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The Rupert & Rothschild estate on the Franschhoek wine route was the first to implement the UASB treatment technology.

A project funded by the Water Research Commission has successfully adapted UASB technology to the treatment of winery wastewater. Sue Matthews reports.

South Africa's wine industry has grown phenomenally over the last decade, mainly because the end of apartheid allowed access to international markets, but also due to a worldwide increase in wine consumption. At the same time, local winemakers have had to take heed of tighter legislative controls on environmental impacts, and a rise in consumer demand for 'enviro-friendly' products.

While farming of any kind has a range of effects on the natural environment, at the cellar level it is wastewater that poses the most environmental risk. Large quantities of wastewater are generated during the wine-making process, particularly around harvest time, when grapes are crushed and the juice fermented. Since this water generally has a high organic content, is acidic, and contains both suspended and dissolved solids, it does not meet the stringent criteria set by the Department of Water Affairs & Forestry (DWAF) for disposal in a natural water resource.

Most wineries therefore dispose of their wastewater by spraying it onto land. However, even this practice must be authorised by DWAF, and is subject to restrictions. For a start, it is not permitted where the sole aim is wastewater disposal, but only where it is beneficial in terms of crop irrigation. Given that kikuyu grass is considered a crop, a few horses or cows can be seen feasting on lush pastures on most of the Cape's wine farms, while wine-tasting centres are typically surrounded by flawless green lawns.

Irrigating with massive quantities of highly polluted wastewater could result in soil degradation and groundwater contamination though, so DWAF has also set limits on the quantity and quality of wastewater that can be used for irrigation, published as General Authorisations in terms of the National Water Act in March 2004. Although limits have been defined for a number of water quality parameters (Table 1), it is the COD value that most obviously affects the quantity of wastewater that may be irrigated on any given day.

The COD – or Chemical Oxygen Demand – is a measure of the total organic content of the wastewater, expressed as the amount of oxygen required to bring about its destruction through oxidation. The General Authorisations stipulate that up to 500 m^3 of wastewater may be irrigated per day if the COD is less than 400 mg/ℓ, but only 50 m^3 per day if the COD exceeds this. Wastewater with a COD above 5000 mg/ℓ may not be used for irrigation, and must instead be disposed of at a municipal wastewater treatment works.

However, two audits conducted during the last few years have shown

that the average COD of wastewater from South African wineries is in the 7 000 – 9 000 mg/ℓ range, although values as high as 70 000 mg/ℓ were recorded at one winery. Some kind of pre-treatment of wastewater is therefore necessary if wineries want to avoid paying the stiff charges imposed for disposal at municipal facilities, and irrigate within the legal limits.

In 2002, the WRC began funding a project that investigated the potential of treating winery wastewater using combined UASB and ozonation processes. The project was led by the Food Science Department at the University of Stellenbosch, and the resulting technology has now been implemented at the Rupert & Rothschild winery in Franschhoek. Last year an information session was held at the wine farm to demonstrate the technology to interested parties.

"UASB stands for Upflow Anaerobic Sludge Blanket," explained Prof Trevor Britz to a large group that included winery managers, consultants and environmental staff from local authorities and DWAF. "It was originally designed in the 1960s by Dr Bill Ross, a South African, but was patented by the Dutch. Worldwide, there are now more than 3 000 full-scale UASB plants for treatment of industrial effluents, but most have operational volumes of 100 000 to 10 million litres – very few operate on less than 50 000 ℓ."

UASB technology relies on anaerobic digestion, a biological process in which organic matter is converted in the absence of air to methane and carbon dioxide. The process involves a synergistic relationship between four different trophic groups of bacteria, namely hydrolytic, fermentative acidogenic, acetogenic and methanogenic. The bacteria cluster into granules, which settle out to form a dense bed of sludge that is retained in the system. This is a distinct advantage over aerobic systems, which produce masses of surplus sludge that must be disposed of.

TABLE 1
LEGISLATED LIMITS FOR IRRIGATION WITH WASTEWATER

Parameter	< 50 m³/day	< 500 m³/day	< 2000 m³/day
COD [a]	5 000 mg/l	400 mg/l	75 mg/l
Faecal coliforms	1 000 000 per 100 ml	100 000 per 100 ml	1 000 per 100 ml
pH	6 - 9	6 – 9	5.5 – 9.5
EC [b]	200 mS/m²	200 mS/m²	70 – 150 mS/m²
SAR [c]	< 5	< 5	Other criteria apply

[a] Chemical Oxygen Demand (COD) is the amount of oxygen required to oxidise all organic constituents in water to inorganic end products.

[b] Electrical Conductivity estimates the amount of total dissolved salts (TDS), or the total amount of dissolved ions, in the water.

[c] Sodium Adsorption Ratio (SAR), the concentration of sodium relative to calcium and magnesium, is an indicator of the sodium hazard of irrigation water.

On the down side, nutrient removal is not feasible in anaerobic systems – although winery wastewater is in any case low in nutrients – and trained staff are needed to operate them.

Anaerobic digestion is often limited by the presence of refractory and toxic compounds in wastewater, but ozone helps counter this effect. Pre-ozonation has been shown to enhance the biodegradability of organic matter by converting these compounds into simpler molecules, while post-ozonation may be used as a 'polishing' step. The project team therefore set out to investigate the efficiency of using various ozonation scenarios with UASB technology for optimal treatment of winery wastewater.

They began with a laboratory study, and later scaled up the combined treatment process in a 600 litre mobile unit, which was tested at the Bergkelder winery in Stellenbosch. Here the raw winery wastewater had an average COD of 5 370 mg/ℓ, and UASB treatment alone was able to reduce this by 77-81%. Adding a pre-ozonation step increased the reduction efficiency to 92%, bringing the

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WRC Research Manager Gerhard Offringa and the bio-active filter.

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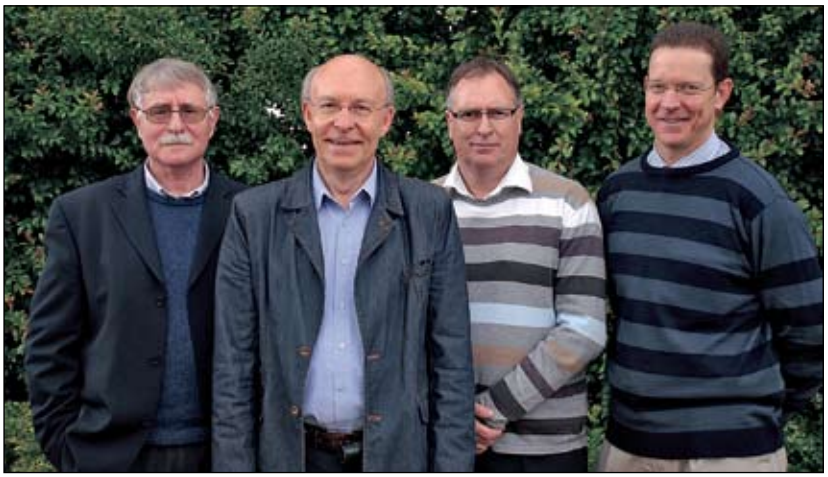
Delegates at the information session view the treatment plant.



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Trevor Britz, Gerhard Offringa, Neels Barnardt and Gunnar Sigge presented the treatment technology at the information session.

COD value down to 455 mg/ℓ. Post-ozonation was found not to be as effective as pre-ozonation, and even adding it as a final polishing step only increased the reduction efficiency by another 1%.

"Importantly, though, this little bit extra was enough to reduce the COD to 377 mg/ℓ," said Dr Gunnar Sigge, during his presentation at the information session. "That brought it below the legal limit of 400 mg/ℓ for irrigation of 500 m^3 of wastewater per day."

The WRC project came to an end at that point, but the story doesn't stop there. Dr Neels Barnardt, an environmental consultant working with the Rupert & Rothschild winery to help reduce their 'footprint', was keen to put the technology to the test. The winery had already become the first in South Africa to achieve ISO14001 environmental management certification, and improved wastewater control had been identified as a future target. Under the project team's direction, a 14 000 ℓ full-scale treatment plant was therefore constructed at the winery and housed in a dedicated building, at a total cost of R270 000. Named the bio-active filter, it consists of four tanks driven by four recirculation pumps, with a diesel-driven boiler to maintain the temperature above 20°C. The plant processes up to 25 000 ℓ/day of wastewater, incurring running costs of about R1 500/month.

While the COD of the winery's raw wastewater varies between 3 000 and 6 500 mg/ℓ depending on the season, that of the treated effluent is now well below 1000 mg/ℓ throughout the year, and often below the holy grail of 400 mg/ℓ.

"The fact that the COD is not maintained below 400 mg/ℓ can be attributed to the manual operation," noted Dr Barnardt. "This system requires that somebody checks the flow regularly and adds lime on a daily basis to control the pH. We have since installed a duplicate, but fully automated, system at the La Motte winery, and the COD stays at around 250 mg/ℓ all year round, which tells me that the technology is fully capable of achieving the 400 mg/ℓ goal."

Dr Barnardt also stressed the importance of good cellar practices, such as reducing water consumption – and hence the volume of wastewater produced – and separating out solids as soon as possible to keep the COD low. He noted that Rupert & Rothschild had reduced water consumption to four litres of water per litre of wine produced, compared to the industry average of 6,5:1, and had replaced all the conventional drains in the cellar with wedge wire ones to prevent solids from entering the wastewater stream.

WRC Research Manager, Dr Gerhard Offringa, who oversaw the project and chaired its steering committee, expressed his delight at the success of the project. "The project team did the fundamental research in the lab, transferred it to a pilot plant, evaluated it, then built a full-scale plant," he said. "They went from innovative idea to implementation in five years, which is very impressive."

Hopefully, other wineries will harvest the fruits of their labour and implement the technology, helping to ensure that the red and white wine we drink is just a little more 'green'.