Development of Indicators and Surrogates for Chemical Contaminant Removal during Wastewater Treatment and Reclamation

This study 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. The recent detection of a variety of chemicals in municipal wastewater effluent has raised concerns about the potential presence of wastewater-derived chemical contaminants in water produced by indirect potable reuse systems. Since it is impossible to measure all chemicals present in recycled water, the approach developed in this study uses a combination of surrogate parameters that are easy to measure and can serve as performance measures of a treatment process. WERF, as a co-sponsor, worked with the WateReuse Foundation, the Bureau of Reclamation, and the California State Water Resources Control Board on this report. This project was managed by the Water Reuse Foundation.

Pilot-scale membrane bioreactor at Facility 1.

Selecting multiple indicators representing a broad range of properties will allow water managers to account for compounds currently not identified ("unknowns") and new compounds synthesized and entering the environment in the future (e.g., new pharmaceuticals). The underlying concept is that absence or removal of an indicator compound during a treatment process would also assure absence or removal of unidentified compounds with similar properties.

Regulatory agencies and utilities have struggled with this issue because the wastewater-derived chemicals often are present at extremely low concentrations and no standardized analytical methods are available. In only a few cases have specific compounds been detected at concentrations that pose potential risks to drinking water supplies (CDPH, 2007) or aquatic ecosystems (Jobling et al., 1998; Kelce and Wilson, 1997). Therefore, the objectives of this project were to: (a) identify surrogate parameters and indicator compounds for wastewater-derived chemical contaminants that might be useful in the assessment of indirect potable reuse systems; (b) identify and assess the performance of analytical methods for the chosen surrogates and indicators; and, (c) validate the ability of chosen surrogates and indicators to predict the occurrence and removal of wastewater-derived contaminants in indirect potable water reuse systems.

The Concept of Indicators and Surrogates to Monitor Removal Efficiency

In this study, an indicator compound is an individual chemical occurring at a quantifiable level, which represents certain physicochemical and biodegradable characteristics of a family of trace constituents that are relevant to fate and transport during treatment, providing a conservative assessment of removal. A surrogate parameter is a quantifiable change of a bulk parameter that can serve as a performance measure of individual unit processes or operations regarding their removal of trace compounds. The research team

BENEFITS

- Provides guidance 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.
- Provides guidance on how the surrogate and indicator framework could be integrated into performance monitoring programs and compliance monitoring for overall treatment trains leading to indirect potable reuse.

RELATED PRODUCTS

Removal of Endocrine Disrupting Compounds in Water Reclamation Processes (01HHE20T)

Contributions of Household Chemicals to Sewage and Their Relevance to Municipal Wastewater Systems and the Environment (03CTS21UR)

Fate of Pharmaceuticals and Personal Care Products Through Municipal Wastewater Treatment Processes (03CTS22UR)

Trace Organic Compounds and Implications for Wastewater Treatment (CEC3R07)

Evaluation of QSPR Techniques for Wastewater Treatment Processes (U2R07)

RELATED ONGOING RESEARCH

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grouped potential indicator compounds into four removal categories: "Good Removal" (> 90%), "Intermediate Removal" (90% < x < 50% and 50% < x < 25%), and "Poor Removal" (< 25%). For each treatment process where analytical methods existed, a master list of indicator compounds was provided from the final list of viable indicator compounds present in secondary or tertiary treated wastewater effluents. Results revealed that surrogate parameters are not strongly correlated with the removal of indicator compounds occurring at ng/L-level concentrations. Adopting the treatment bin framework can assist in properly tailoring multiple barriers of treatment processes with a demonstrated ability to remove wastewater-derived contaminants in indirect potable reuse applications.

The proposed framework is designed to assure proper removal of identified and unidentified wastewater derived organic contaminants and to detect failures in system performance. The individual steps to develop a surrogate/indicator monitoring framework are summarized in Table 7-2 in the report.

Monitoring Chemical Contaminant Removal

To monitor system performance at a given facility, the selection of appropriate indicator compounds will depend on the treatment processes employed comprising an overall treatment train and the geographic and temporal variations in the occurrence pattern of certain wastewater-derived contaminants. Therefore, the determinations of an indicator/surrogate monitoring framework for a given treatment train will likely be site specific. Examples in the report are provided for soil-aquifer treatment, advanced oxidation processes, and reverse osmosis treatment to describe what a monitoring program may look like.

Recommendations for Full-Scale Operation/Compliance Monitoring

The research team recommends a monitoring program adopting the surrogate/indicator framework that distinguishes monitoring during an initial piloting or start-up followed by full-scale operation/compliance monitoring for indirect potable reuse.

Table 1. Sensitive Surrogate Parameters Identified for Different Treatment Categories.

Mechanism	Surrogate for Treatment Process	Performance Assessment
Biodegradation	Soil-Aquifer treatment Riverbank filtration Membrane bioreactor	BDOC; DOC; UVA; TOX; ammonia; nitrate Specific fluorescence; SUVA; 3D-Fluorescence TOC; UVA
Chemical Oxidation	Ozone	UVA; color; 3D-Fluorescence formate; AOC Contact time (CT)
	AOP (ozone/H_2O_2; ozone/UV; UV/H_2O_2)	UVA; color; 3D-Fluorescence formate; oxalate; aldehyde; AOC
	Chlorination	Contact time (CT)
	Chloramination	Not a viable process to remove wastewater-derived organic contaminants
Ultraviolet Disinfection	Low-pressure UV	Not a viable process to remove wastewater-derived organic contaminants
Adsorption	Powdered activated carbon Granular activated carbon	ΔUVA; 3D-Fluorescence ΔUVA; 3D-Fluorescence; ΔTOC
Physical Separation	Reverse Osmosis Nanofiltration	conductivity; boron calcium; magnesium

CONTRACTOR

Jörg E. Drewes, Ph.D.
Colorado School of Mines

RESEARCH TEAM

David Sedlak, Ph.D.
Mong Hoo Lim
University of California-Berkeley

Eric Dickenson, Ph.D.
John Luna
Colorado School of Mines

Shane Snyder, Ph.D.
Brett Vanderford
Becky Trenholm
Southern Nevada Water Authority

PROJECT STAKEHOLDER ADVISORY COMMITTEE

Anthony Andrade
Southwest Florida Water Management District

Rick Arber
Richard P. Arber and Associates

Steve Carr, Ph.D.
Martha Tremblay
County Sanitation Districts of Los Angeles County

Jim Crook, Ph.D.
Crook Environmental

Douglas Drury, Ph.D.
Clark County Water Reclamation District

Andy Eaton, Ph.D.
MWH Laboratories

John Kmiec
Tucson Water

Sam Mowbray, Ph.D.
Orange County Sanitation District

Mike Neher
City of Henderson

Margie Nellor
Nellor Environmental

Rick Pleus, Ph.D.
Intertox, Inc.

Dave Rexing
Southern Nevada Water Authority

Rick Sakaji, Ph.D.
California Department of Public Health

Mike Wehner
Orange County Water District

David York, Ph.D.
Florida Department of Environmental Protection

PROJECT ADVISORY COMMITTEE

Robert Huiltquist
California Department of Public Health

Edward Bouwer, Ph.D.
Johns Hopkins University

Frank Leitz, Ph.D.
U.S. Bureau of Reclamation

William Mitch, Ph.D.
Yale University

Lola Olabode, M.P.H.
Water Environment Research Foundation