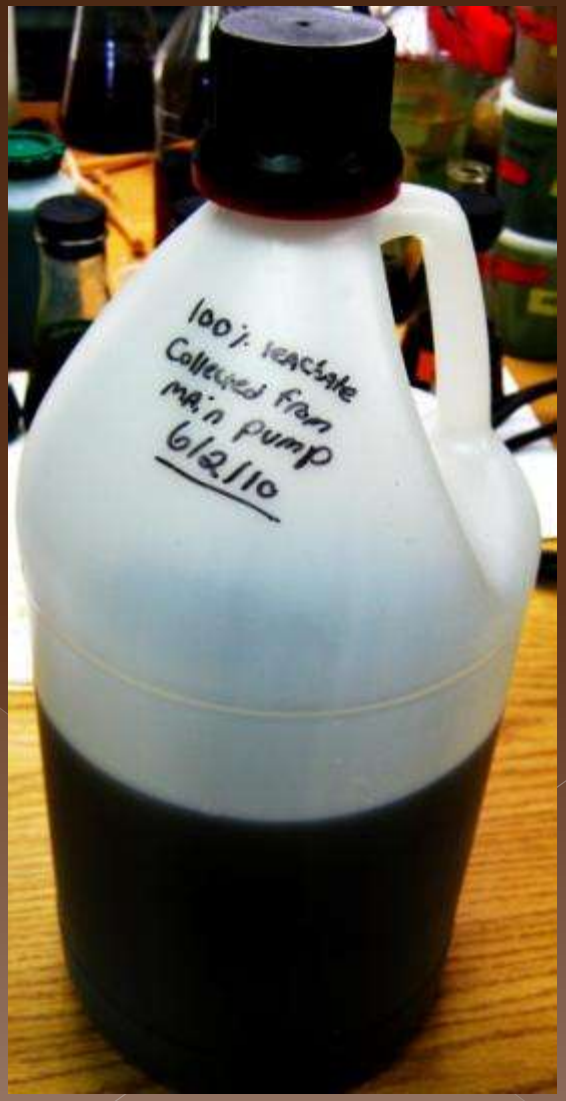
Phycoremediation of Landfill Leachate

Problem Definition

- 1,754 Municipal solid waste landfills in U.S. (2007)
- Leachate - water percolated through a landfill
  - Can pollute groundwater
  - High COD, ammonia, dissolved solids
  - Must be managed + treated
- Treatment
  - Ship to existing water treatment facility
  - On site chemical/physical process
  - Constructed Wetland
- Alachua County Southwest Landfill
  - Explore on site leachate treatment



Phycoremediation

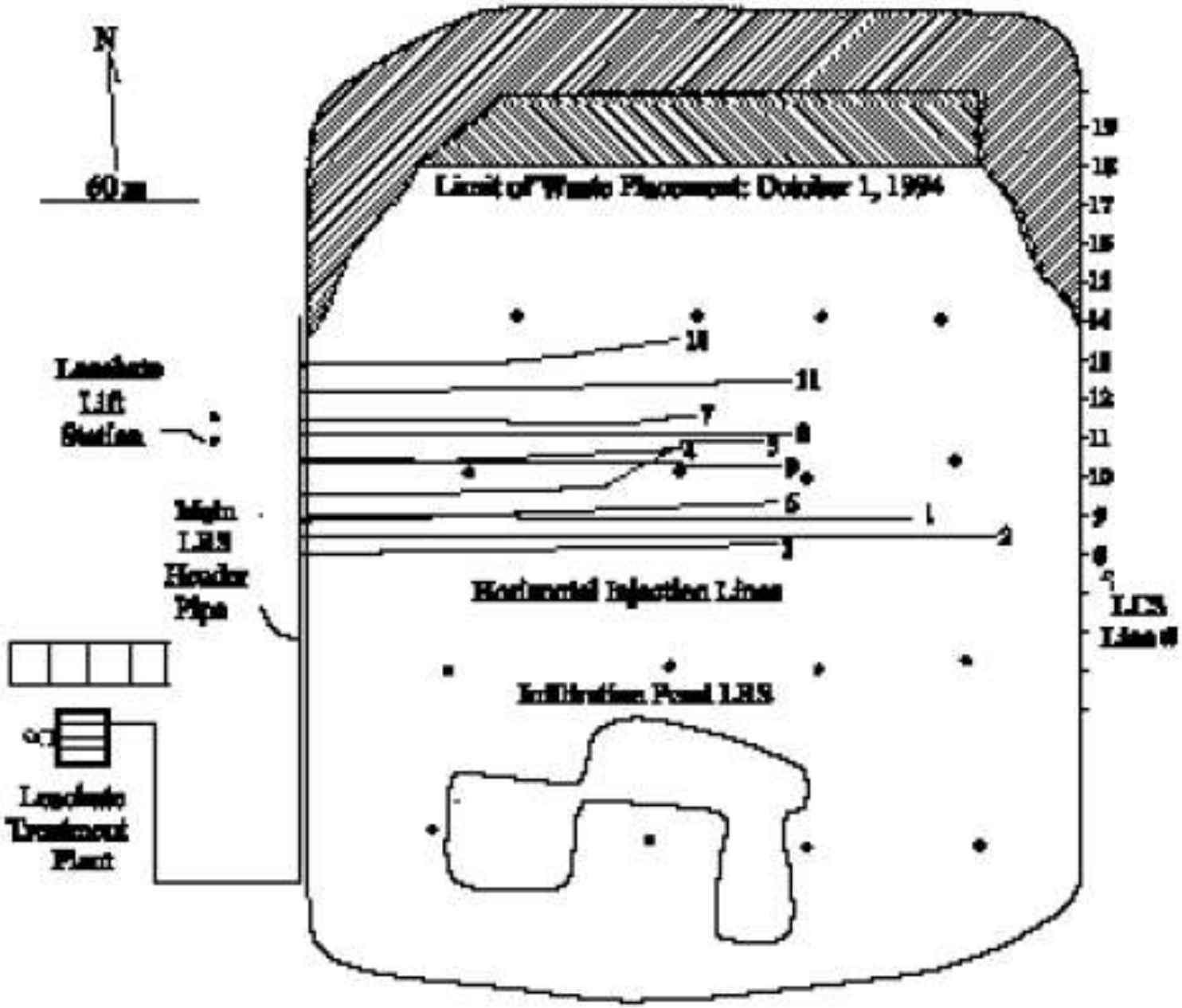
- Growing algae as water treatment
  - Algae uptake nutrients and dissolved solids
  - Historically associated with polluted water (blooms)
  - Huge diversity of species
    - Found in fresh & salt waters
- Benefits of Algae
  - Biomass useful for fertilizers, feedstocks, etc.
  - Possibility for production of bioenergy
    - Lipids in algae cells

Energy & Materials

- Current leachate treatment
  - Energy sink
  - Disposal of useful nutrients (N & P compounds)
  - Leachate as a cost
- Phycoremediation
  - Potential energy source
  - Development of useful nutrient/material cycle
  - Leachate as a resource

Alachua County Southwest Landfill

- Opened in 1973, Closed in 1999
- 27 acre Lined cell open from 1988-1999
  - Operated at ~300 tons/day
  - Used as experimental bioreactor by UF
    - Leachate circulation & methane production
- Leachate recirculated 1990-1995,2002-present
  - 3.7 Million gallons groundwater added 2004-2005
  - Original pretreatment on site before shipped to GRU wastewater facility

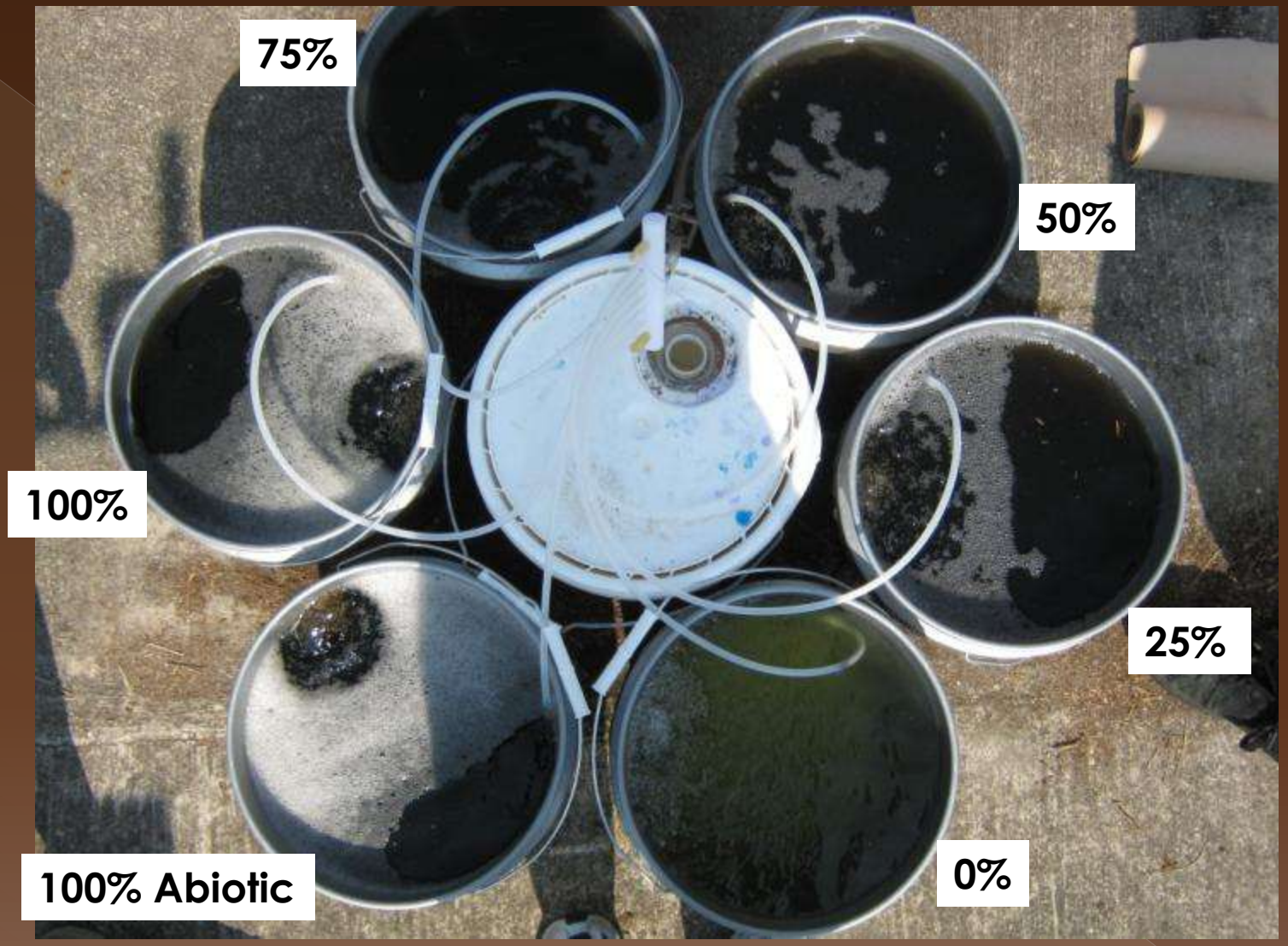

N
60 m
Limit of Waste Placement: October 1, 1994
Leachate
Lift
Station
Main
LRS
Header
Pipe
Horizontal Injection Lines
Infiltration Pond LRS
Leachate
Treatment
Plant
LCS
Lines

Phycoprospecting

- Search for algae adapted to landfill conditions
- Examination of bioresource potential
  - Lipids, pigments, etc
- Native polycultures
  - Improved robustness over monocultures

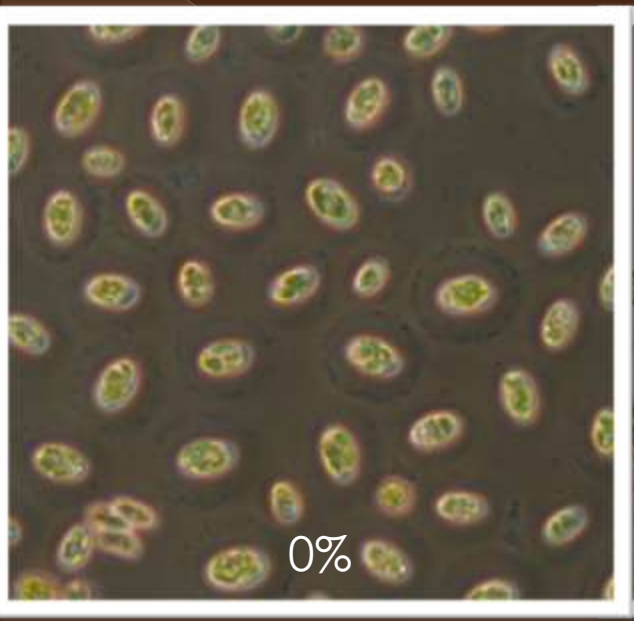
Micro-Tub Experimental Design

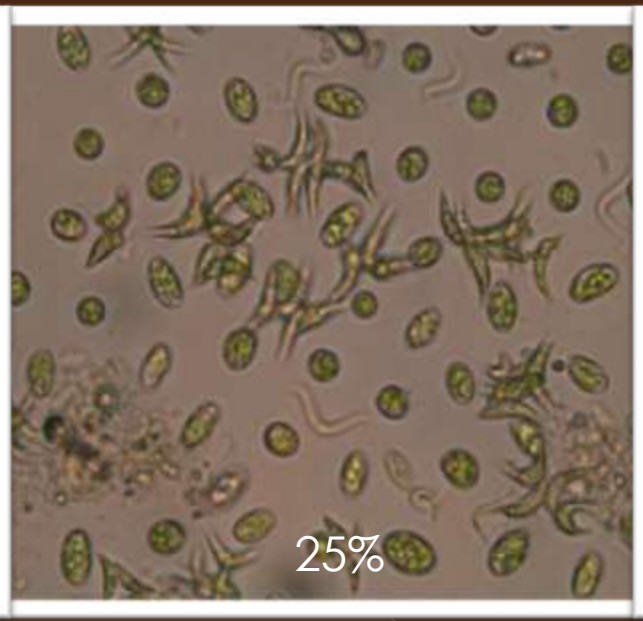
Macro-Slope Experimental Design

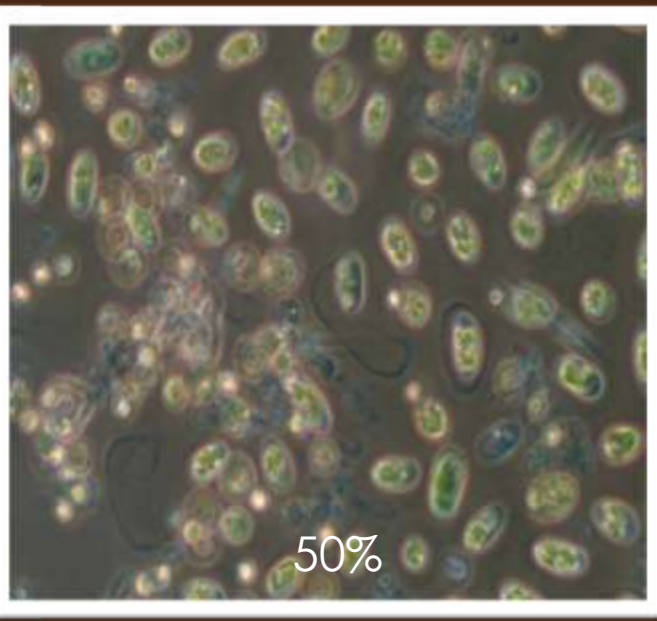


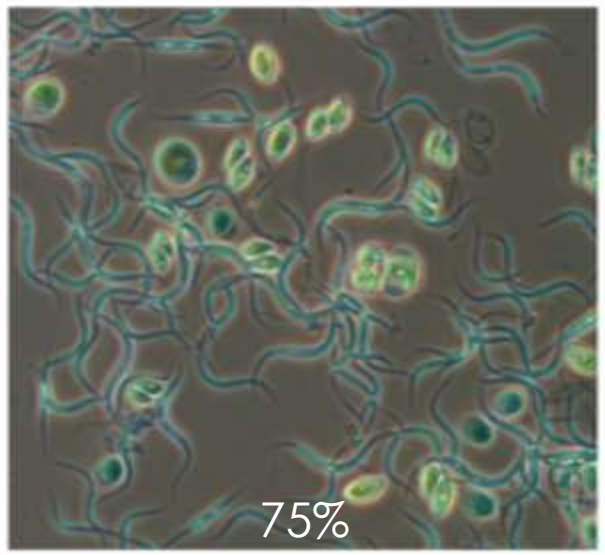
Dilution Test Experimental Design

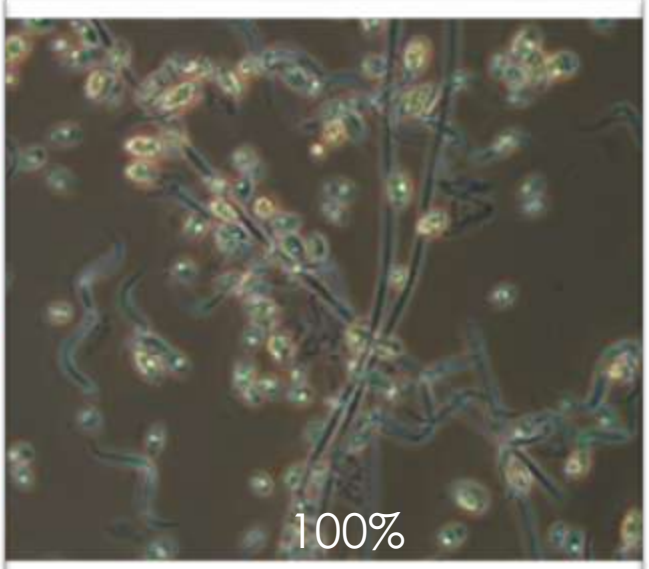
Algae Diversity

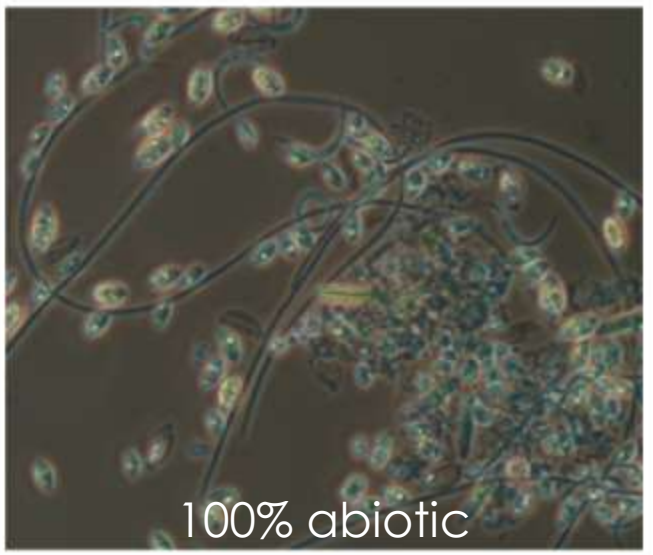












Experimental Methods

- **Cell Counts**
  - Allows count of cells/mL using microscope
- **Conductivity**
  - Measures ability of sample to carry electrical current
- **Phosphorous**
  - spectrophotometer, which measures light absorbance, used to test phosphate levels in samples
- **Fluorescence**
  - Chlorophyll autofluoresence used as a proxy for culture growth
- **Ammonia**
  - The ammonia test measures the total ammoniacal nitrogen in the sample
- **pH**
  - Monitored due os its affect on ammonium deprotonation and biology

Above: Ammonia Probe;
Below: Hemacytometer

pH meter

Above: Flourimeter
Below: Conductivity Probe

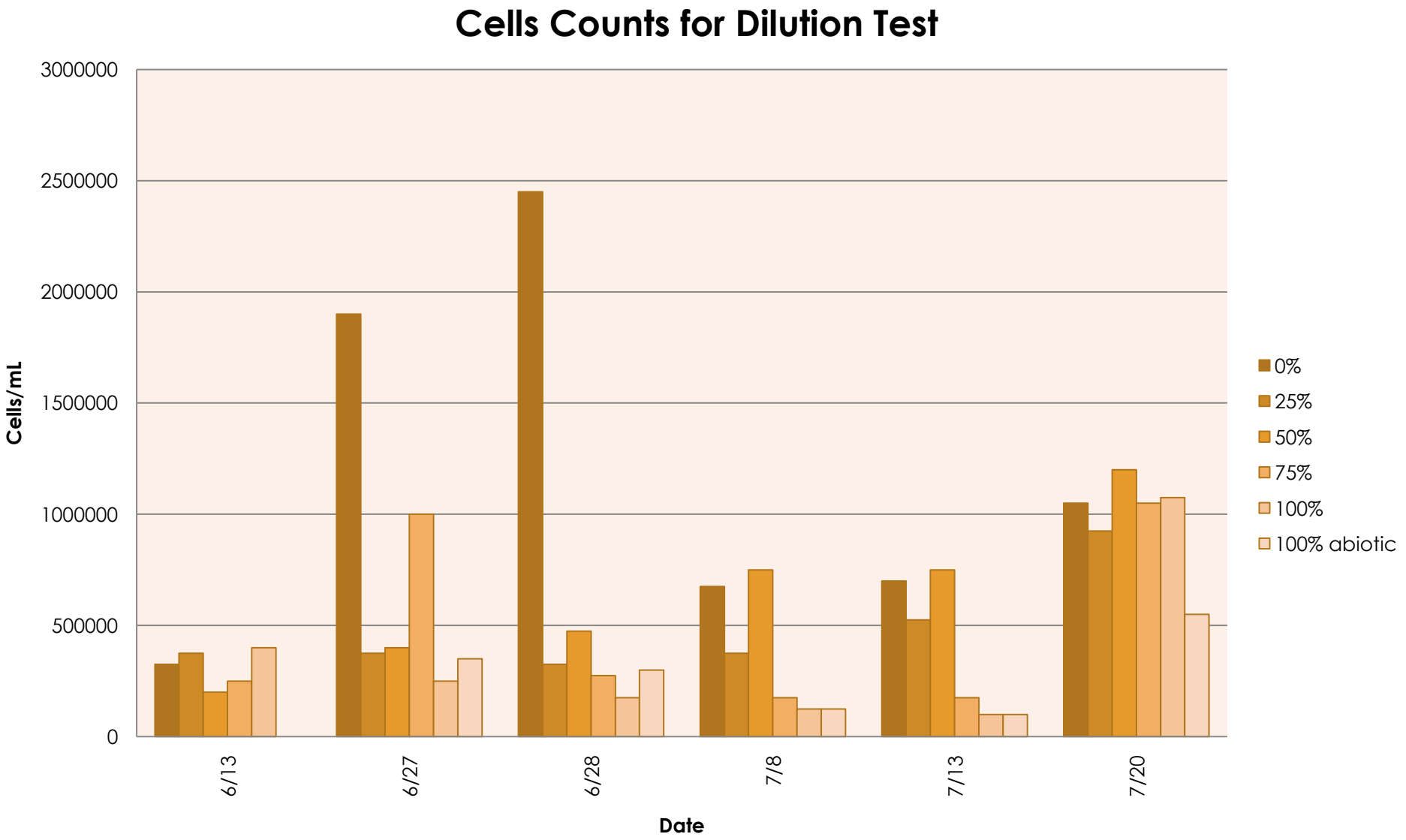
Phosphorus Setup

Results Overview

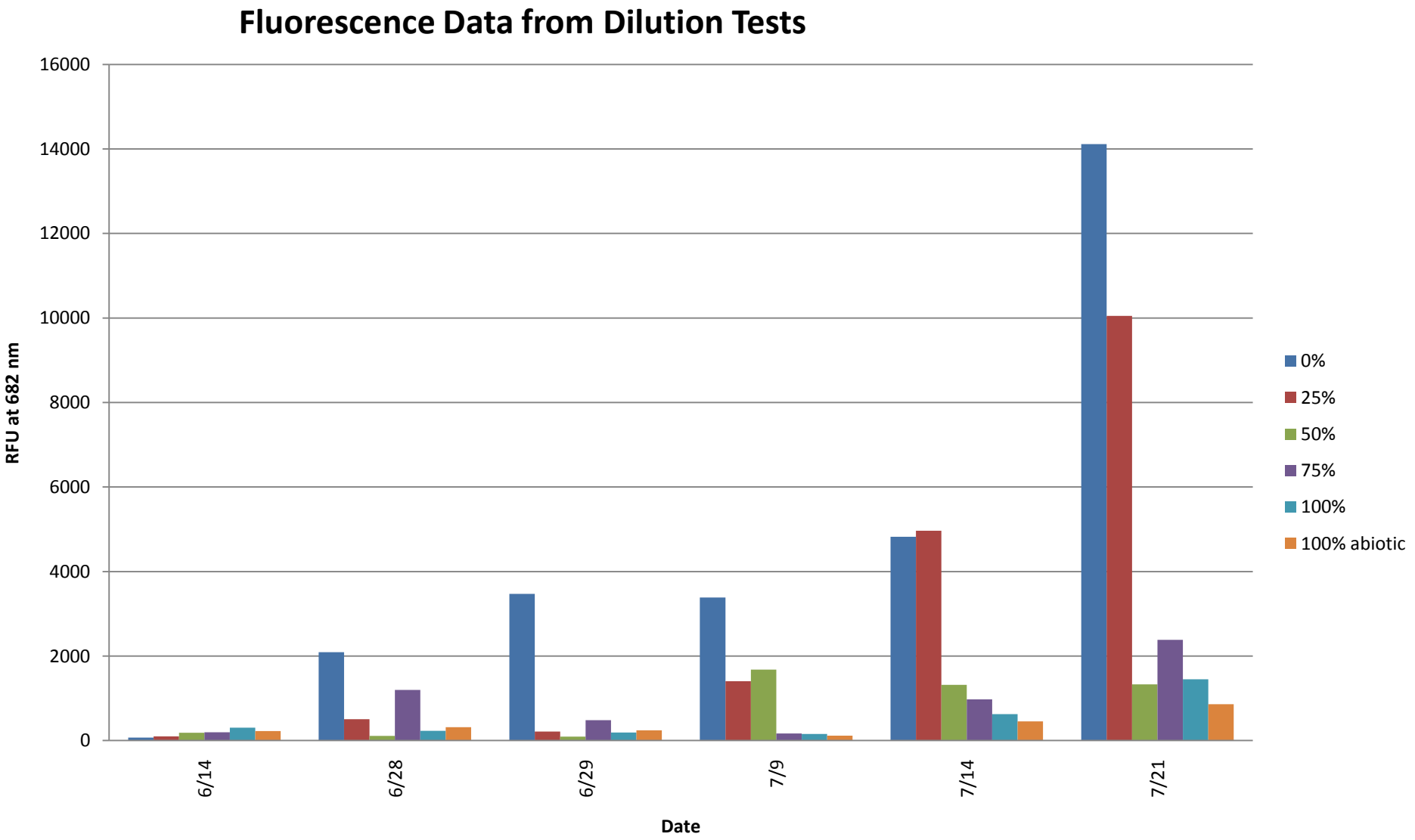
- Fluorescence data for dilution tests
- Cell counts for dilution tests
- Algae diversity in leachate dilutions
- Ammonia data for dilution tests
- Electro conductivity data
- Phosphorus and pH readings for dilution tests
- Dry weight and lipid calculations

Micro Tub	Macro Pool
Concentration 90 percent	Concentration 60 percent
pH 9.00 - 9.27	pH initial 8.5, max 10.24 on 6/11
NH4-N decreased from 133.21 mg NH4-N/L to <1.00 mg NH4-N/L in 12 days and remained	NH4-N mirrored downward trend in micro tub
Cell counts reached peak of 4.25 x 10^6 cells/ml on 6/15	Cell count peaked on 1.74 x 10^6 cells/ml on 7/21
EC decreased from 5.47 mS/cm on 5/28 to 3.63 mS/cm on 7/9	EC decreased 2.33 mS/cm to 1.55 mS/cm, dramatic increase to 3.18 mS/cm after 3 cm of raw leach ate added
Fluorescence had first peak on 6/15 at 1965.4 RFU to 6191.5 RFU on 7/21	Fluorescence coincides with the addition of leachate peaks on 7/9, max at 20,322.3 RFU on 7/21
PO4 decreased until 6/9, increased until 6/15, significant decrease after	PO4 increased until 6/15, dropped significantly after

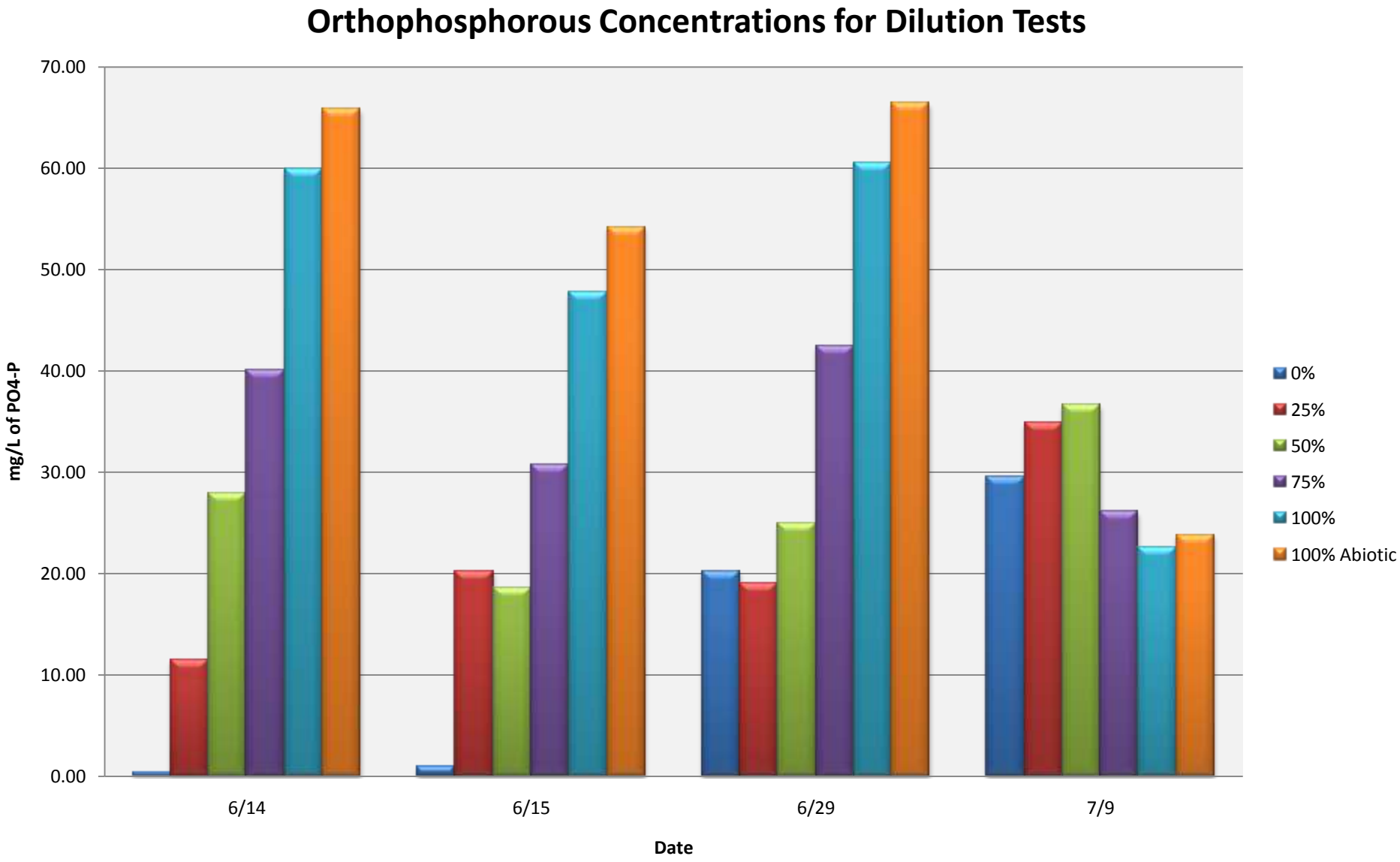
Cell Counts


Cells Counts for Dilution Test
3000000
2500000
2000000
1500000
1000000
500000
0
Cells/mL
6/13
6/27
6/28
7/8
7/13
7/20
Date
0%
25%
50%
75%
100%
100% abiotic

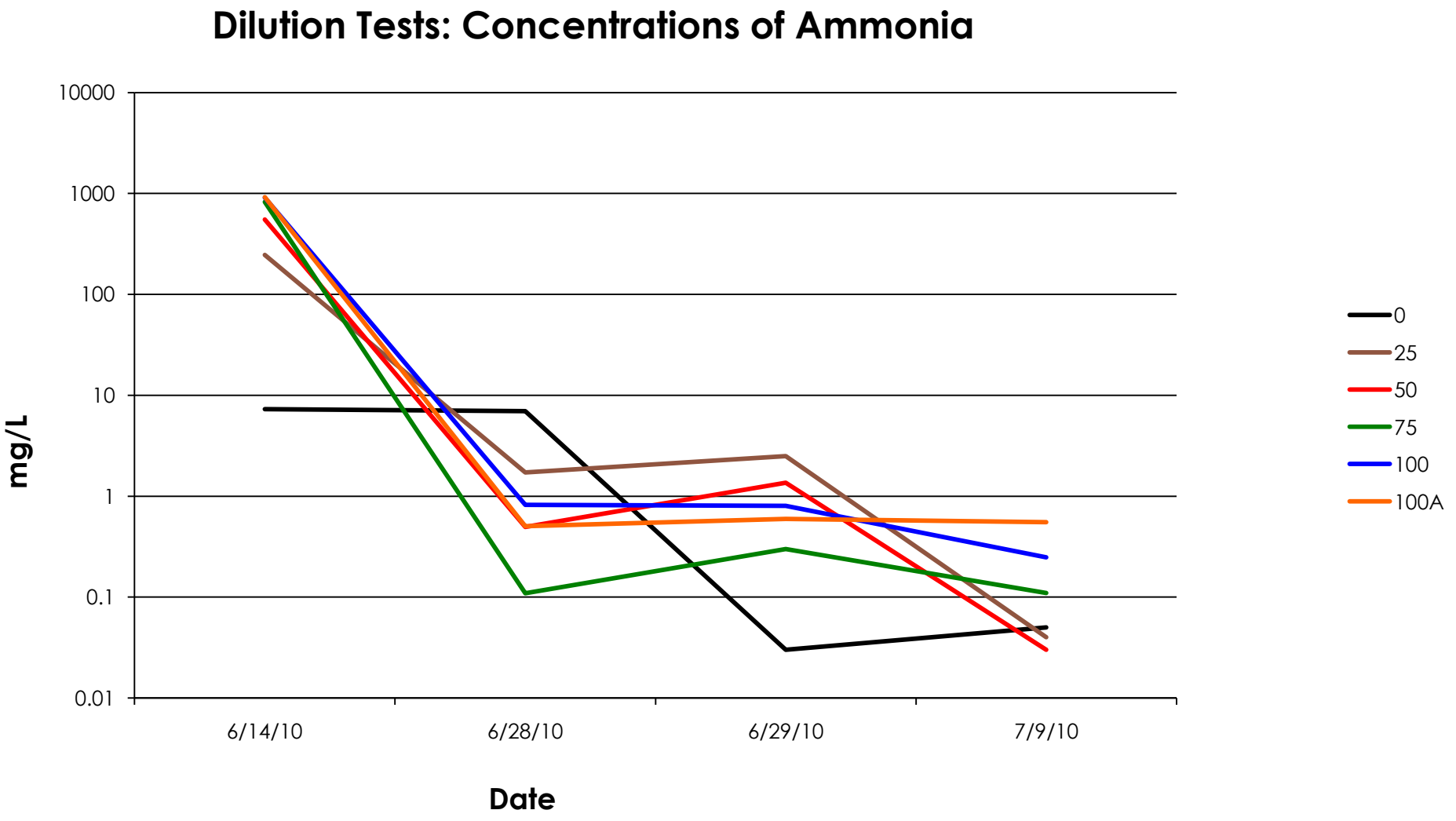
Fluorescence



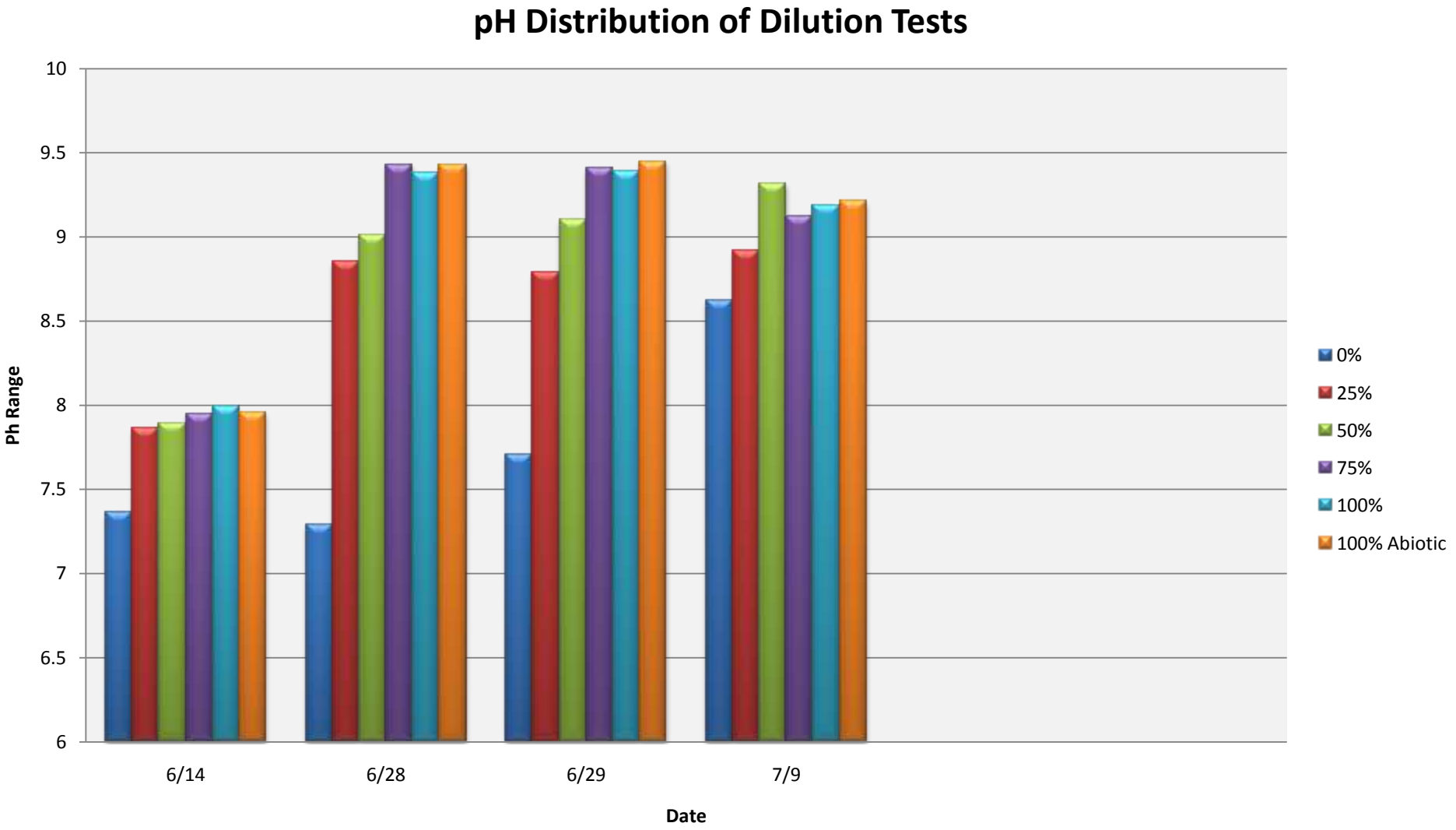
Phosphorus


Orthophosphorous Concentrations for Dilution Tests
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
mg/L of PO4-P
6/14
6/15
6/29
7/9
Date
0%
25%
50%
75%
100%
100% Abiotic

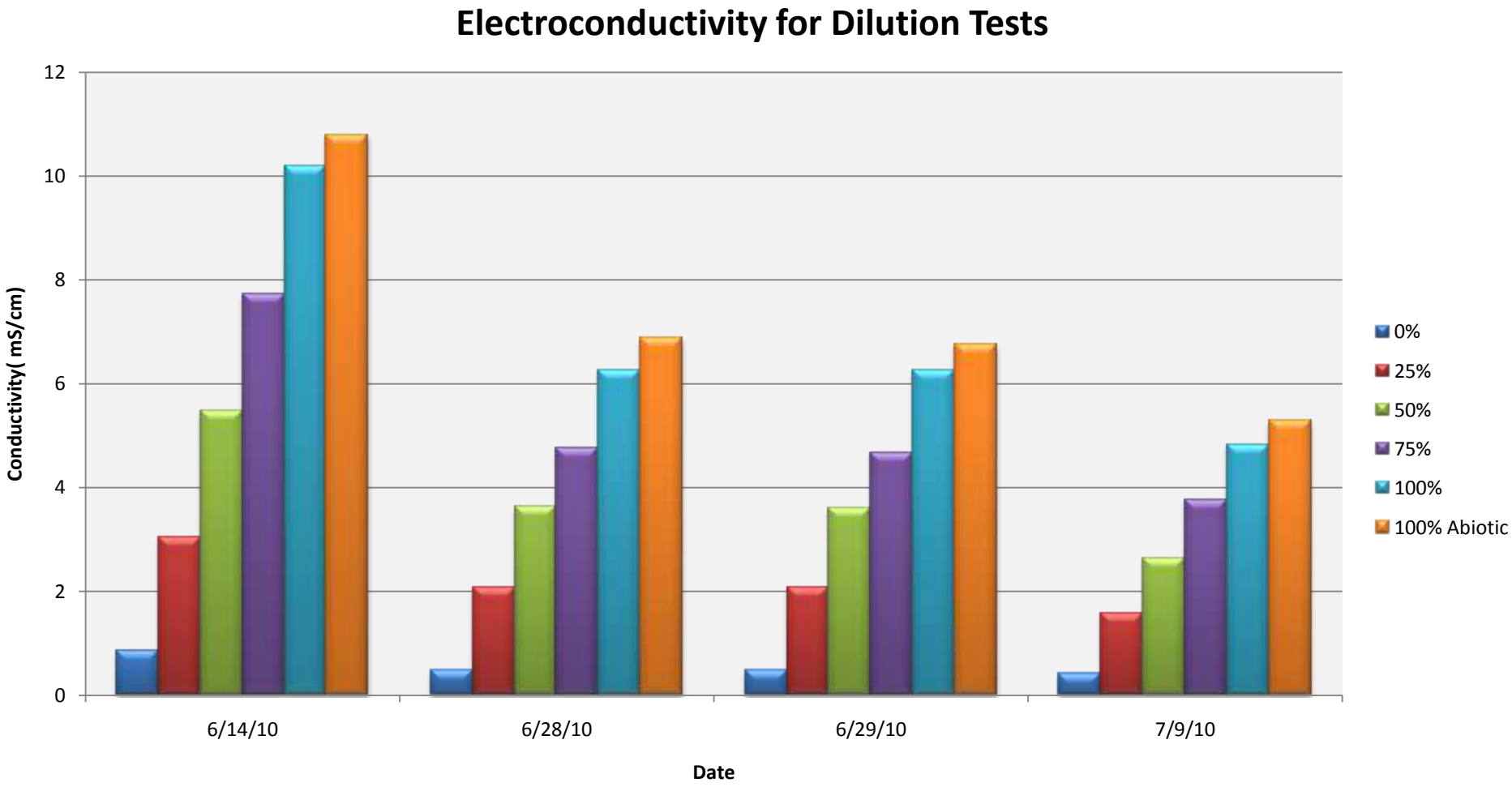
Ammonia


Dilution Tests: Concentrations of Ammonia
10000
1000
100
10
1
0.1
0.01
mg/L
6/14/10
6/28/10
6/29/10
7/9/10
Date
0
25
50
75
100
100A

pH


pH Distribution of Dilution Tests
10
9.5
9
8.5
8
7.5
7
6.5
6
Ph Range
6/14
6/28
6/29
7/9
Date
0%
25%
50%
75%
100%
100% Abiotic

Electroconductivity



Conclusions

- Algae are capable of growing in all dilutions of leachate
  - 25-50% dilutions exhibited greatest growth and photosynthetic activity
- Algae shows potential as remediation strategy
  - Further research necessary on uptake of dissolved ions
  - More intensive investigation of algae growth in leachate
    - Reproduction, Biomass, Lipid production, etc…
  - Application at landfills including harvesting

References

Abeliovich, A. & Azov, Y. (1975). Toxicity of Ammonia to Algae in Sewage Oxidation Ponds. *Applied and Environmental Microbiology*, *31*(6), 801-806.

Azov, Y. and Goldman, J.C. (1981). Free Ammonia Inhibition of Algal Photosynthesis in Intensive Cultures. *Applied and Environmental Microbiology*, *42* (4), 735-739.

Lin, L., Chan, G.Y.S., Jiang, B.L., & Lan, C.Y. (2007). Use of ammoniacal nitrogen tolerant microalgae in landfill leachate treatment. *Waste Management, 27*(2007), 1376-1382.

QUESTIONS?