Winery wastewater treatment and attaining sustainability

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There is no panacea for treating winery wastewater and the choices for treatment are site specific. Mitch takes readers through the various options and considerations.

INTRODUCTION

The management of winery wastewater is important to both business and environmental performance aspects of the wine industry, impacting on the sustainability of the facility. An appropriate approach to wastewater will potentially involve cleaner production, and re-use of properly treated effluent. Suitable wastewater treatment (i.e., treating winery wastewater to the standard required for discharge or recycling) will improve water use efficiency and reduce the risk of environmental impact (GWRDC 2014).

Water cycle management at wineries should be close to the heart of all good vignerons, although many wineries struggle with managing water usage and dealing with wastewater that can be quite difficult to treat.

WASTEWATER CHARACTERISATION

Winery wastewater is generated from cleaning and washing operations during crushing and pressing of grapes, rinsing of tanks, barrel washing, bottling, residuals drainage, clean-in-place operations, filter washing, etc. Waste streams are extremely variable in volume and quality (with peak flows and contaminant concentrations occurring during vintage - typically over 80% of the annual wastewater is produced during this time). This, coupled with stretched budgets and resources, means that choosing and maintaining a treatment system can present daunting tasks.

Wastewater characteristics will dictate, to a large extent, the type of treatment system required.

WASTEWATER TREATMENT

Because environmental issues are such a critical factor in industry competitiveness, the optimisation of wastewater treatment and robust choice of processes in order to reduce impacts and save energy becomes important. As indicated by the high biochemical oxygen demand (BOD) (see Table 1), winery wastewater is highly biodegradable (due to the high concentration of ethanol or sugars) (Andreottola *et al.* 2014). Consequently treatment should typically involve biological processes. However, there are several broad options for treatment of winery wastewater, including:

- physical/chemical processes (e.g., screening, settling tanks, filtration, pH correction)
- mechanically based biological processes (activated sludge, trickling filtration, etc.)
- lagoons and natural systems (biological processes, including anaerobic and aerobic ponds, and wetlands).

The favoured treatment system is largely dependent on site-specific factors, including:

- wastewater characteristics
- effluent quality requirements (i.e., what the effluent is used for, which dictates how clean the effluent needs to be based on regulatory guidelines)
- space availability including buffer requirements (lagoons can involve a footprint some 30+ times greater than mechanical systems)
- budget – capital and annual (lagoon systems generally represent significantly lower costs than mechanical systems and are simpler to operate)
- technical capability – treatment systems require checking and maintenance, although different treatment systems have different operational requirements.

Table 1. Winery wastewater characteristics - vintage vs. non-vintage.

Parameter	Vintage period	Non-vintage period
BOD, mg/L	2500 – 7000	800 – 1500
pH	4 - 8	6 - 10
Suspended solids, mg/L	500 - 1500	200 - 800
Nitrogen, mg/L	20 – 75	5 – 25
Total phosphorus, mg/L	10 - 20	5 - 10

(Laginestra 2012)

Figure 1. Lagoon treatment – consider boosting aeration during vintage.

Table 2. Typically adopted winery wastewater treatment.

Type of winery	Small with limited land availability	Medium – with land availability	Large winery
Type of treatment	Physical system or proprietary biological coupled with filtration	Lagoon system, with aerobic and polishing ponds in series being most common	Mechanical treatment methods for biological treatment and reuse
Aspects for treatment	Can be complex, small space and tucked away, often leads to out of mind mentality when it comes to operations	Lagoons, while forgiving can cause odours particularly during vintage. May suffer from excess algae	Mechanical systems need to be well operated and maintained to optimise performance and mitigate odour issues

Biologically-treated effluents are typically suitable for irrigation (which is the most common form of treated effluent disposal). Filtration downstream of the biological process will further reduce contaminants (mainly aimed at suspended solids) and potentially enables a wider use for the effluent (cleaning of non-wine production areas and washdown).

It should be noted there is no panacea for winery wastewater treatment, and choice is site specific. Wineries are often located in rural locations, with space, and consequently lagoon treatment systems are common, followed by irrigation of effluent on vineyards. This is not always the case, and there are many mechanical systems that are generally perceived as easier to implement with minimal footprint. In general, however, systems with a small footprint (higher applied load) have a higher level of complexity. In reality, there are many cases where both types of systems do not perform, or minimal treatment is practised, and poor quality wastewater irrigated, which presents an environmental risk (e.g., soil degradation, surface run-off) ultimately leading to a future cost risk to the winery.

While lagoon systems are very forgiving, and can handle hydraulic variations, the vintage period presents greater contaminant loading, and unless additional treatment is introduced, then effluent quality can deteriorate, resulting in odour generation. Overcoming this issue might involve installation of additional mechanical aeration units at the onset and throughout the vintage period (Figure 1).

For mechanical systems, it is important to design for vintage BOD (by providing additional aeration). However, hydraulic variation can be an issue and flow balancing is important (often combined with pH correction, as the biomass in mechanical systems is sensitive).

A comparison of typically adopted systems based on winery size is outlined in Table 2 (note that there are economies of scale).

While there are number of new technologies available in the wastewater industry (in most cases new intensive process - Bassett *et al.* 2014, Gunderson 2015) these will need to be proven specifically for the winery industry and cost and subsequent viability for wineries is considered dubious.

A viable alternative to provision of additional aeration during vintage might include implementation of an anaerobic system (degradation of organic matter in the absence of oxygen – involving longer detention times and deeper lagoons >4m). Anaerobic lagoons are rare at wineries because of the vintage/non-vintage period (and subsequent mismatch in loading, as well as potential for odours and perceived expense of control and installation of the lagoon, which requires much longer detention). Covering of anaerobic lagoons is becoming more common place in other industries, typically for control of odours and collection of methane gas for power generation (Figure 2). This, then, provides an opportunity to obtain a beneficial by-product – methane rich

Figure 2. A covered anaerobic lagoon can potentially be used to generate electricity from gas while providing treatment during vintage.

biogas that can be used to generate electricity at the winery. Anaerobic ponds are designed to cater for high organic loading, so are suitable for wineries during vintage. Anaerobic systems can lie dormant for long periods of time (non-vintage) but could also be used to cater for residuals from wastewater treatment (aerobic stage) or even external waste streams. If electrical or thermal energy was regarded as beneficial, supplementary organic waste such as manures during the projected high BOD shortfall (non-vintage period), might be considered. However, if no electricity generation is required, covering of the system and flaring of biogas could be adopted (during vintage), and non-vintage wastewater could bypass the anaerobic pond (occasional desludging of solids from the aerobic pond would be fed to the anaerobic system).

RESIDUALS MANAGEMENT

All wastewater treatment systems produce sludge, which is the result of settlement and organic matter degradation in the biological processes, and must be removed to enable optimal operation of the treatment plant. While lagoons might require desludging only every few years, mechanical systems produce more sludge because of energy input and biomass reproduction rate and so require frequent purging of excess sludge (daily to weekly).

Residuals generated from wine production (marc and lees) present another issue, and unless dealt with within a short period of time can result in odours. Land spreading is typically employed for disposal, but there are limitations and organic loading of land can be an issue. However, they are biodegradable and, consequently, there is an opportunity to stabilise via an anaerobic system (same as that used for wastewater). Products of anaerobic digestion (sludge) contain nutrients and good organic material that might be beneficially used to improve soil characteristics.

SUSTAINABLE OPERATIONS

Today, it is common in industry to seek sustainable solutions for all activities. Whilst there are a number of definitions, sustainability is generally achieving appropriate environmental, economic and social outcomes. There is perhaps a perception that the term 'sustainability' is overused, although I don't agree. It does mean different things to different people, such as:

- implementing development that meets present needs without compromising those of future generations
- achieving the best outcomes for users using least resources
- use of raw resources that are regenerable
- recycling and use of recycled materials
- waste to energy and reduced power consumption.

So for wineries, sustainable practices might include reduction in use of fertilisers insecticides/fungicides and targeted irrigation (drip), which have been demonstrated in Australia and the USA (Daily News, Quackenbush 2015). Financial sustainability presents another concept, although could be related, through incorporating reduced environmental impact while strengthening a winery's commercial position. An example could be regarded as treatment of winery wastewater and effluent irrigation which provides greater water supply security for the vineyard. Additional aspects would include energy generation from waste, and beneficial use of residuals by-products from treatment systems and avoiding potential soil deterioration.

Consequently, there are broad opportunities to achieve largely sustainable operations at wineries through (see Figure 3):

- treatment of wastewater to produce an effluent quality for irrigation (making use of the wastewater, optimising the treatment plant operation and regarding it as a resource)
- application of residuals by-product for compost production to provide a beneficial organic resource which may be used to improve soil qualities
- re-use of treated winery wastewater beyond irrigation of vineyards or woodlots, with other potential uses of the reclaimed water including washing of concrete areas, service water for heating and cooling and landscape irrigation.

Suitable practices to ensure ongoing vineyard sustainability might include:

- monitoring (soil chemistry, salinity, crop yields) and working out nutrient budgets
- irrigation and soil management practices (incorporating additives required and nutrients/fertilisers added as well as those stemming from recycled water (GWRDC 2014).

CONCLUSIONS

There is no panacea for winery wastewater treatment. There are a range of aspects to consider and this should be developed

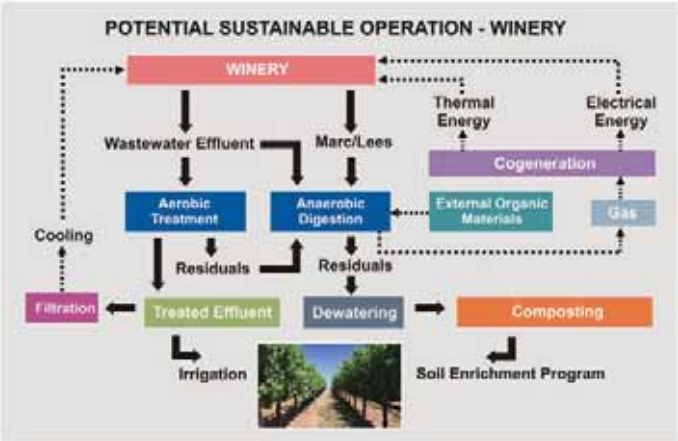

Figure 3. Sustainability concept for winery wastewater treatment.

on a site-specific basis. Treatment of winery wastewater can be difficult over vintage due to seasonal flow and contaminant increases. Lagoons are cheaper and simpler to build and operate compared with mechanical wastewater treatment systems. However, there are limitations, including lower standard of effluent, algal blooms impacting on effluent quality and neglect in desludging (also impacting on effluent quality). Whilst lagoon systems are very forgiving, the vintage presents much greater loading, and unless additional mechanical aeration capacity is introduced, then effluent quality can deteriorate. Anaerobic systems provide additional opportunities (upstream of aerobic).

While wastewater treatment involves a cost, there is a satisfaction from treating the effluent to a standard that allows re-use and there is a payback from ensuring the correct standard of effluent is achieved to prevent deterioration in soil characteristics. If anaerobic systems are utilised, gas generation and utilisation provides energy (thermal and electrical). In addition, waste sludge from the treatment processes could be combined, after dewatering, with marc lees and composted, which could provide a soil conditioning agent. All these components contribute to the sustainability of the winery.

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Wine Australia Resource Kit: Winery Wastewater Management & Recycling – Key Principles for Vineyards (http://research.wineaustralia.com/tools-resources/winery-waste-water-online-resource-kit/)

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