Removal of PFAS from drinking water by reverse osmosis membranes, residential filters, and a novel resin

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NORTH CAROLINA PFAS Testing Network

NC PFAS Testing (PFAST) Network, a research program funded by the NC Policy Collaboratory

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Membrane treatment

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Ion exchange treatment
Electrochemical treatment

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Activated carbon treatment

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Novel resin treatment

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Home filter treatment

PFAS removal by membrane filtration

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http://lanxess.co.za/

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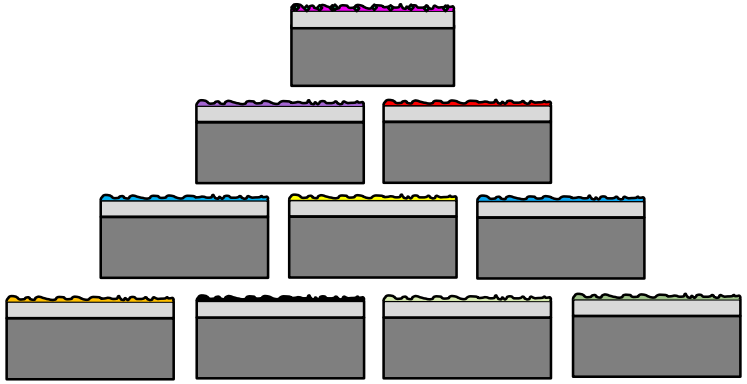
Motivation: The quantity and scope of studies evaluating PFAS rejection by high-pressure membranes is limited

Experimental design

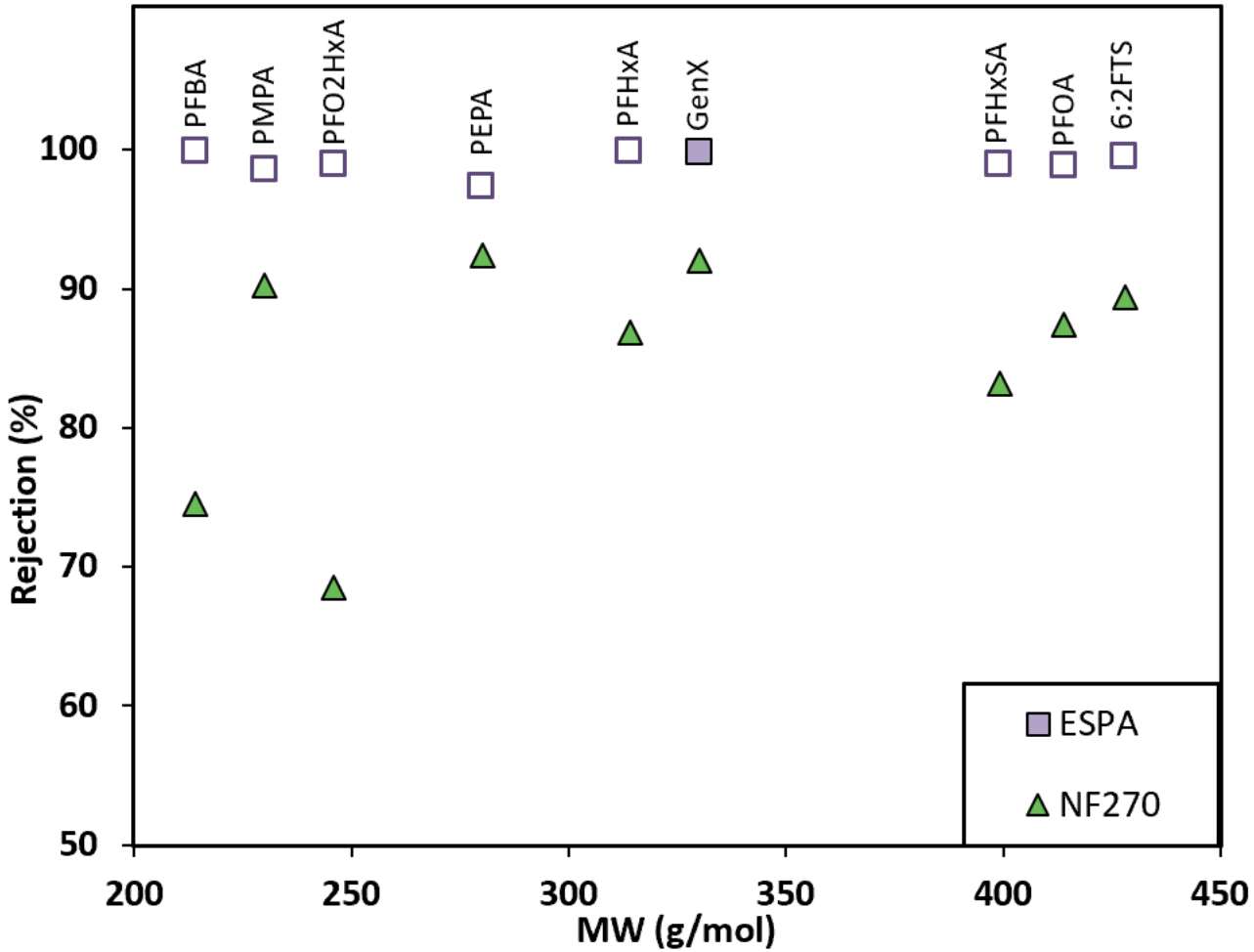
Broad range of PFASs

Broad range of high-pressure membranes



Various water matrices

RO membranes consistently showed >90% PFAS removal
NF membranes showed often <90% PFAS removal



Residential reverse osmosis membranes

- Residential membranes performed as well as reverse osmosis membranes marketed for community/municipal water treatment
- Residential membranes showed PFAS removals greater than 97% for most PFAS species (e.g., PFBA, PMPA, PFO2HxA, PEPA, PFHxA, GenX, PFHxSA, PFOA, 6:2FTS)
- Changing the pressure of the feed water did not substantially impact the level of PFAS rejection by residential membranes

Ionic fluorogel resins for PFAS removal from water

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Orlando Coronell[2], Frank Leibfarth[1]

Ionic Fluorogels made in our lab

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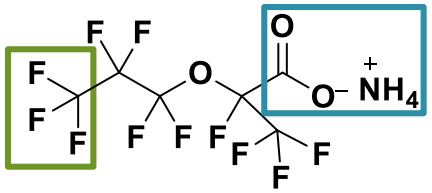
Motivation: More effective resins (i.e., capacity and kinetics) are needed for the removal of PFAS from water

Ionic Fluorogel (IF) resins for PFAS remediation

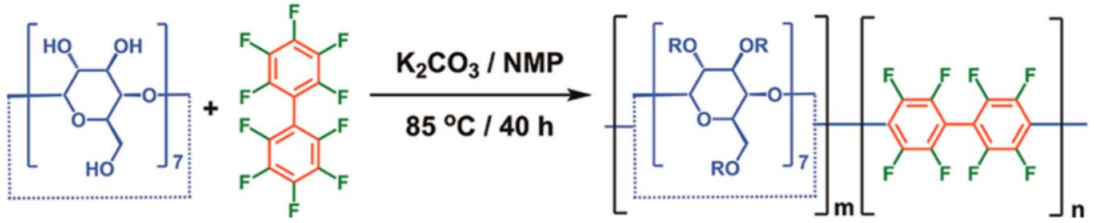
Existing commercial materials do not adequately remove emerging, short-chain PFAS from water.
We identified two approaches to create a synergistic PFAS removal strategy.



GenX

Fluorophilicity

- Allows separation of fluorous-tagged compounds from complex media
- Has been shown to aid in PFOA sorption

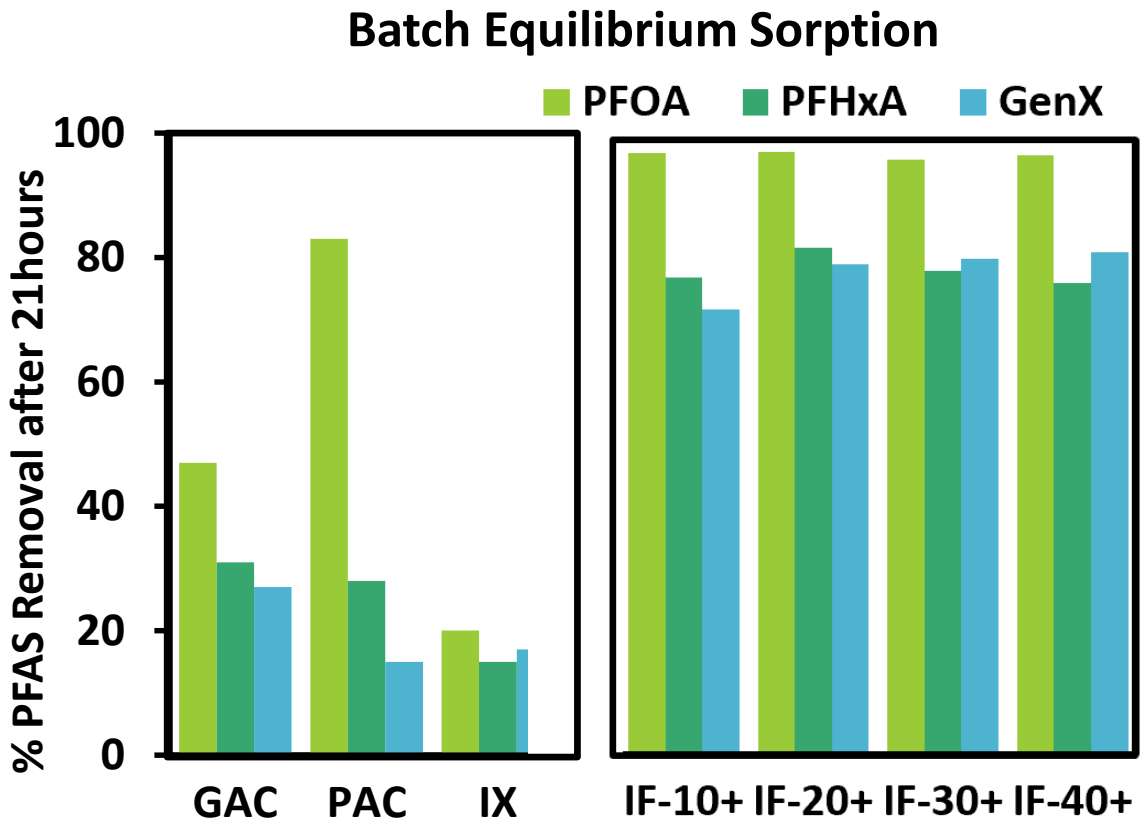


Ion Exchange

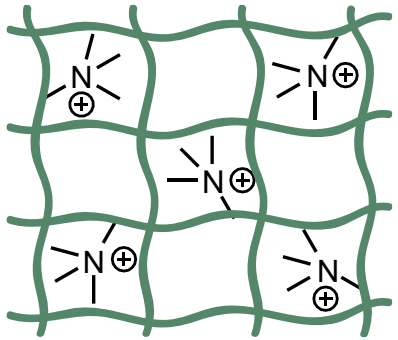
- State-of-the-art resin technology
- Relies on exchange of carboxylate group with a cationic resin (crosslinked polystyrene)
- Limited success for short-chain PFAS

Xiao et. al, *J. Am. Chem. Soc.* **2017**, *139*, 7680–7692.

IF resins show a higher affinity for PFAS than commercial technologies



GAC: Filtrasorb 400,
PAC: Picahydro MP23
IX: PFA 694E

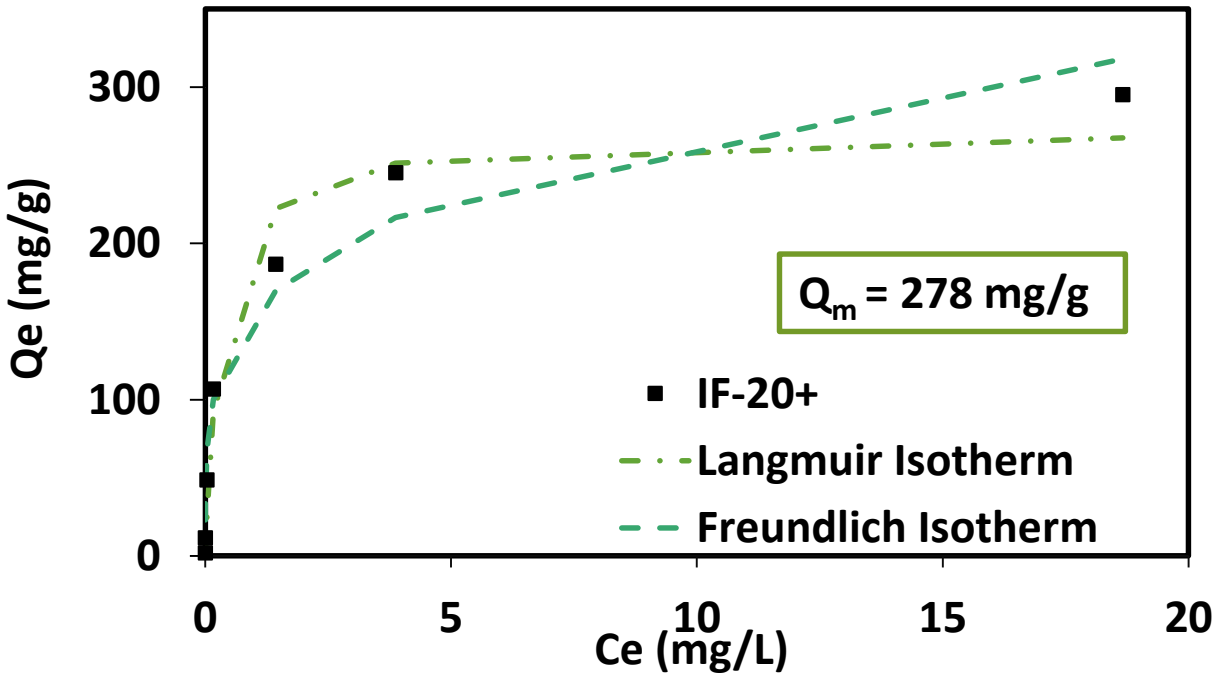


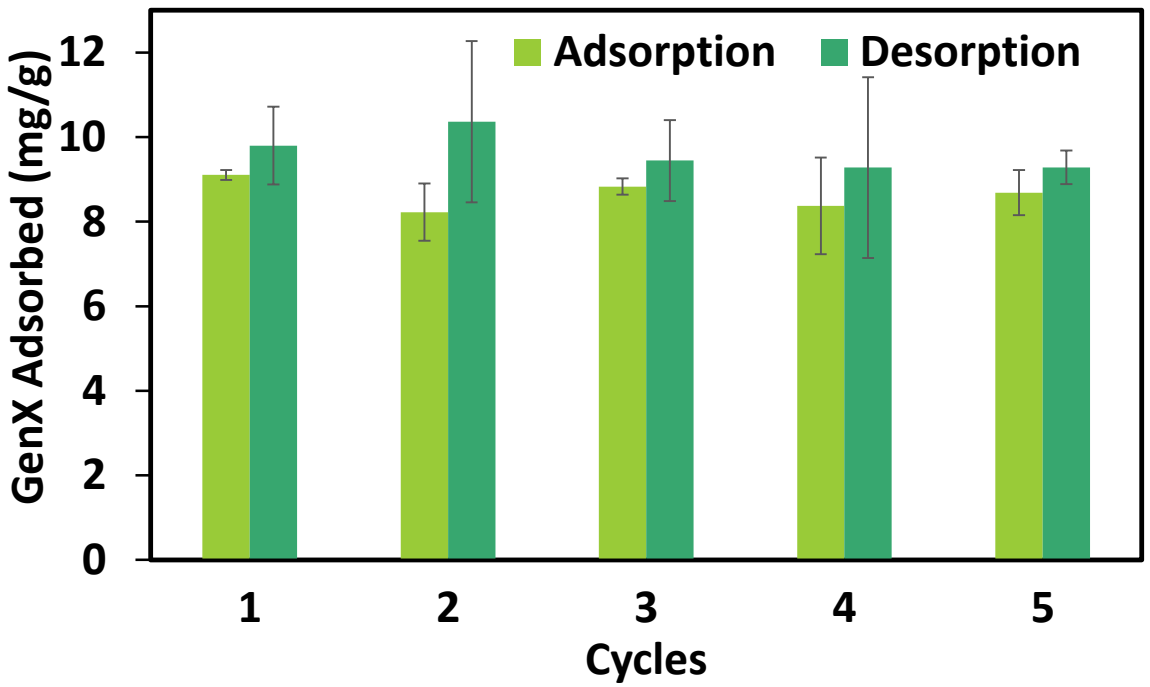
IF-X+

[Resin] = 10 mg/L
$[PFAS]_0$ = 1 μg/L
[NaCl] = 200 mg/L
[Humic Acid] = 20 mg/L
Equilibration time = 21 hours

E. Kumarasamy *et al.*, *ChemRxiv.* **2019**, doi: 10.26434/chemrxiv.10046576.v1

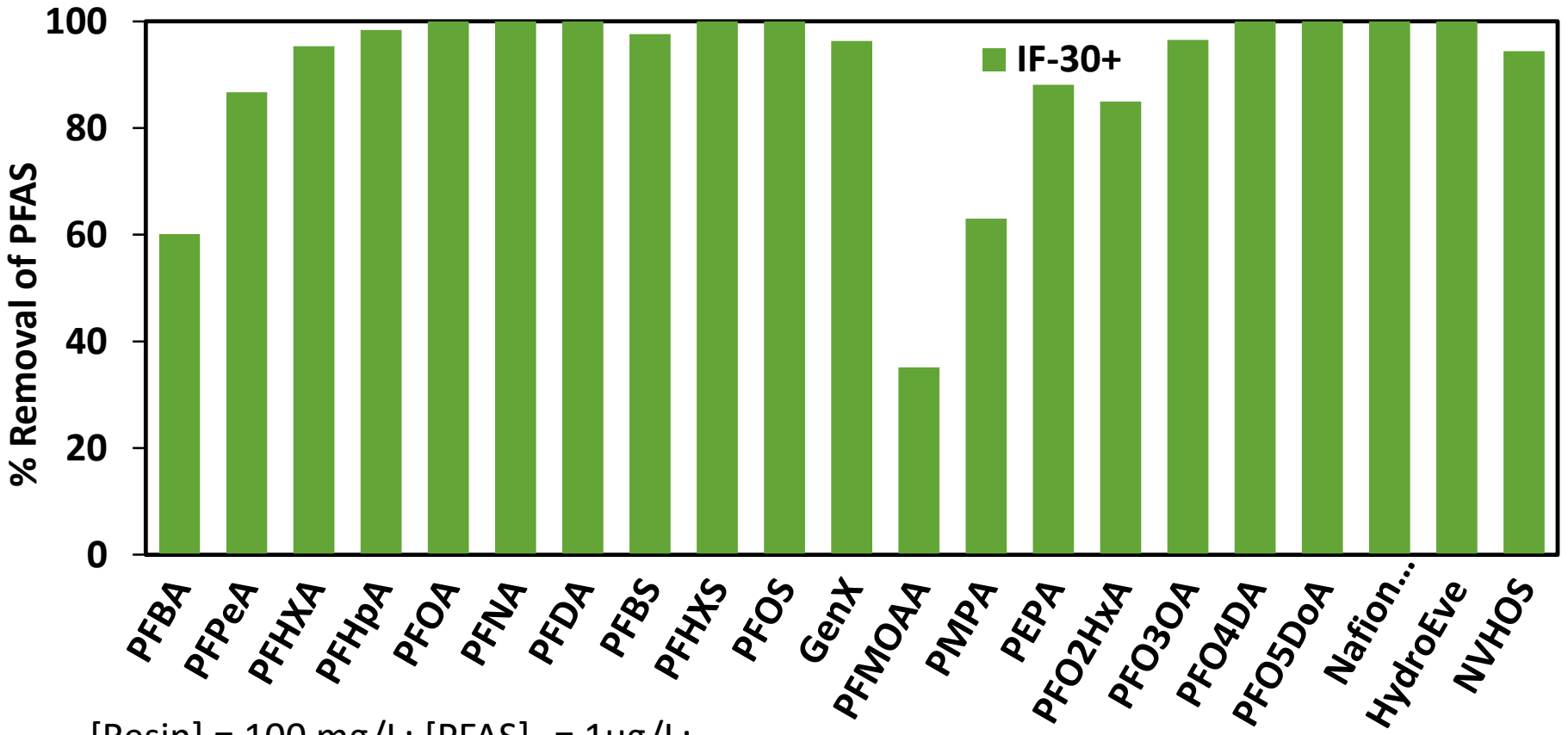
IF resin has high GenX binding capacity and is amenable to regeneration





E. Kumarasamy *et al.*, *ChemRxiv.* **2019**, doi: 10.26434/chemrxiv.10046576.v1

IF resin demonstrated high removal of 21 PFAS from settled surface water



[Resin] = 100 mg/L; $[PFAS]_0$ = 1ug/L;
Equilibration time = 2 hours

E. Kumarasamy *et al.*, *ChemRxiv.* **2019**, doi: 10.26434/chemrxiv.10046576.v1

PFAS removal by point-of-use residential water filters

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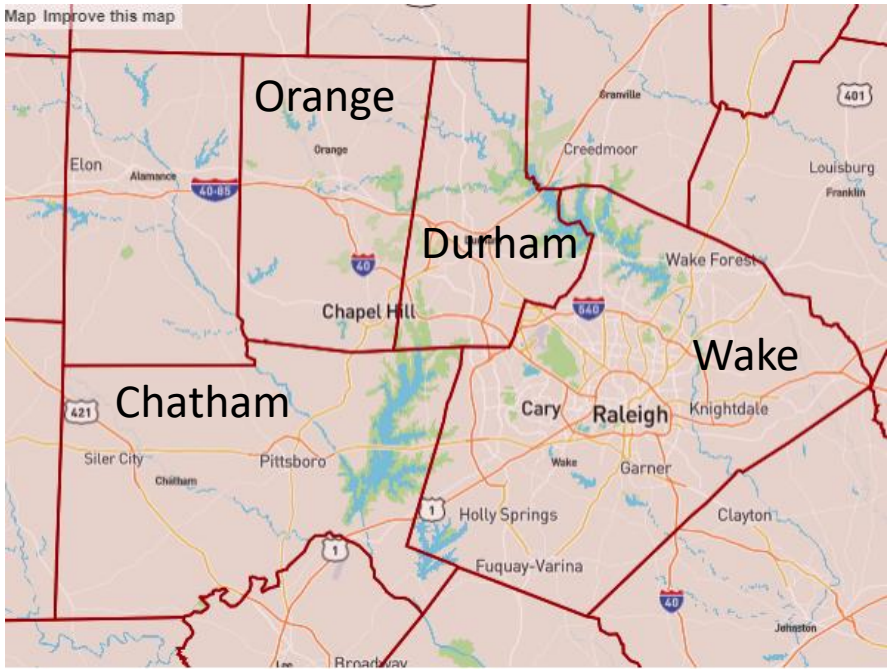
Motivation: The quantity and scope of studies evaluating PFAS rejection by POU residential water filters is limited

Herkert et al. under review

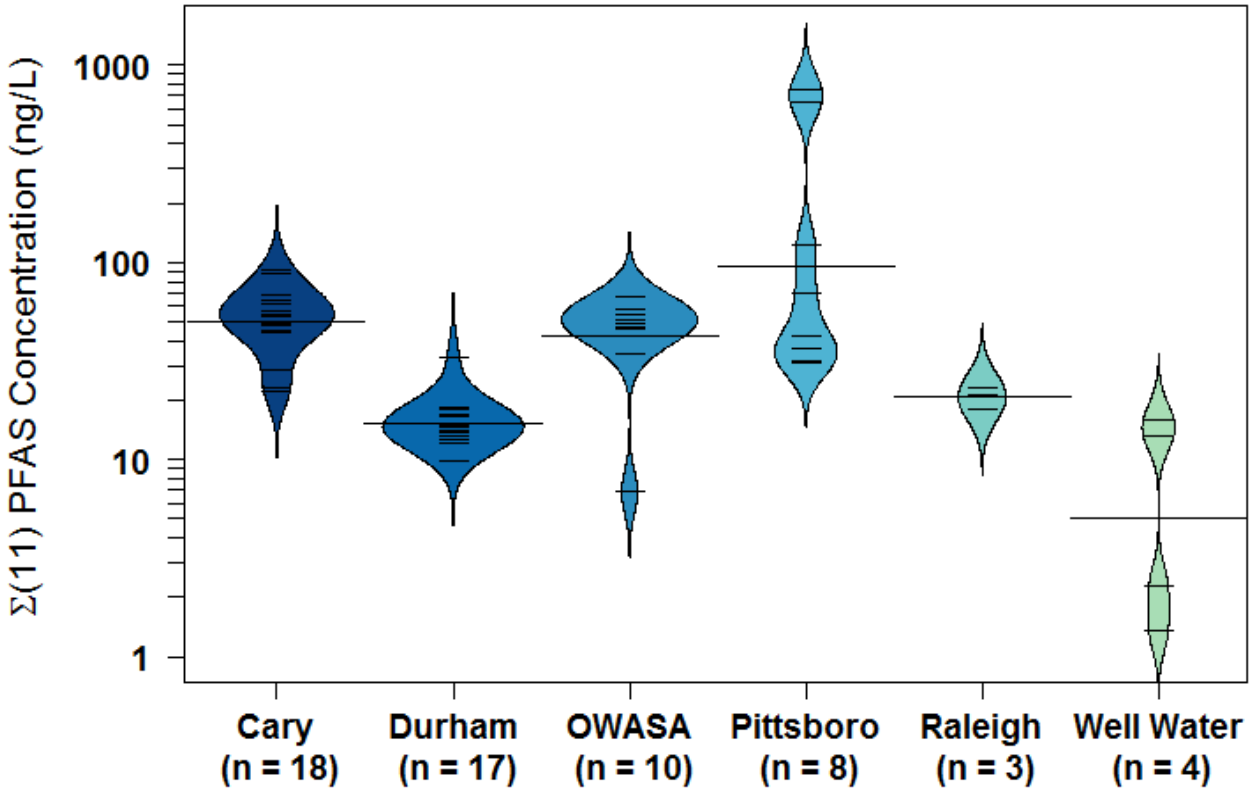
Experimental design

- **Participants:** Interested homeowner residing in Chatham, Durham, Orange and Wake counties
- **Samples Collected:**
  - A 1L water sample from a faucet in the home with no in-line filtration
  - A 1 L water sample will be collected from the owner's source of filtered water
  - A written survey to collect information on home's water source and drinking water habits
- **Samples Analysis:** Analyzed for a suite of 11 perfluorinated chemicals (PFCs)



Herkert et al. under review

PFAS concentrations in sampled areas



Source water concentrations for different water utilities. On average the ∑(11) PFAS across all water utilities was 62 ng L^{-1} and ranged from 7 ng L^{-1} to 729 ng L^{-1}.

Herkert et al. under review

PFAS removal via POU Filters

- All reverse osmosis and dual-stage filters had near complete PFAS removal.
- Activated Carbon based filters demonstrated much greater variability across our study.
  - Single stage under-sink filters (n=5) removed a majority of PFSAs (% removal > 84%) but only removed half of PFCAs.
  - Both refrigerator (R) and pitcher (P) filter showed increased removal efficiency for long-chain PFAAs (61% for P & 65% for R) compared to short-chain PFAAs (46% for P & 47% for R).
  - Whole house POE system were largely ineffective and 4 of 6 POE systems showed increase in concentration after filtration.

Refrigerator Filter

Pitcher Filter

Reverse osmosis

Herkert et al. under review

PFAS removal correlated well with chain length

- Long-chain PFAS compounds we removed more efficiently than short-chain PFAS compounds.
- Statistically significant (p-value < 0.05) positive correlation between average percent removal by AC filters and chain length for **PFCAs**
- Suggestive correlation between average percent removal by AC filters and chain length for **PFSAs**, though not statistically significant.

Refrigerator Filter

Pitcher Filter

Herkert et al. under review