Microalgae for wastewater treatment and energy and nutrient recovery (E2.2A)

Energy and resource recovery

Re-Inventing the Nation's Urban Water Infrastructure (ReNUWIt)

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Background

Current wastewater treatment plants use activated sludge system to remove dissolved organic compounds from the wastewater; followed by nitrification-denitrification to remove ammonia. These processes consume a large amount of energy and are costly to operate.

In this project (E2.2), an algal-based system has been engineered to remove dissolved organic compounds, ammonia, and phosphates from the wastewater in a single step and to recover net energy and nutrients as fertilizer. A pilot scale version of this Photosynthetically Oxygenated Waste-to-Energy Recovery (POWER) system has been deployed at a local wastewater treatment plant.

Following long term batch testing, in this study, the POWER system has been operated in fed-batch mode utilizing a mixed culture. Goal of this study was to transition the operation of the POWER system from batch mode to fed-batch mode and to monitor the removal of dissolved organics, nitrogen, and phosphates by the mixed cultures.

Approach

- Operation: Fed-batch mode with a working volume of 700L, consisting of 400L of fresh primary settled wastewater per cycle.
- Cycle Time: Cycle time is the time taken to meet the discharge standards for dissolved oxygen, nitrogen, and phosphates.
- Wastewater Replacement: After discharge standards have been achieved, algae is allowed to settle and 400L of water is taken from the top of the reactor. The water is then replaced with 400L of fresh primary settled wastewater.
- Sampling: Phosphorus, nitrogen, ammonia, optical density, and pH are analyzed daily. BOD analysis is done once every two days.

Figure 1: One of the two 700L pilot scale algal reactors of the POWER system deployed at the Las Cruces wastewater treatment plant

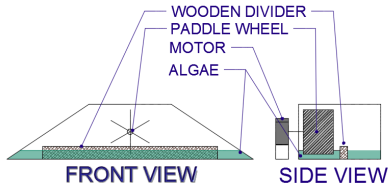

Figure 2: Schematic of algal reactor in the POWER system

Results

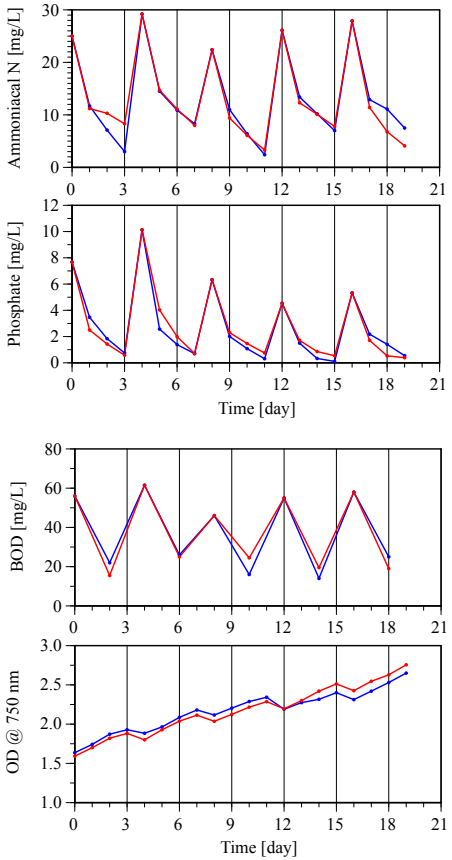

Figure 3: Typical results from five successive cycles of fed-batch operation of the POWER system showing temporal profiles of ammoniacal nitrogen, phosphates, BOD, and optical density in two parallel reactors fed with primary-settled wastewater.

Conclusions

- ✓ Based on the results from fed-batch operation of the POWER system, it is concluded that it can remove dissolved organics, ammoniacal-nitrogen, and phosphates to the mandated discharge standards in a cycle time of 3 to 4 days, depending on the influent loadings.
- ✓ This study showed that the POWER system can perform better under fed-batch mode than in batch mode due to the high levels of BOD, N, and P.
- ✓ Comparable removals of N, P, and BOD as well as growth of biomass in the two parallel reactors confirmed that the system can be operated in a reproducible manner.
- ✓ Consistent performance of the system under continuous operation fed with varying influent concentrations confirmed that the system can be operated in a reliable manner.
- ✓ Continuous monitoring of the pH conformed that the system can self-adjust the pH from an initial pH value of 2 to a value of 4 at the end of each fed-batch cycle.
- ✓ Results of this study warrant further long-term testing of the POWER system in fed-batch mode under a range of seasons and influent concentrations.

Next Steps

- Continue fed-batch operation of the POWER system with warm season cultures
- Compare performance of POWER system with cold season cultures against that of warm season cultures
- Scale up fed-batch operation from 400:300 mixing ratio to 500:200 mixing ratio
- Monitor performance and optimize system under 500:200 mixing ratio
- Compare performance of POWER system at 400:330 mixing ratio to that at 500:200 mixing ratio

Acknowledgements

- Financial support provided by National Science Foundation Engineering Research Center for Reinventing the Nation's Urban Water Infrastructure (ReNUWIt), the National Science Foundation Energize New Mexico (EPSCoR), Ed & Harold Foreman Endowed Chair.
- Support provided by City of Las Cruces in accommodating the pilot scale POWER system and in providing the BOD analytical services.
- Support provided by Duplex Tchinda and Isuru Sachitra Abeysiriwardana, ReNUWIt team members in project E2.2.

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Supported by the National Science Foundation at: