Integrated Algae-Wastewater Systems for Wastewater Treatment and Simultaneous Bioenergy Production

Navpreet Kaur [Mentor: Dr. Yongli Zhang]
[a] Department of Civil and Environmental Engineering, Wayne State University, 5050 Anthony Wayne Dr. Engineering Building #2168, Detroit, MI 48202, USA
*Corresponding author. Email: zhangyl@wayne.edu; Tel.: 1 313 577 9962

SWEET Lab
Sustainable Water Energy-Environment Technologies Laboratory

1 Introduction

- As demand for sustainable energy increases due to rising carbon dioxide levels in the atmosphere, there has been a growing level in algae-to-biofuel production in wastewater.
- Cultivating algae in wastewater allows algae to obtain rich nutrients (Nitrogen, Phosphorus) while simultaneously treating wastewater.

12,452 WWTPs

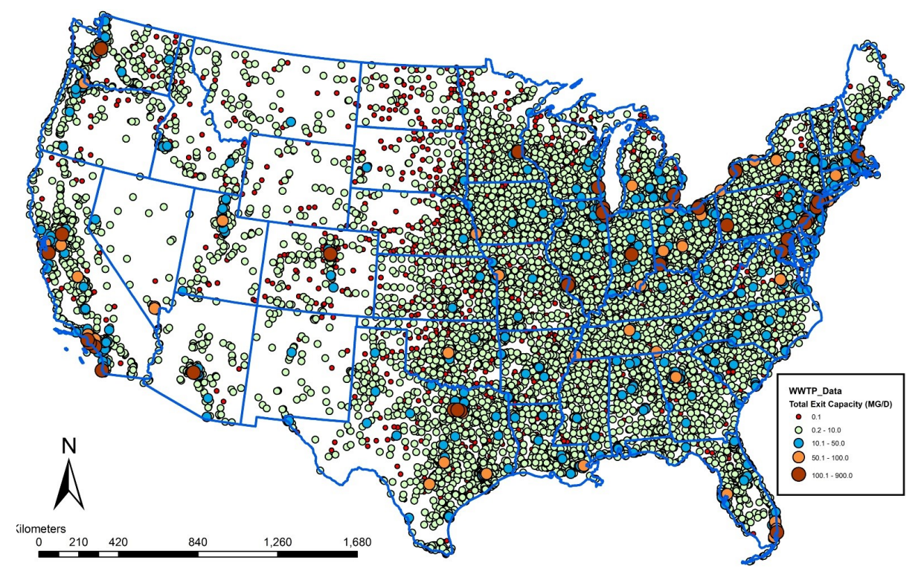


Fig. 1: Projection of WWTPs for the US

- Specific algae strains can yield up to 7 times more energy per acre than corn-based ethanol, which is the major source of biofuel today.

Fig. 2: Example of Open Algae Pond for Cultivation

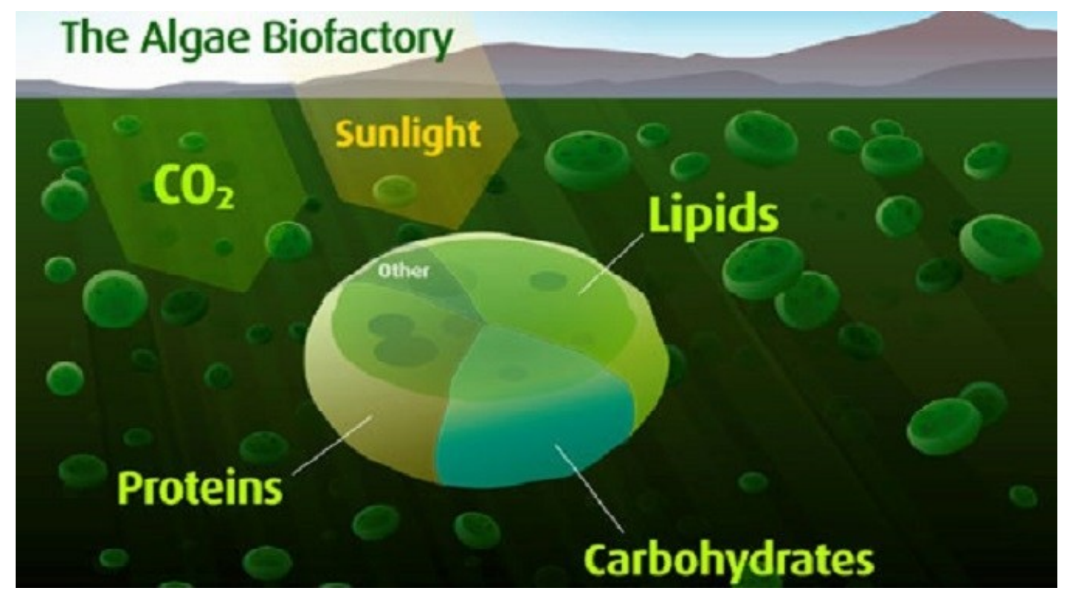


Fig. 3: Projection of Algae Cell

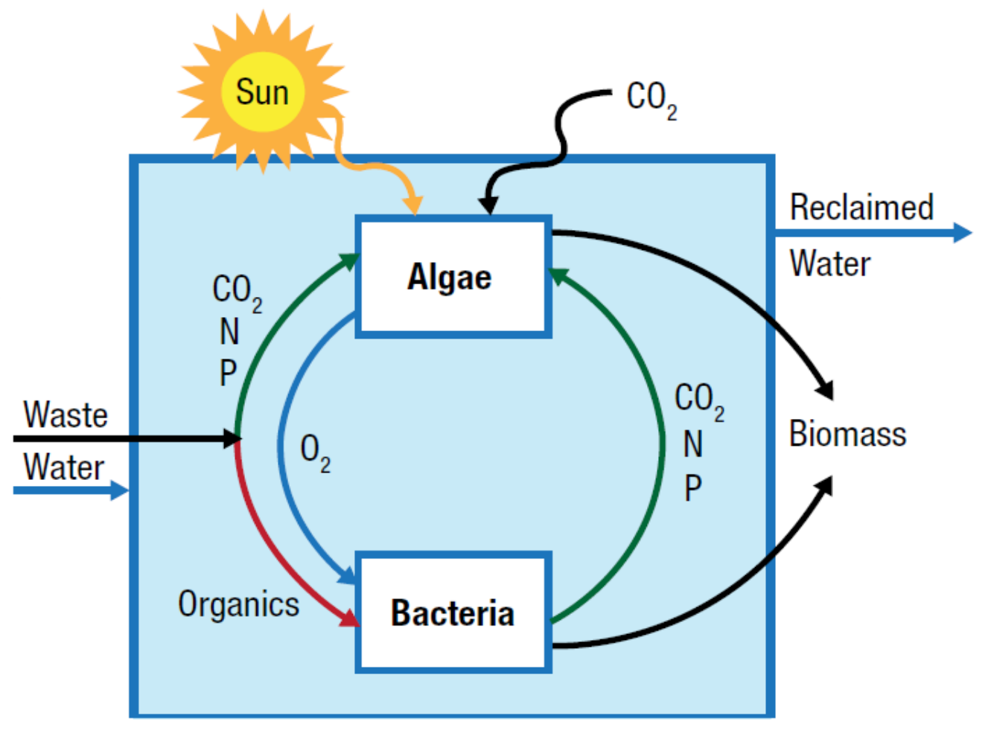


Fig. 4: Basic principle of operation ponds with algae (DOE, 2010)

2 Materials and Methods

- Measure mixotrophic and autotrophic algae growth rates in 3 different mediums (MB3N, Secondary WW, & Primary WW) to determine maximum production.
- Algae strain (unidentified) obtained from Detroit Wastewater Treatment Plant .
- Methods of Analysis (2):
  1. Measure OD of each sample. (1.5 mL)
  2. Measure algal mass of each sample. (25 mL)

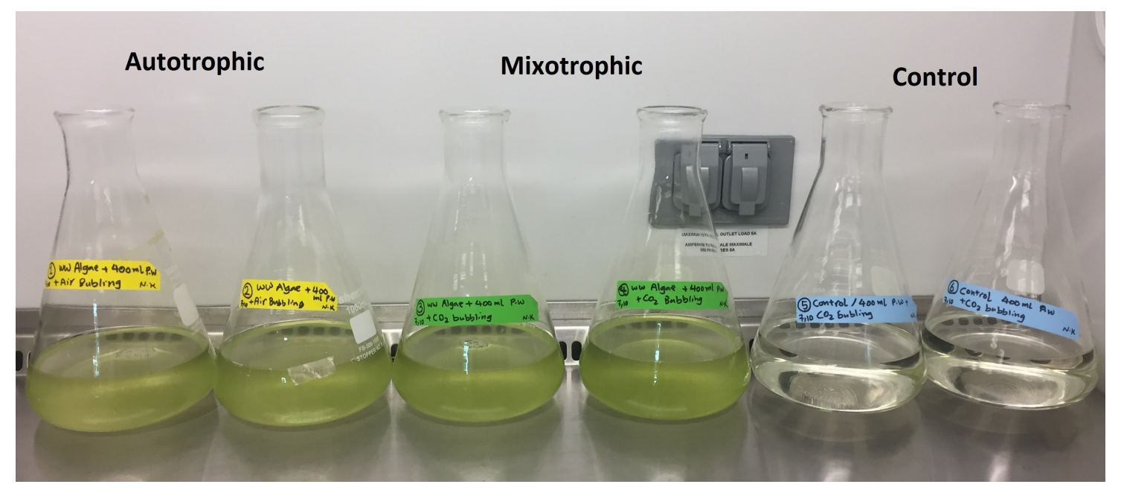
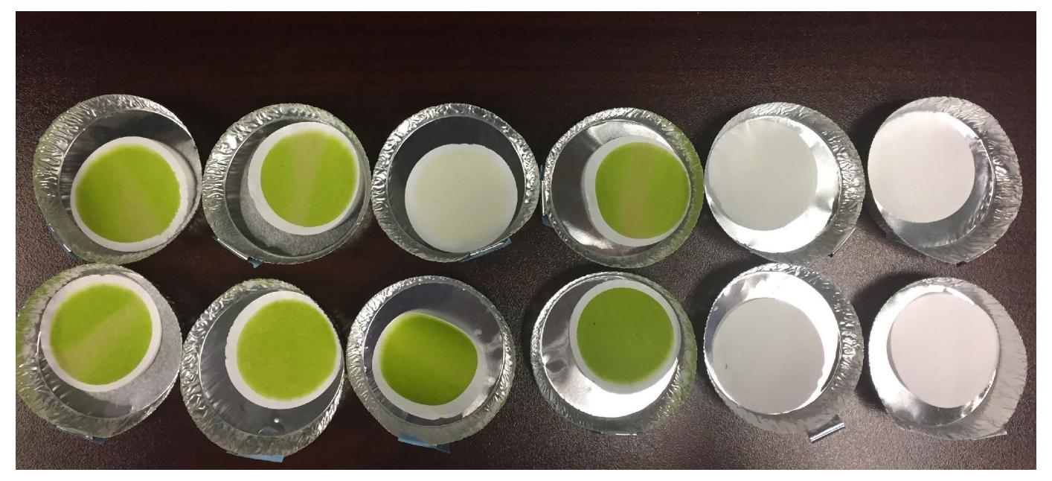


Fig. 5: Day 0 Flasks Samples in Primary WW

Fig. 6: Day 2 Algae Mass Samples in Secondary WW



3 Results

- The DWTP algae strain grew at its fastest rate in autotrophic conditions [0 g G/L] rather than in mixotrophic conditions [1 g G/L], with the preference of air bubbling or CO2 bubbling varying for each medium.

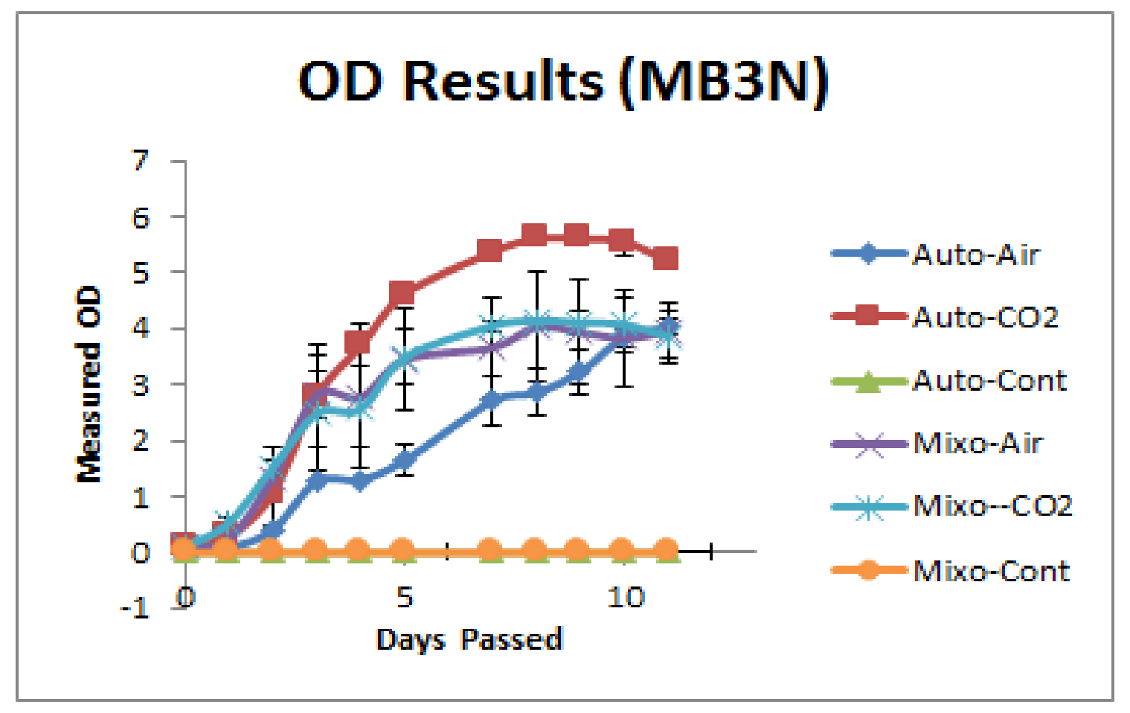
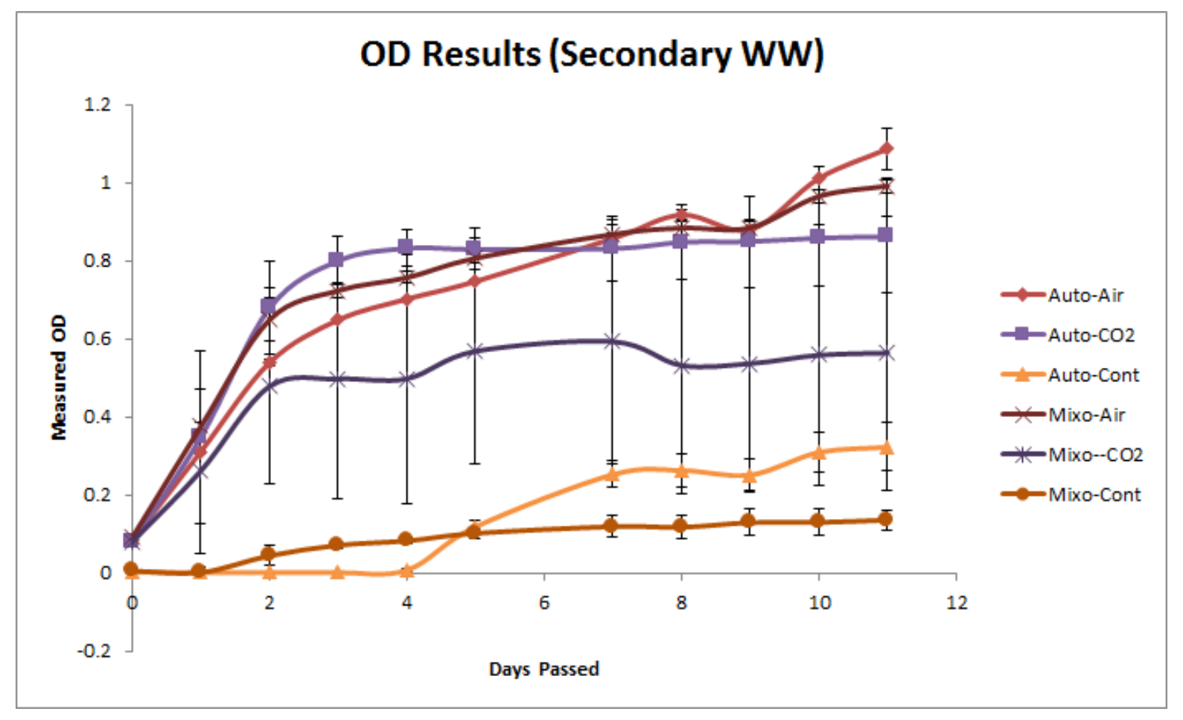


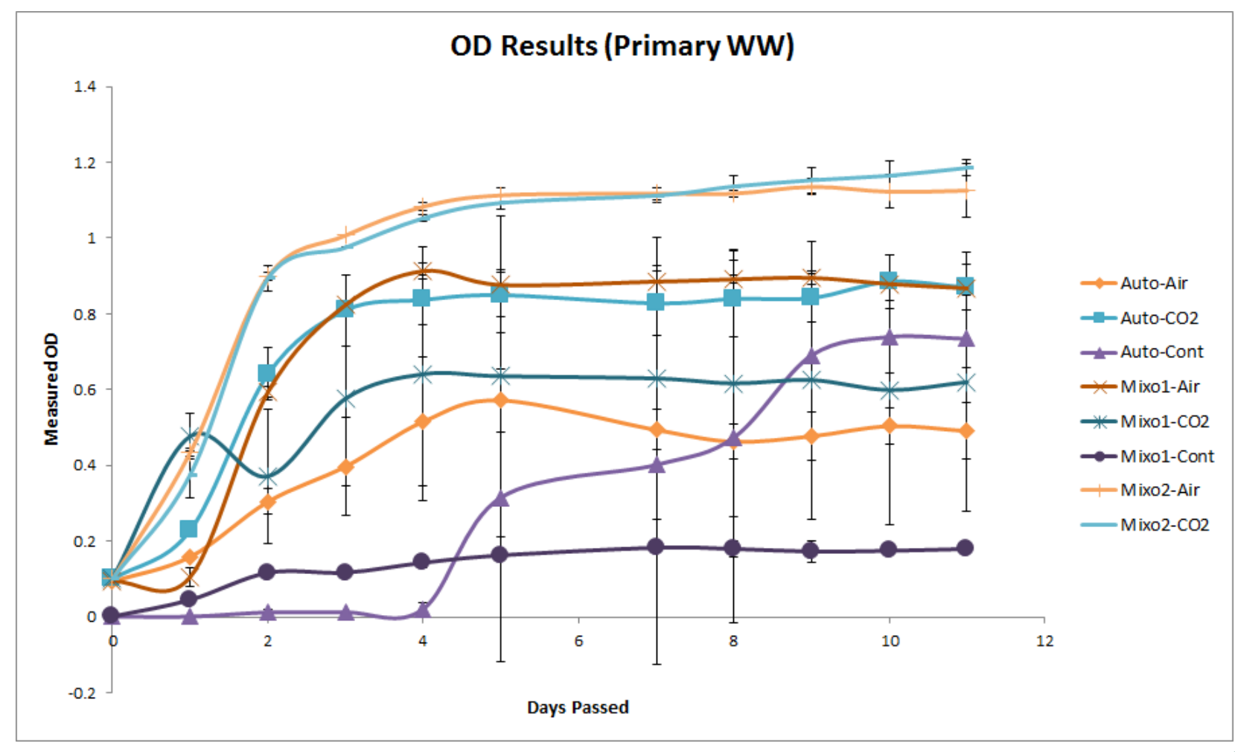
Fig 7: OD Results in MB3N

Fig 8: OD Results in Secondary WW



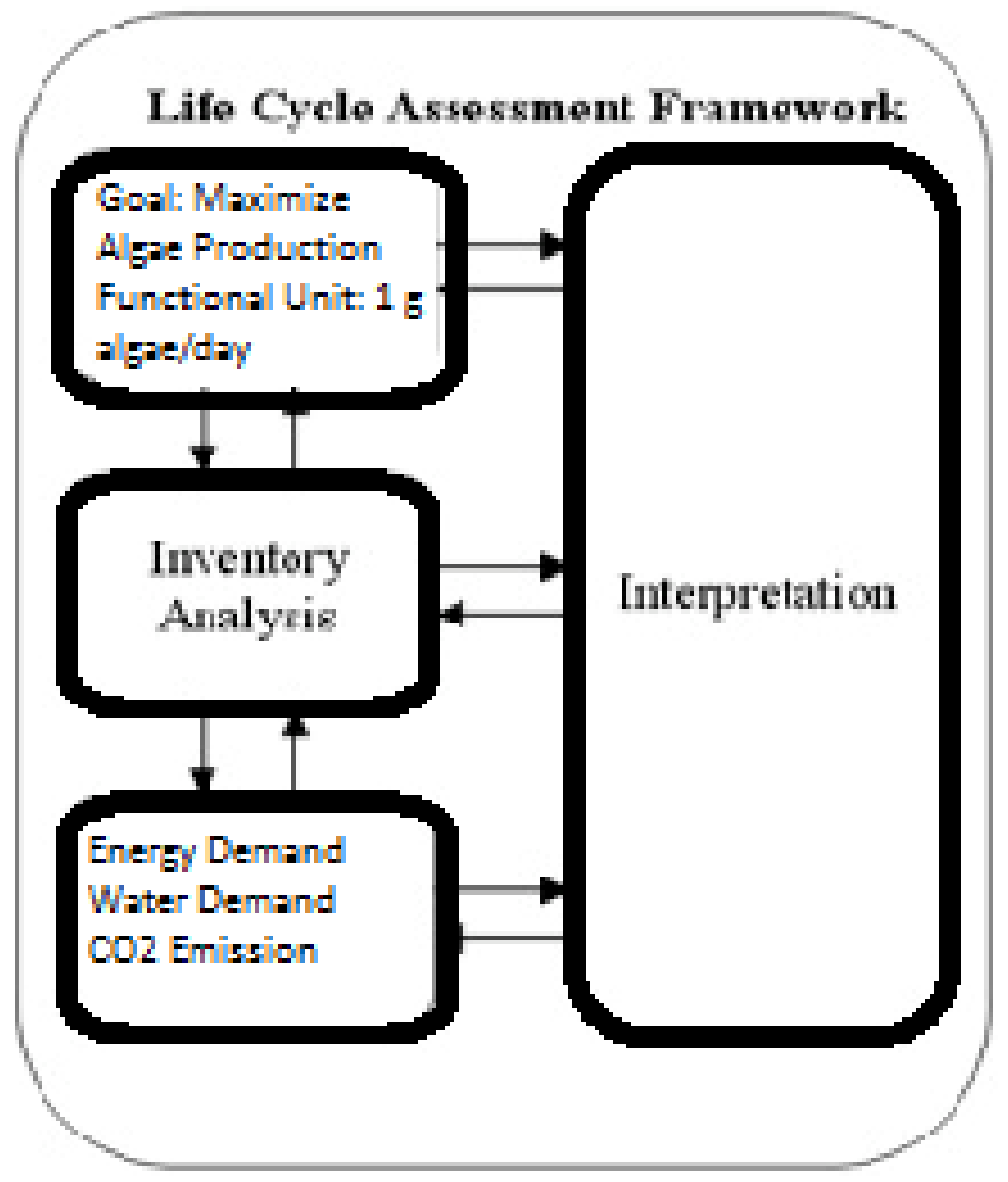
- When comparing all three mediums together, the greatest amount of algae growth was measured to be in MB3N medium, with algae in Secondary WW having the second greatest growth rate.
- Perhaps, the amount of nutrients in the wastewater were overbearing, leading to the algae's diminished growth. This same reasoning can also contribute to why the algae cells in mixotrophic conditions [1-2 g G/L] had a lower growth rate than those in autotrophic conditions [0 g G/L].

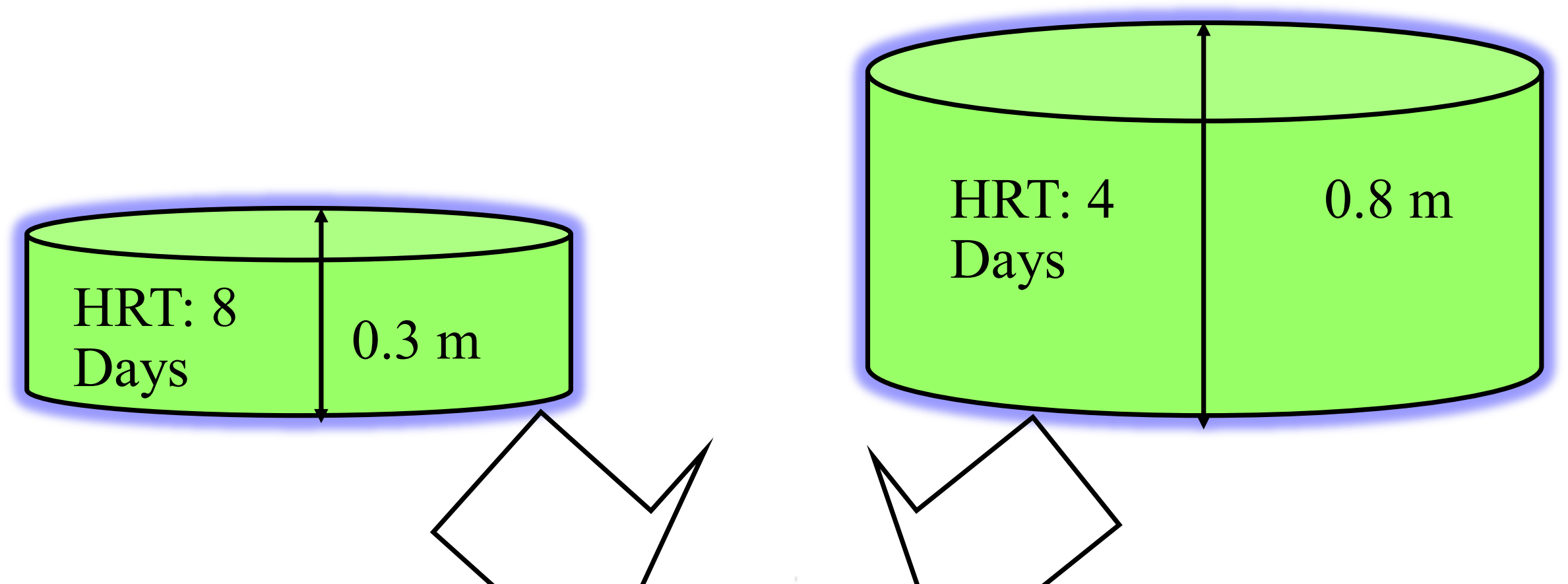
Fig 9: OD Results in Primary WW



4 Life Cycle Assessment

- Industries currently use autotrophic ponds at a depth (0.3m -0.5m) to cultivate algae for biofuel production.
- In this section, the environmental benefits and impacts of cultivating algae using an autotrophic open pond (0.3 m depth) and mixotrophic open pond (0.8 m depth) is evaluated.





Algae lipid content can be extracted for sustainable biofuels.

- Although the concrete needed for production for mixotrophic algae ponds is greater, the demand for water, energy, and CO2 emitted per 1 g dry algae/day is significantly less for a mixotrophic open pond system per 1 g dry algae/day.

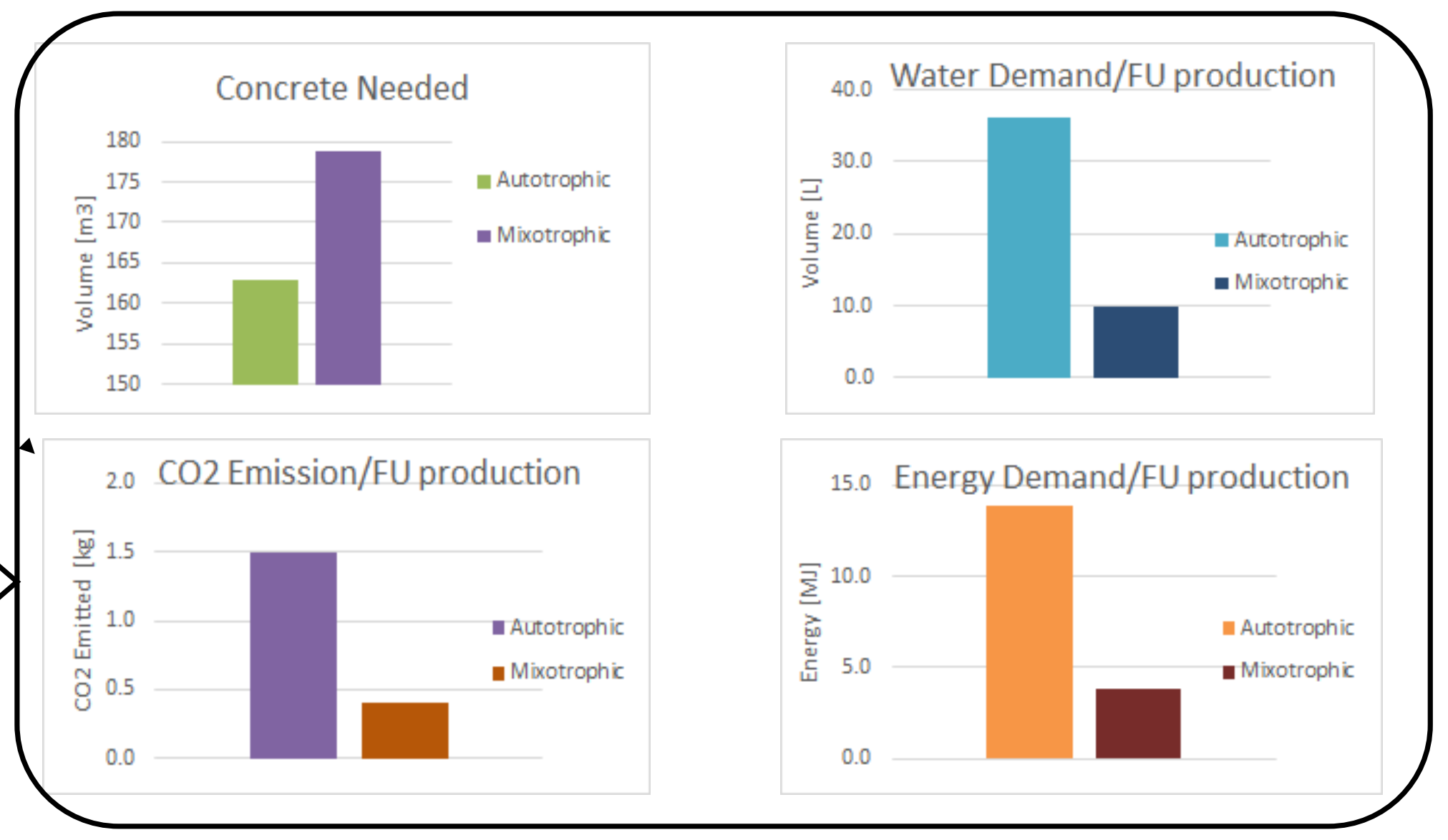


Fig. 10: LCA Results of Concrete Production, Energy/Water Demand, and CO2 Emission

5 Conclusion

- The DWTP algae strain is not a good candidate to be grown in mixotrophic wastewater; the overbearing amount of nutrients hinders its growth.
- The growth of this strain can be optimized under autotrophic conditions in MB3N medium.
- Mass production of algae can be optimized by switching to mixotrophic open algae ponds at a low hydraulic retention rate of 4 days. This analysis advises industries to consider this method of production as it allows for greater profit while reducing one's carbon footprint.

6 Relation to Sust. Mfg.

- Inputs of algae-to-biofuel production are sunlight and CO2, both of which are abundant and sustainable resources.
- This method of production emits fewer greenhouse gases, reducing society's carbon footprint substantially.

7 References

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