Executive Summary

Designing and operating WRRFs: Gaining a better understanding of the complex factors needed to meet stringent P levels

Aerial photo of the City of Kalispell, Montana Advanced Wastewater Treatment & Biological Nutrient Removal Facility, one of the facilities that participated in the study.

Evaluation of Performance and Greenhouse Gas Emissions for Plants Achieving Low Phosphorus Effluents (NUTR1R06v)

The Central Issue

As stringent effluent phosphorus limits of 0.1 mg/L and lower become more common, water resource recovery facility (WRRF) operators need a better understanding of the factors that impact the sustainability of operating to meet those levels. By using greenhouse gas (GHG) emissions as a parameter, the researchers were able to convert various wastewater treatment parameters to the normalized GHG emissions platform while comparing several different WRRFs.

Context and Background

The project team evaluated operating practices and estimated GHG emissions associated with phosphorus removal at 11 WRRFs seeking to identify methods of operating more sustainably while meeting the stringent effluent limits. These plants were designed to meet very low total phosphorus concentrations. Assessments were made of overall performance, chemical consumption, influent characteristics, tertiary treatment performance, and resource recovery. GHG emissions were estimated for the phosphorus removal component of each facility. In addition, several research elements were examined at full scale to help establish the effectiveness and the practical differences in performance. These items included the impact of chemical dosing location and waste chemical solids on phosphorus removal operation; the impact of primary sludge, return activated sludge, and mixed liquor suspended solids fermentation on enhanced biological phosphorus removal (EBPR); and the impact of EBPR on anaerobically digested biosolids dewaterability.

Findings and Conclusions

This study ultimately focused on minimizing consumption of resources while maintaining reliable performance. The researchers recognized that GHG emissions and overall sustainability of a process are significantly impacted by outside factors, as well as operating practices. They determined that phosphorus recovery can improve the reliability of EBPR by reducing the high phosphorus load in dewatering return streams.

In evaluating the 11 WRRFs, the researchers found that while plant size did not seem to influence GHG emissions for phosphorus removal, the results from the GHG evaluation showed that the carbon footprint for phosphorus removal is heavily influenced by the permit limit. This could be tied to the need to add a higher dose of chemicals, as well as operation of a tertiary treatment process to reach lower limits. The carbon footprint for WRRFs with EBPR mixing, tertiary treatment, metal salt addition, and/or alkalinity addition comprised a significant portion of total GHG emissions, but levels varied significantly between plants.

GHG Emissions and Chemical Dosing vs. Phosphorus Removal Process Used

P-removal Process	Average (lb CO_2 eq/lb P removed)	Range (lb CO_2 eq/lb P removed)	Range Me^{3+}/P removed Molar ratio across plant	Average Me^{3+}/P removed Molar ratio across plant
EBPR	6.3	2 to 9.4	0.0	0
EBPR + Chemicals	13.5	6 to 21	0.41 to 1.76	1.18
Chemical P Removal	15.7	12 to 22	1.08 to 2.25	1.57

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Management and Policy Implications

This study concludes that operators can use the tools that are given to optimize performance and reduce consumption. It identifies design and operating practices that impact phosphorus removal performance and consumption of resources. It suggests there is a significant opportunity to optimize parameters such as chemical dosing.

The research also explains how planners and managers would benefit from understanding the balance between phosphorus removal process selection, solids handling and disposal practices, facility design, and community and financial impacts. For regulators, the research indicates a need to be cognizant of how effluent criteria may impact the design, operations, costs, and overall sustainability of WRRFs. It also identifies the advantages of considering the alternatives that can meet water quality needs in a more sustainable manner.

Related WERF Research

Project Title	Research Focus
Striking the Balance Between Nutrient Removal in Wastewater Treatment and Sustainability (NUTR1R06n)	Provides an analysis on finding the balance between nutrient removal and sustainability in order to determine if 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.
Factors Influencing the Reliability of Enhanced Biological Phosphorus Removal (01CTS3) **Sustainable Technology for Achieving Very Low Nitrogen and Phosphorus Effluent Levels (02CTS1)** **WEF/WERF Study Quantifying Nutrient Removal Technology Performance (NUTR1R06h)**	This body of research suggests that while low levels of phosphorus in effluents can be achieved, there are knowledge gaps between the application of research results to best sustainable phosphorus removal practice and the interaction between chemical and biological processes for reliable phosphorus removal to varying lower levels (such as 0.1, 0.05, and 0.01 mg/L).
Solids Role in Tertiary Chemical Phosphorus Removal by Alum (NUTR1R06t)	Demonstrates that sludge produced from chemical P removal processes can be used to further remove P from upstream processes, as well as in the chemical P removal process.
Tertiary Phosphorus Removal Compendium	Focuses on factors that need to be considered to reduce phosphorus below 0.5 mg/L and, in particular, the requirements to reduce phosphorus to very low limits, below 0.05 mg/L (50 ug/L) or lower.
Greenhouse Gas Emissions and Biological Nutrient Removal Compendium	Examines what wastewater treatment facilities can do to respond to global warming concerns.

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