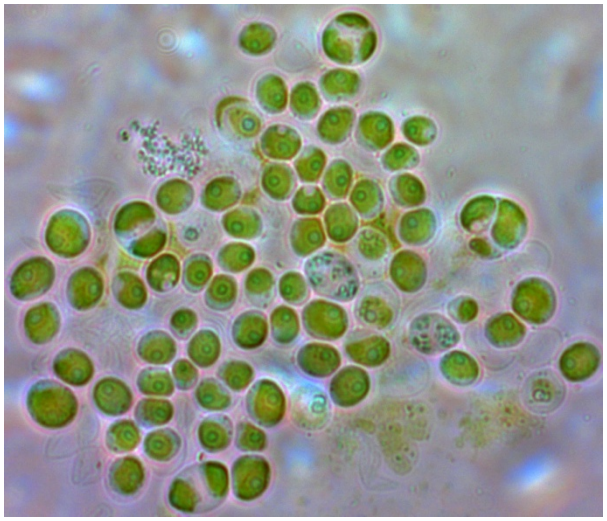
INTEGRATING DAIRY WASTE WITH PRODUCTION OF BIOFUELS AND HIGH VALUE BIOPRODUCTS

Sridhar Viamajala

Utah State University



SERC SUSTAINABLE ENERGY RESEARCH CENTER AT UTAH STATE UNIVERSITY

USU USTAR BIOFUELS INITIATIVE

Our interdisciplinary team crosscuts multiple internal organizations:

College of Agriculture
- Conly Hansen
- Carl Hansen
- Jeff Broadbent

College of Business
- Cathy Hartman
- Ed Stafford

College of Engineering
- Ron Sims (Biological Eng.)
- Sridhar Viamajala (Biological Eng.)
- Byard Wood (Mechanical Eng)

College of Science
- Lance Seefeldt
- Brett Barney

Technology Commercialization Office
- Brett Fritz

Affiliated faculty, Graduate and Undergraduate Students (~30)

Other Resources:
- $6.5 million over 5 years
- New facilities
- State-of-the-art equipment
- Related infrastructure

SUSTAINABLE ENERGY RESEARCH CENTER
AT UTAH STATE UNIVERSITY

INTEGRATED BIOFUELS – WITH ANAEROBIC DIGESTION

Blain Wade Dairy – An Anaerobic digester test site

Dairy waste

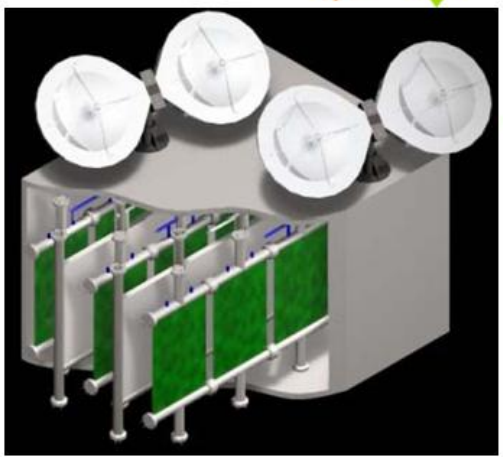
Industrial-scale Anaerobic digester

CH_4 fuel

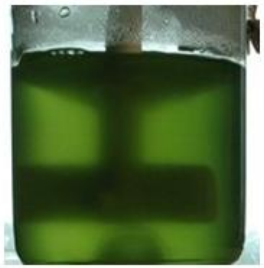
CO_2 from Digester

Nutrients from Digester

Sunlight



Algae

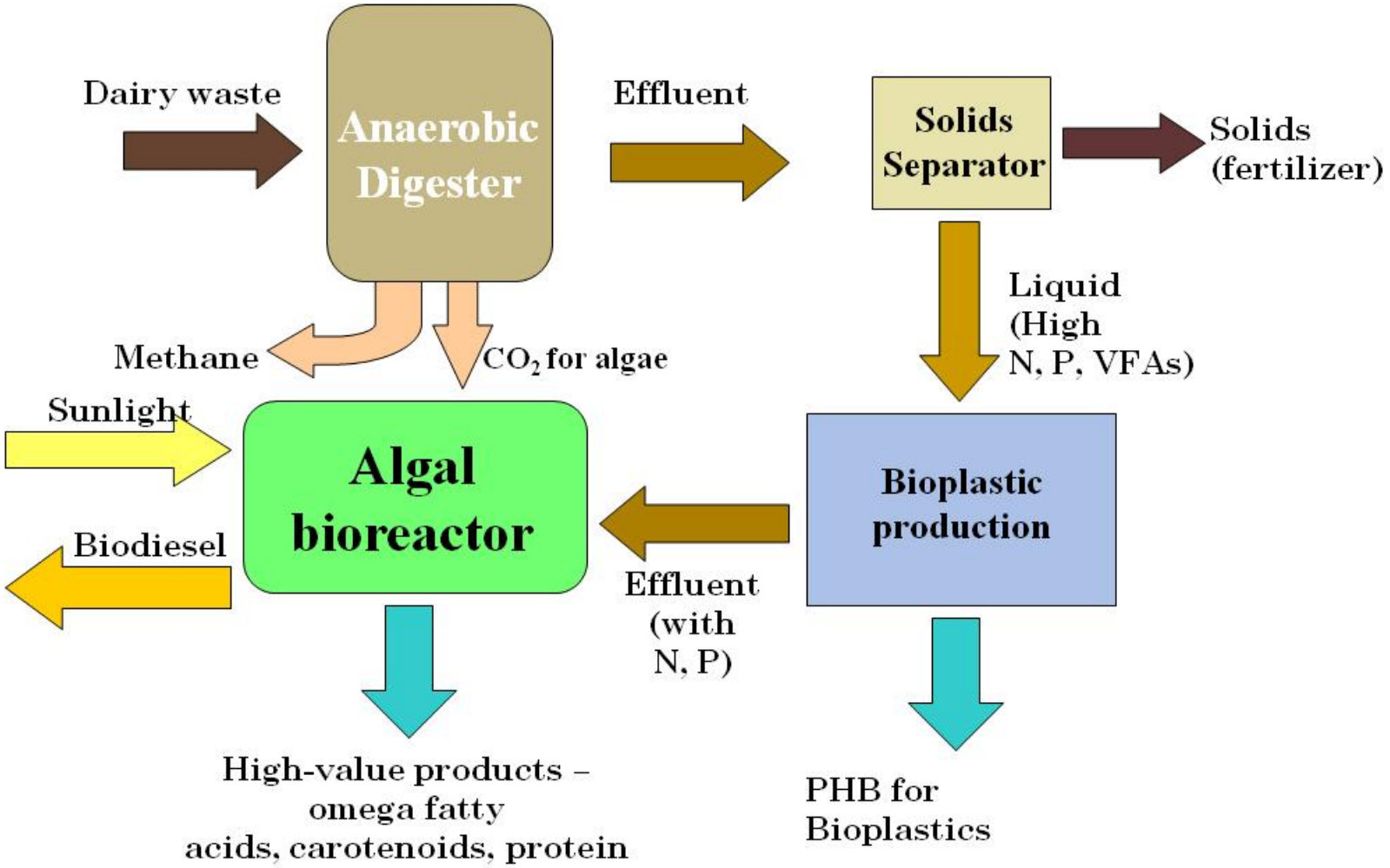


Biodiesel

SUSTAINABLE ENERGY RESEARCH CENTER

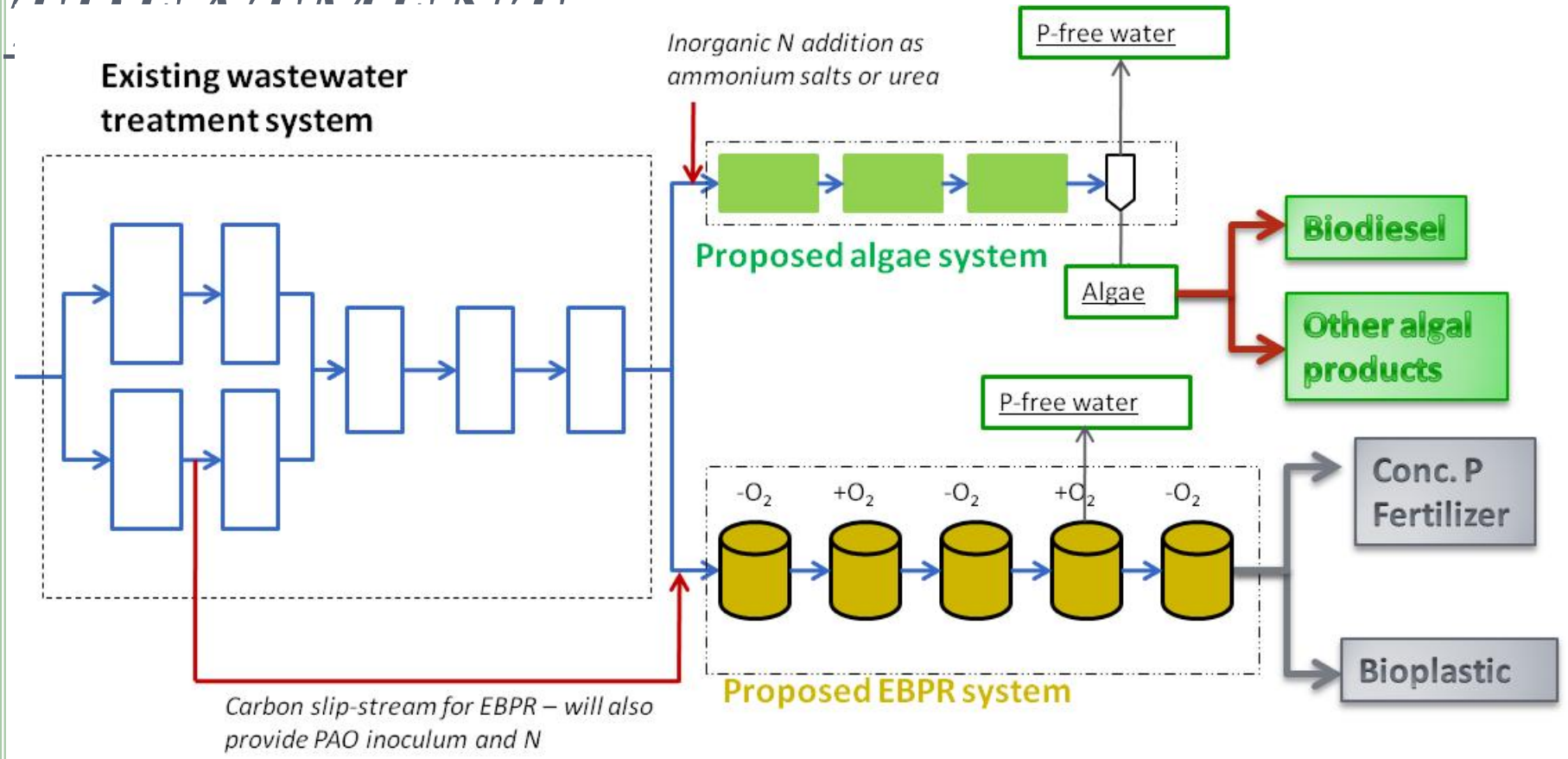
AT UTAH STATE UNIVERSITY

INTEGRATED BIOFUELS *AND BIOPRODUCTS*



SUSTAINABLE ENERGY RESEARCH CENTER
AT UTAH STATE UNIVERSITY

INTEGRATED BIOFUELS, BIOPRODUCTS *AND WASTEWATER TREATMENT*



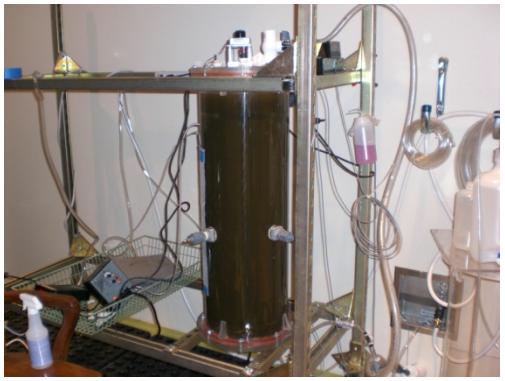
ANAEROBIC DIGESTION

Challenges:

- Hydraulics, Kinetics, Scale-up
- Reliability and optimization
- Co-production of hydrogen
- Gas clean-up – economical removal of CO_2 and H_2S at medium-scale rural systems
- Nutrient removal (N&P) – integration with algal production and bioplastic production

Pilot-scale: Sunderland and Wade Dairies

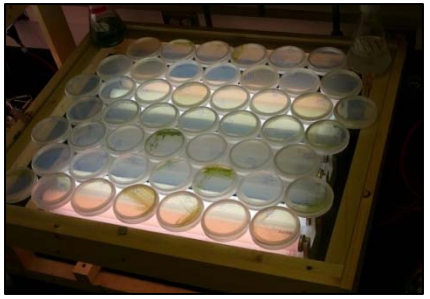
Lab-scale (~10 gal)

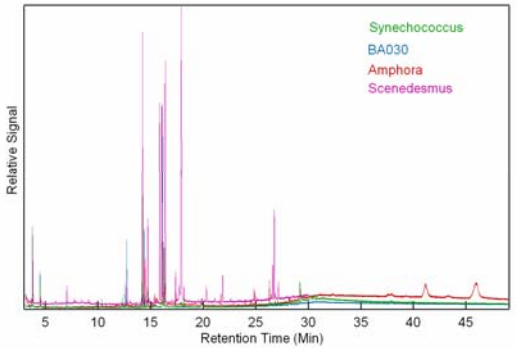


SUSTAINABLE ENERGY RESEARCH CENTER
AT UTAH STATE UNIVERSITY

ALGAE SELECTION AND MAINTENANCE

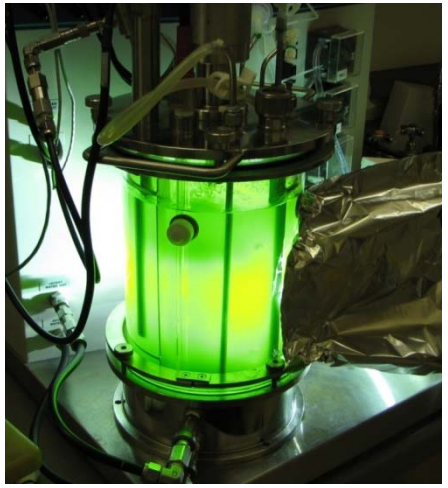
- Organism choice
  - Rapid and dense growth.
  - Minimal nutritional requirements.
  - Low adhesion or fouling.
  - Low contamination - (e.g. salt or pH extremes).
  - Stable mixed populations
  - Ease of separation
  - Over 30 diatom and algal strains being cultured and evaluated
- Lipid profile
  - Content and type
  - Free fatty acids vs. triglycerides
  - Analytical techniques – GC-MS, LC

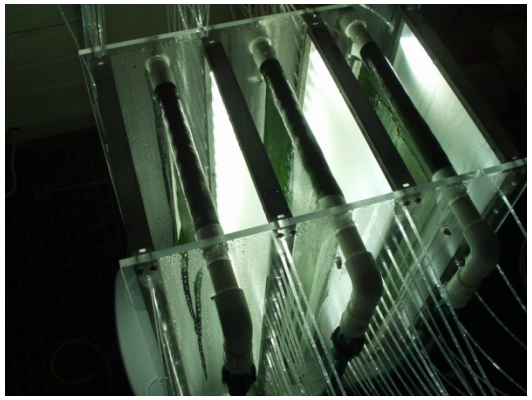




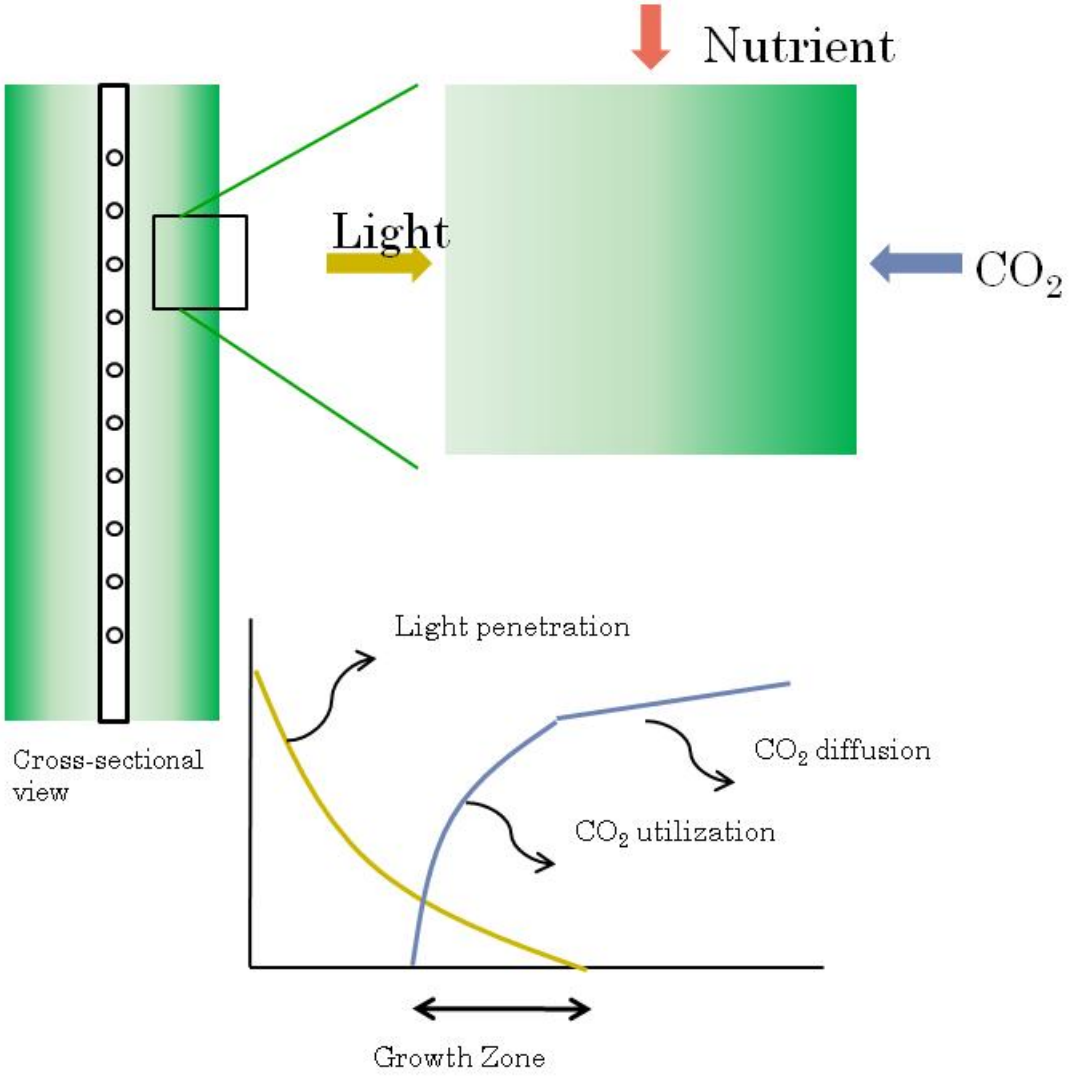
BIOREACTOR DESIGN - ISSUES

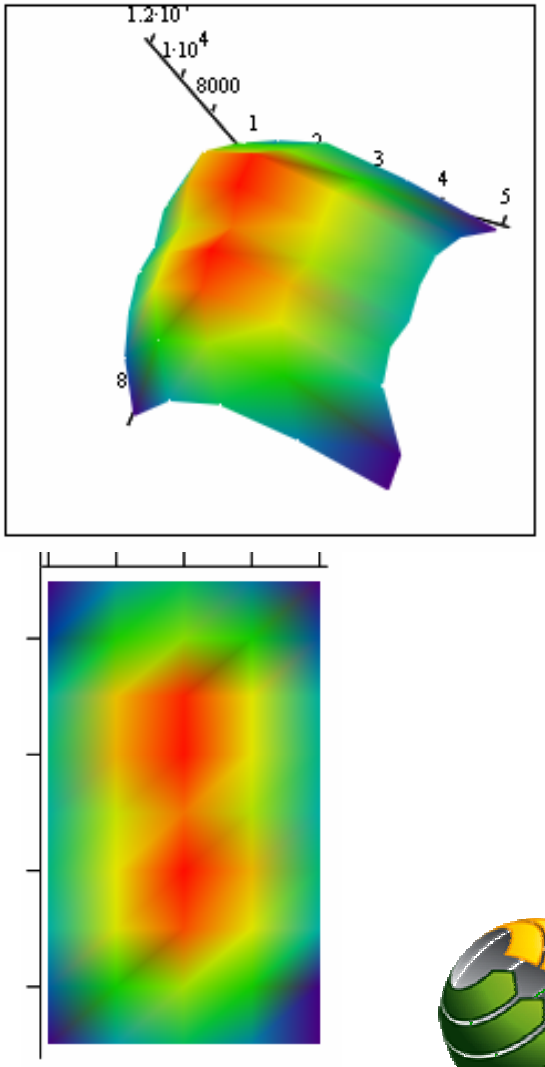
- Variables affecting kinetics and yield
  - Irradiance levels, light-dark cycles,
  - CO_2 concentration,
  - temperature, pH, salinity,
  - nutrient types and loading parameters
- Suspension versus Biofilm growth
- Scale-up
- Gas and nutrient management
- Fluid dynamics
- Performance models





BIOREACTOR DESIGN – MODELING





SUSTAINABLE ENERGY RESEARCH CENTER
AT UTAH STATE UNIVERSITY

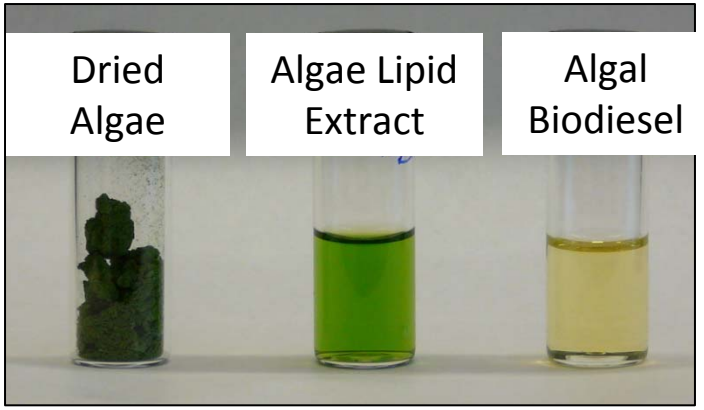
BIOREACTOR DESIGN – SCALE-UP

- Large-scale systems
  - Species control
  - Temperature control
  - Light distribution
  - CO_2 distribution

Raceway Ponds, Earthrise, Inc., Calipatria, California From: http://wwwscieng.murdoch.edu.au

DOWNSTREAM PROCESSING

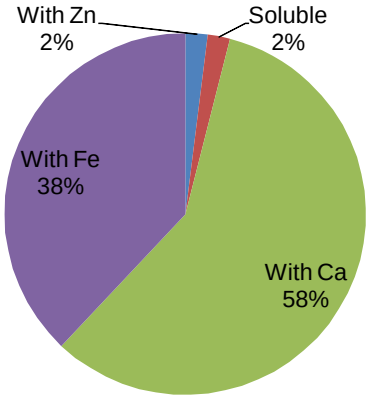
- Issues:
  - Very different from oil-seed biodiesel processing
    - Solvent extraction methods required
  - Effectiveness of solvents.
  - Selective extraction of lipids.
- Options:
  - Drying followed by extraction with a non-polar solvent (e.g. hexane) - Drying cost.
  - Extraction of wet biomass with a polar solvent (e.g. alcohols) - May be less effective.
  - In-situ trans-esterification
- Approach:
  - Experimental determination of extractability.
  - Thermodynamic modeling of lipid-water-solvent system



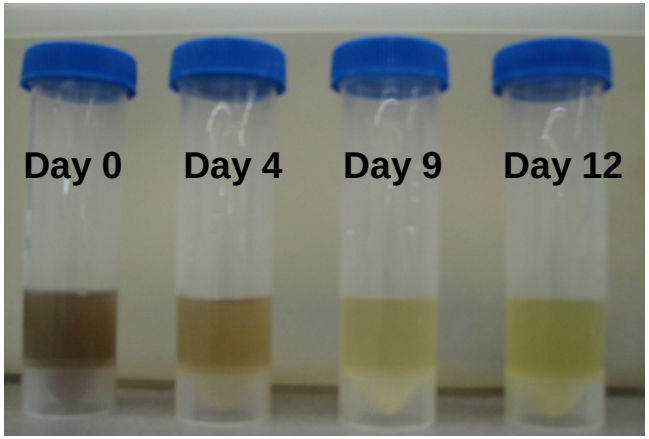
SUSTAINABLE ENERGY RESEARCH CENTER
AT UTAH STATE UNIVERSITY

INTEGRATION CHALLENGES – ANAEROBIC DIGESTION

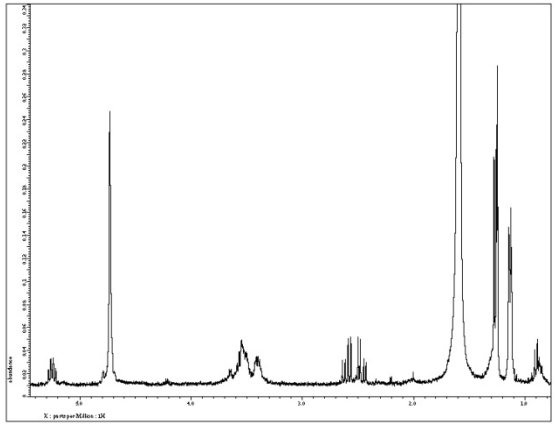
- Effluent chemistry and biology
  - Complex organic and inorganic interactions
- Competition of natural species with inoculated algae
- Integration of by-products e.g. bioplastics



GEOCHEM prediction of ortho-P species in effluent.



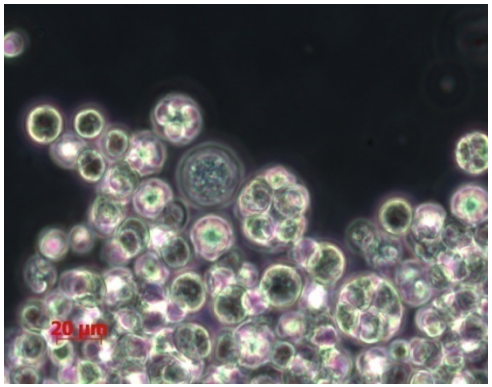
Growth of natural algal consortia on digester effluent

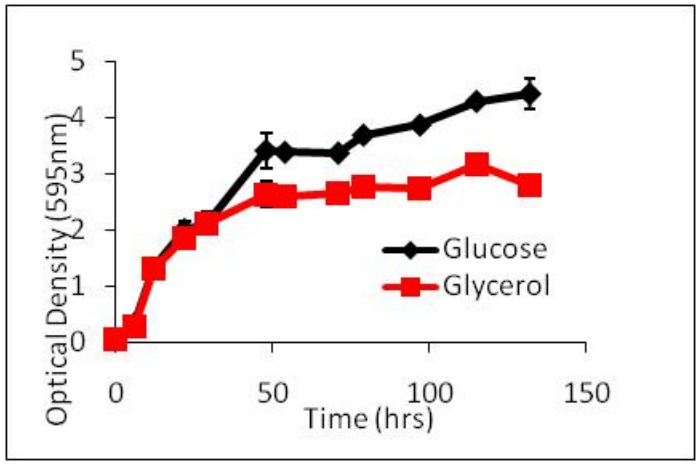


NMR spectrum of PHB from anaerobic digester effluent

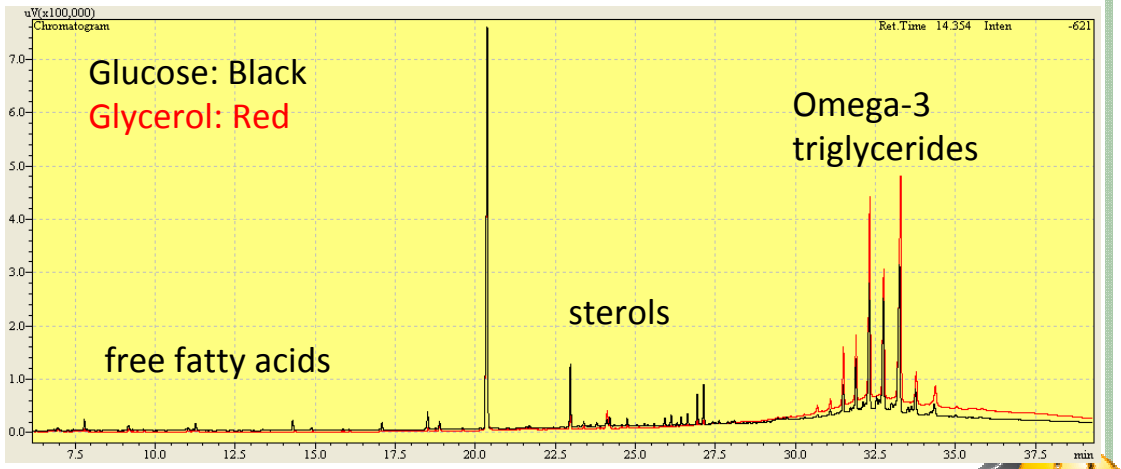
INTEGRATION CHALLENGES – GLYCEROL UTILIZATION

- Omega-3 fatty acids production
- Heterotrophic growth
  - *Schizochytrium limacinum* SR21





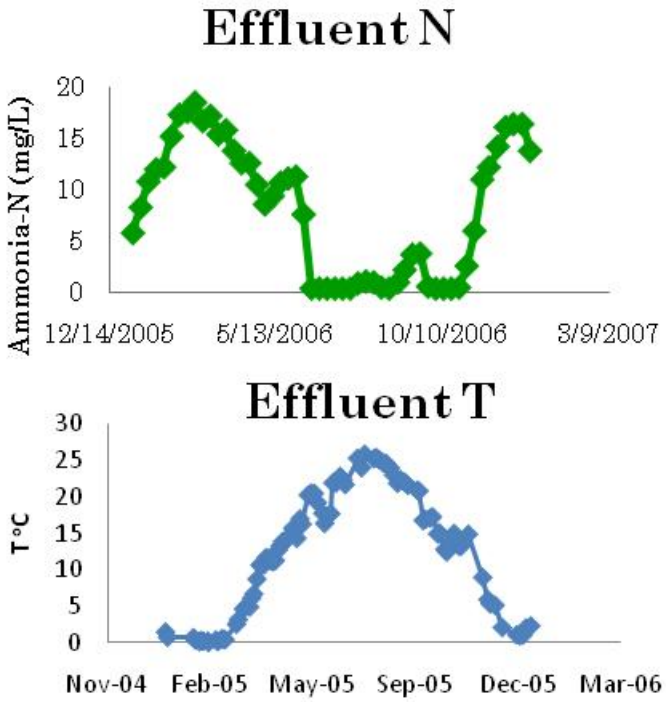
SR21 heterotrophic growth

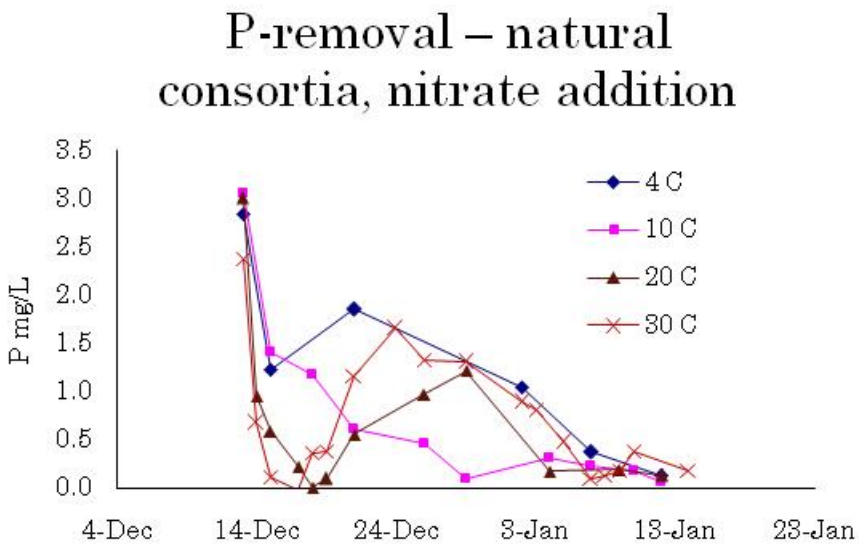


SR21 lipid profile

INTEGRATION CHALLENGES – WASTEWATER TREATMENT

- 460 acre open pond wastewater treatment, 14-18 M gal/day
- N-limitation in summer and T limitation in winter
- Integration with P-removal
  - New treatment unit could cost Logan $200Mn ($60/household/month)





SUSTAINABLE ENERGY RESEARCH CENTER
AT UTAH STATE UNIVERSITY

ACKNOWLEDGEMENTS

Ph.D. Students

- Dan Dye
- Shaun Dustin
- Shantanu Wahal
- Brad Wahlen
- Pete Zemke

M.S. Students

- Steve Broby
- Joseph Camire
- Erick Griffiths
- Steve Merrigan

Undergraduate Students

- Elizabeth Linton
- Dan Nelson
- Danny Price
- Nick McKee

SUSTAINABLE ENERGY RESEARCH CENTER

AT UTAH STATE UNIVERSITY

QUESTIONS?