Understanding sources, management, and impact of Endocrine Disrupting Compounds (EDCs) in the Potomac

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WEF Fellow, IWA Fellow
Manager, Research and Laboratory
DC Water
Outline

• Background/ Context
• What are the typical estrogenic compounds in wastewater?
• What are the treatment impacts?
• Where do we go from here?
General Information

- 370 mgd ADF
- 1,076 mgd Peak
- CSO Flows
- 2 Million Customers
- 725 sq mile Service Area
Evidence of Reproductive Disruption in Fish Downstream WWTP Discharges

1. Sex Ratio: skewed toward females downstream of WWTP Discharges

2. Vitellogenin (estrogen-dependent female yolk protein) elevated in males downstream of WWTP.

3. USGS have conducted research in the Potomac Fish but no causal link to Blue Plains
“The proximity to wastewater treatment plants may influence the reproductive health of bass in the Potomac watershed, but inputs from other sources likely contribute to the widespread, high incidence of testicular oocytes”.

“The Potomac River in Washington, D.C. is showing multiple benefits from restoration efforts. Reduced nutrients and improved water clarity have increased the abundance and diversity of submerged aquatic vegetation (SAV) in the Potomac, according to direct measurements taken during the 18-year field study”.

Long-term reductions in anthropogenic nutrients link to improvements in Chesapeake Bay habitat
PNAS. 107, 16566-16570.
Wastewater study and testing:

-the Authority shall initiate a study that tests for the presence of endocrine disruptor compounds in wastewater effluent

-the Authority shall present the findings of the study to an advisory Panel, the General Manager, the Mayor, and the Council within 30 days of the study’s completion

-this section shall be subjection to appropriation
• Natural estrogens- estrone (E1) and estradiol (E2)

• Synthetic estrogen- Ethinylestradiol (EE2)

• Alkylphenol Ethoxylate Degradation Products (Octylphenol/Nonylphenol)
Major Estrogenic Compounds

- Ethinyl Estradiol (Synthetic Hormone)
- Estradiol (Natural Hormone)
- Nonylphenol Isomer
Metabolites of Nonylphenol Ethoxylates (from Ahel et al., 1994; Naylor, 1992)

NP ethoxylate
\[ \text{C}_9\text{H}_{19} \] \( \text{(OCH}_2\text{CH}_2 \text{)}_n\text{OH} \)

NP2EO
\[ \text{C}_9\text{H}_{19} \] \( \text{OCH}_2\text{CH}_2\text{OCH}_2\text{CH}_2\text{OH} \)

NP1EO
\[ \text{C}_9\text{H}_{19} \] \( \text{OCH}_2\text{CH}_2\text{OH} \)

NP
\[ \text{C}_9\text{H}_{19} \] \( \text{OH} \)
Bans and Restrictions on Use of NPE in European Union and Canada
Yeast Estrogen Screen

- Estrogenic Compound
- Plasmid
- hER
- Nucleus
- Cytoplasm
- CPRG
- B-galactosidase
- Estrogen Response Element
- Promoter
- Lac-Z
- Plasmid Details

Routledge and Sumpter, 1996
## YES Standards Data

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$^1$ Eeq data courtesy of Dr. Benjamin Stanford, Hazen and Sawyer (Data originally published in 2007).
Graphic courtesy of Hazen and Sawyer.
Blue Plains AWTP

- 370 mgd (AA) to 518 mgd (Max Day)
- TN < 7.5 mg/l & TP < 0.18 mg/l
- Future TN ~ 3 mg/l peak annual flows
- 12°C winter monthly average
### YES Assay

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<th>Nitrification Effluent</th>
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*expressed as 17β-estradiol equivalent
YES Assay

Filtrate through 1 kD
Filtrate through 30 kD
Filtrate through 0.45 um
Filtrate through 1.5 um
Unfiltered primary effluent

*Primary Treatment Effluent of 4 plants
EPA recommended water quality criterion for nonylphenol.

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CCC- Criterion Continuous Concentration- Chronic
CMC- Criterion Maximum Concentration- Acute
Nonylphenol


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<th>Influent</th>
<th>Nonylphenol</th>
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### Effluent

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NPE= Nonylphenol Ethoxylates- 0-5 Ethoxylates

What do we know about these compounds?

• They like to attach to solids
• They can be degraded or altered to reduce estrogenic effects
  – Mechanisms for degradation are a topic of intense scrutiny
Preliminary work indicates;

• Estrogenic Activity can be removed by processes that separate solids
  – Estrogenic activity associates with solids

• Estrogenic activity can be degraded in ENR process
  – Higher SRTs and longer detention times have been linked to removal

• It can accumulate in the solids treatment processes
• We plan to continue our collaboration on this work and stay informed
The Proposal Team

- Erik Rosenfeldt has over 10 years of EDC/PPCP occurrence and treatment experience. He is a principal engineer at Hazen and Sawyer, an Industry Leader in Emerging Contaminants Applied Research.

- Luke Iwanowicz, USGS is a fish health scientist with expertise in the fields of virology, molecular biology, immunology, endocrine physiology, endocrine disruption and environmental health monitoring.

- Clifford Rice, USDA is a scientist at the Animal and Natural Resources Institute, Agricultural Research Service and specializes in the detection of trace organic chemicals in the environment.

- Sujay Kaushal, UMD focuses on understanding the interactive effects of land use on ecosystem ecology.

- Sudhir Murthy, DC Water is Manager, Research and Laboratory and leads technology development associated with $1 billion Blue Plains CIP.