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Transitioning the Benefits of Algal Growth to the Byproducts of Oil and Natural Gas Production

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Transitioning the benefits of algal growth to the byproducts of oil and natural gas production

I. Introduction

Produce water

- Produced water, a waste water by-product of oil and natural gas extraction, is the largest waste stream produced by the oil and natural gas industries worldwide.
- Utah produces 148,579,000 barrels of produced water per year.

Algal production in produce water

- The ability to culture algae in non-potable water would allow for the benefits of algal production without using water that is suitable for direct human use.
- Algal biomass can be utilized in a variety of applications including bioenergy, livestock feed, fertilizer, and high value products.

Phycocyanin

- Phycocyanin is a high value photosynthetic pigment found in most cyanobacteria valued at $60-$120/mg for high purity product.
- Uses of phycocyanin include: food products, cosmetics, potential pharmaceuticals and nutriceuticals among others.

Study conducted with funding from the Utah Water Research Laboratory.

II. Methods

- Various medias were prepared from produced water obtained from varying sample sites at a Uinta Basin, Utah produced water disposal facility (dilutions are given as ratio of produced water to deionized water).
- All solutions were amended with sodium nitrate and diabasic potassium phosphate.
- Triplicate flasks of each solution were prepared and equal amounts of cotton rope and algae inoculum (Logan Lagoons Cyanobacteria 2 (LLC2) ) were suspended in each flask [Figure 2].
- Flasks were placed on a shaker table at 100 rpm with 85 μE m² s⁻¹ cool white fluorescent light.
- Biomass and phycocyanin production were measured at 10 Days

III. Results

- Successful culture of algae was observed in all samples except samples consisting of non diluted and half diluted produce water from site B [Figure 1].
- Ash free dry biomass was produced at the following average rates.
  
<table>
<thead>
<tr>
<th>Site</th>
<th>Biomass (g/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BG-11</td>
<td>0.87±0.07 g m⁻² d⁻¹</td>
</tr>
<tr>
<td>Site A</td>
<td>1.21±0.16 g m⁻² d⁻¹</td>
</tr>
<tr>
<td>Site B</td>
<td>1.03±0.15 g m⁻² d⁻¹</td>
</tr>
</tbody>
</table>

- Phycocyanin production was seen in all samples where growth was observed. The largest production of phycocyanin was seen in algae cultured in site A [Table 1].

IV. Conclusions

- The ability to culture algae in produced water of certain compositions was supported.
- Algal biomass production from produced wastewaters provides for a sustainable remediation and nutrient recovery process.
- Production of high value compounds from algae, such as phycocyanin, generates revenue streams and enhances the economic viability of algal culturing systems.
- Future work will include scale up testing and evaluation, including a Rotating Algal Bioreactor (RABR), at a partner Uinta Basin, Utah produced water disposal site.

Table 1 – TDS and phycocyanin production

<table>
<thead>
<tr>
<th>Site</th>
<th>TDS (mg/L)</th>
<th>Phycocyanin Production (mg/g biomass)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BG-11</td>
<td>10,400</td>
<td>34.9±1.8</td>
</tr>
<tr>
<td>Site A</td>
<td>11,000</td>
<td>15.2±1.0</td>
</tr>
<tr>
<td>Site B</td>
<td>230,000</td>
<td>N/A</td>
</tr>
<tr>
<td>Site B 1:10</td>
<td>23,000</td>
<td>7.0±2.2</td>
</tr>
<tr>
<td>Site B 1:20</td>
<td>11,500</td>
<td>10.3±1.9</td>
</tr>
</tbody>
</table>

Figure 1 – Average Ash Free Dry Biomass Productivity

Figure 2 – Shaker flask configuration showing growth at day 5

Figure 3 – Phycocyanin isolate

Figure 4 – Biomass growth on rope substratum

Figure 5 – Absorbance of cyanobacteria extract indicating phycocyanin production

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