Ongoing Research into Supercritical Water Oxidation (SCWO) as a PFAS Destruction Technology

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What does the Office of Research and Development (ORD) do?

- ORD is the scientific research arm of EPA
- Its leading-edge research informs Agency decisions and supports the emerging needs of EPA stakeholders, including the Agency's state, tribal, and community partners

ORD's Role in Understanding PFAS Destruction & Disposal

Data Gap: Knowledge regarding end-of-life management and ultimate disposal of PFAS-containing materials

Actions:

- Characterize end-of-life PFAS disposal streams
- Evaluate efficacy of disposal/destruction technologies
- Evaluate possibility of products of incomplete combustion/destruction

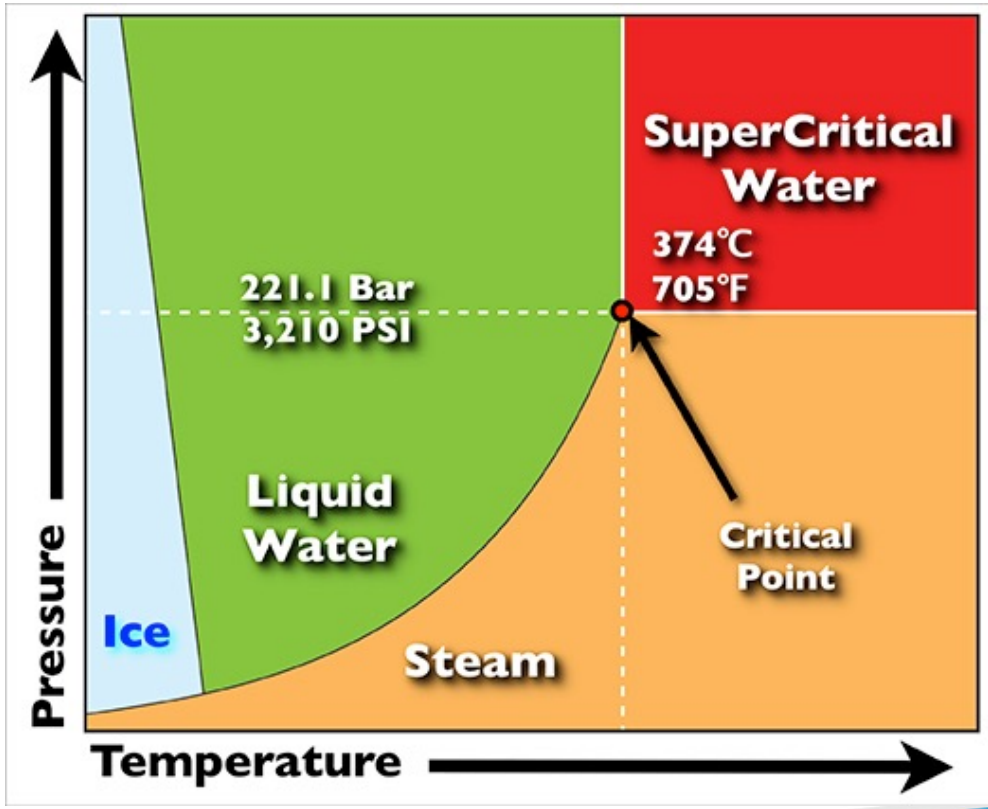
Research Products:

- PFAS presence in different types of landfills and leachates
- PFAS behavior in incineration environments
- Thermal treatment of PFAS-contaminated biosolids

Impact: Responsible officials will be able to effectively manage end-of-life disposal of PFAS-containing materials

Supercritical Water Oxidation (SCWO)

- Water above 705 °F and 3,210 PSI is considered supercritical
- Special state of water
  - Has properties of liquid and gas-phase
- Beneficial for hazardous waste degradation
  - Halogenated compounds most studied in peer-reviewed literature



Source: https://en.wikipedia.org/wiki/Supercritical_water_oxidation

Status of SCWO Work

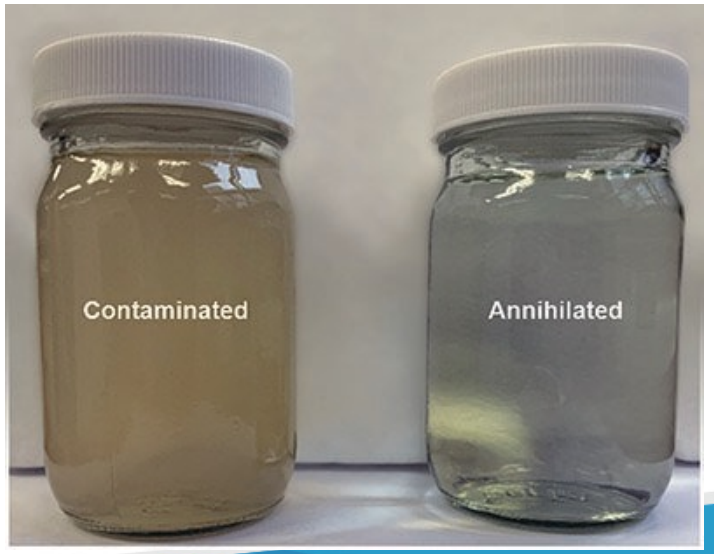
- For the past two years, EPA has been conducting a range of lab-, pilot-scale evaluations
- SCWO demonstrations of outside groups' technologies
  - Three lab demonstrations
  - One pilot study

Source: General Atomics, https://www.ga.com/hazardous-waste-destruction

SCWO Case Studies

- Case studies performed with four separate SCWO operators
  - Aquarden (Denmark)
  - 374Water (Durham, NC)
  - Battelle (Columbus, OH)
  - General Atomics (San Jose, CA)
- Tested SCWO on dilute AFFF
- Analyzed for PFAS, TOF, fluoride, and COD
  - Some gas-phase PFAS sampled w/General Atomics

Source: https://aquarden.com/



Source: https://www.battelle.org/government-offerings/energy-environment/environmental-services/pfas-assessment-mitigation/pfas-annihilator-destruction-technology

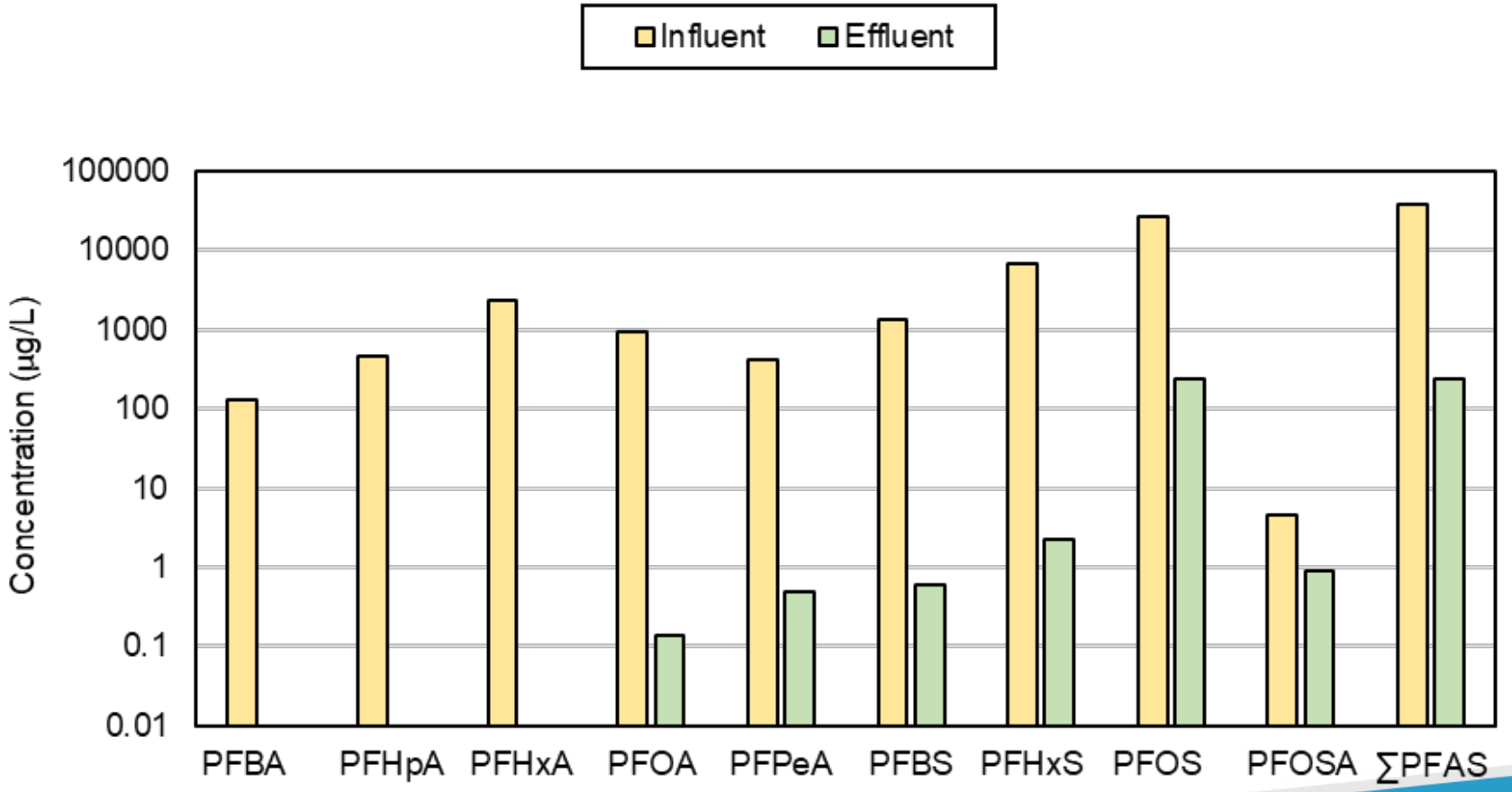
Case Study on SCWO AFFF Destruction

SCWO Providers	Temperature (°C)	Pressure (MPa)	Reaction residence time (s)	Oxidizer	Alkaline treatment type	Alkaline treatment location
374Water	595	CBI	6-8	Air	CBI	Influent
Aquarden	590	24	60	Air	KOH	Influent
Battelle	590	CBI	10	CBI	CBI	Effluent

Source: Krause et al. (2022)

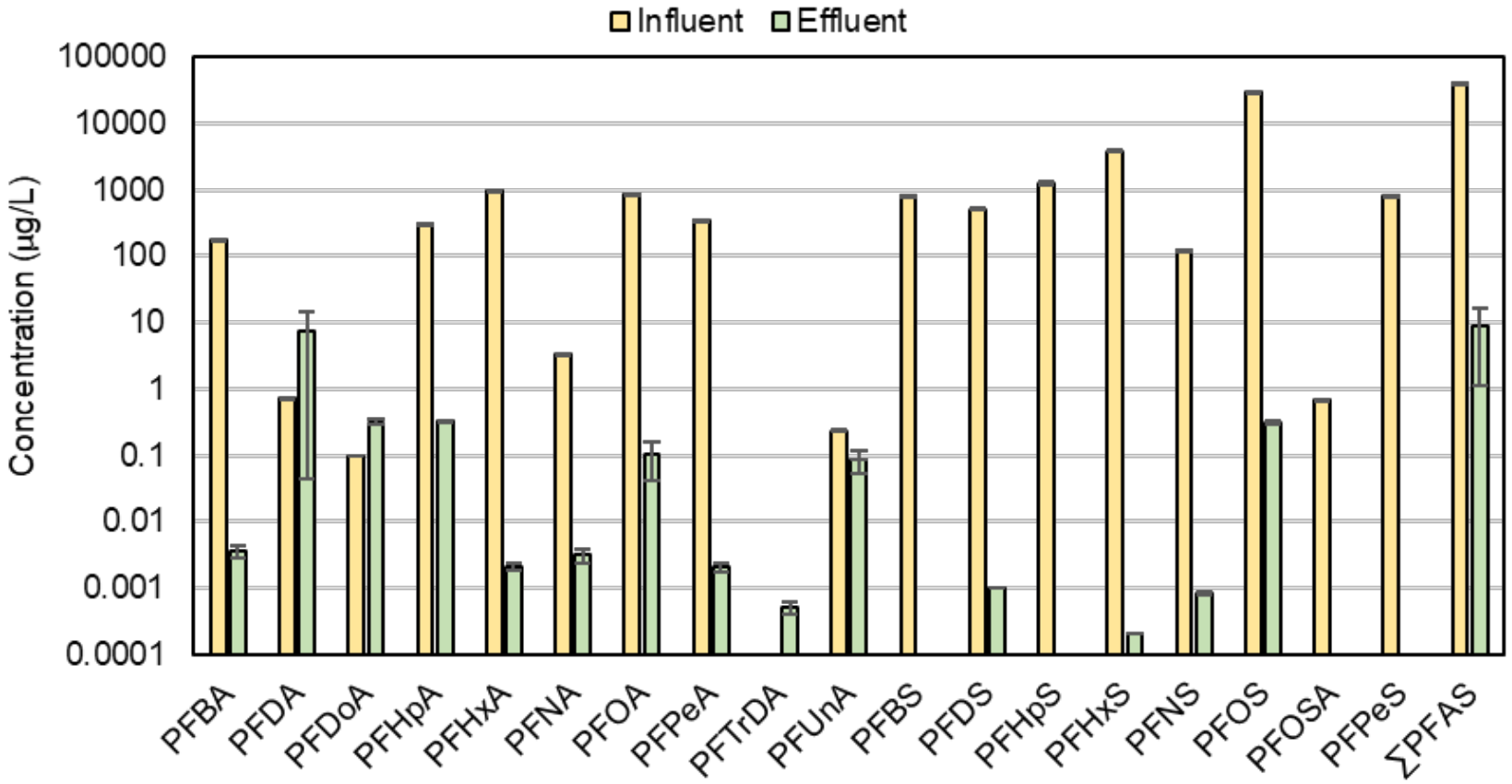
- Testing on PFOS-based AFFF solution (3M Light Water samples)
- Analysis of 12-28 PFAS influent and effluent

SCWO: Aquarden, 100x dilute AFFF



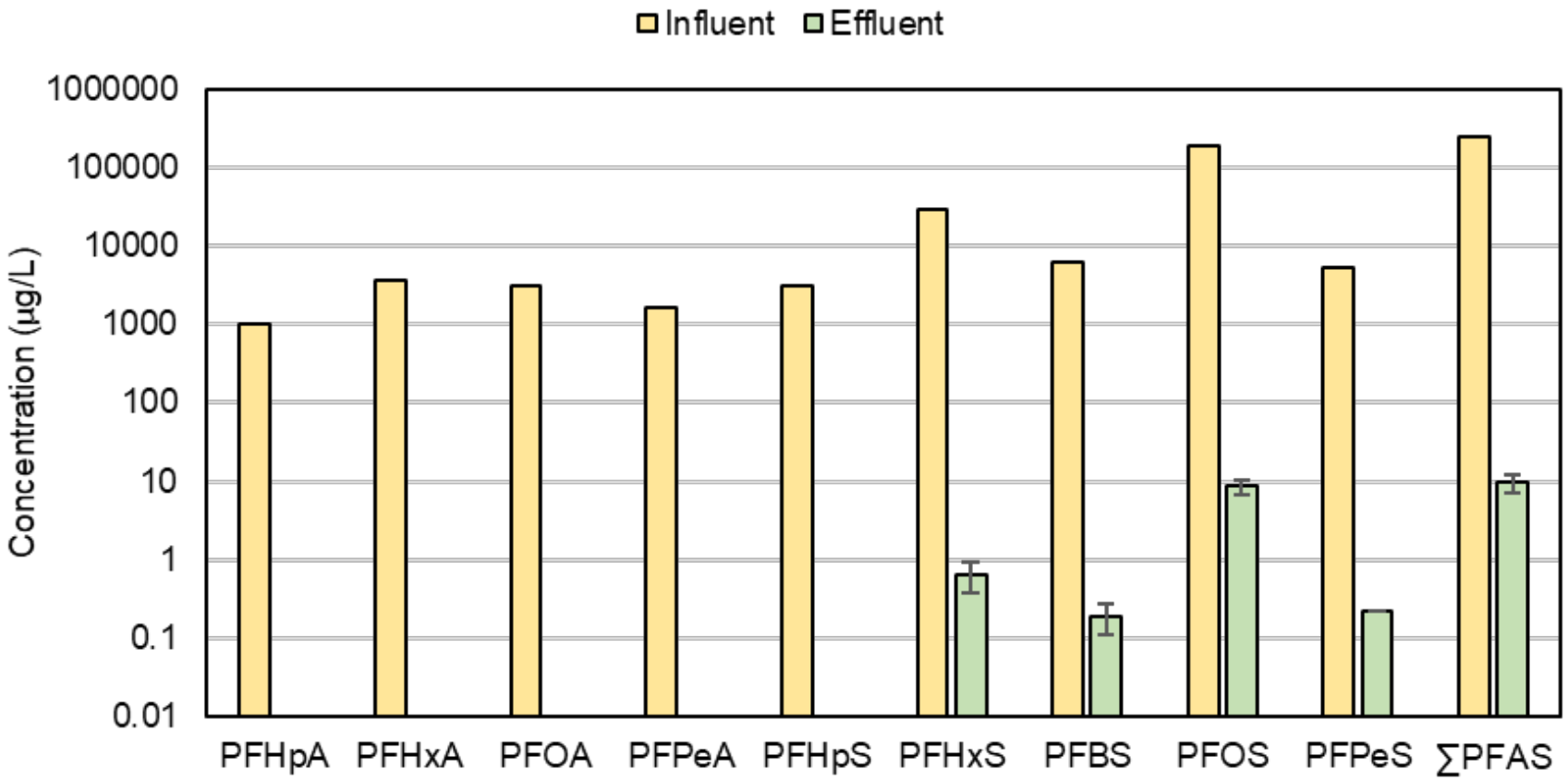
Source: Krause et al. (2022)

SCWO: Battelle, 100x dilute AFFF



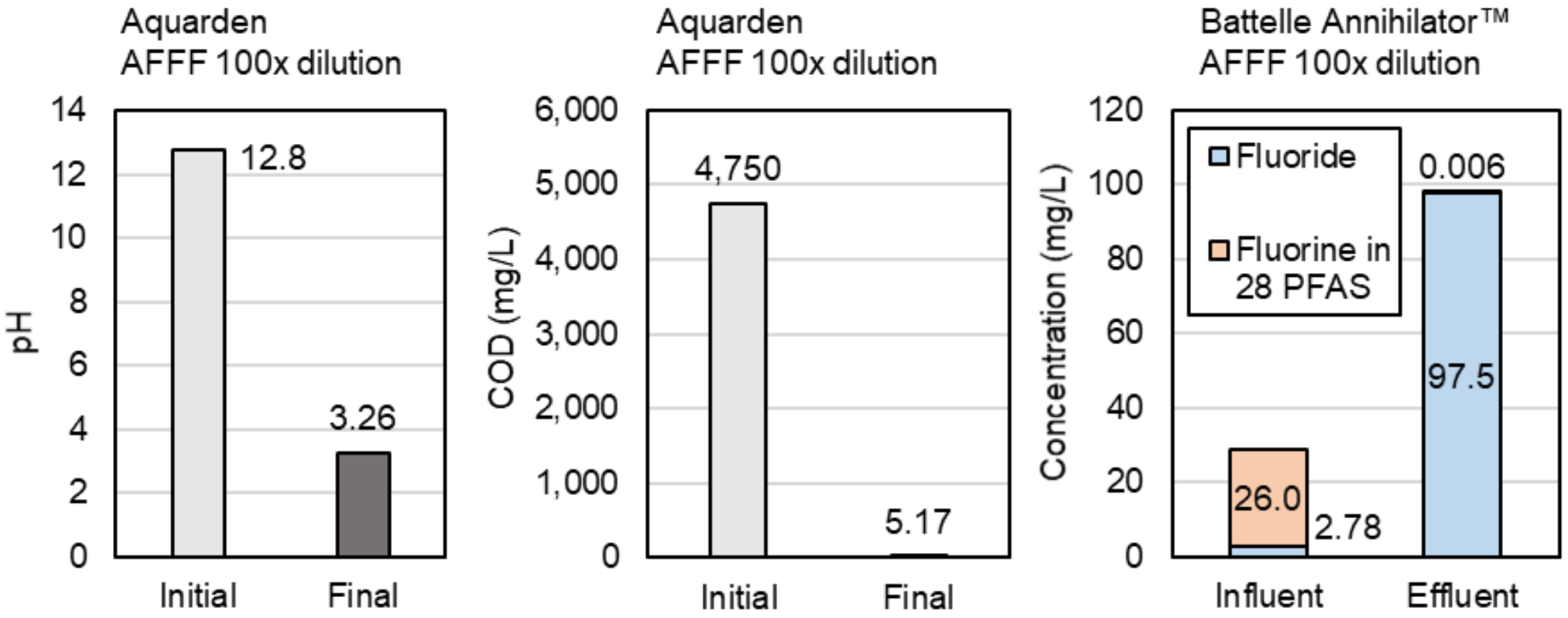
Source: Krause et al. (2022)

SCWO: 374Water, 30x dilute AFFF



Source: Krause et al. (2022)

Other Parameters for Consideration



Source: Krause et al. (2022)

State of Hydrothermal Research

- Called many things, all similar in concept (i.e., pressure-cooking PFAS)
  - Hydrothermal processing (HTP)
  - Hydrothermal liquefaction (HTL)
  - Hydrothermal alkaline treatment (HALT)
  - Supercritical water oxidation (SCWO)
- Consistent findings that high temperature/pressure water can de-fluorinate solutions
  - Combination of targeted analysis and measured fluoride ion (F-) increased in effluent
- Alkaline treatment prevents formation of hydrofluoric acid (HF)
- Pros and cons to operating at sub- or super-critical conditions
  - Salts precipitate but faster destruction times
- Subcritical reaction times are on the order of minutes to hours for sub-critical reactors
  - Seconds for SCWO systems (Krause et al. 2022; Pinkard et al. 2021)
- Supercritical conditions precipitate non-soluble salts

References

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