Life Cycle Energy Use and Greenhouse Gas Emissions for a Coupled Algal-Membrane System versus a Potable Reuse Technology

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Introduction

The use of algal-based wastewater treatment along with a Forward Osmosis (FO) and Reverse Osmosis (RO) system to produce clean water, can be an attractive alternative to meet water demands, and effectively augment water supplies.

The algal treatment consists of the utilization of enclosed photobioreactors with algal bacteria *G.Sulphuria* and later a hybrid membrane system of Forward Osmosis (FO) and Reverse Osmosis (RO) for water recovery. This system can effectively treat primary effluent water to discharge standards at a period of 2-3 days.

This study compares the energy use and greenhouse gas (GHG) emissions of the Algal FO-RO system with a potable water reuse system using the Life Cycle Assessment (LCA) methodology.

Goal & Scope (Phase 1 of LCA)

The goal of this research focused on the comparison of the environmental impact and energy consumption of a Coupled Algal-Membrane System versus a Direct Potable Reuse (DPR) wastewater treatment technology.

The data and results collected throughout the LCA will be utilized for the improvement of different aspects of the Algal Membrane System treatment train, to promote the reduction of resource requirements, and to minimize emissions that may harm the environment.

Exclusions from LCA assessment:

- *Collection and transportation of wastewater across the pipelines*
- *Construction phase*
- *Sludge and waste disposal*
- *Preliminary and primary treatment*

System Boundary of the assessment only focused on the treatment process inputs and outputs. The reference feed flow for both systems set at 100 GPM and the functional unit was cubic meters (m^3) of water recovered.

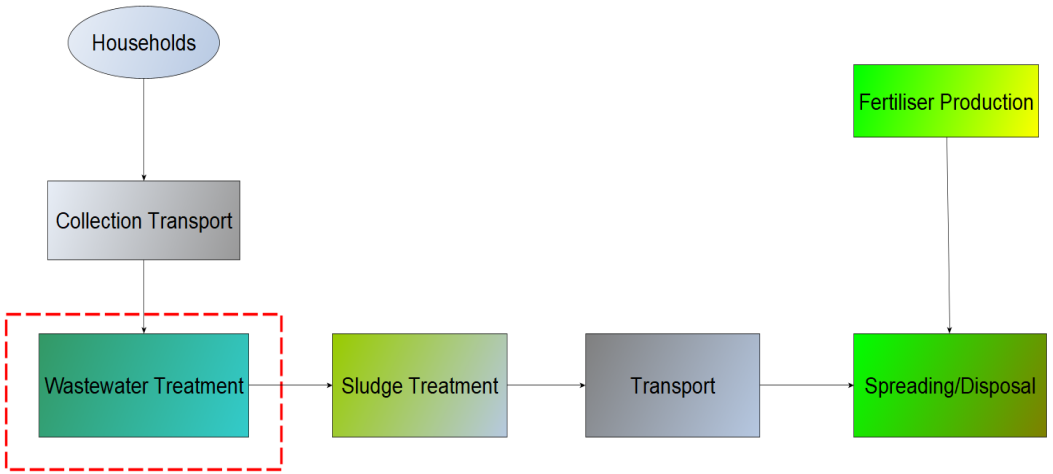


Figure 1: System Boundary specification

The Algal FO-RO system compared with the El Paso Advanced Water Purification Facility (AWPF) with a treatment train of Microfiltration (MF), Reverse Osmosis (RO), Ultraviolet Advanced Oxidation Process (UV/AOP), and Granular Activated Carbon for peroxide quenching (GAC).

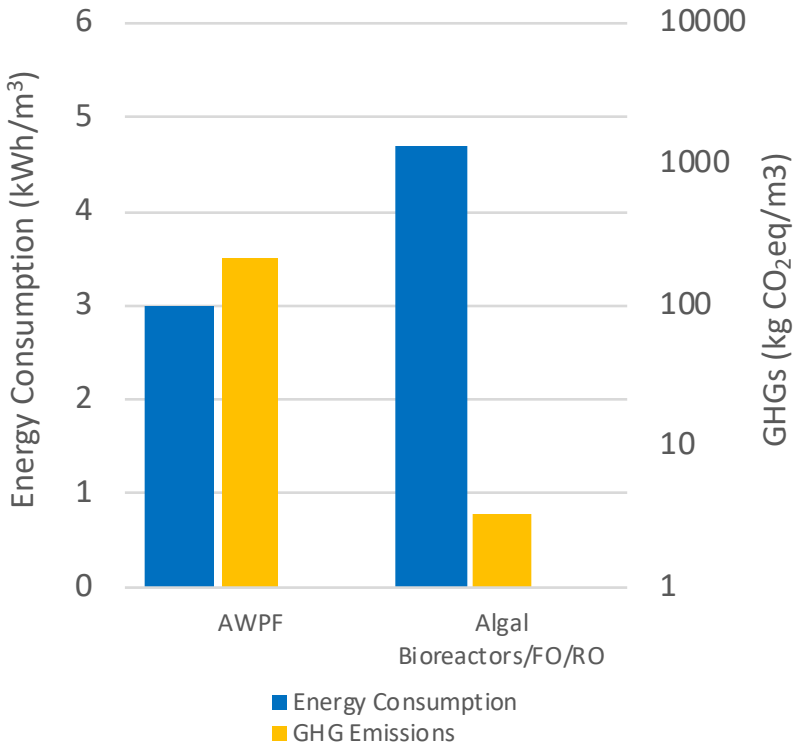
The initial reference point for the LCA on both systems is the feed water origin. In the case of the Algal FO-RO system, it was the Algal photobioreactor. For the AWPF, it was their secondary treatment process, which consists of an activated sludge system with extended aeration and a secondary clarifier.

Inventory (Phase 2 of LCA)

A life cycle inventory consists of quantifying the different inputs and outputs of the systems that are being evaluated, via the use of a spreadsheet. Typical inputs and outputs that are quantified can be energy and raw material requirements, atmospheric emissions, waterborne emissions, solid wastes, or any other releases throughout the entire life cycle of a product, process, or activity.

Inputs of energy consumption and chemical consumption quantified for both systems via pilot-scale report data and typical literature data. The only output considered on both systems was the greenhouse gas (GHG) emissions, which consisted of CO_2 & N_2O.

Impact Characterization (Phase 3 of LCA)



While the Algal FO-RO system shows a higher energy consumption, its environmental impact is lesser than the typical potable reuse systems. Respective energy values for the feed water secondary treatment for the AWPF based on assumptions due to minimal information provided by the institution.

Interpretation of Results (Phase 4 of LCA)

Results for the Algal FO-RO from this study indicate:

- Algal FO-RO has a higher energy consumption than the AWPF, but a lower environmental impact.
- The seawater RO used on the system is responsible for 64% of the energy consumption.
- The water recovery of both systems based on a 100 GPM flow:
  - ✓ Algal FO-RO = **90% recovery**.
  - ✓ AWPF = **75% recovery**.

Improvement on the membrane system could eventually lead to a lower energy consumption value.

Future Work

The continued development of the LCA for the Algal FO-RO system, could eventually lead to a viable implementation strategy with low energy consumption.

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