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

- Physicochemical characteristics of wastewater such as pH, BOD (Biological Oxygen Demand), COD (Chemical Oxygen Demand), TOC (Total Organic Carbon), salinity, (EC) electrical conductivity, nutrients, heavy metal contaminants, (SAR) Sodium Adsorption Ratio and (TSS) total suspended solids were analysed following standard wastewater analyses methods (APHA/AFFA, 1995).

2. Toxicity of water from a series of wetland cells (p1-p4) to waterflea, 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 sampling and data analyses

- 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).

Table 1. Winery wastewater flows into the wetland system

Season	Winery wastewater flow (kL/month)
Vintage	1500 - 1800
Post-vintage	1200 - 1400
Non-vintage	450 - 650
Total	12,800

Table 2. Winery wastewater quality improvement through the wetland system

Water quality	Inflow WW	Pond 4	Dam
pH	5.5	6.8	8.5
EC (µS/cm)	2220	1980	1700
BOD (mg/L)	3700	14	6
TSS (mg/L)	670	62	21
Potassium (mg/L)	481	201	109
SAR	4.5	4.7	4.0
TOC (mg/L)	2400	945	77

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 2).
- 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 waterflea, Ceriodaphnia and In-situ midge toxicity

- The wetland tested in this study was highly impacted during the vintage season but showed significant recovery in the non-vintage season.
- 100% *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).

3. Macroinvertebrate diversity

- The wetland system recovered during the post-vintage and non-vintage seasons with higher species diversity in all wetland cells (Figure 3).
- Cells 1 and 2 were of the wetland system were highly impacted during the vintage season, as macroinvertebrates were absent from these two cells (Figure 3).

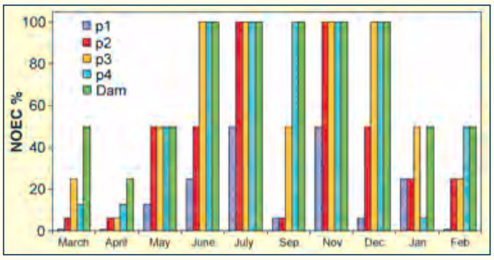

Figure 1. *Ceriodaphnia dubia* toxicity in the wetland cells

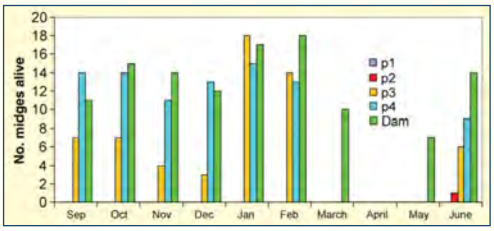

Figure 2. *In-situ* midge toxicity in the wetland cells

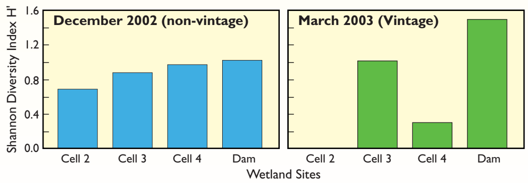

Figure 3. Macroinvertebrate diversity in the wetland cells

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.
- In general, the species diversity was low at this treatment wetland system in comparison to any natural wetland system. However, this wetland system was able to improve winery wastewater quality in the dam making it suitable for irrigation purposes.

As the wine industry continues to expand in Australia, treatment wetlands provide a low-energy, low maintenance, aesthetically pleasing advanced wastewater treatment option for wineries. Wetland systems adapt well to the wastewater fluctuations of wineries Removal of solids from winery wastewater entering wetland ponds, pH adjustment and aeration of first pond are important management strategies for wetland systems receiving winery wastewater.

Poster design and production by Greg Rinder
Arris Pty Ltd (www.arris.com.au), Adelaide, South Australia - July 2007