Impacts of winery wastewater reuse on soil health

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Introduction

Land application is the main method of waste disposal currently used for many organic wastes. This is a major agricultural research priority in order to maintain sustainability of production systems and environmental quality. The organic residues in the winery waste may stimulate microbial activities and the possible use of wastewater for irrigation may help to cut down the use of nitrogen and phosphorus based fertilisers. However, repeated application of winery wastewater could result in long-term effects on soil properties and soil dwelling organisms. The main aim of this study was to assess the changes/impacts due to long-term application of saline winery wastewater at selected sites in the Barossa and McLaren Vale regions.

Methodology

- In order to investigate the impact of winery wastewater on soil status in terms of microbial health and general soil properties (e.g. physico-chemical characteristics), surveys were undertaken from several sites. Site details are given in Table 1.
- The following soil physico-chemical characteristics parameters were measured: TOC, EC (dS/m), Calcium, Magnesium, Sodium (mg/kg; 1:5 soil:water for the determination of Sodium Adsorption Ratio (SAR)), pH (pH units; 1:5 soil:water), Total available phosphorous (mg/kg; Bicarbonate extraction method), Potassium (mg/kg; Bicarbonate extraction method), Total Kjeldahl nitrogen (mg/kg).
- Soil microbial assays conducted under this study are provided in Table 2.

Table 1. Sites selected for the soil health monitoring

Land use	Sites with winery wastewater application	Period of winery wastewater irrigation
Vineyard	1. MV 2. TH 3. TB	4-6 years
Woodlot	1. Woodlot Y 2. Woodlot F	8 years 10 years
Pasture	1. Wildlife reserve 2. Irrigated pasture Y 3. Long-term irrigated pasture	15 years 20 years More than 100 years

Results

- Higher organic carbon content of the winery wastewater resulted in increased total organic carbon content in the soils irrigated with winery wastewater.
- Woodlots soils irrigated with winery wastewater exhibited increased SIR in comparison to the control woodlot soils (Figure 1). Nitrification (conversion of NH_4^+ in NO_3^-, the major source of nitrogen for plants) followed the same trend.
- Microbial enzyme analyses also confirmed that the winery wastewater irrigation of soils was not adversely impacting the microbial activity of soils (Figures 2 and 3).
- Salinity, sodicity and available potassium in soils, were noted to be elevated in the wastewater treated plots, especially woodlot and pasture sites, in comparison with the control plots (Figure 4, Table 3).

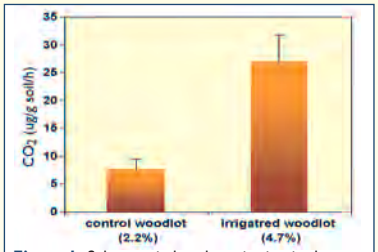

Figure 1. Substrate induced respiration in the woodlot soils irrigated with winery wastewater. *(Figures in parenthesis represent TOC)*

Table 2. Physico-chemical properties of control and winery wastewater irrigated soils from a woodlot and two pastures and vineyards

Indicator	Significance
Substrate Induced Respiration (SIR)	This is a measure of the organic carbon mineralisation after the addition of glucose (organic substrate) to the soil. This is a potential metabolic activity and can also be used to quantify the pool of active micro-organisms in soils. Therefore it is an assessment of overall microbial activity in soils.
Substrate Induced Nitrification (SIN)	This is another potential metabolic activity, but concerning nitrification this time (and not carbon mineralisation unlike SIR). Nitrification being the transformation of NH4+ into NO3-. Sometimes while the overall activity is not affected the specialists such as nitrifiers are affected.
Acid Phosphatase	Is the measure of phosphorus cycling in the soil by enzymes released by plant root systems.
Alkaline Phosphatase	Measures the phosphorus cycling in the soil by micro organisms.
B Glucosidase	Measures the carbon cycling in the soil by micro organisms.
Chitinase	Looks at the fungal activity in the soil. Nutrient cycling is slower by fungal enzymes as they tend to attack more complex organic compounds.

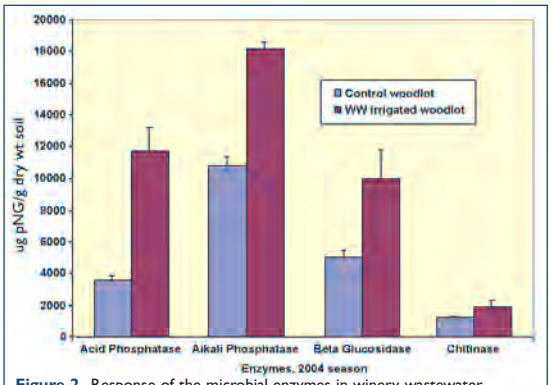

Figure 2. Response of the microbial enzymes in winery wastewater irrigated woodlot soils

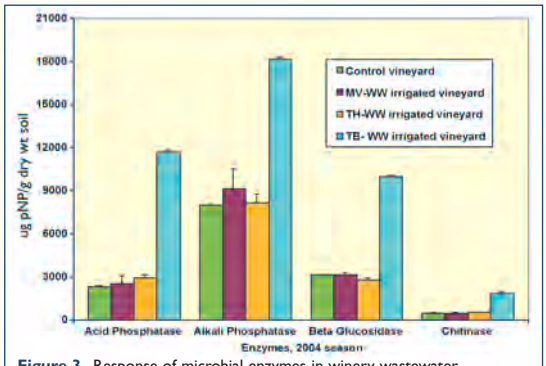

Figure 3. Response of microbial enzymes in winery wastewater irrigated vineyard soils

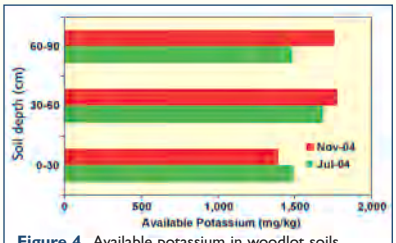

Figure 4. Available potassium in woodlot soils irrigated with winery wastewater

Conclusions

Soil microbiological activity was not adversely affected in the wastewater treated plots. Greater microbial activity was observed in wastewater treated plots, most likely due to the build up of organic carbon content. However, indirect effects due to excessive water application leading to prolonged waterlogging conditions and structural decline were not tested. Currently, very little information exists on the loads of salts that different soil types can tolerate before ecological effects could be observed. Therefore, information on the tolerance of different soil types to winery wastewater in terms of adverse soil biological functions and/or soil chemistry parameters is urgently required.

Table 3. Physico-chemical properties of control and winery wastewater irrigated soils from a woodlot and two pastures and vineyards

Site	Winery wastewater volume applied (mm/annum)	Wastewater application History (years)	EC (µS/cm)	pH	Organic Carbon (%)	SAR
Vineyard control	-	-	295	7.3	1.4	5.1
Irrigated vineyard (2)	285	6	895	7.7	2.2	9.6
Control woodlot	-	-	350	7.5	1.4	3.8
Irrigated woodlot	485	9	1700	8.2	4.8	12.9
Control pasture	-	0	190	6.8	1.1	3.7
Irrigated pasture (3)	0.2	100	550	7.7	4.2	4.6

Acknowledgements
South Australian wineries for participating in this project. CSIRO and GWRDC for funding this project.

Australian Government
Grape and Wine Research and Development Corporation


Winery wastewater irrigated Wildlife reserve


Soil sampling at vineyard study site


Sampling at vineyard study site


Irrigated woodlot

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