

WesternWater Centre

RESEARCH THEME

- **Value Recovery**
 - >\$16M in external funding (last 10 years)
 - Current HQP: 40 graduate students and PDFs
 - 3 state-of-the-art laboratories

4. Value Recovery

FOCUS

- Application of biochemical engineering
- Value recovery from wastewater
- Clean water recycling
- Hydrothermal liquefaction

OVERVIEW

- 40 graduate students and postdoctoral fellows
- >\$16 M in external funding (last 10 years)
- 10+ industrial partners
- 7+ international academic collaborators
- 3 state-of-the-art laboratories
- Advanced bioenvironmental lab
- State-of-the-art equipment for cell cultivation and analysis



Amarjeet Bassi



Lars Rehmann



Charles Xu

4. Value Recovery

RESEARCH PROJECTS: BASSI LAB

- Microalgae cultivation on anaerobic digester effluent for water recycle and value recovery
- Novel microalgal bioreactor design for enhanced product yield
- Bio-electro desalination cell for road salt mitigation
- Phosphate recovery from wastewater using uninterrupted ion exchange (UIX-Renix) www.renix.ca
- Micro-plastic capture from waste using bio-surfactants
- Bio-surfactants from anaerobic digestate

4. Value Recovery

RESEARCH PROJECTS: BASSI LAB



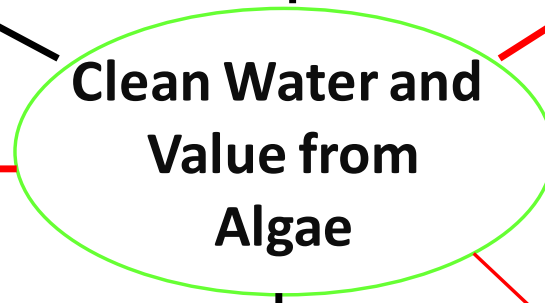
Animal feed



Soil conditioner



water treatment
and recycle



Biological
antioxidants

CO2 capture



Bioethanol

Biodiesel



Aqua culture-
Fish food

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RESEARCH PROJECTS: BASSI LAB

Microalgae Applications for Value Addition

- Biofuels: Biodiesel, oil from hydrothermal treatment (*Chlorella*, *N. gaditana* etc.)
- *Dunaliella salina*: beta carotene, lutein, lycopene
- *Haematococcus pluvialis*: Astaxanthin

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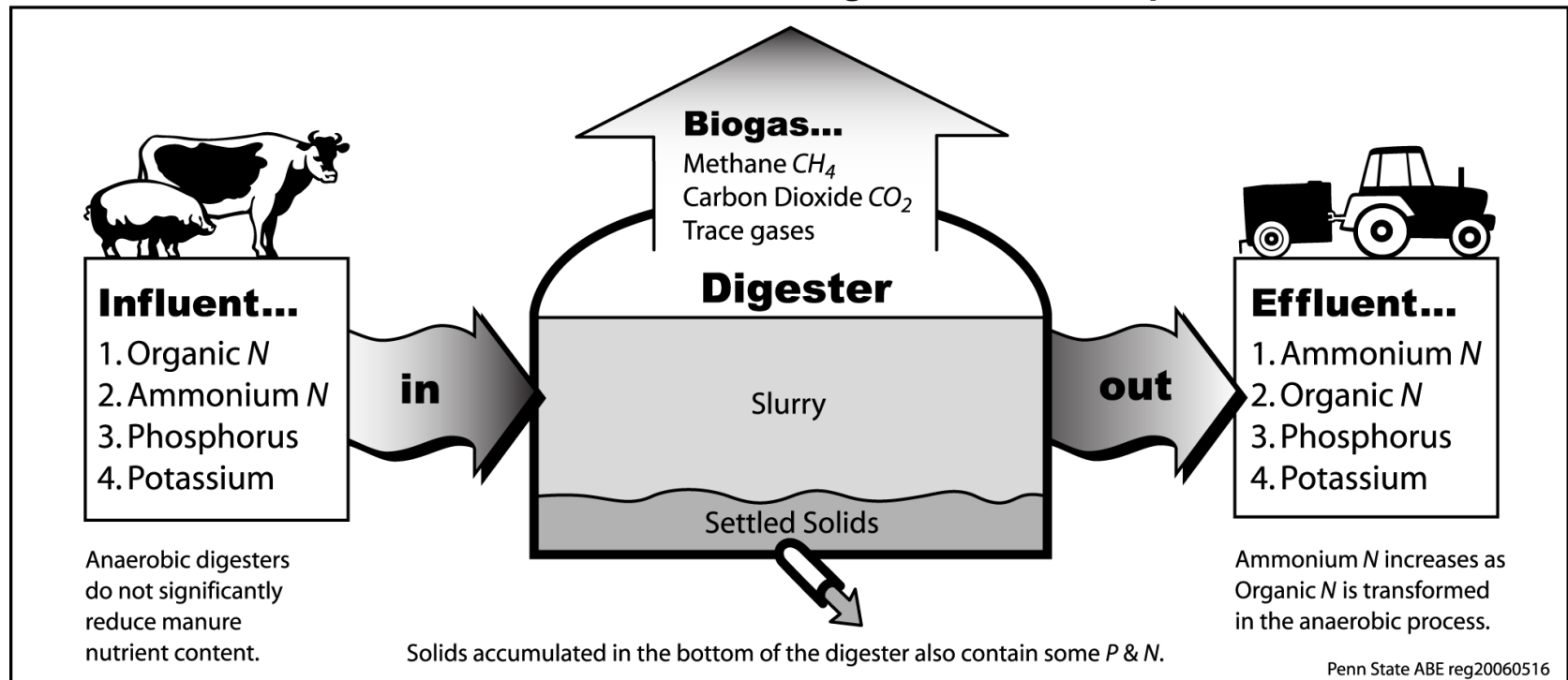
- Dairy farm Effluents
- Hog Farm Effluents
- Septic Tank overflow
- Surface Run-off from Farms/Fields
- Anaerobic Digester Effluent
- Greenhouse (vegetable/ flower) effluent
- Landfill Leachate

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How Do Anaerobic Digesters (AD) Work?

Nutrients are not reduced through the anaerobic process.



Source: <http://www.abe.psu.edu/extension/factsheets/g/G71.pdf>

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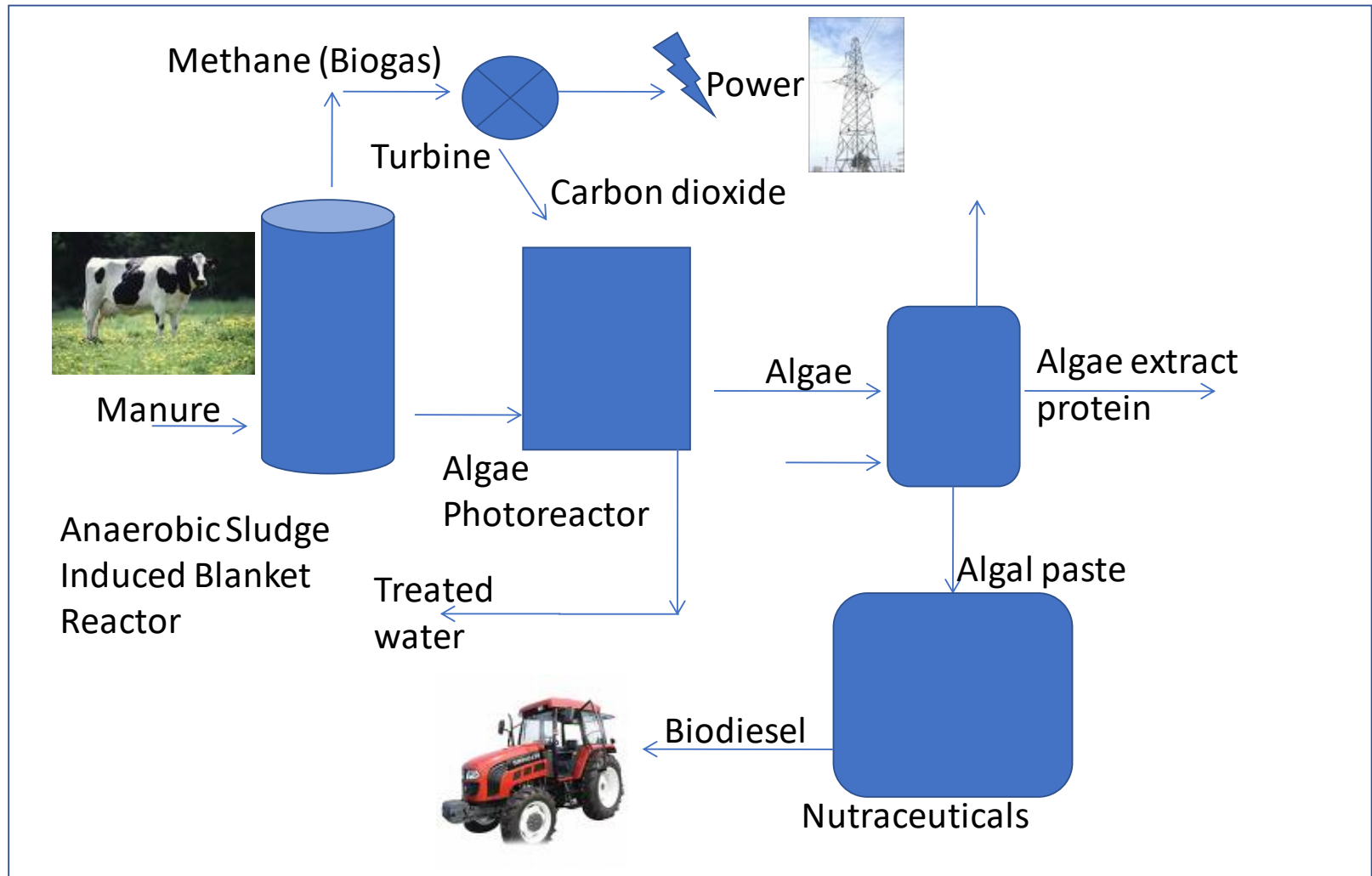
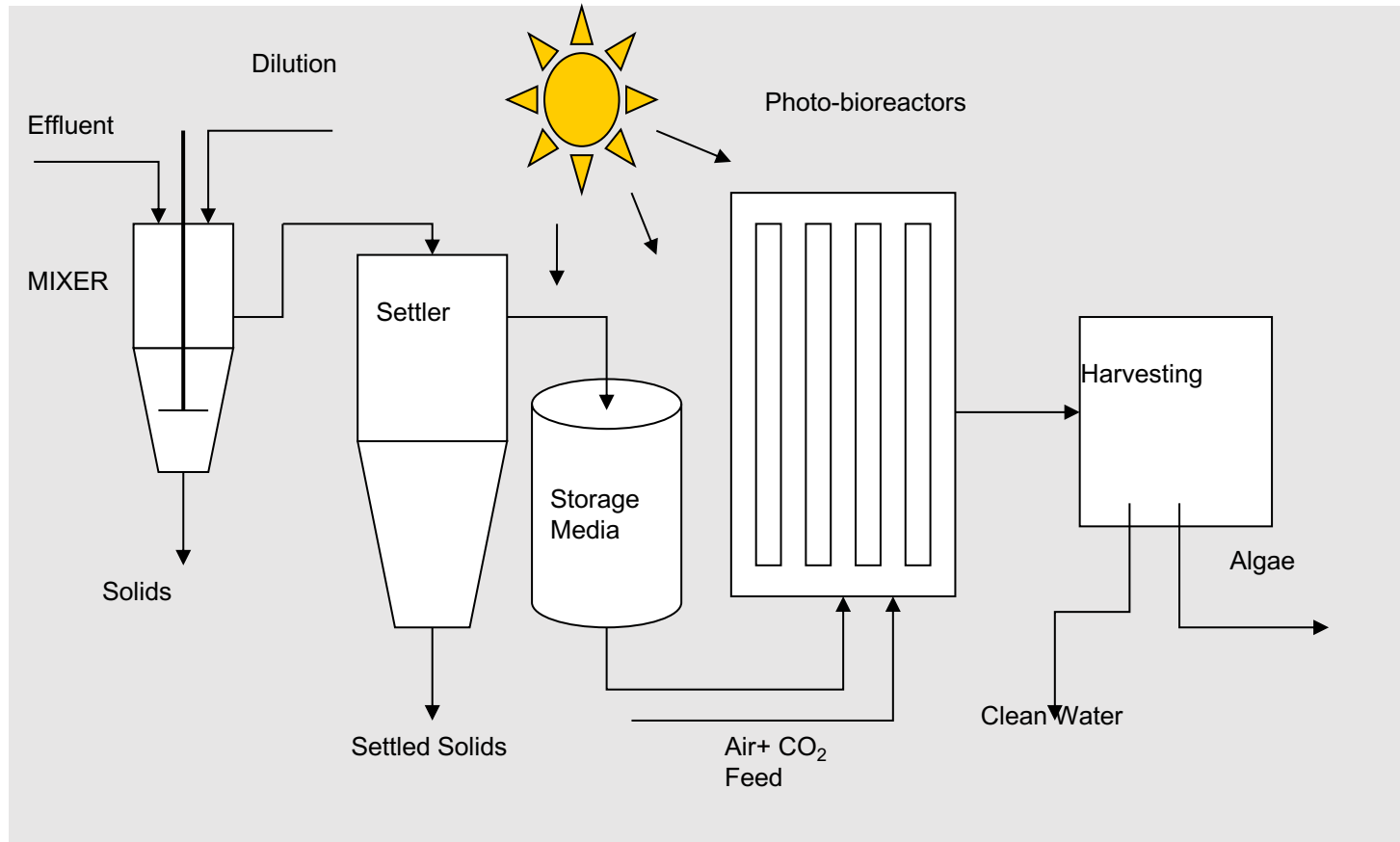


Figure: Closing the Loop- A simplified representation of high value from waste using microalgae

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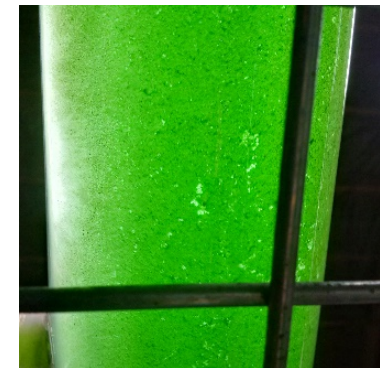
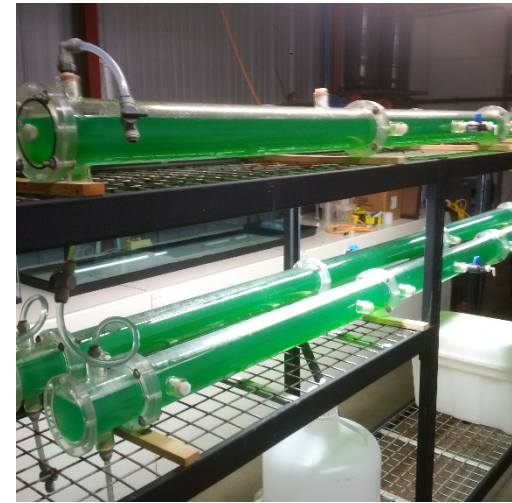
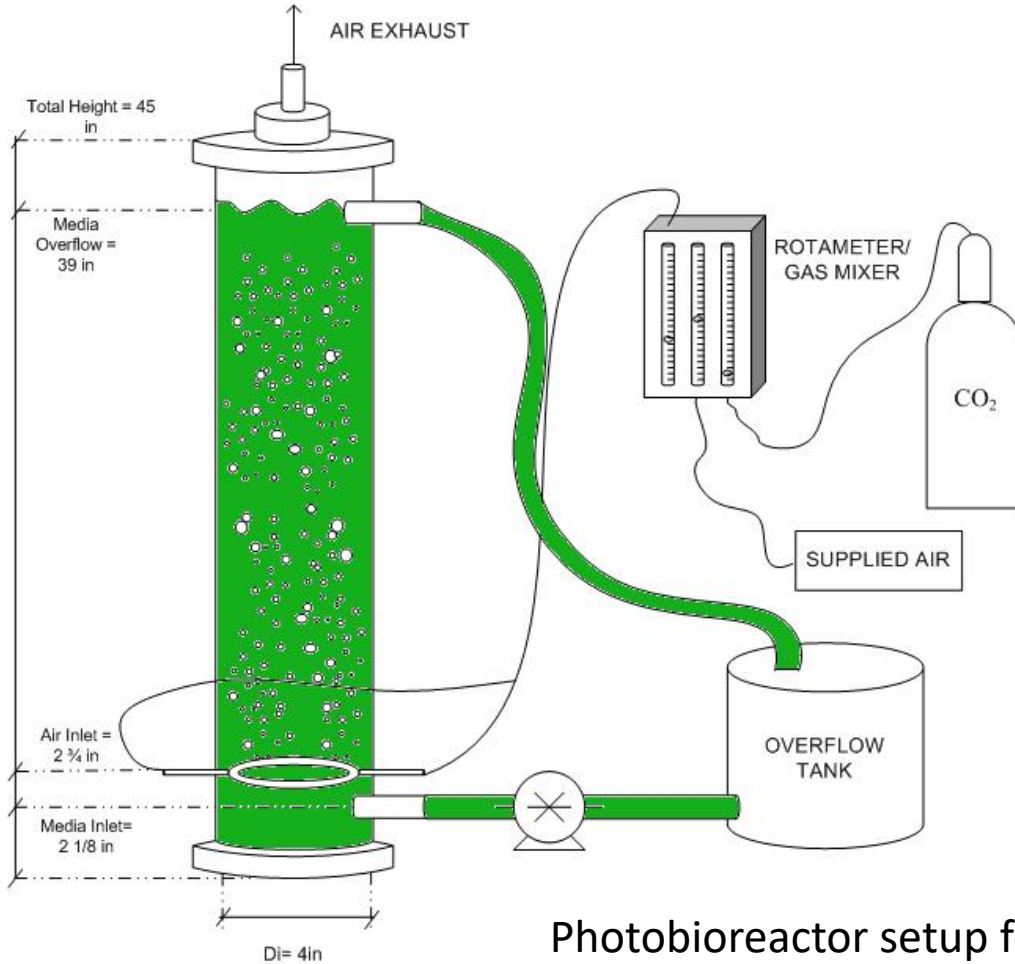
On farm Algal Cultivation



UWO-STANTON FARMS COLLABORATION

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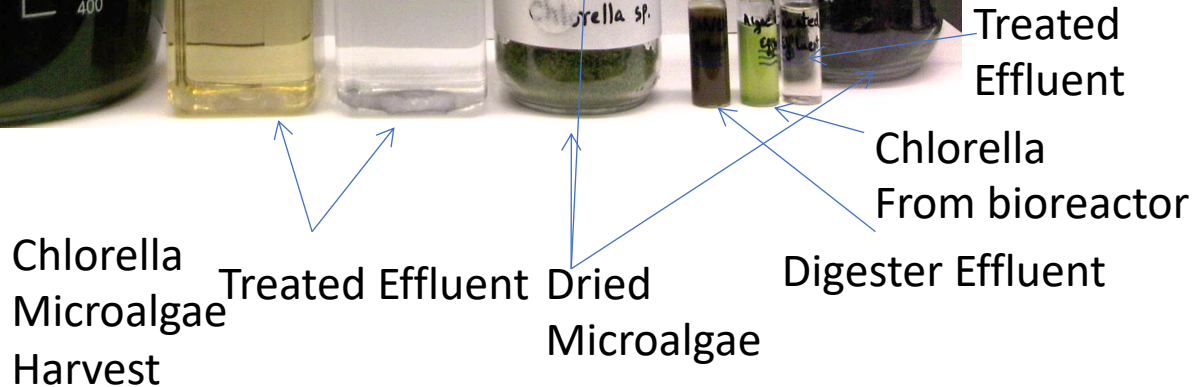
Photobioreactor setup for Microalgae production- on farm
(University of Western Ontario)

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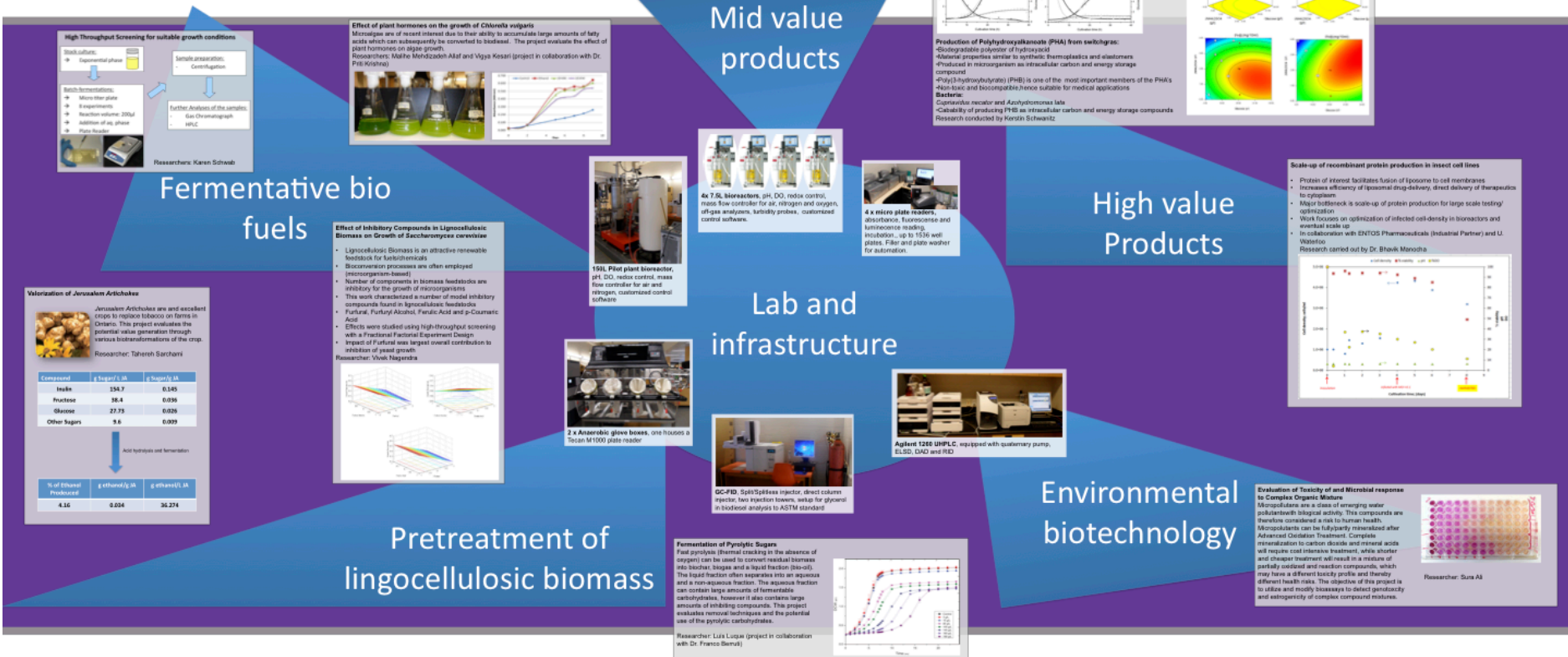
Bio-oil extracted from algae using steam explosion



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RESEARCH PROJECTS: REHMANN LAB

From Fuels to Pharmaceuticals: Biotransformation Process Development



High Throughput Screening for suitable growth conditions

Stock cultures
Experimental phase

Batch bioreactors
Micro titer plate
Requirements
Reaction volume 200ul
Addition of ag. phase
High Throughput

Safety, sterilization, Centrifugation

Further Analysis of the samples
Gas Chromatograph
HPLC

Researchers: Karen Schraub

Effect of plant hormones on the growth of *Chlorella vulgaris*

Microalgae are of great interest due to their ability to accumulate large amounts of fatty acids which can subsequently be converted to biodiesel. The project evaluate the effect of plant hormones on algae growth.

Researchers: Mahir MohdZadeh Alaf and Vages Kesan (project in collaboration with Dr. Priyankhya)

Production of Polyhydroxyalkanoates (PHA) from switchgrass:

Bio(degradable) polymer of hydroxyacid

Material properties similar to synthetic thermoplastics and elastomers

Produced in microorganism as intracellular carbon and energy storage compound

Poly(3-hydroxybutyrate) (PHB) is one of the most important members of the PHA's aliphatic and biodegradable hence suitable for medical applications

Bacteria:

- Coprinus necator and *Acetivibrio* sp.
- Capability of producing PHB as intracellular carbon and energy storage compounds

Research conducted by Kerstin Schwartz

Mid value products

4x 7.5L bioreactors, pH, DO, media control, mass flow controller for air, nitrogen and oxygen, off-gas analysis, turbidity probe, customised control software.

4 x micro plate readers, absorbance, fluorescence and luminescence reading, incubation - up to 1536 well plates, filter and plate washer for automation.

150L Pilot plant bioreactor, pH, DO, media control, mass flow controller for air and nitrogen, customised control software.

Lab and infrastructure

2 x Anaerobic glove boxes, one houses a Torcon M1000 plate reader

GC-FID, Split/Splitless injector, direct column injector, two injection towers, setup for glycerol in biodiesel analysis to ASTM standard

Agilent 1260 HPLC, equipped with quaternary pump, ELSD, DAD and RID

Valorization of Jerusalem Artichokes

Jerusalem Artichokes are an excellent crop to replace tobacco on farms in Ontario. This project evaluates the potential value generation through various biotransformations of the crop.

Researcher: Tahereh Sarhani

Component	g Sugar/L JA	g Sugar/L JA
Inulin	156.7	0.145
Fructose	16.4	0.026
Glucose	27.75	0.026
Other Sugars	3.6	0.009

↓ Acid hydrolysis and Fermentation

% of Ethanol Produced	g ethanol/L JA	g ethanol/L JA
4.16	0.014	36.274

Effect of Inhibitory Compounds in Lignocellulosic Biomass on Growth of *Saccharomyces cerevisiae*

- Lignocellulosic Biomass is an attractive renewable feedstock for fuels/chemicals
- Bioconversion processes are often employed (microorganism-based)
- Number of components in biomass feedstocks are inhibitory for the growth of microorganisms
- This work characterized a number of model inhibitory compounds found in lignocellulosic feedstocks: Furfural, Furfuryl Alcohol, Ferulic Acid and p-Coumaric Acid
- Effects were studied using high-throughput screening with a Fractional Factorial Experiment Design
- Impact of Furfural was largest overall contribution to inhibition of yeast growth

Researcher: Sivak Nayandla

Pretreatment of lignocellulosic biomass

Fermentation of Pyrolytic Sugars

Fast pyrolysis (thermal cracking in the absence of oxygen) can be used to convert residual biomass into biochar, biogas and a liquid fraction (bio-oil). The liquid fraction often separates into an aqueous and a non-aqueous fraction. The aqueous fraction can contain large amounts of fermentable carbohydrates, however it also contains large amounts of inhibiting compounds. This project evaluates removal techniques and the potential use of the pyrolytic carbohydrates.

Researcher: Luis Lopez (project in collaboration with Dr. Franco Berni)

Scale-up of recombinant protein production in insect cell lines

- Protein of interest facilitates fusion of liposome to cell membranes
- Increases efficiency of liposomal drug-delivery, direct delivery of therapeutics to cytoplasm
- Major bottleneck is scale-up of protein production for large scale testing/optimization
- Work focuses on optimization of infected cell-density in bioreactors and eventual scale up
- In collaboration with ENTOS Pharmaceuticals (Industrial Partner) and U. Waterloo

Research carried out by Dr. Bhavik Moxhala

Evaluation of Toxicity of and Microbial response to Complex Organic Mixtures

Microplastics are a class of emerging water pollutants with biological activity. These compounds are therefore considered a risk to human health. Microplastics can be fully purified/recovered after Advanced Oxidation Treatment. Complete mineralization to carbon dioxide and mineral acids will require cost intensive treatment, while shorter and cheaper treatment will result in a mixture of partially oxidized and non-oxid compounds, which may have a different toxicity profile and identify different health risks. The objective of this project is to utilize and modify bioassays to detect genotoxicity and ecotoxicity of complex compound mixtures.

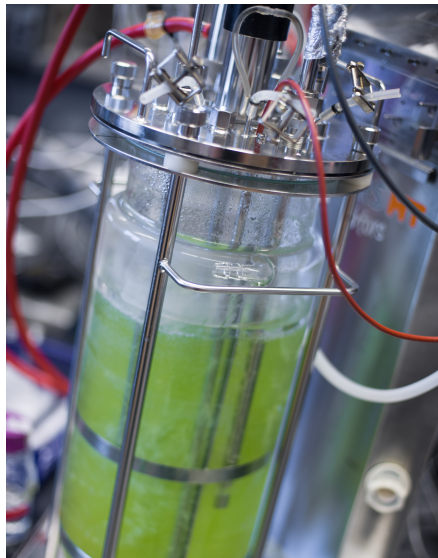
Researcher: Susa Ali

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RESEARCH PROJECTS: REHMANN LAB

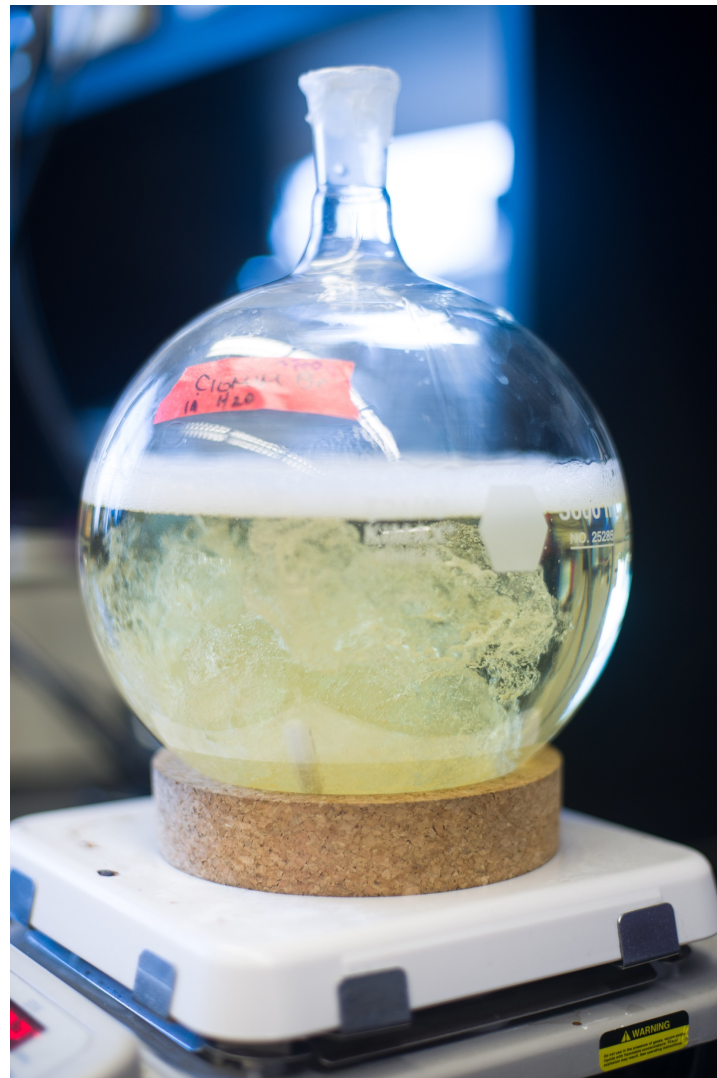


Figure 3.2: Pervap 4060 membrane and test cell: (A) Assembled test cell showing permeate (vacuum) connection, (B) assembled test cell showing feed and retentate connections, (C) test cell permeate part showing sinter plate, membrane and O-ring installed.



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RESEARCH PROJECTS: REHMANN LAB



4. Value Recovery

RESEARCH PROJECTS: XU LAB

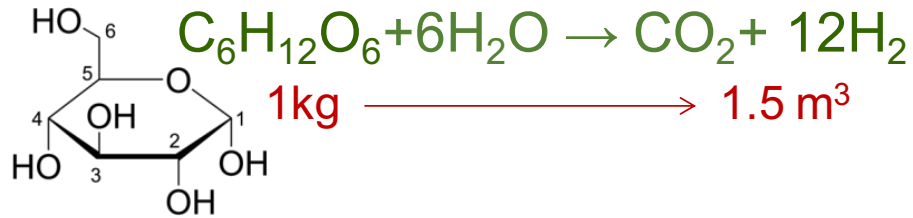
- Renewable hydrogen from high TOC wastewater via supercritical water gasification (Dr. Xu)
- Hydrothermal Liquefaction and conversion of bio-solids/ wastewater sludge into bio-crude oils for bio-fuels and high-value bio-products (Drs. Xu, Bassi, Ray)

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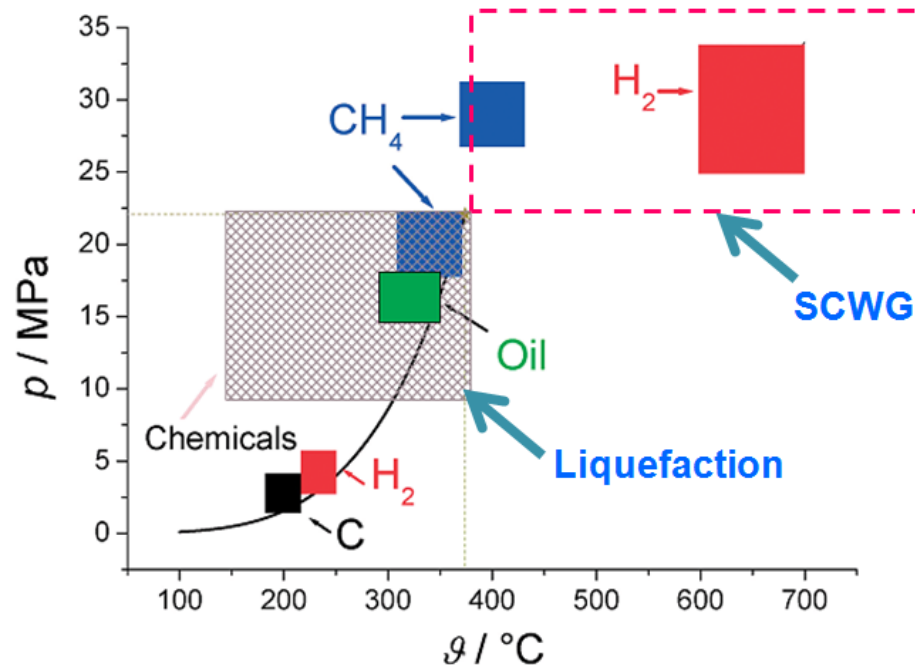
RESEARCH PROJECTS: XU LAB

Renewable hydrogen gas production via supercritical water gasification

- Overall reaction (Take glucose as an example)



- Unique features
 - Water is a solvent & reactant
 - Homogeneous reaction
 - Small footprint
 - High efficiency



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RESEARCH PROJECTS: XU LAB

Continuous-flow SCWG tractor at Xu lab

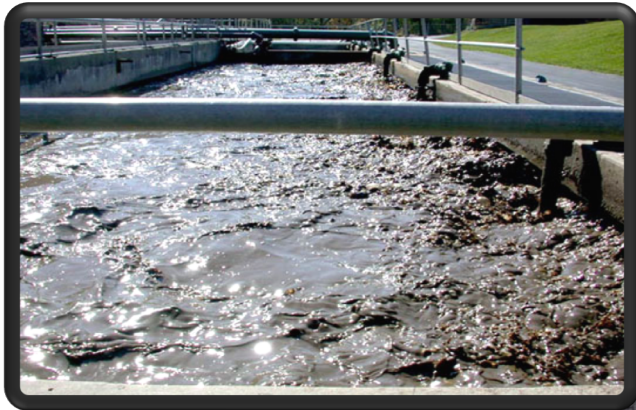


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RESEARCH PROJECTS: XU LAB

Wastewater Sludge

- Wastewater sludge is the main waste from wastewater treatment plants
- It contains high percentage of water (> 90% on wet mass basis)
- Sludge management is one of the most difficult and challenging, and hence costly tasks of wastewater treatment plants
- Traditional sludge disposal methods: incineration, land application and landfill

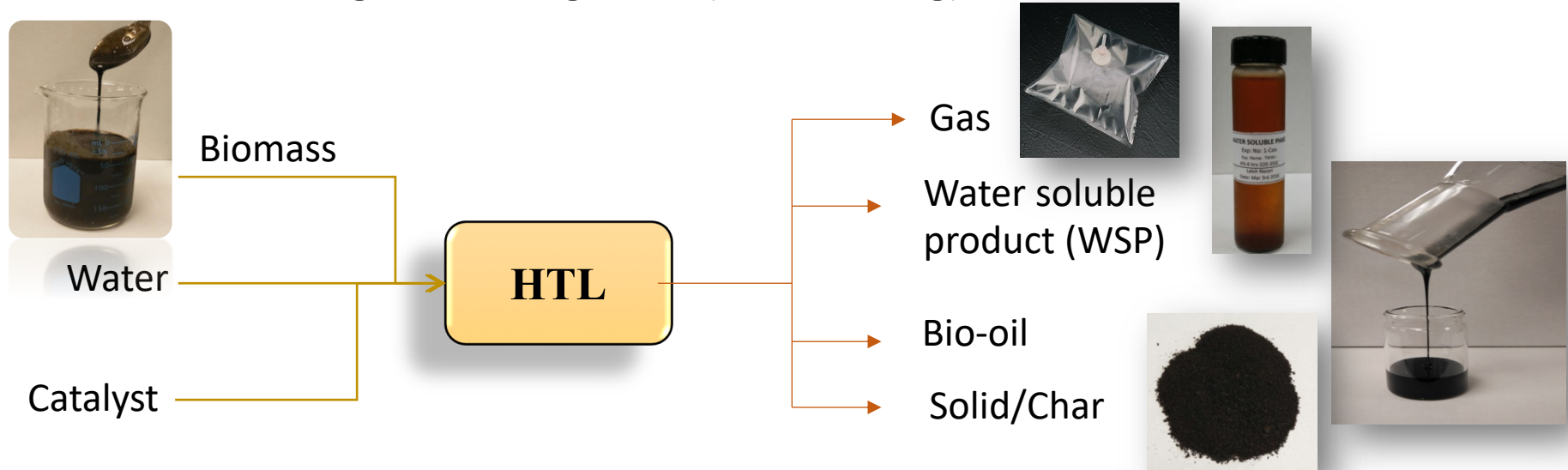


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RESEARCH PROJECTS: XU LAB

Hydrothermal Liquefaction (HTL)

- A thermo-chemical process for conversion of high-water-content biomass
- Does not require drying
- Mostly uses water as solvent
- Operates at high pressures (5-20 MPa) and moderate temperatures ($< 400\text{ }^{\circ}\text{C}$)
- Compared to pyrolysis, the bio-oil from HTL has lower water and oxygen content and thus has higher heating value (30-35 MJ/kg)



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RESEARCH PROJECTS: XU LAB

Hydrothermal Liquefaction (HTL) reactors in Xu Lab



16 L large batch reactor for liquefaction of biomass into bio-crude oils (5kg per batch)

