Effect of Produced Water Integration into Microalgae Cultivation

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Mechanical Engineering
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Acknowledgments

Support from:
• Katerine Napan, Ph.D.
• Ron Sims, Ph.D.
• Jason Peterson
• Lexi McNeil
Microalgal Biofuels

Large-scale algal growth system

Global lipid productivity model

Opportunities:
- Industrial flue gases
- Wastewater
- Oil & gas produced water
Flue Gas Integration

**Nannochloropsis salina**
with 14 heavy metals

**Scenedesmus obliquus**
with 10 heavy metals

Napan, et.al. 2015
Oil & Gas Produced Water

• Water produced as a byproduct of oil or gas
• Commonly associated with hydraulic fracturing
• Almost always unusable as drinking water
• Treatment of produced water is expensive
• Integration into algae cultivation may be a possible solution
• This experiment used produced water from the Uintah Basin to evaluate microalgae integration
Cultivation System

- Vertical photobioreactors
- *Nannochloropsis salina*
- Operated in triplicate

- High light intensity
- Temp maintained at 23°C +/- 0.5°C
- pH maintained at 7.0 +/- 1.0
Experimental Setup

Baseline
Produced Water

Tap Water

Dilution
0%
25%
50%
75%

Recycle
Week 1
Week 2
Baseline Results

![Graph showing the increase in algae (g/L) over time (days) with error bars for both control and produced samples.](image)
Baseline Results

![Graph showing algae growth over time with control and produced lines]

Algae (g/L) vs Time (days)

- Control
- Produced
Lipid Results

<table>
<thead>
<tr>
<th>Media</th>
<th>Lipid Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>30%</td>
</tr>
<tr>
<td>Produced Water</td>
<td>15%</td>
</tr>
</tbody>
</table>
Experimental Setup

Baseline
Produced Water

Tap Water

Dilution
0%
25%
50%
75%

Recycle
Week 1
Week 2
Dilution Results

![Graph showing algae concentration over time with different dilutions]
Dilution Results

![Graph representing dilution results over time.](image)
Dilution Results

![Graph showing dilution results over time with labels for avg con, avg 1/4, avg 1/2, and avg 3/4]
Dilution Results

![Graph showing dilution results]

- **Algae (g/L)** vs. **Time (days)**
- Lines represent dilution factors:
  - avg con
  - avg 1/4
  - avg 1/2
  - avg 3/4

The graph illustrates the growth of algae over time for different dilution factors.
Lipid Content

Produced Water Concentration

<table>
<thead>
<tr>
<th>Lipid Content</th>
<th>0%</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Produced Water Concentration</td>
<td>0%</td>
<td>25%</td>
<td>50%</td>
<td>75%</td>
</tr>
</tbody>
</table>
Lipid Productivity

![Lipid Productivity Graph]

- **Lipid Productivity (g/L/week)**
- **Produced Water Concentration (%)**

- The graph shows a decrease in lipid productivity as the produced water concentration increases.
- The productivity peaks around 25% concentration and drops significantly as the concentration increases to 100%.

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Experimental Setup

Baseline
Produced Water

Tap Water

Dilution
0% 25%
50% 75%

Recycle
Week 1
Week 2
REPLACE
Control
½ Produced Water

![Graph showing algae growth over time.](image)

- **Y-axis**: Algae (g/L)
- **X-axis**: Time (days)

- **Line colors and labels**:
  - Blue: week 1
  - Green: week 2

The graph illustrates the increase in algae concentration over time for two weeks, with week 1 showing a steady increase in algae concentration compared to week 2.
½ Produced Water

![Graph showing algae growth over time for two weeks.](image)

- **Y-axis**: Algae (g/L)
- **X-axis**: Time (days)
- **Legend**:
  - Blue line: week 1
  - Green line: week 2
Recycle

Graph showing the growth of algae over time, with two lines representing different weeks. The x-axis represents time in days, ranging from 1 to 8, and the y-axis represents the concentration of algae in g/L, ranging from 0 to 7.
Week 1

![Graph showing algae growth over time with four different conditions: average control (avg cont), average half (avg 1/2), average recycle (avg recycle), and average replace (avg replace). The graph plots Algae (g/L) against Time (days) from 1 to 8 days.]
Week 1 Lipid Content

- Control
- 50% PW
- Recycle
- Replace
Week 2

Lipid Content

Control | 50% PW | Recycle | Replace
Lipid Productivity

- **Control**: 2.8 g/L/week
- **50% PW**: 1.5 g/L/week
- **Recycle**: 1.2 g/L/week
- **Replace**: 0.8 g/L/week
Conclusions

Produced water significantly reduces microalgae growth
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Dilution with clean water restores growth
Produced water significantly reduces microalgae growth

Dilution with clean water restores growth

Lipid productivity increases in 25% produced water media
Conclusions

Produced water significantly reduces microalgae growth

Dilution with clean water restores growth

Lipid productivity increases in 25% produced water media

Produced water recycle increases subsequent lipid productivity
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