Denitrification in an anoxic rotating biological contactor under two carbon/nitrogen ratios

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Introduction

In biological denitrification of wastewater nitrate (NO$_3^-$) or nitrite (NO$_2^-$) are converted into nitrogen gas (N$_2$), in the absence of dissolved oxygen (DO) or under limited DO concentrations. A rotating biological contactor (RBC) is an attached growth bioreactor, that constitutes a very unique and superior alternative technology for carbon oxidation, phosphorus removal, nitrification and denitrification. Although in the last decade RBCs tightly closed to avoid air entrance have started to be used for denitrification, few studies have still been conducted with anoxic RBCs.

The aim of this work was to compare the performance of an anoxic bench-scale rotating biological contactor (RBC), in terms of the denitrification of a synthetic wastewater under two carbon/nitrogen (C/N) molar ratios: 1.5 and 3.

Methodology

Inoculum:
- Suspended biomass from an activated sludge tank from a wastewater treatment plant
- Acclimatized in a denitrification medium

Synthetic wastewater:
- Phosphorus concentration of 10 mg P/L
- Nitrate
- Acetate as carbon source
- Trace elements
- Tap water

Reactor:
- 8 PMMA discs mounted on a horizontal shaft
- Working volume: 2.5 L
- T = 28 ºC
- Rotational speed: 4 rpm

Figure 1. Scheme of the anoxic rotating biological contactor.

Table 1. Operation parameters of the anoxic rotating biological contactor

<table>
<thead>
<tr>
<th>Days of operation</th>
<th>HRT (h)</th>
<th>N-NO$_3^-$ (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 8</td>
<td>10.00</td>
<td>50</td>
</tr>
<tr>
<td>8 – 15</td>
<td>10.00</td>
<td>100</td>
</tr>
<tr>
<td>15 – 22</td>
<td>6.84</td>
<td>100</td>
</tr>
<tr>
<td>22 – 28</td>
<td>5.68</td>
<td>100</td>
</tr>
</tbody>
</table>

Analysis:
- Nitrate
- Acetate
- Nitrite

Reactor operation:

<table>
<thead>
<tr>
<th>HRT (h)</th>
<th>N-NO$_3^-$ removal efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>80</td>
</tr>
<tr>
<td>6.84</td>
<td>60</td>
</tr>
<tr>
<td>5.68</td>
<td>40</td>
</tr>
</tbody>
</table>

Figure 2. Nitrogen-nitrate (a) and carbon-acetate (b) removal efficiency along the time at two C/N ratios: 1.5 and 3.

Table 2. Nitrogen-nitrite effluent concentration along the time at two C/N ratios: 1.5 and 3.

<table>
<thead>
<tr>
<th>HRT (h)</th>
<th>N-NO$_2^-$ (mg/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>6.84</td>
<td>10</td>
</tr>
<tr>
<td>5.68</td>
<td>5</td>
</tr>
</tbody>
</table>

Figure 3. Nitrogen-nitrite effluent concentration along the time at two C/N ratios: 1.5 and 3.

Results

Conclusions

- For the tested conditions, and for economical and environmental reasons, the use of C/N=1.5 is advantageous.
- The substrate removal efficiencies decreased as the C/N ratio increased from 1.5 to 3.
- The increase of nitrogen-nitrate and carbon-acetate influent concentrations, keeping C/N constant, and the decrease of hydraulic retention time (HRT) had a slight negative effect in terms of substrate removal.
- The accumulation of nitrite-nitrogen (NO$_2^-$-N) was verified and it can be speculated that the influent phosphate concentration limited the conversion of nitrite to nitrogen gas. Alternatively, the accumulation of nitrate can result from the microbial population present inside the RBC rich in nitrate reducing bacteria.

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