Biodegradation of MCPA and Nitrate Removal in an Anoxic SBR

Deepak Chouhan - Ph. D candidate
R. Bello-Mendoza, D. G. Wareham
University of Canterbury
Christchurch, New Zealand

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Background

- Agriculture

✓ Economy
Pesticides and other chemicals (such as nitrate)
Potential solution

- Biological Denitrification
  - Easy
  - Effective
  - Economic
Target Compound

• Chlorinated herbicide – MCPA

✓ Frequently detected in both surface and ground water bodies

✓ There is a significant knowledge gap in the removal of MCPA via denitrification (i.e. under anoxic conditions)
Research Objectives

• To investigate the biodegradability potential and limit of MCPA degradation in an anoxic SBR
Experimental Design

Anoxic condition: 25 L Cylindrical Reactors semi-sealed

Nitrate pump

MCPA pump

Control reactor: (no MCPA)

Test Reactor: (with MCPA amine salt)
Operating Conditions

- HRT: 24 hours & SRT: 40 – 60 days
- Synthetic wastewater: Acetic acid
- Solubility
  - Pure MCPA acid (<100 mg/L)
  - MCPA Salt (DMCPA) (Up to 750 g/L)
- SBR
  - Phase I (20 mg/L)
  - Phase II and III (50 mg/L)
Results and Discussion

- Baseline data collection
  - Consistent TSS & VSS
  - Stabilized ORP
  - > 95% removal of COD and Nitrate
Baseline data

TSS & VSS (mg/L)

Time (d)
Baseline data

![Graph showing COD and Nitrate over time]

- **COD**
- **Nitrate**

**Y-axis:** C/Co

**X-axis:** Time (h)

0 to 5 hours
Phase I - 20 mg/L of DMCPA

Concn of MCPA (mg/L) vs Time (h)

- Concentration of MCPA at different time points:
  - 0,5 mg/L at 0 h
  - 1 mg/L at 2 h
  - 1,5 mg/L at 4 h
  - 2 mg/L at 6 h
  - 2,5 mg/L at 8 h
  - 3 mg/L at 10 h
  - 3,5 mg/L at 12 h

- The concentration of MCPA increases rapidly to a peak at 2 h and then decreases gradually over time.
Phase I - 20 mg/L of DMCPA
Phase II - 50 mg/L of DMCPA (24 h HRT)
Phase II - 50 mg/L of DMCPA (24 h HRT)
Phase II - 50 mg/L of DMCPA (24 h HRT)
Phase III - 50 mg/L of DMCPA (48 h HRT)
# MCPA metabolites

<table>
<thead>
<tr>
<th>Intermediate compound</th>
<th>Retention time (min)</th>
<th>Similarity percentage (%)</th>
<th>50mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>4h</td>
</tr>
<tr>
<td><strong>4-Chloromethyl phenol</strong></td>
<td>5.2</td>
<td>83</td>
<td>√</td>
</tr>
<tr>
<td>Phenol, 2,4-bis(1,1-dimethyl)</td>
<td>6.94</td>
<td>85</td>
<td>√</td>
</tr>
<tr>
<td>Propanoic acid, 2-methyl-, 1-(1,1-dimethylethyl)-2-methyl-1,3-propanediyl ester</td>
<td>7.45</td>
<td>94</td>
<td>√</td>
</tr>
<tr>
<td>Pentanoic acid, 2,2,4-trimethyl-3-carboxyisopropyl, isobutyl ester</td>
<td>7.45</td>
<td>93</td>
<td>√</td>
</tr>
<tr>
<td>Cyclobutane, 1,2-diphenyl</td>
<td>8.45</td>
<td>91</td>
<td>√</td>
</tr>
<tr>
<td>Cyclooctane, 1,5-dimethyl</td>
<td>9.36</td>
<td>79</td>
<td></td>
</tr>
<tr>
<td>Ethanol, 2-3,3-dimethylcyclohexylidene</td>
<td>6.50</td>
<td>78</td>
<td>×</td>
</tr>
<tr>
<td>(2,3-Diphenylcyclopropyl)methyl phenyl sulfoxide, trans</td>
<td>12.188</td>
<td>76</td>
<td>√</td>
</tr>
<tr>
<td>Cyclic 3-(1,2-ethanediyl) acetal</td>
<td>8.45</td>
<td>75</td>
<td>×</td>
</tr>
</tbody>
</table>
Conclusions

• An anoxic SBR can be operated for long periods while simultaneously removing MCPA and nitrate.

• More than 98 % removal of the MCPA (concentrations up to 50 mg/L) was achieved.