# Design of an Airlift Column Photo-Bioreactor that Increases Remediation Rates of Reverse Osmosis Permeate

**Jose St Louis**

**2012 BioEnergy and Sustainability School**

**August 7, 2012**


# Landfill Leachate

- A liquid solution resulting from the extraction of soluble constituents from waste in landfills by downward percolating water.
- Analogous to the liquid that sometimes collects at the bottom of trash cans
  - Why is it important?
    - Landfill leachate has a very high pollution potential
    - Landfills are required by law to manage leachate
  - How is it handled?
    - Widely trucked to waste water treatment plants

# Alachua County Southwest Landfill (ACSWL)

- Experimenting with reverse osmosis (RO) system to remediate leachate
- Advantages
  - Quickly removes most of the contaminants from the leachate
- Disadvantages
  - Energy intensive
  - Inefficient at ammonium removal
    - Requires multiple run-throughs to remediate the leachate to dischargeable levels

# ACSWL -BEST Project

- BEST and the ACSWL partnered to create a combined algal/RO remediation system
  - Algae remediate ammonium after single stage RO
  - Permeate (the result of single RO run) is a nitrogen source for algae
- Advantages
  - Less energy intensive because the sun powers the algal remediation
  - Remediates permeate to dischargeable levels
- Disadvantages
  - Takes a longer time for remediation to occur

# Objective

- Design a photo-bioreactor capable of increasing the algal remediation rates of reverse osmosis permeate

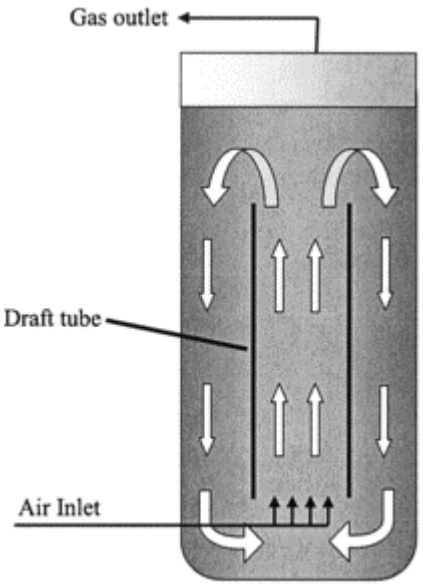
# Types of Photo-bioreactors

- What is a photo-bioreactor?

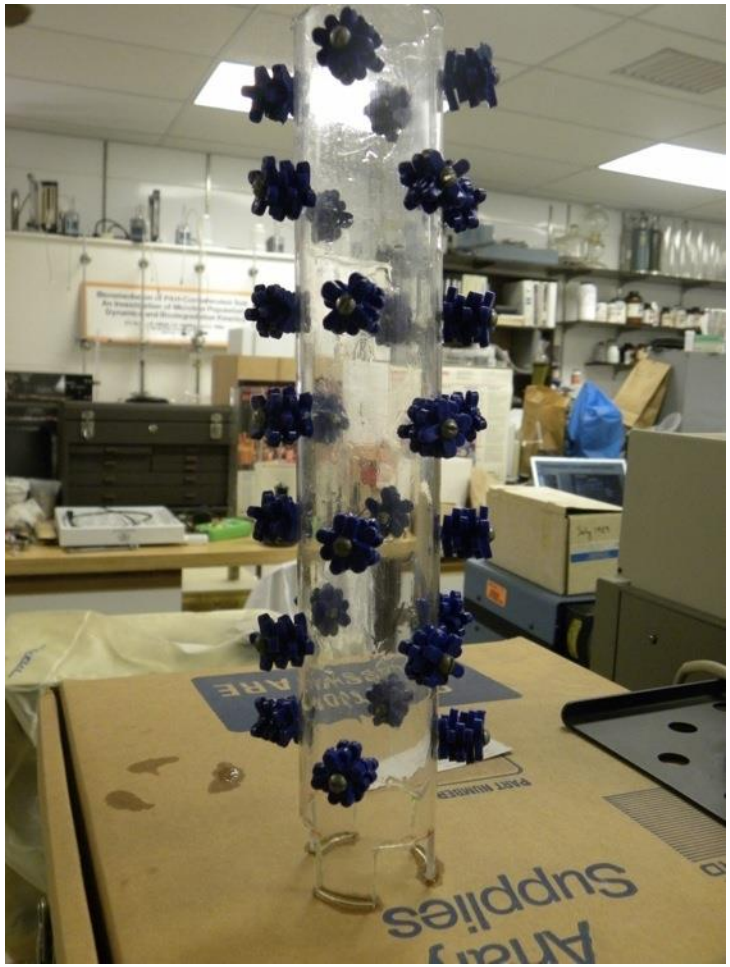
- Types of photo-bioreactors:
  - Flat plate reactors
  - Tubular reactors
  - Bubble column reactors
    - Airlift reactors

# Airlift Reactors

- Modified bubble column reactor
- Very defined flow



# Modifications




- Focused on increasing mixing within the system
  - Mixing increases mass transfer rates and light/dark cycles (Posten 2009)

# Methodology

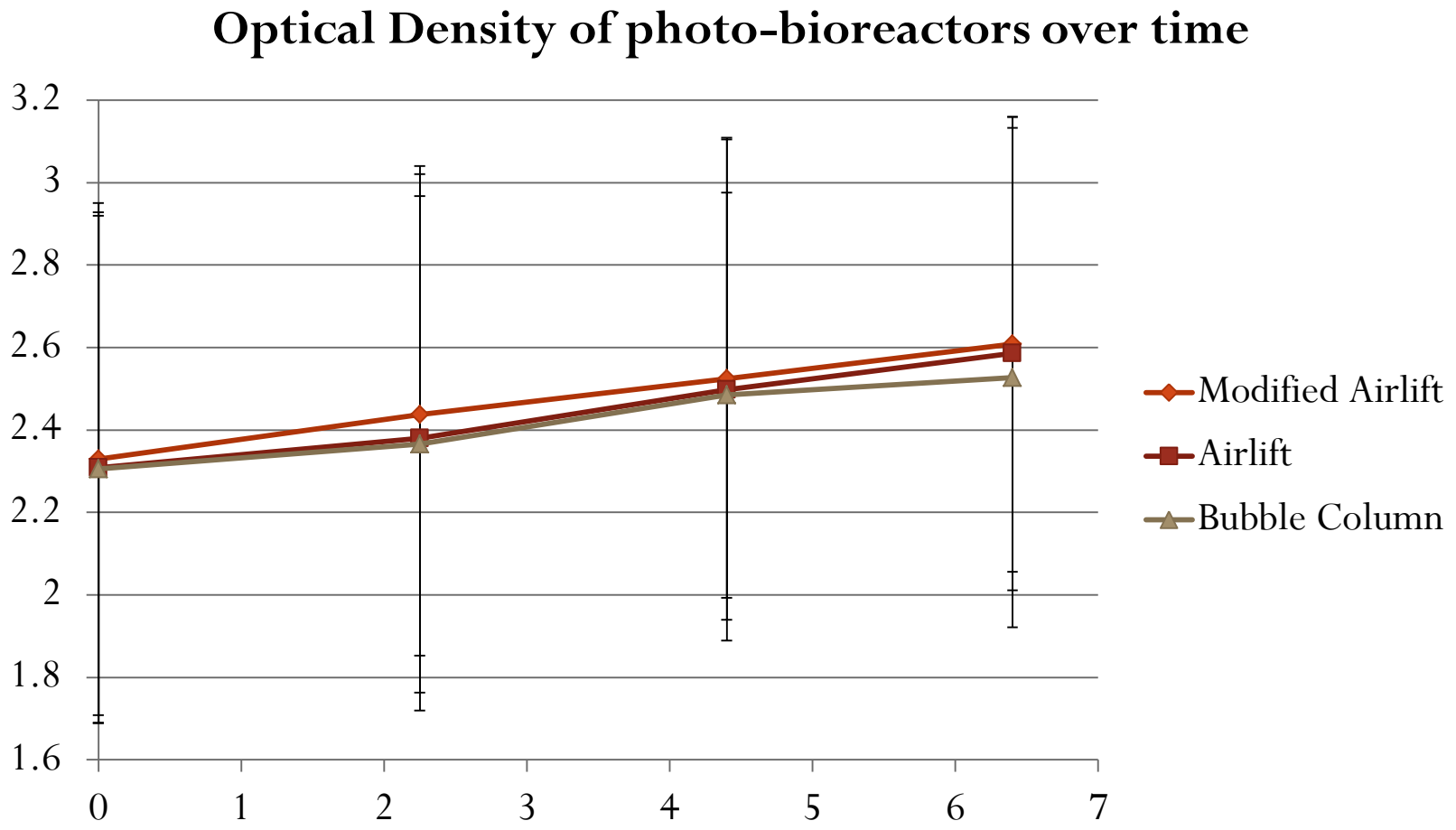
- Three bioreactors were constructed out of identical containers
  - 1 bubble column, 1 airlift, 1 airlift modified with static mixers
- Identical lighting, air, and $CO_2$ supply
- pH controlled $CO_2$ delivery

# Methodology (cont.)

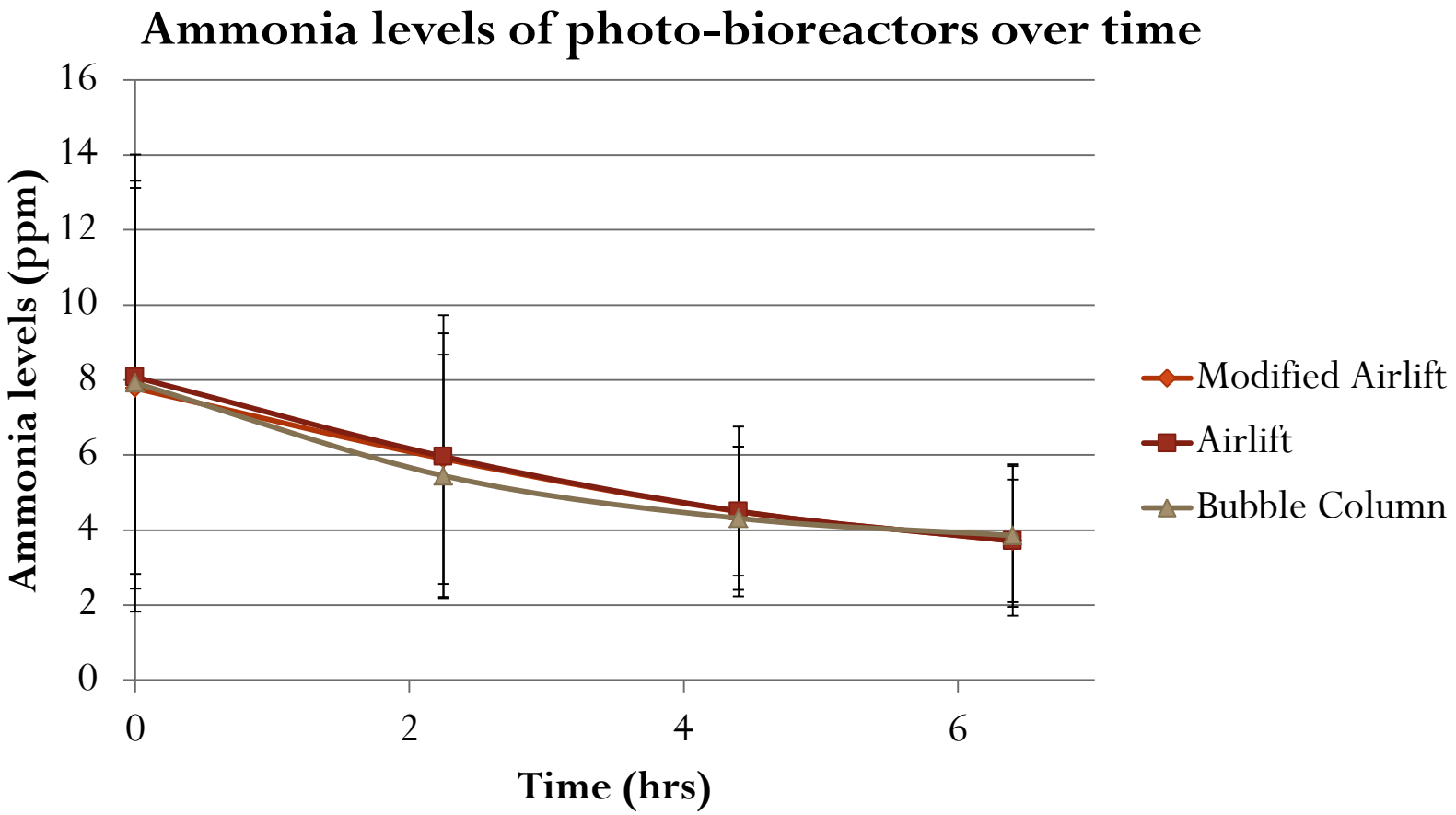
- Bioreactors inoculated with 91% algae and 9% permeate
- Supplemented with required elemental nutrients (based on Adrian Brene's experimentation)
- Samples taken roughly every two hours
- Measured:
  - pH
  - Optical density
  - Ammonia
    - Ammonia volatilization controlled by low pH (6.5-6.7)

# Experimental Set-up

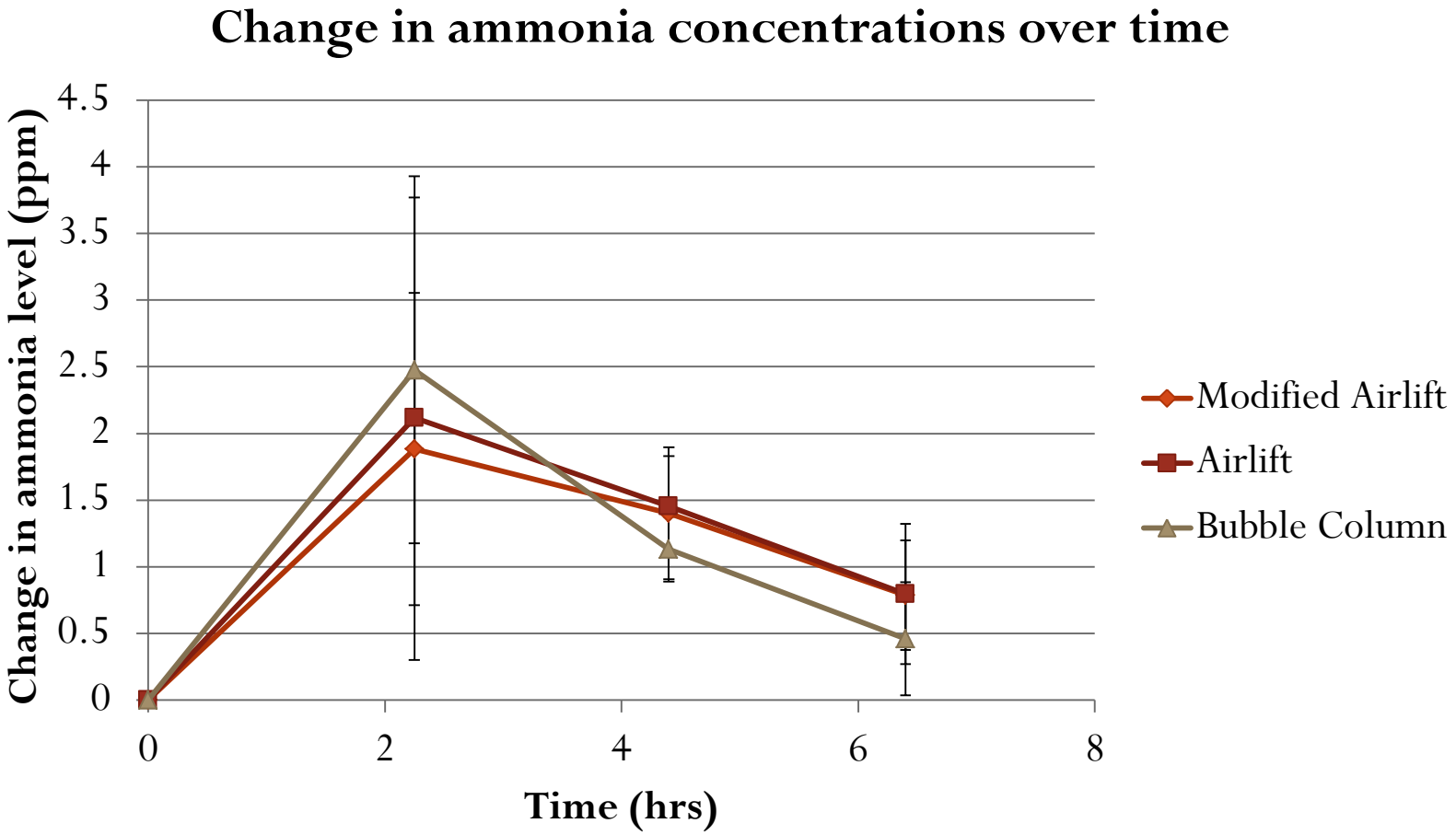
# Results


Optical Density of photo-bioreactors over time
3.2
3
2.8
2.6
2.4
2.2
2
1.8
1.6
0
1
2
3
4
5
6
7
Modified Airlift
Airlift
Bubble Column

# Results (cont.)

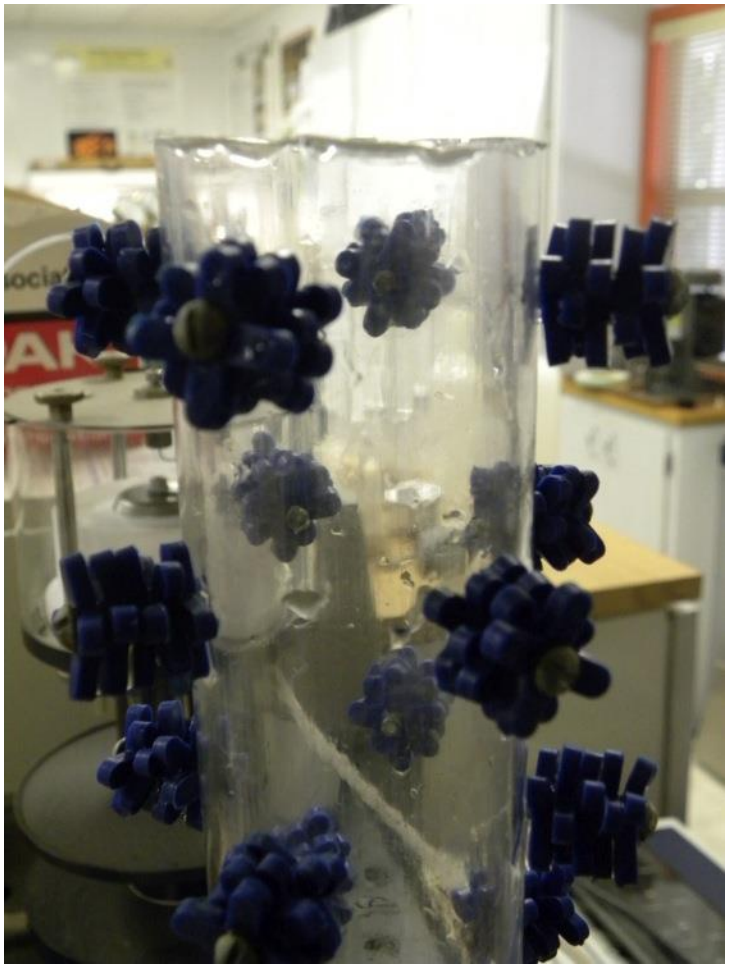


# Results (cont.)



# Conclusion

- Airlift modifications did not significantly increase remediation rates of landfill permeate
  - Possibly because of small turbulences
  - Possible that other factors are limiting algae remediation



# Possible Future Research

- Remediation using nitrogen starved algae
- Operating the algal remediation system based on culture density
- Increasing light intensity, changing photoperiod
- Increasing mixing rate
- Changing diameter of riser column

# Questions?