
Poster paper
Anaerobic Bioflocculation of Wool Scouring Effluent

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ABSTRACT

A two-stage anaerobic bioflocculation process is investigated to successfully flocculate the emulsified wool grease from wool scouring effluent. After 110 days of continuous operation, the laboratory process gave promising results by removing between 70 and 90% wool grease and about 60 to 86% COD at a combined hydraulic residence time (HRT) of 4 to 10 days. Methane production and volatile fatty acids consumption were negligible. Most of the grease was thought to be removed by flocculation as a result of anaerobic activity. Since the supernatant of the treated effluent still contained residual grease of over 1,500 mg/L, further purification is necessary. The supernatant was easily treatable by the classical aerobic activated sludge treatment (internal sludge recycle), which removed virtually all of the residual wool grease resulting in less than 100 mg/L in the final effluent, at an HRT of 3 days.

Keywords: wool scouring effluent; wastewater; bioflocculation; anaerobic; lanolin; emulsion; biodegradation

INTRODUCTION

Effluent from the wool scouring industry is considered to be the most strongly polluting waste in the textile industry (Anderson & Wood, 1973). It typically contains 3,000 to 20,000 mg/L wool grease, 7,000 to 15,000 mg/L suint salts (salt produced by natural secretions) and 10,000 to 30,000 mg/L dirt (sand, vegetable matter and fibre). The biological oxygen demand (BOD) and chemical oxygen demand (COD) of the effluent can be as high as 40,000 mg/L and 120,000 mg/L respectively, if the actual scouring strongflow is separated from the less polluted rinse waters (Christoe & Bateup, 1987; Townsend et al., 1989).
The major causes of problems in treating this waste stream is the residual wool grease (lanolin) which is relatively resistant to biodegradation (Choa and Yang, 1981; Isaac and Cord-Ruwisch, 1991), and the detergent which produces a stable emulsion of the wool grease in water (Mccracken and Chikin, 1978).

At CSIRO (Division of Wool Technology) the destabilization of the stable lanolin emulsion has been successful using aerobic bacteria which caused partial oxidation and partial flocculation of the wool grease, giving a clear supernatant (Cord-Ruwisch et al., 1990). The problems of this process were the large amount of air required, the foam formation and the large amount of sludge produced.

The present study aims at biologically destabilizing the lanolin emulsion by using anaerobic bacteria (biological flocculation). The process described is not designed to represent a comprehensive treatment process but to remove the bulk of wool grease which is the major source of COD, therefore serving as a pretreatment step, necessary prior to classical biological processes (either aerobic or anaerobic).

MATERIALS AND METHODS

A two-stage bioflocculation process was conducted by using 2 cylindrical columns as reactors. The feed for the first column was wool scouring effluent collected from a plant in Jandakot (Perth, Western Australia). The overflow from this column was collected in a 2 litre separating funnel. The supernatant from the funnel was fed to the second column as feed. Both columns were automatically fed in 4 equal allotments per day to give the desired total load per day. The contents in both columns were gently mixed by circulating the liquor using separate pumps operated automatically for 15 minutes every hour.

RESULTS AND DISCUSSION

Operational Performance.
By changing both the hydraulic residence time (HRT) and the grease concentration in the feed, the grease loading rate of both stages was gradually increased (Table 1).
Table 1 - Average grease load and HRT during the period of operation

<table>
<thead>
<tr>
<th>Stage</th>
<th>Days:</th>
<th>1-10</th>
<th>11-23</th>
<th>24-40</th>
<th>41-110</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Grease - feed (g/l)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stage 1</td>
<td></td>
<td>34.0</td>
<td>18.0</td>
<td>16.4</td>
<td>12.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HRT (days)</td>
<td>9</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grease load (g/l/d)</td>
<td>3.8</td>
<td>3</td>
<td>4.1</td>
</tr>
<tr>
<td>Stage 2</td>
<td></td>
<td>3.8</td>
<td>4.2</td>
<td></td>
<td>5.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HRT (days)</td>
<td>15</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Grease load (g/l/d)</td>
<td>0.25</td>
<td>1.0</td>
<td>2.6</td>
</tr>
</tbody>
</table>

The first stage of the process appeared to play a major role, removing more than half of the grease content from the effluent, while the second stage was more unstable and removes less than 20% of the original grease content in the liquor or about 50% of the effluent from stage 1 (Figure 2). However, the efficiency from both stages was over 64% at all times and reached 90% grease removal (both steps combined) at an HRT of 4 days (2 days in each stage).

The performance of the culture was found to vary with wool scouring effluents from different origin. At continued constant hydraulic loading rates, the grease removal efficiency of the process was found to increase with the grease content of the wool scouring effluent. This finding suggests that effluent from wool scouring plants which can concentrate the grease in their strongflow (to about 20 g/l will be more economically treatable than more dilute strongflows of the combined effluents (strongflow plus rinse liquors).

As the COD in the effluent is mainly a result of wool grease, the removal of grease is correlated to the removal of COD as shown in Figure 3. During the period of experiment the efficiency of COD removal was 60-86%.

Figure 2 The efficiency of grease removal using the bioflocculation process

Figure 3 Total grease and COD removal from anaerobic bioflocculation process
It is interesting to note that even though anaerobic bacteria were employed in this process, only small amounts of methane production and volatile fatty acid (VFA) consumption were observed at the beginning, and almost no methane was produced when the process reached steady state. This evidence shows that the process does not greatly rely on biodegradation of wool grease, as in other anaerobic processes, but simply destabilizes (flocculates) the wool grease through bacterial anaerobic activity.

The final effluent from the process still contained more than 1500 mg/l of grease which requires further purification before discharge to the environment. An aerobic treatment process was attached to the anaerobic bioflocculation step and resulted in the continuous removal of virtually all residual grease (>97%) to less than 100 mg/L (HRT 3 days). The total BOD removal of the total treatment line was >99%.

CONCLUSIONS

The action of bacteria on wool scouring effluent results in both partial degradation, and partial flocculation of the grease. Since the grease removal by bioflocculation is more rapid at similar performance than grease removal by biodegradation, the former process looks economically promising. In contrast to chemical flocculation or aerobic biological flocculation the anaerobic biological flocculation did not require any further additives such as acid or oxygen. Since, in all treatment systems for wool scouring effluent, vast amounts of sludge accumulate; the dewatering and disposal of such grease containing sludge is a common problem which is not satisfactorily resolved. Although the mechanism of biological flocculation is not understood, bacterial attachment to the surface of the grease particles and partial degradation of the detergent is believed to be responsible. A similar treatment process might work for other wastes with emulsified, dispersed or suspended pollutants.

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REFERENCES


