CEIC1000 GROUP SUBMISSION 2

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ABSTRACT

The report following addresses the issue of waste water management in the Wine making industry. Alcohol production carries the burden of having high volumes of waste water to manage. Unfortunately, the processes in place at the current time are not of a satisfactory level. This report aims to look at both existing and emerging processes to attempt to locate areas for improvement in regards to waste water processing. As there is no single solution to the issues associated with waste water in the Wine Industry, the report will outline a series of methods which when used together will vastly increase the efficiency and quality of waste water processing.

For further understanding, the report will outline the Wine making process, including inputs and outputs. This will provide an overview of how waste water fits into the whole process. From here, current methods will be reported as a comparison to the new methods suggested, along with environmental and cost issues associated with treatment and Wine making. The improvements suggested as replacements to current methods will decrease levels of Chemical Oxygen Demand, Turbidity and Solids significantly. As such, the justification of the report concludes that for a large scale process such as the one in consideration, these new methods are vastly superior to the original.

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1. INTRODUCTION

Wine industry is one of the significant contributors to the Australian market. In 2009-2010, the industry contributes $4.8 billion to the national economy through production, sales, export, and import of wine beverages [1]. One of the growing issues in the wine industry is the sustainable waste management. It is widely known that the winemaking activities result in the production of waste. The major concern is the disposal of the solid waste and the wastewater management where improper management could cause serious adverse environmental effects. For medium to large-scale wineries, water is manly used for cleaning and sanitation of the equipment. Winery generally produce 1 ML to 5 ML of wastewater for every 1000 tonnes of grapes crushed [2]. Over the peak vintage period, around March to May in Australia, the wastewater generation is at its maxima. The problem is this wastewater could potentially carry organic matters (BOD, TOC, and COD), Calcium bicarbonate, chloride, sodium, and metal contamination, depending on the winemaking process. So that inappropriate disposal/treatment could lead to the death of aquatic organisms, undesirable odours generation, and degradation of soil structure [2]. Some wineries also have an issue with the volume of water being used. The rapid growth of industries in Australia has increased the pressure on resource shortages such as water. Water restriction has forced winemakers (or company) to run their businesses as efficiently as possible. Thus, it is essential for wineries to have technology that is able to reduce the water consumption. Without proper handling, solid waste from winemaking process could also be a source of environmental problem. This solid waste includes grape's marc, stems, lees, leaf litter, and packaging materials [3]. Therefore, application of appropriate practice is required to help minimize the impact of winery waste to the environment. Many waste and wastewater treatments have been discovered. Nowadays, from old simple waste treatments to new advance technology treatments are all available in the market for industrial needs. Some of the basic waste management, like waterway disposal, is not an option anymore for wine producer. New environmental regulations have also forced wine companies to use treatments that not only effective but also environmentally friendly. However, it all comes down to the production cost. Most of the high–end treatments are efficient but they could cost up to 10 times the conventional way. At the end, this cost will be based on how much waste produced during the process. Thus, designing a new process or treatment that can reduce the waste and wastewater generation is one of the rapid growing issues these days.

2. OBJECTIVES

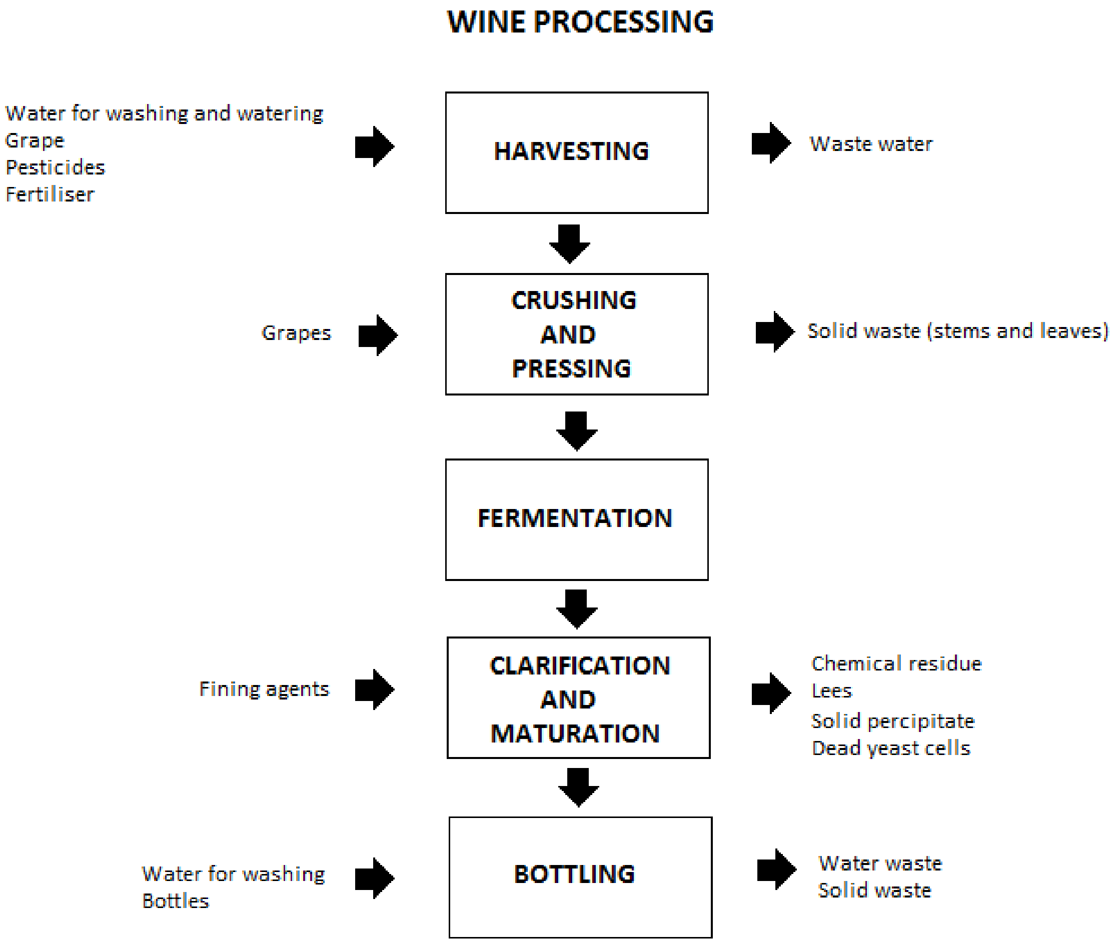
With respect to the issues mentioned above, the objective of this report is to provide:

1. Evaluation of the existing waste management technology
2. Evaluation of waste and wastewater reduction option
3. Assessment of the new developing technologies
4. Evaluation of efficiency and cost

3. WINE MAKING PROCESS

There are five basic steps in wine making: harvesting, crushing and pressing, fermentation, clarification and maturation and lastly, bottling. The flow diagram showing wine process is presented below:

Figure 1: Wine making process



3.1. Harvesting

Harvesting is the first process in winemaking. In order to produce high quality wine, grapes must be harvested at the precise time. The weather has a massive impact in determining the behavior of the grapes in a bottle wine [4]. Under hot weather, it is difficult to grow grapes as it is humid and the chance of suffering from fungal disease is high. The ideal weather for growing grapes is usually during the winter time where there is good moisture and a cool temperature. Grapes rely heavily on water for their growth; the moisture will help farmers to reduce their water consumption for watering [4]. Farmers need to construct a support that should be able to hold the weight of mature grapes, usually farmers use wires, rail fences or arbors [5]. The decided frame work needs to last so that it may be able to support the vine for many years.

Grape vine is usually pruned during mid winter when the juice is still low and all the sticks have hardened. The idea of pruning is to trim away dead or overgrown branches or stems to maximize fruitfulness and growth. Vines are also propagated to obtain a satisfying product. In this step healthy and well ripened stems are carefully selected. Ideally the stems would have three or four buds. The stems are then trimmed (at an angle) above and below the bud. The stems are then placed into the soil for the growing process [6].

Growing grapes requires a soil pH in the range of 6.0 to 6.5. Usually soil is acidified by using sulfur and is fertilised using Nitrogen fertilizer [7]. This technique will create the best soil for growing grape vines. Red wine grapes usually take longer to mature compared to white wine grapes [4]. Once the green grapes turn red, the entire vine yard is covered in nets to prevent the birds from consuming the fruits [5]. Typically the grapes are left on the vine for a few more months after turning red to produce desired sugar level contents. The key to determine maturity level of wine is by tasting it [7]. Principally the grape's tannin, acid and sugar verify how ripe the grape is. They are also the key components in influencing the quality of the wine [4].

Harvest can be done by hand or mechanically. Most growers prefer to handpick the grapes because machineries may be too tough on the grapes and vineyards and may cause the grapes to oxidise due to damaged skin [4]. Harvest time is typically in the morning when the temperature is relatively low. This is done so that grapes do not become too warm and are spoiled during the transportation process from the vineyard to the wine processing site. It also maintains the grape's astringency to a minimum level [4]. Straight after grapes arrival, wine makers will select the qualified grape bunches and trim away any under ripe and rotten grapes as preparation in order for the grapes to go though the crushing process. Grapes are also washed for hygienic purposes.

3.2. Crushing and Pressing

Grapes can be crushed mechanically by machineries or by traditional method in which men and women stomp or trod on the grapes in the attempt of obtaining juice. Most of the current wine makers prefer to use mechanical pressing rather than traditional method because mechanical pressing is proven to improve efficiency and increase hygiene. Mechanical pressing has also improved the quality and longevity of wine, while reducing the winemaker's need for preservatives [4]. Before the crushing process, grapes are de- stemmed using a de-stemmer where stems are separated from the grapes. Sometimes when the grape requires more tannin, the stems are left on the fruit for a longer period of time, however when left too long it may produce unusual taste. The next step in line after crushing is fermentation.

3.3. Fermentation

Fermentation is the process in which sugar such as glucose is broken down by bacteria and is converted to carbon dioxide and alcohol. It uses an anaerobic respiration method. This method does not require the use of oxygen. In most plant cells including yeast, the enzymes break down glucose to produce ethyl alcohol, carbon dioxide and water [12]. The equation of the conversion of sugar to alcohol and carbon dioxide can be shown below:

Fermentation Equation:

$$C_6H_{12}O_6 \implies 2(CH_3CH_2OH) + 2(CO_2) + \text{Energy}$$

Sugar (Glucose)	====>	Alcohol (Ethyl alcohol)	+	Carbon dioxide gas	+	Energy

Red wine is left in contact with its skin and seeds to produce the desired colour, flavor and additional tannins during fermentation [10]. A higher temperature is applied to ferment red grapes compared to white grapes. The taste and the speed of fermentation rely strongly on temperature. The suitable temperature of red wine fermentation process lies between 28 -30 degree Celsius. A temperature lower that 15 degree Celsius will result in a slower yeast activity and a temperature above 30 degree Celsius will kill the yeast and thus preventing conversion of sugar to alcohol to occur [11]. Yeast is initially present in wine however at the fermentation tank, indigenous natural yeast is added on top of the initial yeast to assist and synchronize fermentation process. Yeast is only able to withstand a certain alcohol level, high concentrations of alcohol damage the enzymes and cause the yeast to die. The level of alcohol in which the yeast is able to tolerate varies. Wine yeast is only able to withstand an alcohol level between 10%-15% [13].

There are a number of different sizes and styles of fermentation available such as a rotary fermentation machine and large static vessels [13]. Rotary fermentation is one of the ways to make wine which produces the high quality wine that results in some companies receiving some awards. The design allows setting the temperature precisely and automatic discharge of the grape skin which is one of the advantages that makes the process more efficient. Because of the advantages of it, it allows the fermentation process to occur in only 4 days which allows the turnover of the product extremely fast [17]. Static fermentation is basically a system that applies the law of gravitation to produce wine. It uses slope in an incline plane by elevating the galvanized stand to help wine making process in marc discharge. This is one of the cheapest ways to produce wine compare to SWAP or rotary fermentation which allows the customer to choose the dimple plate. The dimple plate allows managing temperature in low, medium and high pressure [14]. To allow better control of the extraction process, top quality red wines are commonly fermented within an open environment [10].

Alcoholic fermentation begins after approximately 8-10 hours from yeast injection. Approximately, 24 L of carbon dioxide, 24 Kcal and 60 ml of ethanol are produced for every 100 grams of sugars fermented [11]. During the fermentation process, yeast cells consume sugar, multiply and release alcohol as well as carbon dioxide. Some of the sugar that is not able to be fermented will linger in the liquid creating sweeter product. Carbon dioxide produced by the process shifts the skins and pips upwards [11]. As skins and pips are continually rising in this process continuous stirring and pushing down has to be done. This non-stop stirring and pushing down is referred as “punching down the cap”. Grape juice can also be separated by collecting juice from the bottom of the vessel and pumping using a hose over the cap. A cap is the top solid layer formed by skin and pips [8]. The skins of the grapes are pressed after the alcoholic fermentation is completed.

The minor products produced by alcoholic fermentation include acetic acid, higher alcohols, acetaldehyde and glycerol. Low concentrations of acetic acid, higher molecular weight alcohols and acetaldehydes determine the quality of wine [11]. Extraction of mixtures from pips, tannins, anthocyanin pigments and skins are controlled to produce the desired colours, flavours and aromas [11]. Wine makers usually stop the fermentation process before the conversion of sugar to alcohol is completed to produce sweet wine. The length of fermentation varies depending on the wine maker's decision to produce specific wine. Usually it lies between ten days to months [15]. The alcohol level of wine will also vary as the length of the fermentation varies. The grape juice then proceeds to malolactic fermentation.

Malolactic fermentation is used to reduce acid content in wine. It is used for all red wine and some white and sparkling wines. Malolactic improves the wine's microbial stability by converting malic acid to lactic acid [9]. This fermentation can only occur when the temperature is greater than 20 degree Celsius and pH is greater than 3.2 [11]. Malic acid may be the cause of different kinds of spoilage organism. Other than stabilizing and lowering acid content, malolactic fermentation also improves the aroma of wine. Usually this process is completed in 2-4 weeks time [11].

3.4. Clarification and Aging

After fermentation process has been done, wine proceeds towards the clarification process. Some wineries may decide to add clay, egg whites and other compounds that will bring out solid precipitate and dead yeast cells. These added substances will linger on the solids, making it denser so that it can sink to the bottom of the tank [16]. Wine makers usually leave the wine for a certain period of time so that a solid precipitate known as pomace settles to the bottom of the vessel. The wine is then transported via a hose into another tank. This process may occur a few times to ensure that wine is as pure as possible. Fining agents such as copper, bentonite, gelatin and Sulphate are added to remove excess wine components. The clear layer of wine is then ready to be filtered or centrifuged.

Wine is filtered or centrifuged to maintain microbiological stability of wine by eliminating microbes and thus controlling the sugar level in wine. Filtration traps solids into a clean filter pad, separating solid residues and liquid. After filtration, wine is placed in a sub-zero temperature room to form excess potassium bitartrate precipitate. Its pH is adjusted by adding tartaric, malic or citric acid. Clarified wine may be stored into an oak barrel for a period of time (maturation) to improve flavor and aroma. Wine makers can also blend different wine together to produce specific flavor. Usually a final stage of filtration is included before wine is bottled [9].

3.5. Bottling Wine

After maturation and final filtration wine needs to be packed in the bottle as soon as possible to reduce the oxidation process that can cause loss of flavour in the wine itself. Wine cannot be packaged in an arbitrary bottle. For example desert wines need to be packed in a bottle which is dark, not in a transparent bottle. It is used to reduce the effect of the light, and it is suggested to put the desert wine in a place that cannot reach sunlight. There are three types of wine bottles which are green wine bottles, blue wine bottles (dark coloured bottle), and clear wine bottles (transparent). To make the bottle of the wine, it has a standard which has to be followed. Good wine bottles are designed to take a cork. Usually the standard size is a ¾ inch opening for the cork.

After choosing the right bottle for the wine, we need to choose the right cork for it. There are two types of cork available on the market which is the mushroom cork and straight cork. A straight cork is to be used if the wine is going to be kept for more than 18 months and the mushroom for less than 18 months. Corks are used to close the bottle to reduce the amount of air that can go inside the bottle than can cause oxidation of the wine [17].

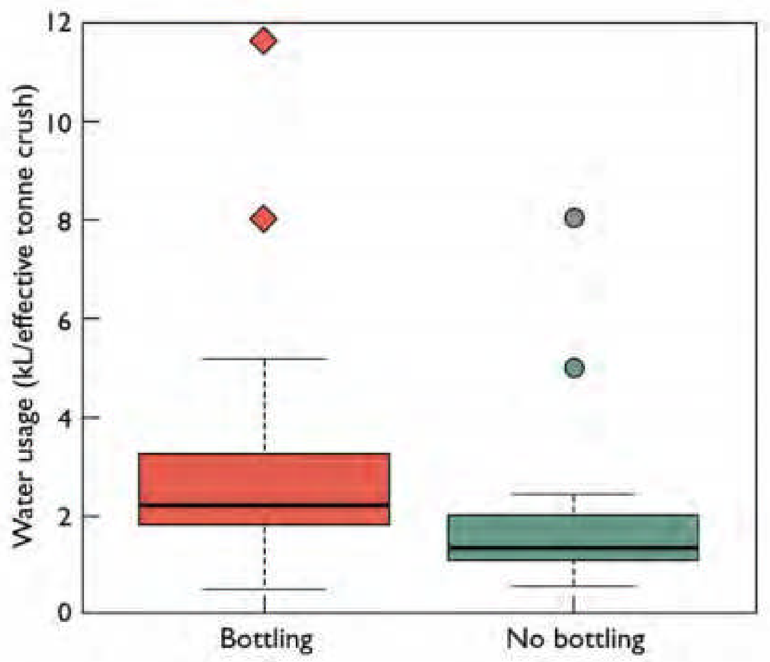
Wine processing has resulted in a large volume of CO2 emissions. CO2 gas is generated mainly from bottling and transport. The bottling of a 365 g of glass bottle which contains 80% recycled glass releases approximately 220 g of CO2. Production of a synthetic cork usually releases 3 g of CO2 per bottle where as natural cork releases 1 g of CO2. Grapes are transported from vineyard to wine industry via a large truck which uses diesel as its fuel. Diesel is known to produce a higher volume of CO2 compared to other sources of fuel. Other than transport, fuel is also required to perform various farm operations such as the application of pesticides and fertilizer that may be used in harvesting grapes [19].

4. CURRENT WASTE AND WASTEWATER PRODUCTION MANAGEMENT

The production of wine has an impact on environment since it triggered a great volume of waste and waste water production. The water required to produce 750 ML bottle of wine is approximately 1.94 KL per tonne of grapes crushed. Bottling itself requires 1.4 L of water for every bottle of wine. The average water usage from bottling on site is roughly 2.3L per bottle of wine.

The main use of water in wineries is in washing down grapes, equipment and barrels, tanks and transfer lines and cleaning bottles. The main waste includes solid waste such as grape skins, stems, seeds and water sediment (lees). To reduce the production of waste and waste water, wine makers can minimise transfer, reduce their wine making process complexity and increase the use larger volume of barrels instead of many small ones [9]. Wine makers also often use high pressure cleaning equipment, automatic nozzles, ozone cleaning inert gas push-through and pigging. The effect of bottling in water usage can be shown in the figure below.

Figure 2: Water generation [6]



Steam cleaning is an example of high pressure cleaning equipment highly used in cleaning bottling lines, wine tanks/bins, wine barrels, conveyor belt and equipments in wineries. The high pressure and temperature of the steam helps to dissolve residues in barrels faster compared to cleaning using hot water. The vapour cause the oak barrels to open its pores so that it could release residues such as residues from oak wine and bitter tannin that was once absorbed by the oak. As steam is water, cleaning oak barrel does not cause it to burn or dry out. It helps moisturise the oak barrels allowing it to be more long lasting. Usually the steam temperature is above 100 degree Celsius, this temperature kills germs and bacteria and thus sterilising the barrel. Firstly wine barrels are rinsed with high pressure water and then a steam diffuser is inserted into the barrel for a period of time until the temperature inside the barrel achieves approximately 100 degree Celsius. The barrel is finally rinsed with cold water. During the cleaning process using steam, leaks can be detected as the steams will go through the hole in the barrel.

In cleaning bottles, a hose is connected to a bottling line and a steamer. A steam cleaning took place using a pressure up to 6 bars and temperature exceeding 100 degree Celsius. This temperature and pressure also helps to sanitise bottles as well as proven to increase efficiency. Using this technique, approximately 1000 bottles can be sanitised and clean in a period of time of one hour. Wine tanks and bins are disinfected and clean from parasites and residuals using steam cleaning. The conveyor belts are cleaned really quickly so that no delays were to be made in the wine making process. This steaming technique enables equipment to be both cleaned and sterilised only in 15 minutes. No chemicals are used in cleaning equipment which results in a decrease in water consumption and production as well as helping wineries to save thousands of dollars per year [20].

Automatic nozzles works similarly as high pressured equipment as it also releases high pressure water. It can come in a small and convenient size allowing it to be hand held. The advantage of using this is that it is flexible and thus is able to reach residues in a narrow area. As an automatic nozzle also uses high pressure water, it can reduce water consumption and increase efficiency. The disadvantage of using this nozzle is that it cannot set the water pressure to low pressure [21].

Ozone cleaning is a method in wine industry that is used to sanitize and clean barrels, tanks, and other equipment by eliminating bacteria and yeast without reducing the quality of wine. After usage, this method does not leave chemical residues [22]. Ozone is produced by the exposure to radiation with a ultra-violet wavelength of 185nm [23]. It can also be generated by a corona discharge technology in which dry oxygen is passed through. Ozone cleaning is able to reduce water consumption by 50% and reduce loss of product due to spoilage [23]. On top of that, it also reduces the chemicals consumption that wine makers need to purchase to clean equipment therefore saving wineries a huge amount of money [22]. One of the disadvantages of using ozone cleaning is that ozone (O_3) is a toxic gas and will be risky to store and has to be monitored consistently [23].

Pigging refers to cleaning pipelines by inserting tools through the length of the pipeline and scraping the edges to remove debris, corrosion and material sediment. Furthermore, pigging can also be used as a water removal where water is left behind in the pipe after a hydraulic test is removed. In scrapping the pipe, less water is needed to clean the pipe and therefore reduces water waste to the environment. Pigging is capable of recovering good product residue that can be sold. There is no requirement for a long flush out when using 'pig' (Pipeline Intervention Gadget) thus reducing waste water production. A pigging system works by moving the pig around the pipe with either a gas or a liquid. Propulsion is a process where the pig is moved, has 2 different types which is gas propulsion and liquid propulsion [24]. Gas propulsion can be accomplished by using compressed air or nitrogen (inert gas push through) by pushing waste through the pipe. Nitrogen is specifically used because of its properties of having low density and high pressure that enable fluent flow and well cleaning. After pigging process is completed, nitrogen gas is used to clean pipe line by passing dry gas though the pipe in order to dry the remaining water residue left inside the pipeline [26]. Liquid propulsion pushes the pig with another product or the flush media used in the field. The system consists of the components to launch and receive the pig, route pig to multiple destinations, and detecting the location of the pig. It can be operated manually or automatically [24].

Unfortunately, the methods currently used are not very effective because some of the methods such as pigging are fairly expensive to install and needs to be maintain frequently. Waste flow is related to the quantity of grape used. To reduce waste disposal costs some less developed wineries cut down their wine production. However, this leads to a decrease in profit since Profit = (Volume x Margin) – Fixed Cost. Recycling water is another method to reduce water waste but for small wineries cost, storage and treatment may be a concern.

4.1. Solid Waste Management

The production of wine has an impact on environment since it triggered a great volume of waste and waste water production. Wineries are required to dispose waste efficiently. At the moment, some wineries dispose their waste and waste water into a pond and landfill. This results in overflow and bad odour. The waste has a PH less than 7, indicating acidic behavior which contaminates water as well as soil and thus interrupt plant's growth. Some of the methods used in treating solid waste include composting, landfill disposal and recycle/re-use.

The solid waste produces by wine process can often be composed to create a mixture that can be mixed to the soil and act as a fertilizer. Some of the components in solid waste include organic compound (e.g. seeds, skins, pulps, and stems), potassium, magnesium, sodium, phosphorus, nitrogen and etc. All of these components are mixed together and may be blended with other substance such as horse, sheep, cow manures and saw dust. Some grape growers also prefer not to add any other substances and allow composition process to occur naturally with the soil.

Often, seeds of grapes are distributed back into the vineyard after it is weighed out and separated from other material. Potassium, magnesium and calcium are both very important macronutrient essential for plant's growth. Calcium is usually found in the grape marc. It is responsible for replacing minerals that was removed from the soil during grape harvesting. Sodium is proven to be taken enthusiastically by grape vines and is very beneficial in improving the growth of certain plant. Phosphorus and nitrogen are both commonly used as organic fertilizer for plant's growth. Nitrogen chemical fertilizer is one of the main energy used in fruit harvesting. This entire component was mixed systematically to produce around 200 L of samples. These samples are refrigerated for analysis purpose. At times, before storage, samples may be treated for one day at a temperature of 458 degree Celsius in order to kill microscopic organism such as Phylloxera aphids [26].

3R (Reuse, Recycle, Reduce) and disposal are one of the few ways in which waste can be manage. Each material has its own characteristic to be considered as waste or waste that can be treated. For example, plastic bottle can be recycled again but plastic bag is not recyclable [24]. Reducing is a way where engineers and designers of materials decided to reduce and avoid the material used in production in order to prevent it into becoming waste. It can be also achieved by maintaining vineyard to reduce any damage causes and the need for replacement. As an example, in the vineyard, a long-life vine-guard is used so that the need of disposal is reduced [28].

On the other hand, recycle means that a material that has been used is processed through some chemical and physical process so that the material can be used again. Not all plastic material can be recycled. For example, official recycle of tractor's tyres, batteries of a tractor and etc. Reuse means that a material can be used multiple times during the harvest season. For example: trellis wire, posts and plastic vine guards.

In addition, landfill disposal should be the last option selected but at the same time it is often more desirable. It is not suggested by environmentalist because of the damage it causes to the environment. Waste is usually dumped in private plant own by the wineries. This method is usually chosen because there is no need for further processing after dumping. At times, gas is generated from the waste and can be captured and used for electricity (e.g. Biogas). Biogas is generated when organic wastes are stored in a tank for a period of time to produce methane gas which can be passed through a generator to produce electricity [29].

4.2. Wastewater Treatment

4.2.1. Land FILTER

FILTER stands for Filtration and Irrigation Cropping for Land treatment and Effluent Reuse [30]. Land Filter system provides sustainable and low cost land based treatment through soil filtration to a subsurface drainage system. It is not only designed to produce low-pollutant drainage water but also to provide leaching to manage salt in the soil profile [30]. This system is particularly good for winery with poorly drained soil, where effluent irrigation could lead to water logging, salination and sodification [31]. The treated water can then be disposed, reused for irrigation, or recycled back to the winery (after further treatment).

Figure 3: land FILTER system [31]

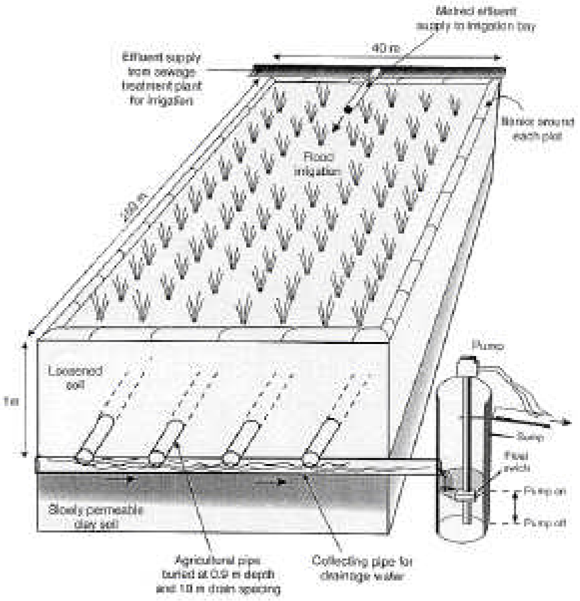


Figure 1 shows the diagram of FILTER system. The wastewater application is by surface flooding of the bays which takes approximately 12-24 hours [30]. The wastewater then flows through the soil to the subsurface drainage system and is applied on 10-14 day rotation [31]. The pollutant concentration is then measured by the end of drainage. If necessary, the filtration can be followed by cropping to remove any contaminants left in the soil [31].

Table 1: Wastewater quality before and after application [30]

Composition/Concentration	**Before**	**After**	**Unit**
PH	5-7.5	6-7.2	
Salinity	3.4	4.3	dS /m
Ca	25.3	160	mg/L
Mg	10.6	70	mg/L
P	8	0.1	mg/L
K	415	120	mg/L
Na	1200	800	mg/L
NH4-N	10.3	1.5	mg/L
NH3-N	0.25	< 0.25	mg/L

From the table it can be seen that overall, FILTER works well in eliminating pollutants in the drained water. The average concentration of P, K, Na, NH4-N, and NH3-N had been reduced significantly. FILTER also neutralized the PH of wastewater which means it minimized the organic acids level as well. However, there was an increase in the concentration of Ca and Mg and the salinity. This high Ca and Mg concentration in the treated water could be caused by dissolution of carbonates in the soil and evapo-concentration as a result of water removal by crops [30]. The salinity increased slightly from 3.4 ds/m to 4.3 ds/m, yet the value still exceeded the maximum EPA limit of irrigation water of 3.3 ds/m [30].

In terms of organic matters removal, FILTER had successfully reduced the level of BOD just after the first day of drainage. Nonetheless, the total suspended solid (TTS) levels varied through each drainage event. The level usually decreased after one day of drainage but shows significant increase by the end of drainage. The TTS level of most of treated water was greater than 200 mg/L which was far above the applied wastewater [30].

Table 2: BOD level of treated water [30]

Wastewater applied	3500
Drained water on 1st day	1500
Reduction on 1st day	57%
Drained water on 2nd day	500
Reduction on 2nd day	86%

4.2.2. Biological treatment

One of the common management practices for wineries wastewater in Australia is biological treatment [31]. This type of treatment is often a choice for winery with high biodegradability (high concentration of ethanol and sugars) in the wastewater [32]. Biological treatment offers three choices of process: aerobic, anaerobic and constructed wetlands [32].

4.2.2.1. Aerobic treatments

Aerobic treatment uses a series of lagoons in which large pumps are installed to provide oxygen transfer through the water to support the natural aerobic bacteria [31]. There are a variety of designs for aerobic systems, some of them are the use of suspended biomass, membrane bioreactors, activated sludge, etc [32]. Nevertheless, they all have some common features. They provide pretreatment to reduce the amount of clogging solids, settling for suspended growth system, and final disinfection [33]. One study reported that this treatment shows a good COD removal, up to 93% efficiency [34]. The study also reported a significant reduction of pollutant concentration in the wastewater, especially in the vintage period, where water volume and pollutants level are at the maximum. Table 3 shows the comparison of chemical composition of wastewater before and after the application of one design of aerobic treatments. The treated water of this treatment can be reused for irrigation purpose.

Table 3: Water quality before and after treatment [34]

Parameter	Untreated wastewater	Treated wastewater
PH	5-7	7.7-8.8
Conductivity (μS/cm)	1885-2110	750-1050
COD (mg/L)	5360-10170	40-200
TSS (mg/L)	340-550	10-60
Phenolic compounds (mg/L)	6-32	0.4-0.6

The downside is that aerobic treatments generally require large amount of energy and some systems even require both high energy and more advance technology, resulting in higher production costs [31].

4.2.2.2. Anaerobic treatments

Anaerobic treatments offer a much simpler and cost-effective version of biological treatment. The treatment also provides 80-98% removal of COD loads in winery wastewater [31] and comes with a variety of designs. Anaerobic treatments involve the use of covered lagoons or tanks to create an oxygen free environment for bacteria to break down organic matters into gas and sludge [35]. Compared to aerobic treatments, anaerobic treatments do not require oxygen and produce fewer by-products (sludge) which makes the process simpler and less energy intensive [36]. At high organic loading rates, such as in vintage period, anaerobic treatments might be the primary choice for water treatment as they have higher treatment capacity, hence they are space-saving, and the small amounts of sludge produced reduces the chance of developing odour problems [32],[37].

Having lower treatment costs than aerobic processes, anaerobic treatments come with some technical problems. The drawbacks of the processes are (1) the systems have slow start-up time, usually takes at least 15 days after a shut down [32], [36]; (2) there are occasional accumulation of scum and problems with clogging or channeling which means on-line monitoring is needed [32]; and (3) some designs still require aerobic post-treatment for high concentration effluents which will increase the total costs of production [32].

4.2.2.3. Constructed wetlands

In Australia, constructed wetland is used by wineries in South Australia region, like Barossa Valley and McClaren Vale, as a secondary treatment [32]. Constructed or artificial wetland system is usually constructed on a land area with less than one metre depth [38]. It removes contaminants by means of filtration. There are two types of constructed wetland: Free Water Surface (FWS) and Vegetated Submerged Bed (VSB).

Figure 4: FWS constructed wetlands [39]

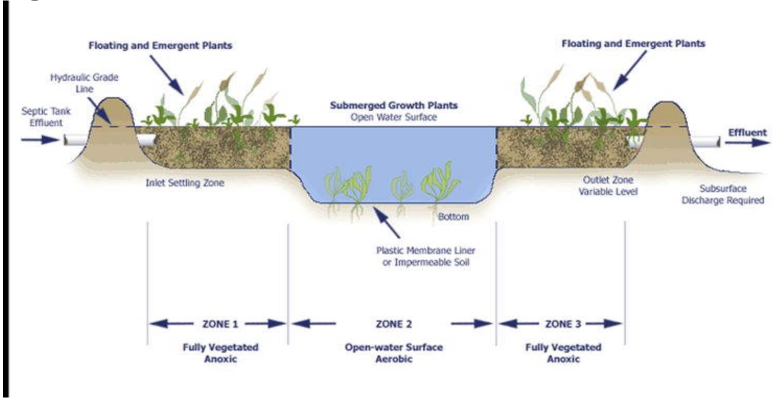
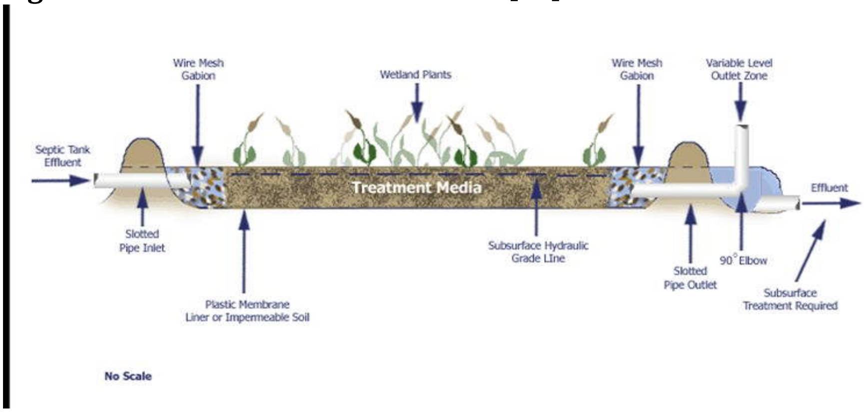


Figure 5: VSB Constructed wetlands [39]



In general, they work with the same concept. As water passes through substrate, it is purified through the activity of bacteria attached to plant roots, soil and other particles [39]. Scientific studies show that constructed wetland is just as effective as other biological treatments [32]. It is reported that constructed wetland reached 92-98% efficiency on BOD removal, 87-98% efficiency on COD removal and 70-90% efficiency on TSS removal.

Table 4: Pros and cons of constructed wetlands system [35]

Pros	**Cons**
• High quality discharge • Effective in reducing COD and TSS • Easy to manage • Subsurface treatment minimize odours generation	• Can only handle small volume of water • Large open area is required • Must be periodically renovated to avoid accumulation of contaminants • Pretreatment is required to remove large solids

5. WINE PRODUCTION COST ANALYSIS

Cost Analysis of Wine production is an important factor to consider in regards to waste water management. The reason for this is that Wine production needs to be profitable, and as such, the treatment methods which are to be used must compliment this requirement. As such, the following details the costs and profits associated with such a process to allow for further comparison.

5.1. Raw Materials

Raw material of wine production is grape. Grape used for the process is generally *Vitis vinifera* L or usually called 'wine grape' [40]. There are a lot of varieties of wine grapes; some of them are Chanel Paradisa, Riesling, Muscadelle, etc [41]. Each of them has different qualities and is used to process different types of wine. Wine grape price varies depending on the region and varieties. The average grape cost range from $400 per tonne (basic wine) to $5000 per tonne (luxury wine) [42]. However, In the case of oversupply, many wine grape varieties are obtainable at price as low as $200 per tonne [42]. Here is the summary of wine grapes prices based on their region [43]:

Table 5: Winegrapes prices

Region (Australia)	Average Purchase Price ($ per tonne)
Adelaide Hills	1,098
Adelaide Plains	651
Barossa Valley	942
Clare Valley	828
Coonawarra	823
Currency Creek	786
Eden Valley	978
Fleurieu - Other	597
Goulburn Valley	652
Grampians	1,245
Great Southern	1,027
Gundagai	563
Heathcote	728
Hilltops	757
Hunter	909
King Valley	972
Langhorne Creek	553

Limestone Coast - Other	812
Lower Murray - Other	329
Margaret River	1,393
McLaren Vale	985
Mornington Peninsula	1,933
Mount Lofty Ranges -Other	854
Murray Darling – Swan Hill	277
Orange	692
Padthaway	689
Perricoota	494
Pyrenees	1,286
Riverina	275
Riverland	296
Southern Flinders Ranges	796
Strathbogie Ranges	913
Tasmania	2,371
Tumbarumba	923
Wrattonbully	643
Yarra Valley	1,330

5.1.1. Vineyards production

Some large wineries obtain grapes from their own vineyards. This is where the grape production costs are taken into account. The production cost can vary depending on the level of mechanization, ranges from $8000/ha to $14000/ha. This cost includes the operating and overhead costs of the vineyard [44].

5.2. Processing and Storage

Processing costs of wine production covers all wine making process including labour, overheads, and depreciation. According to Wine Survey from Wine Australia [42], the average processing costs for large wineries is around 36c per litre ($270 per tonne). For small wine business, the processing costs range from $2 to $3 per litre while the medium scale wineries incur processing costs on average of $1 per litre of wine produced [45],[46]. In addition, storage and handling of wine cost 1.5c per month per litre for large wineries, 3c per month per litre for medium wineries and 6.5c per litre per month for small wine businesses [42],[45],[46]. Wine that requires special care may cost 2-3 times this amount. However, the margin of this high-priced wine should cover this additional expense.

5.3. Packaging

This cost covers the cost of bottling, labeling, cartons, and other packaging supplies [3]. For large, medium, and small wineries, the packaging costs range from $10 per case (basic) to $24 per case (luxury) [42],[45],[46].

5.4. Revenue

According to Wine Australia, major and large wine business in Australia has annual turnover of more than $20 million [42]. Meanwhile, small and medium scale wineries' revenue has a range of $1 million to $20 million per year [45], [46].

5.5. Water Consumption

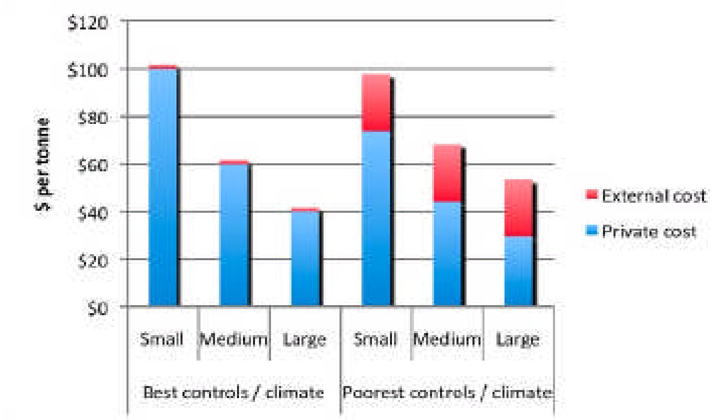
Water is critical for wine production. Wineries use water for cleaning and sanitation of machinery, tanks, barrels, and other equipments. It is reported that, on average, wine industry uses 2000 litres of water per tonne of grapes crushed [47]. However, water is not only essential for wine industry, but also for other industries, household and human consumption. Thus, water is regarded as a valuable resource and needed to be used efficiently. Due to excessive use of water, Australia has been dealing with decreasing water resources for years [48]. In the recent circumstances of water shortage, the Australian government has increased the water price to promote the water value in industries and community. The average water price increased from $0.40/kL in 2004-2005 to $0.78/kL in 2008-2009 [48]. That means wine industry paid 95 percent more than what they paid in 2004-2005.

5.6. Waste Management

5.6.1. Landfill disposal

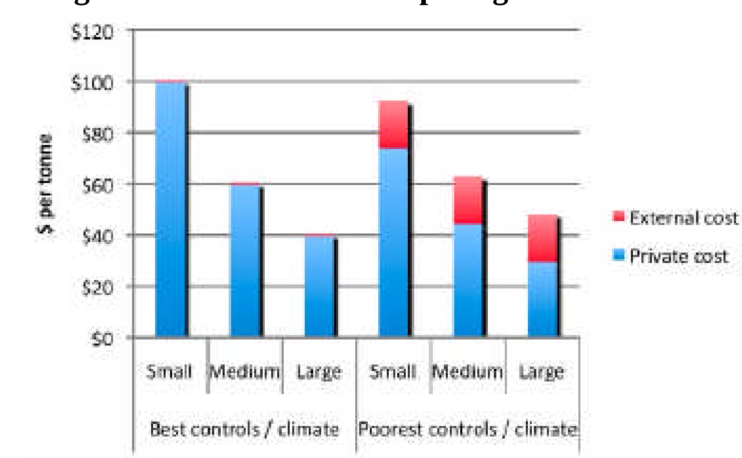
The use of landfill is one of the common practices in winery waste management. The landfill costs are divided into 2 sections: external and private costs. The private costs cover all costs related to landfill establishment, operation and end of life management while external costs incurred for environmental impact, human health, and other costs outside of private costs such as the cost of greenhouse emission [51]. Here is the estimate of full cost of disposing putrescible waste to landfill in Australia [51]:

Figure 6: the full cost of disposing waste to landfill in urban areas [51]



Source: BDA group, Economic and Environment, 2009

Figure 7: the full cost of disposing waste to landfill in rural areas [51]



Source: BDA group, Economic and Environment, 2009

Best controls landfill is defined as the one with leachate management system, incorporated gas collection with energy recovery, and remediation for up to 30 years [51]. In short, it is located to reduce the environmental risk and amenity impact. Poor practice controls landfill can be described as the one with lower establishment, operational and aftercare cost but has poorer management system and inferior waste treatment. From the figures, it can be seen that the total costs for both areas are similar, ranging from $40 to $100 per tonne of waste. Also, for both areas, in poorest controls or climates section, the external costs are significantly higher than the private costs. This condition was due to the higher cost of greenhouse emission and amenity impact. Industrial waste has potential to release greenhouse gases and possible toxic compounds to surrounding air and soil. Thus, the lack of sufficient treatment could increase the level of emissions, pollutants, and disamenity of the landfill which would result in increase of external fees [51]. In wine industry case, to get the best practice landfill, a large scale winery with just 1000 tonnes waste generated would still have to pay a large sum of money.

5.6.2. Composting

Despite some issues related to potential environmental and nuisance impact, some wineries with owned vineyard still prefer to treat their solid waste (grape marc) by composting. For large sized winery, this process is usually done off-site by the composting company. Fin Pty Ltd, one of Australia's composting company, set the cost of processing grape marcs at $15 per tonne [52]. Some other companies like Bark Suppliers Pty Ltd and Van Schaik Organic Soils compost grape marcs at a cost of $10 per cubic metre plus transport costs [52].

5.6.3. Distillation

As distillation is done at the comfort of wineries owned land [52], the cost of the process varies, depending on the technology and equipments used.

5.7. Wastewater Treatment

Nowadays, various processes and treatments to treat wastewater are available. Winery can also combine several treatments together to treat their wastewater. Therefore, the cost of wastewater treatment will vary for each winery. Similar to distillation, the cost depends on the equipments and technologies used. It also depends on the region of winery where land cost might be higher in one place than the other. Generally, the installment cost of the treatment would be very high as wineries are required to build the treatment plants or buy the lands. However, in the long run, the cost would be greatly reduced as winery just needs to pay for energy consumption and any other additional expenses. Also, the better the quality of the treatment, the lower the cost wine company needed to pay for land or site rehabilitation.

6. ENVIRONMENTAL IMPACTS

As the winey in question is a large-scale production, waste produced during process is generally less than minor and therefore the level of management and monitoring needed to minimise the potential environmental impacts is quite high and increasingly important. As the consumers of the world become more environmentally conscious, and the technology to prevent further damage to the Earth becomes more readily available it is vital that all large-scale production, including the red wine-making process, move towards ‘greener’ and more environmentally friendly processes. In this way the world can be preserved for future generations and the surrounding environment can be greatly improved.

In order to effectively prevent and treat waste and wastewater produced by the red wine process we must first understand what this waste is, where it is coming from and how it is effecting its surrounding environment. The type of waste and wastewater produced varies significantly throughout entire red wine making process, with some aspects being considerably worse than others. Below each type of waste, where it is produced, as well as what impact it has will be further explored.

6.1. Wastewater

The largest source of wastewater in the pre-mentioned process is cleaning and rinsing. This includes the “cleaning of tanks, the hosing down of floors and equipment, rinsing of transfer lines and barrel washing” [53]. However “spent wine and product losses, bottling facilities, filtration units, laboratory wastewater and stormwater diverted into, or captured in, the wastewater management system”, are also notable sources.

A study undertaken by the CSIRO, involving over 20 wineries, revealed that the recorded water usage per tonne of crush averaged 2.0L for every 750mL bottle, while FSA counselling recorded figures between 1-5ML for every 1000 Tonnes of grapes crashed in their guide for the Environmental Protection Agency and the Department of Tourist, Fair Trading and Wine Industry Development. This is a quite a significant number but what is more alarming is the quality this wastewater.

Wastewater produced by the red wine making process is generically; saline, high in organic matter, low in acidity and full of nutrients, heavy metals and solids.

There are three indicators on the amount of organic matter within wastewater, all usually measured in parts-per million (ppm) [54];

- BIO, or biological oxygen demand, is the amount of dissolved oxygen that aerobic organisms need to respire organic matter in the water.
- TOC, or total organic carbon, is a sum measure of the concentration of all organic carbon atoms covalently bonded in the organic molecules of a given sample of water.
- COD, or chemical oxygen demand, is the amount of oxygen required to degrade the organic compounds of waste water.

Organic matter can have largely detrimental effects on the surrounding environment if untreated. Depleting oxygen in water systems may cause unpleasant odours to be generated and may even lead to death aquatic organisms, such as fish.

The alkalinity/acidity of water is determined by the pH, which is based on the concentration of H^+ ions and usually tested with an indicator, is lower than 7 (acidic) for wastewater from wine-making, due to organic acids that are generated during treatment. This can affect the microbial activity, stunt crop growth and at extremely low pH may again cause death to aquatic life.

Levels of nitrogen, phosphorus, potassium and sulphur can be tested in order to get a good indication on the amount of nutrients in the water. Excessive nutrients can often lead to eutrophication (when aquatic plants grow abundantly due to the high presence of nutrients) and algal bloom (an excessive growth of algae and cyanobacteria). This can then stave waterways of oxygen and sunlight by preventing sufficient penetration. The oxygen levels can then be further deduced as blooms die and decompose in an aerobic process. Smelly gases can be formed and in extreme cases this leads to a body of water that is stagnant.

High levels of nutrients may also be toxic to crops and plants, potassium may affect soil structure and nitrogen in the forms of nitrate and nitrite is toxic to infants in drinking water.

Salinity (concentration of salt) in water can be toxic to all aquatic organisms including fish, and can affect the water uptake by crops and cause soil degradation, reducing plant growth and yield influencing agricultural production. It also gives the water an undesirable taste. Levels of salinity are indicated by testing the EC, or electrical conductivity, and the TDS, or total dissolved solids [55]. Wine wastewater is usually moderately saline, with cleaning agents increasing this property.

Sodicity is the effect the water will have on the physical properties of the soil due to an accumulation of sodium [56]. SAR, or sodium absorption ration, is one of the two ways this is usually tested. SAR is an indicator of the relative proportion of sodium ions with those of calcium and magnesium. The second method is an ESP, or exchangeable sodium percentage with works in a similar way. Sodicity can destroy soil structure, reducing the water movement and aeration of soil, poisoning various plants, increasing soils susceptibility to water-logging and cause deficiencies of calcium and potassium.

Contamination of water with metals such as cadmium, chromium, cobalt, copper, nickel, lead, zinc and mercury can be extremely toxic to both plants and animals.

The amount of solids in a system of water will affect the quality of the water. Large amounts may reduce soil porosity, that is; the ratio of the volume of pores to the volume, which will lead to reduced oxygen uptake and light transmission to water, negativity affecting the health of the entire ecosystem. Again foul odour may also be generated from anaerobic decomposition. Looking at the TTS, or total suspended solids, is how this property of water quality is tested.

It is interesting to note that wastewater production changes throughout the year, with the peak vintage period (around March to May in Australia); the generation is at its maxima. The BOD and total nutrients generally increase around this time as well, while the acidity is lowered.

6.2. Solid Waste

Solid wastes are also produced by wineries. Generally these are not as harmful to their surrounding environment but must still be dealt with appropriately.

Some of these wastes are;

Grape marc is the left over grape material after the grapes are crushed and pressed. It includes the pulp, the skin and the seeds. Lees, on the other hand, are the material that accumulates in the bottom of tanks during the fermentation process. The grape stalks that are separated during the crushing process and are also considered waste.

Filtered solids such as bentonite clay, wastewater sludge (composed of microbial cells and grape residues) and general wastes from empty chemical containers, packaging wastes and wooden pallets are all other examples of solid waste.

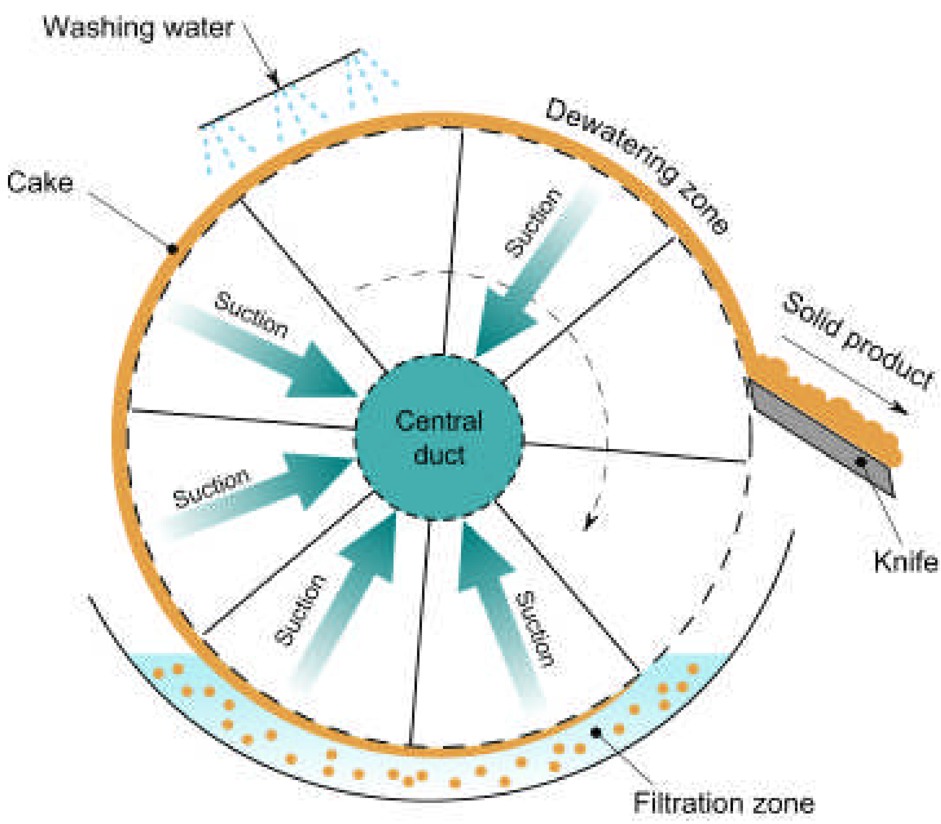
7. NEW PROCESS

The need for new processes is clear from previous sections of the report, as the current waste water management techniques have many issues associated. As such, the new methods that follow are focused on producing a high quality of waste water treatment, most particularly in regards to major water quality factors such as Chemical Oxygen Demand, Turbidity and Total Solids.

7.1. Rotary Drum Vacuum Filter

A Rotary Drum Vacuum Filter is a large mechanical filter which is especially suited to filtering liquids which are very high in solids so is ideal for use in wine-making [57]. It consists of a large cylindrical drum with filtering medium around the side; it spins around on its axis in a pool of the liquid to be filtered. A vacuum sucks liquid through the filter leaving the solids stuck to the side of the outside of the drum as shown in the image below.

Figure 8: Rotary Drum Vacuum Filter [54]



This allows the solid filter cake to be separated and discharged as the liquid is filtered and prevents build-up of solids which would interfere with the filtration and this makes it greatly superior to other course filters. The solid product is also very dry due to the strong suction so this process removes almost all of the juice from the lees and so increases the efficiency of the process.

The cost of this addition will be large upfront but will result in an increase in efficiency of the process since more juice will be extracted from the grapes. This will also significantly reduce the amount of wastewater which is important in minimising the cost of the coagulation process discussed below. Rotary drum vacuum filters, due to their high speed of filtration [58] can process a large amount of liquid for their size and can be made portable, so one could be shared between multiple small wineries decreasing the cost substantially.

7.2. Cross Flow Filtration

Another amendment which we will make to the winemaking process is the addition of a cross flow filtration system in the wine clarification stage. Cross flow filtration differs from conventional filtration because, instead of the flow of liquid being towards the filter it runs perpendicular to it, hence the name "cross flow" [59]. This prevents the solid particles in the wine from clogging up the filter as show in Figure 2.

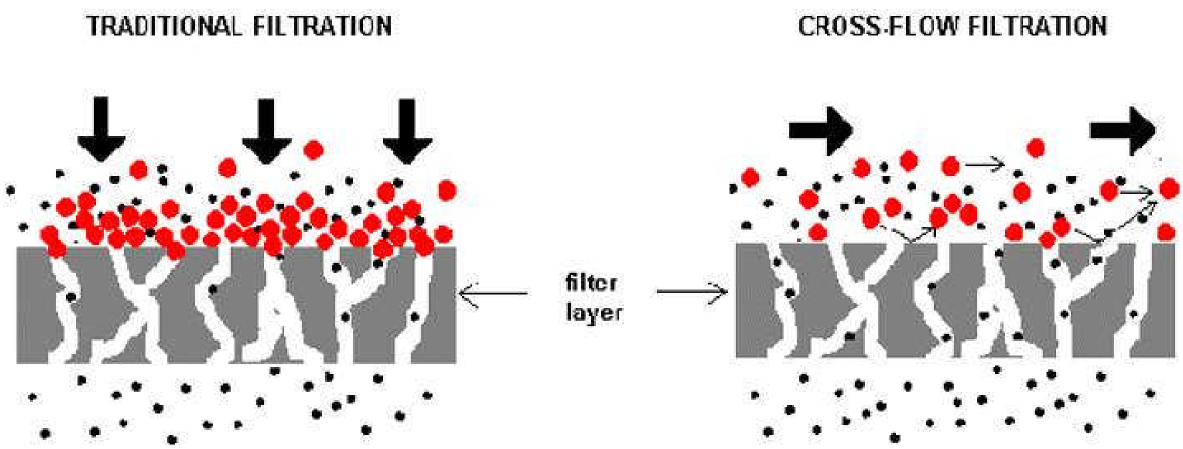


Figure 9: Cross flow filtration working principles [59]

Since there is virtually no risk of clogging the system has been proven to achieve consistent flow rates of wine of 4,000 Litres per hour [60]. Clogging of filters can also result in damage to the filter so this method requires considerably less maintenance. It also allows membrane technology to be utilised effectively resulting in an extremely clear wine with no oxidation, very low loss of wine and with no leaking of the pollutants carbon dioxide and sulphur dioxide [60].

The cross flow filtration system will integrate into the current process easily since they are ordered from companies such as Bucher Vaslin assembled and require only power and a fresh water supply [61]. The cost of this filter will be quite high, but will result in a superior product and less losses due to leakage as the current filter so will be financially advantageous in the long run.

7.3. Aerated Storage

Aerated storage is a method of breaking down organic material present in liquid by microorganisms. The waste water is pumped into large containers in which organisms will effectively feed off the waste, removing nutrients which give the water high biochemical oxygen demand and giving off gases like nitrogen and carbon-dioxide. This process uses an aerobic process, meaning the organisms require oxygen to function. For this reason the tank must have air bubbled through it to provide enough oxygen for the aerobic digestion to take place. This process works best as a batch process since it takes approximately 11 weeks to treat the wastewater. While this is a long time it takes minimal effort and cost input and the fact that it is a batch process works well since the winemaking process is also.

This is essentially the same reaction which happens in nature if wine wastewaters are simply released into waterways. However, since the organisms use up oxygen to digest the organic material this results in the dissolved oxygen levels of the water being depleted rapidly which kills fish. Performing this process in conjunction with chemical flocculation has been shown experimentally in the report by Braz et al. to reduce total chemical oxygen demand by 84.5%, and soluble chemical oxygen demand by 87.9%. [62]

This process has low energy requirements and few other ongoing costs since the only energy requirements for this stage is pumping the water into the large containers, occasionally mixing them and bubbling water through them. The study by Braz et al. also found that the optimal amount of aeration in terms of results for cost input is a period of four hours once per day [63] so energy requirements for this will be low, resulting in low running costs. While running costs for the long term storage and aeration process are low the installation costs will be quite high since it requires new containers and pumps to be purchased. This stage of the process also provides very little in terms of long term financial gains. There is the benefit of being able to recycle a significant proportion of wastewater for irrigation which will save some money, as well as reducing the cost of disposing of waste.

7.4. Flocculation and Coagulation

In wastewater from wineries there is a high level of suspended solids which give the water high biochemical oxygen demand and turbidity [64]. These solid particles are difficult to remove from the water because they not dissolved so can't be precipitated out and they are too small to be removed by any conventional filter. They exist as small particles or colloids, which are dispersed through the liquid. They have small negative charges [65] which makes them repel each other so instead of binding into larger particles they remain dispersed in the water, effectively forming a stable emulsion so are difficult to remove from the water.

One way to remove these particles is to use the process of coagulation and flocculation. While these terms are often used interchangeably they refer to distinctly different processes [C5]. Coagulation is using a particle of opposite charge, in this case a 'cation' or positive ion to the suspended colloids to attract them and bind to them which neutralises the charge. Once the charge is disrupted the particles are no longer dispersed evenly and collide with each other to form larger particles called flocs. It is important not to add an excess of the positively charged coagulants or they could reverse the charge on the colloids and remain suspended, repelled by their like positive charges. After coagulation flocculation occurs where the larger neutral flocs adsorb onto each other to form larger clumps.

After these larger clumps of solids have been formed they are much easier to remove from the wastewater. The particles can be filtered out but the easiest method is sedimentation provided the particles are considerably denser than the water, which they will be for this process [64]. Sedimentation is simply the process of allowing the mixture of water and particles to settle and the particles will sink to the bottom of the container allowing the clear supernatant water to be removed from the surface and leaving behind sludge at the bottom of the container.

The study by Braz et al. provides details on the specifics of this process as it applies to the treatment of winery wastewater specifically. The study determined that the best flocculant/coagulant to use is calcium hydroxide. Between the long term aerated storage and coagulation they were able to remove 96.6% of turbidity, 84.5% of total chemical oxygen demand, 99.1% of total suspended solids (TSS) and 98.7% of volatile suspended solids (VSS). The pH should be optimised at about 6.0.

These two processes do not significantly impact the way the rest of the winemaking process is carried out. It requires the addition of several large containers fitted with pumps for transporting water into and out of the containers. After the main wine-making process, instead of disposing of the wastewater it is pumped into large stainless steel containers. The wastewater is stored here for 11 weeks with air from the atmosphere bubbled through it once a day for four hours. At the end of this period the pH is adjusted to 6.0 by adding a base such as sodium hydrogen carbonate (bicarbonate of soda) since the wastewater is typically acidic. Solid calcium hydroxide is then added to the wastewater and mixed for several hours and then allowed to settle. The supernatant water is the pumped off the surface leaving behind sludge.

A study by Rizzo et al. [63] proposed the use of chitosan, an organic compound as the coagulant for a similar process as this, however the results of the experiment were not as promising, reducing turbidity by only 94% and total suspended solids by only 81% chitosan is also a more expensive chemical to buy than calcium hydroxide so is clearly an inferior choice of coagulant.

The cost of these containers will be the most significant upfront cost of this addition to the winemaking process. However, since wineries already use containers like this for fermenting wine it would be feasible to either recycle old containers from this or other wineries or to use containers which are not currently in use for this purpose. This would offset a significant amount of the cost of adding this process. Another major cost will be that of the calcium hydroxide which will be a continual running cost and is unavoidable for this process, it is only offset by the money saved by recycling water for irrigation and in the long run will be the major cost input for this addition to the process.

7.5. Disposal of Solid Waste

The grape marc left behind by the wine making process, as well as the sludge left over from the coagulation have been considered a big environmental problem coming from the wine making process, but they are also a valuable resource that can be composted and recycled back into the vineyard. It has been known for a long time that the solid waste from the process is high in nutrients; however it is also high in salts which can be detrimental to some soils [66]. This has raised the question of whether adding the solid waste to the vineyard would cause a problem for the grape vines.

A study from 2009 by Antonio. F et al. [D1] conducted an analysis of several different grape marcs from wine making. This study showed that while the waste is high in salts that most of these are beneficial to the vineyards and help to replace the salts that were leached out of the soil by the vines in the first place. Other worries about organic residues and heavy metals were shown to be unfounded and it was shown that the composted grape marc is extremely beneficial to the vineyard and would partially or in some cases completely replace nutrients removed from the soil during wine making [66]. It was, however, show that the levels of nitrogen and phosphorus in the compost were quite low (only 0.1-0.3% and 1-2% respectively) so the compost should be supplemented by other compost such as manure or just conventional nitrate or phosphate fertilisers.

In order to take full advantage of the compostable solid waste, we propose that at the end of every harvest the solid waste from the grape press, wine clarification and also the coagulation process be stored in large containers to be composted and then used on the next year's crops.

8. JUSTIFICATION OF NEW PROCESSES

The use of Cross Flow Filtration as opposed to other filtering methods is mainly justifiable in that the method involves the stream to be filtered travelling tangentially to the filter. The reason this is quite useful in wine making is that the wine mixture after fermentation has occurred contains a high percentage of solids. These solids are known as Lees and consist most generally of dead yeast and grape seeds. As such, Cross Flow Filtration prevents the build of filter cake against the filter, which would reduce the amount of filtrate that is able to pass through the filter. As such, the filter is able to run on a more continual basis, as it will not have to be shut down to be cleaned as often as a filter where the feed runs through the filter.

Of course, Cross Flow filters still carry the benefit of being able to separate particles by their size. This is a useful property as not only can the wine be filtered out to be sold as a final product to the customer, other wastes can be separated by size which may be required to be treated in many different ways. Further, the waste stream leaves the filter as a mixture which is able to be piped through the processing plant for further treatments with ease.

The use of a Rotary Vacuum-Drum Filter is exceptionally beneficial in the removal of solids from high solid waste streams. The reason it is advantageous is because again other filters would block up in handling such large amounts of solids. In addition the cutting away of solids into a separate stream allows easy collection and handling. In this case, a suitable use for the waste could be in composting, which could improve any losses in the process if this is recycled back into the growing of the vineyard.

However, one main issue with the filter in question is that in most standard models there are metallic components. This is an issue as the wastewater stream generally has a low pH level, indicative of a high concentration of Hydrogen Ions in the solution. Hydrogen Ions cause many metals to be displaced into solution and thus cause corrosion problems with the equipment. This would result in poor operation of the filter and high maintenance costs. As such, the justifiable solution to this issue is the use of many plastic filter designs, which are not affected by such low pH levels.

The use of Flocculants to precipitate out certain waste water products is quite useful in the lowering of many unwanted properties that are associated with the waste water streams of a Wine making process. These properties include removal of solids and lowering of both Chemical Oxygen Demand and Turbidity. Chemical Oxygen Demand refers to the measurement relating to the number of organic species in a solution. A high demand is detrimental as adding this waste water back into natural ecosystems can cause death of native species. The reason for this is due to these new species increasing the Oxygen Demand to a point which cannot be sustained. Turbidity on the other hand generally refers to the amount of material that is suspended in a solution. High levels of Turbidity are an issue as suspended particles absorb heat, which will result in waterways containing this waste water to warm up more readily. This inherently decreases the solubility of Oxygen, which can cause death of many native species.

As such, the lowering of all of these properties helps greatly to contribute to a more environmentally friendly waste water stream, which is one of the key factors to consider. However, while the removal of solids and lowering of Turbidity is quite high in the Flocculation process, there is an issue that the method only removes approximately 30% of the Chemical Oxygen Demand from this waste water. Considering this treatment does not satisfy the requirements of lowering all unwanted properties of the waste water stream, another method must be used in conjunction. A solution to the lower Chemical Oxygen Demand removal is the use of aerated storage of the waste water before release. This greatly improves the removal to levels up to the same as Turbidity and Solids for Flocculants. As such, these methods used in combination with each other are a justifiable way to treat these waste water streams.

The main issue however with all of these processes is monitoring Toxicity levels within these waste water streams, as none of these methods address this factor. While there will be key toxins associated with Wine production, for many reasons there could be a variety of toxins present in the waste water stream. While routine checks should be carried out on soil and at various stages of the process, this would be inadequate. Releasing any significant levels of toxic waste waters into streams would cause serious harm to both ecosystems and humans if the water is consumed. Thus, before release, samples of the waste water should be tested for a variety of known toxins that could occur in the waste water. All of these methods listed above will significantly improve the quality of waste water coming from a large scale Wine production facility.

9. CONCLUSION

Overall, the processes outlined above significantly improve upon current methods for waste water treatment. The new processes have been shown to be economically effective in terms of streamlining treatment approaches to preference continuous processing over batch processes. A large focus has been placed on the main water quality properties which include Chemical Oxygen Demand, Turbidity and Solids. However, the methods that have been outlined in the report have the flaw in that continuous testing for toxicity levels from outside stimulants is required, as there is no method for removing any anomalies that may pop up for natural or manmade reasons. Hence, the justification has shown that these new processes are far more effective in waste water treatment for the Wine Industry than the methods currently in practice.

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