Executive **Summary**

WATER ENVIRONMENT & REUSE FOUNDATION

Reducing energy consumption, improving pollutant removal and transformation, and producing a high-quality potable effluent

A Low-Energy Wastewater Treatment Process for Producing High Quality Water – Phase 2 (Reuse-10-06)

The Central Issue

There is a need for a process for wastewater reuse that requires minimal energy consumption while operating with a high removal efficiency and small footprint. This study investigates an innovative wastewater treatment process to produce potable-quality water while relying on energy-efficient biological processes to treat contaminants, followed by a resource recovery unit to produce struvite.

Context and Background

The researchers conducted lab-scale and pilot-scale experiments on specific components of a novel wastewater treatment system with three goals in mind:

- Reduce energy consumption.
- Improve pollutant removal and transformation.
- Produce a high-quality potable effluent.

The process scheme studied consisted of forward osmosis followed by membrane distillation for potable water production and anaerobic membrane bioreactors coupled to partial nitritation/Anammox with a sidestream phosphorus removal process for pollutant removal, energy production, and product recovery. The system tested included state-of-the-art membrane processes coupled to low-energy biological systems for contaminant destruction, rejection, and removal.

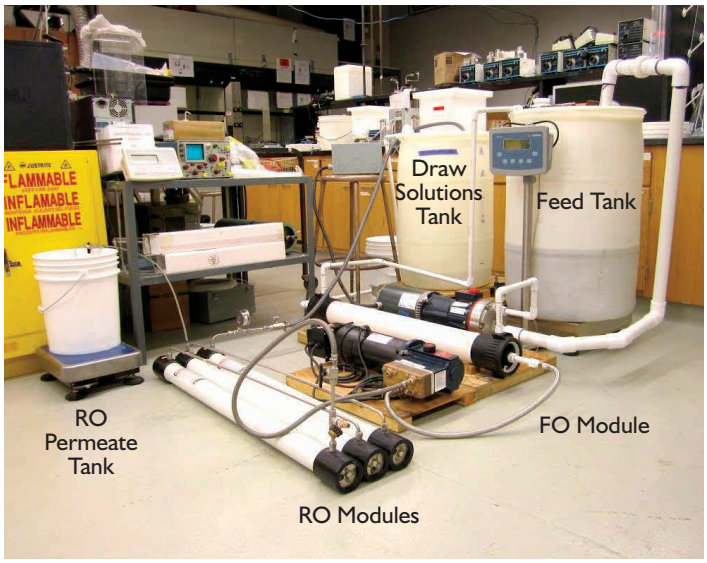
The proposed system used proven technologies and combined them in such a manner that individual processes could play to the strengths and weaknesses of other processes. The goal of this Phase 2 investigation was to assess the feasibility of this innovative process scheme for wastewater reuse with minimal energy consumption while operating with a high removal efficiency and small footprint. The unit process was studied at the pilot-scale using fine-screened primary effluent collected from a regional wastewater treatment facility (Truckee Meadows Water Reclamation Facility in Reno, NV).

Findings and Conclusions

Overall, it was found that high nutrient and organic carbon rejection can be obtained using the coupled forward osmosis/direct contact membrane distillation (FO/DCMD) system, allowing for a high-quality potable effluent stream from the DCMD process, along with a concentrated waste stream that can be fed to the anaerobic membrane bioreactor (AnMBR). It was also found that high chemical oxygen demand (COD) removal can be obtained using the AnMBRs with both low- and high-strength wastewaters. Temperature was found to play the greatest role on the performance of the dual-membrane FO/DCMD system, while no detrimental temperature effects were observed with the AnMBRs, confirming the compatibility of the two subsystems. System scale limited the quantitative validation that energy consumption is reduced with the system, although utilization of the biogas produced by the AnMBRs and use of onsite waste heat for DCMD thermal energy requirements can be incorporated to decrease electrical energy requirements. A mathematical model was also developed for the FO/DCMD processes that predicts a decrease in specific energy consumption with scale of the membrane processes, which agrees with the available literature.

Management and Policy Implications

Results from this research revealed that the subsystems tested (FO/DCMD, AnMBR, FO treatment of primary effluent) were capable of meeting performance standards for water quality enhancement. Management of aeration in activated sludge wastewater treatment plants will be improved for the industry following the model developed in this project. Implementing a system based on the model and therefore lowering energy consumption could potentially inform decision making in the future by presenting an attractive alternative to the conventional air activated sludge system.



Combined FO-RO Pilot-Scale System.

Related WE&RF Research

Project Title	Research Focus
Challenge Projects on Low Energy Treatment Schemes for Water Reuse, Phase I (WRRF-10-06A/ENER2C12a)	Focuses on identifying emerging low energy treatment technologies ranging from alternatives to existing treatment processes to innovations in energy recovery systems. The team concluded that two key treatment technologies for Phase II research: the anaerobic MBR (AnMBR) and mainstream Annamox process.
Challenge Projects on Low Energy Treatment Schemes for Water Reuse, Phase I (WRRF-10-06B/ENER2C12b)	Examines a novel wastewater treatment system with three goals in mind: reduce energy consumption, improve pollutant removal and transformation, and produce a high-quality potable effluent. The project investigated the use of a multi-barrier system to produce a potable effluent from a common wastewater effluent.
Challenge Projects on Low Energy Treatment Schemes for Water Reuse, Phase I (WRRF-10-06C/ENER2C12c)	Shows the potential energy and cost savings of a novel biofilm reactor technology based on aerated membranes in comparison to conventional activated sludge for water and wastewater treatment.
Challenge Projects on Low Energy Treatment Schemes for Water Reuse, Phase I (WRRF-10-06D/ENER2C12d)	Anaerobic membrane bioreactors operated at psychrophilic temperatures is one possible approach to improve the sustainability of domestic wastewater treatment operations, particularly in the context of reuse. This project creates life cycle assessment (LCA) and life cycle costing (LCC) data that can be used to support decisions regarding the selection of anaerobic vs. aerobic membrane bioreactors as water reuse enablers.
Anaerobic Membrane Bioreactor for Sustainable Wastewater Treatment (U4R08)	Findings indicate that there are inherent benefits to AnMBR treatment of DWW, but they must be quantitatively compared relative to conventional DWW treatment to determine under what conditions AnMBRs can be successfully applied.
Low Energy Alternatives for Activated Sludge – Advancing Anaerobic Membrane Bioreactor Research (ENER4R12)	Advances greater understanding and implementation of anaerobic membrane bioreactors (AnMBR), a high-rate anaerobic treatment technology that may offer a more energy-efficient alternative to conventional activated sludge treatment processes for domestic (municipal) wastewater.
Evaluation and Optimization of Emerging and Existing Energy Recovery Devices for Desalination and Wastewater Membrane Treatment Plants (WRRF-08-14)	Investigates the treatment, disinfection, and operational practices that will help ensure that high-quality recycled waters are maintained through storage and distribution. The Excel-based tool permits utilities, engineers, and plant operators to provide greenfield, cost-based decisions on which, if any, commercially available energy recovery device to implement in their facilities.
Renewable Energy Technologies and Energy Efficiency Strategies (WRRF-08-13)	Guidebook provides utilities and water practitioners with energy minimization strategies and renewable energy utilization guidelines. Provides a comprehensive knowledge base for U.S. utilities and includes updated developments in energy minimization and renewable energy techniques.

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