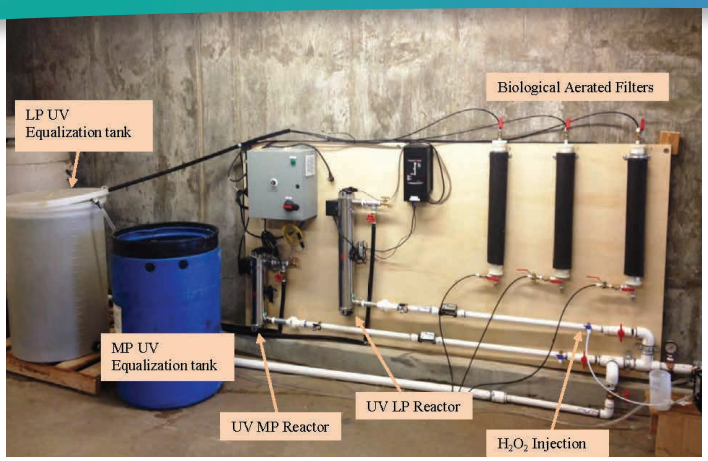
Executive Summary

WERF

Using ultraviolet and advanced oxidation processes to break down trace organic contaminants

Demonstrating Advanced Oxidation/ Biofiltration for Pharmaceutical Removal in Wastewater (U2R11)



The UV/AOP + BAF Pilot System.

The Central Issue

Since the mid 1990s, trace organic compounds (TOrC) have repeatedly been detected in wastewater and in the environment. Wastewater treatment plants are not typically designed to remove TOrC. Use of ultraviolet (UV)-based advanced oxidation processes (AOP) to remove emerging contaminants has been well demonstrated. One of the outcomes of AOP transformation of TOrCs is generation of more biodegradable oxidation products. This research evaluated the efficacy of UV-based AOP followed by bio-filtration as an integrated treatment solution to remove TOrCs from wastewater.

Context and Background

This research sought to develop and demonstrate design criteria for UV/hydrogen peroxide H_2O_2 AOP followed by downstream biofilm-based treatment for removing biologically recalcitrant pharmaceuticals from wastewater bioreactor effluents. Eighteen compounds belonging to different classes were selected for the study based on their environmental relevance (detection frequency and potential toxicity). The team first conducted bench-scale experiments on UV/H_2O_2 combined with biodegradation. When these experiments demonstrated the potential of the proposed UV/AOP plus biodegradation treatment train, the team evaluated the transformation of TOrC during UV disinfection of wastewater at eight full-scale treatment facilities. In the final task, the research team extended the benchscale study to a pilot plant that was installed at the City of Boulder Colorado's 75th Street wastewater treatment facility.

Findings and Conclusions

The team concluded that many of the transformation products formed during the UV/AOP could be removed by subsequent BAF, demonstrating the potential of the treatment train combination to remove TOrC from wastewater. Specific conclusions drawn from each phase of the research are included in the full report.

Management and Policy Implications

This research addresses questions directly relevant to the full-scale use of existing infrastructure for TOrC removal optimization. UV/AOP breaks down recalcitrant TOrC, generating biodegradable transformation products which can be further removed by subsequent biofiltration. This research also validates use of an inexpensive sweetener (sucralose) as a conservative probe for characterizing the UV/AOP transformation of TOrC.

The 18 Target Compounds Selected for This Study

Compound	Class
Trimethoprim, clarithromycin, sulfamethoxazole	Antibiotics
CBZ	Anti-epileptic drugs
Naproxen, diclofenac, ibuprofen	Anti-inflammatory
Atenolol, metoprolol	ß-blockers
Diphenhydramine	Antihistamines
Gemfibrozil	Lipid regulators
Lamotrigine, venlafaxine	Antidepressants
IOP	X-ray contrast agent
Acetaminophen	Pain reliever
2,4-D	Herbicides
Caffeine	Stimulant
Sucralose	Artificial sweetener

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Related WERF Research

Project Title	Research Focus
Trace Organic Compound Removal during Wastewater Treatment (CEC4R08)	Multi-faceted effort intended to answer: ■ What compounds should be best monitored to assess performance? ■ How does process operation affect trace organic chemical removal? ■ Can we model predict PPCP removal at a WWTP? ■ How well does solids processing (e.g., anaerobic digestion) remove TOrCs?
Understanding Microaerobic Metabolism in a Sustainable World (U1R09)	Evaluates the fate of pharmaceuticals at trace concentrations through bioreactors that either achieve nitrogen removal (anoxic/aerobic, microaerobic with nitrate limitation, microaerobic with nitrate sufficient) or achieve ammonia oxidation but not nitrogen removal (aerobic).
Demonstrating Advanced Oxidation Coupled with Biodegradation for Removal of Carbamazepine (INFR6SG09)	The basis for the U2R11 research project, this effort focuses on carbamazepine (a frequently found and recalcitrant PPCP in conventional wastewater treatment) that was removed to a lesser extent in the root zone during irrigation with recycled water. However, UV light in combination with hydrogen peroxide produced breakdown products that could then be completely biodegraded. This advanced treatment holds promise for other ring-bearing compounds.

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