Cultivation of Blue-Green Algae on Landfill Leachate

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Abstract

There is an increasing challenge to remediate landfill leachate (LL), the liquid waste generated from municipal solid waste landfills. LL contains high ammonium content and therefore must be collected and treated. However, current LL remediation methods are expensive and energy intensive. Through use of photosynthetic filamentous algae, a sustainable and holistic approach can be developed to combine LL remediation with simultaneous algal biomass production for renewable liquid fuel production. Through this system, both remediation and biodiesel production could potentially overcome the challenge of attaining economic and technical feasibility. This project tested the capability of *Spirulina* for growth and remediation of LL. Four treatment mediums were investigated: *Spirulina* Medium (positive control), 5% LL, 10 % LL, and 20% LL. *Spirulina* cells were exposed to 120 µmol photons/m^2/s fluorescent lighting at a 24:0 photoperiod for 5 days. Algal remediation potential was measured via total ammoniacal nitrogen (TAN) reduction, and algal biomass growth was evaluated by spectrophotometry at 680nm. Results confirmed *Spirulina's* ability to grow on dilutions of leachate up to 10%, with final biomass dry weights of 0.89 g/L (5% LL) and 0.80 g/L (10% LL) compared to 1.93 g/L for the control, and 99% TAN removal for both leachate treatments.

Introduction

What is Landfill Leachate?

- Liquid that percolates through a landfill and extracts soluble matter from the collected waste
- Leachate generated in municipal solid waste contains large amounts of organic and inorganic contaminants [1]
- This wastewater must be removed and treated before it can be discharged to avoid ground and surface water pollution

Benefits of filamentous algae like *Spirulina Platensis*?

- Ubiquitous, high yielding plants
- Large cell size that facilitates efficient biomass harvesting [2]
- *Spirulina's* ease of cultivation is facilitated by a reduction in predation, competition and contamination [3]
  - Thrives in warm, alkaline fresh-water bodies
- Cellulosic feedstock for biofuel

Figure 1. Leachate sampling at ACSWL

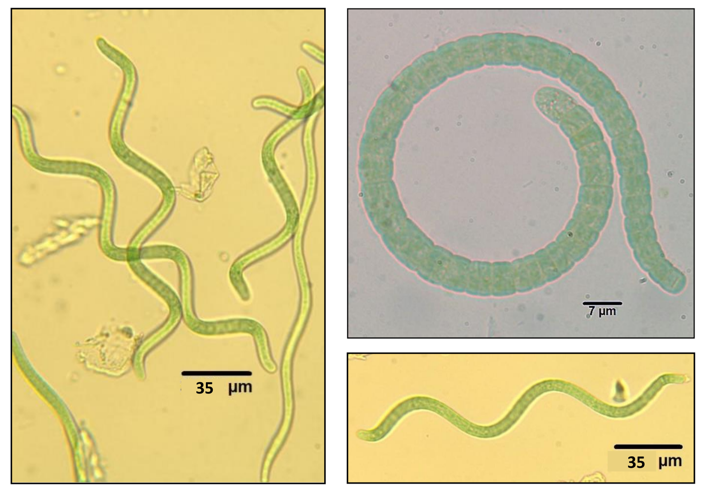


Figure 2. Spirulina under 25x (left and bottom right) and 100x (top right) magnification

Objective

This project evaluates landfill leachate treatment from the Alachua County Southwest Landfill (ACSWL) located in Archer, Florida using filamentous algae, *Spirulina Platensis*.

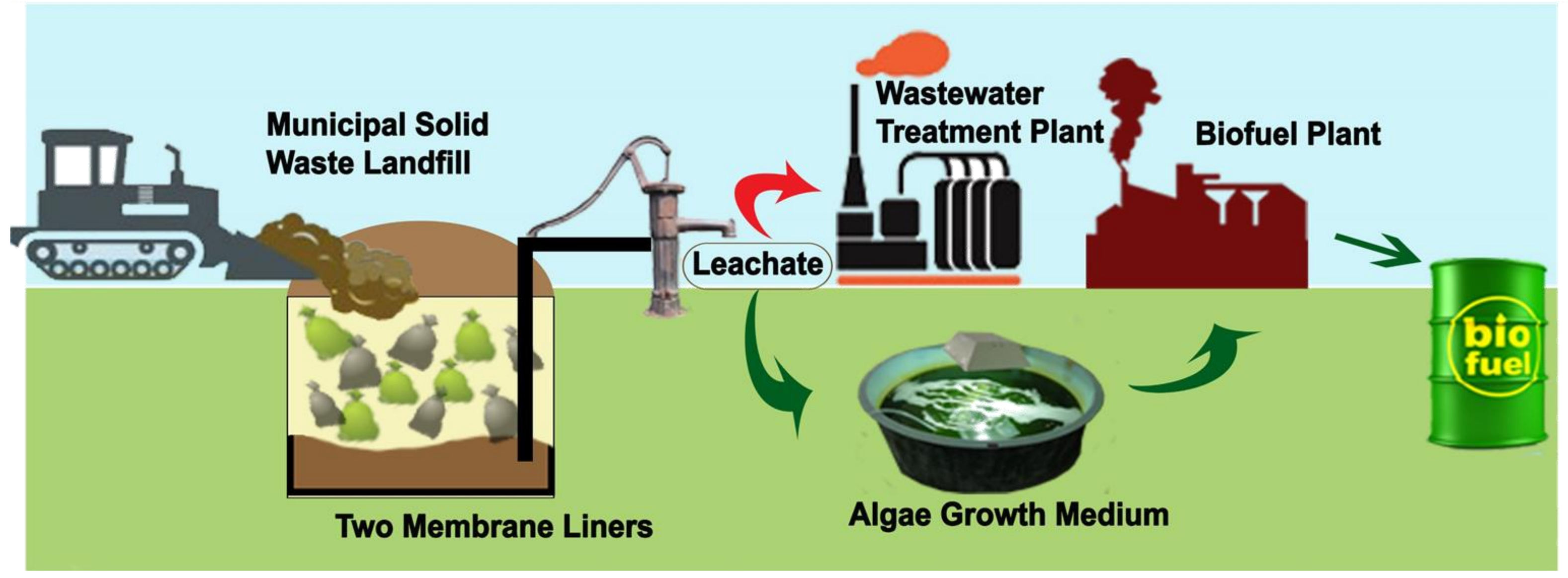
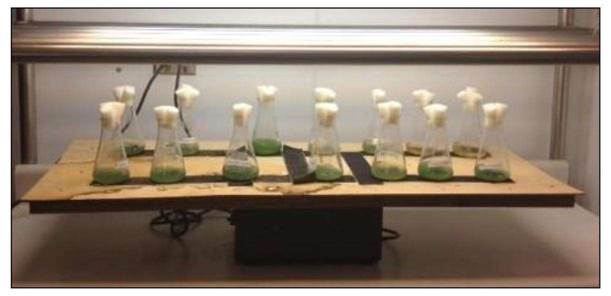


Figure 3. Utilization of algae as an alternative treatment for leachate management

Materials & Methods

- **Landfill Leachate Characterization** for pH, transmissivity, total ammoniacal nitrogen, conductivity, and alkalinity according to standard methods [4]
- **Algae Cultivation:**
  - *Spirulina* inoculum cells were obtained from Bioenergy and Sustainable Technology Lab and cultivated in standard *Spirulina* Medium
  - Subcultures with 10% inoculum were grown in 4 treatment mediums: *Spirulina* Medium (control), 5% LL, 10% LL, and 20% LL



Experimental Setup

- Cultures cultivated at 25°C over 5 days on an orbital shaker at 90 rpm
- Light intensity of 120 µmol photons/m^2/s on a 24:0 photoperiod
- Biomass growth was measured at 680 nm spectrophotometrically [5]
- pH and total ammoniacal nitrogen concentrations were measured daily

Results

Table 1. Characterization of Landfill Leachate

Component	Average ± STD (n=3)
pH	7.76 ± 0.01
Transmissivity (%)	80.7 ± 0.1
Total Ammoniacal Nitrogen (ppm)	818 ± 17.6
Conductivity (mS/cm)	19.08 ± 0.14
Alkalinity (mgCaCO$_3$/L)	6950 ± 0.00

Leachate Dilutions

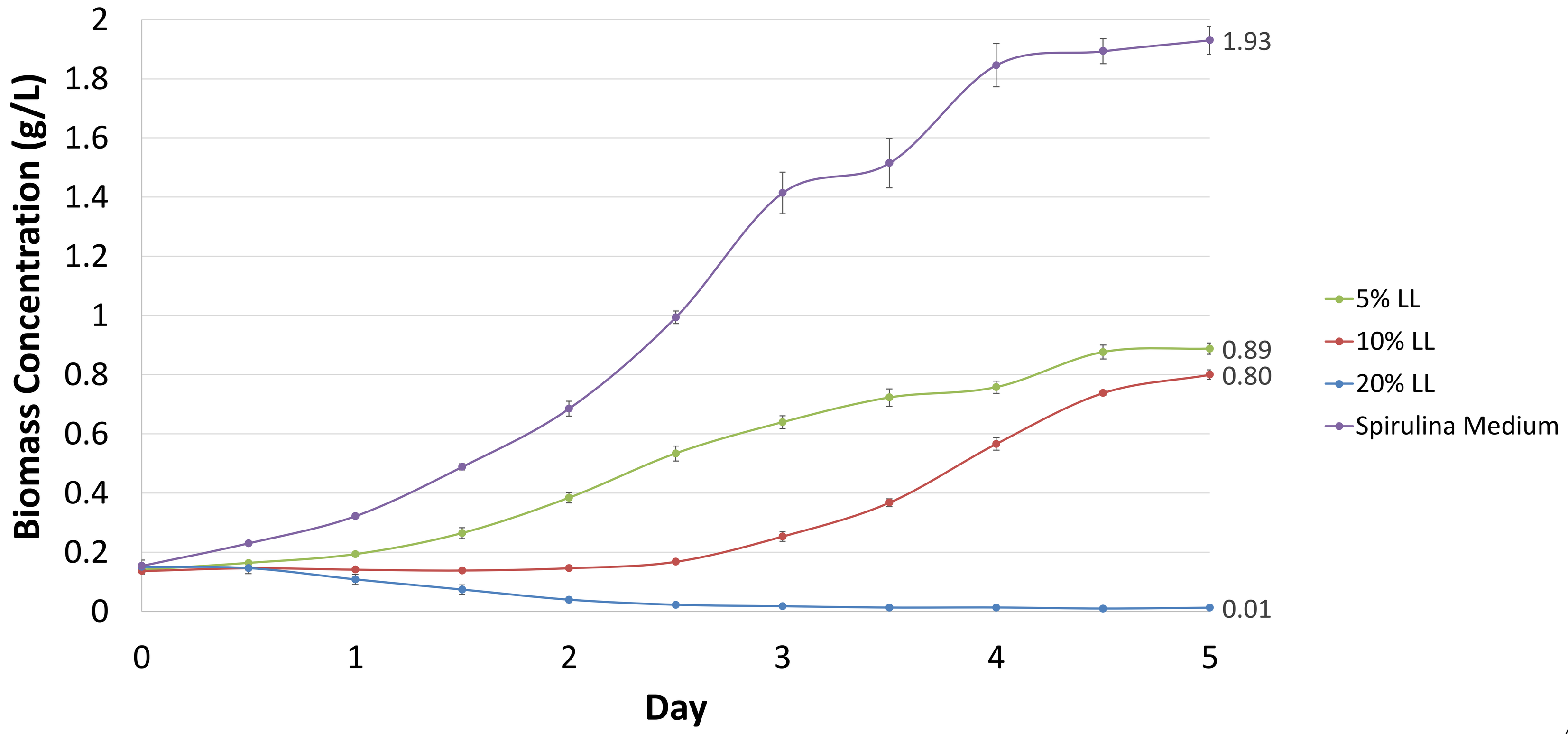


Figure 3. Spirulina Growth Curve

- Cultures grown in 5% LL and 10% LL exhibited cell growth, achieving maximum biomass yields of 0.89 g/L (46% of control) and 0.80 g/L (40% of control), respectively.

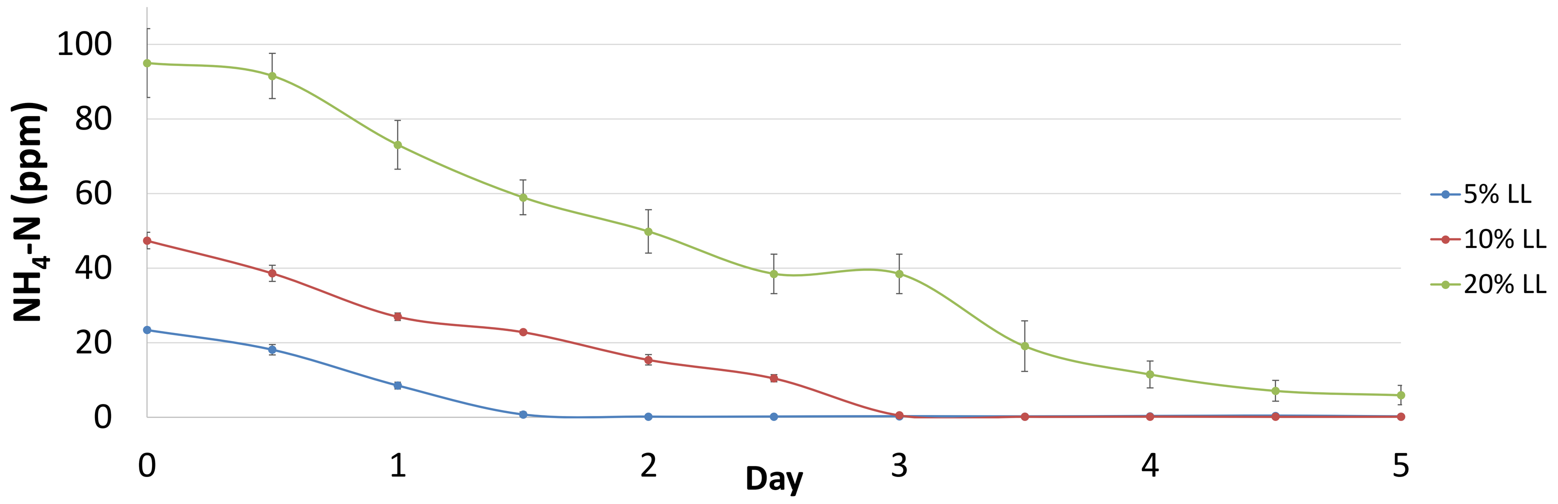


Figure 3. Nitrogen Removal

- Approximately 94% of the ammonium-nitrogen was removed within the first 3 days of the experiment in 5% LL and 10% LL cultures.

Carbon Supplementation

- A preliminary experiment was conducted to evaluate the effect of cell growth with addition of 1% w/v sodium bicarbonate on 10% LL

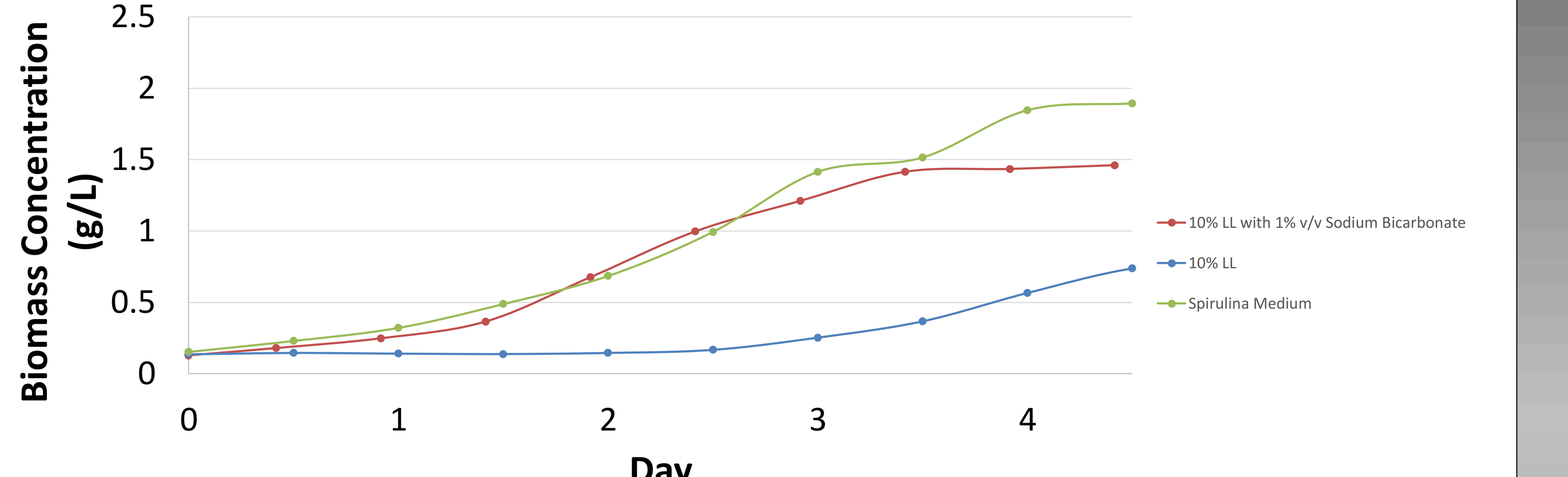


Figure 3. Spirulina Growth Curve: 10% LL with NaHCO$_3$ with superimposed growth curves from Figurre 2 of 10% LL and Spirulina Medium

- Cultures grown in 10% LL with 1% w/v NaHCO$_3$ achieved 77% of biomass yields generated in positive control

Conclusions

- *Spirulina* can potentially be used to remediate landfill leachate
- *Spirulina* growth was successful in 5% and 10% LL
- *Spirulina* supplemented with carbon in 10% LL had approximately a 98% greater biomass yield than that of the 10% LL cultures without NaHCO$_3$

References

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Acknowledgements

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