Algae Reactors for Wastewater Treatment

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Wastewater treatment: nutrient removal is ok to current standards

Coagulant
Influent
Primary sedimentation
Waste sludge
Return activated sludge
Secondary sedimentation
Waste sludge

Anaerobic
Influent
Aeration
Clarifier
Return activated sludge

Phosphorus
\[1 \text{ mg.L}^{-1}\]
Need additional stage to reach tighter consents. Is this a role for algae?
Which type of reactor should we use?

- High rate algal pond
- Photobioreactor
- Immobilisation
- Attached
Need appropriate HRT & footprint

Within viable range

Ponds and biofilm systems long retention times
What is immobilisation?

- Concentrates biomass
- Reduced footprint
- Easy removal – gravity settlement post-treatment
**Methodology**

### Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cells.bead(^{-1})</td>
<td>(10^5) (Hameed et al., 2007)</td>
</tr>
<tr>
<td>Beads.mL(^{-1})</td>
<td>10 (Hameed et al., 2007)</td>
</tr>
<tr>
<td>Temperature</td>
<td>20°C</td>
</tr>
<tr>
<td>Microalgal species</td>
<td><em>Scenedesmus obliquus</em></td>
</tr>
<tr>
<td>Resin &amp; curing solution</td>
<td>2% Na-alginate and 2% CaCl(_2)</td>
</tr>
<tr>
<td>Light – wavelength &amp; intensity</td>
<td>200 μmol.m(^{-2}).s(^{-1}), white light</td>
</tr>
<tr>
<td>HRT</td>
<td>3, 6, 12 and 20 hours</td>
</tr>
</tbody>
</table>

Performance analysed for three wastewaters.
How did it perform?

20 h

0.03 mg.L⁻¹

Concentration (mg.L⁻¹)

Time (days)

Dissolved PO₄³⁻ (mg.L⁻¹)  Total PO₄³⁻ (mg.L⁻¹)  Dissolved TP (mg.L⁻¹)  Total TP (mg.L⁻¹)  pH
How did it perform?

20 h
0.03 mg.L$^{-1}$

12 h
0.17 mg.L$^{-1}$

6 h
0.10 mg.L$^{-1}$

3 h
0.43 mg.L$^{-1}$
And works for ammonium too.

Average residual concentrations after treatment

Suitable for poor performing N sites too!
IBR design parameters beginning to be understood

Performance

Uptake rate of beads – reactor sizing

Bead life and replacement

Trade off between cost and performance

Inform pilot scale trials
IBR performance when scaled up

Packed bed

Fluidised bed

<0.2 mg.L\(^{-1}\)
Is an IBR a viable option for nutrient polishing?

<table>
<thead>
<tr>
<th>Option</th>
<th>NPC (£k)</th>
<th>Risk reduction (DR)</th>
<th>Risk Index (NPC/dR)</th>
</tr>
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<tbody>
<tr>
<td>Increase Fe dosing</td>
<td>--</td>
<td>--</td>
<td>0.2</td>
</tr>
<tr>
<td>Sand filter and Fe dosing</td>
<td>--</td>
<td>--</td>
<td>11.6</td>
</tr>
<tr>
<td>FBBR IBR + AD (thermal pre-treatment)</td>
<td>--</td>
<td>--</td>
<td>11.6</td>
</tr>
<tr>
<td>PB IBR + AD (thermal pre-treatment)</td>
<td>--</td>
<td>--</td>
<td>11.0</td>
</tr>
</tbody>
</table>

RI <4 = a really good option, 4 – 8 = a good option, >8 = an option that is not as good value for money
Is an IBR a viable option for nutrient polishing?

Further development of an IBR

- Currently over performing, adjust OPEX for savings
- 10 beads.mL$^{-1}$ to 8 beads.mL$^{-1}$
- Light regime 24 h.d$^{-1}$ to 12 h.d$^{-1}$
- Extension of bead life

RI <4 = a really good option, 4 – 8 = a good option, >8 = an option that is not as good value for money

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<tr>
<td>FBBR IBR + AD (thermal pre-treatment)</td>
<td>--</td>
<td>--</td>
<td>7.2</td>
</tr>
<tr>
<td>PB IBR + AD (thermal pre-treatment)</td>
<td>--</td>
<td>--</td>
<td>6.7</td>
</tr>
</tbody>
</table>

Highlights areas for further development
Many thanks

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