BioAlgaNyx™

Phagotrophic algae enhanced sludge management

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9/21/2017
BioAlgaNyx™: A new Technology based on phagotrophic algae for resource recovery and sludge management

◆ INTRODUCTION
◆ AEROBIC DIGESTION ENHANCEMENT
◆ ANAEROBIC DIGESTION ENHANCEMENT
◆ ALGAL OIL PRODUCTION FROM SLUDGE
Problem

Sludge Disposal represents one of the highest operational costs for a Waste Water Treatment Facility.

Disposal can represent as much as 30% of the plant O&M Costs.
Ovivo’s BioAlgaNyx™ Technology

Ovivo, in partnership with the University of Akron, is developing a unique solution for:

• Organic Carbon capture
• Enhancing Sludge Digestion

Phagotrophic Algae is to be used for Resource Recovery and Biosolids Management
Phagotrophic algae

Phagotrophic Algae does NOT require sunlight

It is capable of:

• Ingesting small microbial, viral and other organic particulates (*Phagotrophic*) – Ideal for harvesting

• Consuming dissolved organics (*Heterotrophic*) – Ideal for harvesting

• Can Survive with light (*Phototrophic*), not for growth
Photosynthetic algae (limited in sludge treatment)

- Phototrophy (light)
- Heterotrophy (dissolved organics)
- Phagotrophy (bacteria)

Phagotrophic algae

INTRODUCTION
INTRODUCTION

Grow with free bacteria

a. With pure *Ecoli* cells
   ➢>98% bacterial cells were consumed in 21 h
   ➢Algae yield from bacteria was 43.7%

b. With mixed bacterial cells originated from waste activated sludge
   ➢>98% bacterial cells were consumed in 15 h
   ➢Algae yield from bacteria was 53%
INTRODUCTION

Grow with waste activated sludge (WAS)
Aerobic Digestion Enhancement

Benefit:
- a. Less time requirement
- b. Less aeration requirement

Algae oxygen uptake rate (SOUR is only 1/10 of bacteria.

**Bacteria**
SOUR: 500 mg O2/ g-TS*h

**Algae**
SOUR: 50 mg O2/ g-TS*h
1. WAS dissociation by anaerobic pretreatment
   a. Lab study

Aerobic Digestion Enhancement
Aerobic Digestion Enhancement
Aerobic Digestion Enhancement

b. Pilot test

Total volume: 6,000 gallon

Test duration: Aug 2016 to Nov 2016, 3 month

Temperature: 15 °C – 31 °C
Aerobic Digestion Enhancement

WAS ➔ Anaerobic Pretreatment ➔ Algal Growth ➔ Aerobic Digestion

Meet Class B biosolids in 10 days
Pathogen: 0.84 million/g-TS
SOUR: 1.2 mg O2/g-TS*h
2. WAS dissociation by short-time ultrasound  
a. Lab studies

Aerobic Digestion Enhancement

- WAS floc
  - Ultrasound: 0.9 min
  - 5.6% bacterial cells
  - 4.2% soluble organics
Aerobic Digestion Enhancement

- Algae yield from released bacteria and soluble organics was 38.6%
- WAS VS was reduced by 18.5% in 48 h
Aerobic Digestion Enhancement

b. Pilot test

- Ultrasound power: 950 watt
- Chamber volume: 5 L
- Energy intensity: 190 watt/L
Aerobic Digestion Enhancement

WAS → Ultrasound Pretreatment → Algal Growth → Aerobic Digestion

Meet Class B biosolids in 8 days
Pathogen: 0.83 million/g-TS
SOUR: 1.5 mg O2/g-TS*h
Anaerobic digestion enhancement

Anaerobic digestion

Limitation step

Protect cells against mechanic stress

Protect cells against osmotic lysis
Anaerobic digestion enhancement

- No cell wall, easy to break
- Rich in oil, good starter for anaerobic digestion

<table>
<thead>
<tr>
<th>SAMPLE COMPOSITION</th>
<th>DAYS</th>
<th>VS REDUCTION</th>
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<tbody>
<tr>
<td>100% WAS</td>
<td>15</td>
<td>30%</td>
</tr>
<tr>
<td>90% WAS + 10% Algae</td>
<td>15</td>
<td>35%</td>
</tr>
<tr>
<td>10% WAS + 90% Algae</td>
<td>15</td>
<td>50%</td>
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</tbody>
</table>
Anaerobic digestion enhancement

WAS → Vigorous dissociation → Algal Growth → Anaerobic Digestion

- More bacteria release
- More soluble organic release
Anaerobic digestion enhancement

Lab study

WAS → Ultrasound 10 min → Algal Growth → Anaerobic Digestion

50% WAS VS release → 20% Algal yield

29% Algal biomass
Oil production from sludge

Phagotrophic algae – oil reservoir

- With bacteria, oil content of phagotrophic algae is about 40-50%;
- With WAS, oil content of phagotrophic algae is about 30-40%;
Oil production from sludge

- Vigorous dissociation
- Algae Growth
- Flocs removal
- Aerobic Digestion

WAS

Flocs-rich solution

Algae-rich solution

Algae harvest

Oil extraction
Oil production from sludge

<table>
<thead>
<tr>
<th>Settling time (min)</th>
<th>Volume ratio: Supernatant/settling (v:v)</th>
<th>Algae ratio: Supernatant/settling (N:N)</th>
<th>Flocs ratio: Supernatant/settling (w:w)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0.24±0.02</td>
<td>0.23±0.01</td>
<td>0.013±0.001</td>
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<tr>
<td>15</td>
<td>0.63±0.01</td>
<td>0.62±0.01</td>
<td>0.028±0.005</td>
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<tr>
<td>30</td>
<td>3.77±0.32</td>
<td>3.59±0.41</td>
<td>0.044±0.003</td>
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<tr>
<td>60</td>
<td>3.96±0.28</td>
<td>2.88±0.42</td>
<td>0.067±0.003</td>
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</table>

At settling time of 30 min: 95.8% of the remaining WAS flocs were settled down 78.2% of algal cells presented in supernatant.
Oil production from sludge

Algae harvest → Flocculant

1 min

5 min
Phagotrophic algae provides unique, easy-to-operate solutions for sludge treatment

- Up to 50% reduction in digestion time requirements feasible
- No light source necessary to grow/sustain algae
- Lower O&M Costs
Example: 1.5 MGD Plant Evaluation

<table>
<thead>
<tr>
<th></th>
<th>Sludge Holding Tank Expansion</th>
<th>Conventional Aerobic Digestion</th>
<th>BioAlgNyx Enhanced Aerobic Digestion</th>
</tr>
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<tbody>
<tr>
<td>Capital</td>
<td>$118,750</td>
<td>$682,750</td>
<td>$381,336</td>
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<tr>
<td>O&amp;M</td>
<td>$347,236</td>
<td>$408,391</td>
<td>$205,025</td>
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<tr>
<td>Year 1</td>
<td>$465,986</td>
<td>$1,091,141</td>
<td>$586,361</td>
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<td>Year 2</td>
<td>$813,222</td>
<td>$1,499,532</td>
<td>$791,386</td>
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<tr>
<td>Simple Payback</td>
<td>0</td>
<td>never</td>
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