RUTGERS
New Jersey Agricultural Experiment Station

Waste and Wastewater Management for New Jersey's Wineries

Best Management Practices Manual

Introduction

This manual provides the winery industry of New Jersey best practices for managing waste and wastewater that is generated as part of their day-to-day operations. This manual is based upon the latest information on best practices and technologies from across the nation and an in-depth review of the existing New Jersey winery industry. By implementing these best management practices (BMPs), the environmental impact from the wineries of New Jersey will be minimal.

There are three main possible areas where New Jersey's winery industry could impact the environment:

1. Wastewater from cleaning equipment and sanitation
2. Solid waste associated with the crushing and pressing operation
3. Domestic waste associated with employees and people visiting the tasting room

The environmental impact of each of these areas of concern are closely linked to the size of the operation. Based upon regulations from other states, small farm wineries range in size from 13,000[1] gallons of wine per year to 50,000[2] gallons per year. Using this range, almost all the wineries in New Jersey would be considered "small wineries." In most states, small wineries are not subject to environmental regulations but must operate using a set of best management practices and standard operating procedures. This manual was developed based upon a review of information from California, New York, Kentucky, Wisconsin, Washington, Texas, Michigan, Virginia, and British Columbia.

Wastewater from Cleaning Equipment and Sanitation

Water is a key resource used throughout the winemaking process from vineyard to bottle for irrigation, temperature control, cleaning, sanitation, sterilization, and filter rinsing. Wastewater characteristics vary from winery to winery and appear to be significantly influenced by climate and wine type produced. Wastewater loads also vary seasonally, with the highest organic loads produced during vintage.

Some factors to watch for in winery wastewater are[3]:

- Chemical and biochemical oxygen demand (COD and BOD)
- Total suspended solids (TSS) and total dissolved solids (TDS)

[1] State of California, California Water Quality Control Board, Central Coast Region, Staff Report for Regular Meeting of September 10, 2004.
[2] 2013 Kentucky Revised Statutes, Chapter 241 - Alcoholic Beverages -- Administration and Control, 241.010 Definitions for KRS Chapters 241, 242, and 243.
[3] Sustainable Winegrowing British Columbia, 2018. Winery Process Wastewater Management Handbook: Best Practices and Technologies.

- Salts such as sodium (Na), calcium (Ca), magnesium (Mg), and potassium (K)
- Salinity (electrical conductivity)
- Nutrients such as nitrogen (N) and phosphorus (P)
- Acidity or alkalinity (pH)
- Dissolved oxygen levels (DO)

Cleaning waste is by far the biggest contributor of wastewater because it is generated at every processing stage during wine manufacturing. Cleaning water can be classified as caustic, acidic, and rinse water. Caustic cleaning agents are most commonly used to dissolve solid deposits of tartrate, pigments, tannins, and proteins. Acidic cleaning agents such as dilute solutions of citric and/or tartaric acids are then used to remove caustic residues. Following the caustic/citric washing, water is used to rinse away traces of the cleaning agents. Rinse water is the largest contribution to the wastewater stream from a winery.

Crushing and Pressing Operations

During the crush season, wastewater associated with crushing and pressing operations typically makes up a large portion of the winery's total wastewater. Wastewater sources include spills, rinsing, and sanitizing activities for the crushing, de-stemming, and pressing equipment.

Tanks Washing

Tank washing is a regular activity in every winery, but the total volume and characteristics of wastewater generated on a daily basis will vary depending on the number of tanks in use, tank size, the nature of residuals in the tank, additives used in cleaning, and sanitation protocols.

Barrel Washing

Barrel washing activities that generate wastewater include cleaning and sanitizing the barrel interiors and to a much lesser extent, washing the barrel exteriors.

The COD and TDS concentrations particularly from the crushing operation can range from 800 to 1,500 mg/l and 80 to 2,900 mg/l[4]. While these concentrations are high, the pollutant loading is very low because the volume of wastewater is typically small. The winery is typically using less than 200 gallons of water when cleaning and sanitizing equipment, which happens 10 to 20 times per year.

There are several methods of disposing of the wastewater associated with cleaning and sanitizing equipment. The first would be to simply discharge the wastewater to the municipal sanitary sewer systems. Since most of the wineries are in rural areas and are not connected to the public sanitary sewer, a direct discharge is not possible, and the wastewater would have to be stored onsite and

[4] Bruce Zoecklein, 2010. Winery Wastewater. Grape Chemistry Group at Virginia Tech.

transported to the municipal wastewater treatment plant. The second method would be to discharge the wastewater to their existing septic system. Since the volumes are so small, these systems may be able to handle the additional flow. If not, a new septic system may have to be installed. The third method and the recommended method would be to land apply the wastewater to the agricultural fields. This is an inexpensive option and should not have any impact on the environment since the volume of wastewater is so low.

While literature can provide a range of pollutant concentrations that are expected in the wastewater from wineries, it may be necessary to characterize the chemical composition of the wastewater prior to land application. Additionally, the winery should install water meters to determine daily water usage. In-line meters can be used on water fixtures, and hose meters can be installed to monitor water at the point of use. This will allow for the pollutant load to be determined and will clearly demonstrate that the land application of wastewater will have minimal impact on the environment.

Solid Waste Associated with the Crushing and Pressing Operation

Pomace is the dry or pulpy residue of grape from which a juice has been pressed. When making wine, about 20% pomace[5] is produced, which must be discarded. The grape pomace is high in nitrogen, phosphorus, potassium, and calcium and could be recycled as a soil conditioner given its organic and nutrient content. The value of grape pomace as compost/fertilizer depends upon the presence of the proportion of organic matter, which can be converted into humus with a favorable effect to the soil. Grape stalks, grape marc, wine lees, and dealcoholized marc have low pH, low electrical conductivity, and high organic matter content. Grape stalks and seed coats contain high C/N (carbon/nitrogen) ratios because of their lignocellulosic nature. Grape stalks also have a high content of polyphenols. In addition, grape stalks and seed coats are rich in tannins. Nitrogen, phosphorus, and potassium are noted in the lees. It is reported that the average content of organic matter in grape branches and leaves is 15%, containing 44.22% carbon, 0.62% nitrogen, 0.25% phosphorus, and 1.44% potassium. It also contains magnesium, calcium, sulfur, and other elements, which are essential nutrients needed for the growth of grapes.[6]

There are two methods to dispose of this highly organic material. The first is to compost the material using standard composting practices. This would require placing windrows at least 100 feet from local waterways and minimizing the stormwater runon and runoff. Due to the high organic content, a bulking agent may need to be added to the compost mix. Often wood chips are used as a bulking agent. The finished compost can then be added to the agricultural fields. Rutgers Cooperative Extension can provide guidance on the proper way to compost the winery waste.

The second method is to simply land apply the pomace to the agricultural fields. This should be completed in accordance with a nutrient management plan from the Natural Resources Conservation Service (NRCS). Testing may be needed to determine the nutrient content of the

[5] Muhlack, Richard A., R. Potumarthi and D.W. Jeffery, 2018. Sustainable wineries through waste valorisation: A review of grape marc utilisation for value-added products. Waste Management. Volume 72, Pages 99-118.
[6] Why Grape and Winery Waste are Suitable for Composting? https://compost-turner.net/composting-technologies/grape-stalks-and-pomace-composting-process.html .

pomace prior to land application. Understanding the nutrient content of the waste is important for developing a nutrient management plan.

Domestic Waste Associated with Employees and People Visiting the Tasting Room

Domestic wastewater is used water that carries bodily wastes (primarily feces and urine), washing water, food preparation wastes, laundry wastes, and other waste products of normal living. Domestic sewage is a primary source of pathogens (disease-causing microorganisms) and putrescible organic substances. Domestic waste from a winery is associated with employee bathroom facilities and bathroom facilities in the wine tasting room. Since most wineries are in rural areas of New Jersey, the domestic waste is primarily treated by onsite wastewater treatment systems or septic systems.

New Jersey has standards for individual subsurface sewage disposal systems or septic systems (N.J.A.C. 7:9A). These systems are typically designed with a septic tank (often 2,000 gallons in size) and a leaching field. The tank holds the solids and must be pumped on a regular basis (usually every two years) and the leaching field discharges the liquids into the underlying soils. The New Jersey standards have specific requirements for designing systems and determining the volume of sanitary sewage to the system.

> "The volume of sanitary sewage from establishments which have activities other than single residential occupancy shall be based upon the types of activities that are expected to occur that will generate sanitary sewage, the size of the facility and the maximum expected number of persons that may be served during any single day of operation. The total expected volume shall be estimated for each activity generating sanitary sewage by multiplying the number of gallons per unit per day by the maximum anticipated number of units" (N.J.A.C. 7:9A)[7]

The regulation states that the system should be designed for 15 gallons per day for each employee and three gallons per day for each seat/person up to the maximum occupancy. The standard septic system is design for a minimum flow of 350 gallons per day, which equates to 3 employees and 100 people (i.e., 100 people visiting the tasting room).

Wineries should determine the size of their existing septic system and use the above calculation to limit the number of daily visitors to the tasting room. If the winery is having a special function such as a festival or fair, portable toilets, temporary restrooms, or holding tanks should be used.

[7] N.J.A.C. 7:9A Standards for Individual Subsurface Sewage Disposal Systems (2012)

Best Management Practices and Standard Operating Procedures (SOPs)

To reduce the environmental impact of the winery, the focus should be on using less water and keeping solids and chemicals out of the drain. This section of the manual has been adapted from Sustainable Winegrowing British Columbia. The keys points are:

- Tackle the source, not the symptoms
- Improving the wastewater quality of any winery operation depends on understanding both the quantity of process water being generated and the quality of that water
- Two-thirds of all water used in a winery is for cleaning and sanitation
- Simply reducing water use does not improve the quality of the process water and can concentrate organics and inorganics, degrading the quality of the process water further
- Cleaner production practices that stop solids and other contaminants from going down the drain, reduce water use, and segregate wastes (especially strong wastes) are key
- It is always more cost effective not to generate waste than to spend energy to remove it

Although every winery is different, there are a few areas that typically contribute to a majority of the water use:

- tank cleaning and sanitation
- barrel cleaning and sanitation
- bottle sterilization
- vacuum pumps
- pushing wine

In addition, 30 to 50% of a winery's annual water use typically occurs during the 60 days of harvest.

Solids contribute to the BOD loading in process water. Once in the process water stream, solids can accumulate, putrify, and require a significant amount of energy to treat. Primary sources of solids include:

- crush pad
- barreling
- lees handling
- fining
- filtration
- centrifuge

Many wineries say that they experience a 30% or more reduction in water use just by paying closer attention. The following are low to no-cost best management practices for the winery:

- Tracking and monitor water use
- Standard Operating Procedures (SOPs) for cleaning and sanitation activities
- Auditing against SOPs
- Employee education, training, and incentives
- Provide employees with tools - timers on hoses, spray nozzles, brooms, and squeegees
- Leak patrol

Best practices for cleaning and sanitation:

- Use brushes, brooms and/or squeegees to pre-clean equipment, tanks, and floors before using water; color code your brushes to emphasize their use and make it easier on your employees and organize the brushes and cleaning materials on a cart with wheels to allow for movement throughout the facility
- Use high pressure nozzles with automatic shut off whenever possible
- Use PIGs (pipeline inspection gauges) instead of flushing with large amounts of water; PIGs are inserted into transfer lines and pressure-driven through the pipeline along with the wine and/or water using compressed gas such as nitrogen
- Develop standard operating procedures for washing barrels, cleaning and sanitizing tanks and equipment, and other processes; post the procedures where employees can see them and provide training and regular refreshers
- Capture, filter, and reuse cleaning solutions
- Consider ease of cleaning when purchasing new equipment
- Use sanitation methods and products that do not require a final rinse
- Evaluate whether ozone could be substituted for the final rinse; ozone offers higher sanitization quality, time and energy savings, and decreased chemical use
- Automate sanitization procedures or set cleaning times
- Substitute steam cleaning for individual sanitation steps or throughout the winery

Best practices for crush pad operation:

- Cover the reception area and crush pad to shade the waste material; the juice and grape skins will be easier to remove from equipment, thereby reducing the amount of effort (and water) needed for cleaning

- Consider using a water-recycling bin washer rather than cleaning picking bins individually
- Segregate stormwater from process wastewater
- Filtering out solids from the wastewater stream is the most cost-effective way to reduce BOD in the wastewater

Best practices for washing of barrels:

- Use only enough water to soak the end of a barrel
- Hydrate multiple barrels consecutively
- Leave barrels wrapped until they are ready to be used
- Use rinse water from one barrel to do initial cleaning of the next
- Minimize tank and barrel transfers
- Adopt clean in place barrel washing

Standard procedures for barrel washing may include: i) what temperature of water to use, ii) how long wash and rinse cycles should last, iii) how water is captured and reused and iv) what type of equipment to use.

Best practices for washing tanks and transfer lines:

- Minimize tank transfers and equipment changeovers
- Adopt clean in place tank washing
- Recycle ozone rinse water when feasible
- Use pigging for transfers (can also result in faster turnovers) and to help clean hoses
- Capture and recirculate water and caustic
- Use the shortest and smallest diameter hose necessary for transfers
- Use nitrogen to transfer wine instead of water

Best practices for clarification, filtration and bottling:

- Use nitrogen instead of water to rinse bottles
- Use protein adsorption columns to eliminate the need for bentonite
- Use in-line white juice flotation for clarification to remove solids at the point of generation

Best practices for handling lees, pomace, and other solids:

- Use source control methods to capture solids (screen, sweep, squeegee, or segregate) from production areas (e.g., crush pad, lees handling, fining, centrifuge, filtration)
- Filtration options to assist in lees separation include lenticular filters, cross-flow filters, rotary vacuums, and standard plate-and-frame filters
- Develop value-added products from pomace and lees

Best practice to design new winery:

- New wineries should be designed with water-use efficiency and easy removal of solids in mind; the layout should allow for easy isolation of stormwater, and for the separation of process wastewater and domestic wastewater flows
- Use separate drains for different wastewater streams (e.g., high-strength process water, low-strength process water, greywater); drain system designs should also include access points and sumps for sampling and wastewater diversion
- Floors should be level with a slight slope to direct water to drains and should have a smooth, durable surface (such as an epoxy coating)
- Install easily serviceable baskets or screens in trench drains; screens only work if they are kept clean; train staff to empty them regularly and put them back after cleaning
- Install pea traps to prevent odor back up

Water recycling and reuse:

In many other wine growing regions, 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, rainwater harvesting, capture and reuse water systems, high pressure water, and pigging transfer lines. There are several discharges that can potentially be reused:

- final rinses from tank cleaning and fermenters
- bottle soak and rinse water
- barrel cleaning water
- cooler flush water
- filter backwash
- sterilizer water

Here are several areas for possible water reuse:

- first rinses in wash cycles
- filter backflush
- caustic dilution
- boiler makeup
- refrigeration equipment defrost
- equipment cleaning
- floor and gutter wash
- irrigation

Select suitable cleaning agents:

In the past, the industry has been dependent on sodium-based products and caustic soda. Now, many in the industry are beginning to take a source-centric approach to winery wastewater management by understanding the idea of reduce, reuse, and recycle. Many are now using "green" cleaning materials and have replaced sodium with potassium products. Examples of the impact of potassium-based products on pH adjustment include the following:

- acid solution: 20mM $KHSO_4$ provides pH 2.5
- basic solution: 20mM KOH provides pH 11.5

The benefits of using potassium over sodium include the following:

- Potassium is a plant macronutrient and preferentially taken up by crops in wastewater reuse areas, whereas sodium is not a plant macronutrient; 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 K^+ ions is dramatically reduced when compared to 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

Summary

By implementing best management practices identified in this document along with standard operating procedures, the environmental impact from the wineries of New Jersey will be minimal. Recommendations for each of the three main possible areas where New Jersey's winery industry could impact the environment are addressed in this document. By following the recommendations, the wineries can cost-effectively minimize their impact from wastewater, solid waste, and domestic waste generated as part of the winery and the tasting room operation. The wineries are strongly encouraged to prepare standard operating procedures (SOPs) and have the Rutgers New Jersey Center for Wine Research and Education review the SOPs and provide input.

List of the resources

1. Comprehensive Guide to Sustainable Management of Winery Water and Associated Energy
Author: Kennedy/Jenks Consultants
Prepared for: American Vineyard Foundation, California Wine Institute, and Pacific Gas & Electric Company
Available: www.wineinstitute.org/files/AVF-Guide.pdf

2. Sustainable Water Management Handbook for Small Wineries
Author: California Sustainable Winegrowing Alliance
Year: 2014
Available: https://www.sustainablewinegrowing.org/docs/CSWA_Sustainable_Water_Management_Guide_for_Small_Wineries.pdf

3. Winery Process Wastewater Management Handbook: Best Practices and Technologies
Year: 2018
Available: https://bcwgc.org/sites/default/files/uploads/Wastewater%20Management%20-%20Final%20Digital.pdf

4. Winery Wastewater Management & Recycling Operational Guidelines
Author: Australian Government Grape and Wine Research and Development Corporation
Year: 2011
Available: https://www.wineaustralia.com/getmedia/72627da6-d28a-42f2-b600-28fdd5a6c85c/Operational-Guidelines.pdf

5. Winery Waste Water – Enology-Grape Chemistry at Virginia Tech
Author: Dr. Bruce Zoecklein, Professor Emeritus, Virginia Tech.
Year: 2010
Available: https://www.apps.fst.vt.edu/extension/enology/downloads/wm_issues/Winery%20Waste%20Water.pdf

6. Why Grape and Winery Waste are Suitable for Composting?
https://compost-turner.net/composting-technologies/grape-stalks-and-pomace-composting-process.html

7. N.J.A.C. 7:9A Standards for Individual Subsurface Sewage Disposal Systems (2012)
https://www.state.nj.us/dep/dwq/pdf/njac79a.pdf