Executive **Summary**

WATER ENVIRONMENT & REUSE FOUNDATION

Rationale for effluent permits to ensure overall net benefits to water quality

Sustainability Evaluation of Nutrient and Contaminants of Emerging Concern Removal Technologies Using Life Cycle Assessment (NUTR5R14f)

The Central Issue

Both high level nutrient removal and contaminants of emerging concern (CEC) removal require advanced treatment processes. These processes are generally energy and chemical intensive. Higher usage of chemicals and energy are associated with the increased life cycle toxicity and other environmental impacts. Therefore, it is necessary to evaluate the balance between benefits achieved from removal of nutrients and CECs, and the environmental costs due to additional chemical, energy, and materials usage.

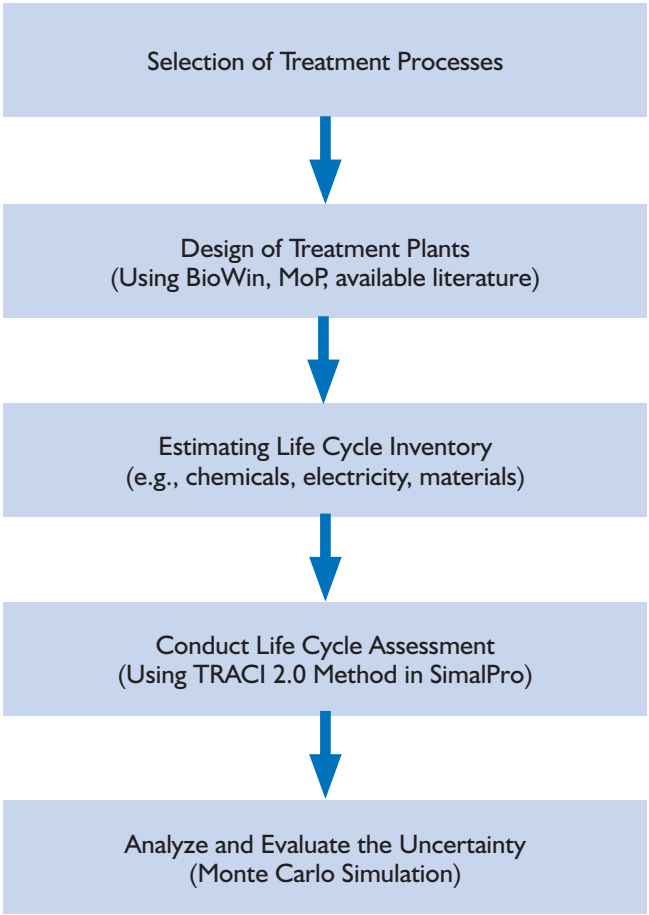
Context and Background

This study evaluated and compared the environmental impacts associated with different levels of wastewater treatment technologies that are designed for various degrees of nutrient removal and for potential CEC removal using the Life Cycle Assessment (LCA) method. Based on a previous WE&RF project *Nutrient Management: Regulatory Approaches to Protect Water Quality Volume 1: Review of Existing Practices* (NUTR1R06i), three levels of treatment with a variety of 27 treatment technologies and process scenarios for nutrient removal were evaluated and compared for environmental, economic, and health impacts. 62 treatment alternatives consisting of different combinations of advanced tertiary processes for CECs elimination were designed and analyzed applying the LCA method to interpret the environmental impacts associated with CEC removal technologies.

The research provides a method which demonstrates a multi-criteria analysis of the environmental, social, and health impacts associated with wastewater technology implementation for nutrient and CEC removal. It evaluates and compares the potential co-benefits and co-costs brought by implementing advanced treatment technologies for removing and transforming a large variety of CECs. It also provides an LCA analysis of 27 nutrient removal technology scenarios targeting three levels of nutrient removal, as well as an LCA analysis of 64 different treatment scenarios that incorporate various secondary and tertiary processes for both nutrient and CEC removal.

Findings and Conclusions

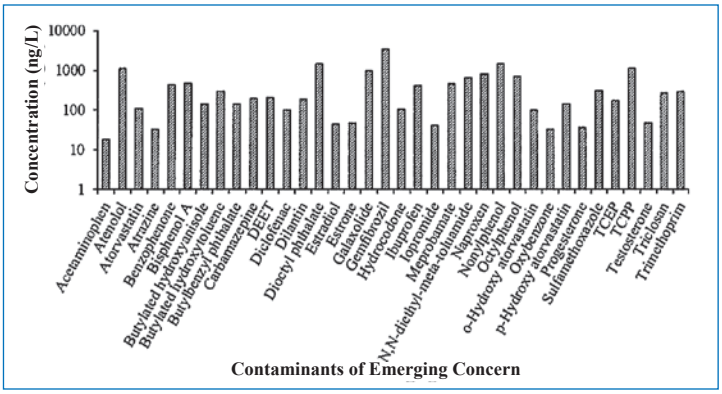
The implementation of more advanced technologies to achieve higher-level nutrient removal significantly reduced the point-source eutrophication potential. However, the LCA of the different nutrient removal technologies indicated that the benefits achieved from the reduction of eutrophication through nutrient removal can be outweighed by the negative impacts caused from the additional chemical and energy usages needed. Implementation of advanced tertiary technologies for enhanced CEC removal revealed that treatment scenarios designed for CEC elimination led to significantly small improvements in toxicity reduction. In contrast, the high amount of energy and chemical usage required in these processes actually produced higher toxicity levels compared to the benefits achieved.



Overview of Scope and Tasks.

Management and Policy Implications

This report provides summaries of eutrophication and human toxicity impacts based on various treatment scenarios for nutrient and CEC removal. The findings can provide a basis for utilities to communicate with regulatory agencies regarding the effluent permits and rationale for regulation changes to ensure larger scale and overall net benefits to water quality.



Estimated Typical CECs Concentration after Secondary Treatment.

Related WE&RF Research

Project Title	Research Focus
Protocol to Evaluate Alternative External Carbon Sources for Denitrification at Full-Scale Wastewater Treatment Plant (NUTR1R06b)	Includes a road map, guidance, and protocols which provide comprehensive information for WRRFs to conduct systematic assessments of the efficiency, feasibility, and cost effectiveness of external sources of supplemental carbon to support and enhance biological denitrification processes.
Nutrient Management: Regulatory Approaches to Protect Water Quality Volume 1: Review of Existing Practices (NUTR1R06i)	Provides a better understanding of the unique challenges that utilities and regulators face setting and meeting low nutrient effluent limits. It expands understanding of the practical capabilities of nitrogen and phosphorus treatment technologies.
Nutrient Management Volume 2: Removal Technology Performance and Reliability (NUTR1R06k)	Looks at a comprehensive study of nutrient removal plants designed and operated for three or more years to meet very low effluent total nitrogen and total phosphorus concentrations to help inform decision makers about proper choices for both technologies and rationale bases for statistical permit writing. The results will help establish a practical and quantifiable protocol for the analysis of nutrient removal and nitrification plants striving to achieve low effluent concentrations.
Phosphorus Fractionation and Removal in Wastewater Treatment: Implications for Minimizing Effluent Phosphorus (NUTR1R06l)	Investigates wastewater treatment configurations to determine the various phosphorus fractions, and their fate and susceptibility to a range of different phosphorus removal processes to gain better insights into the removal efficiency and mechanism of different phosphorus fractions through various treatment technologies.
Striking the Balance Between Nutrient Removal in Wastewater Treatment and Sustainability (NUTR1R06n)	Provides a bench-top analysis on finding the balance between nutrient removal and sustainability and examines whether a point of diminishing returns is reached where the sustainability impacts of achieving increased levels of nutrient removal outweigh the benefits of better water quality.

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