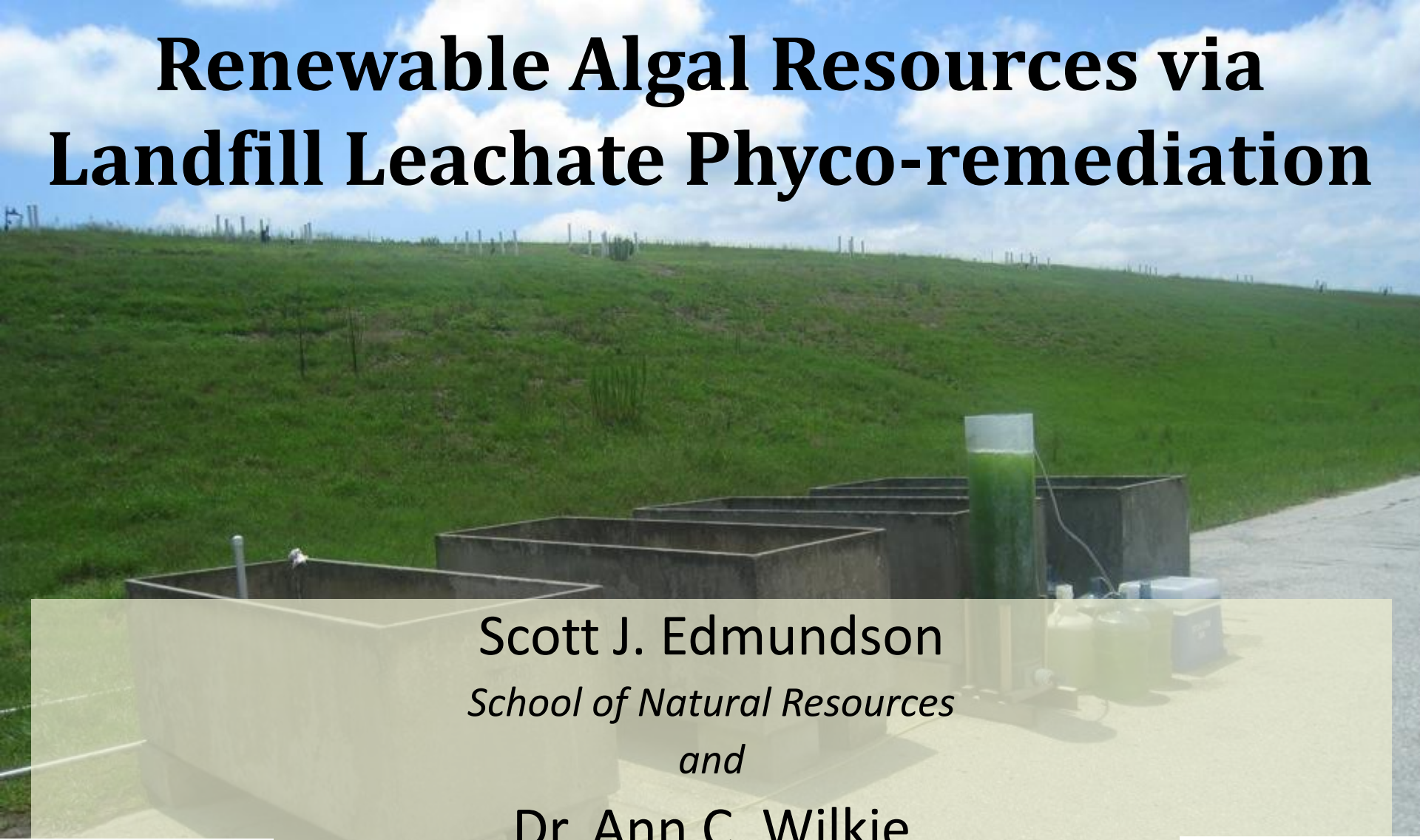
Renewable Algal Resources via Landfill Leachate Phyco-remediation



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a university-wide program in ecology, environmental science and sustainability

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Outline

- Problem Definition
- Background
- Leachate Composition
- Bio-prospecting Algae
- Results
- Discussion

Global Issues

- The human impact upon our planet is steadily increasing.
- Human communities are consuming more energy than they are producing.
- Communities are reliant almost entirely on nonrenewable resources for prosperity.

Landfill Problem Definitions

- Humans generate considerable amounts of waste
- Over 3,500 active landfills in the U.S. (US EPA)
  - All landfills produce leachate
- Landfill leachates are detrimental to surface and ground water resources
  - 90% of Florida's population depend on ground water as a primary drinking water source

Landfills- a primer

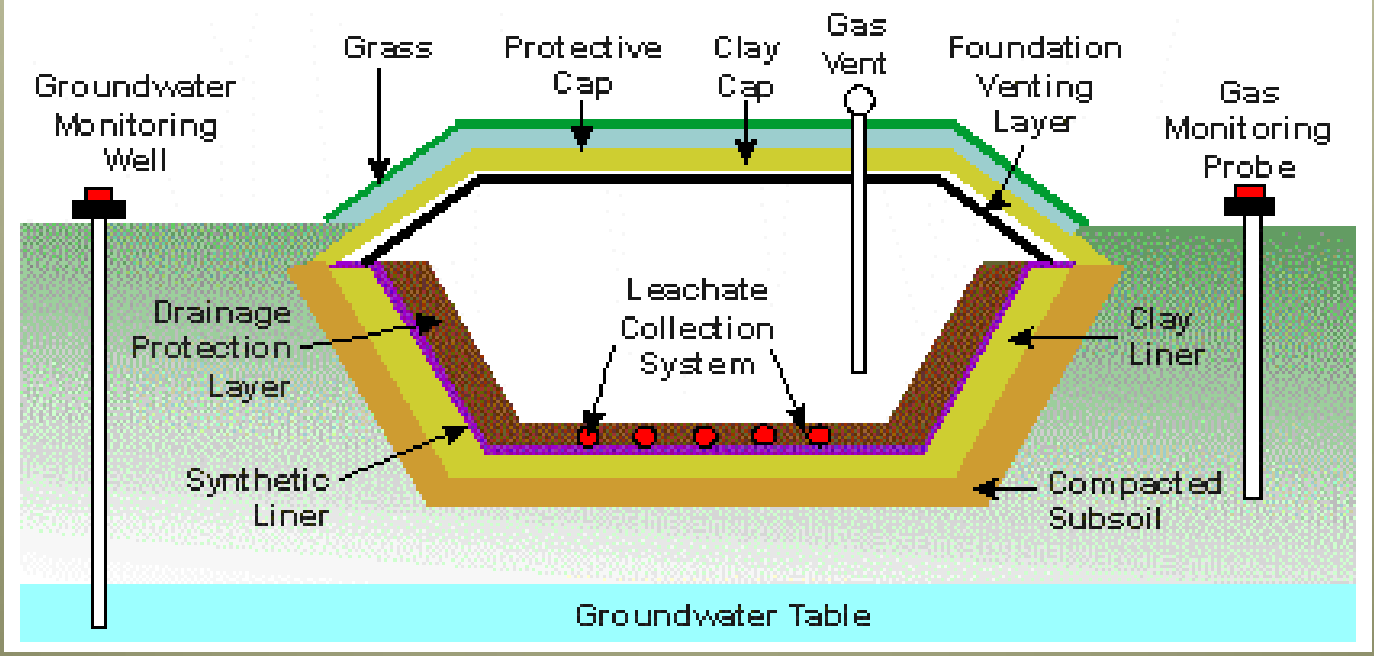
- Prior to regulation, unlined open dumps were the most common method of trash disposal.

- Water contamination from unmanaged waste disposal spurred environmental regulation.
  - Resource Conservation and Recovery Act 1976 (regulation of hazardous and solid waste disposal)

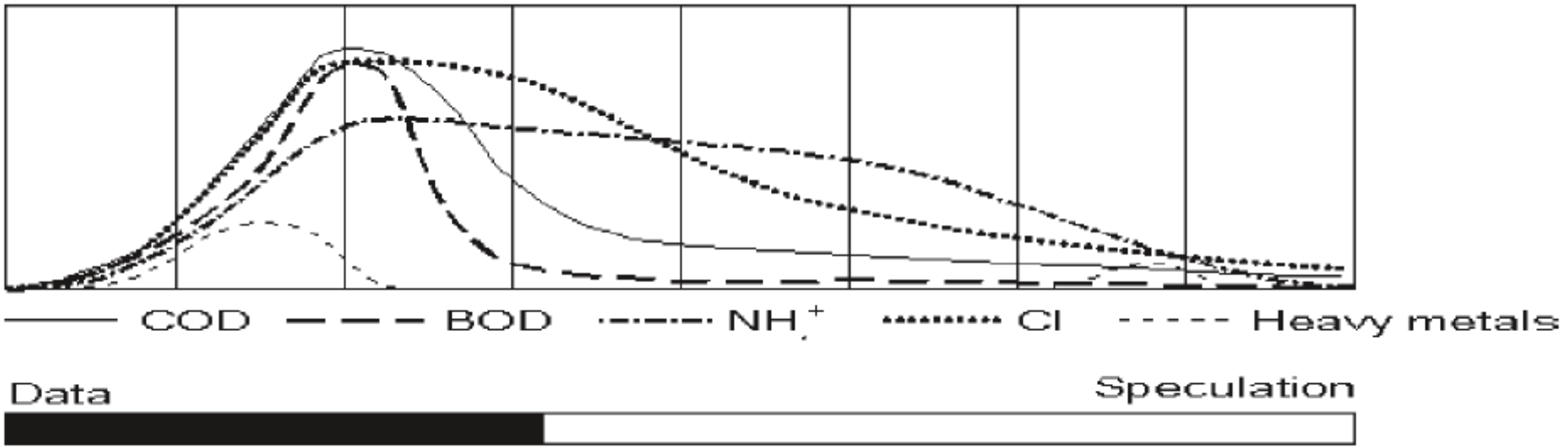
- The lined landfill is developed to minimize environmental exposure to disposed waste.

Landfill Leachate

- Impermeable liners are used in landfills to reduce seepage of waste liquids into groundwater resources.
- **Leachate** is defined as *"*a liquid that has passed through or emerged from solid waste and contains soluble, suspended or miscible materials removed from such wastes" *–US Code of Federal Regulations*
- Landfill operators must manage their leachate for ~30 years post closure.



Landfill Leachate Composition over time



Kjeldsen *et al*. 2002. Present and Long-Term Composition of MSW Landfill Leachate: A Review. Critical Reviews in Environmental Science and Technology

South West Archer Landfill

- Gainesville's primary landfill from 1988-1999
  - 27-acre Class I, lined landfill
  - Operated at 300 tons MSW/day

Leachate Characteristic (mg/L)	Southwest Landfill Leachate	Groundwater Cleanup Target Level (FDEP 2005)
Total ammonia-N	1300	2.8
Iron	6.41	0.3
Sodium	2290	160
Chloride	2100	250
Arsenic	0.0602	0.01
Chromium	0.0774	0.1
Mercury	< 0.0001	0.002

Landfill Leachate Management

- Landfill leachates are detrimental to surface water and ground water resources.

- Landfill leachates are toxic to natural ecosystems and can pose health issues for communities
  - Toxic constituents:
    - Ammonia
    - Xenobiotic organics (e.g. chloroform, pesticides, pharmaceuticals)
    - Heavy metals

- Leachate generated at landfills must be remediated.
  - Most common method is transportation to off-site water reclamation facility.

Algae-Based Remediation

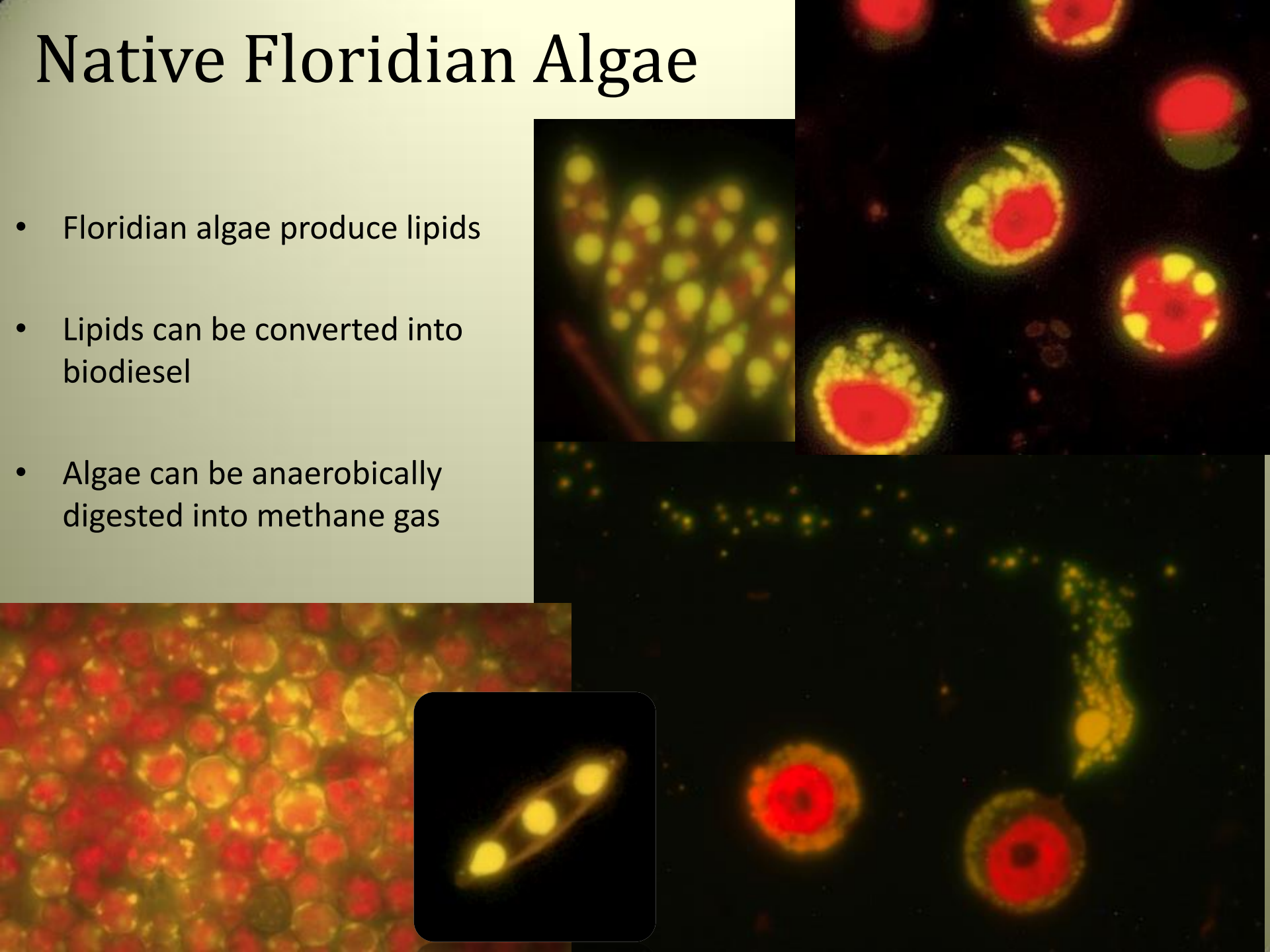
- Why use algae for remediation?
  - Remediate water through cellular uptake
  - Oxygen produced in photosynthesis reduces oxygen demand
  - Solar powered
  - Continuous biomass production
  - Small footprint (on-site treatment)

The Botanical Diversity of Algae

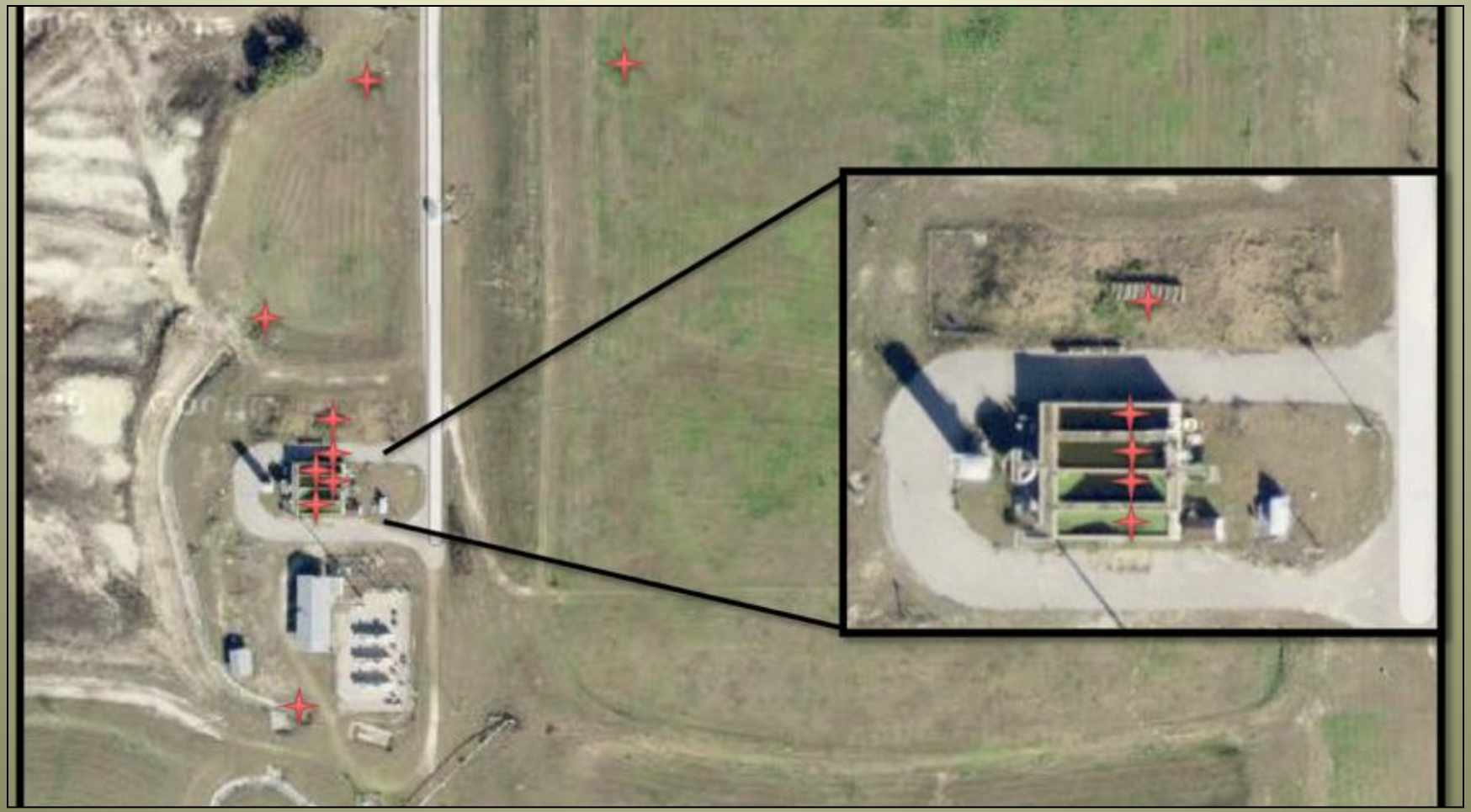
- Ubiquitous, found on every continent and in every ocean.
- Algae are a diverse polyphyletic group of organisms
  - 10,000 - 40,000 recognized species
  - May be as many as 10,000,000 species yet to be described

Native Floridian Algae

- Floridian algae produce lipids
- Lipids can be converted into biodiesel
- Algae can be anaerobically digested into methane gas



Bioprospecting a closed MSW landfill (Archer, Fl)

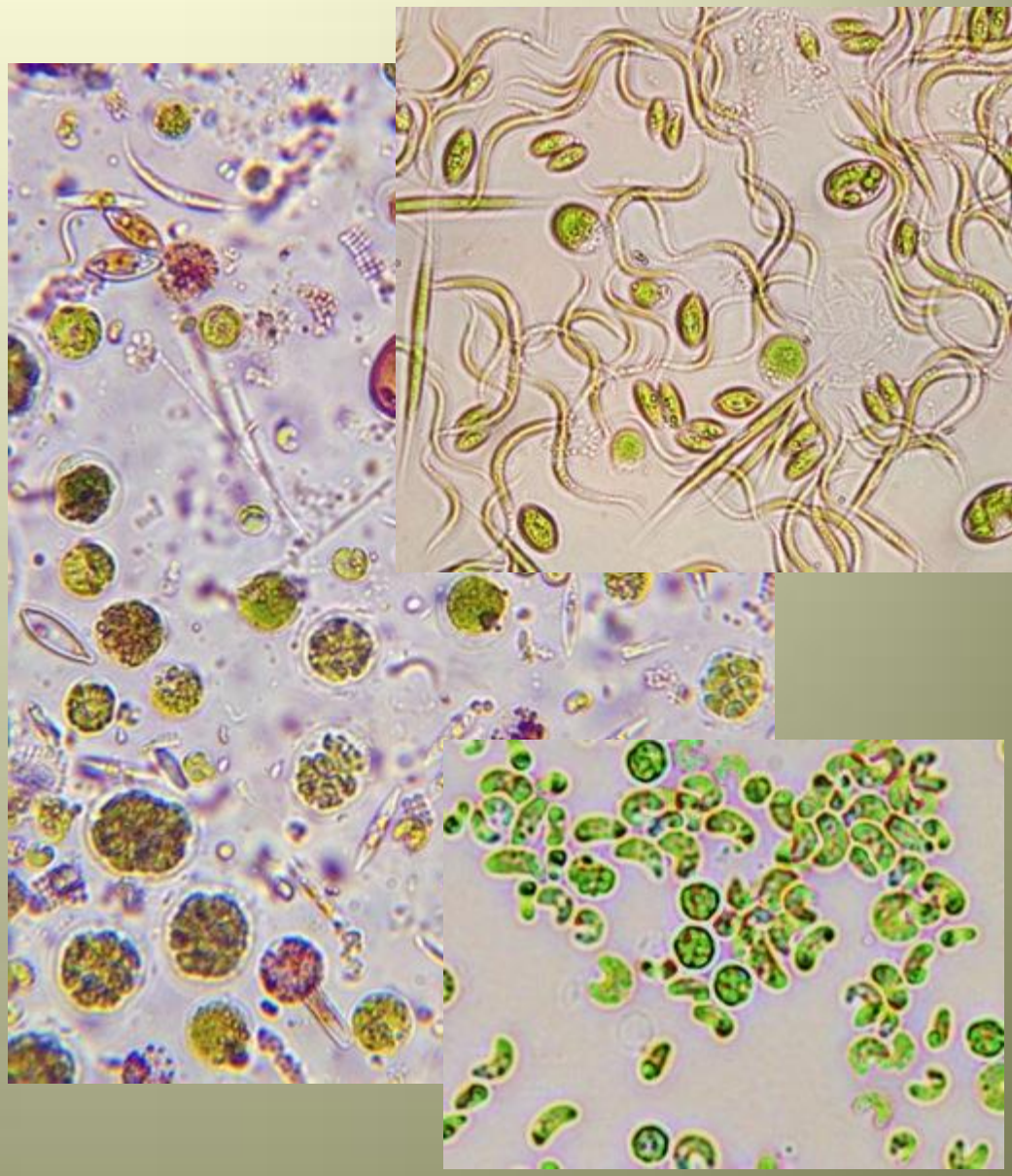


Indicates sampled location

Bioprospecting SW Archer Landfill

Algal Genera found:

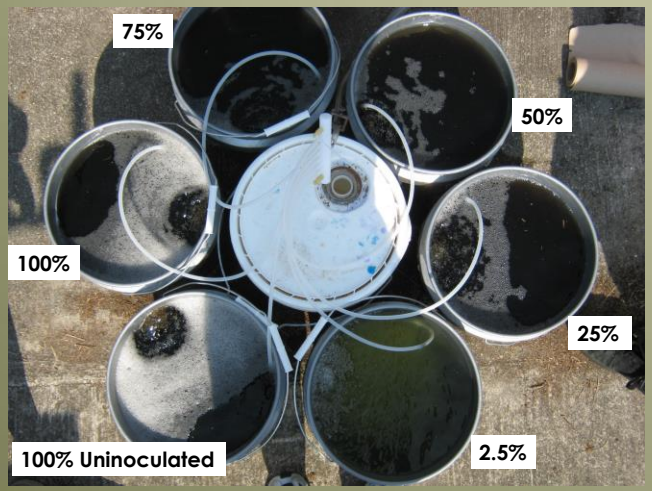
- *Chlorella* spp.
- *Ankistrodesmus* sp.
- *Kirchneriella* sp.
- *Chlamydomonas* sp.
- *Selenastrum* sp.
- *Scenedesmus* spp.
- *Pandorina* sp.
- Unidentified diatoms



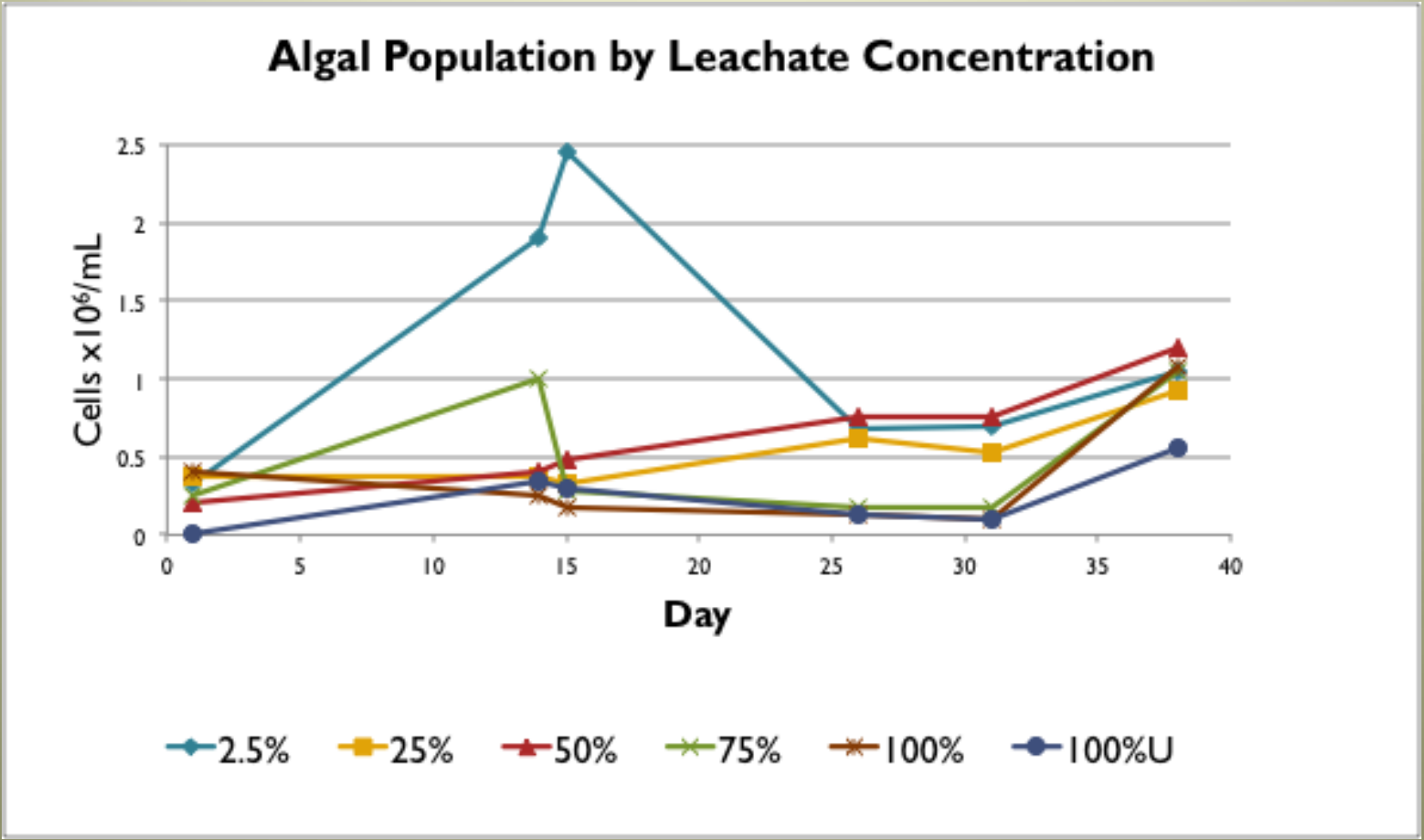
Selective Enrichment in Landfill leachate

- Traditional technique in micro-algal isolation used as a primary step to single cell isolation from a mixed population.
  - Common enrichment substances include algal media, soil extract, organics, etc.
  - Landfill leachate used as an enriching substance- selective cultivation
    - Rational step towards selecting from native algal population for leachate tolerance

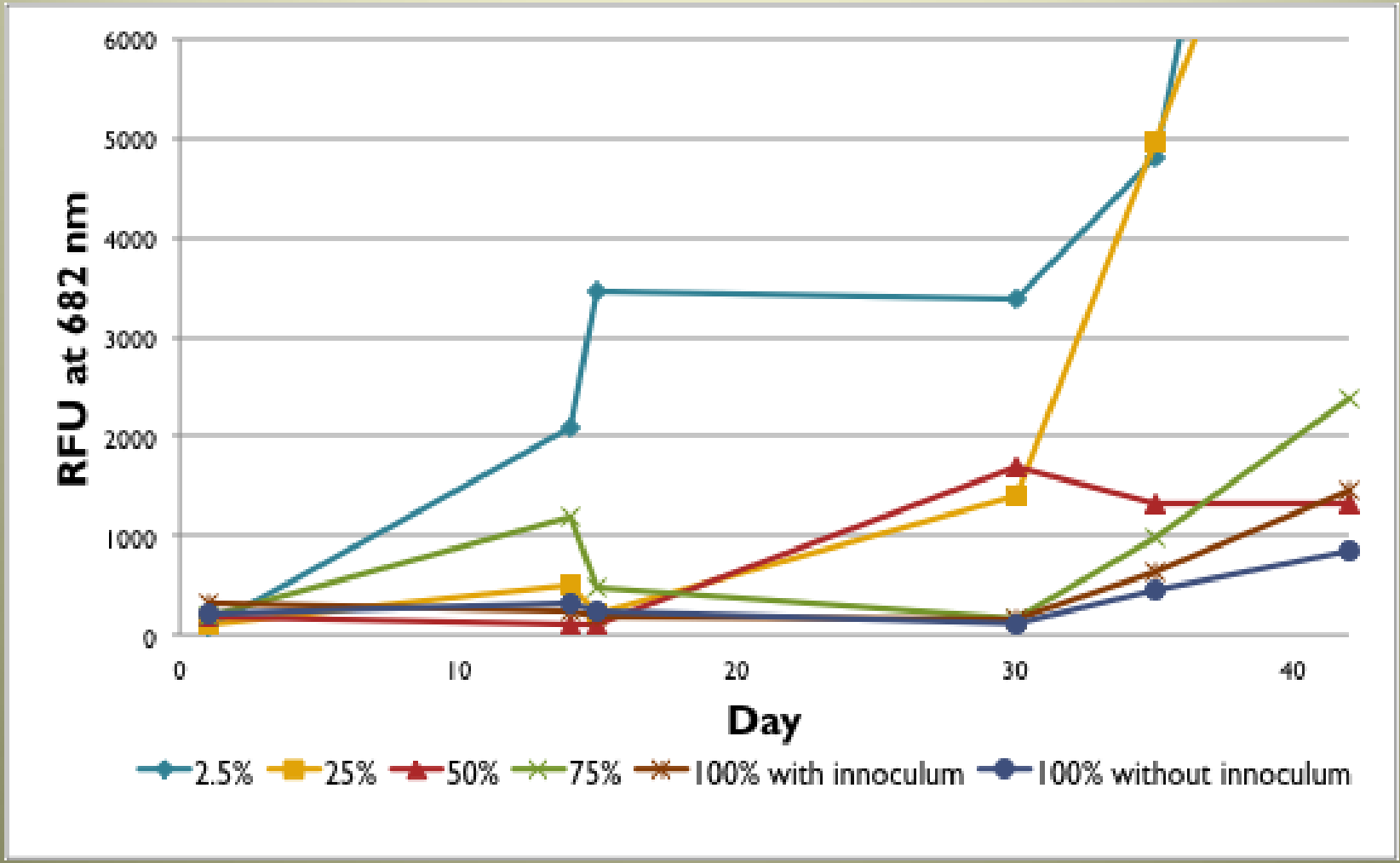
- Landfill leachate diluted with groundwater to concentrations
  - 2.5, 25, 50, 75, and 100%
  - Inoculated with a natural, mixed population found at the landfill site.



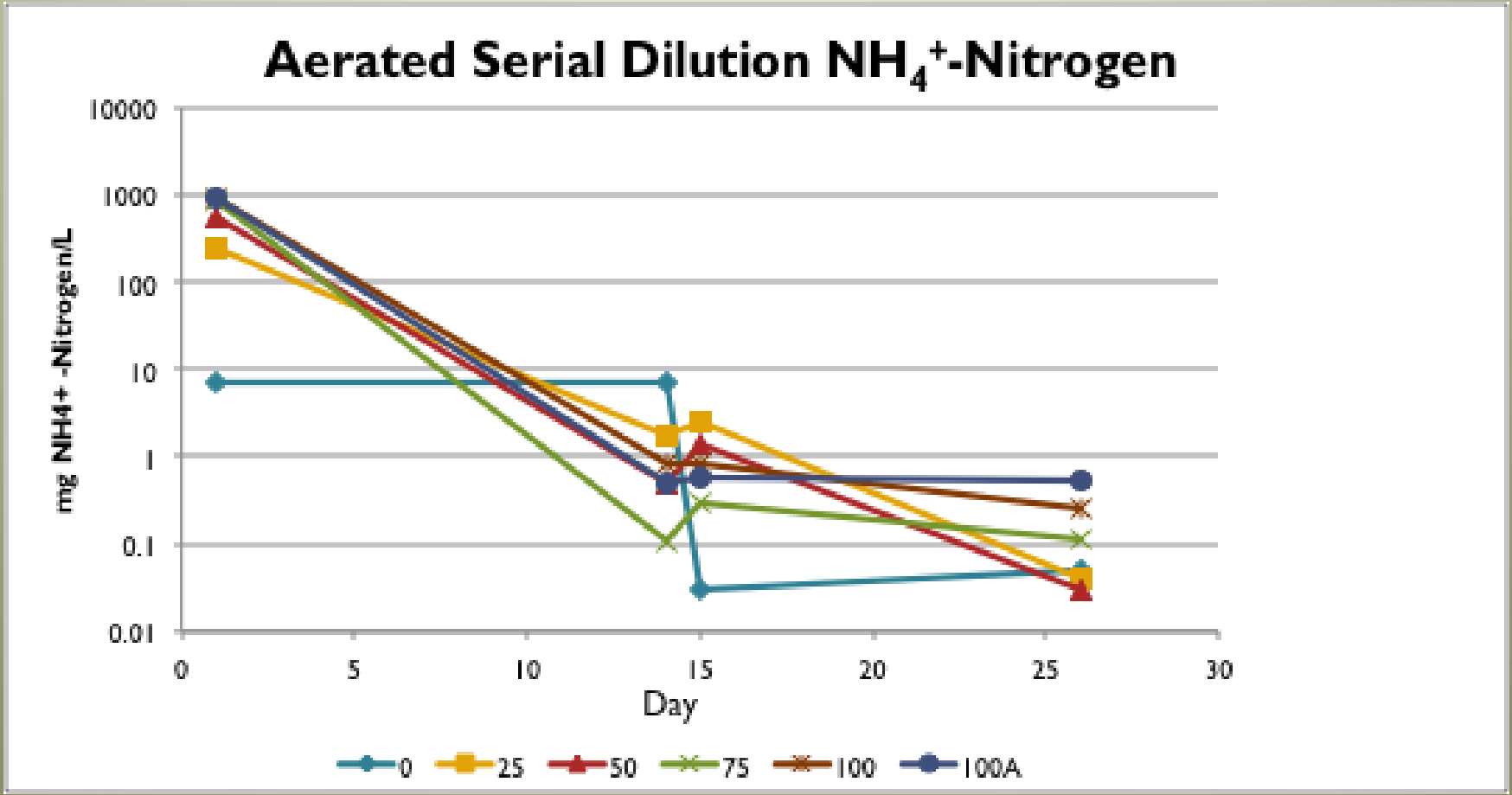
Selective Enrichment: Cell Count



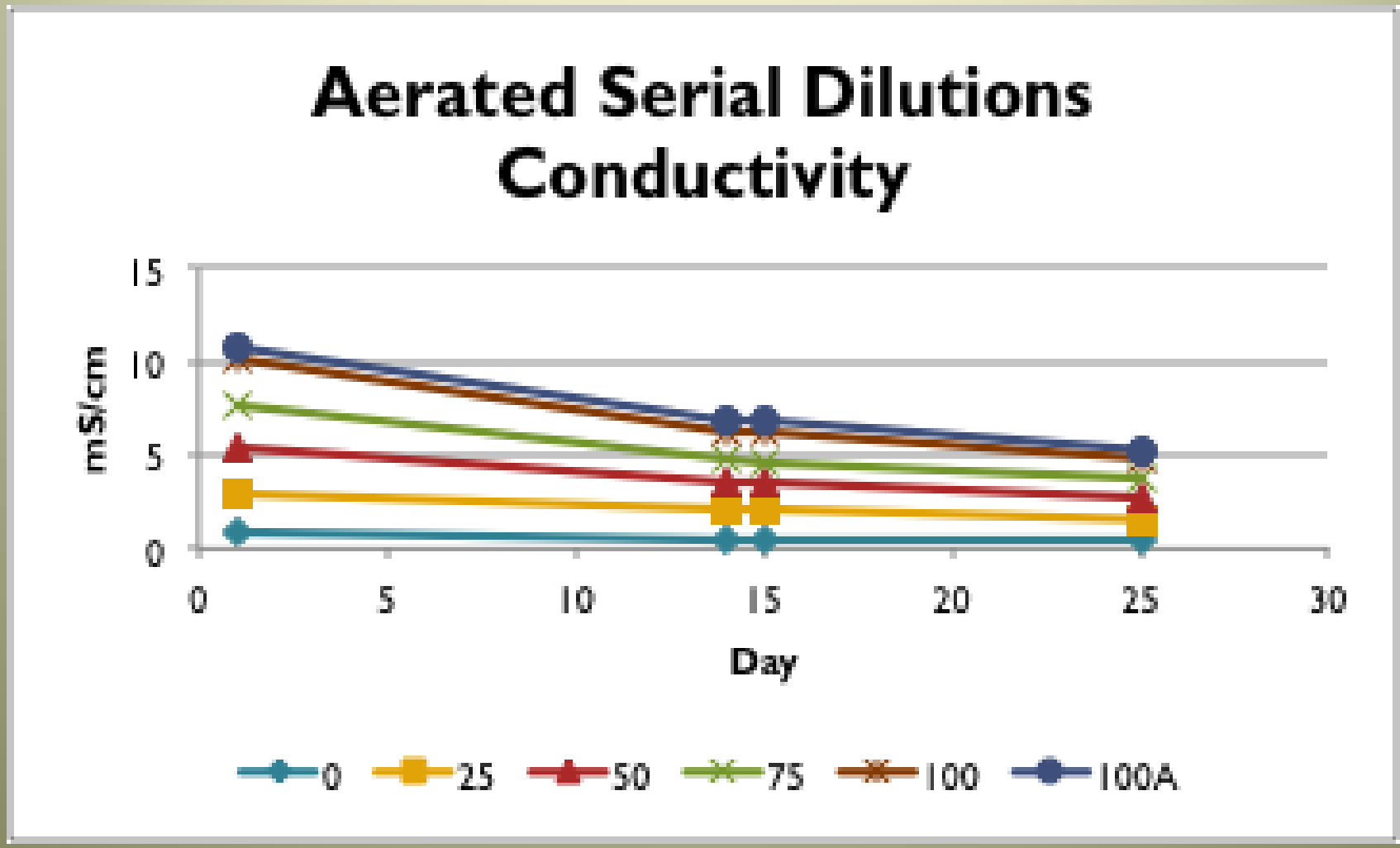
Selective Enrichment: Chlorophyll fluorescence



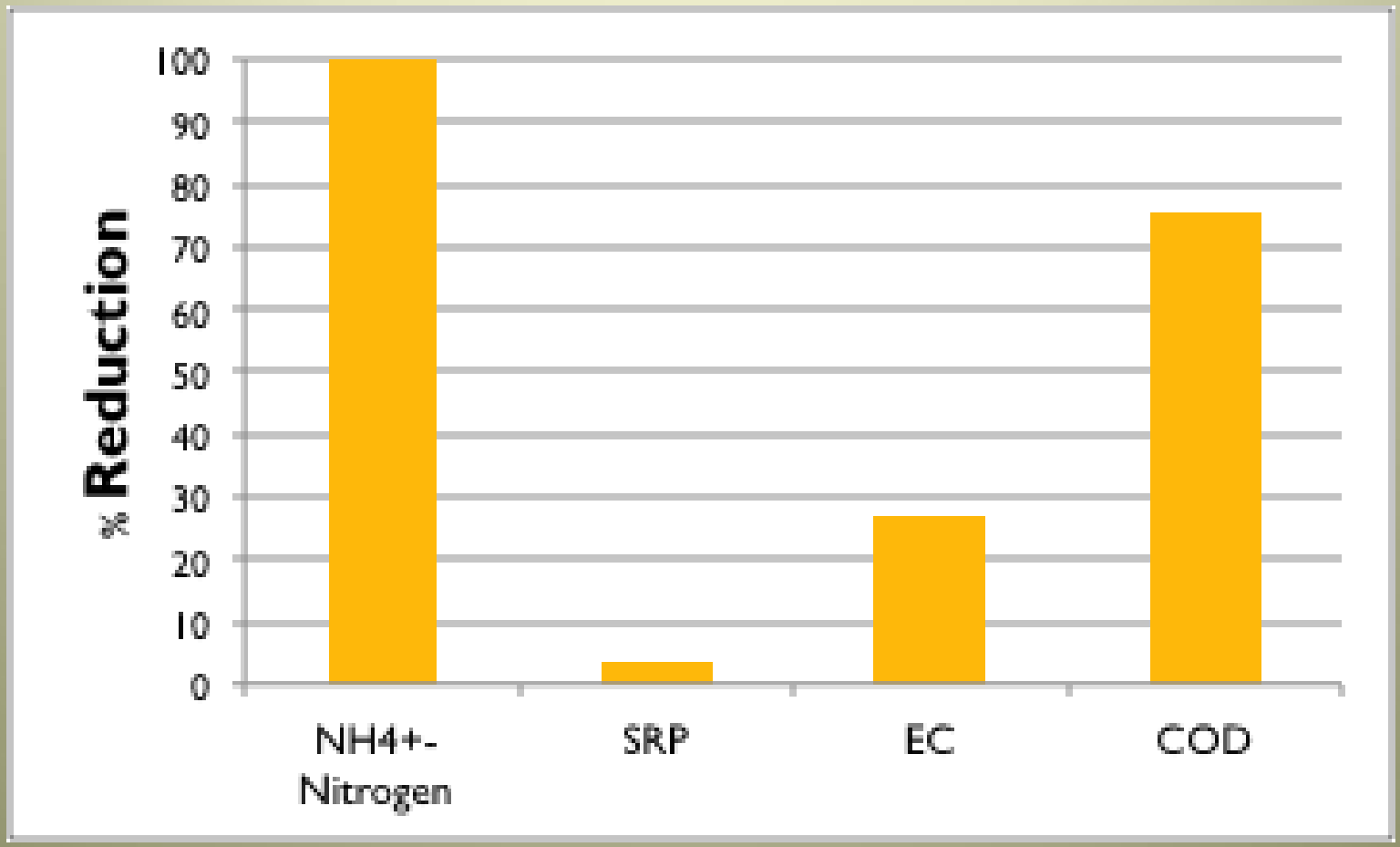
Leachate Remediation: Ammonia Removal



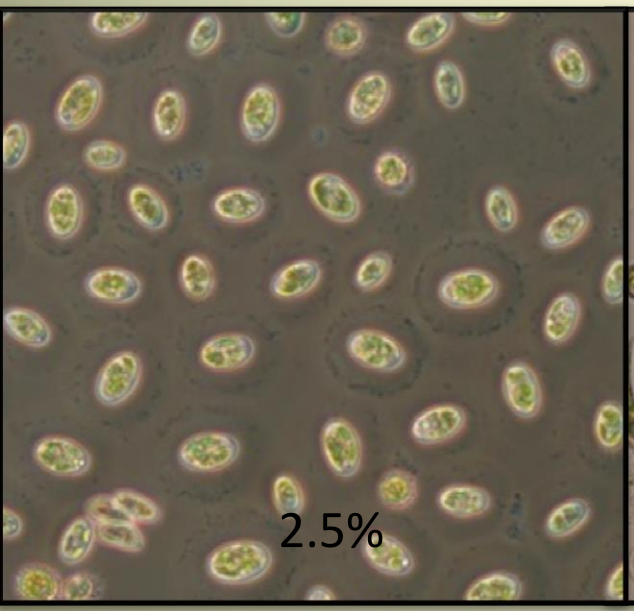
Leachate Remediation: Conductivity Reduction

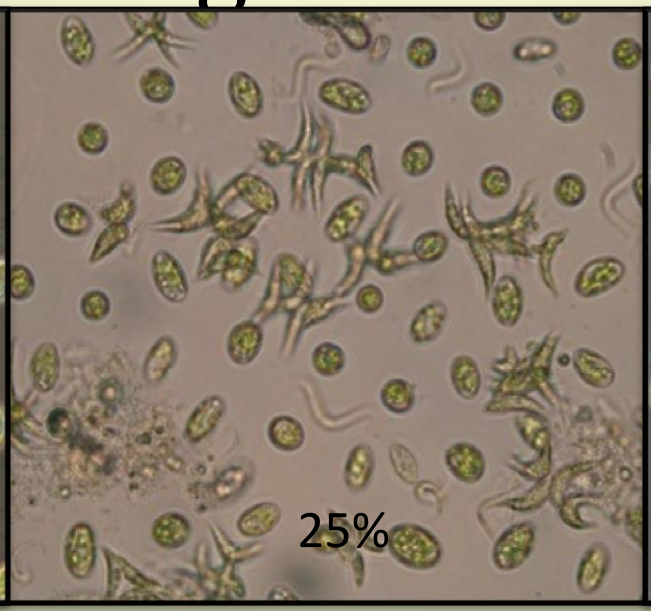


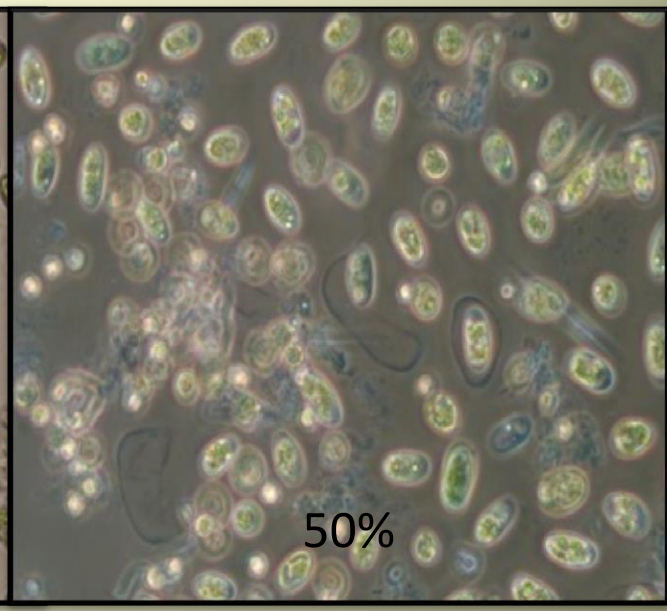
PhycoRemediation

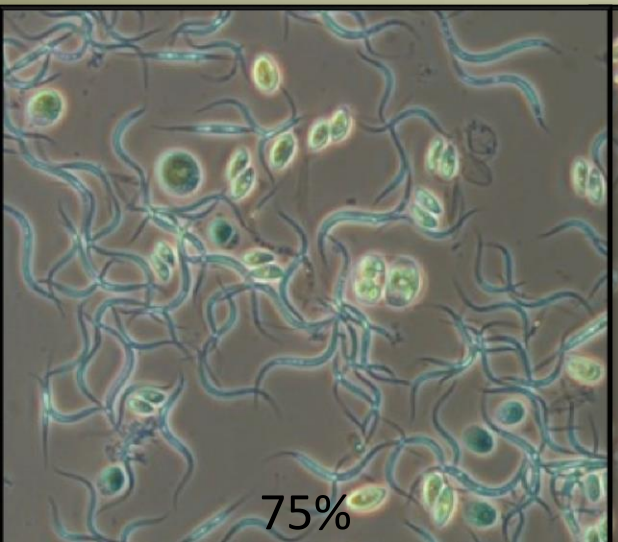


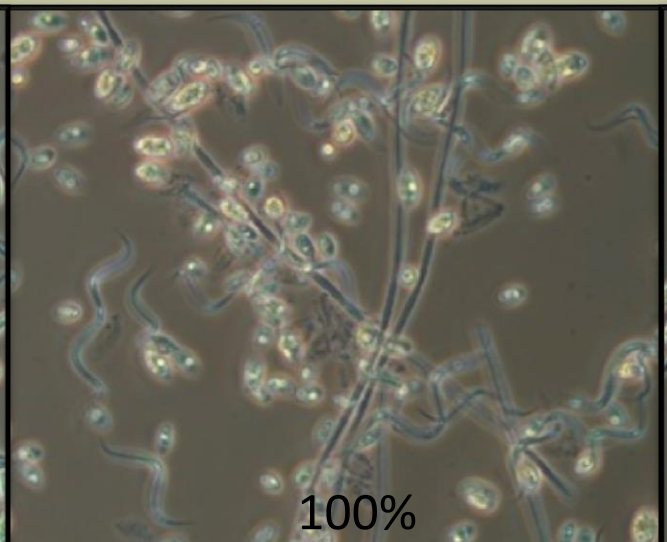
Selective Cultivation: Biological Results

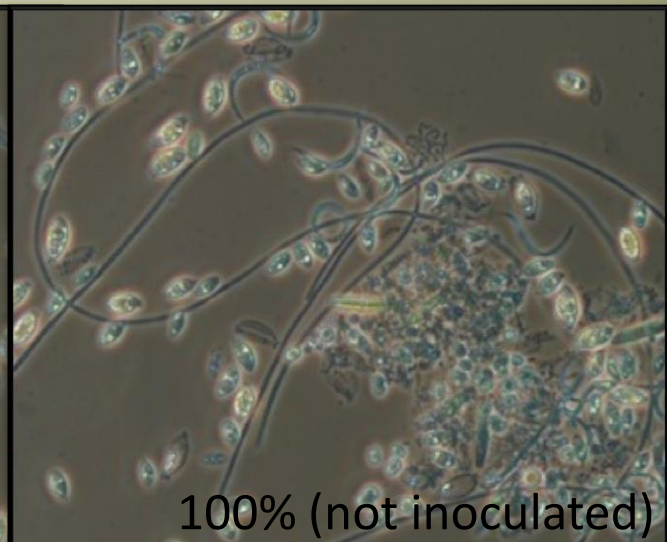








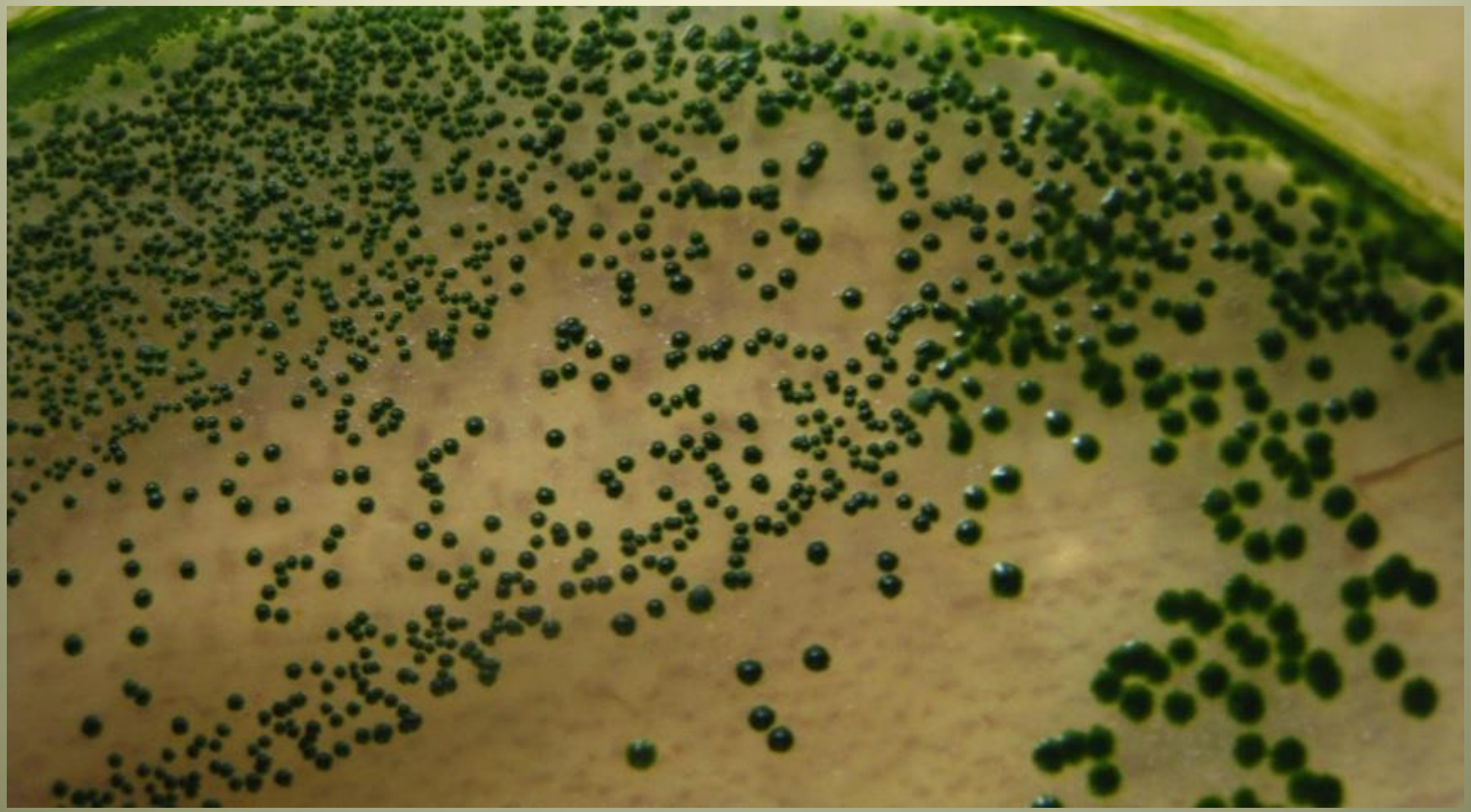




Where are we now? Characterizing Algal Tolerance to Landfill Leachate

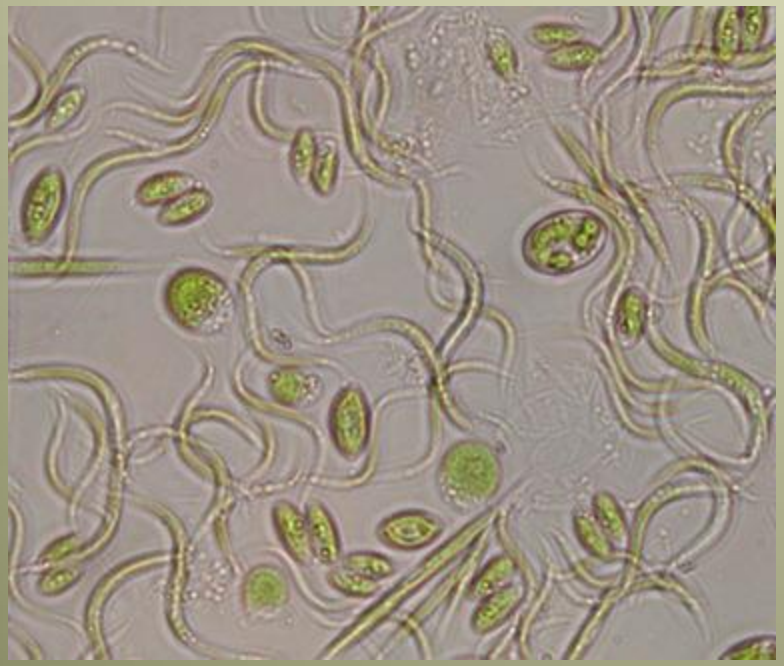
- **Algae Prospecting**
  - Identify algae that are capable of thriving in the leachate environment.
- **Characterizing Algae**
  - Maximum growth rates
  - Biomass productivities
  - Critical concentration of leachate tolerated
  - Storage products (lipids, starches, pigments)

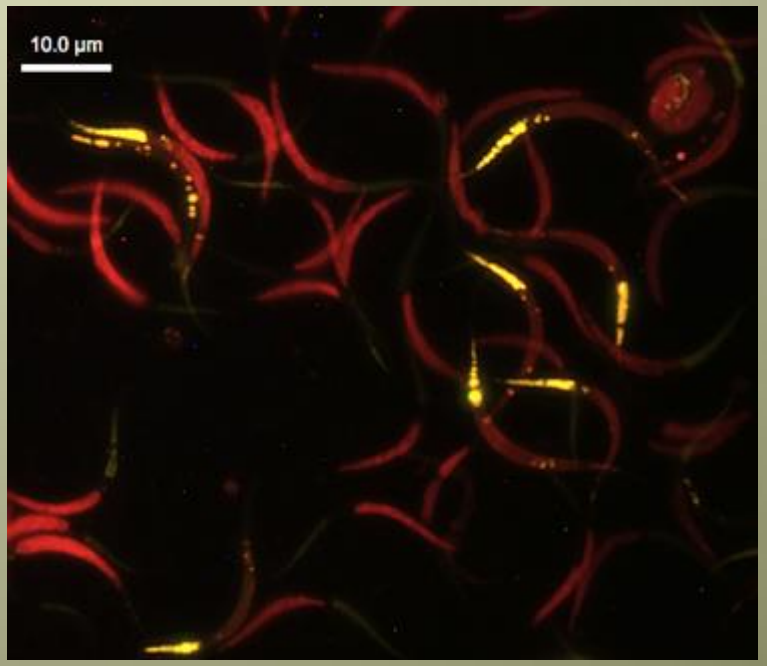
Isolation of Indigenous Algae



Ankistrodesmus sp.

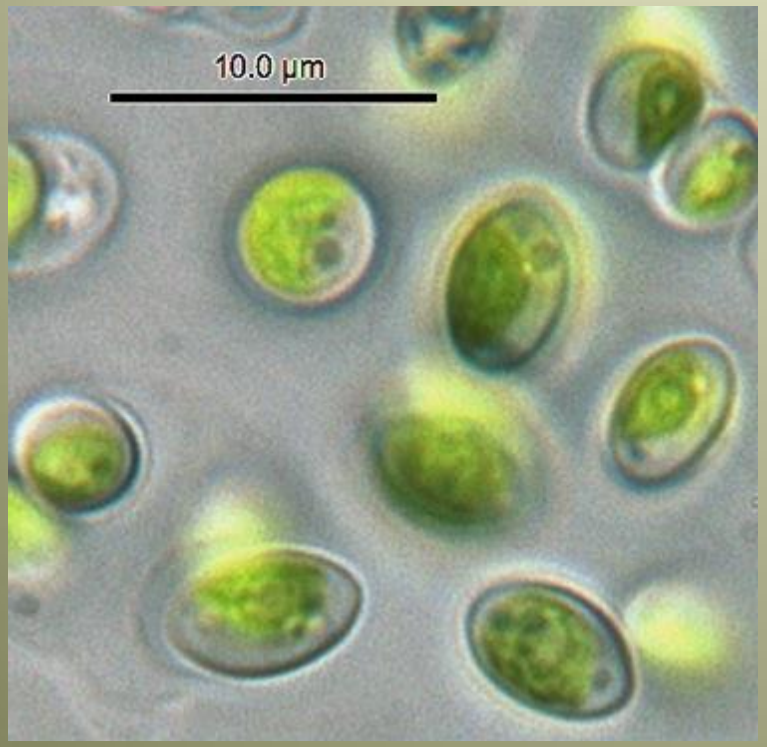
- Often the dominant organism in concentrations greater than 60% landfill leachate.
- Accumulates lipids
- Difficult to culture in the laboratroy

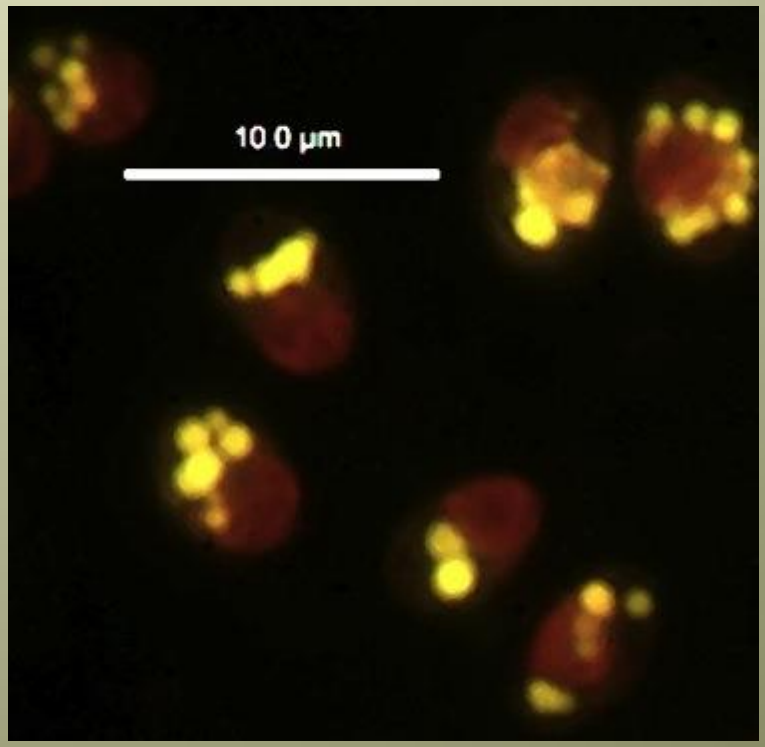




Chlorella ellipsoidea

- Present in all concentrations of selective enrichment cultures
- Dominant growth in leachate (low concentrations)
- Stores lipids





Conclusions

- Algae are capable of growing in all tested dilutions of leachate
  - 25-50% dilutions exhibited greatest growth and photosynthetic activity
- Algae-based remediation shows potential as remediation strategy