substances (PFAS)—North Carolina, 2018

Summary

What is the purpose of this report?

This report presents results of an investigation conducted to improve understanding of exposure to GenX and other PFAS among people living near a manufacturing facility in Bladen County, NC. It describes concentrations of 17 PFAS in the blood and urine of 30 people with evidence of exposure to GenX through their private drinking water wells.
NC PFAS Biomonitoring Project

• 30 residents
  – NC DEQ well testing list
  – Highest GenX concentrations
  – Up to 2 people per house—one adult, one child

• Measured 17 PFAS in blood and urine

<table>
<thead>
<tr>
<th>PFAS Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>GenX</td>
<td>PFHxS</td>
</tr>
<tr>
<td>PFBS</td>
<td>n-PFOA</td>
</tr>
<tr>
<td>PFHxA</td>
<td>Sb-PFOA</td>
</tr>
<tr>
<td>PFBA</td>
<td>PFDA</td>
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<tr>
<td>PFHpA</td>
<td>PFUnDA</td>
</tr>
<tr>
<td>PFPeA</td>
<td>Sm-PFOS</td>
</tr>
<tr>
<td>ADONA</td>
<td>n-PFOS</td>
</tr>
<tr>
<td>9Cl-PF3ONS</td>
<td>PFNA</td>
</tr>
<tr>
<td>MeFOSAA</td>
<td></td>
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</tbody>
</table>
NC PFAS Biomonitoring Project: Results

- GenX and 7 other PFAS not detected
- Nine other PFAS detected in at least one participant
  - PFHpA, MeFOSAA, PFHxS, n-PFOA, PFDA, PFUnDA, Sm-PFOS, n-PFOS, PFNA
- Four PFAS detected in all participants
  - PFHxS, n-PFOA, Sm-PFOS, n-PFOS
- Median levels of PFHxS and n-PFOS higher than US population
NC PFAS Biomonitoring Project Results (cont.)

![Bar chart comparing NC Median to NHANES 2013-14 Median for n-PFOS and PFHxS.]

- **n-PFOS**: NC Median is significantly higher than NHANES 2013-14 Median.
- **PFHxS**: NC Median is slightly above NHANES 2013-14 Median.
NC PFAS Biomonitoring: Conclusions

- Most PFAS not detected (including GenX) or detected at levels similar to US population
  - May indicate GenX doesn’t stay in body long

- Two legacy PFAS median levels higher than US population
  - Long half-lives
  - Unclear if ongoing or past exposure
NC State University GenX Exposure Study: Wilmington

- 345 participants (56 children)
  - 310 enrolled in November 2017
  - 35 enrolled in May 2018

- Collected tap water, blood and urine
  - 44 participants gave two blood samples
  - Measured 23 PFAS in blood

https://chhe.research.ncsu.edu/the-genx-exposure-study/
NC State University GenX Exposure Study: Wilmington

• GenX was NOT detected in blood

• Found four “new” PFAS in blood
  – Nafion byproduct 2 (99% of samples)
  – PFO4DA (98%)
  – PF05DoDA (87%)
  – Hydro-EVE (76%)

• Levels decreased after six months

• Levels of historically-used PFAS higher in Wilmington than United States

https://chhe.research.ncsu.edu/the-genx-exposure-study/
NC State University GenX Exposure Study: Wilmington

Median blood concentration (parts per billion)

- PFOS
- PFOA
- PFHxS
- PFNA
- PFDA

Comparison between Wilmington and US.
Challenges/Knowledge Gaps

• Traditional toxicology approach may not be suitable
  – Thousands of PFAS
  – Health effects unknown for many emerging PFAS

• Risk from exposure to PFAS mixtures unknown

• Limited information about other exposure routes
  – Food, household exposures

• Limited information about treatment/removal technologies
Ongoing DHHS Activities and Next Steps

• Review new and ongoing environmental testing results
• Provide communities with information and assist with outreach and health education
• Conducting community survey around facility to identify new or ongoing health concerns
• Ongoing coordination with CDC, EPA, and NIEHS to review new and updated health and toxicology information
Questions?