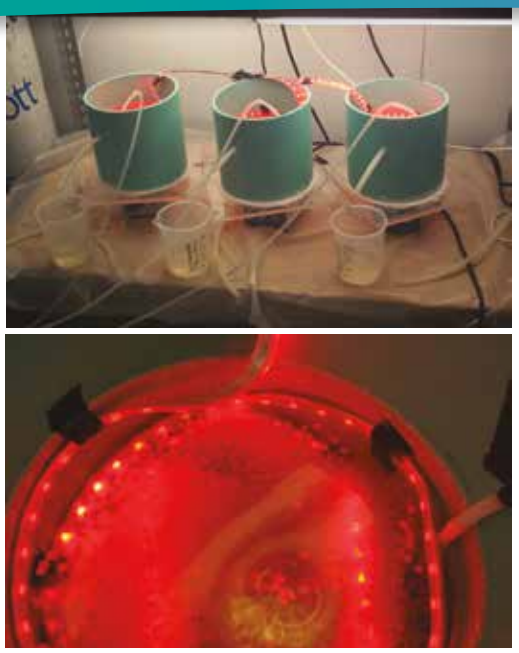
Executive Summary

WERF

An affordable nutrient removal/resource recovery technology for small- to mid-sized treatment plants

Algal Nutrient Removal During Wastewater Treatment (U4R10)



Flow-through bioreactors lined with red LEDs in triplicate (A) and the view from the top of a single bioreactor (B).

The Central Issue

While major improvements in wastewater treatment using enhanced biological nutrient removal (BNR) systems have reduced nutrient loading to natural receiving waters, current limits of technology preclude further nutrient reductions using established traditional BNR processes. Yet, because it is easier to manage point source discharges of these compounds to natural waters, water resource recovery facilities (WRRFs) that discharge into streams, rivers, estuaries, and marine systems are being targeted for further regulation in watersheds such as the Chesapeake Bay. Cost-efficient and easily adaptable approaches to wastewater treatment must be designed to further reduce total nitrogen (N) and phosphorus (P) in effluents from WRRFs.

Context and Background

The goal of this research was to develop phycoremediation strategies that employ phytoplankton to remove N and P from treated effluents before discharge; all at a lower cost. The research employed encapsulation techniques that allow for ease of removal of the algae while removing nutrients at high rates. An evaluation matrix was developed to assess algal encapsulation with conventional BNR technology. The matrix compared:

- Traditional denitrification filters present in current WRRFs.
- Open algae ponds.
- Algal photobioreactors.
- Immobilized algae via rotating biological contactors.
- Encapsulated algae vial alginate.
- Immobilized algae with moving bed biofilm reactor-like technology.
- A completely unknown process.

Each technology was evaluated with criteria based on:

- Level of technical development.
- Operational development.
- Financial performance.
- Sustainability.

Findings and Conclusions

Researchers found that algal encapsulation would allow WRRFs to maintain the existing footprint, have scale-up potential, improve effluent quality, remove nutrients, have a low hazard exposure, have available parts and equipment, and low capital and operating costs. Results showed removal efficiencies up to 100% for nitrate, nitrite, and phosphate with a hydraulic retention time of 6.5 h. The high reduction efficiencies were achieved by incorporating wavelength-specific submersible LEDs, maintaining a constant pH, and with constant mixing.

Management and Policy Implications

When considering carbon emissions, energy consumption, the potential for renewable energy production, and the use and recycling of algal biomass, algal nutrient removal and encapsulation are important technologies that must be investigated beyond the bench-scale and could be used at WRRFs operating at less than 1 MGD.

Appendix A of the report contains a matrix that compares the encapsulated algae technique described in this study with traditional treatment options. Treatment facility operators can consider the best technologies or even their current technologies for algal nutrient removal. The matrix can be used to help determine the best modifications to make to enhance N and P removal and recovery at WRRFs.

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Algal Nutrient Removal During Wastewater Treatment

Related WERF Research

Project Title	Research Focus
Nutrient Management Volume II: 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 nitrogen (TN) and total phosphorus (TP) 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.
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 in order to determine 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. Looks at sustainability/impacts of nutrient removal in wastewater treatment – impacts of "unintended" consequences – GHG, energy and chemical costs, etc.
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.

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