Effectiveness of municipal-scale and home filters for PFAS removal

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3rd National PFAS Conference, Wilmington, NC, June 17, 2022

Granular Activated Carbon

GAC filters can remove longer-chain PFAS for a longer time than shorter-chain PFAS

Data from CFPUA pilot study
Empty bed contact time: 20 min
GAC: Calgon F400

PFMOAA

PFO2HxA

Nafion
BP2

Fraction of influent PFAS concentration
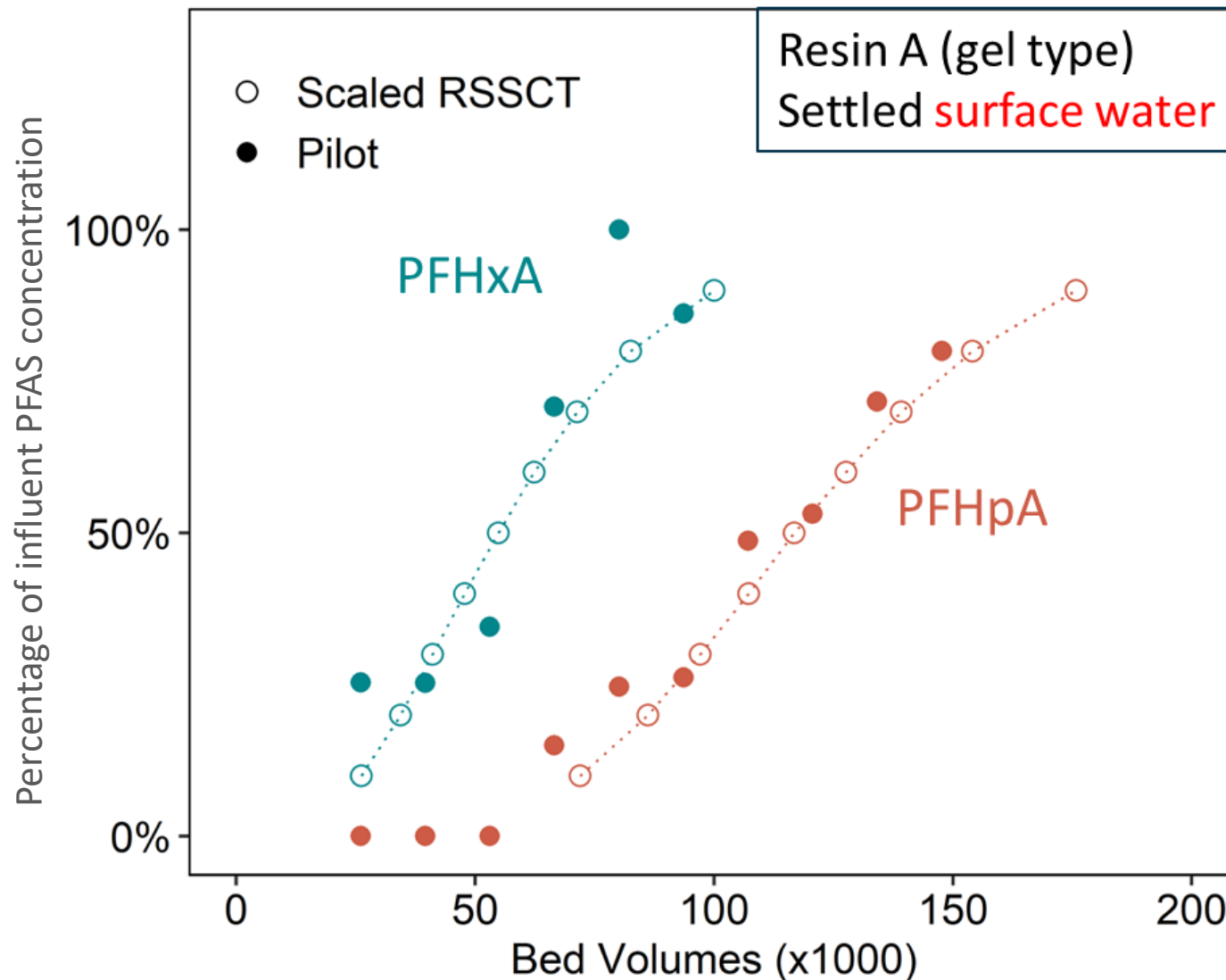
Bed Volumes
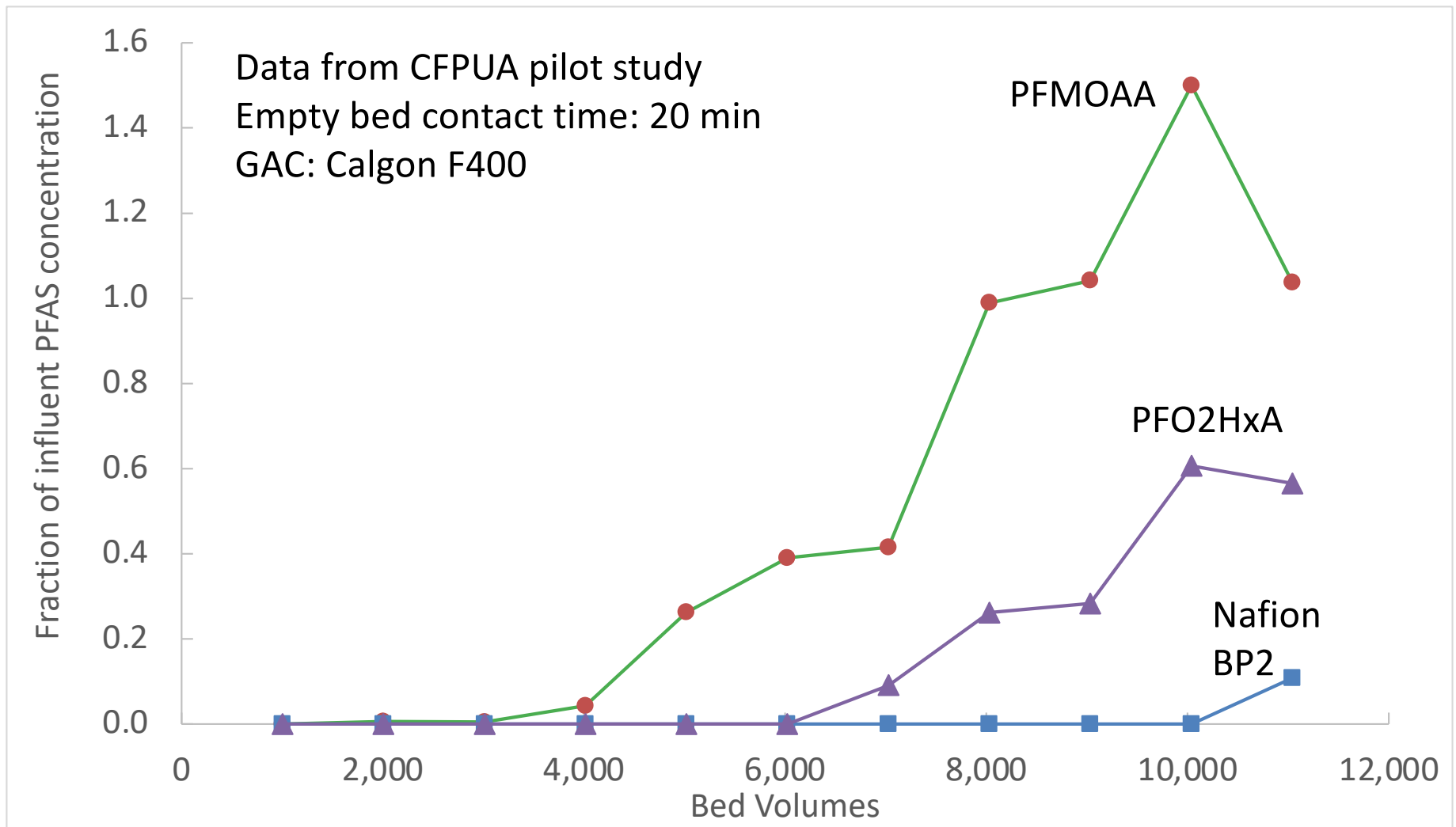
Ion Exchange
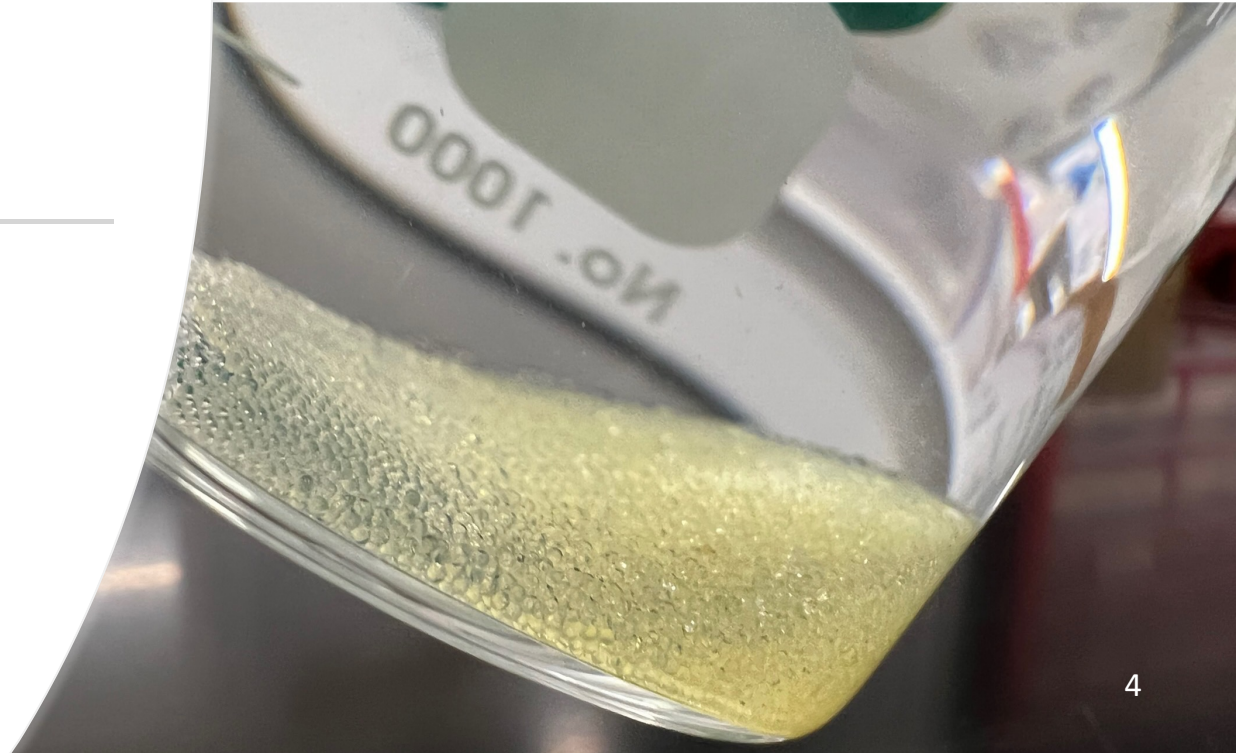
IX filters can remove longer-chain PFAS for a longer time than shorter-chain PFAS

High-Pressure Membranes

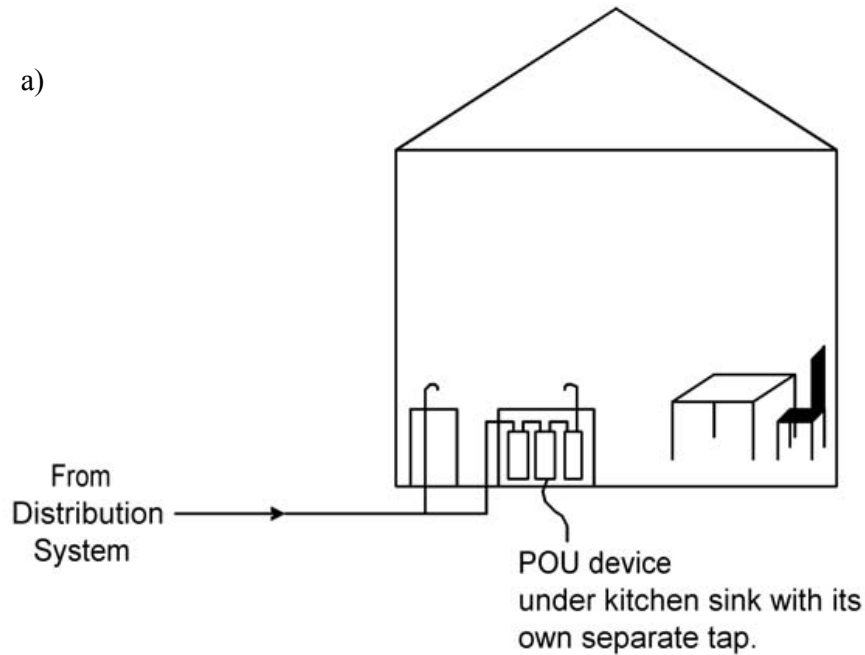# Reverse osmosis and tight nanofiltration membranes effectively filter out PFAS

Data from Christopher Bellona, Colorado School of Mines
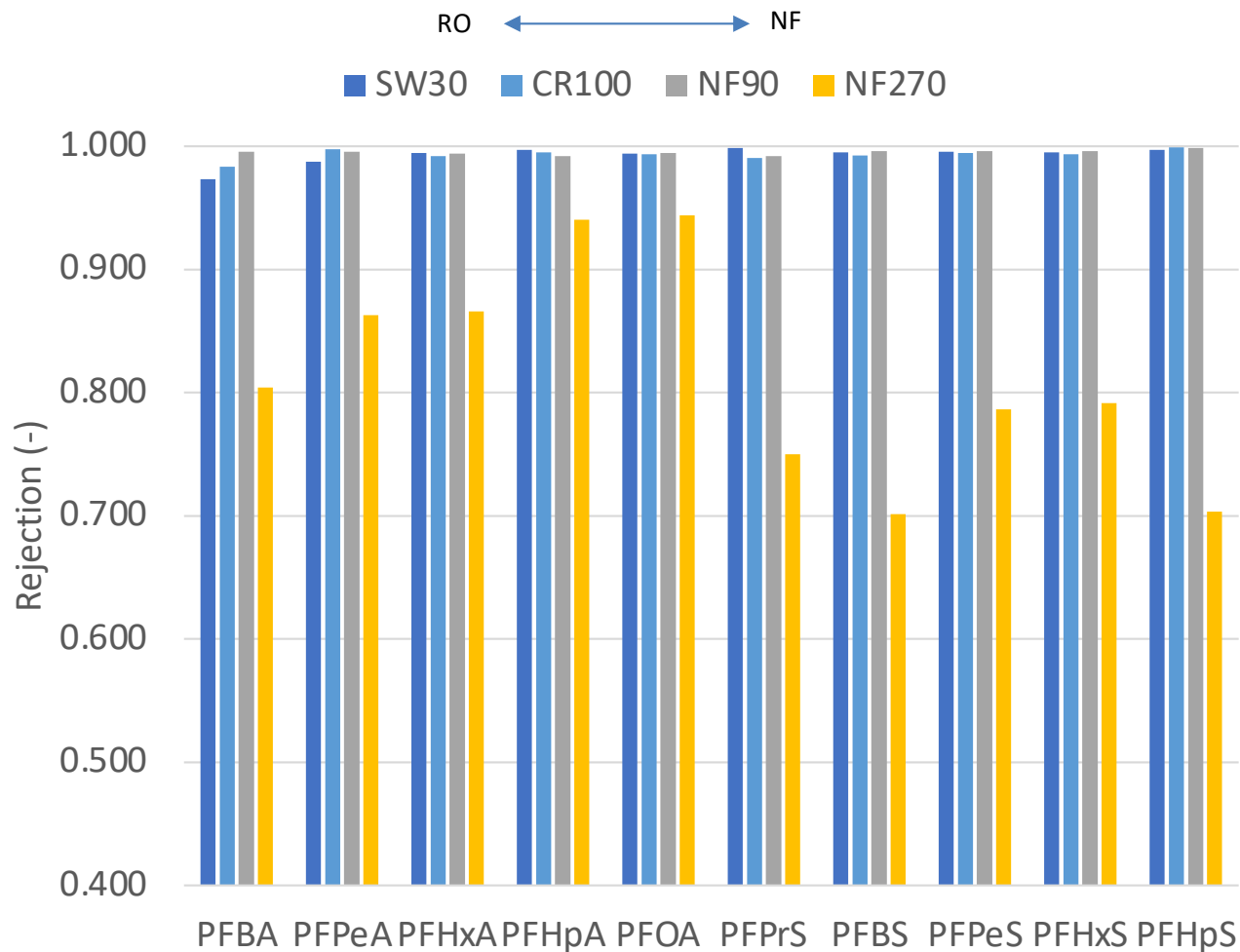
Home filters can be point-of-use (POU) or point-of-entry (POE) devices

a)

From Distribution System →

POU device
under kitchen sink with its
own separate tap.

b)

To Irrigation System

From Distribution System →

POE installation
that treats all water prior
to entering the house.

To Irrigation System

From Distribution System →

POE installation

Source: USEPA (2006)

8
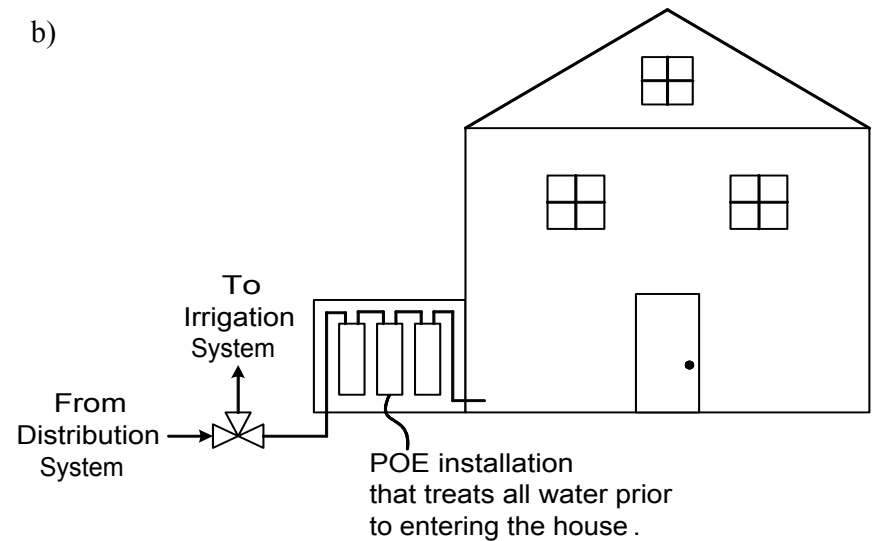
Common point-of-use home filters

Pitcher filter

Faucet filter

Under-sink reverse osmosis filter

Refrigerator filter

2-stage under-sink filter

How well do home filters remove PFAS?

Letter

Assessing the Effectiveness of Point-of-Use Residential Drinking Water Filters for Perfluoroalkyl Substances (PFASs)

Nicholas J. Herkert, John Merrill, Cara Peters, David Bollinger, Sharon Zhang, Kate Hoffman, P. Lee Ferguson, Detlef R. U. Knappe, and Heather M. Stapleton*

Read Online

https://pubs.acs.org/doi/pdf/10.1021/acs.estlett.0c00004

PFAST Project: Evaluating POU Water Filters for PFAS Removal

- Targeted homeowners in Durham, Cary/Apex, Chapel Hill, Pittsboro & Raleigh

- In home sampling (2 samples: tap and filtered water)

- Survey completed by homeowner

- Human subjects approved study

Dr. Nick Herkert

Dr. Heather Stapleton

PFAS Removal via POU Filters

		counter filter (n = 0)	faucet filter (n = 2)	pitcher filter (n = 13)	fridge filter (n = 22)	single-stage under-sink filter (n = 5)	whole-house, GAC (n = 6)	whole-house, GAC/CIX (n = 0)	two-stage filter (n = 4)	reverse osmosis (n = 11)
PFSA	PFBS	na	94%	65%	29%	>84%	18%	na	>92%	94%
	PFHxS	na	88%	54%	65%	>84%	32%	na	>95%	>96%
	PFOS	na	99%	71%	61%	>99%	67%	na	99%	100%
PFCA	PFBA	na	63%	36%	45%	15%	−34%	na	98%	>98%
	PFPA	na	67%	42%	35%	52%	−85%	na	>99%	>99%
	PFHxA	na	79%	43%	59%	53%	−63%	na	>97%	98%
	PFHpA	na	75%	43%	65%	52%	−37%	na	>97%	98%
	PFOA	na	84%	67%	71%	56%	19%	na	>99%	>92%
	PFNA	na	92%	>54%	72%	45%	28%	na	>99%	>88%
	PFDA	na	99%	>57%	57%	64%	44%	na	>99%	>93%
PFEA	GenX	na	63%	46%	56%	51%	21%	na	>99%	>99%

Herkert et al. *ES&T Letters* 2020

Lower Cape Fear River Basin Study

- Targeted homes served by public drinking water utilities
  - Cape Fear Public Utility Authority, Wilmington
  - Brunswick County
- Cross-sectional study
  - Filters of varying ages
    - 7 under-sink reverse osmosis filters
    - 12 activated carbon block filters
    - 7 whole-house filters
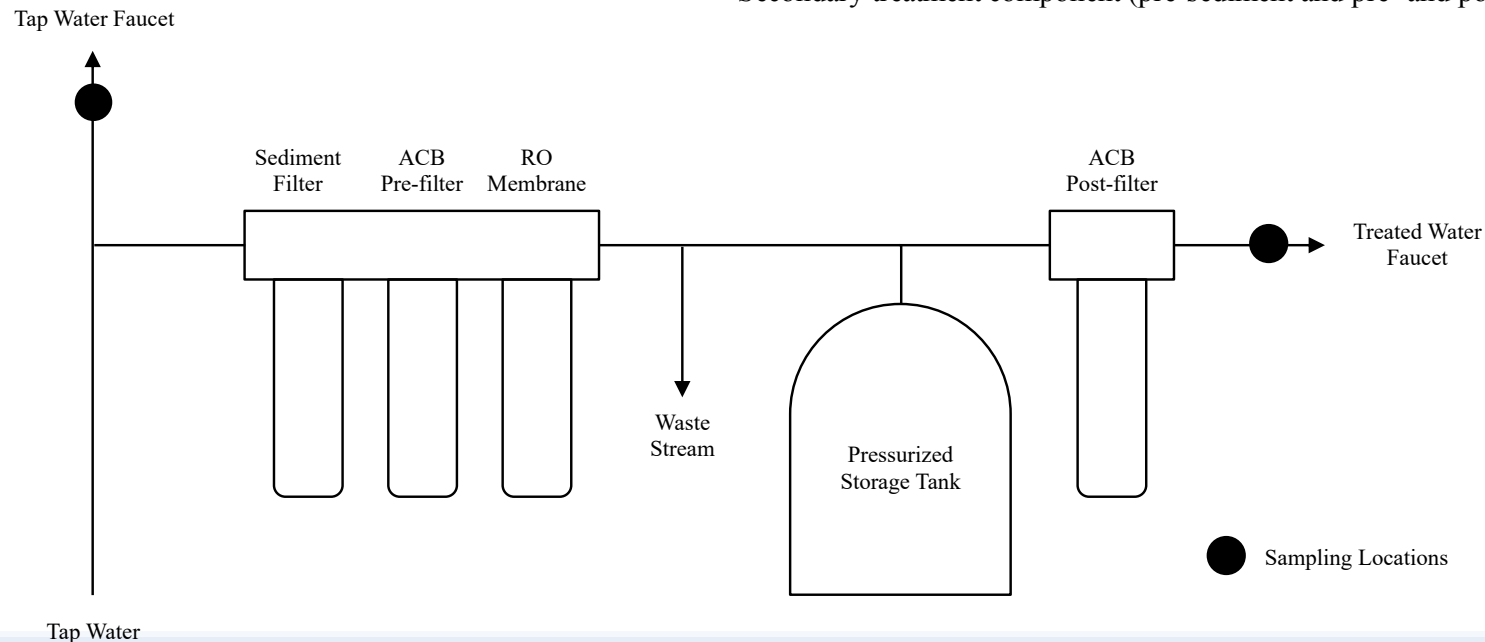 - Sampled between June and December 2017

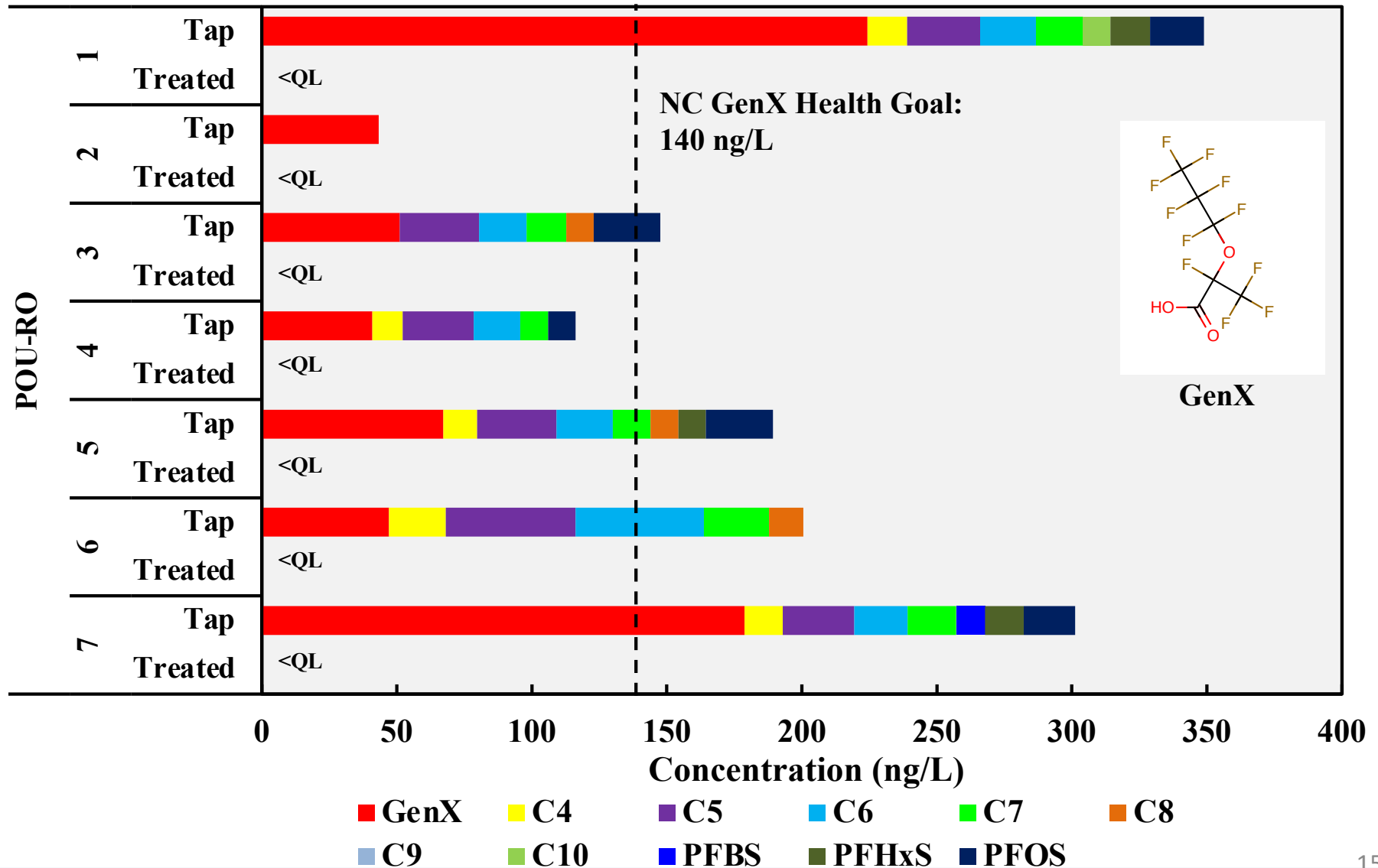John Merrill

RO System Models and Ages

Device Type	Device Manufacturer/Model	Age as Sampled (yrs)[a]	% of MNEL[a]	Age as Sampled (yrs)[b]	% of MNEL[b]
POU-RO	Kinetico K-5	0.03	1%	0.03	3%
	Puronics Micromax 7000	0.04	1%	0.04	4%
	Titan Water Pro NW-RO50-NP35	0.03	1%	0.03	3%
	Culligan Aqua-Cleer RO30	0.08	2%	0.08	8%
	Culligan Aqua-Cleer	0.16	4%	0.16	16%
	Puronics Micromax 7000	0.51	13%	0.51	51%
	APEC RO-45	5.62	141%	0.74	74%

[a]Primary treatment component (RO membrane)

[b]Secondary treatment component (pre-sediment and pre- and post-ACB filters)

Tap Water Faucet

Sediment Filter — ACB Pre-filter — RO Membrane — ACB Post-filter — Treated Water Faucet

Waste Stream

Pressurized Storage Tank

Tap Water

● Sampling Locations

Under-Sink Reverse Osmosis Filters Effectively Removed PFAS

NC GenX Health Goal: 140 ng/L

GenX

Legend: GenX, C4, C5, C6, C7, C8, C9, C10, PFBS, PFHxS, PFOS

X-axis: Concentration (ng/L)

...including fluoroethers, for which we lacked standards at the time
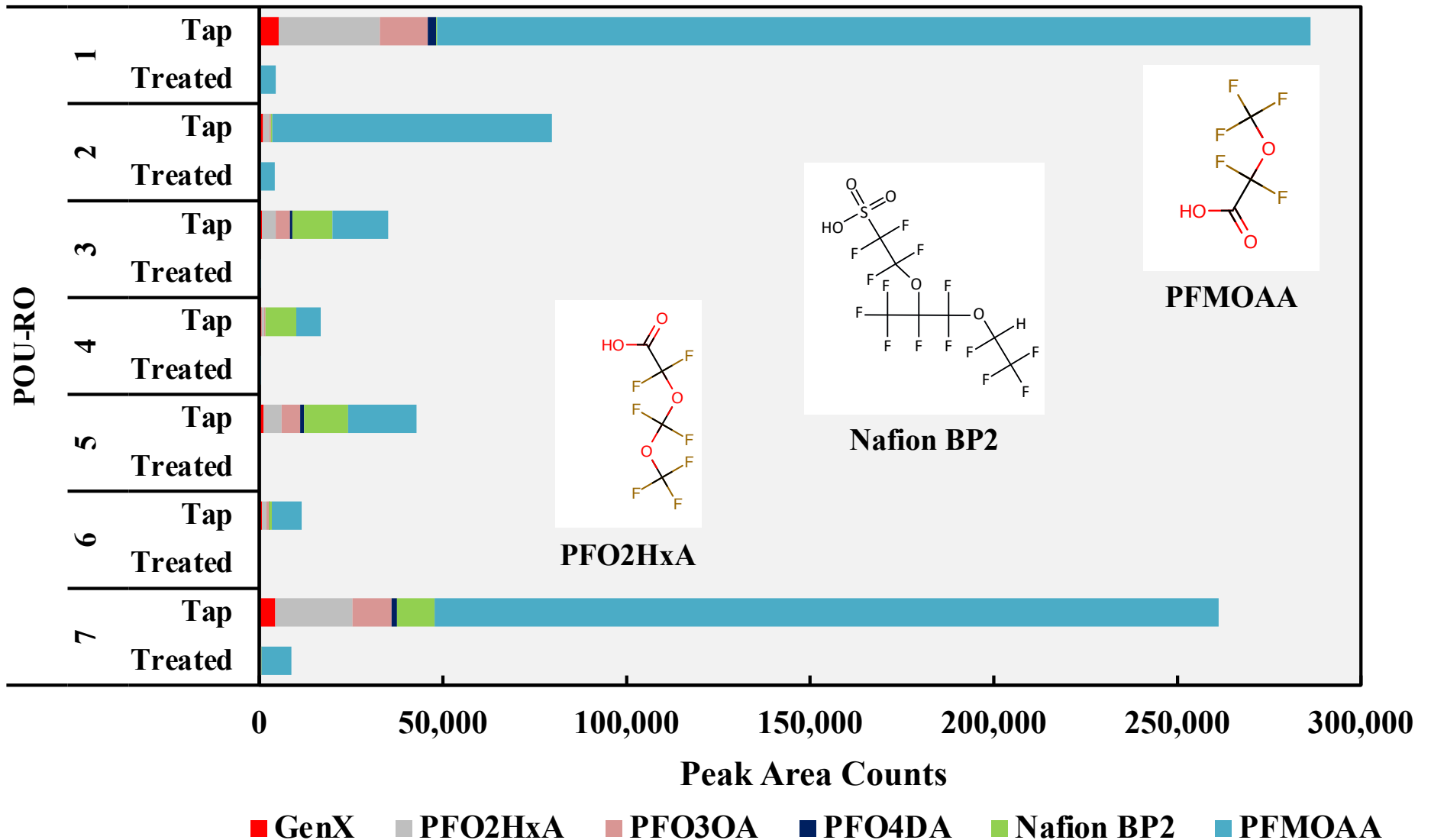
Two-Stage Activated Carbon Block Filter Models and Ages

Device Type	Device Manufacturer/Model	Age at Sample[a] (yrs)	% of MRL/MEL[a]	Age at Sample[b] (yrs)	% of MRL/MEL[b]
POU-ACB	Custom Formulations KDF/GAC	0.09	3%	-	-
	EcoAqua EFF-6027A	0.09	12%	-	-
	Aquasana AQ-5200	0.07	13%	-	-
	Custom Formulations KDF/GAC	0.47	16%	-	-
	Hydroviv Tailored Tapwater & HDX Whirlpool 3	0.12	16%	0.12	25%
	Hydroviv Tailored Tapwater	0.12	24%	-	-
	Big Berkey with 2 Black Filters	2.15	29%	-	-
	eSpring 100189 (UV lamp off)	0.35	35%	-	-
	EcoAqua EFF-6027A	0.47	62%	-	-
	Hydroviv Tailored Tapwater & HDX Whirlpool 3	0.50	66%	0.50	100%
	LG 5231JA2006B	0.38	77%	-	-
	Hydroviv Tailored Tapwater	0.50	99%	-	-
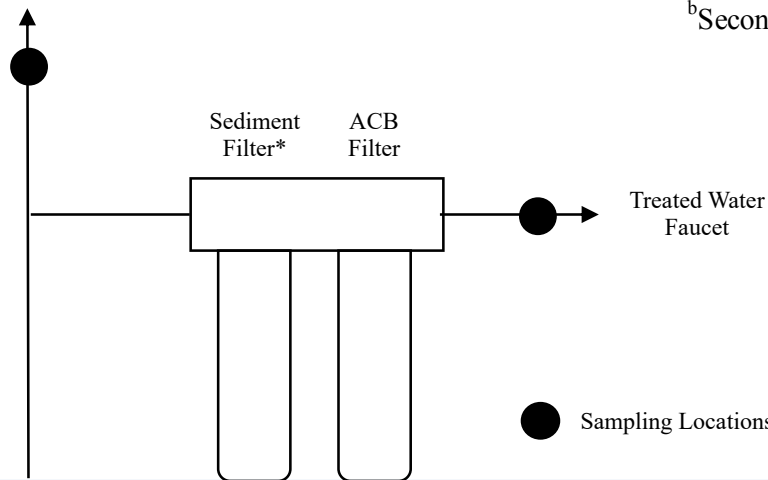
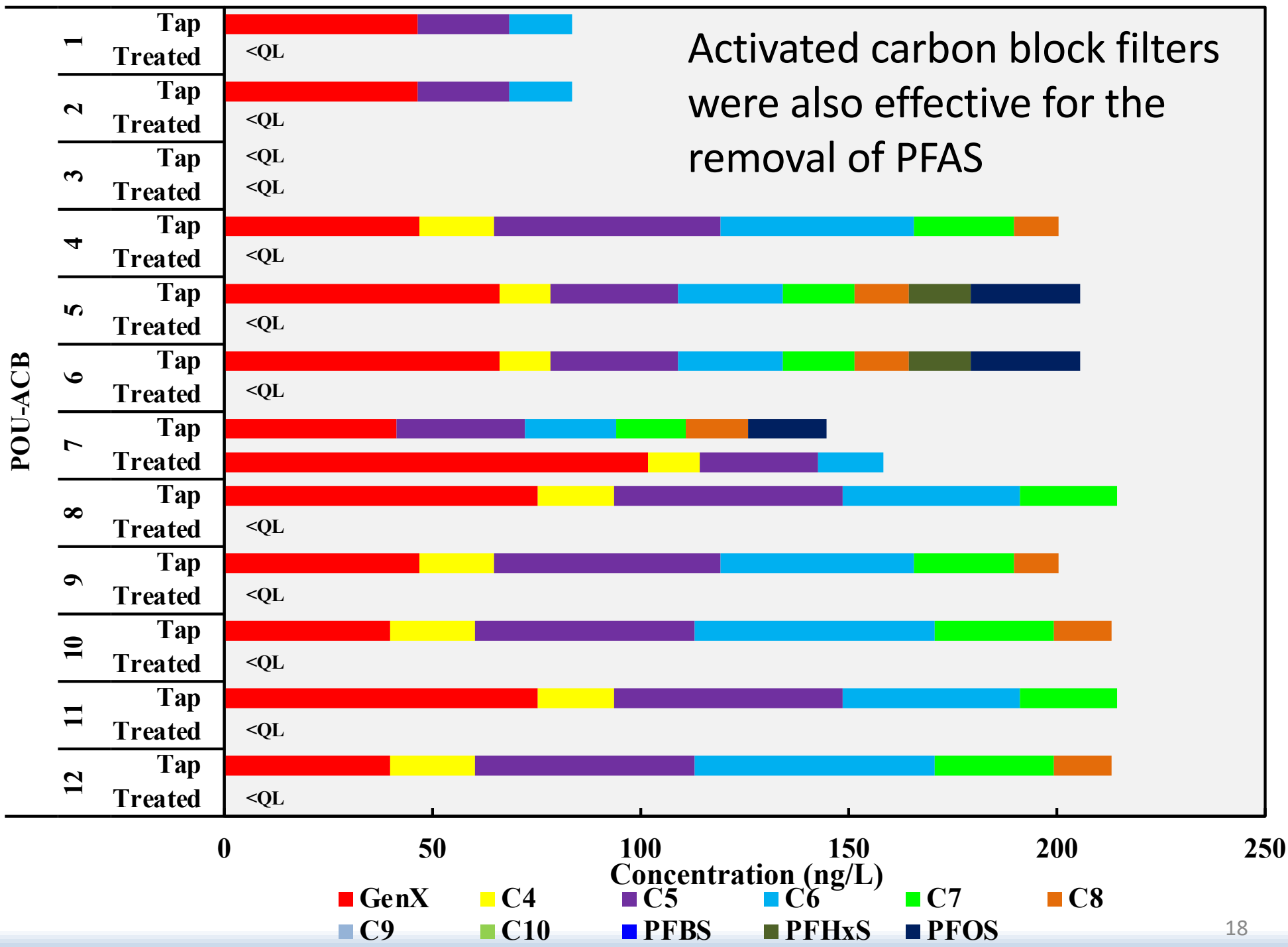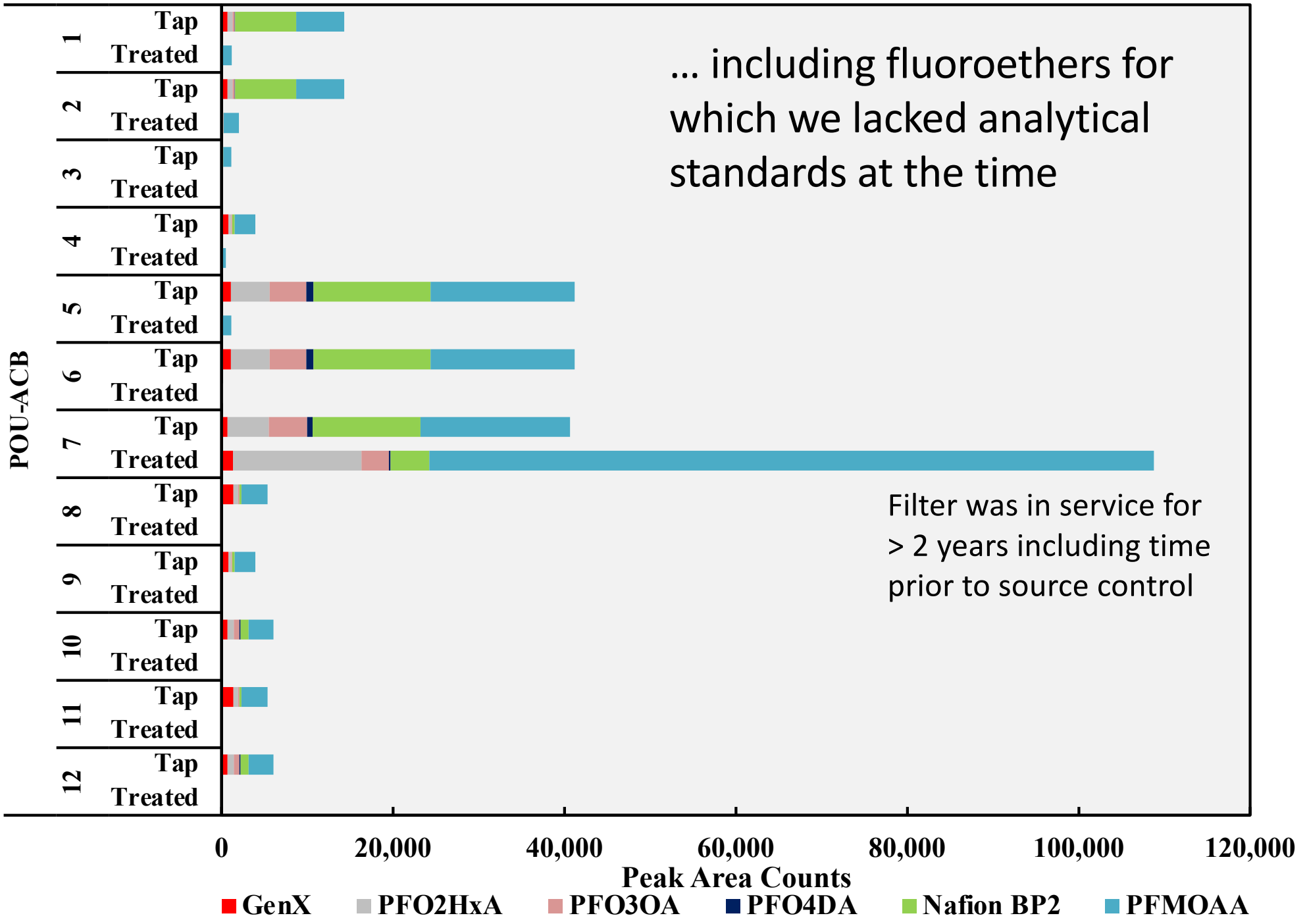[a]Primary treatment component (ACB filter)

[b]Secondary treatment component (for devices 5 and 10, two ACB filters were in series)

Tap Water Faucet

Sediment Filter*

ACB Filter

Treated Water Faucet

Sampling Locations

Tap Water

Activated carbon block filters were also effective for the removal of PFAS

... including fluoroethers for which we lacked analytical standards at the time

Filter was in service for > 2 years including time prior to source control

POU-ACB

Peak Area Counts

■ GenX   ■ PFO2HxA   ■ PFO3OA   ■ PFO4DA   ■ Nafion BP2   ■ PFMOAA

Whole-House Filter Models and Ages

System ID	Device Type	Device Manufacturer/Model	Age at Sample Collection (years)	% of MEL
1	POE-GAC	Aquasana EQ-1000	0.10	1
2	POE-GAC/CIX	Puronics Clarius-W IGEN	0.14	-
3	POE-GAC/CIX	Puronics Clarius-W	0.38	-
4	POE-GAC	Aquasana EQ-1000	0.47	5
5	POE-GAC/CIX	Puronics Clarius-W IGEN	0.51	-
6	POE-GAC/CIX	Puronics Defender IGEN	1.25	-
7	POE-GAC/CIX	Puronics Clarius-W	1.93	-

Whole-house filters containing activated carbon dechlorinate water and leave premise plumbing vulnerable to growth of opportunistic pathogens (e.g. Legionella). This is of particular concern for homes connected to public water systems that treat surface water.

Whole house filters were least effective for PFAS
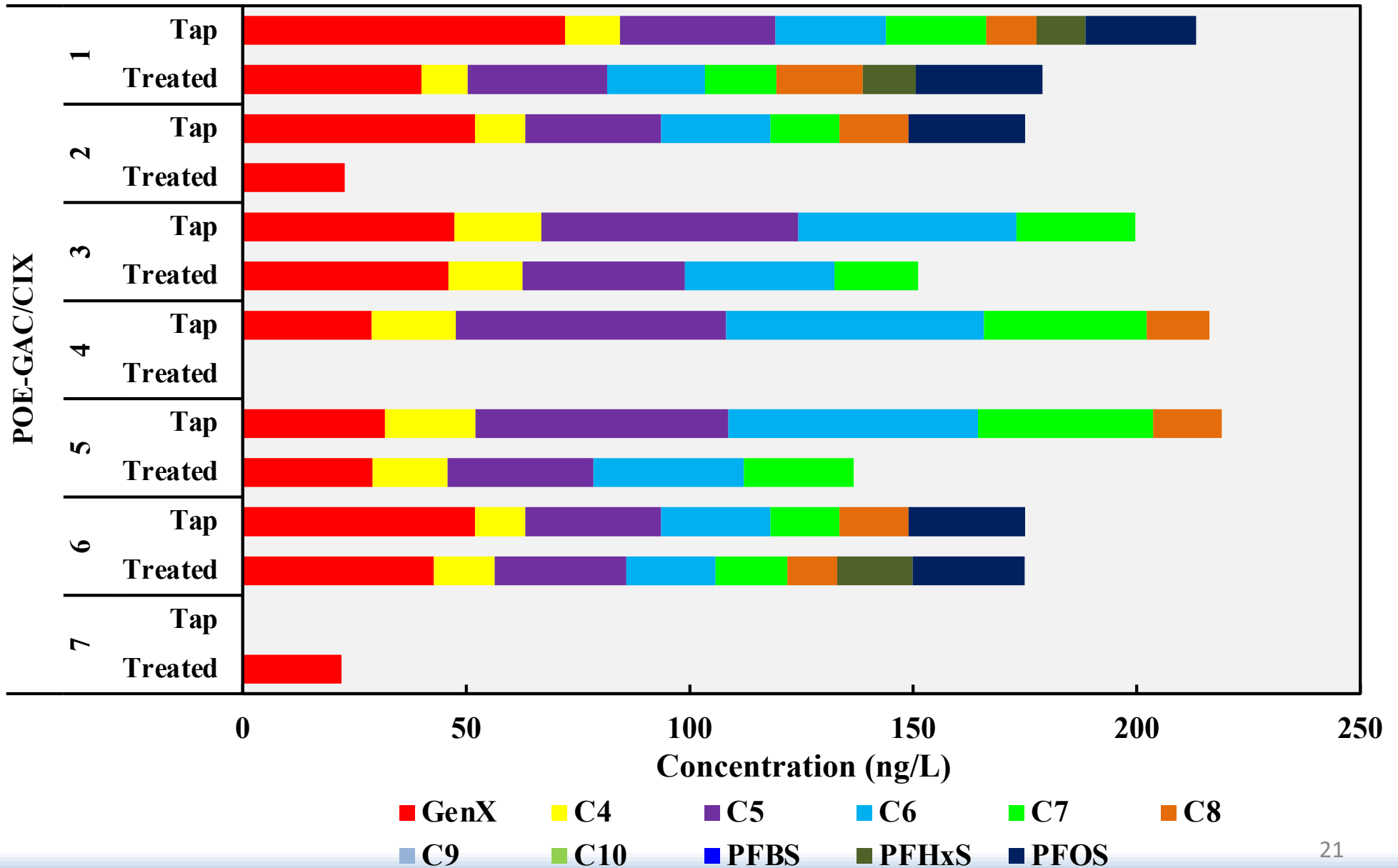
Take-home messages

- Under-sink reverse osmosis filters effectively removed PFAS
- Two-stage under-sink activated carbon block filters effectively removed PFAS
- Smaller POU filters (e.g., pitcher, faucet) achieved partial removal of PFAS
- Whole house filters did not perform well

Acknowledgements

We would like to thank our **study participants** for providing samples for this study.

Funding Sources

- PFAST Network

- National Science Foundation (#1449768)

- NC Water Resources Research Institute

Disclaimers

- No endorsements should be inferred
- I have not received funding from manufacturers of home filters
- I do not benefit in any form from the sale of home filters

Thank you!

Questions?

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