An assessment of the efficiency of a constructed wetland in treating high strength winery wastewater

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Introduction

As the wine industry expands and attracts tighter scrutiny from regulators, many wineries are not finding conventional pond or lagoon systems sufficient to meet waste discharge requirements and limits. In addition, insufficient treatment of wastewater used for irrigation purposes can cause degradation in the quality of grapes produced and in groundwater quality. Wineries have reacted to these problems by upgrading their pond systems or, in a few cases, adding bioreactors or treatment wetland systems to their treatment processes. In this study, the performance of a constructed wetland in treating winery wastewater from a medium-sized winery was investigated using ecotoxicological approaches.

Methodology

• The wetland selected for this study was a constructed wetland at the medium sized winery with annual crush of 10,000 tonnes grapes/year.
• The winery wastewater flow into the wetland system was highly variable with maximum flows in the vintage season (1500-1800 KL/month, Table 1).
• Solids were removed from the winery wastewater by treatment with polymer before it entered the first cell of the wetland. After passing through a series of four cells the wastewater was stored in a dam. The polished water from the dam was then used for irrigation purposes.

Sampling regime

Sampling was conducted once a month from December 2002 until June 2004. The sampling involved collection of water samples from the four wetland cells and the dam. Each sampling period involved the following three components:

1. Chemical characterisation of water from a series of wetland cells
2. Toxicity of water from a series of wetland cells (p1-p4) to water flea, Ceriodaphnia dubia and In-situ midge toxicity
3. Macroinvertebrate sampling and data analyses

Results

1. Chemical characterisation of water from a series of wetland cells
• Winery wastewater quality was significantly improved during its residence time in the different cells of the wetland system (Table 1).
• pH significantly increased from being as low 5.5 in cell 1 to 6 - 8.5 in the dam. Similarly, the dissolved oxygen of water in cell 4 of wetland increased to 5-7 mg/L while it was as low as 0.5 mg/L in the first cell of the wetland system.
• Total organic carbon content was lower in the dam (50 – 150 mg/L) in comparison to that of cell 1 of the wetland system (300 – 900 mg/L, Table 2).

2. Toxicity of water from a series of wetland cells (p1-p4) to water flea, Ceriodaphnia dubia and In-situ midge toxicity
• 48-hour acute bioassays with C. dubia were performed according to USEPA (1993).
• In situ studies were conducted in 2003-2004 by placing midges (in cages) in the different ponds of the wetland. Every month survival after 24 h exposure was monitored.

3. Macroinvertebrate diversity
• To obtain data on macroinvertebrate abundance and diversity, quantitative samples were taken using a hand-held D framed dip net on a monthly basis.
• Analysis of Diversity Data was based on the Shannon Index (Shannon and Weaver 1949).

Conclusions

• The wetland tested in this study was found to be highly impacted during the vintage season but showed significant recovery in the non-vintage season.
• All Ceriodaphnia survival was observed in cells 2, 3 and 4 of the wetland during the post-vintage season (Figure 1).
• During the vintage season, only 0-10% midge survived in all the wetland cells (Figure 2). In the non-vintage season, the wetland system recovered significantly, with 40-60% survival in the first cell and 70-100% survival in cells 2, 3 and 4 (Figure 2).
• The wetland system recovered during the post-vintage and non-vintage seasons with higher species diversity in all wetland cells (Figure 3).

Table 1. Winery wastewater flows into the wetland system

<table>
<thead>
<tr>
<th>Season</th>
<th>Winery wastewater flow (KL/month)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vintage</td>
<td>1500 - 1800</td>
</tr>
<tr>
<td>Post-vintage</td>
<td>1200 - 1400</td>
</tr>
<tr>
<td>Non-vintage</td>
<td>455 - 650</td>
</tr>
<tr>
<td>Total</td>
<td>11,000</td>
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</tbody>
</table>

Table 2. Winery wastewater quality improvement through the wetland system

<table>
<thead>
<tr>
<th>Water quality</th>
<th>Inflow WW</th>
<th>Pond 1</th>
<th>Pond 2</th>
<th>Pond 3</th>
<th>Pond 4</th>
<th>Dam</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>5.5</td>
<td>6.8</td>
<td>8.5</td>
<td>6.8</td>
<td>8.5</td>
<td></td>
</tr>
<tr>
<td>EC (µS/cm)</td>
<td>2220</td>
<td>1980</td>
<td>1700</td>
<td>1700</td>
<td>1700</td>
<td></td>
</tr>
<tr>
<td>BOD (mg/L)</td>
<td>3700</td>
<td>14</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>TSS (mg/L)</td>
<td>670</td>
<td>62</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Potassium (mg/L)</td>
<td>481</td>
<td>261</td>
<td>109</td>
<td>109</td>
<td>109</td>
<td></td>
</tr>
<tr>
<td>SAR</td>
<td>4.5</td>
<td>4.7</td>
<td>4.0</td>
<td>4.0</td>
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<td></td>
</tr>
<tr>
<td>TOC (mg/L)</td>
<td>2400</td>
<td>945</td>
<td>77</td>
<td>77</td>
<td>77</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1. Ceriodaphnia dubia toxicity in the wetland cells

Figure 2. In-situ midge toxicity in the wetland cells

Figure 3. Macroinvertebrate diversity in the wetland cells