



## WINERY WASTEWATER

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***Learning Outcomes:*** *The increased tension between urban, agricultural, and environmental water use highlights the need for wineries to be on the forefront in water conservation. This review highlights winery wastewater sources and composition, conservation, and treatment.*

### Chapter Outline

- Winery Water and Wastewater**
- Winery Wastewater Treatment Systems**
- Winery Wastewater Components**
- Rinse Water Options and Annual Flow Rates**
- Cleaning Agents and Waste Minimization**
- Wastewater Reuse**

### Section 1.

#### **Winery Water and Wastewater**

In some regions of the world, water seems to be a limitless commodity, while in other regions, it is just the opposite. As our industry continues to present itself as sustainably-oriented, we must continue efforts to understand how to wisely use this precious resource.

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The word *sustainable* became common vernacular in the wine industry years ago. Never fully defined, it meant different things to different people, which was likely part of its initial appeal. It added a virtuous green dimension, which often represented some nebulous combination of ecology and the environment. For those in the wine industry, it usually meant some professed emphasis on energy, water, chemical, and/or packaging management.

For wineries to truly understand sustainable features, they need an energy/water/materials and chemical HACCP plan (see the module on Hazard Analysis and Critical Control Points). This plan must involve active audits, quantification, and metrics. Without metrics, there is no way of knowing the true nature of the winery's energy footprint, or the ability to compare one operation against another.

### Water Use Auditing

Water limits are a crisis in many areas, and they are expected to be exacerbated by global climate change. California's urban population consumes 21% of the state's water, while agriculture uses 79%. While a water crisis is looming in California, other regions of the country must also consider the use of this valuable resource. Regardless of the region, water has both an on-site and embedded energy cost that includes municipal water treatment, conveyance, and pumping.

It has been estimated that 16 – 20 L of effluent may be generated for every ton of fruit crushed (Smith, 2002). Older wineries generate more water, with modern facilities generating 7 – 10 L of wastewater per ton of fruit (Smith, 2002).

Any comparison of energy and water use must be made with an understanding of surface area and volume (Boulton, 2010; Michael et al., 2009). For example, a

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large winery will use less energy and water on a per-surface area or per-liter basis, compared to a small winery, simply as a function of size, not necessarily operational efficiency. As such, energy and water utilization must be scaled.

Industry members should establish benchmarks for comparative purposes and for evaluation matrices (Michael et al., 2009). For comparative purposes, the important feature is water use per volume of product produced. Only with scaling is it possible to compare one facility to another.

Currently, a significant effort is being undertaken to explore the principles and practices for water recovery and reuse, including clean in place (CIP), green solutions, storage and solution recovery, reverse osmosis (RO) and nanofiltration, rain water harvesting, capture and reuse water systems, high pressure water, and pigging transfer lines (Muhlack, 2008).

### **Winery Wastewater Treatment Systems**

Winery wastewater treatment systems vary from the simple and direct discharge to septic tanks, to more complex, capital-intensive systems, such as aeration ponds and aerobic digesters (Hamoudi-Viaud et al., 2004).

Winery process water management systems should have features of cost effectiveness, reliability, and ease of management and, optimally, should be reasonably compact. Controlling the amount and quality of process water results in realizing operational and capital savings, reducing water and chemical usage, reducing the amount of organic solids going down the drain and, optimally, a reduction in operational costs. Next to simple discharge into septic systems, aerobic treatment systems are the most common.

### Aerobic Treatment Systems

A typical, traditional winery aerobic treatment system includes the following (Hamoudi-Viaud et al., 2004; Szymanski et al., 2007):

- collection of wastewater in the winery, or its connection to the collective system
- sedimentation facility for collected wastewater
- screening of wastewater
- transfer of wastewater into an aeration basin
- sand filtration of treated wastewater
- monitoring of treated wastewater in a flow chamber before release into the environment
- recovery and spreading of sludge

The industry is looking at wastewater treatment systems that will allow the elimination of high energy and land-intensive aeration ponds, and a reduction in the required storage volume. These have included wetlands. Aerobic systems are often characterized by the following (adapted from Szymanski et al., 2007):

- wastewater evaporation ponds, leading to ever-increasing storage requirements, and limited land available for such purposes
- high salinity levels in the earthen evaporation basins and limited options for disposing of saline evaporite
- odor
- substantial freshwater use
- substantial costs and energy usage
- threats to sustainability in taking effluent from the system

Modern improvements in wastewater systems have occurred. Some have involved new or improved systems, such as distillation (Pregler, 2009), and

others simply operational changes, including the following:

- stabilization of wastewaters by basic pH manipulation
- reduction or removal of sodium
- improvement in water use efficiency in the winery
- reuse of wastewater and maximizing nutrient removal through irrigation of cropland

### *Aerobic Digesters and Dissolved Air Flotation Systems (DAF)*

Dissolved air flotation systems are, or will become, a popular method of choice for treating winery wastewater. Such systems inject micron-size air bubbles into the flow from the bottom of a reaction vessel. Buoyancy lifts the air and materials, which are removed from the surface for disposal. Subsequently, the unit functions as a bio-digester (Johansen, 2003, 2004).

The system first screens the incoming influent (5-7 mm), followed by the removal of solids (TSS, total suspended solids), which reduces the load on the reactors. The “sludge” coming from a DAF unit goes into a series of aerated digester tanks.

DAF units contain materials (plastics, wood, etc.) to increase the surface area and, therefore, the bio-mass within the reactors, which allows for relatively small reactors. The final effluent leaving the system can range around 10-20 mg/L TSS. After the digestion period, the sludge can be used in composting operations.

## **Winery Wastewater Components**

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Winery wastewater contains inorganic salts, organic compounds, yeast, and bacteria. The components that should be evaluated include the following (adapted from Chouinard, 2009; Deans, 2003; Kumar et al., 2008; Shepherd and Grismer, 1997):

- BOD<sub>5</sub> (5-day biochemical oxygen demand): represents organic load, primarily of a soluble nature, consisting of alcohols and sugars
- domestic wastewater BOD is 200 mg/L on average; winery process wastewater BOD is 7,700 mg/L; lees could have a BOD upwards of 100,000 mg/L
- COD (chemical oxygen demand)
- pH
- total suspended solids (TSS)
- total dissolved solids (TDS): water with high TDS, and salt accumulation in the soil, adversely affects crops, and takes away from other beneficial uses; in some areas, regulatory agencies impose stringent TDS standards for effluent intended for land use
- nitrogen
- nitrate
- phosphorous
- sulfate

Pretreatment includes the following (adapted from Smith, 2002; Szymanski et al., 2007):

- Initial steps include physical and chemical treatment prior to biological treatment.
- pH adjustment is required to create favorable conditions for biological treatment operations that follow pretreatment; currently, adding aqueous ammonia is common to adjust pH of winery process wastewater.

- Sedimentation removes solids by allowing settling out of suspension; approximately 30 percent of BOD can be removed by a properly-designed pretreatment system.

The average winery loses 7% of product post-press: for every 100 liters of juice or wine that drains from the press, only 93 liters ends up on the customer's table; the rest is lost down the drain (Goss, 2006). Process water management involves a reduction in water usage, and in nutrient (wine) and salt loads in the wastewater.

Water minimization has the potential to concentrate the nutrients if the loss of product is not reduced in conjunction. The higher the BOD level, the more product has been potentially lost in the process.

Potassium and nitrogen levels in wastewater are barometers of the source of the product loss. Generally, potassium is found in wine product, and nitrogen in pomace. The higher the potassium in wastewater, the more wine product and lees is lost. The higher the nitrogen levels, the more pomace has been wasted into the drains (Goss, 2006).

**Table 1. BOD, COD, and Physical and Chemical Values of Winery Wastewater** (Chouinard, 2009)

	<b>Crush (mg/L)</b>	<b>Non-Crush (mg/L)</b>	<b>Reclaimed Water (mg/L)</b>
BOD <sub>5</sub>	500 - 12000	300 - 3500	50
COD	800 – 1500	500 – 6000	90
pH	2.5 – 9.0	3.5 – 11.00	7.9
TSS	40 – 800	10 – 400	50
TDS	80 – 2900	80 – 2900	900
Nitrogen	1 – 40	1 – 40	5.0
Nitrates	0.5 – 4.8	---	1.5
Phosphorus	1 – 10	1 – 40	5.0
Sulfate	10 – 75	20 – 75	25

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Estimated BOD, COD, and physical and chemical values of winery wastewater are shown in Table 1.

BOD load reduction means lower treatment processing costs. Every kg of BOD requires about 2 kWh of treatment energy. Five liters of lost wine means a one kW aerator needs to operate for around one hour to treat that wine loss (Goss, 2006).

A reduction of 144 tons of BOD could result in a saving of approximately \$51,840/yr in energy costs at California prices, not including water volume reduction (Goss, 2006).

Installing grates in the crush pad and pressing areas to prevent egress of skins, etc., can reduce the BOD level. The reduction in loss of product results in lower potassium levels in the wastewater. Lower salinity levels reduce salt loading, and make irrigation with wastewater more sustainable.



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### Section 2.

#### Winery Water Source Points

Water quality monitoring and conservation require an understanding of point sources, i.e., where and how water is used. Water sources and use areas include the following:

- wells
- wastewater ponds
- septic systems
- storm water
- crush operations
- press
- fermentation
- barrel washing and soaking
- cellaring
- bottling
- laboratory operations
- landscaping operations

Typical Winery Sources of BOD (adapted from Goss, 2006)

Crush pad:

- 3% of BOD load
- average BOD of 50,000 mg/L
- while only a small load on the system, the wastewater from pomace is difficult to treat

Fermentation and pressing:

- 23% of BOD load
- average BOD of 4,950 mg/L

Transporting wet pomace for pressing is an area of potential high loss. Wet, under-extracted pomace can allow wine to seep into drains and increase salt loading. Pomace that slops onto the floor and enters the drainage system carries product which could have been processed into wine. Wastewater rotary screens for a 5,000 ton winery can remove as much as 1 ton/day in skins.

Tank farm:

- 31% of BOD load
- average BOD of 3,500 mg/L

Focus should be on recovery of product and reducing spillages and dumps of wine, particularly during transfers. According to some industry estimates, on average each liter of wine is moved 10 times.

Pigging of major wine lines in and out of the tank areas can result in reduced losses. Reuse of tank cleaning chemicals can reduce salinity and water volume, and should be considered by every winery, regardless of size.

Barrels:

- 15% of BOD load

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- average BOD of 11,500 mg/L

The barrel cellar is an area of potential wine loss. Additionally, barrel lees have a very high BOD.

Juice and wine clarification:

- 15% of BOD load
- average BOD of 7,950 mg/L

Ideally, any area where DE is used should be isolated so that all DE can be collected. DE lost down the drain becomes a transfer medium into the wastewater stream.

### **Rinse Water Options and Annual Flow Rates**

Winery wastewater varies markedly in terms of its characteristics, particularly when comparing vintage and non-vintage periods.

**Table 2. Typical Annual Winery Wastewater Production** (Chouinard, 2009)

<b>Month</b>	<b>Percentage of Annual Flow</b>
January	2.5%
February	2.5%
March	5.5%
April	9.0%
May	8.5%
June	4.0%
July	4.0%
August	12.5%
September	18.5%
October	16.0%
November	12.0%
December	5.0%

Typical monthly flow distribution, as a percentage of annual flow, is shown in Table 2.

A typical small winery (5,000 cases or 11,900 gal. annual production) could have the following water usage (Table 3), according to Chouinard (2009):

**Table 3. Typical Water Usage for a Small Winery (Chouinard, 2009)**

<b>Parameter</b>	<b>Water Usage</b>
Estimated annual water use	up to 90,000 gallons
Avg. daily flow	247 gallons/day
Peak day flow (crush)	415 gallons/day
Peak day flow (non-crush)	200 gallons/day
Peak flow rate (crush)	7 gallons/minute

Seasonal changes are important, as are day-to-day and hour-to-hour changes. Variability in flow rates adds difficulty in designing biodigester-type wastewater treatment systems. As such, buffering storage has several advantages:

- Can dampen the volumetric peaks and troughs, producing greater consistency in the quality of wastewater, prior to introduction to the main treatment system.
- Provides a more uniform and continuous stream for pH adjustments.
- Provides for some pre-settling for BOD reduction.
- Allows for easier segregation of particular waste streams, and only introduces each into the main wastewater stream very late in the treatment process.
- Possible control of odor production. Low pH values and high BOD and COD in wastewater favor the production of H<sub>2</sub>S (hydrogen sulfide, which smells like rotten eggs). Raising the pH favors the production of

its non-odorous disassociation product,  $\text{HS}^-$  (the hydrosulfide ion).

The net effect of these modifications is greater consistency in the volumetric flow rate and chemical and biological characteristics of wastewater discharge.

### **Cleaning Agents and Waste Minimization**

In the past, the industry has been dependent on sodium-based products and caustic soda. Now, many in our industry are beginning to take a source-centric approach to winery wastewater management by understanding this mantra: recycle, reuse, and reduce (Szymanski et al., 2007). Many are now using “green” cleaning materials and have replaced sodium with potassium products (Deans, 2003; Szymanski et al., 2007). Examples of the impact of potassium-based products on pH adjustment include the following (Boulton, 2010):

- acid solution: 20mM  $\text{KHSO}_4$  provides pH 2.5
- basic solution: 20mM  $\text{KOH}$  provides pH 11.5

The benefits of using potassium over sodium include the following:

- Potassium is a plant macro-nutrient, and preferentially taken up by crops in wastewater reuse areas, whereas sodium is not a plant nutrient. The very limited uptake of sodium is of an incidental nature only, and results in little net removal in harvested crops.
- Potential for soil degradation by  $\text{K}^+$  ions is dramatically reduced when compared to  $\text{Na}^+$  ions.
- While potassium hydroxide is more expensive than sodium hydroxide, any upfront cost disadvantage is more than offset by the lower mitigation and remediation costs associated with addressing impacts on soil in wastewater utilization areas.

## Wastewater Reuse

Because of the relatively-high potassium load in winery wastewater, it may not be suitable for wine grape irrigation in some instances. In the past, the cleaning agents and processes in wineries were heavily dependent upon the use of sodium-based products and, in particular, caustic soda.

Treatment systems have focused on removing organic matter, nitrogen, and phosphorus but, generally, they are incapable of removing sodium. Through replacement of sodium products with potassium products, we have re-engineered the chemistry of the wastewater so that its relative content of calcium and potassium (both of which are plant macronutrients) has increased, with a reduction in sodium (Carson, 2008).



## Study Questions

1. In the winemaking operation, the major sources of wastewater include crush, pressing operations, fermentation tanks, barrel washing, barrel soaking, and bottling. Outline appropriate steps to reduce the water load for each of these sectors.
2. What is the significance of BOD and COD? What are the relationships between these and pH?

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3. Winery wastewater can be a difficult issue for small wineries. List and outline the common small wastewater handling methods, including the advantages and disadvantages.
4. Chlorine in the winery is considered detrimental due to the possibility of environmental taint. What impact would this have on winery wastewater?
5. What are the advantages of reducing the wastewater NSS content?
6. List some possible uses of water from winery waste ponds. What components would have to be monitored for successful use?
7. What problems are associated with having storm water combined with winery wastewater?

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