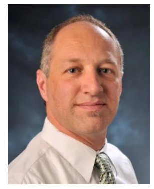
RESEARCH BRIEF
Start Date: December 2023 | Duration: 24 months

NAWI
National Alliance for Water Innovation

222nm KrCl* Driven Advanced Oxidation for Reverse Osmosis Pretreatment: Fouling Control and Chemical/Pathogen Abatement



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Challenge

When reverse osmosis (RO) is used for water reuse, pretreatment is employed to reduce large organic molecules and microorganisms responsible for organic- and biofouling, respectively but fouling is still a problem. Recent discoveries in UV advanced oxidation (UV/AOP) position UV/AOP as a novel pretreatment process for RO. KrCl* excimer lamps emit UV light at 222 nm and are highly effective at pathogen reduction, organic matter transformation, and contaminant degradation compared to conventional 254 nm LP-UV treatment. The proposed research investigates key knowledge gaps in the use and emerging application of KrCl* excimers as a UV/AOP, as few studies exist to date.

Research Approach

The overall objectives for the project are to determine the extent of RO fouling mitigation possible in real wastewaters using practical UV treatment scenarios benchmarked to LP-UV 254 nm, and the mechanism by which the observed fouling mitigation is achieved. It is also to determine the extent to which organic contaminants and viruses can be degraded using UV 222 nm technology in water matrices to meet potable water reuse goals. The project will elucidate fundamentals relevant to the proposed KrCl* 222 nm AOP pretreatment, including significant mechanisms of radical generation, the impact of water quality, and byproduct formation; to evaluate scale-up of the 222 nm technology in collaboration with industry partners and design and test a flow-through system, and support scale-up estimates; to conduct a techno-economic analysis of the proposed AOP, compared to UV 254 nm UV/AOP and integrate this analysis into NAWI's WaterTAP tool. Municipal and oil and gas wastewaters will be sourced for UV-RO fouling studies from the various project partners. Wastewaters will be exposed to both 222 nm and 254 nm UV and fouling will be measured post UV exposure and compared to observed fouling in the absence of any UV pretreatment.

RESEARCH PARTNERS

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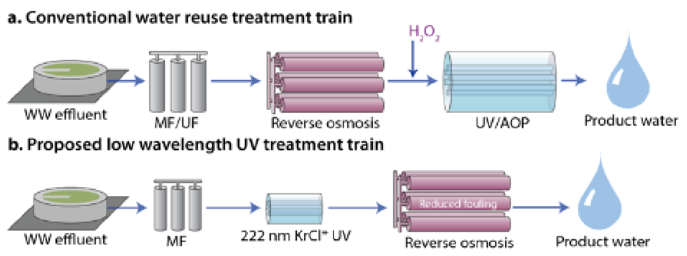

Figure 1. Proposed UV 222 nm pretreatment train to mitigate RO fouling. Note this process train would eliminate the need for UF pretreatment and LP UV/H_2O_2 AOP posttreatment of RO.

Impact

The proposed project has a specific target of reducing membrane fouling by at least 20% and meeting or exceeding performance of the current state of the art LP UV technology in a side-by-side comparison. If achieved, this improvement will translate to decreased operations and maintenance costs associated with both reverse osmosis and UV advanced oxidation. These cost savings will in turn facilitate reuse of the complete suite of source waters of interest to NAWI and has positive impacts on many NAWI pipe parity metrics. Examples include leading to a more efficient use of electricity (i.e., fewer "wasted" photons). KrCl* excimer lamps do not contain mercury and are thus more environmentally friendly and consistent with the goal of reducing the use of mercury under the Minamata Convention. The proposed UV/AOP requires few inputs other than electricity, reducing cost and chemical consumption. If in situ nitrate, chloramines or free chlorine are used as the radical promoter then the only chemical input required is for routine lamp cleaning, as opposed to a chemical-based disinfection unit process for control of biofouling. Potable reuse FAT trains already have downstream UV/AOP installed, so they likely already have the technical and operational capacity for an alternative UV/AOP unit process. Electrified treatment such as this proposed UV/AOP can interface with sensors and telemetry, allowing for operational changes in response to a water quality signal or change in treatment goal.

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