

Adaptation of UV Advanced Oxidation for Inland Potable Reuse Treatment

WateReuse in Texas
San Marcos, TX
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Erik Rosenfeldt, PhD, PE – Hazen and Sawyer

What roles can UV AOP fill in a potable reuse treatment train?

The precedent for UV and UV AOP in Texas direct potable reuse projects

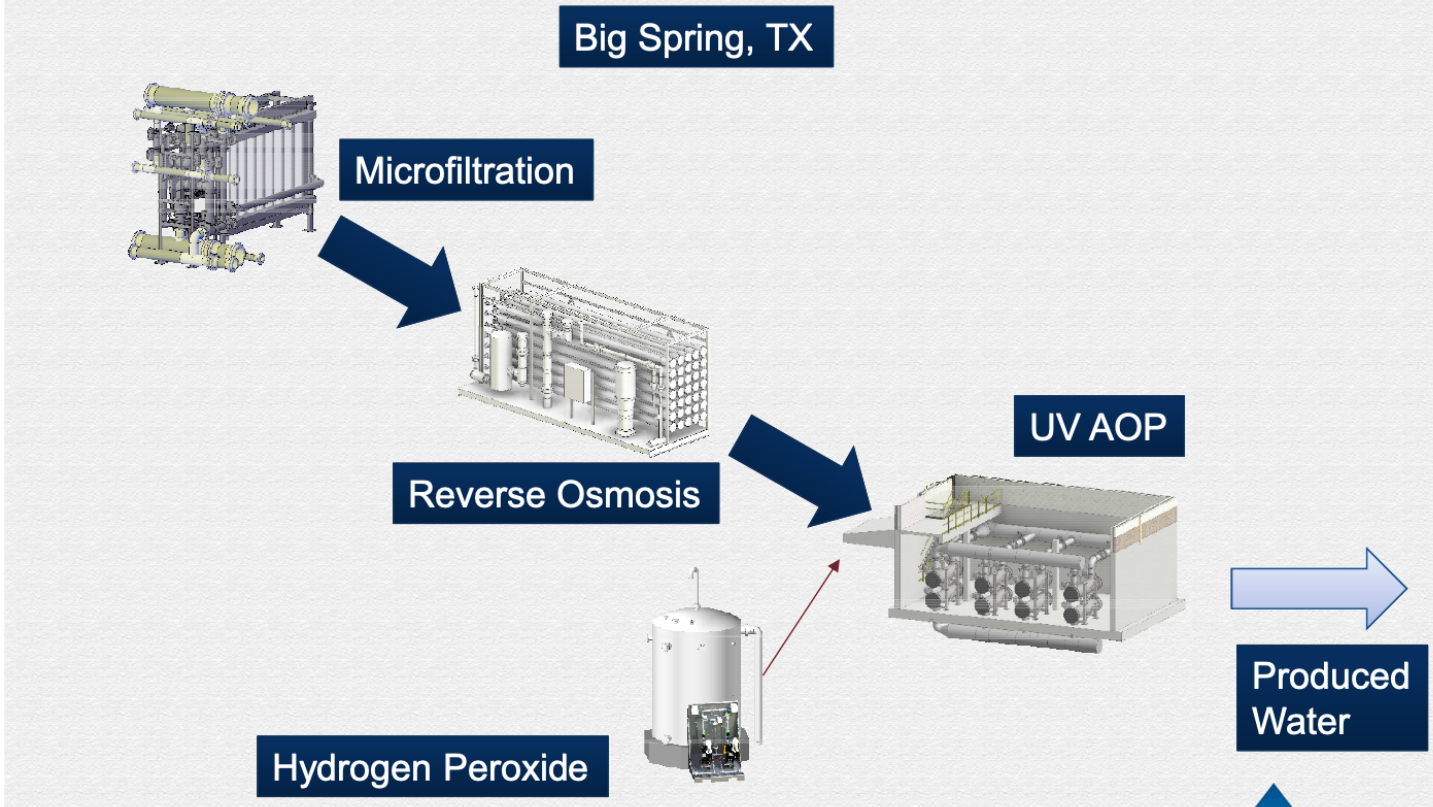
Does UV AOP always need RO pretreatment?

A collaborative research project to assess potential for UV AOP treatment of reclaimed waters of varying quality

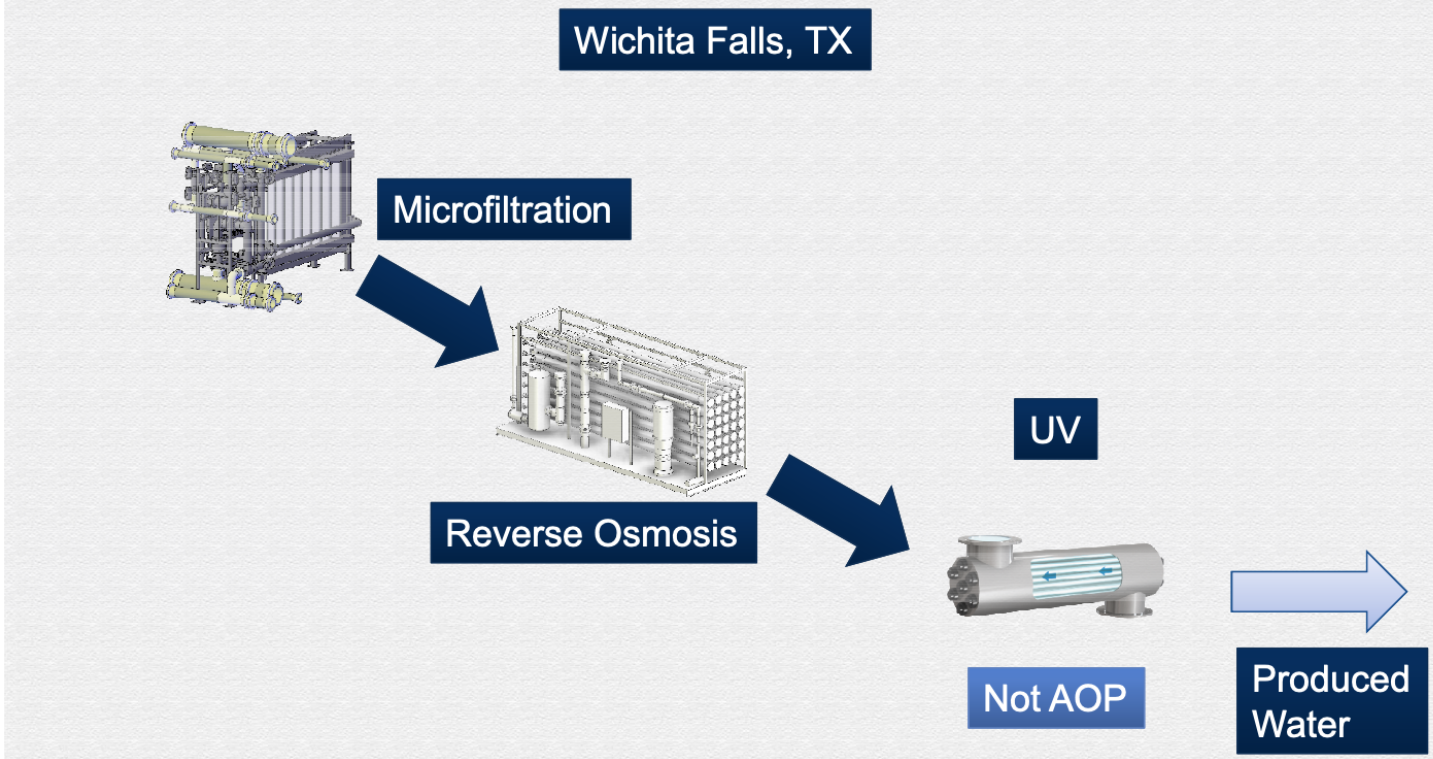
- H_2O_2/UV
- HOCl/UV



Both Texas DPR projects included UV treatment following RO



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Reverse osmosis pretreatment improves the efficiency of H_2O_2/UV advanced oxidation

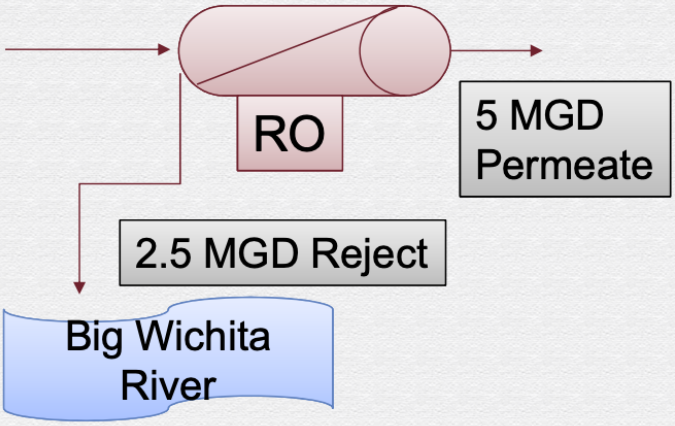
RO pretreatment reduces the dissolved organic carbon concentration, which can limit targeted contaminant oxidation

RO pretreatment minimizes photon scavenging by substances other than H_2O_2

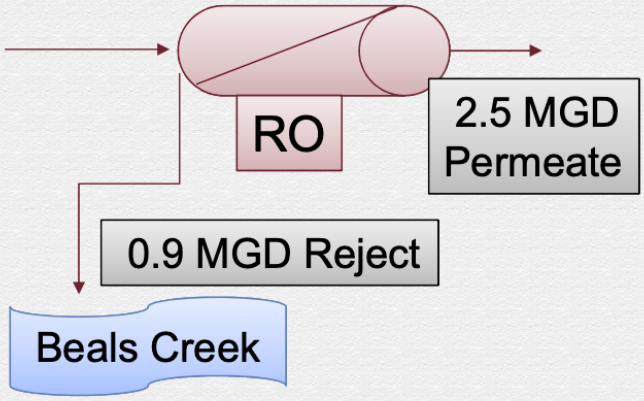
RO pretreatment greatly reduces the concentration of most trace organic contaminants, thereby reducing the competition for available ·OH

Both TX DPR facilities had neighboring streams with capacity to assimilate RO concentrate TDS

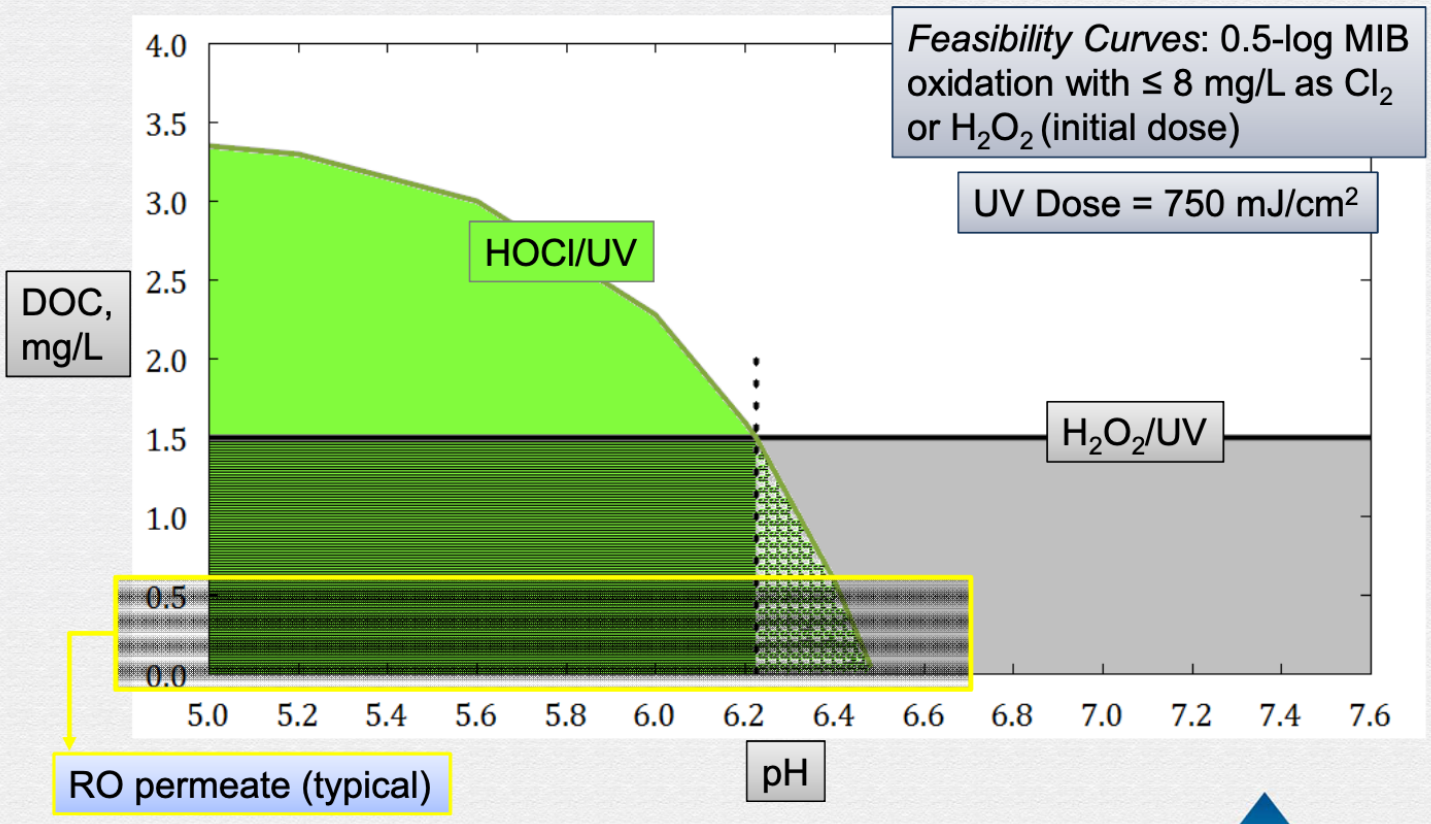
Wichita Falls



Big Spring



A new approach to UV AOP (HOCl/UV) could see effective treatment of *marginal* reuse waters



In 2015, WateReuse Texas sponsored a pilot study of UV AOP after varying levels of filtration

Secondary Effluent

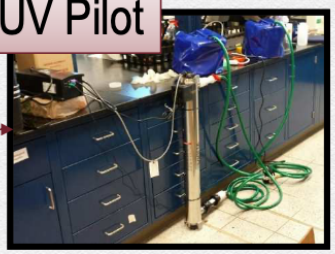
Secondary Effluent

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Media Filtration



UV Pilot



NaOCl *or* H_2O_2

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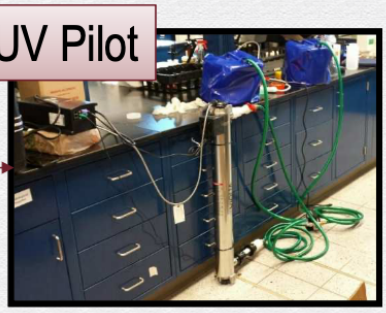
Secondary Effluent

Secondary Effluent

Submerged MF



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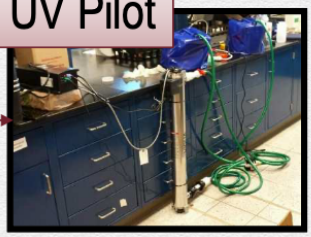


RO



NaOCl *or* H_2O_2

UV Pilot



Objectives for the 2015 pilot study

Assess feasibility of novel indirect [·OH] measurement technique in reclaimed waters of varying quality

Test *Watts, Rosenfeldt, and Hofmann* (2012) steady-state [·OH] model for predicting AOP performance in reclaimed waters of varying quality

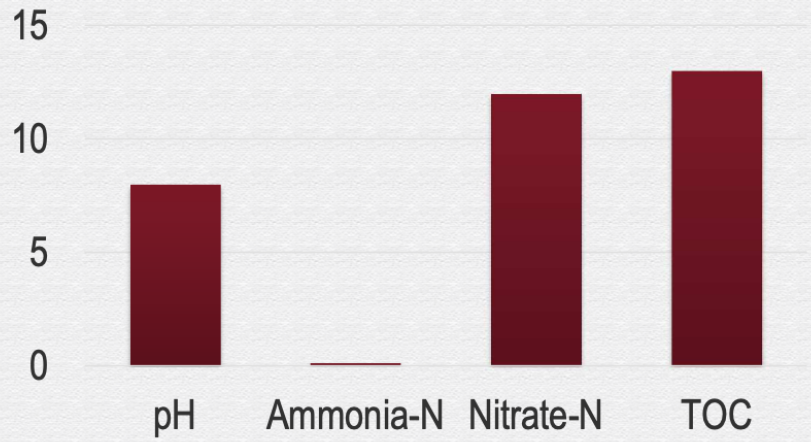
Predict degree of UV AOP treatment needed to see *micropollutant* oxidation in reclaimed waters of varying quality

Initially, each sample from Lawton and Wichita Falls was surveyed for water quality and trace organic pollutant profiles

Media Filtration



UVT = 60%



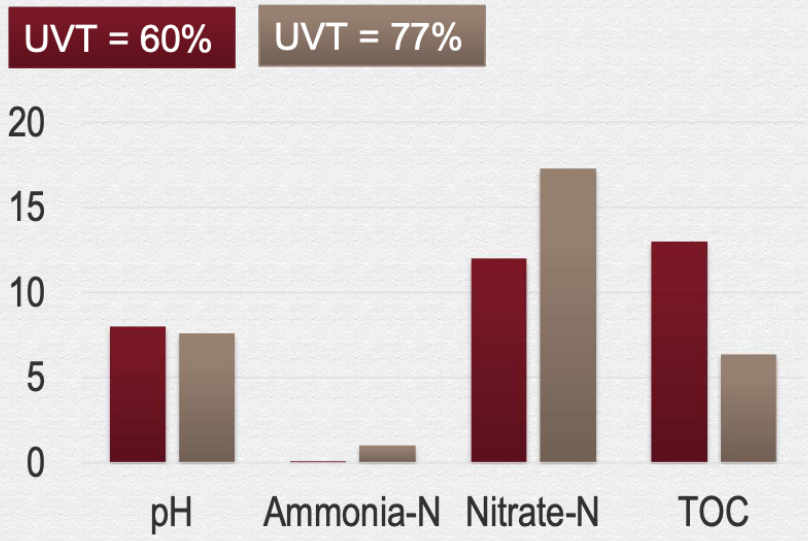
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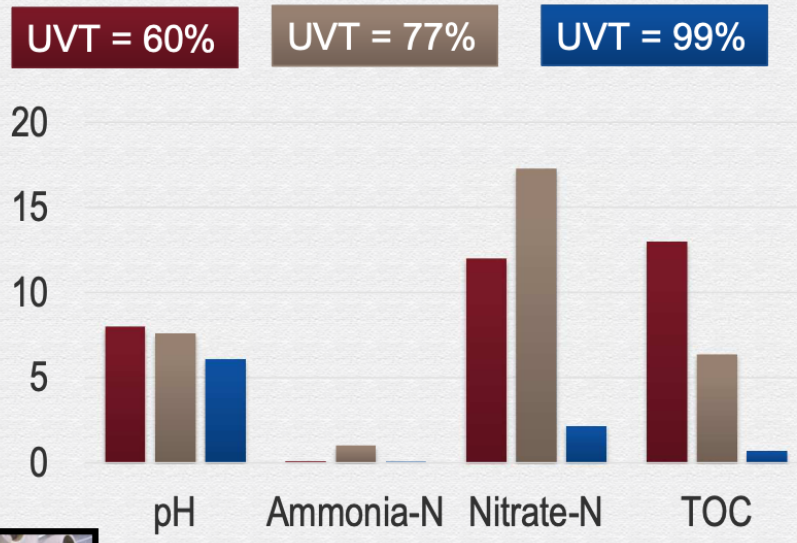


Submerged MF

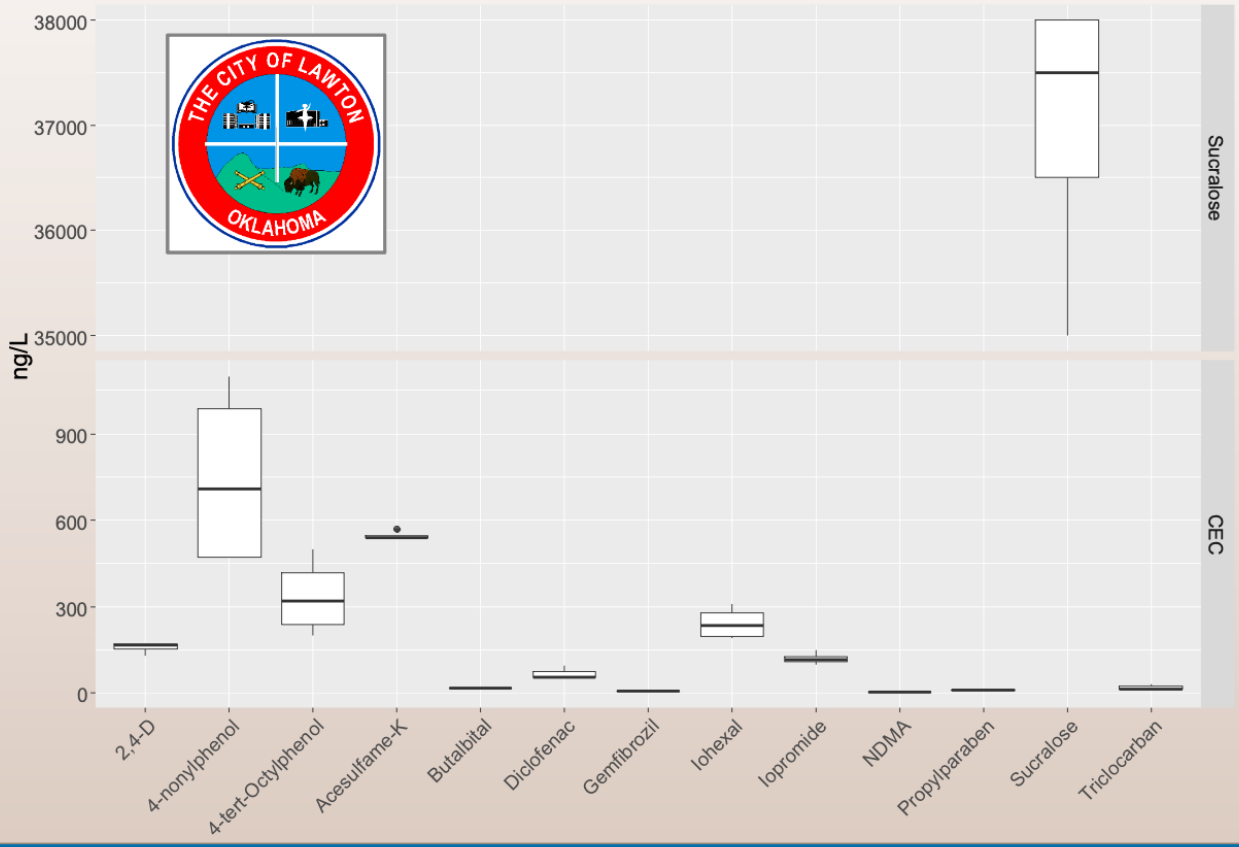


RO

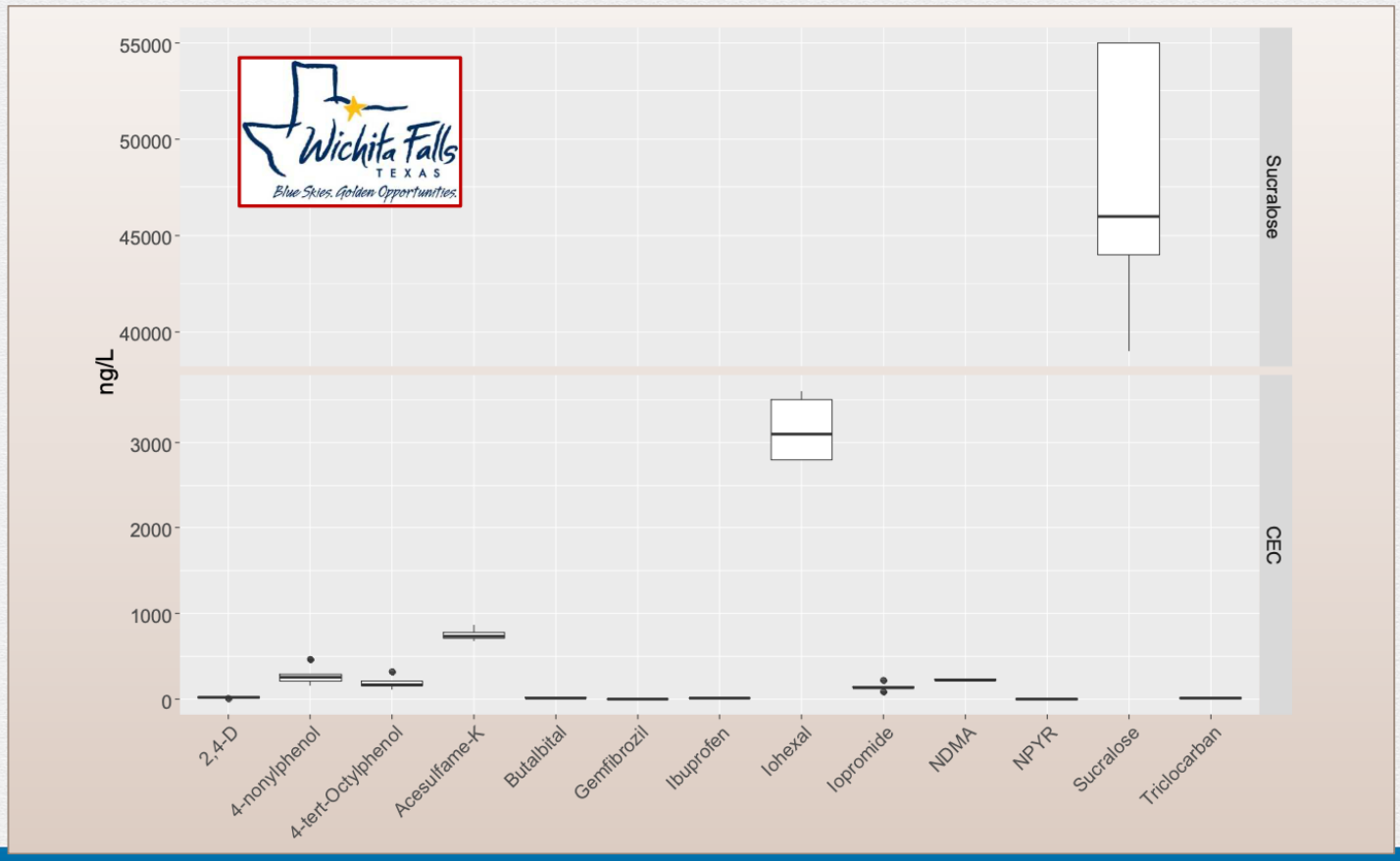




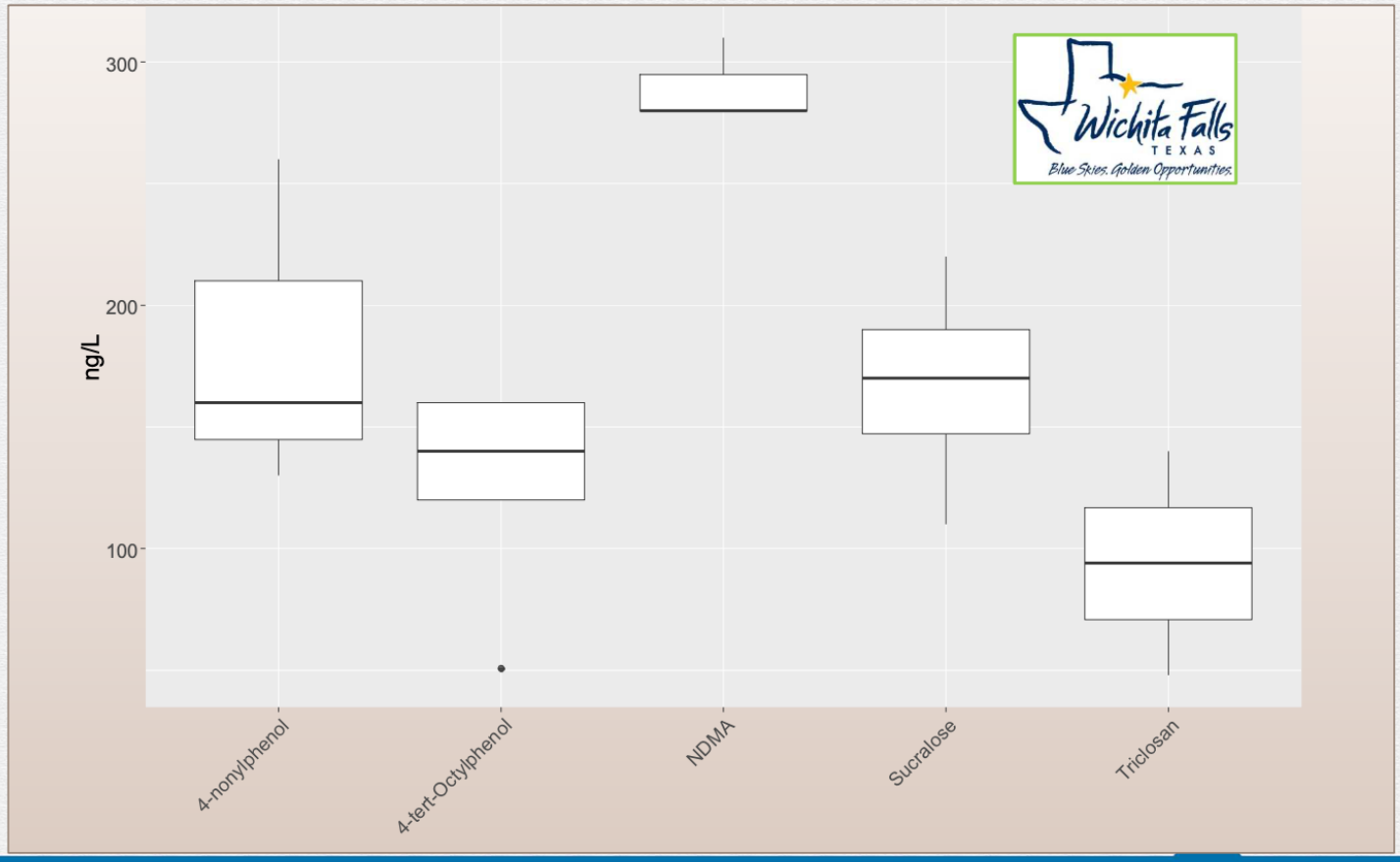
4-nonylphenol and sucralose were most prevalent CECs in Lawton effluent samples



The concentrations of iohexol and sucralose were greatest in MF filtrate from Wichita Falls



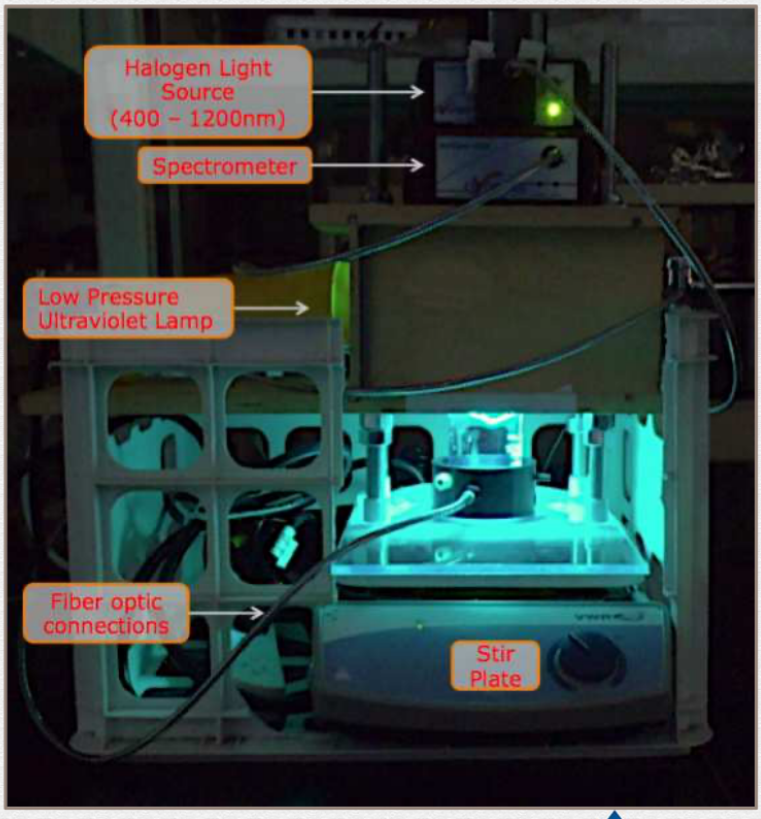
Fewer micropollutants were detected following RO



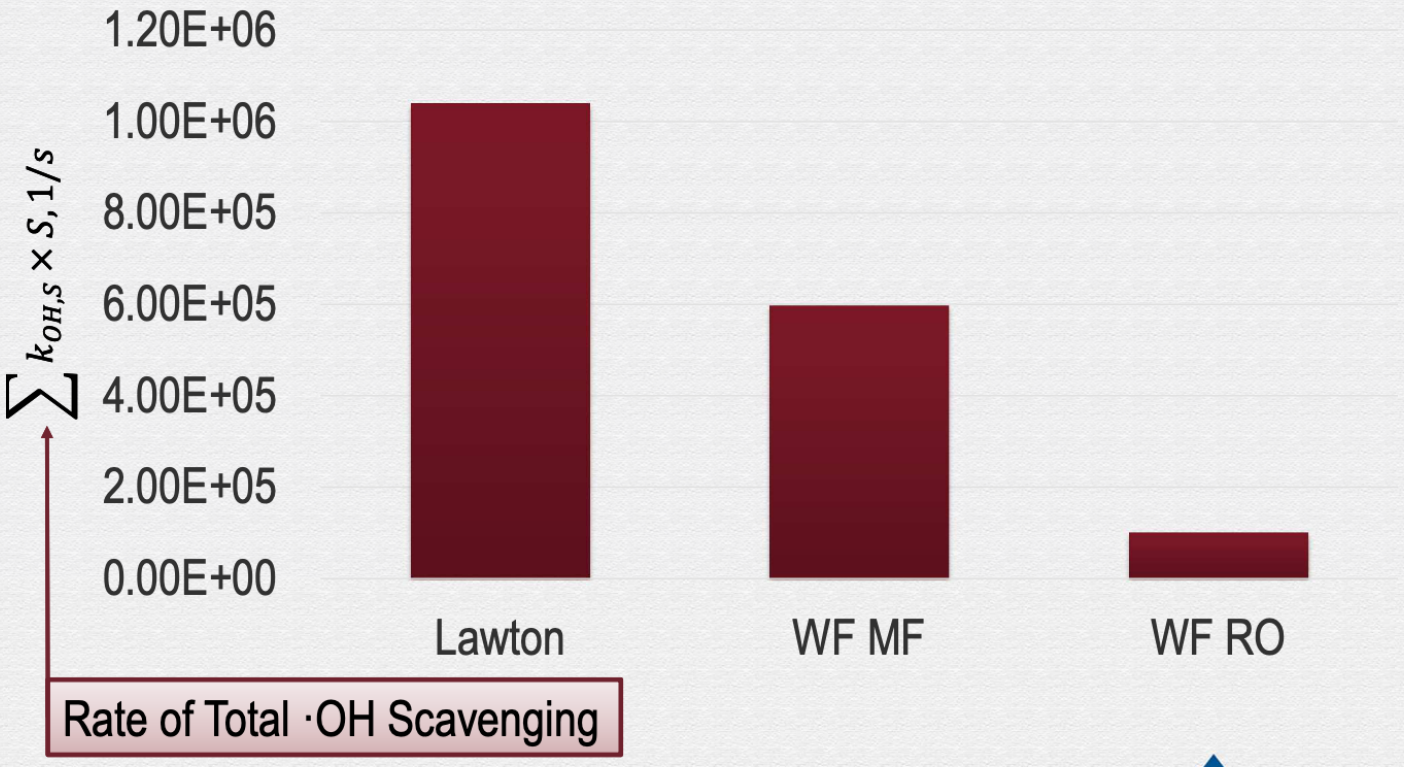
A sample of each water was also tested for Total ·OH-Scavenging ($\sum k_{OH,S} \times S$)

$$[OH]_{SS} = \frac{R_{OH,formation}}{\sum k_{OH,S} \times S}$$

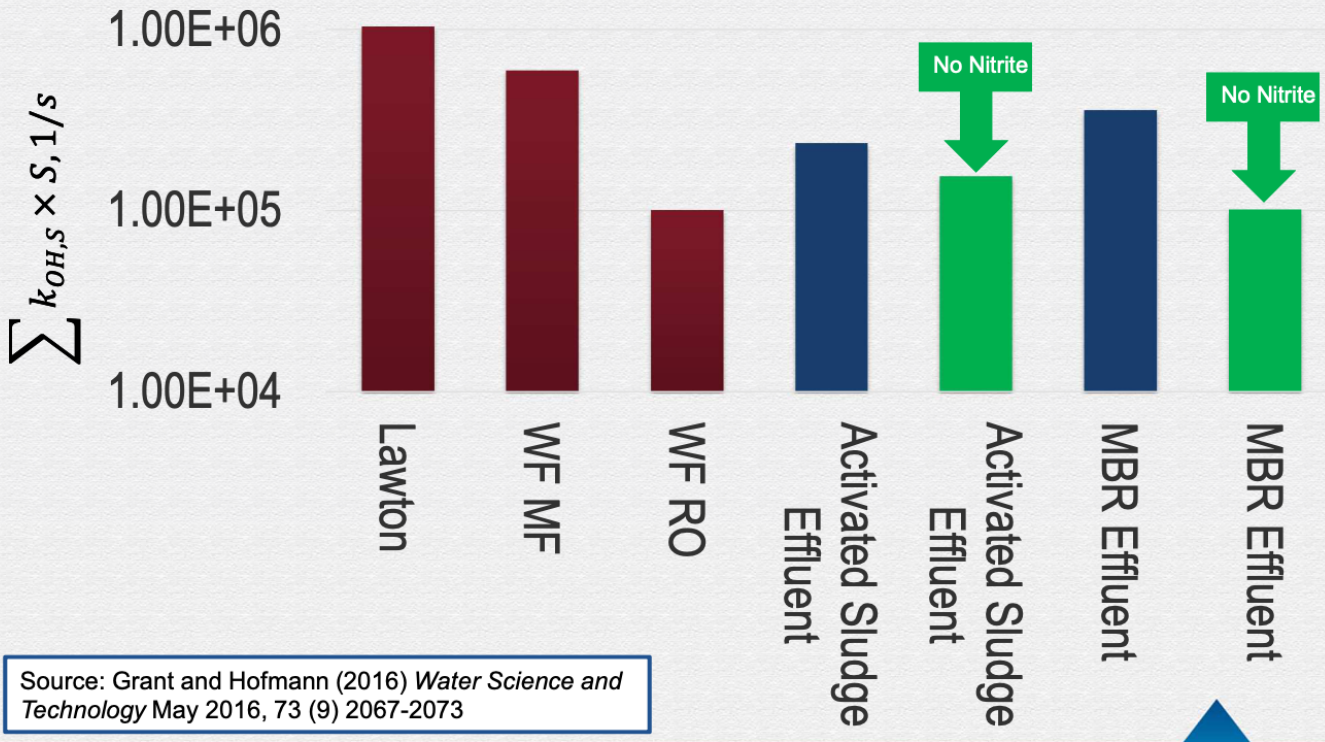
Real-time decay data collected for an ·OH-probe under UV AOP conditions (H_2O_2 and UV)



As expected, Lawton effluent had the greatest Total ·OH-Scavenging



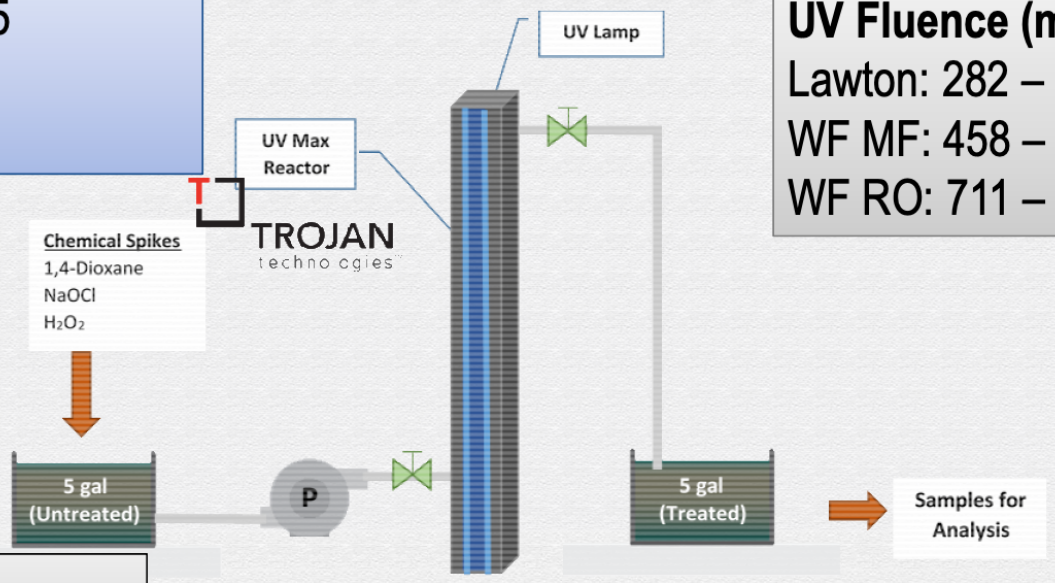
Total ·OH-Scavenging in RO permeate sample equivalent to nitrite-less MBR effluent



Source: Grant and Hofmann (2016) *Water Science and Technology* May 2016, 73 (9) 2067-2073

Each sample was dosed with a chemical oxidant and pumped at controlled rates through the annular UV reactor

NaOCl (mg/L as Cl_2)
Lawton: 12.5
WF MF: 7.8
WF RO: 4.8



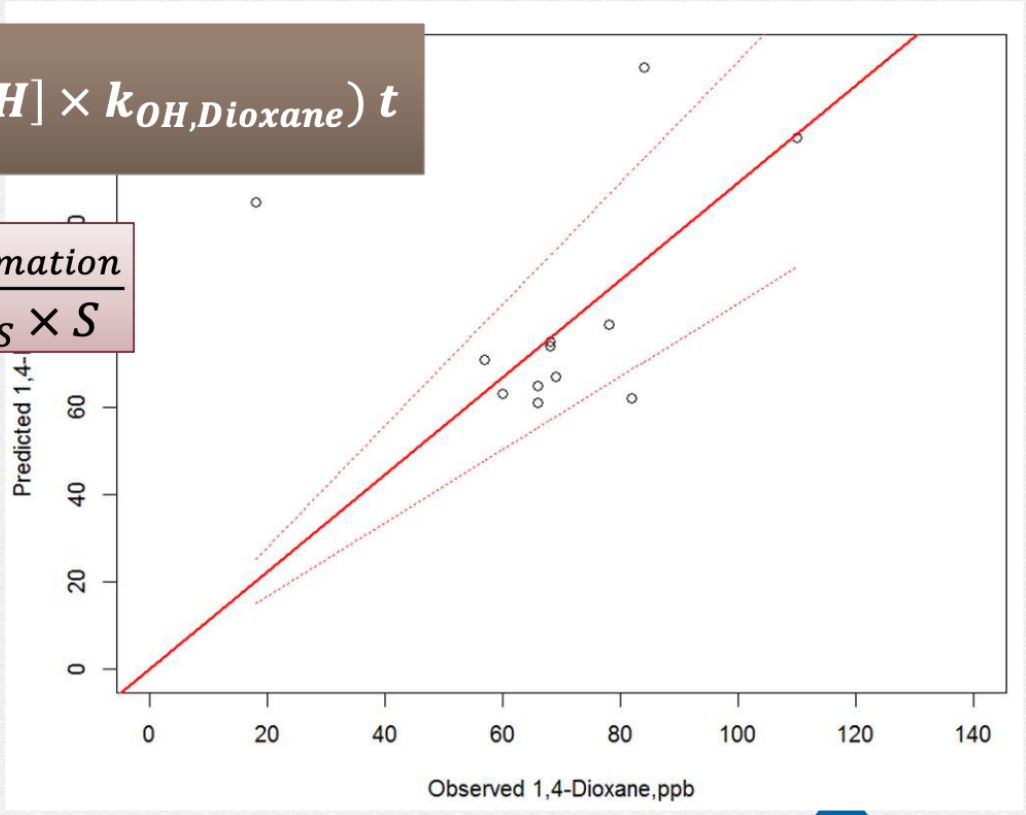
UV Fluence (mJ/cm^2)
Lawton: 282 – 364
WF MF: 458 – 493
WF RO: 711 – 735

pH
Lawton: 8
WF MF: 7.8
WF RO: 6.5

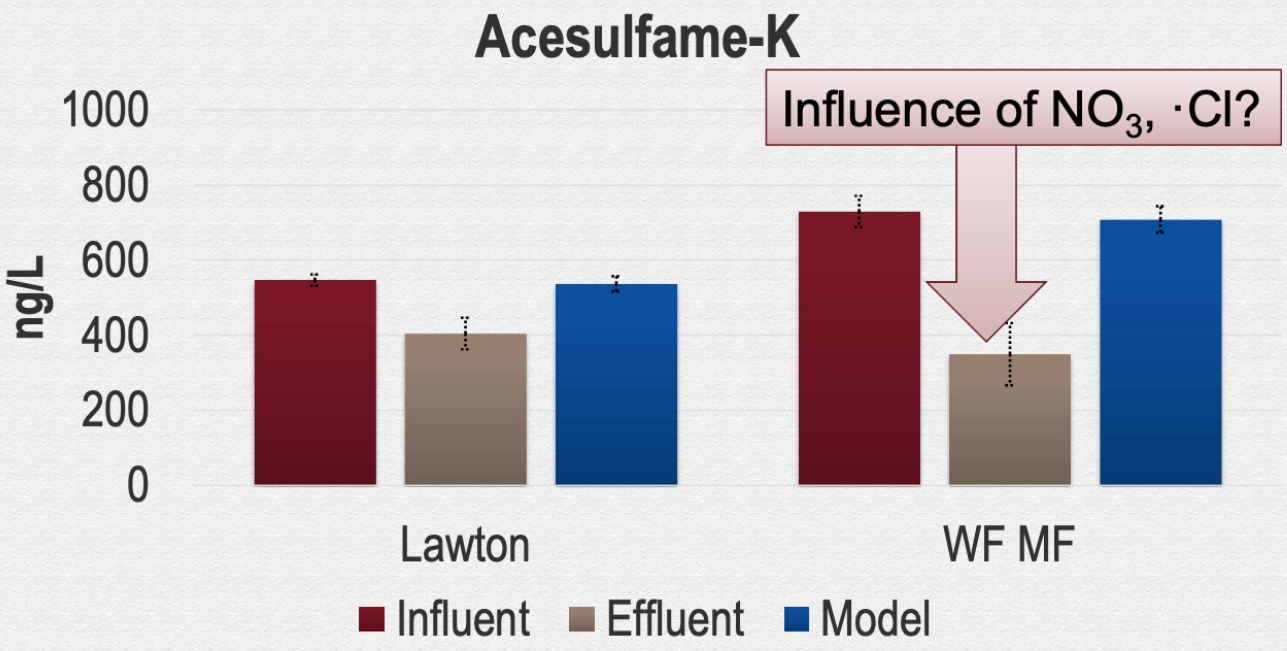
Each sample was spiked with 100 ppb 1,4-dioxane as a probe compound for monitoring AOP treatment performance

$$\ln\left(\frac{C}{C_0}\right) = -([\cdot OH] \times k_{OH,Dioxane})\, t$$

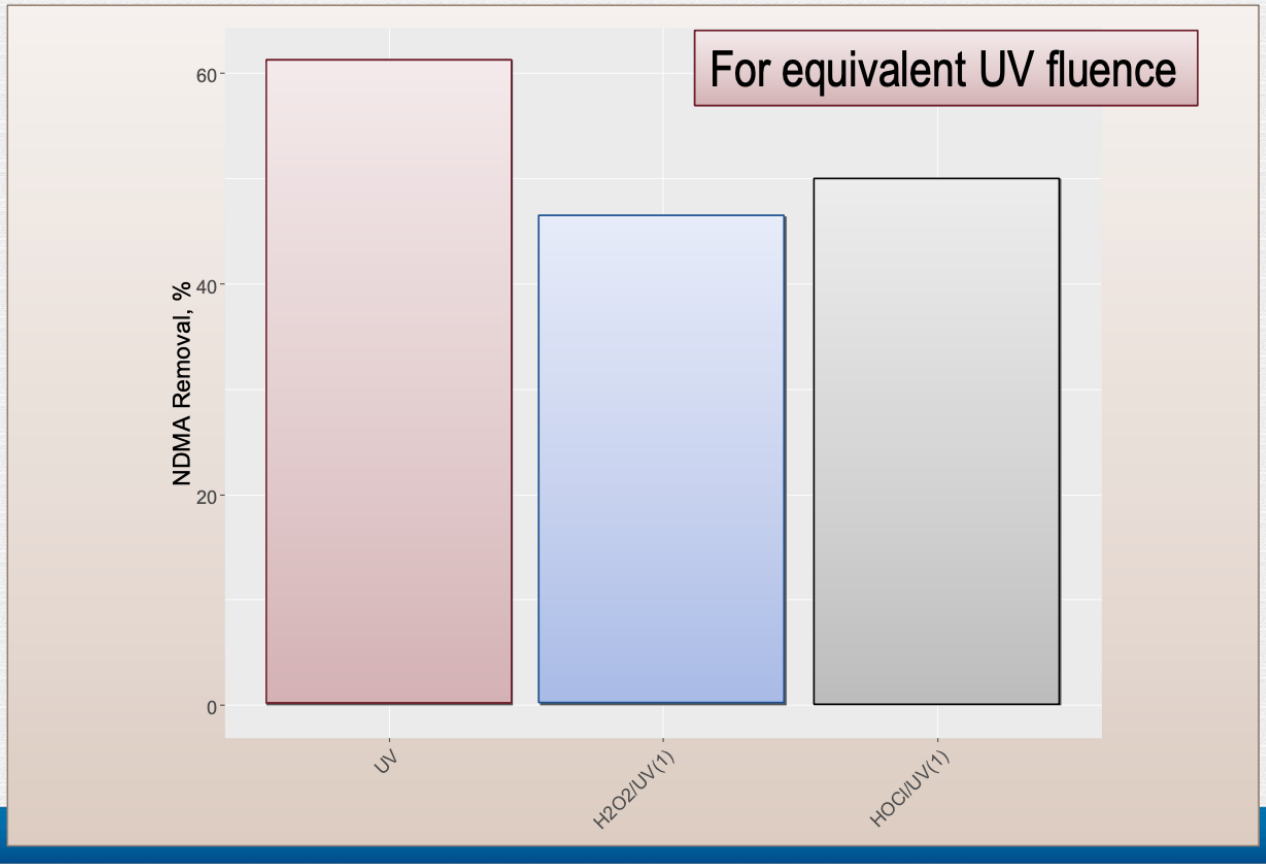
$$[OH]_{SS} = \frac{R_{OH,formation}}{\sum k_{OH,S} \times S}$$



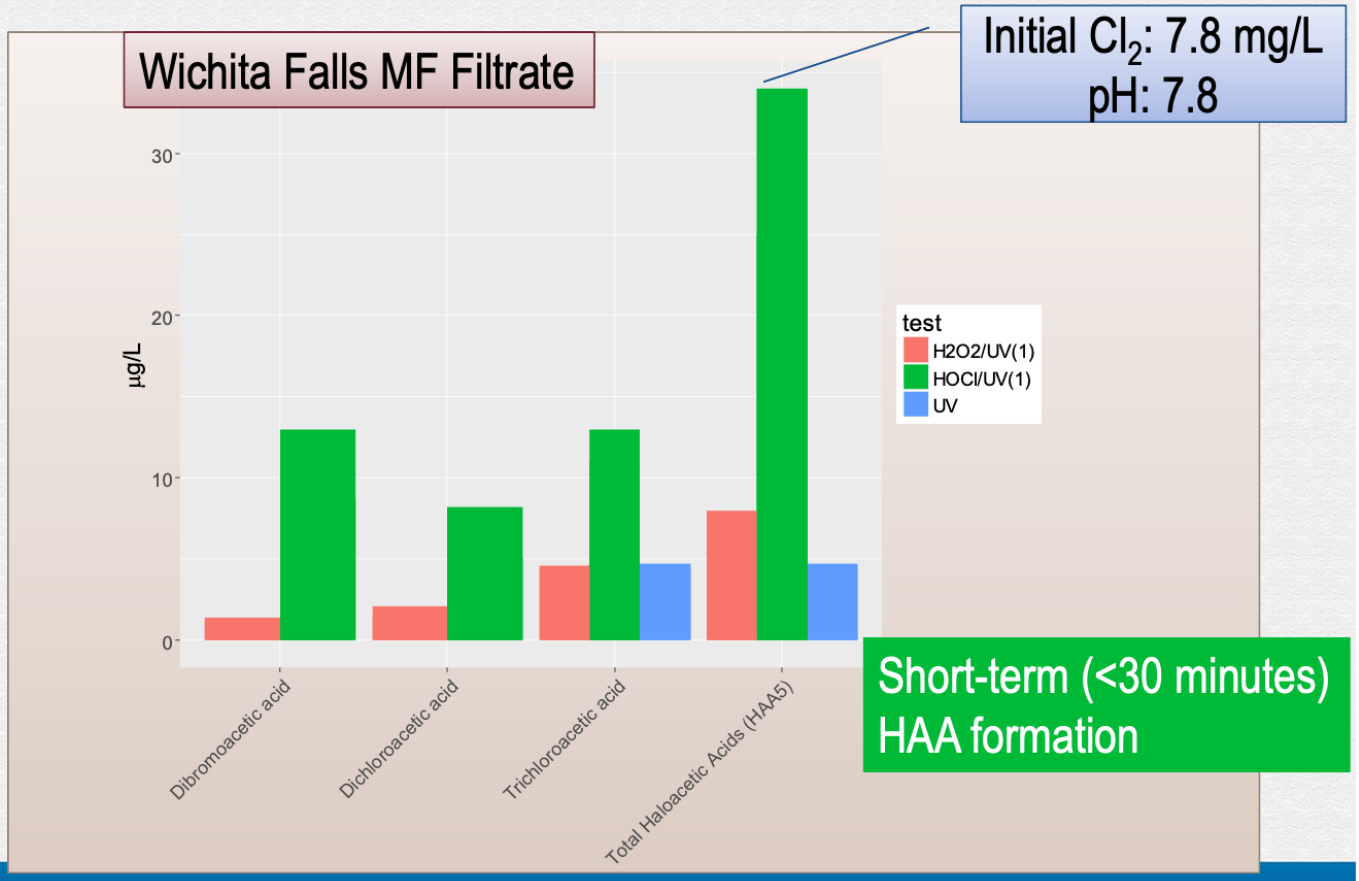
A prevalent artificial sweetener appeared susceptible to multiple oxidation pathways



The most prominent micropollutant in RO permeate samples, NDMA, was most efficiently mitigated with UV alone



Regulated DBPs may be a concern for HOCl/UV AOP



However, RO removed this short-term HAA formation potential

RO Permeate	UV	HOCl/UV	H_2O_2/UV
Dibromoacetic acid	ND	ND	ND
Dichloroacetic acid	ND	ND	ND
Monobromoacetic acid	ND	ND	ND
Monochloroacetic acid	ND	ND	ND
Total Haloacetic Acids (HAA5)	ND	ND	ND

Conclusions Drawn

Trace anthropogenic contaminants (targets for UV AOP oxidation) were detected in all reclaimed water samples, including RO permeate.

In RO permeate, NDMA was detected at greater concentrations than other micropollutants

- UV at AOP doses was most effective treatment for residual NDMA

Is UV AOP necessary following RO? The Wichita Falls DPR Model = **RO** for organics removal + **UV** for NDMA destruction

Conclusions Drawn

Upstream treatment processes that can have a significant impact on UV AOP efficiency:

- Denitrification
- Chloramination
- RO

Remaining Questions to Answer

Can disinfection by-product formation be mitigated for HOCl/UV? *Without RO*?

Which lamp technology will be most effective for HOCl/UV? *MP or LP UV*?

Expand kinetic model for HOCl/UV to assess potential impact of

- Nitrate/Nitrite in Fully Nitrified Reuse Water

Acknowledgements

- The WateReuse Texas Association
- City of Wichita Falls: Mark Southard, Daniel Nix, and Hunter Adams
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- Freese and Nichols: Chris Connolly
- Garver: Kyle Kruger
- Eurofins Analytical: Andy Eaton

Questions?

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