# Executive Summary

WERF

# Predicting the removal of trace organics in conventional wastewater treatment

**Trace Organic Compound Indicator Removal during Conventional Wastewater Treatment (CEC4R08)**

## The Central Issue

Trace organics comprise various groups of compounds including pharmaceuticals, personal care product chemicals, food additives, and other high production chemicals. There is increasing interest in evaluating occurrence and removal of trace organic compounds during conventional wastewater treatment because of aquatic health concerns. Due to the large number and variety of compounds present in municipal wastewater influents, guidance is needed for assessing their removal efficiency in conventional wastewater treatment. This study focused on the performance of activated sludge treatment processes and sought to answer: *Can we predict which types of trace organics are, or are not, efficiently removed during various treatment configuration and operational conditions?*

## Context and Background

Research (including full-scale anaerobic digestion) shows that the degree to which trace organics are removed during conventional wastewater treatment is very compound specific. It also depends on process, operational, and seasonal conditions. This study identifies a suite of 22 suitable performance indicators grouped into nine bin categories that allow for a rapid characterization of performance efficiency of conventional wastewater treatment facilities. Solid retention time (SRT) was found to drive the biotransformation of indicator compounds that are moderately biotransformed. Threshold SRTs were defined for each indicator that exhibited more than 80% removal.

## Findings and Conclusions

This research defines and quantifies synergies between specific operational process changes and process upgrades that may be considered for improving nutrient removal and benefit trace organic removal. Additionally, the findings assess the reliability and accuracy of current fate modeling for predicting trace organic removal during activated sludge treatment.

Findings indicate that highly and moderately sorbable trace organics are found in significant amounts on the wasted solids from secondary treatment systems. Recalcitrant and highly sorbable trace organics such as triclocarban accumulated on the solids in systems operating under long SRTs, resulting in trace organic loads in wasted solids that actually exceeded the secondary influent loads. Additional investigations revealed that several recalcitrant trace organics were not reduced during anaerobic digestion, but were found in increased concentration in the digested sludge in relationship to the solid destruction achieved (e.g., carbamazepine). This finding highlights the potential for accumulation of hydrophobic, non-degradable trace organic sludges in liquid stream processes and on biosolids. Methods need to be investigated to effectively reduce such compounds in solid process streams. Conventional liquid and solid stream treatment proved to be ineffective. Study findings place conventional secondary treatment for trace organic removal into perspective with the costs and benefits of alternative attenuation processes such as activated carbon adsorption, ozone, and membrane treatment.

## Management and Policy Implications

The findings will help utilities, planners, design engineers, and researchers better predict which types of trace organic compounds are, or are not, efficiently removed during various treatment configuration and operational conditions. While regulatory requirements that define discharge limits for trace organics do not exist today, it is anticipated that regulations will be developed in the coming years and some regions of the U.S. already require monitoring for certain trace organics. Many utilities are currently required to invest in process upgrades in order to comply with more stringent nutrient limits for nitrogen and phosphorus. Removal of trace organics generally increases with advanced nutrient removal. Integrating treatment processes capable of attenuating trace organics in current master planning efforts could reduce compliance costs in the long-term.

**Trace Organics Removal Prediction Using Plant Condition and Fate Criteria.**

| | Degradable/Low Sorption | | Sorbable/ Slow Degradation | Sorbable/ Degradable |
|---|---|---|---|---|
| Recalcitrant | Low SRT/HRT | Medium/High SRT/HRT | | |
| Sucralose<br>Carbamazepine<br>TCEP | Ibuprofen<br>Naproxen<br>Acetaminophen<br>Caffeine | DEET<br>Atenolol<br>Trimethoprim | Triclocarban<br>TCPP | Fluoxetine<br>Meprobamate<br>Gemfribrozil<br>Triclosan |

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### Related WERF Research

| Project Title | Research Focus |
|---|---|
| **Contributions of Household Chemicals to Sewage and Their Relevance to Municipal Wastewater Systems and the Environment (03CTS21UR)** | Developed quantitative structure activity and property relationships (QSPR) that can model the behavior of individual compounds through treatment processes. Includes a database of HPV chemicals and organic compounds found in household commodities. |
| **Fate of Pharmaceuticals and Personal Care Products Through Municipal Wastewater Treatment Processes (03CTS22UR)** | Surveyed a list of 20 pharmaceuticals and personal care products (PPCPs) and assessed their removal through secondary treatment. The study data examined if the removal of these compounds is influenced by the solids retention time (SRT) – the master variable in the operation of activated sludge secondary treatment. PPCP removal through subsequent tertiary media filtration, disinfection, and membrane bioreactor processes were also evaluated. |
| **Development of Indicators and Surrogates for Chemical Contaminant Removal during Wastewater Treatment and Reclamation (04HHE1CO)** | Provides guidance to the water reuse industry on how to assure proper removal of wastewater-derived chemical contaminants in indirect potable reuse applications using a combination of tailored surrogate parameters and a select list of indicator compounds. |
| **Diagnostic Tools to Evaluate Impacts of Trace Organic Compounds (CEC5R08a, CEC5R08b, CEC5R08c)** | Developed diagnostic tools for water quality managers to assess and monitor trace organics in their treatment processes and watersheds. Companion parts of this project include a trace organics prioritization method, a report on diagnostic approaches and types of analyses in aquatic systems used to identify causes of ecological impairments, seven case studies, and web-based database to help users search and evaluate trace organic data. |
| **Performance Dynamics of Trace Organic Chemicals in Onsite Treatment Units and Systems (DEC14U06)** | Investigates the fate and occurrence of trace organics in onsite wastewater systems to understand the presence and reduction of trace organics in these systems. |
| **Trace Organic Chemicals in Biosolids-Amended Soils: State-of-the-Science Review (SRSK5T09)** | Explores and prioritizes which trace organics are of greatest concern in the soils based on basic properties such as bioaccumulation and toxicity. A literature review identified relevant data on fate, transport, biotransfer from soil to plants and animals, and toxicity in the terrestrial environment. Findings identified data gaps for conducting terrestrial risk assessments. |
| **Gathering Unpublished Data for Compounds Detected in Biosolids (TOBI1T11)** | Building on WERF's 2010 report *Trace Organic Chemicals in Biosolids-Amended Soils: State-of-the-Science Review* (SRSK5T09), this research assembled high-quality, unpublished data on 61 trace organics detected in biosolids. Human health benchmarks were identified for 29 of the 61 trace organics. Findings help inform the risk assessment efforts underway at U.S. EPA for compounds that have been reported in the Targeted National Sewage Sludge Survey (TNSSS) and data gaps for future research. |
| **Evaluation of QSPR Techniques for Wastewater Treatment Processing (U2R07)** | Evaluated Quantitative Structure Property Relationship (QSPR) techniques for predicting key wastewater treatment processes – sludge sorption, activated-sludge biological, and chlorine oxidation transformation. QSPR provides potentially powerful tools that utilities can use to screen the fate of trace organics during wastewater treatment processes. Study findings were used as input in WERF's CEC4R08 report, which provides reliable mass balance modeling tools that describe and predict removal efficiencies for a wide range of trace organics. |
| **Developing a Standardized Protocol for Assessing the Biodegradability of Trace Organic Compounds (U3R10)** | Establishes a standardized approach for site-specific evaluations of trace organics removal and a protocol that outlines how to perform biodegradation tests under conditions that closely match the system being considered – biological technologies. |

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| **Demonstrating Advanced Oxidation/Biofiltration for Pharmaceutical Removal in Wastewater (U2R11)** | Develops and demonstrates design criteria for UV/$H_2O_2$ advanced oxidation process (AOP) followed by downstream biofilm-based treatment for removing biologically recalcitrant pharmaceuticals like carbamazepine from wastewater effluents. It builds on WERF study *Demonstrating Advanced Oxidation Technologies on Pharmaceutical Removal Downstream of Biological Treatment* (INFR6S609) which demonstrates that UV light in combination with hydrogen peroxide produces breakdown products that could be completely biodegraded. It also established analytical methods. |
| **Holistic Assessment of Trace Organic Compounds in Wastewater Treatment (U3R11)** | Sacramento Regional Sewer District is designing an upgraded $2 billion treatment facility to comply with a new discharge permit. This WERF study of trace organic treatment performance will demonstrate testing of biological nutrient removal (BNR), filtration, and disinfection treatment technologies. The project outcomes will provide a roadmap for agencies considering upgrading for nutrient removal now and trace organics reduction later. |


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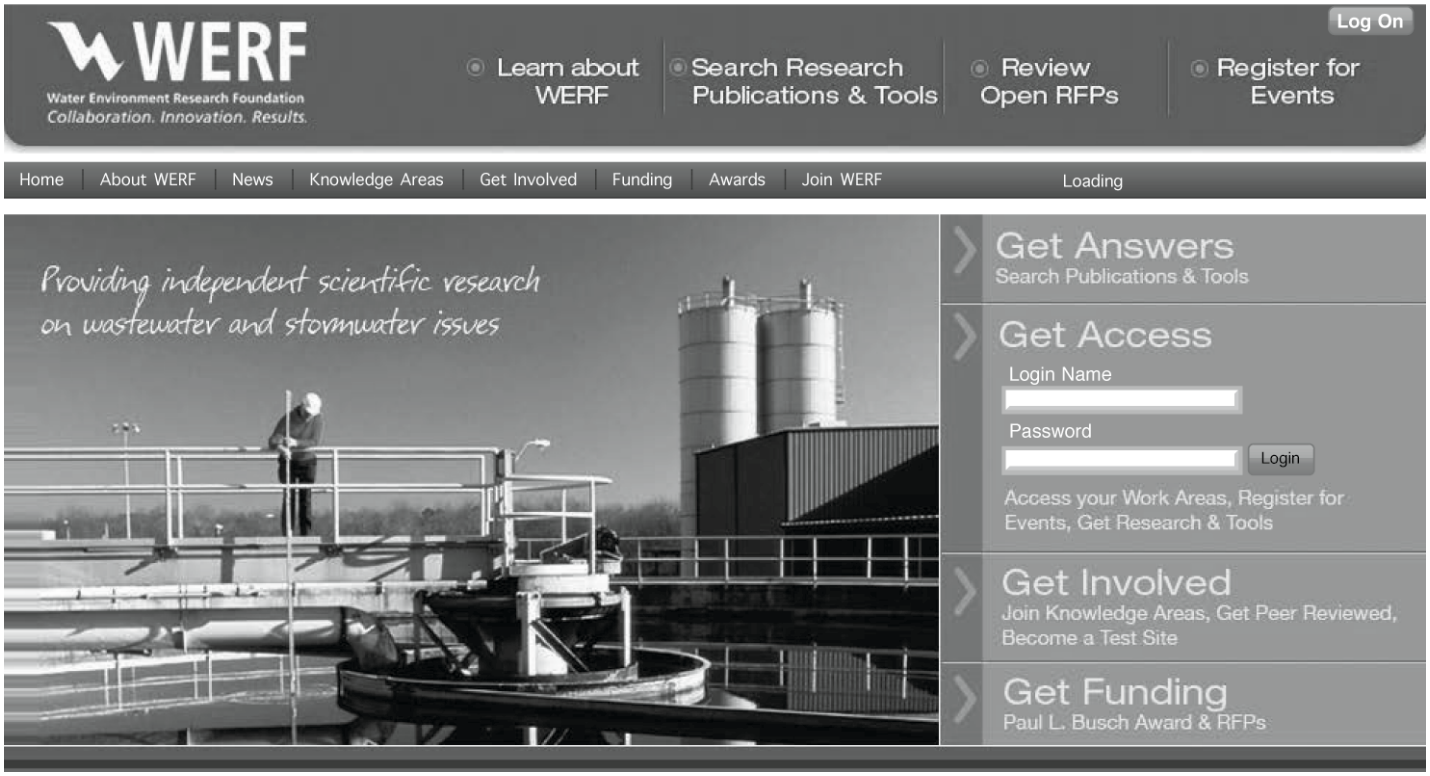


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