diesel oil biodegradation in bioreactors

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3. baffled roller bioreactor
Introduction

- Accidental release of petroleum products into the environment[5]

benzene, toluene, ethylbenzene and xylene (BTEX)

(toxicity of DF)

Cancer

Introduction

- Several methods for the remediation of petroleum contaminated sites[5]

  ✓ Mechanical (e.g. oil–water separators)
  ✓ Chemical (using chemicals dispersants such as surfactants)
  ✓ Biological (based on bioremediation)
Introduction

Arrar et al
jet-fluidized bed reactor[1]

Kleijntjens et al
continuously stirred bioreactor[4]

Nikakhtari et al
baffled roller bioreactor[1]

Whang et al
batch reactors[3]

Bioreactors

The efficiency of a bioreactor[6]

✓ the establishment of an ideal environment
✓ the development of a technology for control of the conditions in the reactor

basic physical modes of providing the microorganisms

✓ fixed-film support
✓ suspended growth in solution
Microorganism and medium

Commercial and donated microorganisms from different sources[3]

- Alabaster Corp
- Pasadena, TX
- Bethlehem
- Bioscience Inc

The indigenous microorganisms isolated from a contaminated soil of an industrial site
To find the best microbial culture, indigenous bacteria isolated from soil from a contaminated industrial site [3].

### Table 1. Bacterial cultures and supplemental chemicals used to identify the most suitable for diesel oil biodegradation

<table>
<thead>
<tr>
<th>Diesel (mg L(^{-1}))</th>
<th>Supplement (mg L(^{-1}))</th>
<th>Inoculants</th>
<th>Days to reach maximum OD</th>
<th>Maximum OD after 14 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1000</td>
<td>Indigenous</td>
<td>11</td>
<td>0.251</td>
</tr>
<tr>
<td>2</td>
<td>500</td>
<td>Indigenous</td>
<td>9</td>
<td>0.171</td>
</tr>
<tr>
<td>3</td>
<td>1000</td>
<td>Indigenous</td>
<td>12</td>
<td>0.296</td>
</tr>
<tr>
<td>4</td>
<td>500</td>
<td>Indigenous</td>
<td>10</td>
<td>0.296</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>Indigenous</td>
<td>12</td>
<td>0.205</td>
</tr>
<tr>
<td>6</td>
<td>500</td>
<td>MWTP(^2)</td>
<td>14</td>
<td>0.216</td>
</tr>
<tr>
<td>7</td>
<td>500</td>
<td>Environoc 101</td>
<td>14</td>
<td>0.191</td>
</tr>
<tr>
<td>8</td>
<td>500</td>
<td>A/B Blend</td>
<td>14</td>
<td>0.150</td>
</tr>
<tr>
<td>9</td>
<td>500</td>
<td>Microcat</td>
<td>14</td>
<td>0.188</td>
</tr>
<tr>
<td>10</td>
<td>500</td>
<td>ELAB</td>
<td>14</td>
<td>0.146</td>
</tr>
</tbody>
</table>

\(^2\) Saskatoon Municipal Wastewater Treatment Plant.
microorganisms

Rhodococcus erythropolis

Pseudomonas aeruginosa

Rhodococcus fascians

Achromobacter xylosoxidans

Cell growth model

![Graph showing the cell growth model](image)

**Formulas**

- Monod equation
- Runge-Kutta method
surfactant (SDS)

Profile of diesel oil concentrations in the baffled roller bioreactor with and without surfactant (SDS) [3].

Effect of temperature

Biodegradation of 1000 mg L\(^{-1}\) diesel oil in the baffled roller bioreactors at different temperatures [3].
Modeling results

The maximum specific growth rate and substrate yield factor ($\mu_{\text{max}}$ and $Y_{S}$) for diesel biodegradation as reported in different works:

<table>
<thead>
<tr>
<th>Study</th>
<th>Initial diesel concentration g/L</th>
<th>$\mu_{\text{max}}$ $\text{h}^{-1}$</th>
<th>$Y_{S}$</th>
<th>$Y_{S}$ mg of biomass/mg diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geerdink et al. (1995), batch reactor</td>
<td>3.3</td>
<td>0.55</td>
<td>0.1 Cmol/Cmol$^1$</td>
<td>0.18</td>
</tr>
<tr>
<td>Geerdink et al. (1995), continuous stirred reactor</td>
<td>1.3 to 5.5</td>
<td>0.25</td>
<td>0.3 Cmol/Cmol</td>
<td>0.52</td>
</tr>
<tr>
<td>Whang et al. (2008)</td>
<td>8.6</td>
<td>0.023</td>
<td>0.25 mg VSS/mg TPH</td>
<td>0.25</td>
</tr>
<tr>
<td>Whang et al. (2008), with biosurfactant</td>
<td>8.6</td>
<td>0.08</td>
<td>0.25 mg VSS/mg TPH</td>
<td>0.25</td>
</tr>
<tr>
<td>Present study</td>
<td>Below 1</td>
<td>1.41</td>
<td>7 x 10^7 cells/mg diesel</td>
<td>0.29</td>
</tr>
<tr>
<td>Present study</td>
<td>Between 1 and 50</td>
<td>0.72</td>
<td>7 x 10^7 cells/mg diesel</td>
<td>0.29$^2$</td>
</tr>
<tr>
<td>Present study</td>
<td>50</td>
<td>0.72</td>
<td>2 x 10^7 cells/mg diesel</td>
<td>0.03</td>
</tr>
<tr>
<td>Present study</td>
<td>200</td>
<td>0.72</td>
<td>8 x 10^7 cells/mg diesel</td>
<td>0.03</td>
</tr>
</tbody>
</table>

$^1$ Cmol is moles of carbon in biomass and diesel oil. Molecular weight has been assumed to be 14 g/Cmol and 24.6 g/Cmol for diesel oil and biomass, respectively$^2$.

$^2$ Yield factor was converted to mg biomass/mg diesel assuming two micrometer average cell diameter$^3$ and 1 g/mL density for the microorganisms.

Comparison of bioreactors

diesel oil consumption in various roller bioreactor configurations:
Biomass growth in various roller bioreactor configurations:
control, baffled, and bead mill [2],[3].
Comparison of bioreactors

- Baffled bioreactor
- Half the working volume of bead mill bioreactor
- Faster biodegradation of diesel in both Baffled and bead mill bioreactors than the control bioreactor[2],[3]

Comparison of different scales

- Biodegradation of diesel oil in 3 different scales of roller baffled bioreactors[3]
REFERENCES


Thank You!