Anaerobic digestion of synthetic wastewater for a biochemical waste conversion system

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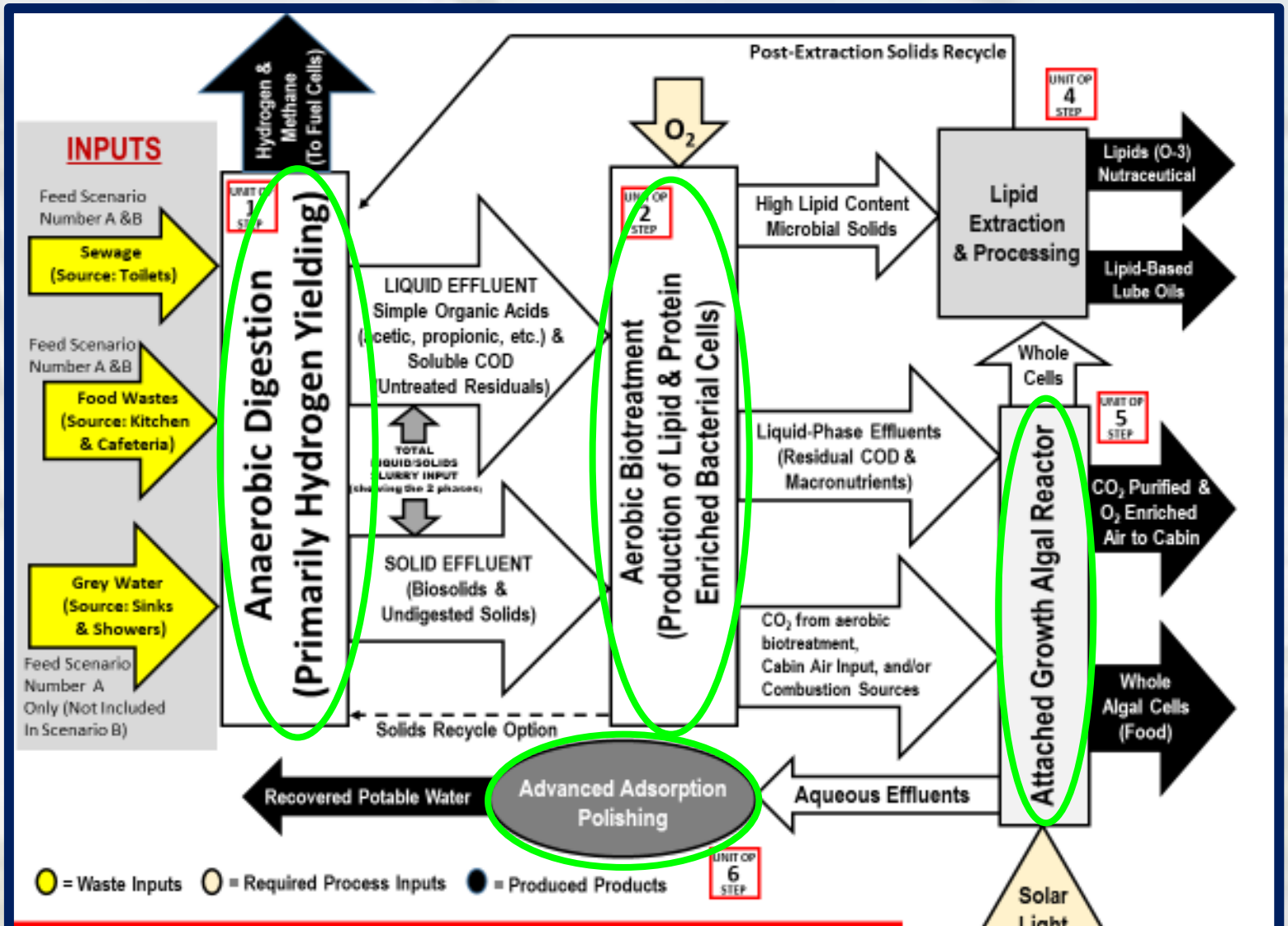
Mission to Mars

- Have human in Mars by 2030
- Generation of life support resources:
  - Potable water
  - Oxygen
  - Energy
  - Proteins and lipids
- Management of waste generated
- Conversion of waste into value added products

Dual data generation

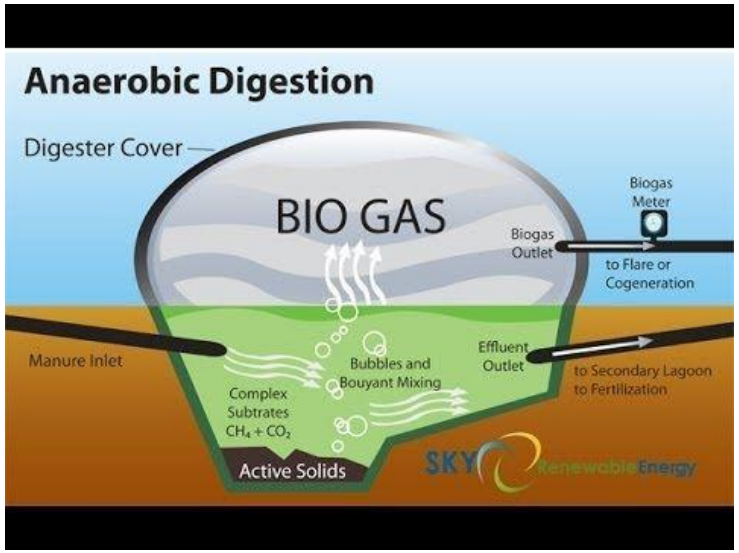
- Use of anaerobic digestion for Chemical Oxygen Demand removal and improve biogas production
- Municipal Wastewater Treatment plants spend 50% of the operation and maintenance cost on solids handling
- 7million dry ton sludge per year requiring disposal
- Average cost of $50/dton to dispose
- Improvement in solids removal could save >$1B
- Improvement in anaerobic digestion could eliminate aerobic treatment which is energy intensive

BIOSYS waste conversion system



Anaerobic digestion

- Biotreatment process that utilizes anaerobic bacteria to metabolically break down organic product and produce biogas
- Does not require oxygen
- **Goal**- Remove chemical oxygen demand of a low strength wastewater by 95%
- Maximize high quality biogas yield (CH_4 >70%)



Biological Production of Biogas or Digas

(Anaerobic Process [ORP <-400 mV])

Biomass Feedstock

+ Proteins
+ Carbohydrates
+ Lipids

Hydrolyzing Bacteria

Hydrolyzed Substrates

+ Soluble break-down Products of feedstock

Key Solids Degradation Step

Acetogens

Low-Molecular Weight Organic Acids

+ Acetic Acid
+ Propionic Acid

Inorganic Gases

+ Carbon Dioxide
+ Hydrogen

Fermentors

Heterotrophs

Autotrophs

H_2

Methanogens:
Heterotrophs & Autotrophs

End-Products:
Methane and Carbon Dioxide

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Preliminary Design Of Experiment

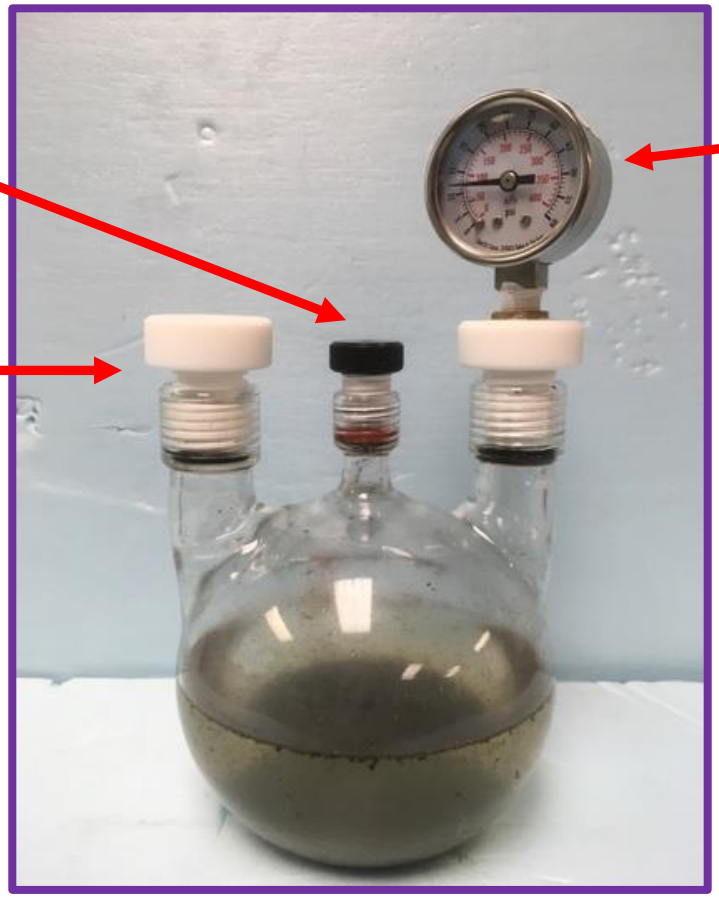
- 500ml microcosms for digestion in batch
- Use of synthetic wastewater (SWW) to simulate waste generated in space
- Addition of inoculum (5% v/v) from Lafayette WWTP for methanogens
- Addition of cafeteria food waste as well as dog feces

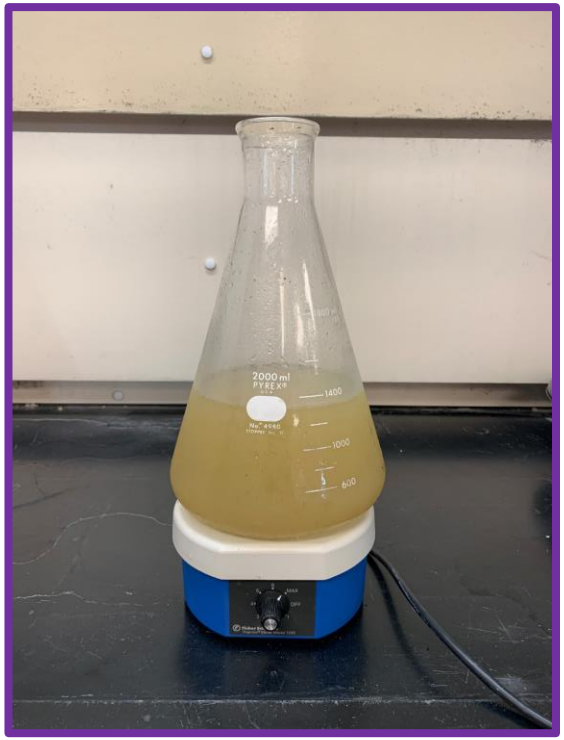
Component	Amount (mg)
Cafeteria food waste (salad)	150
Peanut Oil	100
Urea	50
Starch	150
Glucose	100
Yeast Extract	37.5
Peptone	25
NPK fertilizer+	50
Sodium acetate	75
Ammonium chloride	10
Sodium chloride	15
Potassium Chloride	20
Calcium chloride	15
Ferrous sulphate	1
Magnesium phosphate	6
Potassium phosphate	0.5
Casein	2.5
Bile	5
Dried dog food	75
Dog feces	100

Septum for Gas Sampling

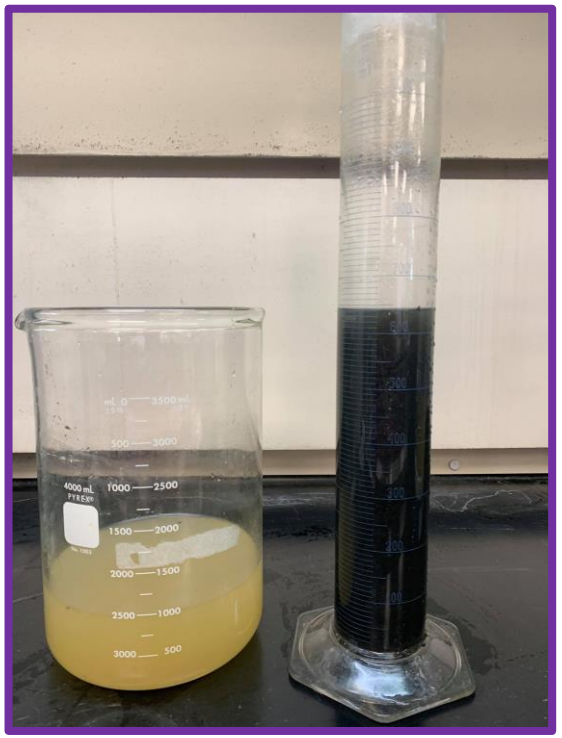
Test Pressure Gauge

Reactor Access for Liquid Addition/Extraction





Preparation of SWW



SWW and seed from Anaerobic digester

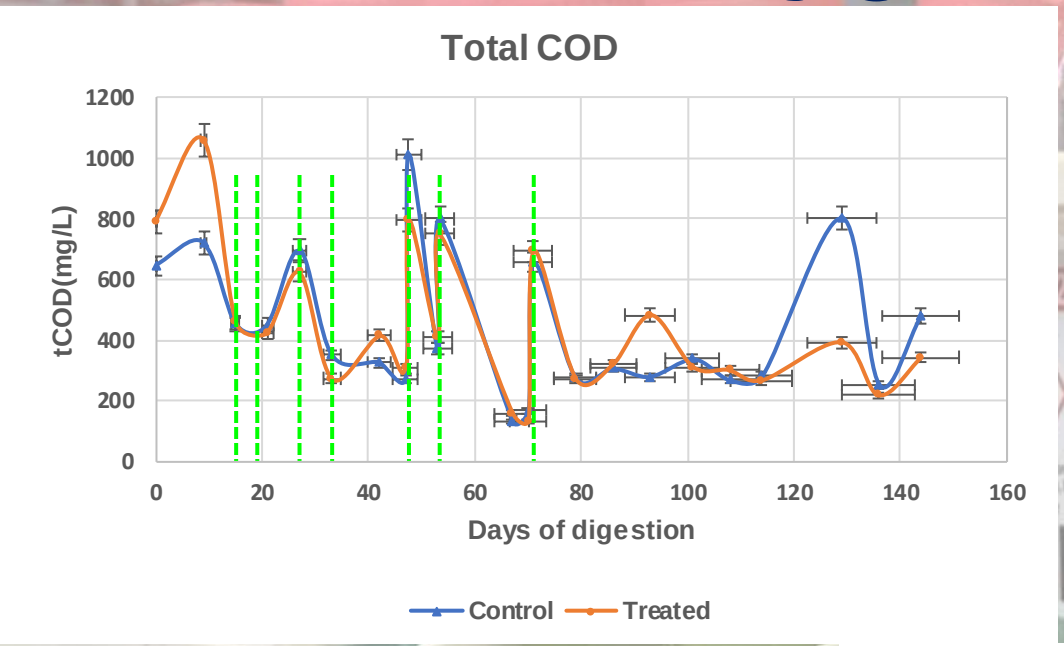
Design of experiment:

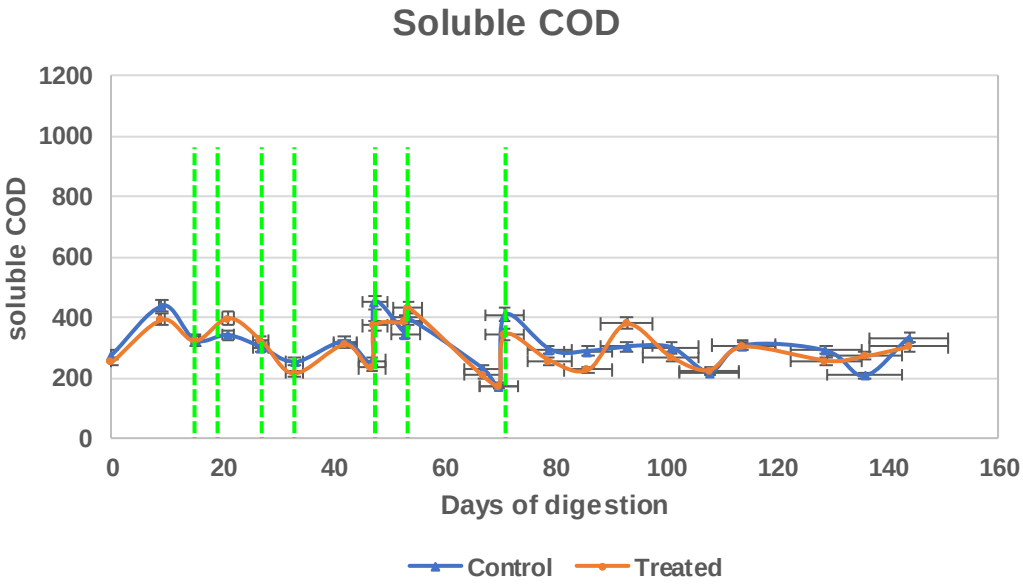
- Initial SWW tCOD- 600-800 mg/L
- Seed 3% (V/V)
- Design of experiment: 2X2 reactors
- 2 control
- 2 pretreated SWW
- **Treatment**: Use of ultrasound for 10 minutes at 0.5 W/mL

RESULTS:

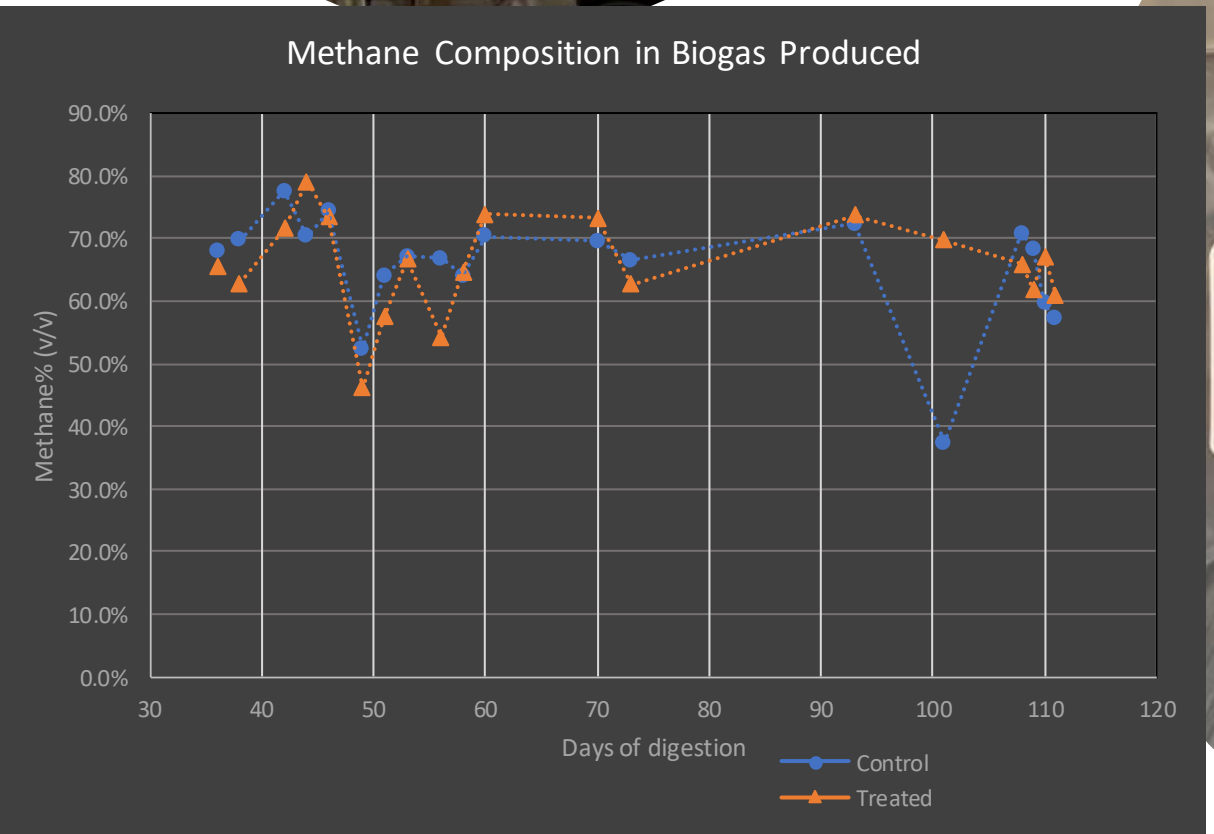
- Chemical Oxygen Demand
- Biogas Composition
- Total Ammonia Nitrogen
- Total Nitrogen
- Total Phosphorus
- pH and ORP

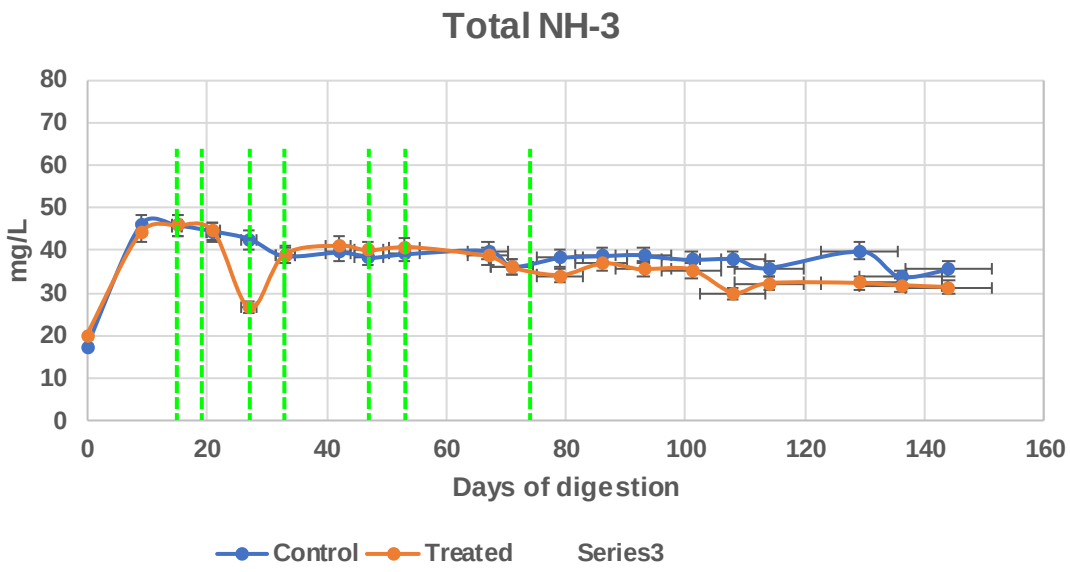
Chemical Oxygen Demand

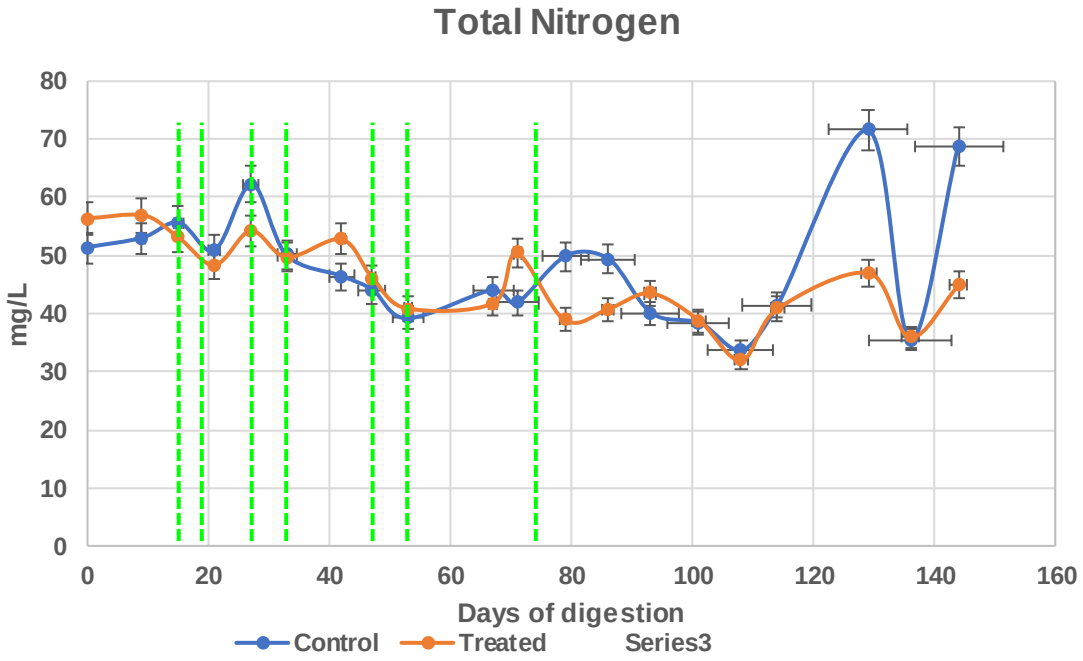




Biogas Composition

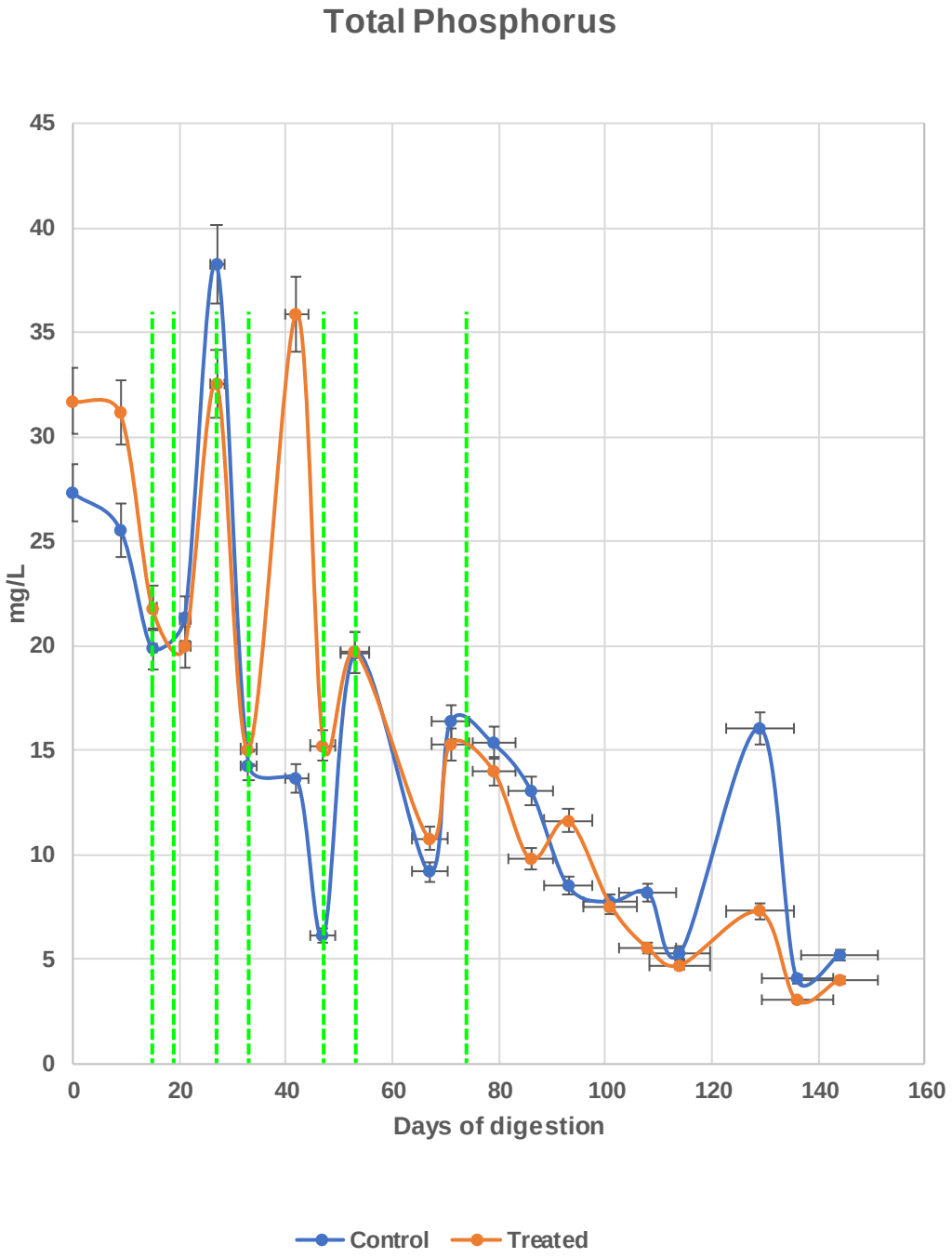




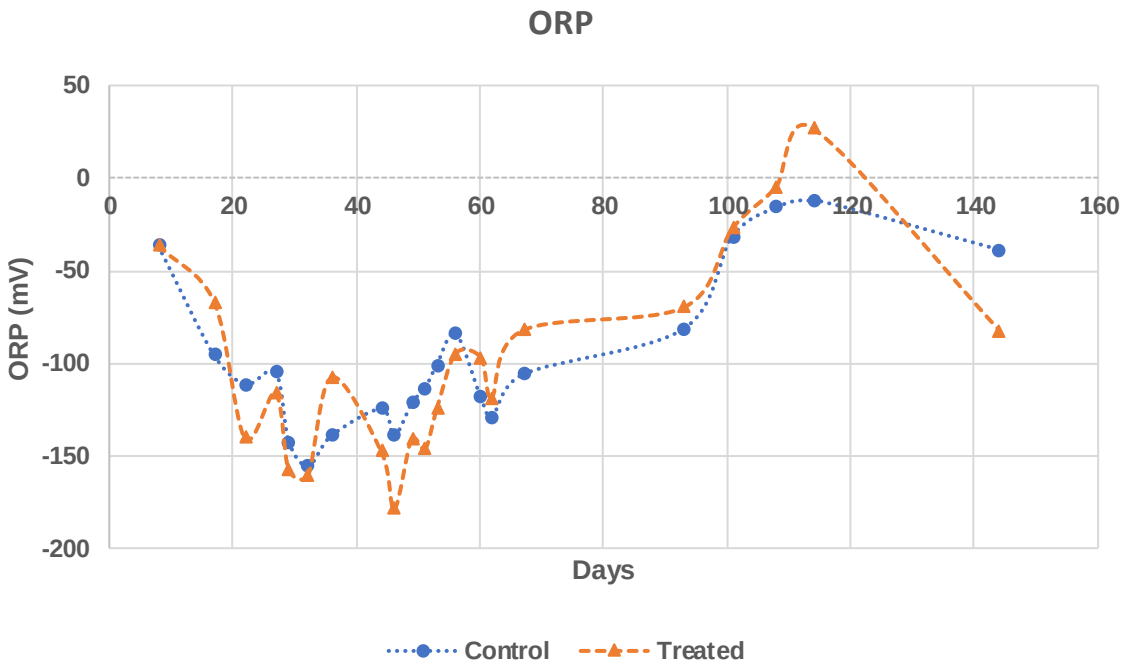


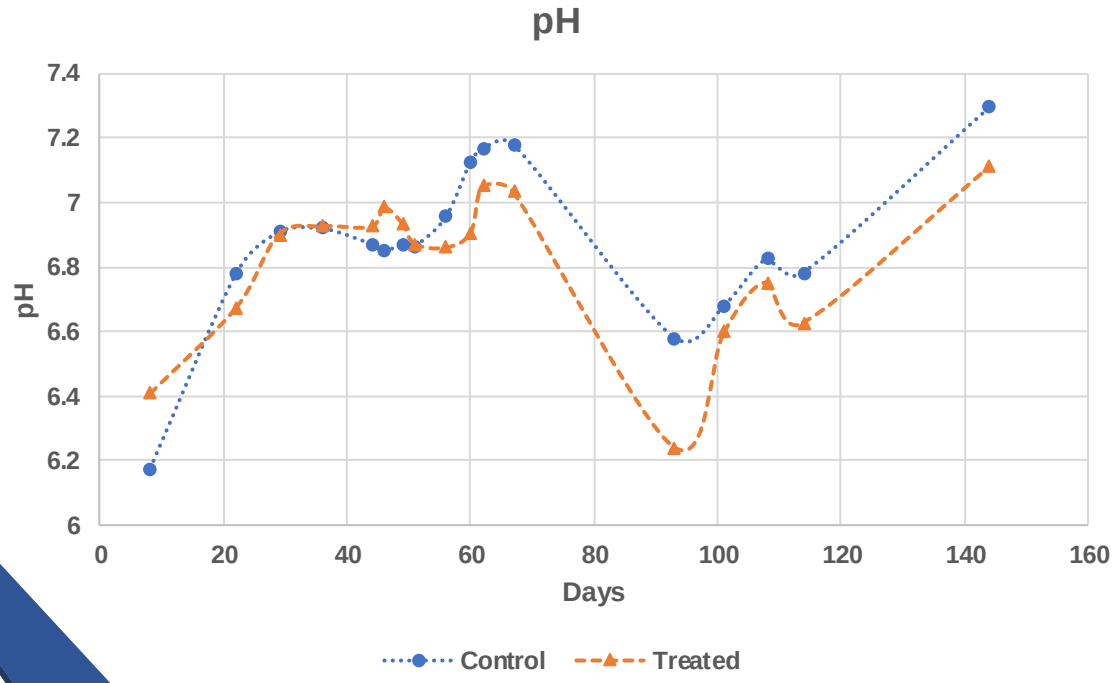
Total Ammonia Nitrogen, Total Nitrogen

Total Phosphorus



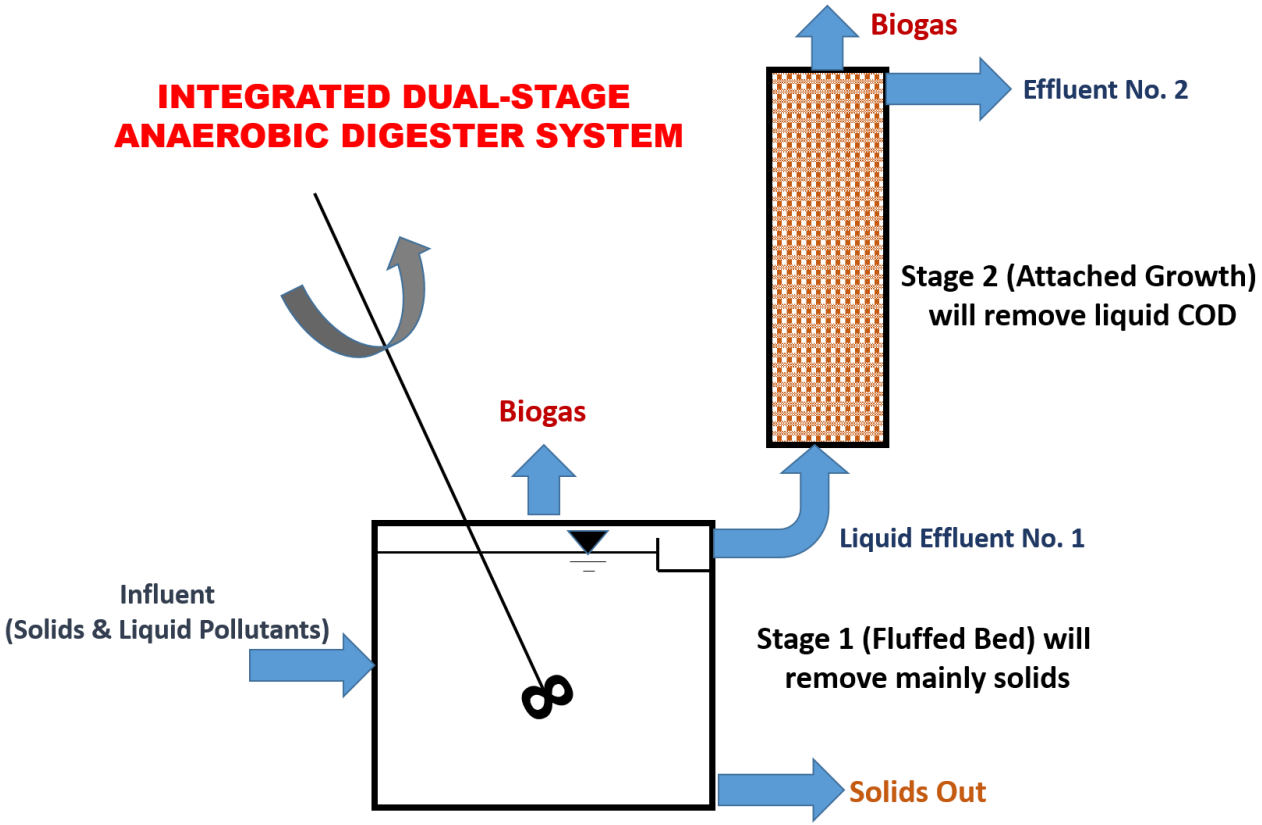
pH and ORP


ORP
50
0
-50
-100
-150
-200
ORP (mV)
0
20
40
60
80
100
120
140
160
Days
Control
Treated


pH
7.4
7.2
7
6.8
6.6
6.4
6.2
6
pH
0
20
40
60
80
100
120
140
160
Days
Control
Treated

Future Experiment

- Micronutrient dosing to enhance microbial activity
- Chemical dosing to maintain ORP levels
- Attached growth reactor for additional removal of COD



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THANK YOU!