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UV-AOP 101 for Potable Reuse: Design Considerations and Practical Applications

UV-AOP 101

1. Common and practical applications
2. Design considerations
3. Knowledge gaps

A Brief History

1900: Peroxide was observed to be decomposed by light

1979: Peroxide + Ozone was introduced

1982: Ozone + UV was described for oxidation of TCE

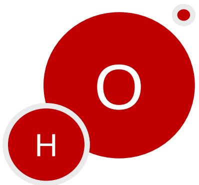
1987: Glaze et al. Introduced the term AOP in the first comprehensive review

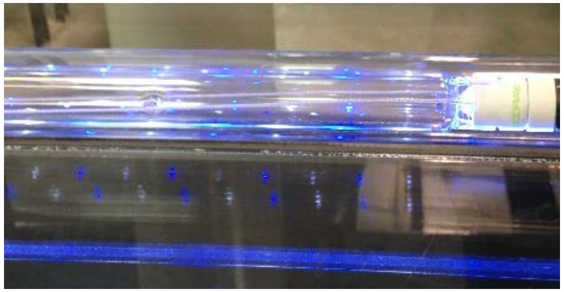
UV-AOP 101

UV + Chemical Oxidation = *Advanced* Oxidation Processes (AOP)

What's Involved:

The creation of hydroxyl radicals for the oxidation and degradation of contaminants





Combine an oxidant with either ultraviolet (UV) light or ozone

Complete mineralization can occur with a long enough contact time (CO_2, H_2O, and mineral acids)

Common Applications

1. Groundwater remediation
2. Seasonal taste and odor control
3. Organic contaminant oxidation
4. Water reuse

Effective Applications

Constituents
Taste and Odor (aesthetic) • Geosmin and methylisoborneal (MIB) from algae blooms
Organic Toxins (health parameters) • Cyanotoxins from harmful algae blooms
Constituents of Emerging Concern • Pharmaceuticals, personal care products, EDCs • Industrial Chemicals (VOCs, NDMA, 1,4-Dioxane) • Pesticides, herbicides (e.g. atrazine)

Often considered cost effective in comparison with granular activated carbon or Membranes for the removal of primarily organic contaminants

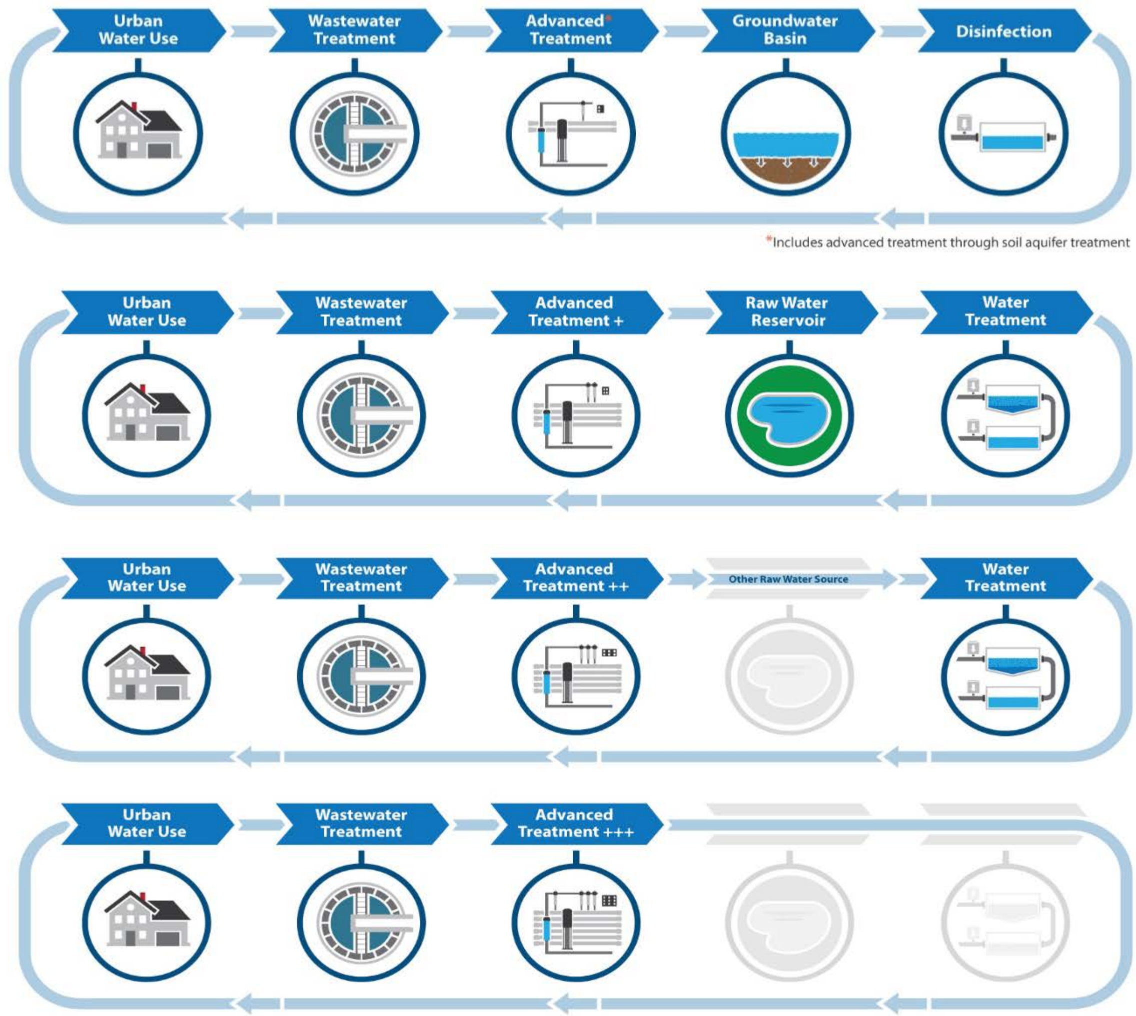
The continuum of Potable Reuse

Groundwater Augmentation

Reservoir Water Augmentation

Raw Water Augmentation

Drinking Water Augmentation



Design guidance

No guidance manuals available to aid in the design and operation of AOP (AWWA, 2016)

- UV-AOP is often applied as part of a multiple barrier treatment approach
- UV-AOP treatment objectives for purified water applications are different than for disinfection applications

Typical design dose range for UV disinfection: 20-120 mJ/cm2
Typical design dose range for UV-AOP: 400-1800 mJ/cm2

Design Considerations

Treatment goals

- Chemical reduction
- Pathogen reduction

Equipment and Chemicals

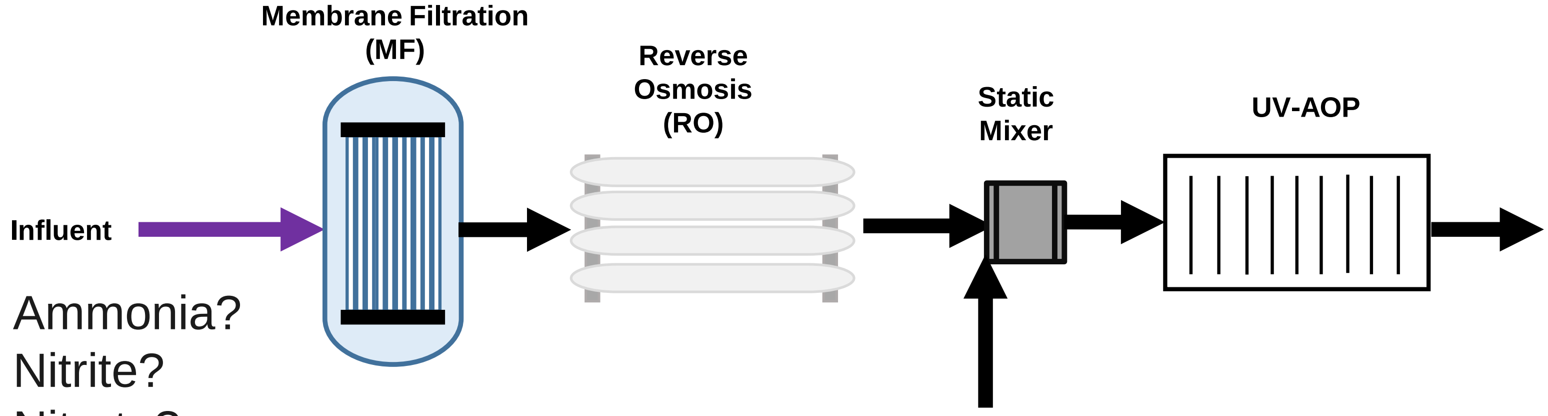
- LP or MP
- Hydrogen peroxide or chlorine

Control Strategy

- EEO
- UV Dose

Design Considerations

Upstream processes impact UV-AOP design



Ammonia?
Nitrite?
Nitrate?

H2O2 or
Chlorine

- ✓ Upstream optimization
- ✓ Industrial pretreatment program

Design Considerations

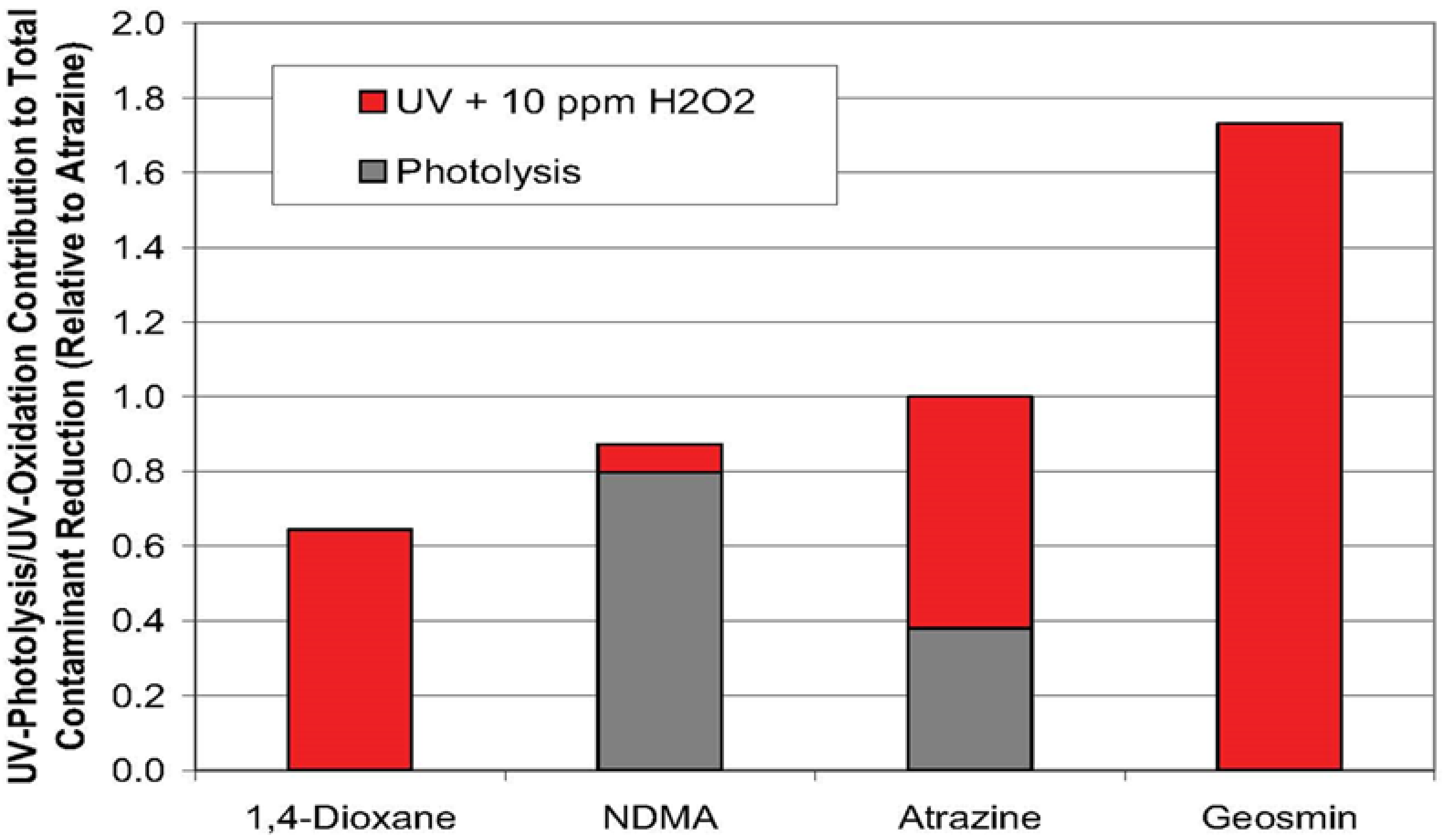
Cost and performance efficacy improves for waters with highest UVT and lowest scavenging demand

- Pilot testing recommended
- Low TOC and alkalinity will reduce scavenging of OH·

Chloramine

Decreases UVT | Increases OH· scavenging

Design Considerations



Courtesy of Trojan Technologies

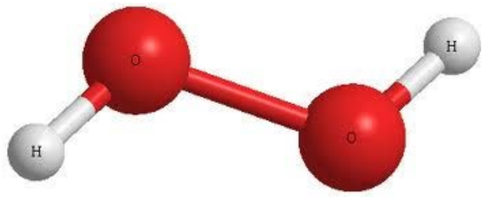
Design Considerations

No standardized validation procedures for UV-AOP

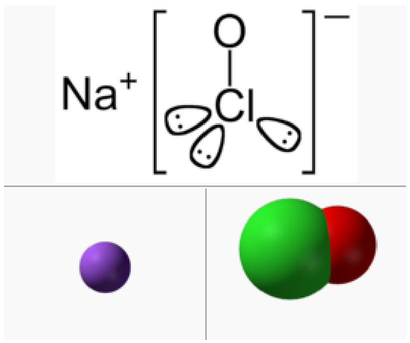
Design Considerations

Selection of Chemical Oxidant

- pH: UV/Cl2 most effective at pH<6 (e.g. RO permeate)
- Quenching requirements
- Ammonia / chloramine



Hydrogen peroxide



Sodium Hypochlorite

“Potential” Byproducts ?

- AOX
- DBPs containing N and Br- (I-)
- THMs, HAAs
- Chlorate
- DCAN, BCAN

Byproducts from AOP may result from disinfection requirements (e.g. chlorine dosing) based on site-specific water quality; and not directly from the AOP

Chlorine demand increase in distribution system after UV-H_2O_2 AOP
(Pantin, Hoffman, 2008)

Knowledge Gaps

Outstanding needs:

1. How can real-time data inform optimized treatment performance?
2. Mechanistic understanding of various AOP activators, and relative DBP production
3. Standardized validation techniques

Key Points

1. UV-AOP is effective for the removal of a broad range of contaminants; from acute to chronic risks associated with pathogens and CECs

2. Understanding site-specific water quality characteristics is critical for design to meet treatment targets

3. More research is needed to understand potential DBPs

References

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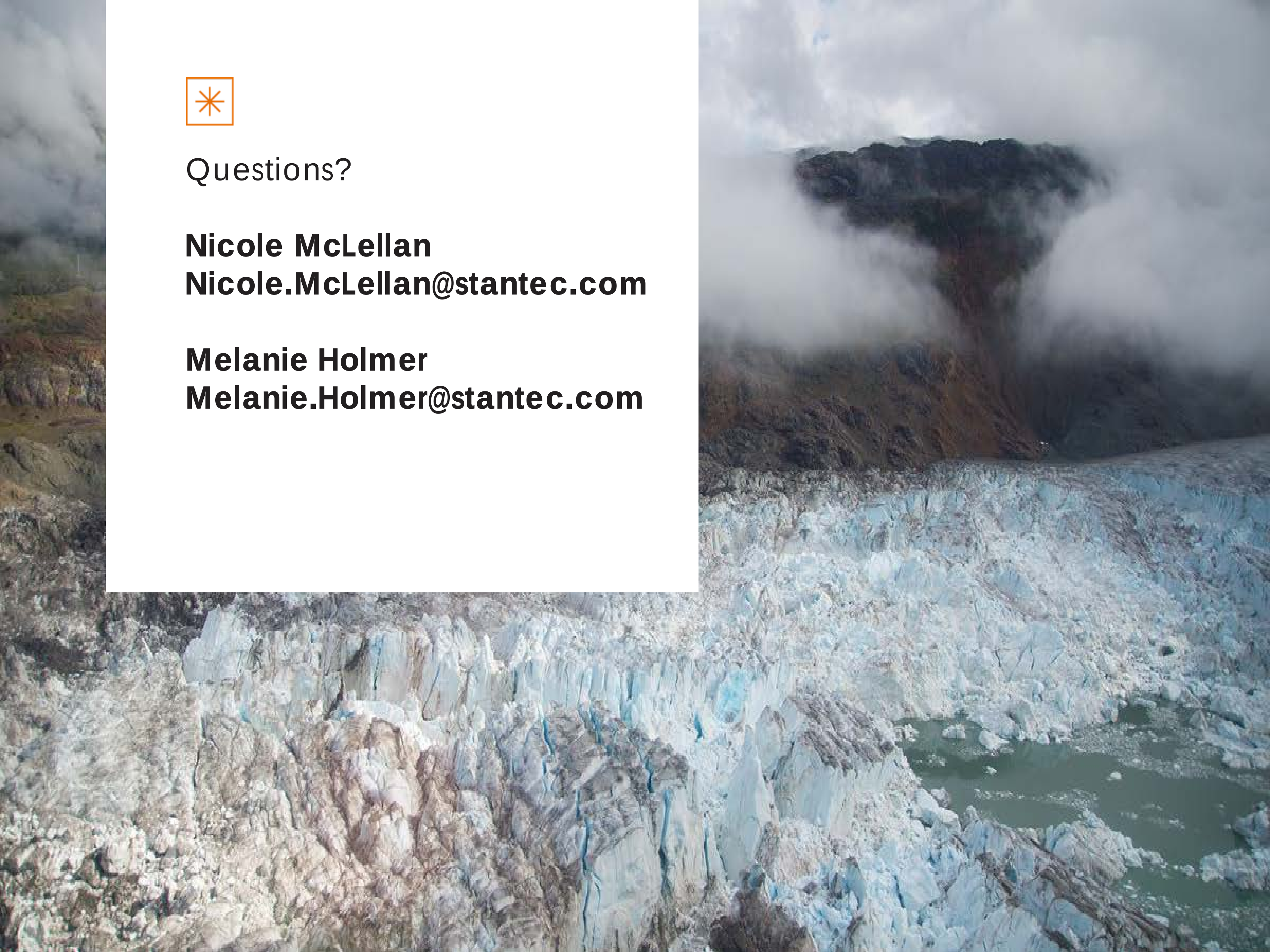

Questions?

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