Executive Summary

WERF

Help for deciding the appropriate MBR BNR configuration design

Application of Membrane Bioreactor Processes for Achieving Low Effluent Nutrient Concentrations (NUTR1R06u)

The Central Issue

Water resource recovery facilities (WRRFs) are increasingly being required to reduce the amount of phosphorus (P) and nitrogen (N) in their treated effluent – often below current detection/measurement levels – using significant amounts of energy and chemicals. Useful guidelines are needed for design and operation of membrane bioreactor (MBR)-based systems intended to achieve low effluent N or P concentrations.

Context and Background

This research examined the process designs, technology performance statistics, and operating issues for meeting low effluent concentrations of N and P at five full-scale operating MBR facilities. These facilities included:

- Broad Run Water Reclamation Facility, Loudoun County, VA.
- Cauley Creek Water Reclamation Facility, Fulton County, GA.
- King William County MBR Plant, VA.
- Ruidoso Water Resources Recovery Facility, NM.
- Yellow River Water Reclamation Facility, Gwinnett County, GA.

The MBR biological nutrient removal (BNR) process configurations were different for each plant evaluated. However, not all possible MBR BNR process configurations were given.

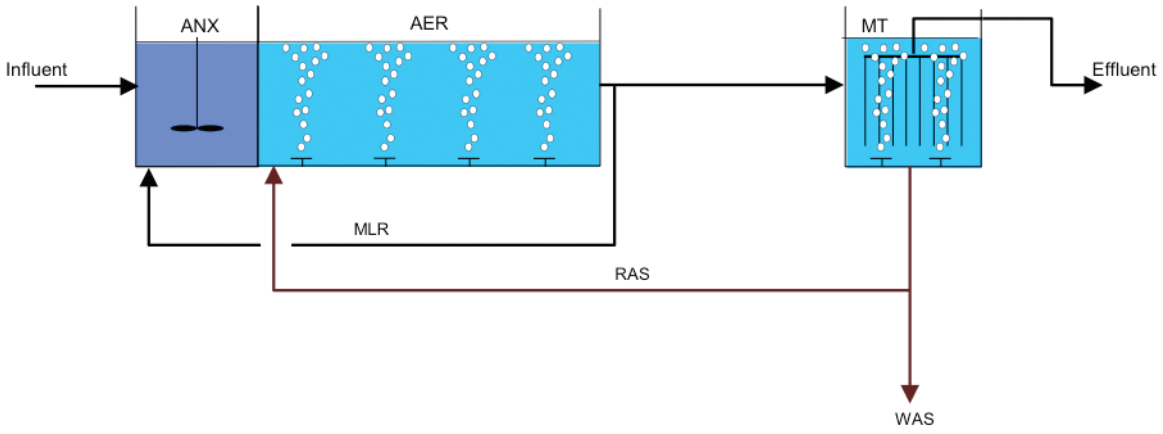
Findings and Conclusions

The researchers concluded that low effluent nutrient goals can be achieved reliably with MBRs. However, it depends highly on the reliability and redundancy provided for each component of equipment such as pumps, blowers, and instruments. Key issues in the design and operation of successful MBR BNR applications were found to be:

- Control of dissolved oxygen within aeration tanks and recycle streams.
- Strategic design of the system baffle walls to minimize DO carryover within the anoxic zone.
- Control of chemical addition and design of injection point.
- Automation versus manual operation of the system.

Management and Policy Implications

The results of this research can assist utilities and their consultants in deciding the appropriate MBR BNR configuration design needed to meet stringent effluent nutrient concentrations. It identifies design and operating conditions to meet low effluent total N, total P, and combined total N and P concentrations. It also looks at various process configurations to identify key design and operating issues unique to MBRs to improve performance and reliability of nutrient removal. Additionally, it provides treatment performance statistics for full-scale MBR nutrient removal facilities.



A nitrification/partial denitrification configuration used for MBR systems which is similar to the Modified Ludzack-Ettinger process used in conventional activated sludge systems with an internal mixed liquor recycle flow from the aeration zone to the preanoxic zone.

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Related WERF Research

Project Title	Research Focus
Uptake by Algae of Dissolved Organic Nitrogen from BNR Treatment Plant Effluents (NUTR1R06e)	Investigates whether a professionally accepted method to measure forms of DON that are not readily taken up by algae can be used by treatment plant operators and regulators to more effectively understand and control eutrophication. Provides a relatively simple and robust method to determine the bioavailability of DON in the effluent from BNR wastewater treatment facilities.
Variability of Low Phosphorus Analytical Measurement (NUTR1R06f)	Provides information regarding the ability of wastewater treatment facilities and commercial laboratories to measure low levels of P (20 µg/L) accurately and reliably. Suggests that measurements to comply with very low limits will inherently vary, making it challenging to determine both the environmental impact of the discharge stream and the performance of the facility.
Nutrient Management: Volume 2 – Removal Technology Performance & Reliability (NUTR1R06k)	Highlights a comprehensive two-year study of 22 real-world, full-scale nutrient removal plants designed and operated over three years to meet very low effluent total phosphorus (TP) and total nitrogen (TN) concentrations (as low as 3 mg/L TN and 0.1 mg/L TP). Provides a database for key decision makers looking for proper choices for both technologies and rationale bases for statistical permit writing.
Phosphorus Fractionation and Removal in Wastewater Treatment – Implications for Minimizing Effluent Phosphorus (NUTR1R06l)	Investigates wastewater treatment configurations to determine the various P fractions, and their fate and susceptibility to a range of different P removal processes in order to gain better insight into the removal efficiency and mechanism of different P fractions through various treatment technologies.
The Bioavailable Phosphorus (BAP) Fraction in Effluent from Advanced Secondary and Tertiary Treatment (NUTR1R06m)	Examines current analytical methods and P speciation and BAP in 17 wastewater treatment plant effluents around the country to compare the different types of advanced secondary and tertiary P removal processes, the impact of chemical addition in the effluent from these advanced nutrient removal processes, and the influence of dissolved P molecular forms on recalcitrance and bioavailability.
Striking the Balance Between Nutrient Removal in Wastewater Treatment and Sustainability (NUTR1R06n)	Sustainability / impacts of nutrient removal in wastewater treatment – impacts of "unintended" consequences – GHG, energy and chemical costs, etc.
Bioavailability and Characteristics of Dissolved Organic Nutrients in Wastewater Effluents (NUTR1R06o)	Investigates the bioavailability and characteristics of various P fractions from effluents in advanced tertiary treatment processes that are targeted for extremely low effluent TP concentrations.
Surface Complexation Modelling and Aluminum Mediated Phosphorus – White Paper (NUTR1R06r)	Tests a conceptual surface complexation modeling framework which had originally been developed for ferric mediated removal finding that the same model framework described for ferric experiments also works for aluminum experiments, albeit at a different rate of removal.
Solids Role in Tertiary Chemical Phosphorus Removal by Alum (NUTR1R06t)	Examines the capacity and kinetics of P removal by chemical solids from wastewater and several factors that affect the reactions. Results from the study can help develop process flowsheets to take advantage of the sorptive capacity of these used solids in a cost-effective manner, which in turn could lead to ultra-low effluent phosphorus concentrations at significantly reduced alum doses.
Development of Sustainable Approaches for Achieving Low Phosphorus Effluents (NUTR1R06v)	Evaluates sustainable operational practices and performance results for water resource recovery facilities designed to meet very low effluent TP concentrations, focusing on maximizing what can be learned from existing facilities to help utilities operate more sustainably while achieving necessary levels of performance.
Phosphorus Analysis in Wastewater: Best Practices White Paper (NUTR1R06cc)	Examines best practices for low level phosphorus analysis in wastewater and discusses whether the lessons learned from freshwater analysis apply to wastewater, or if wastewater has unique characteristics that confound low level P measurements.

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